From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date: Monday, 15 March 2021 7:34:33 pm

TO THE DEPARTMENT OF CONSERVATION

SUBMISSION by [redacted]

in regards to

Proposal: The application is for a new permit to undertake commercial vessel-based viewing of marine mammals in the Hauraki Gulf.

Applicant: Waiheke Whale and Dolphin Watch Limited
Location of proposed activity: Waiheke Island, Hauraki Gulf
Permission type: Marine mammal viewing permit

Submitter: [redacted]
Submitter's address : [redacted]
Phone contact: [redacted]
This submission is on my own behalf as a New Zealand Citizen and a permanent resident of Waiheke Island for 35 years.

Relief sought : I want the application to be declined

My reasons are as follows:

Effects on marine mammals

a) Adding to the pollution of the Hauraki Gulf with another fossil fuel driven large vessel is counterproductive to attempts of improving the marine environment. In the past I have worked as deckhand and supply manager on boats and know from experience that they spill considerable amounts of fumes, oils and other chemicals into the environment which are ultimately absorbed by seabirds, fish and marine mammals.

b) Research shows that individual animals respond differently to nearby viewing vessels. Some react with curiosity, others flee. The fact that changes in natural behaviour due to human interference have been found should be a strong signal that we have to lay off. It is no longer acceptable to put human enjoyment and curiosity - leave alone financial benefits of a business venture – before the wellbeing of marine mammals.

c) Even though seeing whales and dolphins from close by and being given verbal and written information might have some educational value it is by no means the best and only method of improving general awareness regarding the need to look after them and their habitat. Viewing boat passengers make such a tiny percentage of the population that it is negligible. Educating a few people is no excuse for causing stress to marine mammals.

d) Noise is hugely exacerbated under water and carries for considerably longer distances than on land. As a noise sensitive person I experience piercing, humming and throbbing noises not only as nuisance but often as painful and debilitating. I can only imagine what it must be like for sea animals with incredibly acute acoustic senses, being bombarded with motor noises and sonar equipment from miles away, following them around and closing in. Potentially torturing animals by unnecessarily exposing them to noise must be recognised as cruel. The often cited argument that dolphins like to swim with boats does not hold up. It could be compared with the difference between a person going to the odd noisy party and someone having a racket imposed on them on a regular basis when they are trying to sleep or communicate or go about their own peaceful business. There are studies that link whale beaching to boat noises (ref. wildlife eco-physiologist Terrie Williams research 2017).

e) Every time dolphins or orcas visit the bays around Waiheke it is a magical event for locals and visitors. It has something spiritual. We feel a connection, we show respect (those who don't are usually enlightened by others). What a different experience it would be if these beautiful sea creatures were to come into the bays followed by a large boat packed with up to 200 tourists wielding camaras !

The big question is : **would the dolphins and whales continue to come at all ?**

Additional points of concern

a) The applicants did not make a reasonable effort to inform or consult with the Waiheke community and/or local marine protection related organisations.
The only mention of their planned venture in a local news publication was an article in the weekly Gulf News on 11 March, 4 days before the closing deadline for submissions. The NZ Herald is a regional newspaper, not a local publication.

b) There was no consultation with the Ngati Paoa Trust Board, the mandated iwi authority for consent processes in this area. The supporting letter attached to the application by the Ngati Paoa Iwi Trust is invalid as it is neither signed nor dated, nor does the Iwi Trust have the mandate. In addition they have an invested interest as holders of the not yet constructed (and still under court ruling) marina berths where the applicants' boats would be based. In contrast to the applicants who state they would be operating out of the viaduct, the letter states they would be operating out of the Iwi Trust's berths.

c) According to the applicants' map they propose to stop at Matiatia wharf, assumingly to pick up and/or drop off passengers. This would add to the already chaotic situation at the wharf, especially during summer months, and the existing huge traffic and transport problems.

d) Pre (and no doubt post) covid Waiheke was already swamped with drive through tourists which have been identified as the most damaging visitors to the island as they bear heavy on infrastructure (tour buses, public facilities, leaving lots of rubbish behind), with a small number of businesses profiting while most locals increasingly feel robbed of their sense of belonging and more like exhibits. The local board and community groups are currently working on how to address and improve this situation. Spilling another large group of people into our tiny roads and villages twice a day is not going to help.

e) All in all, the application gives very little detail, contains no impact studies and leaves many questions unanswered.

Jenny McNally

From: [redacted]
Sent: Monday, 15 March 2021 10:40 pm
To: Permissions Christchurch
Subject: Application for Waiheke Whale and Dolphin Watch Limited

Kia Ora

I write in support of the application for Waiheke Whale and Dolphin Watch Limited.

One of the company's core values is Kaitiakitanga. This fosters a sense of pride and stewardship towards Whales and Dolphins and is a platform to raise awareness around the health and mauri of Tikapa Moana.
Ngati Paoa are coastal people and so telling our korero on the waters is the right place.
Marine mammal protection is the main priority that provides an incentive to preserve them in their natural habitat.
Taiao (landscape) conservation and cultural tourism offers the reality of experiencing, learning and discovering the attractions in a tourism destination while allowing the mammals to engage in important functions such as feeding and resting.
Also there is the potential to generate income and employment which benefits to the local community.

Nga mihi kia koe
[redacted]

From: By Sea Waiheke Island
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Monday, 15 March 2021 9:19:26 pm
Attachments: bysea submission to doc whale watch 150321.pdf

Kia ora Bethan,

Please find our submission regarding the Waiheke Whale and Dolphin Watch Ltd permit application - attached.

Best Regards,

[redacted]
Waiheke Island By Sea
www.bysea.co.nz

ph +[redacted]

Director-General
Department of Conservation
Christchurch Shared Services
Private Bag 4715
Christchurch Mail Centre
Christchurch 8140

permissionschristchurch@doc.govt.nz

15th March 2021

Re. Submission on Waiheke Whale and Dolphin Watch Limited permit application.

Attention: Bethan Parry, Permissions Advisor

Kia ora Bethan,

Please receive the following submission from Waiheke By Sea regarding Waiheke Whale and Dolphin Watch Limited's request to view marine mammals by motorised vessel in the Hauraki Gulf.

Background context;

1. [redacted] is a family owned maritime excursion company offering eco-focused scenic trips primarily around Waiheke Islands coast with an operating area of the greater Hauraki Gulf Marine Park.

2. We operate from Matiatia bay on Waiheke Island and our vessel [redacted] is moored on a swing mooring in the bay. We board passengers from the old Matiatia wharf, Kennedy Point wharf, Orapiu wharf and various direct beach locations.

3. [redacted] does not offer fishing, preferring visual, video of photographic encounters.

4. By Sea's directors and their family have lived on Waiheke Island more than 20 years

5. By Sea employs youth from family's resident on Waiheke Island.

6. We hold a current Maritime New Zealand MOTC - #[redacted]

7. Our directors are involved marine community groups such as;

   Transport Forum to the Waiheke Local Board, Waiheke Boating Club &

   Waiheke Sea Sea Scouts

8. Our excursions do not deliberately regularly seek Whale and Dolphin encounters as we prefer to discover them in a natural way during an excursion.

9. We follow the Marine Mammals Protection Regulations 1992 and the conditions governing behaviour around marine mammals.

Our views on the application;

10. This application has not been socialised in the wider Waiheke community and the proposal for this new operation is not widely known.

11. SeaChange stated that for this area, our communities should themselves propose a suitable framework of marine protection. We are expecting the Governments news on the execution of *Seachange* imminently and this is expected to include protection for the species in this application.

12. Waiheke has at least 5 other locally based small operators who offer non-fishing marine excursions which encounter marine mammals. These operators earn their livelihood from residents, New Zealand and previously International visitors.

13. We are aware that similar high engagement operations to that proposed in the Bay of Islands have ceased due to the impact on these mammals and we don't want to see a similar decline in numbers in the Hauraki Gulf.

14. Wharf Infrastructure on Waiheke is at capacity now – a currently only one small floating pontoon is available for charter operators on a disused fuel dock. Coastguard are also having berthage issues. Matiatia has a Fullers360 vessel arriving and departing every 30 minutes. A new large operator would add to this pressure. At Kennedy Point there is no berth for larger vessels and even smaller vessels are having issues with the new barge pile installation. There is no certainty over improved facilities in the proposed new marina at Kennedy Point.

15. The proposal of a 200-capacity ferry is very large scale for the size of the area when we have two other large license holders (eg. Auckland Whale and Dolphin Safari) who are encountering business stresses related to COVID19 – and other small operators.

16. The ferries described in the application have old technology engines. There is no indication that these will be upgraded to current EPA/UN tier 4 quality. These old engines release higher levels of harmful particulates into the sea and air.

17. There are no black water or grey water pump out facilities on Waiheke wharves. A 200-person ferry would need to discharge waste in the Moana during a trip of the proposed duration which is culturally and environmentally unacceptable.

18. The community and Mana whenua of Waiheke are having a conversation currently on protection and regeneration of the marine environmen. Waiheke Marine Project has been sponsored and supported by DOC. The project has not been able to consider the impact of a large-scale operation such as proposed.

For these reasons we submit against the application.

Regards,

[redacted]

From:	[redacted]
To:	Permissions Christchurch
Cc:	[redacted]
Subject:	Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date:	Monday, 15 March 2021 8:26:54 pm
Attachments:	Submission on Hauraki Gulf Marine Park Marine Mammal Viewing Permits.pdf

Kia ora,

We attach our submission in response to learning of the proposed permit applications by various companies. Therefore, the submission is not specifically in response to Waiheke Whale and Dolphin Watch Limited but a response to DOC to consider what impacts an increase in tourism pressure may have on the resident marine mammal populations.

If you have any questions, please do not hesitate to contact us.

Thanks,
[redacted]

Director General
Department of Conservation/Te Papa Atawhai
CC: Bethan Perry, Permissions Advisor

Submission on Marine Mammal Viewing Permit Applications

Tēnā koe Director General,

We were recently made aware of the page on the DOC website that lists the permit applications that are open to submissions. We are writing in response to the several marine mammal commercial vessel-based viewing permit applications for the Hauraki Gulf Marine Park as opposed to an individual operator's application.

We are incredibly fortunate to have had over 22 species of marine mammal recorded in the Hauraki Gulf Marine Park / Tīkapa Moana / Te Moananui-ō-Toi's waters of which the common dolphin and Bryde's whales are resident. This gives the Marine Park a unique position in that it is the only place in New Zealand and one of only a small handful of coastal areas worldwide that is home to the non-migratory Bryde's whale species and an oceanic species of dolphin. It was only recently announced that the Bryde's whales in the Gulf of Mexico are in fact a separate species (Rice's whale) further highlighting how few coastal populations of Bryde's whales there are around the world. The Marine Park has also been referred to as the 'safe haven' for the endangered bottlenose dolphins whose presence has declined in the neighbouring Bay of Islands[1, 2,3].

Two population estimates have shown that the Bryde's whales population is currently stable with around 140 individuals[4,5] but we know from our own experiences of spending time working and enjoying the Marine Park that the population is changing their temporal and spatial distribution with noticeable absences within the inner Gulf during certain periods of the year. This is possibly reflected by the research evidence that the main component of their diet has shifted away from fish and towards plankton. The cause of this we believe is not yet understood but it is likely that this population, along with other cetacean species present in the Marine Park, are already under multiple stressors from direct human impacts (i.e. vessel interaction[6,7], vessel noise[8], entanglement[9]) as well as factors such as climate change whereby food webs are changing in response to changing ocean temperatures.

In terms of tourism pressure, the numbers and intensity of marine mammal viewing operators have been low and well controlled compared to other areas of New Zealand. To our knowledge, only 2 permitted operators currently exist with 1 of these actively using their permit on a daily basis. This has allowed, as far as we know, the marine mammal populations to have limited exposure to the tourism impacts that have been well documented alongside other anthropogenic impacts in other areas of New Zealand such as the bottlenose dolphins in the Bay of Islands, Bay of Plenty and Fiordland and the sperm whales in Kaikoura.

Fumagalli et al's recent paper[10] recommends that we acknowledge marine mammal tourism as a sub-lethal industry and that there have been insufficient tourism impact studies in the Hauraki Gulf to know how to manage the populations going forward. With the 2019 Hauraki Gulf Cetacean Research Fund focusing looking at tourism pressures, it would be beneficial to at least put a pause on all new permit applications until the results from the 3 successful projects have been published and can be taken into account by DOC for future management, including permit applications.

Therefore, whilst we firmly believe that tourism, done right, is a valuable tool for science communication and connecting others with the natural environment, we would urge that DOC applies a precautionary principle and does not allow for an increase in marine mammal tourism in the Marine Park. This is in order to reduce the risk of displacing the problem that exists in neighbouring regions as well as the risk of creating new problems for species who we do not yet have a good understanding of the behaviour and ecology for, nor what impacts existing tourism ventures are having.

At a time when there is a focus in New Zealand on creating a sustainable tourism industry, we should also be ensuring that the environment that tourism operators are in, is sustainable too.

Ngā mihi nui

[redacted]

1. Constantine, R., Brunton, D., & Baker, C. S. (2003). *Effects of tourism on behavioural ecology of bottlenose dolphins of northeastern New Zealand* (p. 26). Wellington,, New Zealand: Department of Conservation.

2. Constantine, R., Brunton, D. H., & Dennis, T. (2004). Dolphin-watching tour boats change bottlenose dolphin (Tursiops truncatus) behaviour. *Biological conservation*, *117*(3), 299-307.

3. Tezanos-Pinto, G., Constantine, R., Brooks, L., Jackson, J. A., Mourão, F., Wells, S., & Scott Baker, C. (2013). Decline in local abundance of bottlenose dolphins (Tursiops truncatus) in the Bay of Islands, New Zealand. *Marine Mammal Science*, *29*(4), E390-E410.

4. Wiseman, N., Parsons, S., Stockin, K. A., & Baker, C. S. (2011). Seasonal occurrence and distribution of Bryde's whales in the Hauraki Gulf, New Zealand. *Marine Mammal Science*, *27*(4), E253-E267.

5. Tezanos-Pinto, G., Hupman, K., Wiseman, N., Dwyer, S. L., Baker, C. S., Brooks, L., ... & Stockin, K. A. (2017). Local abundance, apparent survival and site fidelity of Bryde's whales in the Hauraki Gulf (New Zealand) inferred from long-term photo-identification. *Endangered Species Research*, *34*, 61-73.

6. Martinez, E., & Stockin, K. A. (2013). Blunt trauma observed in a common dolphin delphinus sp. Likely caused by a vessel collision in the Hauraki Gulf, New Zealand. *Pacific Conservation Biology*, *19*(1), 19-27.

7. Constantine, R., Johnson, M., Riekkola, L., Jervis, S., Kozmian-Ledward, L., Dennis, T., ... & de Soto, N. A. (2015). Mitigation of vessel-strike mortality of endangered Bryde's whales in the Hauraki Gulf, New Zealand. *Biological Conservation*, *186*, 149-157.

8. Putland, R. L., Merchant, N. D., Farcas, A., & Radford, C. A. (2018). Vessel noise cuts down communication space for vocalizing fish and marine mammals. *Global change biology*, *24*(4), 1708-1721.

9. Stockin, K. A., Duignan, P. J., Roe, W. D., Meynier, L., Alley, M., & Fettermann, T. (2009). Causes of mortality in stranded common dolphin (Delphinus sp.) from New Zealand waters between 1998 and 2008. *Pacific Conservation Biology*, *15*(3), 217-227.

10. Fumagalli, M., Guerra, M., Brough, T., Carome, W., Constantine, R., Higham, J., ... & Dawson, S. (2021). Looking Back to Move Forward: Lessons From Three Decades of Research and Management of Cetacean Tourism in New Zealand. *Frontiers in Marine Science*, *8*, 7.

From:	[redacted]
To:	Permissions Christchurch
Cc:	Kirsty Prior; Nicola MacDonald; Councillor Pippa Coom; John Galilee; Andrew Baucke
Subject:	Marine Mammal Tourism in the Hauraki Gulf Marine Park
Date:	Monday, 15 March 2021 11:16:07 am
Attachments:	image002.png Letter to DoC re applications to view marine mammals.pdf

Kia ora Bethan,

Please find attached a letter from our Co-Chairs for your kind consideration.

Ngā mihi,

Alex

[redacted]

Hauraki Gulf Forum / Tīkapa Moana / Te Moananui-ā-Toi

[redacted]

Have your say on Auckland Council's 10-year Budget 2021-2031.

Hauraki Gulf Forum
Tīkapa Moana
Te Moananui-ā-Toi

Director-General
Te Papa Atawhai
CC: Bethan Parry, Permissions Advisor

He waka kōtuia kāhore e tukutukua ngā mimira.
A canoe that is interlaced will not become separated at the bow. In unity there is strength.

Re: marine mammal tourism applications for Tīkapa Moana, Te Moananui-ā-Toi

15 March 2021

Tēnā koe Lou,

Our tōhora and aihe are our kaitiaki; a taonga to be forever cherished. There are no words to describe the feeling of being out on the Marine Park as a Bryde's whale, false killer whale or dolphin swims up alongside you. This was their moana long before we came to share it.

We were not aware of several applications for renewed or new marine mammal tourism licences in the Hauraki Gulf Marine Park until members of the public drew our attention to them lately. In future it would be appreciated if all such applications within the Marine Park could be copied to the Forum when put out for consultation.

In respect of all existing licences and applications we have the same two concerns:

1. That we find that balance between enabling all Kiwis and visitors to see those kaitiaki *without* increasing the impact that we already have on them. Our enjoyment cannot come at their expense. Every operator must:
    a. have a high level of scientific and cultural education as part of the experience;
    b. be engaging with mana whenua for the areas that they operate in; and
    c. understand their impact on those taonga through the vibration and noise they create.
2. That we enable iwi/hapū aspirations to be part of this special endeavour.

Rather than considering applications on a case-by-case basis, Te Papa Atawhai might consider looking at all existing licences and new applications for marine mammal tourism within the Hauraki Gulf Marine Park together to find the best way forward.

Nā māua noa, nā

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: dolphin and whale watch Waiheke submission
Date: Sunday, 14 March 2021 9:58:16 pm
Attachments: Waiheke Dolphin and Whale Watch submission.doc

Please find submission attached

I am writing on behalf of the Waiheke Branch of the Green Party to comment on the proposed Whale and Dolphin Watch Waiheke venture.

https://www.doc.govt.nz/contentassets/2243525312bc411ca94029f1b649b669/application-by-waiheke-whale-and-dolphin-watch-limited.pdf

We have some concerns.

1) We see no benefits to the whales, the dolphins, the Hauraki gulf or to Waiheke Island. We are dismayed at the lack of time the public has to make their concerns heard. Most of us were unaware of this business proposal until it was publicised in the local newspaper 3 days ago.

2) Research shows that similar Whale Watch ventures alter the behaviour of these marine mammals. Different species react differently.

We have not been able to find research relating to the species commonly found in the Hauraki Gulf.

However we noticed that during lockdown in February 2020 that there were a vast number of sightings of huge numbers of fish and dolphins visible closer to land than usual.

It is likely that the reduced number of boats on the water was the underlying reason for this, therefore sending two large vessels into the area every day (370 trips per year) must surely have the opposite effect. We feel the number and size of boats excessive, given the small amount of research on the potential impact, and that what research there is, appears to be negative.

We note that the Whale Watch operators in Kaikoura run more trips than this, but their boats (and presumably their engines) are considerably smaller.

We feel that more research needs to be done on our local species before risking their wellbeing. We feel the application is incomplete. More information should be supplied on engine noise and turbulence and how this is likely to affect dolphins and whales at close quarters on a twice daily basis.

3)Will the boats be equipped with hydrophones to determine where the dolphins and whales are, in order to maintain a safe distance from them?

What safeguards are in place to ensure the boats do not get too close?

4)We have some concerns about the effect this business could have on Waiheke itself.

We note that it is planning to operate both from the city, and from "the Ngati Paoa" berths at the Kennedy Point Marina (which, by the way, has just begun construction despite still going through a court process)

Presumably this means some tourists would be boarding from Waiheke. There is a shortage of car parking at this site already, and the car-parks planned for the proposed marina would not be sufficient.

This will adversely affect locals - both those who park at Kennedy Point to travel on the ferry, and those living in nearby houses, some of who already have no access to roadside parking during the day due to ferry travellers' cars being parked there.

It is already a problem, one which will worsen if this business goes ahead.

4)The only road to Kennedy Point passes by a number of schools and pre-schools.
While they are accustomed to heavy traffic at ferry times we would ask that (should the business go ahead) the departure and return times be carefully managed to avoid the times that children are likely to be walking to and from school.

5)We perceive that this will be seen as an added attraction to tourists, particularly during the summer months. Pre-covid, and in due course, post-covid we do not have the infrastructure to support more tourists during the summer months. We already have too many.

We have narrow winding roads, insufficient parking, demand outstripping supply on the ferries, congestion at the Matiatia wharf, the supermarket runs short of fresh produce, and most years, not enough water.

The majority of Islanders rely on collected rain-water. In dry years those who run out buy water. My understanding is that the water delivery companies are only allowed to take a certain amount of water each week so as not to adversely affect the water table. Pre-covid during the tourist season there were waiting times of many weeks to get a water delivery. Increasing tourists increases this problem.

There are also some areas where the e-coli count is some of our swimming bays is too high during summer. Increased numbers of tourists will worsen this.

6) There is also a possibilty, as we have large numbers of small vessels active in the Hauraki Gulf, that the existence of a regular Whale and Dolphin Watch business around Waiheke will encourage many smaller vessels to actively seek out whales and dolphins, causing added disruption.

Given the sad state of the Hauraki Gulf, where Gulf regeneration and restoration is a top priority awaiting legislation, this sized business is inappropriate. If permission is granted at all, we feel it should be for one vessel, preferably a smaller one and for a short time, no more than 2 years initially. This vessel should be required to assist D.O.C. with research on it's own impact.

We would really prefer that our marine mammals were simply left in peace.

Yours sincerely

[redacted]

*

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date: Sunday, 14 March 2021 4:02:53 pm

To whom it may concern,
as a Ngāti Paoa descendant who has a long standing history of engagement in the Hauraki Gulf namely as one of the four Mana Whenua representatives on the Tai Timu Tai Pari Stakeholder Working Group; a technical officer on the Hauraki Gulf in the earlier years of its inception for Hariata Gordon (Ngāti Paoa) as a Tangata Whenua rep; involved in NIWA, Auckland Museum and Auckland University research projects, and currently the national science challenge ecosystems based management project. I herewith submit in opposition to this application.
I believe that from a **scientific perspective** there is not enough information that would provide me with a sense of comfort with regards to the knowledge held by its personnel having long and active associations to Tikapa moana. The Bay of Islands is not Tikapa moana. There are also no specialist organisations that have supported this application which also signals that potentially the proposed operator relationships are minimal to non-existent. Our mega fauna and more extensively their waahi kainga Tikapa moana is constantly under threat. Livelihoods are dependent on the wellbeing of our moana and taonga species and vice versa. As far as I know it has also not been socialised with the Hauraki Gulf Forum or any other important bodies political or otherwise.
In addition to climate related change there are the cumulative impacts on cetaceans from ocean noise, vessel traffic, and habitat degradation. In lieu of all the known threats, the activity is not likely sustainable for the target animals. I have also heard that the vessels may well not be suited for an environment conscious of the need for high spec vessels that are more sustainably built with less reliance on fossil fuels. None of this information is provided.
Responsible, **nature based tourism** demonstrates clear social, economic and environmental benefits to communities, in particular, mana whenua. The proposed operation does not meet these indicators:

Tourism development should be based on the best science available. We have a dearth of recent studies on the status of cetaceans and cetacean watching impacts specific to the Hauraki Gulf which should be reviewed in context of the application:

- Following documentation of population decline in bottlenose dolphins due to vessel impacts in the Bay of Islands no operator should not be allowed to interact with bottlenose dolphins.
- A recent Hons student's thesis (Colbert 2019) shows how anomalously warm water years move the Bryde's whales and common dolphins out further, highlighting that Climate change is a key stressor on the Gulf system affecting the distribution of whales.
- Julia Gosticha's MSc (Gosticha 2020) shows that the Bryde's whales have switched prey from mainly fish to mainly zooplankton in the past 10 years. This prey is of lower nutritional value, which could have long term impacts on the health of the population which is only 140 animals.

The health of our environment is a reflection of us as a people. The situation is

dire and less potential negative impacts are vital.
From a **cultural perspective**, the evidence is also poor. The letter from the Ngāti Paoa Iwi Trust is not on a letter head, it is not dated and not signed either. I have raised this with the Trust Board, their Trustees and their CE. I am aware that there has been no engagement with the Iwi, i.e. specifically those three hapū of Ngāti Paoa who have whakapapa ties to Waiheke where this will be based. I personally belong to both Ngāti Hura and Ngāti Kapu. As you may appreciate, the Kennedy Bay Marina continues to be a highly political hotspot with protests happening currently and is where the boat(s) will be moored. I am also heavily involved in the Waiheke Marine Project and never before have I heard Waiheke be referred to as 'Te Motu no Kahu', even though I know who Kahu refers to.
Given Ngati Paoa's recent rahui and but not limited to the Waiheke Marine Project's Future Search wananga highlighted the community's aspiration for tourism sustainability and marine protection, the proposed operation is not aligned with these values, nor is it culturally empowering, low impact, small scale nature tourism that the community envisions.

I personally would advise the applicant to engage in a more robust and respectful manner than what it has been done so far whatever that may have been.
Whilst it could be said that generally there is a potential opportunity for another tourism operation in Tikapa, my preference is that it is a mana whenua owned and operated venture having wider robust mana whenua support and engagement being critical. I therefore also acknowledge that this application is far more extensive across a wider Tikapa Moana than the Waiheke environs. The Minister also needs to consider the ramifications on Mana Whenua specifically given that the Treaty Settlement process with regards to the Harbour claims is still in motion and that the support of this application may unduly impact on those outcomes.

I call on the Minister to decline the application for all those reasons that I have outlined above.

Noho ora mai,

[redacted]

Ngāti Paoa, Ngāti Whanaunga

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Thursday, 11 March 2021 2:03:00 pm

Kia ora

As someone who, as a Fellow of Allied Whale Research Station attached to a university in the United States, has experience researching cetaceans in the field - in particular Finback whales - I know for a fact that boat trips to watch whales and dolphins definitely affect their behaviour and stress levels. Cetaceans exhibit behaviour changes in response to boat traffic. I have seen examples of this time and time again. Our research boat - after years and years of work in the Gulf of Maine - was know to the animals we were studying and would even come up very close to the boat to greet us. Some of them were bigger than the boat. We would observe the whales diving suddenly and, even though we could not yet see the approaching vessels with out naked eyes, we knew that there were whale-watching boats approaching, with engine sounds and people aboard that the whales were not used to or were perceived as threats. Once the boat had passed, the whale(s) would surface once again and continue their interaction with us.

There are much stronger regulations around whale-watching and getting in the water with any cetacean in the US. Little of what is permitted here would be allowed to happen there. I have observed Jet Skis on Waiheke chasing pods of dolphins into the shallows so that they can get up close for their 'selfie' while causing immense suffering to the animal. In the US, this would result in immediate prosecution.

I am totally opposed to Waiheke Whale and Dolphin Watch Limited being granted a permit to start a business out of exploiting animals they obviously have no experience with, nor no expertise in. Moreover, this business is to be based at Kennedy Point Marina - which has not yet, and may not ever, be built.

Ngā mihi

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date: Monday, 15 March 2021 12:48:51 pm
Attachments: Submission Waiheke Whale Dolphin Watch March 2021.docx

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Hi,

Please find attached our submission on the above application.

Regards

[redacted]

Director-General
Department of Conservation
Christchurch Shared Services
Private Bag 4715
Christchurch Mail Centre
Christchurch 8140

Attention: Bethan Parry, Permissions Advisor

15 March 2021

RE: Application by Waiheke Whale and Dolphin Watch Limited

On behalf of [redacted] we lodge this objection to the application by Waiheke Whale and Dolphin Watch Limited on the following grounds:

1. Repeated reports from the Hauraki Gulf Forum indicate the declining health of the Gulf and the loss of both biodiversity and biomass.

   We note that the latest State of the Gulf Report 2020 stated that marine mammals have reduced to 3 per cent in the Gulf and that certain species such as seals and sea lions are no longer present.

   This proposal does not address these problems and will actually add to the problem especially given that according to DOC figures the number of bottlenose dolphins in the Bay of Islands, where the applicant is currently operating, have declined by 91%. (Newshub 20/12/2020)

2. The scale of the proposed operation, with passenger numbers of 200 persons per trip, is totally out of proportion to those of existing small scale, low impact, sustainable and nature based tourism operators that residents living in the Gulf support.

3. The operator has not identified that they have an active intention of contributing to marine science efforts in the Hauraki Gulf that study the impact of vessel operations on cetaceans and overall marine mammal population dynamics.

4. The application fails to detail how the marine mammals will be located, tracked and followed.

5. The proposed operation will further add to the factors stressing the Gulf such as ocean noise, vessel traffic, habitat degradation and climate change.

6. The carbon footprint of the proposed operation should have been included in the application.

   New Zealand has commitments under the Paris Climate Agreement, our own legislation such as the Zero Carbon Act and the Climate Change Commission's emissions budgets to reduce its gross greenhouse gas emissions. It is not acceptable that any tourism proposal submitted to DOC for consideration does not address the declared climate emergency by both the NZ government and Auckland Council and include details about its climate footprint both direct (fuel type, usage) and indirect (support vessels, vehicles etc.).

7. We question whether this type of tourism business has a viable future given the increasing international concerns about the effect of such operations on marine mammals and likely reductions in overseas visitor numbers. New Zealand should, if it wants to maintain it's clean, green image no longer approve such operations.

In conclusion, we request that the application be declined.

Yours faithfully

[redacted]

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Waiheke Local Board submission on Waiheke Whale and Dolphin Watch Ltd permit application
Date: Monday, 15 March 2021 2:48:52 pm
Attachments: Waiheke Local Board Letter on the application to DOC by Waiheke Whale and Dolphin Watch Ltd Final.pdf

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Dear Bethan,

Please find the Waiheke Local Board's submission regarding the Whale and Dolphin Watch permit application. Will there be a hearing regarding the application?

Kind regards

[redacted]

Have your say on Auckland Council's 10-year Budget 2021-2031.

15 March 2021

Director-General
Te Papa Atawhai
CC: Bethan Parry, Permissions Advisor

Dear DOC,

Waiheke Local Board wishes to provide the following feedback on the permit application from Waiheke Whale and Dolphin Watch Limited for Hauraki Gulf encounter tours of marine mammals, based from Waiheke Island.

The board is committed to improving the conservation and regeneration of Waiheke's marine and coastal environments. Key initiatives in our 2020 Local Board Plan[1] include:

- *working with the Hauraki Gulf Forum, community groups and council to support the implementation of marine protection strategies within our local board area and the wider Gulf and to continue to support marine regeneration projects.*
- *supporting eco-tourism on Waiheke that sustains and supports our environment.*

In 2016 the board ran a major consultation to refresh **Essentially Waiheke[2]**, a village and rural community strategic framework to help inform decisions on matters affecting our island and community. Residents expressed concern about further damage to biodiversity and stated that Waiheke's tourism industry should commit to supporting the restoration, protection, preservation, and enhancement of the island's environment, landscape, amenities, culturally significant spaces and essential character. We note that this application does not fulfill several of those goals and may indeed lead to a detrimental effect on the Hauraki Gulf biodiversity.

The board acknowledges that the permit application is supported by the Ngati Paoa Iwi Trust and respectfully acknowledges their cultural expertise and commitment, and their aspirations.

The board notes that New Zealand Marine Mammals Protection Act 1978 clearly states that tourism operations should not have a detrimental impact on marine mammals.

The Hauraki Gulf Marine Park Act 2000 which was established to recognise the national significance of the Hauraki Gulf has as one of its management objectives:

"the protection and, where appropriate, the enhancement of the life-supporting capacity of the environment of the Hauraki Gulf, its islands, and catchments."

Given the board plans and national legislation, the board is deeply concerned about the impact of further marine tourism on the marine mammals in the Gulf, especially given the proposed frequency and carrying capacity of the proposed operation.

In the Bay of Islands, a recent study by Massey University[3] has shown a reduction in the bottlenose dolphin population over the last 20 years from 276 to 26 with a 75% mortality rate for calves. DOC is now calling for a marine mammal sanctuary in the Bay of Islands.

Another study from Auckland University[4] showed that the presence of boats in close proximity to dolphins results in a significant reduction on foraging and resting behaviours which are critical for dolphin health.

Tezanos-Pinto et al[5] in 2017 also provided evidence of a decline in the Bryde's whale population in the Gulf, despite the protective efforts of the Hauraki Gulf Forum in reducing shipping speeds.

A paper by Fumagali et al[6] published in 2021 which looks at 30 years of cetacean tourism in New Zealand, recommends that a precautionary approach be taken which should establish a framework of protective measures to prevent an activity from inflicting serious or irreversible impact, even if the evidence of such harm is lacking or uncertain.

The study promotes four rules for the future management efforts of cetaceans:
(1) acknowledge cetacean tourism as a sub-lethal anthropogenic stressor to be managed with precaution
(2) apply integrated and adaptive site- and species-specific approaches
(3) fully conceptualize tourism within its broader social and ecological contexts
and (4) establish authentic collaborations and engagement with the local community.

This proposal fails to supply species-specific approaches which identify stressors to the mammals and how these should be mitigated.

The board understands that the proposal is for the venture to use two large second-hand diesel ferries and this runs counter to our carbon reduction commitment which sees Waiheke becoming fossil fuel free by 2030. The Local Board Plan commits the board to 'Continue to endorse Electric Island Waiheke in its goal to support Waiheke to become fossil-fuel free by 2030'. We understand that the ferries being proposed for this venture are tier one high-emission ferries, whilst the main ferry operator to the island, Fullers 360, are investing heavily in alternative energies for a future fleet, and tier four vessels (lower emissions) in the interim.

Given the board's concerns about the possible negative impacts of this venture on the marine mammal populations in the Gulf, which is backed by scientific evidence, it is recommended that any such applications should wait for the outcomes of the government's draft proposal for the Hauraki Gulf, and an understanding of the constraints that may be imposed by that legislation.

The board also recommends that any further approvals should not be considered until a national research and management system is developed which is able to effectively protect our dolphins and whales and enable them to flourish.

Whilst it is not within the scope of the permit, it is a concern for the board that a full on-island impact assessment was not tendered by the applicant to demonstrate the traffic movements to and from the Kennedy Point pier and/or Matiatia Bay. Waiheke's transport infrastructure has never been adequately funded to cope with the pressure of tourism and visitor numbers and is not fit for purpose. The carrying loads being proposed (200 pax twice a day), will further exacerbate that problem.

The board has also committed to developing a sustainable tourism strategy and is committed to the current development of a Destination Strategy with Auckland Unlimited, a strategy that will involve significant mana whenua input and liaison. We respectfully seek the opportunity to complete that work prior to DOC permitting any further marine mammal tours.

Nāku iti noa
Nā

[redacted]

[redacted]

References

1. Waiheke Local Board Plan 2020, p.18 https://www.aucklandcouncil.govt.nz/about-auckland-council/how-auckland-council-works/local-boards/all-local-boards/waiheke-local-board/Documents/waiheke-local-board-plan-2020.pdf
2. Essentially Waiheke Refresh 2016, p.18-19 https://www.aucklandcouncil.govt.nz/about-auckland-council/how-auckland-council-works/local-boards/all-local-boards/waiheke-local-board/Documents/essentially-waiheke-refresh.pdf
3. http://www.massey.ac.nz/massey/about-massey/news/article.cfm?mnarticle_uuid=4B09D526-C745-8100-3297-FBFBD5FE7AB9
4. Tourism affects the behavioural budget of the common dolphin Delphinus sp. in the Hauraki Gulf, New Zealand, Stockin et al, 2008,
5. Local abundance, apparent survival and site fidelity of Bryde's whales in the Hauraki Gulf (New Zealand) inferred from long-term photo-identification, Tezanos-Pinto et al 2017.
6. Looking Back to Move Forward: Lessons from Three Decades of Research and Management of Cetacean Tourism in New Zealand, Fumagali et al, 2021.

From: [redacted]
To: Permissions Christchurch
Subject: submission re dolphin and whale watch
Date: Saturday, 6 March 2021 1:26:07 pm

I strongly oppose the submission I have lived on Waiheke 30yrs and our water is becoming a mess the boats will put extra strain on our water interfering with dolphin and whale passage and using proposed marina will put strain on our water and sea life little blue pinguin population so NO sincerely [redacted]
Sent from Mail for Windows 10

From: [redacted]
To: Permissions Christchurch
Subject: Dolphin and Whale watching application
Date: Monday, 8 March 2021 9:17:45 am

I wish to the ‘vote’ against this application for this tourist service being held in the gulf.

At the moment we are trying to protect our gulf and noise from boats is one factor in reducing numbers and confusing dolphins and whales.

One of the negative effects this type of tourism has is on dolphins avoiding the boats, it also affects pregnant ‘mothers’ see study https://www.int-res.com/articles/meps2003/257/m257p267.pdf

One thing that Covid has shown us on Waiheke, is that during lockdown with no boats on the water we saw more dolphins and fish boil up. Do we need more tourists? No, we need to look after our gulf for the future of our mokopuna. To date we have not shown ourselves in the best light, let us move forward with great care so that we can preserve and respect what we have.

So I say no to this application.

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Monday, 15 March 2021 3:23:49 pm
Attachments: Dolphin and Whale watch proposal Hauraki Islands Branch .pdf

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Please find Forest and Bird Hauraki Islands Branch submission.
We do not support the proposal and think it should be declined.
Kind regards
[redacted]

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[redacted]

Via email
11 March, 2021

Dear Sir/Madam

RE: Dolphin and Whalewatch Proposal

We do not support the proposal. Marine mammals are down to 3% in the Hauraki Gulf and we have already lost 100% of our seals and sealions according to the State of the Gulf Report 2020.

We also note that this operation comes from the Bay of Islands where DOC has reported 'More than 270 were living around the islands in 1999 but by 2015 the population had plummeted to 96. And now in 2020 just 26 bottlenose dolphins have been recorded - a decline of 91 percent.' (Newshub, 20/12/2020)

The methodology by which mammals are followed is also not clear, but we're assuming they whales are located and then tracked until they surface for air while dolphin pods are located and followed which could also be adding to their stress and accounting for a 75% decline in 5 years of the dolphins there in 2015.

It is also unclear where the boats will load and unload from. Is that Kennedy Point, Matiatia or other locations? We feel the proposal should be directed to AT for their view, given the fact that another potential 700 people may be boarding and docking from Kennedy Point, in an already over utilised area.

We feel this is a business whose time is past. It may have been acceptable to follow marine mammals until now, but given their almost complete decimation, and the fact tours may be having an effect on them, this is no longer appropriate.

We would have liked to see the appendix and note that the letter of support from Ngati Paoa is oddly presented with no apparent signatory.

We request that the proposal be declined and that DOC. Not to do so would put the decision at odds with the information provided to the public that they should not 'disturb, harass or make loud noises near marine mammals' (Doc brochure on marine mammals). Even if the animals are not deliberately harassed, they are clearly likely to be disturbed.

Yours faithfully

[redacted]

[redacted]
Forest and Bird, Hauraki Islands Branch

References:

State of the Gulf Report 2020: https://www.aucklandcouncil.govt.nz/about-auckland-council/how-auckland-council-works/harbour-forums/docsstateofgulf/state-gulf-full-report.pdf

Newshub 26/12/2020: https://www.newshub.co.nz/home/new-zealand/2020/12/department-of-conservation-issues-dire-warning-for-bottlenose-dolphin-population-in-bay-of-islands.html

Doc: Share our coasts with marine mammals: https://www.doc.govt.nz/nature/native-animals/marine-mammals/sharing-our-coasts-with-marine-mammals/

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Monday, 8 March 2021 1:41:59 pm

Kia Ora Bethan Parry

I am writing with concern for the recent request of Waiheke Whale and Dolphin watch to run dolphin and whale 'watching' tours in the Hauraki Gulf.

I am a resident of Waiheke Island and have a great love for the ocean life that surrounds the motu that I live on.
Over the years I have witnessed various human interactions with dolphins and whales and it greatly concerns me that these animals are increasingly being exploited and stressed to satisfy human curiosity and desires.

The applicant's kaupapa talks about " Education around the protection and well-being of marine mammals in Aotearoa."

In my mind a group who was truely interested in the protection and well being of marine mammals would:

1. Not be seeking out these animals twice daily - the noise stress of engines and large groups of people is not in the best interest of these animals who are already having to cope with high numbers of recreational and commercial boats in the Hauraki.

2. Not be using large amounts of fossil fuel, a major contributor to climate change which is having a large impact of ocean temperatures and the well being of marine life.

3. Not be looking to use a berth in a highly contentious marina development on Waiheke Island. Marina's are not developments that enhance marine life and contribute to the well being of the moana.

There are many ways groups can contribute to the health and well being of the moana and marine life and educate people at the same time. These might include:

1. Marine education centres
2. Making sharing of documentaries about marine environments and animals.
3. Practising behaviours that reduce our carbon footprint.
4. Actively involving people in conservation projects - beach clean ups, foreshore/wetland plantings, etc.
5. Reducing consumption of fish and other marine animals.

All of these ideas can be shared from a te ao Māori perspective, drawing upon tikanga and local iwi histories and pūrākau.

As humans we have a responsibility to protect the habitats and well being of other life forms and to move beyond an economic model that exploits other animals and the environment for personal gain.

The time has come for us to get creative and compassionate in the way that we go about making our livelihoods in this world. While I applaud the 'written intention' of this group to educate and protect marine life, I don't think this application speaks with integrity to this aim.

Therefore in its current form I oppose it,

Kind wishes

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Saturday, 6 March 2021 10:33:03 am

Hi there,

I live on Waiheke and strongly object to this operation. It is yet another example of a business trying to monetise the natural world to the detriment of the natural world.

The unspoiled nature of Waiheke is constantly under attack by tourism when we should be trying to protect the dwindling mammal life and not disturb them with sightseeing vehicles. There are too many boats in Waiheke waters as it is disturbing fish, penguins and dolphins.

This operation will also bring more traffic and pollution as its customers are transported all to enable a private enterprise to make money out of the ocean without putting anything back to the environment.

I strongly object to this application.

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date: Monday, 15 March 2021 4:56:07 pm
Attachments: Ngati Paoa Trust Board Submission re Waiheke Whale and Dolphin Tour Permit Application.pdf

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To whom it may concern,

Attached is the submission from The Ngati Paoa Trust Board on the Marine Mammal Permit applied for by Waiheke Whale and Dolphin Watch Limited.

Should you have any problems or questions, please contact the [redacted] *on* [redacted]

Regards

[redacted] *on behalf of the Ngati Paoa Trust Board.*

Ngati Paoa Trust Board
P.O. Box 204 144
Highbrook
Auckland 2161

Applicant: Waiheke Whale and Dolphin Watch Limited
Location of proposed activity: Waiheke Island, Hauraki Gulf
Permission type: Marine mammal permit
Summary of proposal: The application is for a new permit to undertake commercial vessel-based viewing of marine mammals in the Hauraki Gulf.

Friday, March 12, 2021

Email: permissionschristchurch@doc.govt.nz
Re: Submission on Waiheke Whale and Dolphin Watch Limited permit application.

Director-General
Department of Conservation
Christchurch Shared Services
Private Bag 4715
Christchurch Mail Centre
Christchurch 8140

Attention: Bethan Parry, Permissions Advisor

Dear Ms Parry,

The Ngāti Paoa **Trust Board** (as opposed to the Ngāti Paoa **Iwi Trust**) is the mandated authority and represents the Iwi of Ngāti Paoa. A copy of a letter from Waitangi Treaty Minister Andrew Little is attached, confirming this. Our mandate was upheld in the Maori Appellant Court at the end of 2020.

The **Trust Board** would like to confirm that the Ngāti Paoa Iwi, by way of the Ngāti Paoa **Trust Board does NOT** support the above application for the following reasons:

- The application and activity is contrary to Ngāti Paoa values, namely the protection, conservation and restoration of the Te Moananui o Toi/Hauraki Gulf, its islands (in particular Waiheke, our motu of ahi kaa), environment and all marine life that resides in and visits it.
- There are studies that show that marine mammal tourism has an impact on their behavior and physiology. These studies highlight a lack of research and data on the long-term impacts of populations from tourism activities within the current regulations of the Marine Mammals Protection Act of 1992. Ngāti Paoa have a lack of confidence in the efficacy of these regulations to protect marine mammals based on recent studies. Due

to budget and time constraints, we do not intend to do your research for you. The information is publicly available online.

- We see this activity as contributing to the ongoing degradation of the Hauraki Gulf and is against the intent of the recently laid Rāhui (put down 31.01.2021) which initially puts a ban on the harvesting of Mussels, Scallops, Crayfish and Paua, to allow those species to begin to regenerate.

- The applicant states that one purpose of the activity is to educate and for data collection for research purposes. It would be good for the Applicant to comment further on the education side of things. Who does the intended research benefit? Or are they just collecting data

- The secondary purpose is: “Customary relationship between marine mammals and Iwi in the Hauraki Gulf. Including the education and sharing of cultural narratives of the sights of cultural significance to mana whenua/mana moana.”

  What input do the actual people of Ngāti Paoa have here? Who provides the narrative? Is it put out to Nāa uri o Paoa ki Waiheke for contribution and consultation? How does this benefit Ngāti Paoa iwi really? Are our stories being sold for a commercial enterprise?

Nga mihi

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: FW: Submission on Waiheke Whale and Dolphin Watch Limited permitapplication
Date: Monday, 15 March 2021 7:11:30 pm
Attachments: Scan_20210315 (10).pdf
Ngati Paoa Trust Board Submission re Waiheke Whale and Dolphin Tour Permit Application.pdf

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Sent from Mail for Windows 10

From: [redacted]
Sent: Monday, 15 March 2021 6:57 pm
To: [redacted]
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permitapplication

To whom it may concern,

Attached is the submission from The [redacted] *on the Marine Mammal Permit applied for by Waiheke Whale and Dolphin Watch Limited.*

Should you have any problems or questions, please contact the Principal Officer [redacted]

[redacted]

Auckland Council
Te Kaunihera o Tāmaki Makaurau

31 August 2018

Harry Williams
Ngāti Paoa Trust Board
PO Box 204 144
Highbrook
Auckland 2161

By email: NPTB@ngatipaoatrustboard.co.nz

Tēnā koe Mr Williams

Thank you for your letter of 9 July and subsequent emails to Auckland Council from yourself, Mr Roebeck and Ms Allies on behalf of the Ngāti Paoa Trust Board.

As noted in Phil Wilson's letter to you of 14 August, Auckland Council values its relationship with Ngāti Paoa extremely highly and is committed to engaging in good faith with the mandated representatives of the iwi.

You have advised that the Ngāti Paoa Trust Board is the sole and exclusive mandated representative for Ngāti Paoa, including on Resource Management Act 1991 (RMA) and Local Government Act 2002 (LGA) matters, and have requested an acknowledgement of this from Auckland Council. You have also requested various actions from Council in respect of the Kennedy Point Marina resource consent, and the Stoney Ridge/Hoporata quarry resource consent.

We respond to each of these matters in turn.

Exclusive mandate

The Office of Treaty Settlements has confirmed that Ngāti Paoa Trust Board is the entity that holds the mandate (with mandated negotiators) to conclude historical Treaty settlement negotiations on behalf of Ngāti Paoa. You have forwarded letters from Ministers Sharples and Finlayson from 2011 and 2016 confirming this.

We understand this is common ground among all parties and we wish to acknowledge it.

Ngati Paoa Trust Board
P.O. Box 204 144
Highbrook
Auckland 2161

Applicant: Waiheke Whale and Dolphin Watch Limited
Location of proposed activity: Waiheke Island, Hauraki Gulf
Permission type: Marine mammal permit
Summary of proposal: The application is for a new permit to undertake commercial vessel-based viewing of marine mammals in the Hauraki Gulf.

Friday, March 12, 2021

Email: permissionschristchurch@doc.govt.nz
Re: Submission on Waiheke Whale and Dolphin Watch Limited permit application.

Director-General
Department of Conservation
Christchurch Shared Services
Private Bag 4715
Christchurch Mail Centre
Christchurch 8140

Attention: Bethan Parry, Permissions Advisor

Dear Ms Parry,

The Ngāti Paoa **Trust Board** (as opposed to the Ngāti Paoa **Iwi Trust**) is the mandated authority and represents the Iwi of Ngāti Paoa. A copy of a letter from Waitangi Treaty Minister Andrew Little is attached, confirming this. Our mandate was upheld in the Maori Appellant Court at the end of 2020.

The **Trust Board** would like to confirm that the Ngāti Paoa Iwi, by way of the Ngāti Paoa **Trust Board does NOT** support the above application for the following reasons:

- The application and activity is contrary to Ngāti Paoa values, namely the protection, conservation and restoration of the Te Moananui o Toi/Hauraki Gulf, its islands (in particular Waiheke, our motu of ahi kaa), environment and all marine life that resides in and visits it.
- There are studies that show that marine mammal tourism has an impact on their behavior and physiology. These studies highlight a lack of research and data on the long-term impacts of populations from tourism activities within the current regulations of the Marine Mammals Protection Act of 1992. Ngāti Paoa have a lack of confidence in the efficacy of these regulations to protect marine mammals based on recent studies. Due

to budget and time constraints, we do not intend to do your research for you. The information is publicly available online.

- We see this activity as contributing to the ongoing degradation of the Hauraki Gulf and is against the intent of the recently laid Rāhui (put down 31.01.2021) which initially puts a ban on the harvesting of Mussels, Scallops, Crayfish and Paua, to allow those species to begin to regenerate.

- The applicant states that one purpose of the activity is to educate and for data collection for research purposes. It would be good for the Applicant to comment further on the education side of things. Who does the intended research benefit? Or are they just collecting data

- The secondary purpose is: "Customary relationship between marine mammals and Iwi in the Hauraki Gulf. Including the education and sharing of cultural narratives of the sights of cultural significance to mana whenua/mana moana."

  What input do the actual people of Ngāti Paoa have here? Who provides the narrative? Is it put out to Nāa uri o Paoa ki Waiheke for contribution and consultation? How does this benefit Ngāti Paoa iwi really? Are our stories being sold for a commercial enterprise?

Nga mihi

[redacted]

Ngati Paoa Trust Board

From: [redacted]
To: Permissions Christchurch
Subject: Waiheke Whale & Dolphin Watch
Date: Monday, 15 March 2021 4:33:26 pm

Please accept my submission that this venture’s application NOT be granted due to the vessels being used in the gulf.
The vessels that are proposed for use have tier 1 engines and as such are the most polluting engines which cannot be in any way gentle on the ocean marine environment or for emissions related to climate change.

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Saturday, 6 March 2021 8:29:51 am

Hello

I prefer that we do NOT encourage this tourism business.

Can we be absolutely assured that, having spotted marine mammals the boat would not approach the mammals but turn a safe distance away and **cut their engine**?

Can we be absolutely assured that no harm could come to the mammals, especially their young?

Please respond to my questions.
Many thanks

[redacted]

[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Saturday, 6 March 2021 7:03:01 am

Hi DOC

I am writing to oppose the application for this operation. I have lived on Waiheke for 15 years. The island is becoming nothing more than a place to be exploited for tourism.

We have double decker buses pounding the roads, thousands and thousands of visitors daily in summer, the island infrastructure is buckling. Now more sea pollution with dolphin and whale watching vessels twice daily.

I've seen dolphins and whales a handful of times here. Do we need diesel pollutants in the sea and atmosphere 700+ times per year in the hope that tourists get to see a dolphin? There's dolphin tours in town and up north.

What are the environmental impacts? Do dolphins and whales like being chased by huge boats and shrieking tourists? It's a good way to scare them off I'd think.

Please decline this application. It's a money making private enterprise at the cost of the environment, the sea life and the permanent residents on this island.

Sincerely
[redacted]

Sent from my iPhone

From: [redacted]
To: Permissions Christchurch
Subject: Submission opposing application by Waiheke Whale and Dolphin Watch Ltd
Date: Monday, 15 March 2021 7:30:04 pm

Dear Director-General,

Protect Our Gulf opposes the application from Waiheke Whale and Dolphin Watch to operate whale and dolphin watching cruises in the Hauraki Gulf.

The Hauraki Gulf Marine Park is visited by more than 22 species of dolphins and whales, many of which are endangered.

The operation proposes to primarily target Bryde's whales and common dolphins. Bryde's whales are endangered and have a "nationally critical" status. It would be harmful to these rare, gentle giants to allow an intensive commercial tourism operation to target watching them.

Although common dolphins are not classified as threatened, there are no clear population statistics, so their status remains uncertain. The Hauraki Gulf is a calving ground for common dolphins, which mostly give birth in the summer. This tourism operation is likely to be particularly busy over the summer period, when these dolphins are at their most vulnerable. The noise and disturbance from tourist vessels would increase the risk of population decline among common dolphins and other marine mammals which give birth in the gulf over the summer months.

Orcas are seen in the inner gulf and have "nationally critical" status. Blue whales are found in the gulf and are "critically endangered", with a worldwide population estimated at less than 2,000. The Oceania population of humpback whales, which sometimes enter the gulf, is classified as "endangered" by the International Union for Conservation of Nature (IUCN). Sei whales have an IUCN status of "endangered", use New Zealand waters for calving, and are seen in the gulf. Fin whales use the gulf and have an IUCN status of "vulnerable". New Zealand's population of Southern right whales, which are seen in the gulf, could be fewer than 30 individuals.

Noise from the tourist vessels poses a significant risk of adversely impacting on dolphins and whales. The underwater noise effects of the vessels have not been provided, suggesting the operators are not adequately considering the impacts of their activity on marine mammals. The Department of Conservation has stated there is "concern that noise pollution may affect blue whales' ability to communicate". Dolphins and whales use sound to maintain sophisticated social systems. Echolocation provides critical information allowing dolphins and whales to find food and navigate in dark or murky waters. Noise pollution from these tourist vessels could impact on bonds between mothers and calves, and could harm other bonds within pods of dolphins and whales. Noise could add to pressures caused by climate change and over-fishing, making it difficult for dolphins and whales to find enough food. The stress caused by excessive underwater noise at close range on a frequent basis is also likely to adversely affect these marine mammals.

The proposed operators include Lawrence Hamilton, a former skipper from Bay of Islands dolphin and whale watching tourist operations, and Vicki Hamilton, who has worked as a deck hand and guide on Bay of Islands dolphin and whale watching tourist operations. The Department of Conservation has stated that the dolphin population in the Bay of Islands fell by 66% between 1999 and 2019, leaving a core group of only 19 dolphins frequently using the area heavily visited by tourist vessels. The dolphin calf mortality rate in the area was the highest in New Zealand, with a survival rate of just 25 percent. In response to these adverse impacts, restrictions were placed on the number of commercial vessels allowed to offer dolphin and whale watching tours in the Bay of Islands. It would be wrong to move those adverse impacts from the Bay of Islands to the Hauraki Gulf. The proposed operation could cause dolphin and whale populations to decline in the gulf and reduce the chances of dolphin calves surviving.

The cumulative effects of dolphin and whale watching activity in the gulf must be considered. Auckland Whale and Dolphin Safari already operates tourist trips frequently and many other commercial vessels offer fishing trips and island tours that stop to watch dolphins as a secondary activity. The Hauraki Gulf is the marine playground for New Zealand's largest city and is often busy with recreational boat traffic. Motor boats and jet skis are known to harass dolphins and whales far too frequently. A bumper sticker on Waiheke Island says "Waiheke needs double deckers like the dolphins need jet skis", a slogan that reflects the constant harassment of dolphins by small vessels. DOC has investigated many incidents of dolphins being harassed around Waiheke over recent years. Dolphins and whales do not need more people chasing them and watching them – they need stricter enforcement of regulations that protect them from harassment by people in boats and on jet skis.

Although Ngati Paoa Iwi Trust has given its consent for the operation, DOC should consult with Ngati Paoa Trust Board, which represents the iwi. Recently, Ngati Paoa Iwi Trust has taken financial compensation for other environmentally destructive activities, which are opposed by Ngati Paoa Trust Board.

The Marine Mammals Protection Regulations 1992 part 6c requires that commercial operations "should not have any significant adverse effect on the behavioural patterns of the marine mammals to which the application refers, having regard to, among other things, the number and effect of existing commercial operations". This application should be declined because the operation would have a significant adverse effect on the behaviour of marine mammals and poses a significant risk of causing dolphin and whale populations to decline. The high number of recreational and commercial vessels operating within the Hauraki Gulf makes it inappropriate to add further pressures to marine mammals in the gulf. The endangered status of many of the dolphin and whale species in the gulf makes it particularly important that they are protected from further intrusion by tourist activities.

Part 6 (d) of the Marine Mammals Protection Regulations requires "that it should be in the interests of the conservation, management, or protection of the marine mammals that a permit be issued". This application is primarily commercially driven and is not in the interests of conservation or the protection of marine mammals. Education about marine mammals can easily occur without posing a risk to endangered species of marine mammals, as this operation does.

The Hauraki Gulf Marine Park Act was created in 2000 to make it clear that the gulf is of national importance. It states that decision makers must seek to protect, maintain and, where appropriate, enhance the life supporting capacity of the gulf.

Allowing increased tourism activity that adds to the stressors adversely impacting on whales and dolphins would fail to protect or enhance the life supporting capacity of the gulf.

From: [redacted]
To: Permissions Christchurch
Subject: Sub,mission on dolphin and whale watch Waiheke
Date: Monday, 15 March 2021 7:24:40 pm

I strongly oppose this submission. I believe that the current Ak Dolphin and Whale watch is enough for the Gulf. I do not wish another. I do not think the Hauraki Gulf marine life which is already under stress will benefit from more boats disturbing their environment.
I also believe strongly that Ngati Paoa have only self interest in this application. I do not trust their assertion they support marine life. They have already agreed to a marina at Kennedy pt which can only be detrimental to all marine life. Their support for the marina was influenced by offers from the marine developers to provide berths and a whale watch business. So I suggest you consider all their assertions with a grain of salt.
Regards [redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Waiheke Whale and Dolphin Watch Ltd
Date: Monday, 8 March 2021 3:01:11 pm

To Whom it may Concern
I would like to comment on the application by Waiheke Whale and Dolphin Watch Ltd to operate around Waiheke Island.
I am a resident of Waiheke Island and I would be opposed to such a large operation. I would not be opposed to them operating on a smaller scale.
[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Submission on Waiheke Whale and Dolphin Watch Limited permit application.
Date: Monday, 8 March 2021 5:58:41 pm

I understand an application has been made for a permit for the above.
I strongly oppose such application as there are already 2 official operators in Tikipa Moana and no doubt many unofficial ones as boaties find them in their travels and follow and often hassle them. Not everyone respects the laws around watching dolphin in terms of distance etc when they find them.
With the ever increasing population of Auckland more people are getting boats and getting out on the harbour to fish. Between the recreational and commercial fishing that goes on there is huge pressure on fish stocks and we are seeing stock levels of Snapper and Terakihi at crucially low levels. So dolphin are already under stress in terms of it being harder to find food, ocean warming and people in their habitat. They really dont need another tour going out specifically to look for them. Look at what has happened in the Bay of Island where numbers have plummeted and swimming tours are now prohibited. I am not a scientist and refer you to the submission that Olive Andrew's will submit for that information

[redacted]
Sent from my Samsung Galaxy smartphone.

From: [redacted]
To: Permissions Christchurch
Subject: Application by Waiheke Whale and Dolphin Watch Limited
Date: Tuesday, 9 March 2021 9:20:47 am

To whom it may concern
As a resident of Auckland and in particular the last 30 years living on Waiheke Island, I’ve watched the degradation of our marine environment
I am utterly against this application
It serves no one, least of all these mammals
The Iwi Trust named does not represent all Maori concerned let alone the full spectrum of the rest of us
Recently a rahui was put around the island as an initial effort to begin helping the crustaceans
We, all the ‘residents’, are doing our best. And the best cannot be achieved when faced with yet another way to use and abuse the ocean
Please deny the application
Sincerely
[redacted]

From: [redacted]
To: Permissions Christchurch
Subject: Application by Waiheke Whale and Dolphin Watch Ltd
Date: Tuesday, 9 March 2021 9:01:27 am

Dear sir or madam
I am a resident of Rocky Bay on Waiheke Island. Over our 30 years here we have witnessed the decline of whale and dolphin visits to our bay.
For this reason I am opposed to the above venture going ahead.

Yours sincerely
[redacted]

Sent from my iPhone

From: [redacted]
To: Permissions Christchurch
Subject: Submission on the: Application by Waiheke Whale and Dolphin Watch Limited
Date: Wednesday, 10 March 2021 12:35:54 pm

Just another bums on seats, energy intensive, heavily GHG emitting, tourist "attraction". This one is too big for Waiheke, and worse Waiheke is already overrun with tourist operators to the total dis-benefit of all local long time residents and the struggling ecosystems. Further, whales are not common in the Hauraki Gulf these days, and I'm sure the dolphins would much rather be left in peace away from thumping diesels, propeller noise, and gawking tourists; it is well known what happens is the dolphins, who are intelligent species and have arguably been out in the Gulf for millennia, will move away, thus the end result is that the tourist operation kills the goose which laid the golden egg anyway after having imposed a great deal of invasive stress on the tourist attraction wildlife.
It could be different is the vessel was a quiet sail powered craft.

For this Application I have calculated the "**Discovery 1's**" CO_2 emissions, which are:-
Discovery 1 vessel will emit more than **6 tonnes of CO_2 per day** from the vessel's main engines doing their so-called, "eco-friendly whale and dolphin watch" twice daily tours.

Annual emissions will be at minimum somewhat more than 2,200 tonnes of CO_2 from the vessel's main engines. An electricity generator running galley facilities and refrigeration 24/7 would significantly increase the quantity of CO_2 emitted from the vessel (and if plugged into the Mains would then cause additional CO_2 emissions from Huntly Power Station).

Then additionally there will be collateral CO_2 emissions involved in getting tourists to and from the *Discovery 1's* commercial depots and home ports, also additionally there will be the ongoing energy and CO_2 emission costs involved in supplying the *Discovery 1* with food, fuel, maintenance, and crews.

Given the parlous state of the Hauraki Gulf ecosystem, and the increasingly deleterious effects of GHG emissions, it would certainly appear inadvisable to add further pressure on the Gulf from any tourism enterprises.

Yours sincerely,

[redacted].

From: [redacted]
To: [redacted]
Cc: [redacted]
Subject: FW: Waiheke Whale and Dolphin Watch Ltd. application
Date: Tuesday, 9 March 2021 3:06:42 pm

Thanks Akasha,

Myself and Bethan are the correct people.

Bethan- can you make a note of this as a public submission.
Thanks,

[redacted]
Operations Manager

On 9/03/2021 3:03 pm, permissions <permissions@doc.govt.nz> wrote:
Kia ora [redacted]
We have received what appears to be a complaint against an application that you are currently managing 91805-MAR. It is unclear how Mr Parke found this application in the first place and therefore this seems like a bit of a strange situtation. Regardless Mr Parke has outlined his concerns below.
Please advise if you are not the correct person to be emailing about this matter.
Thanks.
Ngā manaakitanga,
[redacted]
Pronouns: She/Her
Āpiha Hātepe Ture Āwhina | Statutory Processing Support Officer
Planning, Permissions and Land Unit
Kirikiriroa | Hamilton Office
[redacted]

From: [redacted]
Sent: Monday, 8 March 2021 3:06 p.m.
To: permissions <permissions@doc.govt.nz>
Subject: Waiheke Whale and Dolphin Watch Ltd. application
I'm a Waiheke Island resident and I want to comment to the application in question, as seen at https://www.doc.govt.nz/contentassets/2243525312bc411ca94029f1b649b669/application-by-waiheke-whale-and-dolphin-watch-limited.pdf
The scope of this application is way out of line. A 10 year granting of this privilege for 2 vessels operating for a sum total of nearly nine hours per day with a sum total of 80 minutes chasing native marine mammals around is completely inappropriate.
Looking for literature about the effects of humans on dolphins, one is shocked at its paucity, considering how popular this "swimming with dolphins" thing has become as a tourist attraction.
https://www.sciencemag.org/news/2018/04/swimming-dolphins-good-idea raises doubts. It quotes a
University of Otago study published in 2018: "Behavioural responses of spinner dolphins to human interactions"

Maddalena Fumagalli et al, Published:25 April 2018https://doi.org/10.1098/rsos.172044

The abstract starts out: *There is increasing evidence that whale and dolphin watching activities have detrimental effects on targeted cetacean populations.*

The current proposal should be given a very limited term, and should have specific research protocols inclusive, to assess the impact of these cruise will have on Hauraki Gulf marine mammals behaviour, feeding, reproduction and well-being in general. During such an interim period, there should not be two sailings per day, but one. The applicants already state they have an appropriate vessel for this. Giving them a 1 or 2 year permit, provided there is data generated regarding impact on marine mammals, should be sufficient for them to make a go of it. They don’t need to have permission to buy a second boat and double their If the data suggests no negative impacts on the creatures they propose to view, a subsequent application would be well supported. Right now there is no evidence these sorts of activities are anything but detrimental to the cetaceans and other marine mammals.
Regards,

[redacted]

From:	[redacted]
To:	Permissions Christchurch
Subject:	Submission on Waiheke Whale and Dolphin Watch Limited permit application
Date:	Monday, 15 March 2021 3:46:13 pm
Attachments:	Submission to the Department of Conservation Regarding Whale Watching Permit by [redacted] docx Effects of Tourism on Marine Mammals in New Zealand - DoC 1999 - .pdf Looking Back to Move Forward - Lessons From Three Decades of Research and Management in NZ.PDF An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years.pdf Effects of Tourism on the Behaviour of Sperm Whales Inhabiting the Kaikoura Canyon.pdf Why Dolphins May Get Ulcers - Considering the Impacts of Cetacean-Based Tourism in New Zealand.pdf Are we Killing them with Kindness - Evaluation of Sustainable Marine Wildlife Tourism.pdf Kaikoura Whale Watching Review Decisions Media Release 30 July 2012.pdf

To whom it may concern,

Please find attached my submission on the Marine Mammal Permit applied for by Waiheke Whale and Dolphin Watch Limited.

Should you have any problems or questions, please feel free to contact me.

Thank you and best wishes,

[redacted]

SUBMISSION TO THE DEPARTMENT OF CONSERVATION BY

[redacted]

Applicant: Waiheke Whale and Dolphin Watch Limited
Location of proposed activity: Waiheke Island, Hauraki Gulf
Permission type: Marine mammal permit
Summary of proposal: The application is for a new permit to undertake commercial vessel-based viewing of marine mammals in the Hauraki Gulf.

Email: permissionschristchurch@doc.govt.nz
Subject line: Submission on Waiheke Whale and Dolphin Watch Limited permit application.

Preamble

My name is [redacted] of Waiheke Island and I'm a business consultant. I am the co-founder of [redacted]

The primary purposes of the Society are:

a) To preserve and protect the integrity of the ecosystems and landscapes on and around Waiheke Island.
b) To be an advocate for the preservation, conservation, protection and enhancement of the New Zealand environment including without limitation to ecosystems and their parts, natural and physical resources, amenity values, cultural values, and to act in the defence of the environment against harm, misuse, depletion, unsustainable use and destruction. This includes to advocate for the rights of nature within the Hauraki Gulf.

I am committed to these values; however, this is my personal submission and not made on behalf of [redacted]

I have lived on Waiheke Island for 21 years. During this time, I have witnessed firsthand the dramatic increase in tourism numbers to the Island and the massive increase in the number of commuters and the effect this has had on the island and surrounding Hauraki Gulf.

I have 33 years of sailing experience and am a certified Scuba Diving Instructor with over 400 dives. I have worked as a Salvage Diver in the Bay of Islands, New Zealand and have extensive sailing and diving experience in and around the Hauraki Gulf.

As far as possible, I have endeavoured to read and understand the application of the applicant.

Scope of Submission

My submission covers the following matters:

- a) **Marine Mammals Protection Regulations 1992**
- b) **Hauraki Gulf Marine Park Act 2020**
- c) **Effects on Marine Mammals**
    - i. **Disturbance**
    - ii. **Bryde's Whale**
    - iii. **Lack of Research and Issues with Policy and Regulations**
    - iv. **Cumulative Impacts**
- d) **Benefits to the Community**
- e) **Education**
- f) **Conclusions and Relief Sought**

a) Marine Mammals Protection Regulations 1992

The Regulations' purpose is stated as:

> *The purpose of these regulations is to make provision for the protection, conservation, and management of marine mammals and, in particular,*
>
> > ***(a)*** *to regulate human contact or behaviour with marine mammals either by commercial operators or other persons, in order to prevent adverse effects on and interference with marine mammals:*
>
> *"Harass includes to do any act that—*
>
> - *causes or is likely to cause injury or distress to any marine mammal; or*
> - *disrupts significantly or is likely to disrupt significantly the normal behavioural patterns of any marine mammal"*

I believe that any active search and pursuit of whales and dolphins, particularly with the proposed large twin-engine passenger ferries (1x 250pax and 1x 165pax) will by its nature, harass the marine mammals they seek to encounter, through disruption to their normal behavioural activity and patterns, via noise; vibrations; proximity to them and; interfering with the patterns and therefore availability of their food source.

At the time of the establishment of the Marine Mammals Protection Regulations of 1992, research into the effects of commercial tourist operators on various species was very limited. Since this time, research has observed changes in marine mammal behaviour from commercial operators, within the framework of the regulations.

In a 2012 Department of Conservation Media Release, the department stated that a review of the Marine Mammals Protection Regulations is being considered. To the best of my knowledge, this review has not been carried out, meaning that the regulations have not been revised to account for new and concerning research into their effectiveness at protecting marine mammals.

A common finding from recent research papers is that there is still inadequate data to determine if the regulations are sufficient to reduce disturbance to an acceptable level for the long-term viability of marine mammal populations. This is discussed further in Section c of this submission.

b) Hauraki Gulf Marine Park Act 2020

The Hauraki Gulf Marine Park Act 2020 recognises the Hauraki Gulf as having National Significance.

The Hauraki Gulf Forum (HGF) is a statutory body, which promotes and facilitates integrated management and the protection and enhancement of the Hauraki Gulf, under the Hauraki Gulf Marine Park Act 2000.

The Hauraki Gulf Forum produces a triennial assessment of the state of the Hauraki Gulf and the responsiveness of agencies to strategic issues. These State of Our Gulf reports have shown that the Hauraki Gulf is **seriously degraded** and is **continuing to decline**.

As outlined throughout this submission, marine mammal tourism may not assist with protecting species but instead contribute to their decline. I believe that any venture that further exploits the Hauraki Gulf and its marine life is contrary to protection and enhancement under the Hauraki Gulf Marine Park Act 2020.

c) Effects on Marine Mammals

i. Disturbance

Disruption to behavioural patterns such as feeding and resting; changing direction; prolonged dives; changes in habitat use and population viability have been documented. (Constantine, R 1999).

Boat and aircraft noise has been shown to affect marine mammals and there is inadequate research on the acoustic impacts of vessels on whales and dolphin's ability to communicate and forage. (Constantine, R 1999).

Altered behaviour of marine mammals and its potential detrimental impact have been documented in numerous studies. (Orams, M 2004).

> *"This has led to the view that the "use" of whales and dolphins as a tourist attraction could be seen as another form of harmful exploitation of these marine mammals"*.

The Kaikoura Sperm Whales and Tourism Research Project conducted research in 2011 in which changes to whale behaviour were observed when tour boats were present. Presumably, these tourist vessels were operating in line with the regulations.

> *"When boats were present the whales breathed slower, there was more variance in their changes of direction and the whales began to echo-locate slightly later once underwater."*
>
> *"One of the major issues in managing whale watching activities is the detection, interpretation and management of impacts of the anthropogenic activities on the focal species. Interestingly, while the development of the industry has been rapid and is predicted to continue at this pace, scientific research to assess the potential impacts of whale watching has not kept abreast with this development. The current knowledge of whale watching impacts is patchy and difficult to interpret. We found a difference in ventilation patterns for whales alone versus whales accompanied by whale watching vessels. The finding that blow interval varied between surfacings where whales were accompanied by vessels and those where they were not may indicate an effect of whale watch tourism with the potential to influence sperm whale foraging efficiency and energy budgets. If tour vessels are reducing the oxygen intake of the whales, this could be a cause for concern."*

More recently, the following impacts on marine mammals from vessel approach have been documented: decreased foraging or resting activities; increased travel behaviour; changes to frequency and duration of diving; avoidance; altered surface behaviour; changes to group size, cohesion and acoustics / communication; altered ranging patterns and displacement from habitat affecting distribution and abundance. (Machernis, A et al 2018).

Physiological responses such as changes in heart and respiration rates could also impact on reproduction rates and reduce survivorship. (Machernis, A et al 2018). Contaminant exposure and boat strike are additional impacts. (Machernis, A et al 2018).

During encounters with tourism vessels in the Hauraki Gulf, the common dolphin has been shown to: reduce feeding and resting behaviour; increase vocalisation rate; change group cohesion; and alter feeding strategies. (Fumagali, M et al 2021).

Additionally, the application does not state the noise levels or frequency of either of their boats, simply saying that noise levels above and below the sea are "unknown". This means that there is uncertainly regarding the level of impact from this tourism venture on marine mammals and whether it will even meet the guidelines under the Marine Mammals Protection Act 1992.

ii. Bryde's Whales

State of Our Gulf 2020 reads:

> *"The Hauraki Gulf / Tīkapa Moana / Te Moananui-ā-Toi is a special place for the Nationally Critical Bryde's whale. It is one of only three places in the world where these whales live in coastal waters, with around 135 Bryde's whales using the Marine Park."*
>
> *"Bryde's whales are most frequently seen in the area between Kawau Island, Waiheke and Aotea (Figure 65), where they spend around 90% of their time in surface waters resting and feeding on small schooling fish and zooplankton. They need to eat a lot (600–650 kg per day) to maintain their body size, making them vulnerable to declines in prey availability due to fishing, environmental degradation or climate change."*
>
> *"20 YEARS AGO, Bryde's whale had a Nationally Critical conservation status in 2002. IN 2020, There is no change in the conservation status of Bryde's whales due to their small population size."*
>
> *"Change in sealife since human arrival shows a 97% decline in the number of dolphins and whales in the Gulf. Marine mammals were hunted to the brink of extinction but have been protected for 60 years. (page 12)". Despite this protection, Bryde's Whale numbers are still estimated to be 135 (page 70, section titled "TE PAKAKE - Bryde's whales)".*

A media release on the DoC website states:

> "*Research shows the Hauraki Gulf Marine Park is an important area for mother and calf Bryde's whales."*

Another population estimate conducted in Auckland suggests the Bryde's whales have a population of around 140 animals. For this reason they have 'Nationally Critical' status in New Zealand.

> *"The population of Bryde's whales living in New Zealand waters is critically endangered. New Zealand is one of the few places in the world where there's a resident population of Bryde's whale. It is centred on the Hauraki Gulf. Fewer than 140 Bryde's whales frequent the gulf."*

The National Oceanic and Atmospheric Administration (NOAA) reports on the global state of Bryde's Whales as: Protected Status: Endangered. It goes on to say:

> *"Bryde's whale populations are exposed to a variety of stressors and threats, including vessel strikes, ocean noise, and whaling.*

Vessel Strikes

Accidental vessel strikes can injure or kill Bryde's whales. They're vulnerable to vessel strikes throughout their range, but the risk is much higher in coastal areas with heavy vessel traffic. Bryde's whales are the third most commonly reported species struck by vessels in the southern hemisphere.

Ocean Noise

Low-frequency underwater noise pollution can interrupt Bryde's whales' normal behavior by hindering their ability to use sound. That disrupts their ability to communicate, choose mates, find food, avoid predators, and navigate."

https://www.fisheries.noaa.gov/species/brydes-whale

There has been **no research** into the impact of tourism on the Bryde's whale in the Hauraki Gulf (Fumagalli, M et al 2021):

> *"A small number of Bryde's whales are present in the Gulf year round. Over the period 2004–2013, seasonal abundance estimates ranged from 38 to 74 individuals, with a super population of 100–183 whales using the Gulf overall (Tezanos-Pinto et al., 2017). The whales forage most actively in daylight (Izadi et al., 2018) and sometimes in association with common dolphins and Australasian gannets (Morus serrator) (Stockin et al., 2008a; Wiseman et al., 2011), both of which act to increase the whales' detectability by tour operators. Although globally abundant, the Bryde's whale is considered Nationally Critical in New Zealand (Baker et al., 2019) and yet, to date, there has been no investigation of tourism impacts on the species in the Gulf."*

Precaution is recommended for threatened or resident populations. (Fumagalli, M et al 2021). The Bryde's whale is both resident and Nationally Critical in the Hauraki Gulf.

Fumagalli, M et al 2021, specifically recommends that marine mammal tourism increase be prevented in the Hauraki Gulf and that research into the impact of tourism on the Bryde's whale be conducted.

iii. Lack of Research and Issues with Policy and Regulations

An overall lack of research and information surrounding the effects of marine mammal tourism is highlighted as such (Orams, M 1994):

> *"We know little about the long-term, or even short term, effects of humans interacting with marine mammals in the wild. More specifically, issues such as the impacts of noise produced by vessels, boat handling practices, number and proximity of boats and humans, effects of swimmers in the water, continual disturbance versus sporadic disturbance, differences in responses of difference species, age classes, sexes, individuals, or seasonal changes are not known."*

> *"Unfortunately, as is often the case in the development of ecotourism, research on impacts has occurred after the industry has become established."*
>
> *"In particular, the issue of long-term tourism-induced stress deserves much greater attention in terms of research and more careful consideration in terms of management."*

Due to this lack of research and knowledge of the impact of marine mammal tourism and a precautionary approach was recommended in 1999. *"It may be that marine mammal-based tourism does not protect and conserve marine mammals, but conversely reduces the viability of the species targeted by tourism".* (Constantine, R 1999).

More current studies and reviews continue to highlight a lack of research available (including data on physiological impacts which may not be observable in behaviour) leading to ineffective policies and regulations coupled with a need for better implementation and enforcement of regulations. (Trave, C et al 2017):

> *"Despite the overall lack of long-term studies investigating the extended ecological impact of MWT* [Marine Wildlife Tourism]*, the existing evidence on the topic has highlighted the alteration of the behaviour, ecology and physiology of several target species."*
>
> *"In many cases, the problems associated with marine tourism are not the result of direct malpractice or absence of regulations, but rather the consequence of 1) lack of proper structure and coordination, 2) conflicting/ineffective policies (due to being developed without proper scientific knowledge on the species and habitat involved, or 3) lack of enforcement of set regulations. These factors need to be taken in account and properly addressed when developing or managing MWT, particularly when considering that the ecological sustainability of any marine tourism activity varies on a case-to-case basis based on the combination of such factors and how well they are addressed."*
>
> *"Good management plans and guidelines have no value if they are not adequately implemented (Parsons, 2012; Pavez et al., 2015; Sitaret al., 2016; Wiley et al., 2008). Large-scale monitoring of visitors' behaviour and enforcement of regulations are not always feasible due to logistic and economic constraints, and in many cases the management and implementation of guidelines/restrictions takes place at a smaller, local scale (Allen et al., 2007; Constantine et al., 2004; Dobson, 2006). Unfortunately, lack of coordination between operators, lack of compliance from the different stakeholders – including the operators themselves (Parsons, 2012; Pavez et al., 2015; Wiley et al., 2008) – and a greater interest in the economic exploit of the resource rather than in its conservation (Parsons, 2012; Steckenreuter et al., 2012; Van Waerebeek et al., 2007) are not infrequent, and hinder greatly the development of ecologically successful MWT practices. These factors coupled with ignorance*

of the consequences of tourists' actions and unmanaged behaviour of both visitors and operators frequently leads to chronic disturbances and stress on the environment (Garrod and Fennell, 2004; Shaalan, 2005; Zeppel, 2009)."

"There is still quite a way to go before marine tourism around the world can be considered an effective, long-term sustainable activity from both an economic and ecological point of view."

A lack of research and baseline comparative data; and issues with the current policies and regulations around marine mammal tourism in protecting marine mammals, continue to be raised in a recent review of research and management of cetacean tourism in New Zealand (Fumagalli, M et al 2021):

"Despite New Zealand's early establishment of precautionary legislation and advanced tourism research and management approaches, we detected flaws in current schemes, and emphasize the need for more adaptive and comprehensive strategies."

"Recent longitudinal studies, however, have exposed the inadequacy of past and present management regimes (Hartel et al., 2014; Bennington et al., 2020; Dwyer et al., 2020) and outlined the financial, procedural and institutional barriers to effective marine conservation (Bremer and Glavovic, 2013; Dodson, 2014). Effective management of cetacean tourism in New Zealand continues to be a challenge."

"Inevitably, however, short-term responses do not provide information on latent effects, those that appear elsewhere or at a lagged time, or on individuals that may already be avoiding the area due to disturbance. Moreover, short-term behavioral responses must be interpreted with caution, as they display significant variation between and within populations, groups and individuals (e.g., due to sex, Lusseau, 2003b; presence of calves, Guerra et al., 2014; previous exposure to disturbances, Constantine, 2001; Bejder et al., 2009; among others). There is thus a vital need to identify the long-term consequences of tourism disturbance on cetacean populations (e.g., abundance, reproduction and survival rates). Identifying how non-lethal impacts result in population-level consequences has proven a challenge (Lusseau and Bejder, 2007; New et al., 2014; King et al., 2015), but remains an important objective to understand the mechanisms that lead to detrimental effects (e.g., stress, displacement from quality habitat, compromised foraging and resting). Long-term datasets offer precious opportunities to analyze demographic and distribution trends in the context of tourism development and management (e.g., Tezanos-Pinto et al., 2013; Somerford, 2018; Bennington et al., 2020) and shed light on the long-term consequences of tourism disturbance on cetacean populations."

"Detrimental effects on the animals, however, are clear (Samuels et al., 2003; Machernis et al., 2018), and cetacean tourism is now recognized as a sub-lethal consumptive industry (Neves, 2010; Higham et al., 2016). As such, its management is best based on a precautionary principle (Bejder etal.,2006b) and on analytical frameworks incorporating the ecological and social aspects of the industry, and the multiple threats to cetaceans (Higham et al., 2009). Moreover, animal welfare (i.e., individual effects) is increasingly recommended as a necessary complement to conservation indicators (i.e., population-level effects) (Papastavrou et al., 2017; Nicol et al., 2020). To date, however, priorities and approaches to cetacean tourism research and management have varied significantly at both local and global scales."

"Pre-tourism studies should be undertaken, if possible, to assess the impacts of the proposed industry, define initial regulations and establish a baseline for future monitoring (Martinez, 2003; Higham et al., 2009). At the onset of the industry, as well as regularly throughout its development, a main priority is the identification of situations in which cetacean tourism is incompatible with the welfare and conservation of the targeted individuals and populations. For example, there is a moratorium on tourism activities focused on the Critically Endangered and endemic Maui dolphin (Cephalorhynchus hectori maui), and it is currently illegal to approach bottlenose dolphins (Tursiops truncatus) and southern right whales (Eubalaena australis) in several regions."

"A precautionary approach establishes a framework of protective measures to prevent an activity from inflicting serious or irreversible impact, even if the evidence of such harm is lacking or uncertain (Cooney, 2004). The need for precaution arises from the acknowledgment that cetacean tourism is a non-lethal anthropogenic stressor and a form of consumptive exploitation (Neves, 2010; Higham et al., 2016) whose impacts on a particular population are often unknown, uncertain or ignored. Precaution calls for tourism on vulnerable, small, isolated, threatened, or resident populations, or in priority habitats, to be minimized or avoided (Constantine and Bejder, 2008; Ross et al., 2011; Johnston, 2014). This is best achieved by confining operations to populations able to sustain tourism pressure (International Whaling Commission, 2006) and by prohibiting tourism in certain areas or times (i.e., temporal and/or spatial closures) (Tyne et al., 2014)."

"Early management intervention is more likely to be effective and more easily implemented. Once there are clear indications that cetacean populations are declining, it may be too late to reduce tourism (and other) impacts to sustainable levels."

"Looking forward, we recommend that stakeholders engage without delay in formulating a clear policy and vision for this industry, and in developing an

integrated, holistic and adaptive research and management system to tackle the future of cetacean tourism and conservation in New Zealand."

"The [Hauraki] *Gulf case study provides an example of a cetacean tourism industry embedded in a context of multiple stressors (aquaculture, fishing, commercial shipping, contaminants), and targeting two species with different life history, behavior and ecology. Despite establishment of the Hauraki Gulf Marine Park in 2000 (the only one of its kind in New Zealand), most of the conservation issues affecting the area remain unmitigated (Hauraki Gulf Forum, 2020)."*

Recommended actions to increase management efficacy of cetacean tourism in the Hauraki Gulf include: *"Prevent tourism increase; coordinate research and management regionally to protect dolphins exposed to multiple threats; begin research on the impacts of tourism on Bryde's whales; capitalize on the ongoing engagement with the voluntary shipping Transit Protocol to promote science-based and social process in management."*

While there is legislation to protect marine mammals and management guidelines to reduce stress to the animals, regulation and enforcement is problematic with inadequate penalties to deter non-adherence. There is also a lack of research into the full impact of tourism on marine mammals even when the recommended guidelines under the Marine Mammals Protection Act 1992 are adhered to.

The number of vessels and frequency of trips by individual operators also seems to be an issue, as evidenced by the decision to not issue new permits for whale watching in Kaikoura. (DoC 2012 Media Release). Perhaps the focus should be on reducing the incidence of disturbance rather than increasing it and exacerbating the adverse effects experienced by marine mammals from tourism.

iv. Cumulative Impacts

The State of Our Gulf reports highlight multiple stressors for the Hauraki Gulf that are contributing to its ongoing environmental decline.

The combined cumulative effect of multiple different stressors in the context of marine mammal tourism is an area of concern (Fumagalli, M et al 2021):

"Tourism often co-occurs alongside other potential stressors, such as bycatch, climate change, pollution, shipping, or habitat modification. Even when its impact is considered to be mild, cetacean tourism has the potential to aggravate the combined pressures on wild individuals and populations."

"Over the 2000s, despite a moratorium on permits since 1998, heightened pressure from permitted operators was compounded by increasing numbers of

private boat users and non-permitted operators seeking out interactions with dolphins."

"The number of permits, however, is likely to underestimate the actual increase in tourism pressure over time, as operators can increase the number and duration of trips at their discretion. In addition, wild cetaceans have been increasingly exposed to interactions pursued by non-permitted operations and to opportunistic boat encounters. Data on trip number, frequency and duration, and cetacean daily and cumulative exposure to overall pressure, which would have allowed for a more representative description of tourism evolution, are unavailable or sporadic (e.g., Bejder et al., 1999; Green, 2005; Martinez et al., 2011)".

"In many locations, a key impediment to developing effective management strategies is the lack of information on the impacts of different segments of the boating community. For example, it is easy to focus on commercial operators, when they may not be the major source of impact. It is therefore important to quantify the frequency and effects of interactions with different vessel types, including recreational and non-permitted, in addition to permitted tour operators."

There are already a high number of recreational, shipping and fishing vessels, ferries, tourist vessels and one existing marine mammal tourist operator within the Hauraki Gulf. The addition of two daily outings must be viewed in this context. While it may seem on its own to be of minimal disturbance, it will be on top of existing vessel induced disturbance and multiple environmental stressors.

Additionally, there are actually two permits in existence for marine mammal tourism in the Hauraki Gulf (Fumagalli, M 2021), one of which is not actively used but has not been revoked. Should this latest application for a permit be approved, it would bring the potential number of operators in the Hauraki Gulf to three, tripling the potential number of daily encounters and marine mammal disturbance from tourism.

d) Benefits to the Community

While whale and dolphin encounters are an integral component of the economic prosperity of Kaikoura, the Hauraki Gulf already has a thriving tourism economy – old America's Cup Boat Charters, Fishing Charters, Diving Charters, tours to Tiritiri Matangi, trips to Rotoroa, Rangitoto, Waiheke and so on.

Communities living within the Hauraki Gulf and wider Auckland area, have regular interactions with the marine environment including marine mammals via both shore-based experiences where the animals come close to shore, recreational boating and travel on ferries.

Additionally, there are multiple existing ferries travelling daily to and from the Island's of the Gulf that offer opportunities for spotting marine mammals.

Auckland Whale & Dolphin Safari are an existing marine mammal tourist operator in the Hauraki Gulf, so the opportunity is already available. This operator also assists with research studies.

The encouragement of multiple tourist operators and maximising tourist numbers is contrary to a nationwide desire to shift to a values-based tourism experience which is environmentally sustainable and protects and maintains the day-to-day quality of life of local communities.

While the funding opportunities of marine mammal tourism do offer potential benefits to marine mammal species, considering much of the research is directed into assessing the impact of tourism on marine mammals, the funding requirement should be viewed more as a means to offset the adverse effects of the tourist activity rather than providing any meaningful direct benefits to the marine mammals themselves. https://www.doc.govt.nz/news/media-releases/2019/tourist-businesses-fund-whale-and-dolphin-research/

e) Education

While there may be some educational merit in encouraging observation and interaction with marine mammals, the benefits to the animals themselves and their environment is doubtful and outweighed by the risks and negative effects the whale watching activities pose to them. It is not clear how the proposed whale watching operations will contribute to protection of the targeted species.

If marine mammal tourism was an effective tool in protecting the species, one would expect that whale and dolphin numbers to be increasing locally in areas where these tourist activities are operating and for endangered species to be receiving the protection measures necessary to at the very least halt their continued decline. However, this does not seem to be the case for New Zealand's endangered marine mammal species. Data also shows a decline in numbers to complete abandonment by whale and dolphin species across many of the locations in which marine mammal tourism is permitted in New Zealand. (Fumagalli, M 2021).

Through the State of Our Gulf reports, the plight of the Hauraki Gulf is well documented and a high-profile issue for Auckland residents, particularly those of Waiheke Island. Backed by this research, there is growing public pressure and support for strong protection and restoration measures to be implemented including establishing marine reserves. This is strengthened by the high number of recreational boaters who have personal interactions with marine mammals. Shore-based experiences are also common for Waiheke residents. The recent public initiated Rahui for the waters surrounding Waiheke is a recent example of this call for action.

Awareness of the historic treatment of whales, the issues facing the marine environment and the need to protect it, is already high amongst New Zealanders and even globally. The continued whaling activities of some nations within Southern waters is a high-profile issue that continues to keep protection of whale species in the public eye.

Who are the expected customers of this whale watching venture? Will the majority be international tourists? How does this translate to promoting preservation and protection of marine mammal species around New Zealand's coastline? With the rise of social media, where information, images and messages reach millions of people around the World instantly, the nature of conservation awareness and implementation of successful species protection measures has changed. The value of these types of first-hand animal watching experiences is no longer applicable or even desirable from an educational conservation perspective.

It is most likely that people taking part in whale watching **already have an appreciation of the animals** and **believe that they should be protected**, in which case, any educational aspect to the operations are merely "preaching to the converted" as opposed to influencing people's perceptions.

Actively seeking out animals in the wild for public viewing is being seen more and more as a form of exploitative entertainment rather than providing any meaningful benefits to the animals themselves and as studies show, even causes harm.

A Department of Conservation report ('Effects of Tourism on Marine Mammals in New Zealand' 1999), states that: *"… very little information is available on the effectiveness of the educational material provided by commercial operators".*

The area of education around marine mammals that does seem to be lacking, concerns public knowledge of the impact on human interference. Rather than issuing permits for whale watching, efforts should be made on educating recreational boaters, kayakers and swimmers about what constitutes harassment, the negative effects of this and what is appropriate behaviour when encountering marine mammals.

f) Conclusions and Relief Sought

Despite the Marine Mammals Protection Regulations 1992, studies and reviews cast doubt over the effectiveness of these regulations in protecting and maintaining the viability of marine mammal populations in the long-term.

There is a lack of research regarding the long-term impact of marine mammal tourism and the combined effects of multiple stressors on marine mammals. There is currently no information regarding the tourism impacts on the Nationally Critical Bryde's Whale in the Hauraki Gulf.

The Hauraki Gulf is already in a serious state of decline as recognised by the State of Our Gulf reports and the Hauraki Gulf Forum meaning that marine life is already experiencing environmental stressors. The presence of a high number of maritime vessels in the Gulf (shipping, recreational, fishing, ferries, and tourist operators) adds further stressors by increasing the incidence of disturbance events for marine mammals.

A precautionary approach has been recommended for resident and threatened populations along with a specific management response to prevent any increase in marine mammal tourism in the Hauraki Gulf. (Fumagalli, M 2021).

There is no evidence to suggest that marine mammal tourism provides educational benefits which assist with protection and conservation of marine mammals.

For these reasons, I do not support the application by Waiheke Whale and Dolphin Watch Limited and request that it be declined.

Signed this 15th day of March 2021

Thomas Rainer GREVE

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Effects of tourism on marine mammals in New Zealand

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Abstract

There has been a rapid growth in marine mammal based tourism around the world, because marine mammals have a wide appeal for many people and are readily found around many coastal areas and are therefore readily accessible.

Marine mammal based tourism in New Zealand is a wide-ranging, species-diverse industry with an increasing demand for permits from land, boat and air-based platforms. A total of 74 permits at 26 sites have been issued from Maunganui to Stewart Island. The region with the most concentrated effort is Kaikoura.

Past and current research projects in New Zealand evaluating the effects of tourism on marine mammals are reviewed. The only current ones deal with the New Zealand sea lions of the Catlins, and Northland's bottlenose dolphin population.

In New Zealand, toothed cetaceans and pinnipeds form the basis of the marine mammal based tourism industry. We are one of few countries which permit swimming with dolphins and seals.

Boat and aircraft noise has been shown to affect some species of marine mammals. There is an inadequate database on the acoustic impacts of both recreational and commercial vessels on dolphins and sperm and Bryde's whales. As the ability of cetaceans to communicate and forage is frequently dependent on their acoustic perceptions, this area of research should not be underestimated. Research overseas has focused on baleen cetaceans but research on sperm whales in Kaikoura conducted in the early 1990s provided valuable management information.

One of the most important aspects of evaluating the effects of tourism on marine mammals is the presence of pre-disturbance baseline data on the population size, habitat use, home range and behavioural ecology of the target species. Fortunately these data exist for some species (for example the Hector's dolphins near Banks Peninsula), but for many others (for example bottlenose dolphins in the Bay of Islands) similar data were not collected prior to tourism being established.

As management of this industry is still in its infancy, both in New Zealand and overseas, many areas are finding difficulty with enforcement of the regulations and guidelines. New Zealand's Marine Mammals Protection Act 1978 and Marine Mammals Protection Regulations 1992 fully protect marine mammals. The issuing of permits has caused some debate about rights under the Treaty of Waitangi.

The majority of Department of Conservation Conservancies expressed some concern over the number of permits being issued and the lack of knowledge about their impacts. There is very little information on the effectiveness of the educational material provided by commercial operators. Research on the most efficient and effective management system could resolve some of the issues currently facing the industry.

It is important to assess the costs and benefits of this kind of tourism. Issuing permits for marine mammal based tourism makes the operators a stakeholder in

the animals' welfare and may act as a conservation measure in the long run, but only if it does not cause any harassment to the animals. Examples where this is of some urgency due to the threatened status of the species are the New Zealand sea lion and the Hector's dolphins.

The 1990 Marine Mammals Protection Regulations were originally designed to provide the Director-General of Conservation with guidelines for whale-watching, and they were then revised in 1992 to cope with the increase in dolphin-watching. Given the recent findings of species-specific research on responses to marine mammal based tourism and the rapid growth of this industry, the need to consider further revisions to the regulations has been identified and is being actioned.

1. Introduction

Marine mammals are charismatic animals with a wide appeal for many people. They are readily found around many coastal areas of the world (Jefferson et al. 1993) and are therefore accessible to many people. This has resulted in financially viable businesses based on taking tourists to see them. The combination of these factors has led to the rapid growth in marine mammal based tourism.

In New Zealand, since the first commercial operation began at Kaikoura in 1987 with a single six metre vessel taking commercial tours to watch sperm whales (*Physeter macrocephalus*), the marine mammal based tourism industry has experienced a massive increase in the number of operators and the number of tourists (Donoghue 1994). Currently 74 permits are operational in ten DOC Conservancies. There has also been a major but unquantified increase in the viewing of marine mammals from private recreational vessels. In 1993, 45,000 visitors went whale-watching, which accounted for 4% of activities undertaken by tourists whilst in New Zealand (New Zealand Tourism Board 1993). In 1996, 8% of visitors to New Zealand went whale-watching and 14% of visitors participated in dolphin-watching and/or swimming activities (New Zealand Tourism Board 1996). Donoghue (1994) provided a conservative estimate of the economic value of whale-watching to the New Zealand economy in the year 2000 of $15 million direct income (payment of trips) and $45-50 million indirect income to local communities via accommodation, transport costs, souvenirs and food.

The increased interest in marine mammals as a tourist attraction has occurred not only within New Zealand, but appears to be a global trend. For example, in 1991, an estimated 4 million people world-wide went whale-watching. By 1994 this had increased to 5.4 million, with total revenues estimated to be US$504.3 million (Hoyt 1995). In 1983, approximately 12 countries offered whale-watching tours (Hoyt 1994) but by 1995, over 50 countries and overseas territories were offering whale-watching (which includes whales, dolphins and porpoises) (IFAW 1995). International recognition of the extent and rapid development of whale-watching came from the 1983 and 1984 International Whaling Commission (IWC) meetings, where the Commission considered a Report on the Non-Consumptive Utilisation of Cetacean Resources (IFAW 1995). Ten years later, at their 1993 meeting the Commission both recognised whale-watching as a tourist industry which contributed to the economies of a number of countries and supported the development of whale-watching as a sustainable use of resources (IFAW 1995). In recognising the development of such an industry, undertaking a scientific review, and providing advice to members, the IWC acknowledged their role on whale-watching, but considered each coastal state to be responsible for management of their own industry. Twenty-seven of the 40 member countries of the IWC currently host some form of whale-watching (Hoyt 1995). As a result, the IWC has an increasingly important role in guiding this industry (IWC 1997).

There are concerns over impacts of this growing industry on both the animals (Beach & Weinrich 1989, Blane 1990, Corkeron 1995, Constantine & Baker 1997) and tourists (Orams 1995, 1996). In order to minimise these impacts, management strategies have been developed. In 1978 the Marine Mammals Protection Act was passed to protect all marine mammals in New Zealand waters. In 1990 the Marine Mammals Protection Regulations were drafted to provide a series of guidelines for issuing permits and for regulating human behaviour around marine mammals (Donoghue 1996); they include minimum approach distances, the number of vessels allowed near marine mammals, the speed of those vessels and whether or not swimming is allowed. These Regulations were reviewed in 1992 in response to the rapid increases in recreational vessels targeting marine mammals and in commercial operators applying for permits to conduct tours to watch and/or swim with seals, sea lions, dolphins and whales.

Species involved in ongoing studies in New Zealand which have been conducted prior to commercial tourism beginning are the dusky dolphins of Kaikoura (Cipriano 1992, Würsig et al. 1991, Würsig et al. 1998), South Island Hector's dolphins (Dawson & Thorpe 1990, Slooten 1990a, Slooten & Ladd 1990b, Bräger & Schneider 1998) and New Zealand (Hooker's) sea lions (Cawthorn 1993, Gales 1995), but for the majority of marine mammal species there is little information currently available.

An important aspect of maintaining management policies which are relevant is a knowledge of the species and ecosystems concerned (Mangel et al. 1996, Yaffee 1997). This is where research is vital to enable changes in the abundance, habitat use, and behaviour of the species involved to be monitored. With regards to marine mammals, many of them, particularly the great whales, are recovering from years of uncontrolled exploitation which has left stocks dangerously low (Beach & Weinrich 1989). We are only in the early stages of understanding the animals, the ecosystems in which they live, and the impacts upon them (Hofman 1995).

We know little about the long-term, or even short-term, effects of humans interacting with marine mammals in the wild. More specifically, issues such as the impacts of noise produced by vessels, boat handling practices, numbers and proximity of boats and humans, effects of swimmers in the water, continual disturbance vs. sporadic disturbance, differences in responses of different species, age classes, sexes, individuals, or seasonal changes are not known. Research, therefore, has an important role in the future management of this industry. Research programmes with long-term goals can assist with the attainment of conservation and protection goals for marine mammals. If there is not the correct balance between minimising the negative impacts of marine mammal based tourism, allowing for commercial and non-commercial activities, and utilising opportunities to educate participants, then this industry will contribute little to the long-term welfare and health of marine mammal populations. Instead it may become another form of exploitation.

This report reviews the status of the marine mammal based tourism industry in New Zealand as at 1997 and makes recommendations to help DOC guide its future. A review of current and past research both in New Zealand and overseas has been conducted as thoroughly as possible, given that many sources of information exist as unpublished reports. This review has been divided into sections on different species and aspects of marine mammal based tourism. An assessment of New Zealand's management strategy and a brief comparison with those overseas, with an emphasis on the USA and Australia, has been provided. This has been discussed with reference to inter-species differences, current regulations, and research needs. The overseas research and management experience are given in the Appendices.

2. Background to marine mammal based tourism in New Zealand

2.1 LEGISLATION

The legislation under which marine mammal based tourism in New Zealand is controlled is the Marine Mammals Protection Act 1978 and the Marine Mammals Protection Regulations 1992. The purpose of these regulations is:

> ... to make provision for the protection, conservation, and management of marine mammals and, in particular:
>
> (a) to regulate human contact or behaviour with marine mammals either by commercial operators or other persons, in order to prevent adverse effects on the interference with marine mammals;
>
> (b) to prescribe appropriate behaviour by commercial operators and other persons seeking to come into contact with marine mammals.

The primary mechanism used to control commercial marine mammal tourism operators is by permit. There are several criteria under which permits are issued, summarised as:

- Permits should not be contrary to any conservation management strategies or plans under section 3 of the Act.
- They should not have any significant adverse effect on the species targeted.

- They should be in the interests of conservation, management or protection of marine mammals.
- The operator and staff should have sufficient experience with marine mammals and the local area, and should have no convictions for offences involving the mistreatment of animals.
- The commercial operation should have sufficient educational value.

Under the Regulations, these criteria must be met, in conjunction with others, before a permit is issued. In addition, these criteria must continue to be met throughout the duration of the commercial operation issued with this permit.

These Regulations provide a basis for equal evaluation of permit applicants.

2.2 EXTENT OF MARINE MAMMAL BASED TOURISM

In New Zealand it is possible to watch and/or swim with, on a regular basis, five species of dolphins, six species of whales and two species of pinnipeds. These include:

dusky dolphins (*Lagenorhynchus obscurus*)
common dolphins (*Delphinus delphis*)
bottlenose dolphins (*Tursiops truncatus*)
Hector's dolphins (*Cephalorhynchus hectori*)
killer whales (*Orcinus orca*)
sperm whales (*Physeter macrocephalus*)
Bryde's whales (*Balaenoptera edeni*)
New Zealand fur seals (*Arctocephalus forsteri*)
New Zealand (Hooker's) sea lions (*Phocarctos hookeri*)

In addition, the following may occasionally be encountered:

pilot whales (*Globicephala melas*)
southern right whale dolphins (*Lissodelphis peronii*)
false killer whales (*Pseudorca crassidens*)
minke whales (*Balaenoptera acutorostrata*)

Out of 14 DOC Conservancies, ten (Northland, Waikato, Bay of Plenty, Wanganui/Taranaki, Wellington, Nelson/Marlborough, West Coast, Canterbury, Otago and Southland) have some form of commercial wild marine mammal based tourism. Only Auckland, East Coast, Hawke's Bay and the land-locked Tongariro/Taupo Conservancies have none.

In May 1997, a survey was posted to the officer responsible for marine mammal protection in each of the DOC Conservancies with the potential for marine mammal based tourism (Tongariro/Taupo was the only Conservancy not sent a questionnaire). All surveys were completed and promptly returned. The survey asked questions about the number of permits issued and currently operational, how many permits were pending, which species of marine mammal were targeted, whether the permit allowed the use of a boat or aircraft or was land-based, what season the permits were operational, whether a levy system was in place and if not, whether the Conservancy would support the establishment of a levy, whether the Conservancy had any research currently under way on marine mammals and if not, whether they would like to see research being conducted, and finally, which aspects of the industry they felt needed evaluation.

Table 1 shows the current number of permits issued for marine mammal based tourism and the extent of the operations. 'Permits Pending' shows the number of full applications that have been received for consideration for a permit, but this does not necessarily mean that permits will be issued. The actual number of tourists wishing to go on trips means that the majority do not utilise the total number of trips allowable under their permits during the off-peak seasons.

Northland

There are ten permits which allow twelve vessels to operate. Permits have been issued for interaction with all species, but the commercial operators primarily operate (year-round) swim-with-dolphin tours based on bottlenose and common dolphins. During spring there is a peak in sightings of Bryde's whales, which are opportunistically sighted by the operators. Humpbacks are seen occasionally. Four of these permits (five vessels) are not solely dedicated to swim-with-dolphin tours but are part of day sailing and diving trips.

Auckland

Currently there are no permits issued in the Auckland Conservancy area, although one is pending.

TABLE 1. SUMMARY OF THE STATUS OF THE NUMBER OF PERMITS AND APPLICATIONS RECEIVED IN EACH DOC CONSERVANCY.

	PERMITS ISSUED					PERMITS PENDING					PERMITS FOR AIRCRAFT				
	S	D	W	S/D	All	S	D	W	S/D	All	S	D	W	S/D	All
Northland					10		4								
Auckland															
Waikato					1					1					
Bay of Plenty					4					3					
East Coast															
Hawke's Bay															
Wanganui				2					1						
Wellington	1L,1b				1										
Nelson/Marlborough	4L,4b			8	18	3		20	4						5
West Coast					7	1			1						
Canterbury							5								
Otago	5L	1		2	1	1L			1	2					
Southland	1L			1	2	1			10	2					
TOTAL	16	1	0	13	44	16	9	20	17	8	0	0	0	0	5

S, seals; D, dolphins; W, whales; S/D, seals and dolphins; All, all species of marine mammals; L, land-based operation; b, boat-based operation

Waikato

A single permit has been issued for all marine mammals, but the operator primarily runs year round swim-with-dolphin tours targeting common and bottlenose dolphins off Whitianga.

Bay of Plenty

Permits have been issued for interaction with all species, but the operators primarily run year-round tours based on common dolphins. None of the permits allows swimming with seals. One of the permits is for marine mammal viewing only, i.e. no swimming with dolphins or seals. All permits pending are for swimming with and viewing marine mammals. One of these applications is for a change to a current viewing-only permit to also allow swimming.

East Coast

Currently there are no permits issued within the East Coast Conservancy, although some of the operators permitted by the Bay of Plenty conservancy utilise East Coast waters. There are no permits pending.

Hawke's Bay

Currently there are no permits issued to interact with wild marine mammals within the Hawke's Bay Conservancy and no permits are pending. Napier has the only captive dolphin facility in New Zealand and it is possible to swim with four common dolphins at Napier Marineland. They allow five one-hour sessions per day with no more than four swimmers in the water at any time. The swim is constantly supervised, but the dolphins are not directed by the trainer. One end of the pool is excluded to the swimmers to allow the dolphins a form of 'sanctuary'. This is available year-round but during the winter months only three sessions per day occur (G. McDonald pers. comm.).

PERMITS OPERATING				
S	D	W	S/D	All
				10
				1
				4
			2	
1L,1b				1
4L,4b			8	16
				4
	5			
5	1			
1			1	2
16	6	0	11	38

Wanganui

Permits have been issued for boat-based interaction with seals and dolphins. One permit involves fur seal watching for 80% of the year. The other permit is issued as part of a diving trip and allows swimming with dolphins and seals. Common dolphins are observed primarily during summer and are encountered on only 10% of trips.

Wellington

Of the three permits issued (one for Cape Palliser and two for Kapiti Island), one is for boat-based seal-watching, one is for land-based seal-swimming and one is for viewing all species of marine mammals. All three permits encompass interaction with marine mammals as part of their tours but not as the main focus. Operators are able to opportunistically view marine mammals year-round. There are seals present year-round, but the operator is required to avoid known breeding areas in order to minimise harassment.

Nelson/Marlborough

The majority of permits issued are for the Kaikoura area. Many of the on-water and aircraft permits have been issued for all species of marine mammals. Some companies operate more than one vessel from their permits, e.g. Kaikoura Whale Watch operates four vessels from two permits. All permits are operational year-round, but there is a notable decline in dolphin and seal-swimming operations over winter. Some of the applications are for seals, dolphins and also for killer whales, which are included under the regulations regarding whales. The decision to include killer whales and not all species of whale in some permits was made in order to decrease the number of vessels interacting with sperm whales off Kaikoura. All permits 'pending' are applicants and all of these applications for land, boat and aircraft operations are currently on hold. Only three of the applications (for seal-watching) are outside the Kaikoura region.

Species targeted are primarily sperm whales, dusky dolphins and New Zealand fur seals. A summary of the maximum permitted number of trips per week in Kaikoura showed a potential total of 365 trips per week to watch or swim with marine mammals. This includes:

- whale-watch boats (1 company, 4 boats)—112 trips per week,
- dolphin/seal watch/swim boats (3 operators, 4 boats)—78 trips per week,
- boat-based seal swimming (4 operators, 4 boats)—119 trips per week,
- land-based seal swimming (2 operators)—35 trips per week,
- land-based seal watching (2 operators)—21 trips per week (average estimate).

West Coast

Of the seven permits issued, there are currently only four which are operational but the remainder will commence operations in the summer of 1997-98. All operators are primarily targeting Hector's dolphins and New Zealand fur seals but are permitted to encounter all species of marine mammals. Only one commercial operator is permitted to swim with seals and dolphins, but swimming with Hector's dolphins is not permitted in this conservancy. Of the two permits pending, one is for land-based seal-watching and one for boat-based seal and dolphin watching.

Canterbury

Five operators are currently taking commercial dolphin watching/swimming tours to interact primarily with Hector's dolphins in the Banks Peninsula area over the summer and autumn months. None of these operators has been issued a permit and currently all five permits are pending. Permits have not been issued to these operators because of a High Court ruling regarding Maori rights to marine mammal based tourism under the Treaty of Waitangi.

Otago

Many of these permits have been issued to interact with marine mammals as part of their normal operations. Viewing of sea lions is increasing in popularity on the Otago Peninsula.

Southland

Of the four permits currently issued, only one is specifically targeting marine mammals and this is for viewing only. The other permitted operators run boat trips and opportunistically encounter marine mammals as part of their tour. All operators are permitted year round but most tours run regularly from November to April and primarily encounter dusky dolphins, common dolphins, bottlenose dolphins, New Zealand fur seals, New Zealand sea lions, and Hector's dolphins. Only one operator is permitted to focus on Hector's dolphins and swimming is not allowed. Two of the permits pending are for the use of helicopters to watch all species of marine mammals. The Southland Conservancy is responsible for management of New Zealand's sub-Antarctic Islands.

2.3 OVERVIEW

Marine mammal based tourism in New Zealand is a wide-ranging, species-diverse industry with an increasing demand for permits from land, boat and air-based platforms. A total of 74 permits have been issued from the far north to Stewart Island. The region with the most concentrated effort is Kaikoura. The Nelson/ Marlborough Conservancy is the only one with marine mammal watching from aircraft, although there are applications for consideration in the Southland Conservancy. Even though operators focus on a number of species, a recent comprehensive survey of 60 marine mammal based tourism operators found the most popular activity reported was seal-watching (53%), then wildlife viewing cruises (44%) (Beasley 1997). This survey found 58% of operators never swam with seals or sea lions, which suggests that, while viewing was popular, swimming was generally not. New Zealand fur seals were the most frequently targeted species (28%) followed by bottlenose dolphins (23%). Beasley (1997) found 62% of the operators in her survey remained open for tours year round although there was a decline in tourist numbers during the winter months (April–October).

There are a variety of permits for commercial marine mammal tourism issued by DOC including viewing all species of marine mammals and swimming with dolphins and seals (for example Northland); marine mammal viewing only (for example Bay of Plenty); interacting with dolphins, seals and killer whales only (for example Kaikoura); viewing dolphins and seals only (for example West Coast); viewing dolphins only (for example Southland). There are operators with permits which include marine mammals on an opportunistic basis as part of an overall sight-seeing tour (for example Southland). Some operators have times when they are excluded from interacting with certain animals, e.g. the New Zealand fur seals during the breeding season off Wellington. If all criteria of the Marine Mammals Protection Regulations are fulfilled, permits are issued on the basis of the plan of operation which is required as part of the application (R. Suisted pers. comm.) and which operators are bound to observe as a condition of their permit.

In addition to the commercial tours there is an as yet unquantified number of recreational and non-permitted charter vessels interacting with marine mammals in response to growing tourist demand. These operations, too, are bound by the Marine Mammals Protection Act 1978 and must be managed so as to minimise impacts. On-water monitoring of vessels coming into contact with marine mammals occurs in a few areas, e.g. Kaikoura and the Bay of Islands, but is limited by financial constraints despite providing an effective public education opportunity.

3. Research on the impacts of tourism on marine mammals in New Zealand

Research has only recently begun to address the non-lethal effects of human activities on marine mammals. Despite the rapid increase in marine mammal based tourism ventures, the effects of the underwater noise created by boats and aircraft and the physical presence of swimmers and land-based visitors are poorly understood. Research on the effects of tourism has tended to focus on baleen whales exposed to the well-established whale-watching industry off coastal USA (Beach & Weinrich 1989, IFAW 1995). As the development of commercial dolphin-watching and seal-watching is a relatively new occurrence in most places, information on the effects of tourism on these animals is limited.

3.1 PINNIPEDS

There has been little research effort on the impact of tourism on seal and sea lion populations, either in New Zealand or globally. The New Zealand fur seal and the New Zealand (Hooker's) sea lion are the species primarily targeted by operators.

3.1.1 Impacts on sea lions

Research on the New Zealand sea lion has been concentrated in the sub-Antarctic Auckland Islands, where the main breeding colonies are found (Cawthorn 1993, Gales 1995, Gales & Mattlin 1997). There are few recent records of breeding on the New Zealand mainland, but predominantly sub-adult males are known to haul-out on Stewart Island, the Otago Peninsula and The Catlins (McConkey 1994, Gales 1995). DOC has produced a long-term conservation strategy aimed at increasing the numbers of sea lions by reducing potential threats, primarily from the 'take' of sea lions as bycatch in the sub-Antarctic squid fishery (Gales 1995). The overall aim is to have sea lions removed from their current threatened status, and the establishment of two new breeding colonies outside the Auckland Islands will contribute to this. Establishment in other areas will decrease the potential for a sudden catastrophic event, e.g. disease, to cause the population to decline to a non-viable number.

Tourism targets the sea lions at Enderby Island (Auckland Islands), The Catlins and the Otago Peninsula. The number of sea lions on the mainland has been slowly increasing, with animals regularly seen on 14 beaches along the Otago Peninsula (McConkey 1994) and at two beaches at The Catlins (Heinrich 1996a). These mainland haul-out sites have been the subject of recent and ongoing research into the effects of tourism on the sea lions.

Research on the impact of eco-tourism on the yellow-eyed penguins and New Zealand sea lions at Sandfly Bay and Papanui Beach on the Otago Peninsula was completed in 1996 (Wright 1998). One of the aims of this research was to assess whether approaches by people had any short-term or immediate effect on the sea lions. This study was conducted over a short (eight day) period during February 1996 and assessed the responses of male sea lions only. A series of controlled approaches by two people to a distance of 5, 10 and 20 metres were conducted. No differences were found in the behaviour of sea lions with proximity of people. These results differed from those of Beentjes (1989), who found that the sea lions at the same beach would not tolerate an approach much closer than 10 metres. One possibility is that the sea lions in this area have become habituated to close approaches by humans, as the Papanui sea lions are accessible over private land and mainly exposed to controlled tour groups of 6-10 people.

Wright (1998) recommended further research on the behaviour of female sea lions, as it differs considerably from that of males. She also recommended continued monitoring of sea lions in other areas to assess the levels of tolerance to human visitation and possible changes over time. If numbers continue to increase on the mainland, this may result in the sea lions being crowded into preferred areas. Males tend to defend a space around themselves as a territory, but the behavioural implications of crowding and aggression towards humans are unknown.

Research by Sonja Heinrich is focusing on the population dynamics and effects of interactions between visitors and male sea lions at haul-out sites on The Catlins (Heinrich 1996a). In an unpublished preliminary report of encounters between sea lions and visitors at Roaring Bay, Nugget Point, from December 1995 to March 1996, Heinrich (1996b) observed 706 visitors, who were mainly unguided travellers and residents from The Catlins area. Only 38 of them were accompanied by guides. Although the majority of visitors remained at a distance to observe the sea lions, she witnessed three instances where people accidentally approached them and eleven cases of deliberate harassment. People approached or aroused sea lions to get them to sit up for photographs, and on five occasions threw stones at animals to upset them. Many of these close approaches or harassment events resulted in the sea lion charging at the people or moving away from them.

Deliberate harassment of sea lions at The Catlins and the Otago Peninsula has also been reported by Gales (1995). Instances where sea lions have been shot and run over with a vehicle have been reported on the Otago Peninsula (S. Childerhouse pers. comm.). There is concern that harassment could have an impact on the establishment of breeding colonies by females (A. Pillai pers. comm.); to date, breeding on the Otago Peninsula has been limited to one female (McConkey 1994).

Responsiveness to humans varies with breeding status of sea lions (Richardson et al. 1995). The peak in tourist numbers coincides with the breeding season of sea lions, when levels of aggression in males are elevated (Gales 1995, M. Cawthorn pers. comm.). This poses a potential danger to visitors coming too close to the animals, and recommendations have been made to erect information boards about the sea lions and appropriate behaviour when observing them (Heinrich 1996b).

3.1.2 Impacts on seals

There is no reported research on the impact of human disturbance on New Zealand fur seals. Richardson et al. (1995) reported short-term responses of fur seals to human disturbance. This may be seen as temporary displacement from haul-out sites or increased vigilance by sitting up or moving away from the source of disturbance. Seals have been known to habituate to the presence of tour boats but will remain vigilant in other areas. This may be related to breeding stage or age and experience of the animals (Richardson et al. 1995).

Increasing numbers of tourists to the Kaikoura area cause increased pressure on the seals found along exposed highways and public viewing areas (S. Edmunds pers. comm.). As the peak in tourist numbers coincides with the summer breeding months for New Zealand fur seals, disturbance to breeding males and females with pups is likely. Fortunately, habitat excludes tourists from accessing many seal colonies (R. Mattlin pers. comm.).

There has been no research on the commercial operators' impact on the fur seals, although there are reports of commercial operators chasing fur seals into the water in order to swim with them (S. Edmunds pers. comm.). In Kaikoura, where there are both land- and boat-based operators with a maximum allowance of 154 trips per week (although this maximum number of trips is rarely fulfilled), the cumulative effect of these tours combined with the visitors encountering seals along the Peninsula walk is unknown. Seals hauled-out along this area of coast have been subjected to close approaches by unguided land-based visitors, but when attempting to avoid this disturbance by moving into the nearest water, they encounter guided swim-with-seal tourists (pers. obs.). The effects of such harassment are unknown but could result in an aggressive response by the animals such as charging or biting. The consequences of such responses are quite serious and incidents involving tourists being bitten by fur seals have been reported (S. Edmunds pers. comm.).

3.2 EFFECTS OF VESSELS ON CETACEANS

The long-term impacts on cetacean populations from behavioural changes associated with boat disturbance are currently poorly known. The effects may be seen as avoidance of areas at certain times (e.g. humpback whales near Maui (Corkeron 1995) and the bottlenose dolphins of Sarasota Bay (Wells 1993)), disruption to behavioural patterns (e.g. interruption of feeding or resting behaviour), or changes in habitat use and population viability.

There are currently four research projects assessing the impact of boat traffic on dolphins in New Zealand.

3.2.1 Hector's dolphins, Porpoise Bay

Data on the impact of dolphin-watching vessels on the Hector's dolphins found in Porpoise Bay, Southland, were collected over two summer seasons from 1995 to1997 (Bejder 1997). A theodolite was used to track the dolphins' behaviour and movement patterns, both with and without the presence of boats (commercial and recreational) and recreational swimmers. Bejder & Dawson (1998) reported that dolphins were accompanied by one or more vessels for 12.4% of the total observation period (251 hours). They found that dolphins were not displaced by the presence of boats but did respond to the presence of the dolphin-watching boat. Analyses showed that the dolphins approached the vessel mainly during the initial stages of the encounter (10–50 minutes). Even though they did approach the boat during the first 10 minutes, this was not at a significant level. The research showed that after 70 minutes the dolphins did not approach the boat as frequently as expected and that even though they weren't necessarily avoiding the boat, their interest decreased beyond 70 minutes interaction time. Even though the dolphins were interacting with the vessel they formed significantly tighter pods when the boat was present. This behaviour has been observed in other species (Irvine et al. 1981, Au & Perryman 1982) and could be an indicator of the need for greater protection within the group as they may perceive the vessel to be a threat. So even though the dolphins do not avoid the boats, interactions with boats may still be stressful for them.

3.2.2 Dusky dolphins, Kaikoura

The dusky dolphins of Kaikoura are currently the subject of two research projects on the impacts of tourism on the population. One project has involved the use of a theodolite to track the movements over four extended summer seasons (October–May) of the main group of dolphins and any small satellite groups which frequently comprise mother/calf pairs (Würsig & Yin 1994). Data on the movement of tour, recreational and fishing vessels were also collected. Analyses of dolphin movements, speed and behaviour relative to boat movements and speed are under way. In addition, boat-based photo-identification data and acoustic data were collected to better understand the population (Würsig & Yin 1994). Because of the number of tourist boats interacting with the dolphins, it has often been difficult to collect data from control situations in which no boats were present (pers. obs., S. Yin pers. comm.). Fortunately the dusky dolphins of Kaikoura were the subject of a four-year (1984-1988) research project on their habitat use, foraging ecology and behaviour (Cipriano 1992, Würsig et al. 1991). This research was conducted prior to the development of commercial swim-with-dolphin tours, and the dolphins were exposed to only moderate levels of fishing and recreational traffic at that time. The research used theodolite tracking as the primary method of data collection, although some individuals were fitted with a radio transmitter to track their movements; this showed that one dolphin tagged in Kaikoura travelled at least as far north as Cape Palliser (B. Würsig, pers. comm.). This research provides a useful baseline for the comparison of dusky dolphin movements before they were regularly targeted by boats.

DOC -commissioned research on the movements of the main group of dusky dolphins has been completed by Kirsty Barr (Barr 1997). This research involved two extended summer seasons (October–April) of data collection using a theodolite as the primary research tool. Data on movements of the main group of dusky dolphins with the presence and absence of tourist, recreational and fishing vessels were analysed. Barr (1997) found that dolphins were accompanied by vessels for 72% of the observation period. This figure significantly increased from the first field season (65.23%) to the second field season (78.28%) and was due to increased communication between vessels telling the dolphins position and thereby reducing search time for the pod (Barr & Slooten 1998). Commercial dolphin and whale watching vessels made up the majority of boats encountering the dolphins (84.4%) whereas recreational vessels only accounted for 9.4% of the vessels present.

Barr (1997) found an increase in aerial activity with the presence of boats. This increase in activity may be due to excitement, an attempt to improve visual and acoustic communication due to the increase in underwater noise with the presence of boats, or may have indicated disturbance. Barr & Slooten (1998) found the dolphins formed tighter pods in the presence of boats during mid to late afternoon and suggested that disturbance of dolphins in the early afternoon may be detrimental as they normally enter a rest period during this time which may make them more sensitive to vessel presence.

3.2.3 Bottlenose and common dolphins, Bay of Islands

Research was completed in 1995 on the bottlenose and common dolphins in the Bay of Islands and the effects of commercial swim-with-dolphin tours on these populations (Constantine & Baker 1997). This DOC -commissioned research evaluated a number of aspects of these operations, including behavioural responses to the presence and absence of boats. The specific responses to swimmers are reviewed below. Over the 12 month research period, feeding behaviour by bottlenose dolphins was the behaviour least likely to change as the boat approached from 400 m to 100 m. Socialising behaviour was most likely to change. For common dolphins, resting was the behaviour least likely to change and socialising was most likely to change. There was a significant difference between species as bottlenose dolphins changed their behavioural state on 32% of approaches and common dolphins changed their behaviour on 52% of approaches.

Even though a number of the behavioural changes were to approach the boat and bowride and there were few avoidance responses observed, it is possible that the dolphins avoided the boat before they were observed. Observations were conducted from a commercial swim-with-dolphin vessel, so this type of avoidance behaviour was difficult to assess. Dusky dolphins have been observed changing direction away from approaching vessels and subsequently were not seen by the boat (S. Yin pers. comm.). It must also be considered that not all dolphins from all groups encountered would bowride, so it is most likely that less interactive individuals would distance themselves from the vessel whilst still maintaining contact with their group. This subtle form of avoidance is difficult to account for, but the research in Kaikoura may be able to determine the frequency of this behaviour.

During DOC monitoring and enforcement of the Marine Mammals Protection Regulations in the Bay of Islands from 1 March to 31 May 1997, Berghan (1997) found that the permitted operators accounted for 74% of the total contact duration with the dolphins and remained with the dolphins for an average of 57 minutes per interaction. Recreational vessels spent 14% of total contact duration with the dolphins for an average of 8 minutes per interaction. This shows that the permitted operators account for the majority of time in which a vessel is in close proximity to the dolphins.

One of the limitations of conducting research on levels of boat disturbance in the Bay of Islands is the absence of suitable sites from which theodolite observations can be made. This means that the methods of data collection must account for the disturbance levels created by the presence of the research vessel (Shane 1990). Current research by Rochelle Constantine in Northland involves data collection on bottlenose dolphin responses to vessel traffic in order to determine if there are any long-term effects on the population.

3.2.4 Sperm whales

New Zealand is one of few places where sperm whales can be regularly sighted close to shore, and Kaikoura is the only place where regular sperm whale watching tours operate (MacGibbon 1991, Gordon et al. 1992). DOC-commissioned research showed sperm whales respond to the presence of whale-watching boats by having shorter respiratory intervals and decreased surface intervals (MacGibbon 1991). The study also found that whales responded negatively to rapid approaches, sudden changes in speed, and close approaches. Recommendations were made to modify boat handling around the whales and the use of hydrophones to allow better positioning of the vessel before the whale surfaced.

Many of the recommendations by MacGibbon (1991) were implemented, and in 1992, DOC commissioned a further study on the behavioural and acoustic effects of whale-watching vessels on the Kaikoura sperm whales (Gordon et al. 1992). This research found a considerable difference between responses of individual whales. Some were more tolerant of whale-watching vessels and subsequently received a greater amount of attention from these boats. Whales less tolerant of vessel traffic generally spent shorter periods of time at the surface and had shorter respiratory intervals. Whales subject to insensitive boat handling would often submerge without fluking (Gaskin 1964, MacGibbon 1991, Gordon et al. 1992, pers. obs.). Gordon et al. (1992) expressed concern that the reduced surface duration might result in shorter dive times for the whales and a subsequent reduction in foraging efficiency. They also noted the small six metre rigid hulled inflatable vessels used at that time by the whale-watch industry produced an engine noise at frequencies close to the creak vocalisations of whales. However, they were unable to assess the potential impact of this noise in masking the whales' vocalisations.

A DOC report on the effects of underwater noise from tourist operations (Marrett 1992) focused on the effects of noise on the sperm whales exposed to tourism off Kaikoura. In a series of controlled pass-bys by boats, planes and helicopters, it was found that noise levels at a depth of 75 m were not particularly loud and would probably constitute minimal harassment, although at this depth boats were noisier underwater than helicopters, and helicopters were noisier than planes. At the surface, vessels with low frequency sounds produced least noise, and it was suggested that if the whale remained at or near the surface this noise shouls be kept to a minimum. At a distance of 75 m from a whale on the surface, helicopters and planes were noisier than boats.

Marrett (1992) concluded that the noise levels produced by tourist traffic in Kaikoura were well within the range of current background noise levels, e.g. shipping and ambient sound, but recommended that sudden noises in the presence of whales must be avoided. Helicopters should not hover over a whale at the surface as this increases the noise levels, and planes should not 'buzz' whales. By circling around the whales, aircraft could minimise the potential for harassment.

3.2.5 Dolphins and porpoises

Dolphins in coastal waters, particularly bottlenose dolphins, are increasingly the target for commercial dolphin-watching tours and recreational boat users. They are often tolerant of close approaches by boats and sometimes will initiate the approach to boats in order to bowride, but are they also known to avoid boats (Shane et al. 1986, pers. obs.).

Common dolphins sometimes avoid approaching ships, beginning evasive behaviours at some distance, and appearing to change their travel as the ships' course changed (Au & Perryman 1982). It appears that some dolphins react to the sound of an approaching vessel to optimise their avoidance behaviour (Salvado et al. 1992). Cases of avoidance could occur before observers spotted the dolphins and lead to an overall underestimate of negative responses to the presence of boats (Constantine 1995). The type of grouping together and fleeing behaviour observed overseas on occasion is consistent with that reported for dolphins in the eastern tropical Pacific (Au & Perryman 1982) and in the Bay of Islands when disturbed (Constantine 1995).

The effects of these evasive manoeuvres on shipboard censuses of dolphins is discussed by Hewitt (1985). With the use of a helicopter to determine the accuracy of line transect sampling from a research ship, it was found that 8% of dolphin groups moved to avoid the ship before being detected by onboard observers. Theodolite tracking of dolphins from land allows a more accurate assessment of dolphin response to the presence of vessels as the researchers are not themselves a potential source of disturbance (Würsig & Yin 1995, Bejder 1997). Overseas land-based research of harbour porpoise (Evans et al. 1993). suggested that a decrease in avoidance behaviour later in the season may have occurred because the animals had habituated to the presence of vessels or because the calves had grown and were less vulnerable.

Land-based observations of bottlenose dolphins in the Moray Firth, Scotland showed a significant decrease in the number of surfacings by dolphins after a boat had encountered them (Janik & Thompson 1996). Research on the same population of dolphins showed an increase in the behaviours 'stop' (milling), 'change of direction' and 'prolonged diving' when vessels were present (Lütkebohle 1995). 'Changing direction' and 'prolonged dives' were interpreted as avoidance behaviour and were similar to those seen in the Bay of Islands (Constantine 1995).

Individual differences between dolphins are no doubt a major contributor to tolerance levels and responses to vessel traffic. The behaviour of the group prior to approach also has an effect on the response (Shane 1990, Constantine 1995, Ritter 1996, S. Yin pers. comm.). Generally, feeding and socialising dolphins are more tolerant of the presence of boats and less likely to show an avoidance response.

There are few study sites with detailed long-term observations, and the long-term impacts on cetacean populations from behavioural changes associated with boat disturbance are currently poorly known. Land-based research on spinner dolphins in Kealakekua Bay, Hawaii, (Barber 1993) suggests that dolphins exposed to repeated visits by boats and swimmers will shorten their periods of resting behaviour (Würsig 1996). Other effects may be seen as avoidance of areas at certain times (e.g., humpback whales near Maui and the bottlenose dolphins of Sarasota Bay), disruption to behavioural patterns (e.g., interruption of feeding or resting behaviour) or changes in habitat use and population viability.

Populations of resident or semi-resident dolphins as found in Doubtful Sound (Williams et al. 1993, Schneider 1995) are likely to be exposed to greater impacts from boat traffic. These dolphins may avoid boats or may habituate to the presence of boats.

3.3 VESSEL NOISE

As the majority of dolphin- and whale-watching is conducted by motorised vessels, the effects of vessel noise and presence is a primary concern. Reeves (1992) undertook a DOC-commissioned review of whale responses to anthropogenic sounds.

As part of a report for DOC on the impacts of marine mammal watching in the Bay of Islands (see Constantine & Baker 1997), research was conducted on the acoustic impact of vessels on the bottlenose and common dolphins (Helweg 1995). This research aimed to assess noise levels from three swim-with-dolphin vessels; *Tutunui*, a 14 m jet propelled diesel engine catamaran; *Discovery I* and *Discovery II*, two 6.6 m aluminium hulled vessels, one propelled by two 90 hp outboard engines and the other by a single 175 hp engine. Data were collected during a controlled series of pass-bys and engine start-ups.

All three vessels had a peak frequency of sound below the highest sound detectable by both species of dolphins. As the dolphins are sensitive to the sounds produced by the vessels, Helweg (1995) suggested that they could learn to identify the vessels by their sound. Irvine et al. (1981) found that dolphins could identify the vessel involved in their capture for research, and would avoid this vessel.

Helweg (1995) found no detectable changes in the acoustic behaviour of common dolphins with the presence of swim-with-dolphin vessels. Bottlenose dolphin acoustics were recorded on three occasions. On two occasions, a high-intensity burst-pulse sound known as a 'ratchet' was recorded, once when a vessel started its engine, and once when swimmers entered the water. This sound has been recorded in situations where there are high levels of stress, and it has been suggested that this may be a sound associated with alarm or 'anger' (Dreher & Evans 1964, in Finley et al. 1990, Herman & Tavolga 1980). Similar sounds by beluga whales were heard during periods of disturbance by shipping in the Arctic. The coincidence of these sounds with panic movement, suggested the calls were a type of alarm signal (Finley et al. 1990). Helweg (1995) mentions the interpretation of bottlenose dolphin ratchet sounds should be made with caution as knowledge of the intended receiver was uncertain and the sample size small.

On two of three recorded occasions when swimmers entered the water in the Bay of Islands, bottlenose dolphins went silent (Helweg 1995). Whether this silence is a type of 'freeze' response as seen with narwhals when disturbed by vessel traffic in the Arctic (Finley et al. 1990) or a period in which the dolphins are assessing the disturbance of the swimmers is unknown.

3.4 SWIMMING WITH DOLPHINS

Commercial tours which allow watching or swimming with dolphins are a more recent form of marine mammal based tourism. As almost all swim-with-dolphin tours are conducted from a boat, it is difficult to isolate the dolphins' response to the swimmers from the confounding effect of vessel presence. Many countries do not have commercial swim-with-dolphin tours even though dolphin watching is increasing in popularity, but it is possible to swim with both captive and wild dolphins in New Zealand.

3.4.1 Swimming with wild dolphins

New Zealand currently has four research projects: bottlenose dolphins of Northland, Hector's dolphins of Porpoise Bay, and two studies on the dusky dolphins near Kaikoura, assessing the impact of swimmers on dolphin behaviour. Three of the projects involve data collection on the impact of the swim-with-dolphin boats as well as swimmers from them. The research on the Hector's dolphins of Porpoise Bay, Southland, is assessing the impact of recreational swimmers, as the commercial dolphin-watching operator is not permitted to offer swims with the dolphins.

Bottlenose and common dolphins, Bay of Islands

A one year preliminary study on the bottlenose and common dolphins in the Bay of Islands assessed the method of swimmer placement, i.e. in the path of travel, line abreast, or when the dolphins were around the boat, and its impact on dolphin response, i.e. approach, avoidance, or neutral (Constantine & Baker 1997). A swim was attempted with only 37% of all dolphin groups encountered, which reduced the potential impact from swimmers. As was observed for the bottlenose dolphins of Port Phillip Bay, Australia (Weir et al. 1996), the strategy for swimmer entry into the water influenced the dolphins' response. The risk of bottlenose and common dolphins avoiding swimmers was greatest for the 'in path' strategy for swimmer placement. This strategy is in direct conflict with the Marine Mammal Regulations 1992, Regulation 18 (k), under which it is illegal to cut off the path of travel of a dolphin. The 'line abreast' strategy resulted in the lowest rate of avoidance by the dolphins but also had a lower rate of sustained interaction (i.e. where at least one dolphin came within 5 m of at least one swimmer).

The 48% sustained interaction rate found in the Bay of Islands bottlenose dolphin study (Constantine 1995) contrasts with the low rate in Port Phillip Bay, Australia (Weir et al. 1996). A possible reason is the small group sizes of dolphins most commonly seen in Port Phillip Bay, which may be less tolerant of disturbance by swimmers. The lower interaction rate could also be a result of attempts to swim with groups containing juveniles, or with dolphins engaged in all behaviours including resting and feeding in Port Phillip Bay. In the Bay of Islands, regulations prohibit swimming in these situations.

Hector's dolphins, Porpoise Bay

Over two summer seasons, data were collected on swimmers entering the water from the beach to swim with Hector's dolphins in Porpoise Bay (Bejder 1997). A total of 56 swim attempts were observed and swimmers were within 200m of the dolphins for 11.2% of the total observation time. There were no boat-based swim attempts as this is not allowed in Porpoise Bay.

Bejder (1997) found that dolphins remained within 200 m of the swimmers for more than five minutes on 57.1 % of swim attempts. Because the swimmers enter the water from the beach, the impact was minimised, as swimmers were unable to pursue a dolphin in the same manner as swimmers entering the water from a vessel. The research found that dolphins formed significantly tighter pods when the boat was present and that the presence of swimmers also increased the probability of the group remaining in a tight state. Bejder (1997) found that the dolphins extensively used a small area at the southern end of the Bay and concluded that it is an important area for them. This is also the preferred area for recreational swimming and was where the majority of encounters took place. Given that there was some impact from the swimmers, an increase in the number of recreational swimmers in this preferred area of the Bay may have an impact in the long term.

Dusky dolphins, Kaikoura

Research by Kirsty Barr on the dusky dolphins off the Kaikoura coast involved data collection from the commercial swim-with-dolphin operators boats as well as land-based observations. Boat-based data collected on the number of dolphins interacting with the swimmers found, on average, nine out of an average group size of 350 dolphins would interact with swimmers (Barr 1997). As photo-identification was not used in Barr’s research, the exact number of dolphins interacting with swimmers would have been difficult to count, so this number should be interpreted with caution. Barr (1997) found that commercial swim-with-dolphin vessels would spend an average of 43 minutes with the dolphins per trip and the swimmers spent an average of 40 minutes of this time in the water. Similar observations that only a small percentage of the total group of dusky dolphins would interact with swimmers are reported from the four year study by Suzanne Yin (S. Yin pers. comm.).

The observations made by Yin and Barr of only a small number of dolphins interacting with swimmers is consistent with observations of both bottlenose and common dolphins in the Bay of Islands (pers. obs.). The issue of exactly which dolphins are interacting with swimmers (i.e. are certain individuals more likely to interact with swimmers than others?) is being addressed by Rochelle Constantine as part of her research on bottlenose dolphins of Northland.

3.4.2 Swimming with captive dolphins

In New Zealand it is possible to swim with four captive common dolphins at Napier Marineland. There are up to five one hour swim sessions per day which are supervised by a trainer, but the dolphins are not directed by the trainer during the swim. One end of the pool has been restricted for dolphins only to provide a sanctuary area for them. There has been no research conducted on behavioural responses to swimmers outside standard husbandry practices (G. MacDonald pers. comm.).

3.5 FEEDING WILD DOLPHINS

In New Zealand, the Marine Mammals Protection Regulations 1992, section 18(d) state "no rubbish or food shall be thrown near or around any marine mammal", making it illegal to feed dolphins, seals or whales. Although commercial dolphin feeding tourism does not exist in New Zealand, the increased public interest in marine mammals has resulted in situations where members of the public have attempted to feed dolphins (pers. obs.).

3.6 LONE SOCIABLE WILD DOLPHINS

There are a number of examples of lone, sociable dolphins (see Lockyer 1990 for a review), some of which have received considerable public attention and become the focus of tourism. Occasionally an apparently solitary dolphin will actively seek out human contact on a regular basis. Even though these dolphins have the freedom to swim away, they will often allow people to touch them and will involve them in apparent play activities (Alpers 1960, Lockyer 1990, Doak 1995).

For many years there have been recorded cases of lone, sociable dolphins off the coast of New Zealand (see Doak 1995, for a review). One of the best known was Opo, a female bottlenose dolphin from the Hokianga Harbour (Alpers 1960, Lee-Johnson & Lee-Johnson 1994). Opo attracted up to two thousand tourists per weekend to come to observe or interact with her during the mid-1950s. Fisheries (Dolphin Protection) Regulations became law in 1956 with a special provision making it illegal to take or molest any dolphin in the Hokianga Harbour. Shortly after this law became effective, Opo was found dead. Some reports suggest she became trapped in a tidal pool when the tide went out (Alpers 1960). Others suggest an underwater explosive device was detonated and harmed the dolphin (Doak 1995).

Maui or Woody is a female bottlenose dolphin which has a minimum home range which extends from the Mikinui River, south of Kaikoura to the Marlborough Sounds. Maui was first seen interacting with people in the Kaikoura area around 1992 (D. Buurman pers. comm.). At that time there were two companies taking regular swim-with-dolphin tours. One company made a policy of not targeting Maui for tourism (B. McFadden pers. comm.). When the other company encountered Maui, they would only allow small groups of swimmers in the water (D. Buurman pers. comm.). Similar caution was exercised by the dolphin-watching operator in the Marlborough Sounds. The general caution by all tour boats and local boaties combined with strict enforcement of the regulations by DOC resulted in Maui receiving a limited amount of contact with people, which minimised the potential for harassment. In early 1994, Maui was observed interacting less with people and more with the dusky dolphins (D. Buurman pers. comm.). Since this time there has been less interaction between Maui and swimmers, even though she is frequently seen bowriding and interacting with vessels. Her behaviour toward swimmers has changed and now she is less interactive with humans on most occasions. In March 1997, Maui was observed with a newborn calf in the Marlborough Sounds (Z. Battersby pers. comm.).

3.7 VISITOR ATTITUDES AND EXPECTATIONS FROM MARINE MAMMAL BASED TOURISM

Commercial operators have the objective of providing a good experience for their passengers. They also have the responsibility to adhere to regulations and to minimise their impact on the wildlife. In her research on commercial wildlife viewing, Paula Wilson found that operators were the crucial link between the administrators charged with protecting wildlife, i.e. DOC , and the tourists who utilise the natural resources for recreation (Wilson 1993). In a survey of tourists partaking in a variety of wildlife based tours, she found that generally participants were well educated and from upper socio-economic groups. This finding was supported by Amante-Helweg (1995) and Beasley (1997). Her research also found that DOC had greater control over the actions of the operators of marine mammal based tours than other types of tours because of the permit required under the Marine Mammals Protection Act 1978. This was found to be a crucial factor in the planning and management of tours by these operators, and resulted in a relatively consistent standard of operation (Wilson 1993).

In 1995, Verna Amante-Helweg investigated the cultural perspectives of people aboard one of the swim-with-dolphin tours offered in the Bay of Islands. Of the 306 people interviewed after the tour, 96% stated they enjoyed the experience, even though 53% of them did not get to swim with dolphins (Amante-Helweg 1995). Analyses of data collected on participants' beliefs, knowledge, personal values and demographic characteristics, showed that most people interpreted dolphin behaviour anthropomorphically, and 11% of the respondents were of the opinion that "dolphins are here for my enjoyment" (Amante-Helweg 1995 p.73). Most expressed altruistic opinions, but, although 58% of participants were confident about their knowledge of animals, only 33% correctly answered factual questions relating to cetaceans. Because an increase in knowledge about cetaceans based on the commentary provided by the operator could be expected, 33% of correct responses is probably higher than if the participants had been questioned before the trip.

In a comprehensive study on the educational implications and legislation regarding marine mammal tourism (Beasley 1997), 60 permitted marine mammal tourism operators were surveyed, as well as 285 participants on swim-with-dolphin tours at Akaroa, Banks Peninsula. The research sought to identify the quality and sources of information provided by operators and the awareness of the visitors. Beasley (1997) found that the majority (70%) of operators focused their education on aspects of conservation and threats to marine mammals and conservation of the environment (68%). Approximately 60% of operators placed emphasis on marine mammal feeding, social behaviour, and prey. Surveys of the participants showed that this information was of the greatest interest, so it appeared that the operators were consistent with the tourists' expectations of the commentary. The operators' information was obtained mainly from books and personal experience and was not checked for scientific accuracy. Very few operators relied on DOC for access to information despite the DOC production of a booklet on marine mammals (Beasley 1997). Most operators provided inadequate additional information outside the tour commentary for the tourists. The provision of commentary and extra information was highlighted by tourists as being important.

A comparison of the tourists in Akaroa Harbour and Hong Kong found that both groups were generally well educated and from higher socio-economic groups (Beasley 1997). Questionnaires answered prior to the tour were compared with those answered at the conclusion of the tour. This comparison showed an increase in overall knowledge of marine mammals and the environment by the tourists, at least in the short-term.

3.8 OVERVIEW OF RESEARCH

There are currently only two research projects in New Zealand evaluating the effects of tourism on marine mammals: Sonja Heinrich's research on the New Zealand sea lions of the Catlins and Rochelle Constantine's research on Northland's bottlenose dolphin population. Given the rapid increase in the number of permits issued for marine mammal based tourism and the findings of recent research that species respond in different ways to vessels, a more diverse range of research projects should be considered.

The majority of research overseas has focused on the effects of vessels and aircraft on baleen cetaceans (see Appendix 1). In New Zealand, toothed cetaceans and pinnipeds form the basis of the marine mammal based tourism industry. We are one of few countries which allow swimming with dolphins and seals. Given that there are few published data on the effects of swim-with-seal tours, perhaps this is an area of research that should be considered, especially with fur seals being the most frequently encountered marine mammal (and this peaks during their summer breeding season) and with reports of people being bitten and chased by seals and sea lions.

Boat and aircraft noise has been shown to affect some species of marine mammals. There is an inadequate database on the acoustic impacts of both recreational and commercial vessels on dolphins and sperm whales. As the ability of cetaceans to communicate and forage is frequently dependent on their acoustic perceptions, this area of research should not be underestimated. Research overseas has focused on baleen cetaceans but research on sperm whales in Kaikoura conducted in the early 1990s provided valuable management information. A repeat of this work would be helpful, as Kaikoura Whale Watch has changed the boats used on their tours.

One of the most important aspects of evaluating the effects of tourism on marine mammals is the presence of pre-disturbance baseline data on the population size, habitat use, home range and behavioural ecology of the target species. Fortunately these data exist for some species (for example the Hector’s dolphins near Banks Peninsula), but for many others (for example bottlenose dolphins in the Bay of Islands) similar data were not collected prior to tourism being established. This makes it difficult to assess information on the sensitisation or habituation of a population exposed to tourism. As marine mammals are long-lived species with a complex social system and complex interaction with their environment, it may take many years until the effects of tourism are observed.

Given that New Zealand has quite strong legislation which fully protects marine mammals and very little information is available on the effectiveness of the educational material provided by commercial operators, perhaps a precautionary approach would be advisable. It may be that marine mammal based tourism does not protect and conserve marine mammals, but conversely reduces the viability of the species targeted by tourism. Only research will provide these answers and possible solutions to problems.

4. Management of marine mammal based tourism in New Zealand

The New Zealand Marine Mammals Protection Act 1978 (MMPA) has jurisdiction over the fourth largest Exclusive Economic Zone in the world (Donoghue 1996) and is considered one of the most progressive pieces of legislation for the protection of marine mammals (B. Würsig pers. comm.). In 1987, the newly formed DOC gained responsibility for implementing the MMPA from the Ministry of Agriculture and Fisheries. It was at about this time that the first commercial marine mammal based tourism venture began. In 1990 the Marine Mammals Protection Regulations were drafted to aid in controlling the developing whale-watching industry in Kaikoura. These regulations were revised in 1992 in response to the growth in marine mammal based tourism throughout New Zealand (Donoghue 1996).

The regulations are divided into sections relating to: the interpretation, application and purpose of the regulations; requirements for issuing permits; the suspension, revocation, restriction and amendment of permits; behaviour around marine mammals by boats, aircraft and vehicles, with special conditions for whales and dolphins and seals; and miscellaneous provisions.

4.1 WHALE-WATCHING

In New Zealand, the only place currently offering regular tours to encounter whales is Kaikoura. Many companies around New Zealand have whales which may occasionally be seen in their area included in their permit but this is not the main focus, although some interest has been expressed in the Bay of Islands area with regards to watching Bryde's whales. Given that there is one area of concentrated whale-watching, the industry is small in scale compared to the USA and Australia.

New Zealand has included all species commonly known as whales, i.e. baleen whales, sperm whales, beaked whales, killer whales and pilot whales, within its Marine Mammals Protection Regulations 1992. The commercial operators generally treat encounters with killer whales, false killer whales, and pilot whales as if they were dolphins (pers. obs.), and on a few occasions commercial operators have placed swimmers in the water with these species (J. Berghan pers. comm.). Although encounters with these species are generally infrequent, the continued interpretation of these species as whales rather than dolphins is advisable, given knowledge of their attacks on other cetacean species (Jefferson et al. 1991, Palacios & Mate 1996, Weller et al. 1996, Constantine et al. 1998) and one DOC umented report of an attack on a swimmer (Shane 1993).

4.2 DOLPHINS

New Zealand is one of few countries which allow commercial swim-with-dolphin tours in the wild controlled by a permit based system. Research by Weir et al. (1996) in Port Phillip, Australia, highlighted avoidance behaviours by dolphins when swimmers were placed in the water in situations which are deemed illegal under the New Zealand regulations (e.g. towing swimmers through a pod of dolphins (NZ Regulation 20(a)) and swimming with juveniles (NZ Regulation 20 (b)). These preliminary observations suggest that the current New Zealand regulations may be effective in minimising some forms of disturbance to bottlenose dolphins from swim-with-dolphin tours.

Research by Beasley (1997) found that, although some permitted marine mammal tour operators thought the current DOC permit system was neither efficient nor well structured, positive responses slightly outweighed negative responses when operators were asked if the Marine Mammal Protection Regulations 1992 provided adequate protection for marine mammals in New Zealand; however, many operators provided a neutral response. Almost all operators agreed DOC should be the agency responsible for managing marine mammal tourism.

4.3 EDUCATION

The Marine Mammals Regulations 1992 section 6(e) states:

> "That the proposed operator, and such of the operator's staff who may come into contact with marine mammals, should have sufficient experience with marine mammals."

and section 6(h) states:

> "That the commercial operation should have sufficient educational value to participants or to the public."

These requirements are the link whereby marine mammals can benefit from this form of tourism. Guides providing factual information about the animals, their environment, aspects of the local ecology, and what people can do to improve the environment fulfil this requirement of the Regulations.

4.4 OTHER MANAGEMENT OPTIONS

Currently the industry is managed primarily by regulatory approaches which are often difficult to enforce. Other possible management options include the use of fees, creating special protected areas or seasons based on the marine mammals' behaviour, e.g. migration routes, or on species, e.g. the Banks Peninsula Sanctuary for Hector's dolphins.

Many forms of ecotourism have the potential to generate income for the protection and management of resources through the implementation of user fees or charges for the issuing of permits (Wells 1997). Marine mammal based tourism has high appeal to tourists and therefore provides the potential for a community to maximise the economic benefit from these animals, but this must be balanced with the conservation needs of the animals (Hvenegaard 1997).

In some circumstances the protection of an area, e.g. the gray whale breeding areas in the lagoons of Baja California Sur, Mexico, has not only given protection to the whales and their habitat but has instilled a guardianship role in local residents (Dedina & Young 1995). With the rapid growth in whale watching in this area (an 18.8% increase from 1996-1997) and the implementation of new regulations which require foreign vessels to hire local vessels and guides, local economies are benefiting from the presence of the whales and this has in turn has increased the value of the presence of the whales (Sánchez Pacheco 1997).

4.5 OVERVIEW OF MANAGEMENT STRATEGIES

There has been a rapid growth of this industry worldwide, although it appears to have reached a plateau in New Zealand. This growth has been responded to with a wide variation in management approaches, from none at all (Belize) to strongly legislative (New Zealand). In the USA there is strong legislation but an inflexible system with very little enforcement and this results in severe problems particularly with interactions with dolphins and pinnipeds (see Appendix 2). The rationale in the USA that it is illegal to harass whales and therefore there is no reason to issue permits to interact with whales is an interesting one. The problem is that it allows little control of the industry but has an advantage in that it does not differentiate in any way between commercial operators and recreational vessels. In Australia the multitude of differing laws, guidelines and regulations for each State has led to an uncoordinated industry which is growing rapidly, with few consistent nationwide controls and in some cases differences between the public and commercial operators. The issuing of permits has caused some debate about rights under the Treaty of Waitangi.

Of the countries that are actively managing their marine mammal based tourism industries, the majority are using regulations to try and control approach distances, and numbers of vessels/aircraft; these vary depending on the types of marine mammals encountered. There is little information available on whether this industry educates participants about the animals encountered and their environment and if this is transferred into participant behavioural changes which improve the environment.

As management of this industry is still in its infancy, both in New Zealand and overseas, many areas are finding difficulty with enforcement of the regulations and guidelines. Research on the most efficient and effective management system could resolve some of the issues currently facing the industry.

In New Zealand, the majority of DOC Conservancies expressed some concern over the number of permits being issued and the lack of knowledge about the impacts of them. This attitude needs to be changed to one where a precautionary approach is instilled and the burden of proof shifts from those conserving the resource (DOC) to those wanting to use the resource (the permit applicants) (Mangel et al. 1996).

There are some variations in interpretation of the Regulations by DOC staff and operators, and in many cases these differ by species and area: some Conservancies have assisted with the development of a Code of Conduct, but in other Conservancies the operators have developed their own, independent of DOC input. The Southland Conservancy has produced a management strategy for commercial marine mammal viewing, and Northland and Waikato Conservancies have draft plans under way. These Conservation Management Strategies are in order to provide strategic direction to help guide the management of the local marine mammal based tourism industry and do not supersede the Marine Mammals Protection Act or Regulations. A few Conservancies expressed interest in implementing a moratorium on issuing new permits, and one has been issued recently on whale watching in Kaikoura, while others are being investigated (R. Suisted pers. comm.).

New Zealand has no standards relating to the quality of information given to the public and participants on marine mammal based tourism ventures. The portrayal of false expectations on advertising material from tourist operators, e.g. people reaching out to touch the animals or dolphins bowriding a fast moving vessel (Beasley 1996, pers. obs.), mislead the public. These images of often illegal acts do not reinforce appropriate behaviour around marine mammals, despite the other messages the tour may present. According to Beasley (1997), very few of the operators consult with DOC when obtaining information for their commentary. It would seem that better co-ordination of information between operators and DOC would ultimately be the best situation for protection of the marine mammals.

DOC needs to consider a nationwide approach to educating the general public about marine mammal legislation and appropriate behaviour around marine mammals. With the increased interest in marine mammals have come a number of incidents whereby they are harassed, but this is more often through ignorance than intention to harm the animals.

It is important to assess the costs and benefits of this kind of tourism. Issuing permits for marine mammal based tourism makes the operators a stakeholder in the animals' welfare and may act as a conservation measure in the long run, but only if it does not cause any harassment to the animals. If the ability to profit from the mere presence of marine mammals were worth money to a local community, it might encourage a community to protect the animals from direct harassment or bycatch.

Examples where this is of some urgency due to the threatened status of the species are the New Zealand sea lion and the Hector's dolphins. Heinrich's (1996b) report is of some concern, as harassment by predominantly unguided tourists and locals could result in the sea lions avoiding this haul-out site. This is in direct contravention of the Marine Mammals Protection Act 1978 and the DOC recovery plan for removing New Zealand sea lions from the IUCN threatened species list (Gales 1995).

The issuing of permits has had several benefits, not least the change in attitude that has been brought about and which has resulted in an appreciation of the intrinsic value of marine mammals and a high degree of self-policing for avoiding harm to them, for example by fishers off Kaikoura and recreational tuna fishers in the Bay of Islands. Most permits are not issued for dedicated marine mammal viewing trips, but for water taxis and other tourist vessels, for example, the tourist vessels that have been operating in Milford Sound for many years: the issuing of permits gives DOC some degree of control over these operations (R. Suisted, pers. comm.).

Mangel et al. (1996) discuss the common occurrence where the use of wildlife often begins without knowledge of the possible effects on the target species. The 1990 regulations were originally designed to provide the Director-General of Conservation with guidelines for whale-watching, and they were then revised in 1992 to cope with the increase in dolphin-watching (Donoghue 1996). Given the recent findings of species-specific research on responses to marine mammal based tourism and the rapid growth of this industry, there is a need to consider further revisions to the regulations. The Department of Conservation is now undertaking a review of the regulations (R. Suisted, pers. comm.).

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7. Appendices

7.1 INTERNATIONAL RESEARCH ON EFFECTS OF TOURISM ON MARINE MAMMALS

Sea lions

Increased levels of aggression directed towards humans have been recorded for sea lions targeted by tourists at the Galapagos Islands (Boo 1990, in Wright 1996). In some areas off the coast of California, sea lions have become used to fish handouts and are now considered to be a threatening nuisance as they pursue people for food (NMFS 1995).

Research on the reactions of Californian sea lions to weekly human disturbance found many females and pups relocated (Stewart 1982, in Richardson et al. 1995). It was found that this species of sea lion was less disturbed by human presence than those on the Galapagos Islands, which could indicate some degree of habituation. The Australian sea lions at breeding sites were more wary of humans than those at a nearby nature reserve with a higher level of human contact (Stirling 1972). Lewis (1987, in Richardson et al. 1995) reported 22 out of 23 stampedes of northern sea lions were caused by human disturbance during censuses. Although not many pups were killed, there were changes in some animals' behaviour which included reduced mother-pup contact.

Seals

The United Kingdom and Ireland have at least 117 boat-based and land-based seal watching operations with an estimated 500,000 visitors in 1996 (Young 1997). Many of these tours operate without written regulations or guidelines for operation and the impact of these tours is relatively unknown. In 1993, an estimated 10,000 people visited the grey seal rookery at Donna Nook, England. This led to research by Lidgard (1996) on the effects of disturbance on the maternal behaviour of female grey seals at this site. In his preliminary report to the British Ecological Society, Lidgard notes that females in areas of high disturbance were more protective towards their pups, and this increased the chances of aggression directed at humans. He also noted a preference by seals to give birth in areas of low disturbance. Females in areas of high disturbance often gave birth later in the season and had a shorter lactation period. The increase in visitors in such areas may accentuate the increased vigilance of mother seals and the chance of harassment by males, and contribute to shorter lactation times and subsequently pups with a lowered growth rate. Similar research on harbour seals in California found that females hauling-out at disturbed sites had lower pup production and higher pup mortality than those at non-disturbed sites (Allen & King 1991, in Lidgard 1996).

Aggressive responses by harassed seals have been seen off Long Island, New York, where, for example, seven cases of people being bitten by seals were reported to the National Marine Fisheries Service in 1994 (NMFS 1995).

Research on harp seals exposed to seal watching tours in the Gulf of St. Lawrence found that behaviour by mothers and pups, at least in the short-term, was altered by the presence of tourists (Kovacs & Innes 1990). The environmental conditions, numbers of seals and behaviour of the tourists all affected responses to human presence. Almost all aspects of mother-pup behaviour were affected; females attended their pups less, or when they did, they were more vigilant and spent less time suckling their pup. Pups were more active with the presence of humans, engaged in an increased level of agonistic behaviours, and rested less. With fewer seals, more people focused their attention on a small number of individuals, which resulted in a higher potential for disturbance to the animals. Kovacs and Innes (1990) suggested tourists should maintain a distance from the seals and reduce noise levels in order to minimise disturbance.

Effects of vessels on cetaceans

A comprehensive review by Richardson et al. (1995) discusses the effects of industrial activities such as seismic exploration, oil exploration and drilling, marine geophysical surveys, underwater explosions, sonars and vessel noise on marine mammals.

Little is known about the effects of aircraft on cetaceans. The behavioural state of the cetaceans and the type of aircraft often have an effect on the responses observed (Richardson et al. 1995). Some whales responded by diving or reducing their surface intervals, but only when the aircraft circled overhead. The altitude of the aircraft seemed to affect bowhead whale response, with lower altitudes (300 m) resulting in more conspicuous reactions than higher altitude (Richardson 1985, Richardson & Malme 1993).

Baleen whales

Gray whales

Whale watching based on gray whales began in the mid-1950s off the coast of the California. Since then the industry has grown rapidly and in recent years a number of studies focusing on the impact of whale watching vessels have been undertaken. A comprehensive five year research project on the impact of cruise boats taking tourists to watch gray whales in Laguna San Ignacio, Mexico, was prompted by claims of severe harassment of the whales using the lagoons for their winter breeding grounds (Wolman & Rice 1979). Restricted access was enforced in some of the lagoons and research on the population of gray whales and their response to vessel traffic began in 1977 (Jones & Swartz 1984). Responses of whales were influenced by the speed of approach and their behavioural state at the time. But even though the whales would sometimes respond to the presence of vessels, it was concluded that there was no major disruption to the breeding population in this area (Jones & Swartz 1984).

Generally, it was found that tour operators avoided disrupting whale behaviour as it caused the whales to flee and defeat the purpose of the trip. The researchers observed 'friendly' whales which would approach boats very closely and on occasion allow themselves to be touched by people. From this, and the general decline in avoidance response by the whales to boat traffic, Jones & Swartz (1984) concluded that the gray whales had, to some degree, become habituated.

Recent research on gray whales' foraging and movement patterns in Clayoquot Sound, British Columbia has shown that, during the period 1991-1994, the whales moved 20 km further away from the main commercial whale watching port of Tofino (Duffus 1996). This study was unable to attribute the change in habitat use to the presence of the vessels, as the animals appeared not to return to the area each year and therefore were not subject to the annual pressures of whale-watching vessels. Research on the population and habitat use during the 1993-1994 season found only 25-50% of photo-identified animals returned to the area. The researchers considered that a mixture of ecological and human influences affected the whales' use of the area, and recommended ongoing monitoring of movements and responses to whale-watching boats.

Humpback whales

Research conducted over a 25 year period off the coast of Cape Cod, Massachusetts found a degree of habituation by humpback, minke, fin and northern right whales (Watkins 1986). This research began in 1956, before whale-watching activities began in the 1970s. The researchers concluded that individuals in local waters had considerable exposure to boating activities, and a change in behaviour over time was evident. These responses varied from minke whales' initial interest in vessels changing to generally uninterested responses and humpback whales' frequently negative responses changing to often strongly interested or positive responses.

Humpback whales are subject to considerable levels of vessel traffic due to their frequent near-shore habitat use. The Cape Cod area is one example of relatively tolerant whales, but off southeast Alaska, the whales seem less tolerant of vessel traffic, e.g. in Glacier Bay National Park, which forms part of their summer feeding grounds. In the summer of 1970 only four large ships entered Glacier Bay, but in 1977, there were 143 large ships and a number of small recreational and tour vessels (NPS/NMFS, 1984, Baker et al. 1988). In midsummer 1978 all but three out of approximately 23 whales suddenly left Glacier Bay. This behaviour combined with the increase in boat traffic led to concern that the whales were being harassed. The resultant research found predictable short-term responses by whales to vessels operating at distances of less than four km; the speed, size, distance and number of vessels affected responses, which were observed as decreased blow intervals, increased dive times and avoidance of the vessels (Baker & Herman 1989).

Humpback whales wintering near the Hawaiian coast experience considerable levels of recreational and tour boat traffic. There was some concern that the movements of mother/calf pairs off the coast of Maui were affected by levels of boat traffic (Glockner-Ferrari & Ferrari 1985, in Reeves 1992). As the nearshore calf encounter rate decreased, there was an increase in sightings three to four km. offshore, which suggested a shift to the less congested offshore waters (Salden 1988). Although there was no decrease in population size, the effects of boat traffic on mother/calf pairs could in the long term result in them being displaced to other areas. As the humpback whales encountered in Hawaii migrate to south east Alaska, research has shown that they receive disturbance at both ends of their range and it is argued the cumulative impact of this should be considered (Bauer et al. 1993). During a series of controlled experiments off Hawaii, Norris (1994) found that both song phase duration and unit duration were significantly affected with boat presence. Whether there is any significance to the breeding success of affected individuals is unknown. Herman & Antinoja (1977, in Reeves 1992) expressed concern about the levels of commercial and recreational boat traffic, planes and helicopters targeting the whales and an increase in boat strikes was noted by Glockner-Ferrari et al. (1987).

There are similar concerns about the levels and impact of whale watching vessels on humpback whales entering Hervey Bay, Queensland, Australia. From 1991-1992 there was a 47% increase in the number of tourists viewing whales. This resulted in a 16% increase in frequency of trips and a 14% rise in contact with pods of whales (Great Barrier Reef Marine Park Authority 1993). Research conducted by Corkeron (1995) found a number of short-term behavioural changes by the whales associated with the presence of whale-watching vessels. Pods containing calves dived when vessels were present, a behaviour rarely seen when boats were not present. Non-calf pods which were engaged in surface activities changed these activities when boats approached within 300 m. The increase in pectoral slaps and breaches may be attributed to increased levels of agonistic interactions and may increase underwater noise for communication between individuals. These hypotheses need further testing. The fact that there was a change in rates of behaviour, at least in the short term, is of concern, as Hervey Bay is frequented by mother/calf pairs on their migration route and, in the long term, displacement such as that seen off the coast of Maui may occur (Corkeron 1995).

Responses of humpback whales to aircraft is poorly studied (Richardson et al. 1995). Limited results from research near Kauai, Hawaii suggested that at least some pods, particularly those containing a calf or near the surface reacted to the presence of a twin-engine Cessna aircraft by increasing swimming speeds and increased changes in orientation (Smultea et al. 1995). The responses were short-term and the dataset was very small (n=10) so the results should be interpreted with caution.

Right whales

Right whales were less responsive than fin or humpback whales to noise off the Cape Cod coast (Watkins 1986). The right whales were consistently silent when boats were nearby, which may be a sign of disturbance. Approximately one third of all northern right whale mortality can be attributed to human activities including boat strikes (Kraus 1990), which indicates that the whales either fail to detect the presence of the vessel or are unable to avoid it in time. Southern right whales are generally tolerant of vessel traffic if the boat is handled cautiously (Richardson et al. 1995, N. Patenaude pers. comm.) and will often closely approach and bump vessels (Payne 1995, N. Patenaude pers. comm.).

Land-based research on the swimming speeds of southern right whales at Peninsula Valdés, Argentina, suggested the whales swam faster when disturbed (Alvarez Colombo et al. 1990, in Reeves 1992). In Patagonia, southern right whales, particularly mother/calf pods, will generally move away from boats circling them or approaching head on (Campagna et al. 1995).

Fin whales

Research on fin whales exposed to whale-watching vessel traffic in the St. Lawrence Estuary, Canada, found the whales responded to boats at distances of a kilometre or more (Edds & MacFarlane 1987). Whales were observed changing their path of travel to distance themselves from vessels, and there was some concern that an increase in the number of whale-watching tours per day could result in certain individuals being disturbed several times a day. Stone et al. (1992) found subtle differences between respiration rates and dive times of fin whales exposed to whale-watching tours off the coast of Maine, USA. The sample sizes for whales with boats present were small and it was concluded that the differences in whales were too small to constitute a definition of harassment.

Toothed cetaceans

Killer whales

Killer whales are subject to intense pressure from whale-watching vessels operating off the British Columbia and San Juan Islands' coastline (Duffus & Dearden 1993). A six week land-based study by Kruse (1991) showed the approach of boats affected the movements of killer whales off West Cracroft Island, British Columbia. The whales increased their swimming speeds as recreational and commercial vessels approached within 400 m of them. This data should be interpreted with caution due to the limited data collection period. Further research in the same area but with a focus on the Robson Bight rubbing beaches showed a disturbance response by the killer whales when vessels approached to within 300 m (Briggs 1991); the whales would rub for shorter periods or leave the area when disturbed by vessel traffic. Phillips & Baird (1993) discuss Otis's long-term research in the San Juan Islands which shows no change in killer whale behaviour in the presence of vessels and suggest that the whales may have become habituated to the presence of boats. A seven-year, land-based research project focusing on the killer whales of Haro Strait, Washington, is investigating different behaviours in the presence or absence of boats (Burgan & Otis 1995). Preliminary analysis has shown that the number and types of boats affected the whales' behaviour. Also behavioural differences were found between commercial and non-commercial boats, but no relationship was found between boat handling and whale behaviour. Designing a research project to adequately link behaviour to certain stimuli such as boat presence is difficult, but well designed long-term projects are more likely to be valuable for management purposes (Duffus & Baird 1995).

Land-based research on the effects of boat traffic on the killer whales of Tysfjord, Northern Norway, is under way, using theodolite tracking and video recording. A preliminary report (DeNardo 1996) shows that Tysfjord supports a population of at least 500 killer whales during October and November, when they enter the area to feed on the overwintering herring stock. In recent years this has led to a rapid increase in recreational and tourist vessels coming to view the whales. Some observations of direct harassment by fishers have been recorded.

Beluga whales

Responses of beluga whales to tourist vessels on the St. Lawrence River were recorded by Blane (1990). Belugas exhibited avoidance behaviour by decreasing the intervals between surfacings and increasing their swimming speed (Blane & Jaakson 1995). There was a correlation between the increased number of boats present and an increase in intensity of response. Generally responses were short-term and in 75% of cases belugas resumed their pre-disturbance behaviour. Blane (1990) found that when engaged in feeding or travelling behaviours, belugas were less likely to react to boats, but when they did, it was generally a stronger response.

Belugas have also been observed avoiding fast, erratically moving small boats (Richardson et al. 1995). Blane (1990) found speed, direction and the number of vessels influenced the responses of belugas. Even so, they were still found in areas of high vessel use, which led Blane to conclude that these areas must be of considerable importance to the whales. There is a tenuous balance between the ecological significance of a particular area and the stresses placed on the animals. Therefore, it should not be assumed that the regular presence of animals in an area is an indication that the activities in the area have no impact. Caron & Sergeant (1988, in Richardson et al. 1995) found that, with increased levels of vessel activity in the Saguenay River, St. Lawrence Estuary, over a ten year period, there was a decrease in numbers of belugas using this area. In an acoustic study of the St. Lawrence belugas' environment, Scheifele (1997) found that noise levels in two of three study sites exceeded beluga hearing sensitivity curves to the extent that it was possible hearing damage would occur.

Sensitivity of belugas to shipping traffic in the Arctic was demonstrated by Finley et al. (1990). Belugas were found to flee the presence of vessels by undertaking long dives and were displaced by as much as 80 km. The production of 'scream' vocalisations accompanied their flee response. These sounds suggested an alarm signal, and similar sounds by stressed and excited bottlenose dolphins have been heard (Caldwell & Caldwell 1965).

Pilot whales

Research on the impact of whale-watching vessels on pilot whales off Tenerife, Canary Islands, found no significant difference in the behaviour of whales when boats were present or absent (Heimlich-Boran et al. 1994). It was observed that, with the presence of boats, pilot whales delayed surfacing and travelled in tighter groups but these observations were not statistically significant. Behaviours which suggested irritation were directed towards the research boat and could have been a response to harassment.

Dolphins and porpoises

Pelagic dolphins such as spinner dolphins (*Stenella longirostris*), spotted dolphins (*S. attenuata* and *S. coeruleoalba*) and common dolphins are known to avoid approaching ships (Au & Perryman 1982, Hewitt 1985). Avoidance manoeuvres sometimes began at distances approaching the horizon, and evasive behaviours such as bunching of the group and flight occurred at distances of less than one mile (Au & Perryman 1982). The response of dolphins to approaching vessels suggested they changed their course of travel as the ships' course changed (Au & Perryman 1982). It appears that some dolphins react to the sound of an approaching vessel to optimise their avoidance behaviour (Salvado et al. 1992). The effects of these evasive manoeuvres on ship-board censuses of dolphins is discussed by Hewitt (1985). With the use of a helicopter to determine the accuracy of line transect sampling from a research ship, it was found that 8% of dolphin groups moved to avoid the ship before being detected by onboard observers. Of all groups observed (n=13), 38% reacted to the ships' approach. The dolphins subject to this research had probably been exposed to harassment by tuna seiners and may have become sensitised to the approach of these vessels (Norris et al. 1978, in Richardson et al. 1995).

Dolphins in coastal waters, which are increasingly the target for commercial dolphin-watching tours and recreational boat users will sometimes initiate an approach to boats in order to bowride, but are they also known to avoid boats (Shane et al. 1986, pers. obs.). Cases of avoidance could occur before observers spotted the dolphins and lead to an overall underestimate of negative responses to the presence of boats (Constantine 1995). Theodolite tracking of dolphins from land allows a more accurate assessment of dolphin response to the presence of vessels as the researcher are not themselves a potential source of disturbance (Würsig & Yin 1994, Bejder 1997). Theodolite tracking of harbour porpoise in south-east Shetland showed that avoidance responses to larger vessels and speed boats were more apparent than to slower moving vessels such as yachts (Evans et al. 1993). Although this was a short-term study, avoidance behaviour was observed to decrease later in the season, possibly because the animals had habituated to the presence of vessels or because the calves had grown and were less vulnerable. The latter hypothesis was supported by the greater avoidance response early in the season by mother/calf pairs.

Bottlenose dolphins have been observed avoiding boats which were involved in live-capture operations in Sarasota Bay (Irvine et al. 1981). This type of grouping together and fleeing behaviour is consistent with that reported for dolphins in the eastern tropical Pacific (Au & Perryman 1982) and in the Bay of Islands when disturbed (Constantine 1995). Land-based observations of bottlenose dolphins in the Moray Firth, Scotland showed a significant decrease in the number of surfacings by dolphins after a boat had encountered them (Janik & Thompson 1996). Most vessels targeting the dolphins were small recreational vessels but the 10 m dolphin-watching boat accounted for 22 of 34 (64%) interactions observed. The presence of the dolphin-watching vessel caused a significant decrease in the number of surfacings by the dolphins, but there was no significant change in behaviour with other boat traffic. Given that the dolphin-watching vessel targeted and manoeuvred to stay in contact with the dolphins, this may have increased their potential for harassment. Research on the same population of dolphins showed an increase in the behaviours 'stop' (milling), 'change of direction', and 'prolonged diving' when vessels were present (Lütkebohle 1995). Changing direction and prolonged dives were interpreted as avoidance behaviour and were similar to those seen in the Bay of Islands (Constantine 1995).

Individual differences between dolphins are no doubt a major contributor to tolerance levels and responses to vessel traffic. The behaviour of the group prior to approach also has an effect on the response (Shane 1990, Constantine 1995, Ritter 1996, S. Yin pers. comm.). Generally, feeding and socialising dolphins are more tolerant of the presence of boats and are less likely to show an avoidance response.

Many areas are exposed to high levels of boat traffic. In Sarasota Bay, Florida, resident dolphins often ignore or avoid recreational boats, and data show that individuals avoided channels with high levels of boat activity (Wells 1993). The increased incidence of boat strikes involving dolphins in Sarasota Bay correlated with periods of higher than average boat traffic (Wells & Scott 1997). Many of the dolphins struck by a boat were compromised in some way such as having a young calf present or a deformity which may have limited their ability to respond. Odell (1976, in Wells 1993) suggested that a decrease in abundance of bottlenose dolphins in Biscayne Bay, Florida, could be related to an increase in boat traffic. Populations of resident or semi-resident dolphins as found in the Moray Firth (Wilson 1995), Sarasota Bay (Wells 1991) and Doubtful Sound (Williams et al. 1993, Schneider 1995) are likely to be exposed to greater impacts from boat traffic. These dolphins may avoid boats or may habituate to the presence of boats, as seen in Ensenada De La Paz, Mexico, where the dolphins make no apparent modifications to their behaviour with the close presence of boats (Acevedo 1991).

There are few study sites with detailed long-term observations. Land-based research on the effects of human activities on the spinner dolphins using Kealakekua Bay, Hawaii, is currently under way (Barber 1993). These dolphins are targeted by swimmers and tourists in motorised boats and kayaks, despite this being illegal in the USA (Barber et al. 1995). Theodolite tracking data on the dolphins and their interaction with boats, kayaks and swimmers will be compared to long-term data collected on the population (Norris et al. 1994). The 25 years of data collected on the habitat use, behaviour and movement patterns of the Kealakekua population provide an excellent control with which to compare current observations (A. Barber pers. comm.). Preliminary analyses of these data has shown that dolphins exposed to repeated visits by boats and swimmers will shorten their periods of resting behaviour (Würsig 1996).

The long-term impacts on cetacean populations from behavioural changes associated with boat disturbance are currently poorly known. The effects may be seen as avoidance of areas at certain times (e.g. humpback whales near Maui and the bottlenose dolphins of Sarasota Bay), disruption to behavioural patterns (e.g. interruption of feeding or resting behaviour), or changes in habitat use and population viability.

Swimming with wild dolphins

Bottlenose dolphins - Australia

A recent two month study was conducted on a population of over 100 bottlenose dolphins which use the Port Phillip Bay, Melbourne, area (Weir et al. 1996). These dolphins are exposed to commercial swim-with-dolphin tours and high levels of recreational boat traffic. Three swim-with-dolphin vessels were used as the research platform, supplemented by shore-based observations. Two of the operators in Port Phillip Bay use 'mermaid lines' to tow the swimmers behind the boat and position them nearer to the dolphins. One company did not use mermaid lines but instead used an underwater scooter to approach the dolphins. This research found an extremely low sustained interaction rate of 10%, i.e. when the dolphins remained within five m of the swimmers. A possible reason is the small group sizes of dolphins most commonly seen in Port Phillip Bay, which may be less tolerant of disturbance by swimmers. The lower interaction rate could also be a result of attempts to swim with groups containing juveniles, or with dolphins engaged in all behaviours including resting and feeding.

Weir et al. (1996) found that the approach strategy for swimmer placement significantly affected dolphin response. These findings are consistent with those of Constantine & Baker (1997) in New Zealand. The highest rate of avoidance behaviour was observed when the operators drove past the dolphins and veered into their path of travel (a 'J' manoeuvre). Even though this approach is quite invasive, it also had the highest rate of active interaction with swimmers. Weir et al. (1996) suggested that because the dolphins were forced to interact, some individuals may have acted as 'decoys' to take the pressure off the rest of the group. Another possibility is that the dolphins were simply unwilling to detour around the swimmers.

There are plans to create a sanctuary zone from Portsea to Nepean Bay in Port Phillip Bay (Weir et al. 1996), as there was a significantly higher rate of avoidance behaviour and a lower rate of interactive behaviour inside this area. Weir et al. (1996) suggested that the frequent presence of mother/calf pairs in this area combined with boat handling which resulted in dolphins being positioned between the shore and the boats may account for the increased levels of avoidance.

Research on the behavioural ecology of the bottlenose dolphins exposed to swim-with-dolphin tours in Western Australia is also under way (R. Donaldson pers. comm.). Although not focusing on the effects of tourism, it will assess the impact of the operation, which uses four underwater scooters and has up to 12 people in the water for up to two hours at a time (R. Donaldson pers. comm.).

Bottlenose dolphins - Japan

Research is being conducted on the bottlenose dolphin population near Mikura Island, Japan (K. Dudzinski & R. Soeda pers. comm.), which has been exposed to swim-with-dolphin tours since 1993. Currently there are no regulations to manage the industry at Mikura Island or at Ogasawara, the only other area where swimming-with-dolphins occurs in Japan. Population data have been collected every summer (May-October) since 1994. The research aims to collect land-based data on the effects of boat movements on the dolphins as well as continuing the boat-based photo-identification of individuals (R. Soeda pers. comm.).

Bottlenose dolphins - Florida

A comparative study on human interactions with free-ranging and captive bottlenose dolphins was conducted from 1990-1991 off the Florida Keys

(Frohoff & Packard 1995). Fourteen hours of video data were collected on free-ranging dolphins and their response to swimmers towed behind the boat. This research showed dolphin behaviour was variable and that the dolphins were in control of the level of interaction with swimmers. Dolphins did not always approach swimmers, but would often remain near them if the vessel's skipper decreased speed so that the swimmers could let go of the mermaid lines. The study did not elaborate on the categories for analysis and was reported in a subjective way which allowed little comparison with other recent studies.

Canary Islands

From September to December 1995, the cetaceans off La Gomera, Canary Islands, and the impacts of whale-watching tourism were the subject of research (Ritter 1996). On 52% of cetacean sightings, there was at least one swim attempt. The behavioural state and species targeted (pilot whales, rough toothed dolphins, bottlenose dolphins, Atlantic spotted dolphins, dense beaked whales, sei whales and sperm whales) affected the response to the swimmers. Atlantic spotted dolphins were most likely to approach swimmers, and pilot whales were most likely to show indifferent or neutral behaviour. Milling behaviour was most likely to result in an interaction between bottlenose dolphins, rough toothed dolphins, and pilot whales and swimmers. Travel and resting behaviours were least likely to result in an interaction (Ritter 1996). Because of the limited duration of this research and, for some species (e.g. sperm whales and sei whales), small sample sizes, some of the responses should be interpreted with caution.

Spotted dolphins - Bahamas

A long-term behavioural study on the spotted dolphins of the Bahamas has monitored the impacts of tour vessels on the population (D. Herzing, pers. comm.). Similar data were collected by Kathleen Dudzinski (1996), but results of the impact of swimmers have not yet been published. It was observed that an increased level of boats regularly targeting the dolphins was associated with reports of dolphin aggression directed towards humans. Since then, the level of boat traffic has declined and so have the reports of aggression (D. Herzing pers. comm.).

Swimming with captive dolphins

The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) permits four facilities to conduct swim-with-dolphin programmes with captive dolphins. These programmes were formerly under the jurisdiction of the National Marine Fisheries Service (NMFS), but a 1994 amendment to the Marine Mammals Protection Act transferred responsibility for captive facilities to APHIS (A. Terbush pers. comm.). The permits are subject to the results of research on the impacts of swimmers on the dolphins.

A comprehensive quantitative research project assessing all four facilities and the effects of swimmers on dolphin behaviour was completed for NMFS in 1994 (Samuels & Spradlin 1994, Samuels & Spradlin 1995). Swims were conducted under controlled situations, i.e. with the presence of a trainer regulating dolphins and swimmers, or uncontrolled situations, i.e. without the presence of a trainer. Uncontrolled swims involved a high level of agonistic behaviours (aggression and submission) and sexual behaviours directed at swimmers. Controlled swims involved a considerably lower rate of such behaviours, and the trainers eliminated any agonistic behaviours that put the swimmers and dolphins at risk. The use of designated refuge areas where swimmers were not permitted to go was found to provide inadequate sanctuary from swimmers, as dolphins did not voluntarily utilise this area at one facility. This study also involved an assessment of dolphin behaviour during their free time, i.e. without swimmers or trainers, which showed the dolphins' behaviour was modified.

Few males are used in these swim programmes as they have been involved in agonistic encounters with swimmers involving serious injury (Marine Mammal Commission 1994, Samuels & Spradlin 1994). Occasional escalation of agonistic behaviours resulted in the swim being terminated for some participants before they sustained a serious injury.

At Sea World Gold Coast, Australia, there was concern at the levels of aggressive responses by bottlenose dolphins during their captive swim programmes (I. Brieze pers. comm.). This prompted a research project by Ilze Brieze, which involved data collection on controlled and uncontrolled swims as well as behaviour during the dolphins' free time. Preliminary analyses have shown results similar to those of Samuels & Spradlin (1994) (I. Brieze pers. comm.). Recommendations were made to Sea World management that swims should be conducted only under trainer-controlled situations. Currently Sea World offers two half hour swim sessions per day, involving up to ten people per session with two dolphins and two trainers (R. Deakin pers. comm.). Every aspect of dolphin and swimmer behaviour is controlled during the swim (pers. obs.). This strict level of control appears to be vital in order to safely manage interactions between captive bottlenose dolphins and humans. Even during controlled situations, agonistic behaviours signalling signs of disturbance or stress sometimes occurred (Samuels & Spradlin 1994, Frohoff & Packard 1995, I. Brieze pers. comm.).

Research on swims with wild bottlenose dolphins have shown avoidance responses and generally low numbers of interactive individuals within the focal group (Constantine 1995, pers. obs, S. Yin pers. comm.). The ability to avoid swimmers by moving away is limited in a captive situation and may account for the increase in aggression noted in captivity that is not apparent in wild swim situations. Future studies on swim-with-wild dolphin tours should evaluate the incidence of agonistic behaviours by the dolphins.

Feeding wild dolphins

USA

The issue of feed-the-dolphin cruises received considerable attention in the USA during the early 1990s, when over 70 commercial operations were active in the waters off Texas, Florida and South Carolina (Bryant 1994). Because of the rapid increase in these tours, the increasing number of private boaters feeding the dolphins, and the development of tours where people would swim with the dolphins and feed them in the water, NMFS commissioned research on the problem (Marine Mammal Commission 1994). This report, which involved consultation with six independent scientists, concluded that feeding wild dolphins alters their natural behaviour and poses risks to the animals by changing their habitat use, calf-rearing abilities, and loss of wariness to humans (Bryant 1994, Marine Mammal Commission 1994).

In a few cases, individual dolphins had already become dependent on hand-outs from humans and would beg for fish and often become aggressive towards humans if not given any. Some people attempted to feed dolphins beer, pretzels and hooks baited with fish (Bryant 1994). Some of the dolphins were fed bait fish of poor nutritional value and, on occasion, when not fed, they would not resume hunting for themselves and suffered from malnutrition (R. Wells, pers. comm.). Since this report, the feeding of wild dolphins has been made illegal under the United States Marine Mammal Protection Act (1972) on the grounds that it constitutes harassment of the animals (Anon 1993, A. Terbush pers. comm.). Despite it being illegal, feeding dolphins and an increasing number of feed and swim-with-dolphin tours still continue, particularly along the Florida and Texas coasts (Seideman 1997). Seideman reports an increasing number of aggressive incidents by dolphins and harassment of dolphins in these areas.

Australia

In Australia there are three wild dolphin feeding programmes; in Monkey Mia, Western Australia; Bunbury, Western Australia; and Tangalooma, Moreton Island, Queensland. All three areas have a history of human/dolphin interactions which have involved uncontrolled feeding of bottlenose dolphins (Corkeron et al. 1990, Green & Corkeron 1991, Orams 1994, Wilson 1994).

All three areas have had management problems. At Tangalooma it took several months to reduce the level of forceful contact or ‘pushy’ behaviour directed at people by the dolphins when receiving fish from tourists (Orams et al. 1996). This behaviour has been virtually eliminated by feeding the dolphins in shallow water and using operant conditioning techniques to control behaviour. Research on the sociability of the eight provisioned dolphins when stationed at the hand-feeding area has shown increased levels of agonistic displays by specific individuals during feeding (Allen 1996). Observations of these provisioned dolphins when away from the hand-feeding area has shown no significant behavioural differences between them and non-resident dolphins in the bay (I. Brieze pers. comm.). Ongoing research is designed to detect any changes in the social behaviour and habitat use of the dolphins exposed to provisioning.

At Bunbury, people have fed the dolphins at the beach for a number of years. In the late 1980s an attempt was made to attract dolphins on a regular basis. No comprehensive research has been conducted on these dolphins and the effects of feeding them, but since regular provisioning began, an increase in begging behaviour and bait stealing has been reported (Wilson 1994). Currently, these dolphins are fed infrequently as a result of permit controls imposed by the Department of Conservation and Land Management (CALM), Western Australia.

At Monkey Mia, dolphins have been accepting fish from people for over three decades (Connor & Smolker 1985). Evidence of an abnormally high mortality rate of calves born to provisioned animals prompted CALM to commission a report on the situation (Wilson 1994). Research by Richards (1993, in Wilson 1994) found the survival rate of infants in the first year of life was 36% for provisioned and 67% for non-provisioned mothers. These data should be interpreted with caution as the sample sizes were small. Differences in foraging strategies, associations, and calf rearing between wild and provisioned dolphins have been observed as part of an ongoing research project in Shark Bay (Smolker et al. 1992, Mann 1995, Wilson 1994, Connor et al. 1992).

Lone sociable wild dolphins

One of the best examples is Fungie or Dorad found near Dingle, Ireland. This male bottlenose dolphin has been regularly sighted in the area for the past ten years, and there are a number of small businesses which operate tours to interact with him (M. Müller pers. comm.).

Dudzinski et al. (1995) have reported an increase in unregulated tourism to encounter Pita, a female bottlenose dolphin in the waters off Belize. She has been seeking human contact for the past four years, and over time the number of people attempting to interact with her has increased. Groups of up to 30 swimmers at a time have entered the water with her and up to four boats at a time have targeted her for attention. One of the concerns with the increased number of people entering the water with Pita is the increased level of aggression aimed at swimmers (Dudzinski et al. 1995). She has pushed and bumped people forcefully with her rostrum and body. She has been observed positioning herself between the boat and swimmers, thereby preventing the swimmers from leaving the water, and on one occasion she pushed a swimmer away from the boat with her rostrum. In 1995, she injured a swimmer, and since then increased levels of aggression and sexual behaviour directed toward swimmers have been observed.

Increased levels of aggressive and sexual behaviours have been recorded for other lone, sociable dolphins and it appears to increase with age and levels of human contact with them (Lockyer 1990, Lockyer & Morris 1986, Bloom 1991). Cases of lone, sociable dolphins pinning divers to the sea bed, towing swimmers out to sea then preventing them from swimming back to shore and directed aggression towards swimmers have been recorded. The most extreme case reported involved Tião, a male bottlenose dolphin in Brazil. This dolphin was severely harassed by a number of people and its aggressive response resulted in 29 people being injured and one fatality (Santos 1997).

7.2 INTERNATIONAL MANAGEMENT OF MARINE MAMMAL BASED TOURISM

USA

In the USA marine mammals are protected under the Marine Mammal Protection Act (MMPA) 1978. It is illegal to 'take' all species of marine mammals except for scientific research, enhancement of species or stock, public display, commercial or educational photography and a small by-catch in commercial fisheries. Subsistence hunting is also permitted. The MMPA regulations (50 CCFR 216.3) defines 'take' to mean:

Harass, hunt, capture, collect or kill, or attempt to harass, hunt, capture, collect or kill any marine mammal. This includes, without limitation, any of the following:...; the negligent or intentional operation of an aircraft or vessel, or the doing of any other negligent or intentional act which results in disturbing or molesting a marine mammal; and feeding or attempting to feed a marine mammal in the wild.

'Harassment' is defined as:

any act of pursuit, torment, or annoyance which —

(i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or

(ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Under this law, the USA does not recognise commercial or recreational marine mammal based tourism ventures as being eligible for 'take' authorisation (A. Terbush pers. comm.). It is also illegal to operate commercial swim-with-marine mammal based tours and dolphin-feeding tours. However, it should be noted that a wide variety of commercial operators do in fact exist, including swim-with-wild dolphin tours and wild dolphin feeding tours. Ironically the MMPA allows a 'take' of marine mammals for aquariums, and in some cases the US Department of Agriculture's Animal and Plant Health Inspection Service (USDA/APHIS) allows both public feeding and swimming with captive dolphins (Samuels & Spradlin 1994).

Pinnipeds

All interactions with pinnipeds are encompassed by the MMPA. Any swim-with-sea lion or seal operations are considered as harassment and are subsequently illegal. People in the vicinity of pinniped haul-out sites may not approach closer than 100 yards and must move to a greater distance if the animals show signs of disturbance (Carlson 1996).

There has been an increase in the number of people feeding seals and sea lions along the coast of the USA. There are reports of sea lions along the California coast which have become accustomed to fish hand-outs and their decreased wariness of humans means they approach people to beg for food (NMFS 1995).

In some areas these animals are now a potentially dangerous nuisance and there are reports of people throwing seal bombs to deter them. NMFS is the government body responsible for enforcing the MMPA, and to help alleviate this problem they have increased their public education campaign on the dangers of feeding and approaching pinnipeds (A. Terbush pers. comm.).

Whale-watching

The USA does not have a permit system for commercial whale-watching tourism. These tours are meant to be conducted in a manner which does not harass ('take') the animals and therefore do not require permits under the MMPA (A. Terbush pers. comm.). It is illegal to swim-with-whales as these activities constitute harassment on the grounds that they involve acts of pursuit and have the potential to disrupt behavioural patterns (US Department of Commerce/ NMFS 1990, NMFS 1995, Bryant 1994). This assumes that swimming with whales automatically constitutes harassment whilst boat approaches are assumed to be less likely to involve pursuit of the whales and subsequent harassment.

Under US federal law, all vessels are required to keep a minimum distance of 100 yards from whales.

There are separate guidelines for each of the five NMFS regions, and certain areas have special regulations relating to particularly vulnerable species or areas, e.g. humpback whales in Glacier Bay National Park; Massachusetts' northern right whales. Regulations regarding the angle of approach to the whales (no head-on approach), the numbers of vessels, and minimum approach distance exist in Hawaii for humpback whales.

The main species targeted in the USA are humpback whales (both summer and winter migrations), gray whales, fin whales, northern right whales, minke whales and blue whales. Many of the tours depend on the migration patterns of the target species, so they operate seasonally and many are affiliated with whale-watching organisations and independent cetacean research programmes. Off the Massachusetts coast, 18 of the 21 whale-watching operators offer onboard naturalists providing lectures to the tourists about the whales and the natural history of the area (Hoyt 1994).

Approximately half of the companies carry onboard researchers or provide research groups with regular photographic and positional data on the whales observed. As regulations can only protect the whales in the short term, the exchange of information and use of the whale-watching vessels as a research platform has provided a good opportunity to collect long-term data on the population demographics of the whales. Combined with other research on the impacts of whale-watching and general vessel traffic, there have been a number of studies on the whales targeted and the impacts of whale-watching tourism on these populations. One of the main factors is the long-term health and survival of the population. Many of the whales' responses to harassment are subtle and the effects of vessel presence and engine noise in the long term are currently unknown (Beach & Weinrich 1989).

Dolphins

Dolphin-watching is allowed in the USA, but feeding and swimming with dolphins constitute harassment and are therefore illegal. As with pinnipeds and whales, permits are not issued to interact with dolphins on the grounds that, under the MMPA, commercial operators should not be harassing the animals, therefore a permit to 'take' (harass) is not necessary. Despite the illegality of feeding and swimming with dolphins, there are a number of opportunities in the USA to join tours offering these kinds of activities. In Hawaii, there is research on the impact of humans on the spinner dolphins found in Kealakekua Bay (Barber 1993, Würsig et al. 1995), and the spinner dolphins of Midway Atoll are also the subject of research on the impacts of tourism (S. Yin pers. comm.). The spinner dolphins come close to shore during the day to rest and socialise, so it is considered important that they are able to perform these functions undisturbed (Norris et al. 1994). There are now at least six bays, mainly along the coast of the Big Island, Hawaii, where people can pay to interact with these dolphins (Würsig 1996). Swim-with-dolphin tours are also available off the coast of Florida (Frohoff & Packard 1995, Würsig 1996). Despite a well publicised legal battle to have feeding wild dolphins declared a form of harassment and a recent public education campaign on the issue of feeding wild dolphins and pinnipeds, feed-the-dolphin tours are still available in some parts of the USA and members of the general public often still feed dolphins (Seideman 1997, B. Würsig pers. comm.).

Australia

Whale-watching

Like New Zealand, Australia has a permit system to manage their whale-watching industry. These permits are issued by each State but are bound by the Whale Protection Act 1980. This legislation encompasses regulations regarding the angle of approach to the whales (no head-on approach), the numbers of vessels targeting a whale or whales (no more than three), a minimum approach distance (no less that 100 m) and the minimum distance for aircraft (300 m). These regulations are similar to the New Zealand regulations governing behaviour around whales, and are currently under review.

Each State has drafted its own legislation regarding behaviour around marine mammals.

- In Queensland, a draft document 'Conservation Plans for Whales and Dolphins in Queensland' under section 106 of the Nature Conservation Act 1992 has been prepared. As with all State documents, this encompasses the legislation bound by the Whale Protection Act but disallows the use of helicopters for whale-watching purposes. The maximum penalty for breaching the regulations is A$6,000.
- New South Wales has legislation protecting whales under the National Parks and Wildlife Act 1974. They have given special consideration to jetskis, which are allowed to approach no closer than 300 m (other vessels are allowed to approach a non-mother/calf pair to 100 m). Helicopters must maintain a distance of 400 m instead of 300 m for other aircraft. The maximum penalty for breaching the regulations is A$100,000.

- Victoria has legislation encompassed by the Wildlife Regulations 1990, under section 85A of the Wildlife Act 1975. There are no notable differences from the federal legislation, except that the maximum penalty for breaching the regulations is A$4,000.
- South Australia's legislation is covered by the National Parks and Wildlife Act, Section 68. Their legislation is divided into inshore and offshore guidelines. Inshore guidelines allow a vessel to approach no closer than 300 m to the whale; offshore an approach is permitted no closer than 100 m. Helicopters are not allowed to operate for whale-watching purposes. There is no maximum penalty for infringing the regulations, but a Bill is currently being considered in Parliament.
- Western Australia has a Marine Mammal Interaction (Whale Watch) Licensee system. This system has guidelines similar to those in the Whale Protection Act and is administered by the Department of Conservation and Land Management. The maximum penalty for breaching the licensee system is A$10,000. Legislation specific to management of marine mammal tourism is currently being drafted (N. Gales pers. comm.).

Whale watching as a tourist activity has grown rapidly in recent years in Australia. It is possible to observe whales off the Queensland, New South Wales, Victoria, South Australia and Western Australian coastlines. These tours are seasonal, and target the migrating humpback and southern right whales. In South Australia it is possible to watch southern right whales from cliffs overlooking the bay area where they congregate during winter. The development of this as a non-invasive method of watching whales is being promoted in Australia.

The most popular whale-watching area is at Hervey Bay, Queensland, where the first commercial whale-watching vessels began operating in 1987. In Hervey Bay, whales are protected under the Marine Parks Act as well as the Fisheries Act and the Whale Protection Act.

Dolphins

In Australia there are commercial dolphin-watching tours available in Victoria, Western Australia, Queensland, New South Wales, Tasmania and South Australia. Dolphin based tourism was estimated to account for approximately 40% of all cetacean based tourism in Australia and primarily targets bottlenose dolphins, humpback dolphins and common dolphins (Anderson et al. 1995). There is no national permit system, but instead the individual States run licensing systems or guidelines under their State legislation. Most tours are for dolphin-watching only, but in Port Phillip Bay, Victoria, and Rockingham, Western Australia, it is possible to swim with dolphins (Weir et al. 1996; R. Donaldson pers. comm.). In 1995 the operators in Port Phillip Bay developed a voluntary code of practice, and this is currently under review as Regulations are being drafted (W. Dunn pers. comm.).

United Kingdom

Pinnipeds

The UK currently has no legislation which directly accounts for the impact of seal watching (Young 1998). There are many statutes under which seals are covered and the Conservation of Seals Act 1970 primarily deals with lethal takes of seals. This Act deals with management of seals as a resource but only with regard to the sale of seal products rather than as a resource for tourism.

In the UK and Ireland, there are currently a total of 117 land and boat-based seal watching operations (Young 1998). The majority of these are in Scotland (79 operators) as this country has the largest grey seal and common seal populations in the UK. Approximately 500,000 tourists visited the seals in 1996, with 36% of the visitors stating that viewing wildlife was the main aim of their visit. Most of the tours included seal watching as part of a general wildlife watching trip and the peak in seal watching was generally from September-October.

Young (1998) found many of the commercial operators belonged to their local tourism boards, but very few had endorsement from other recognised local bodies. With the apparent increase in seal watching activities in this area and the lack of regulations governing the activities of operators, it is possible that seals will face increased levels of harassment. Given that some operators target the haul-out sites with mothers and pups, this should be closely monitored by research on the impacts of human disturbance on these animals, e.g. Lidgard (1996). Young (1998) suggested the development of legislation protecting the seals from human disturbance and enhancing the conservation and education values of such tours.

Dolphins

In Scotland, England and Wales, voluntary guidelines recommending types of approach, allowing no more than three boats within one km of dolphins at any time, and prohibiting touching, feeding or swimming with dolphins have been developed by independent organisations. In Scotland, the Dolphin Space Programme has been established in order to promote an accreditation scheme for wildlife cruise operators in the Moray Firth (Arnold 1997). The accreditation scheme has been designed in the absence of legislation specifically protecting dolphins from the impacts of tourism, and aims to set local standards for minimally invasive dolphin-watching tours. In 1990 there was one boat-based dolphin watching tour in the Moray Firth, but the increase to nine operators offering tours in 1996 led to concern about the growth of this industry and the subsequent need for some form of control. A proposal for standardised guidelines within the United Kingdom was put forward at the 1997 IWC meeting to standardise codes of conduct such as the example in Ceredigion Bay (Tasker et al. 1997).

Other countries

Whale-watching

The global increase in whale-watching has resulted in a wide range of protection laws and methods of regulating the industry. Some nations have laws which specifically protect all marine mammals, e.g. the United States Marine Mammal

Protection Act 1972; Australia's Whale Protection Act 1980, Argentina's Law 2381/84 and the New Zealand Marine Mammals Protection Act 1978. Other nations have marine mammals protected in part under other laws, e.g. South Africa's Sea Fishery Act 1988; the Habitats Regulations of the European Union 1994, and the Let General del Equilibrio Ecologico y la Proteccion al Ambiente, Mexico. In South Africa, it is illegal to approach a whale closer than 300 m but there is currently pressure from commercial whale-watching operators to change the law to allow closer approaches (K. Findlay pers. comm.)

Most countries do not protect their marine mammals by law, but in response to the increase in whale-watching tourism some nations are currently developing guidelines to help manage the industry. One example is Norway, where in 1991 there was only one operator targeting the killer whales feeding on herring in Tysfjord, but by 1996 this had increased to eight operators with 13 vessels targeting the whales. No regulations existed to control these operations (C. De Nardo pers. comm.). In 1996 guidelines were introduced to Tysfjord, and guidelines are also in operation on the Lofoten Islands, but there are no national laws or regulations protecting whales from tourism in Norwegian waters (Carlson 1996, DeNardo 1996).

A survey of the regulations and guidelines governing whale-watching around the world was conducted by the International Fund for Animal Welfare (IFAW) (Carlson 1996). This report found the majority of nations have general guidelines that often vary between species and seasons, e.g. in British Columbia, Barkley Sound and Clayoquot Sound have regulations for whale-watching (primarily gray whales) which differ from the Johnstone Strait Whale Watching Guidelines (primarily killer whales). Also guidelines may differ by area, e.g. the humpback whales of Glacier Bay have special regulations as they occupy a National Park area; the humpback whales which frequent the Hervey Bay Marine Park, Australia, area have special regulations because the area is protected; gray whales in the San Ignacio Lagoon and Laguna Ojo de Liebre are afforded special protection by the Instituto Nacional de Ecologica, and the Brazilian government have established the Environmental Protection Area of Anhatomirim to protect tucuxi dolphins from tourism and fishing activities. In some areas certain species may be excluded from tourism as a conservation measure, e.g. the St. Lawrence River, where beluga whales must be excluded from the species of whales sought for whale-watching; if a beluga is encountered, the vessel must slow down and proceed at a speed of less than five knots before continuing the direction of travel.

It is possible to swim-with-whales in a few countries, e.g. humpback whales in Tonga and Niue; sperm whales in the Galapagos, and a variety of species of whales (primarily pilot whales and dense beaked whales) off the Canary Islands (Heimlich-Boran et al. 1994, Ritter 1996). These countries have no laws for the protection of whales but do have guidelines to recommend approach types in order to minimise the potential for harassment. Some countries' guidelines explicitly forbid swimming with whales e.g., Turks Islands and Caicos Islands, Caribbean; Ogasawara Islands, Japan.

Dominica and the Galapagos Islands have guidelines relating specifically to behaviour around sperm whales. Neither country has legislation to protect marine mammals, but these guidelines have been developed in conjunction with local operators, government officials and scientists (Carlson 1996). The guidelines for the Galapagos Islands sperm whales are similar to those in New Zealand, although swimming with the whales is allowed. In Dominic the regulations are more stringent than those in New Zealand; only two vessels are allowed within 300 m of a sperm whale, vessels are only allowed to stay with the whales for three dive sequences, no whale or group of whales is allowed to be visited for more than three dive sequences per day, interaction with a group of socialising whales must be limited to 15 minutes, and helicopters are not allowed to be used for whale-watching purposes.

Dolphins

Dolphin based tourism ventures are increasing in number but still account for a small part of the overall global market for marine mammal based tourism (Hoyt 1995). A few countries include dolphins and porpoises in their laws to protect whales, e.g. Australia, Brazil, and the USA, but the majority of nations have no law for dolphin protection.

Specific guidelines for behaviour around dolphins have been included in the New Zealand regulations, and in guidelines developed in Dominica, the Canary Islands, and the United Kingdom (Sea Watch Foundation, Whale and Dolphin Conservation Society 1995, Carlson 1996, Arnold 1997). Some areas have developed guidelines for operating around dolphins but find these are often not adhered to when there is a lack of legislative enforcement, e.g. in Victoria, Australia (Weir et al. 1996) and the Bahamas (D. Herzing & K. Dudzinski pers. comm.).

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REVIEW
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Looking Back to Move Forward: Lessons From Three Decades of Research and Management of Cetacean Tourism in New Zealand

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Cetacean tourism in Aotearoa New Zealand is now over 30 years old and has experienced substantial growth in visitor numbers and operations. The industry is remarkably diverse, targeting several dolphin and whale species, and encompassing varied habitats in coastal waters, fiords and submarine canyons. The knowledge and experience collected over these past 30 years has both advanced the global understanding of cetacean tourism, and influenced scientific practices for its study and management. Here we review the approaches taken in quantifying the impact of cetacean tourism in New Zealand, and critically assess the efficacy of the research and management strategies adopted. We place particular focus on the Bay of Islands, Hauraki Gulf, Kaikoura, Akaroa and Fiordland, areas that include the oldest, and longest studied industries nationally. We propose a set of best research practices, expose the most notable knowledge gaps and identify emerging research questions. Drawing on perspectives from the natural and social sciences, we outline the key determinants of failure and success in protecting cetacean populations from the detrimental impact of tourism. We suggest four golden rules for future management efforts: (1) acknowledge cetacean tourism as a sub-lethal anthropogenic stressor to be managed with precaution, (2) apply integrated and adaptive site- and species-specific approaches, (3) fully conceptualize tourism within its broader social and ecological contexts, and (4) establish authentic collaborations and engagement with the local community. Lastly, we forecast upcoming challenges and opportunities for research and management of this industry in the context of global climate change. Despite New Zealand's early establishment of precautionary legislation and advanced tourism research and management approaches, we detected flaws in current schemes, and emphasize the need for more adaptive and comprehensive strategies. Cetacean tourism remains an ongoing challenge in New Zealand and globally.

Keywords: whale watching, dolphin swim-with, wildlife tourism, tourism impact, cetacean conservation, impact research, tourism management

INTRODUCTION

An increasing demand to interact closely with whales, dolphins and porpoises has led to commercial activities targeting wild cetaceans (hereafter cetacean tourism) becoming a burgeoning industry globally (Hoyt, 2018). Prior to the Coronavirus (COVID-19) pandemic of 2020, the industry had significant potential for further growth (Cisneros-Montemayor et al., 2010), even though there were already clear signs that this form of tourism is often not managed sustainably (Higham et al., 2009). The dramatic post-COVID-19 hiatus in tourism provides a unique opportunity to reflect and build on past experience, and to prepare for future scenarios.

Cetacean tourism can benefit human communities and cetacean populations via improving livelihoods, providing opportunities for education and research, and fostering a climate for conservation initiatives (Hoyt, 2018). This, and the often uncertain effects of tourism on cetaceans, have led to considering the activity a lower priority threat compared to those resulting in direct mortality (e.g., bycatch, hunting) or alteration of habitat (Higham et al., 2016). Detrimental effects on the animals, however, are clear (Samuels et al., 2003; Machernis et al., 2018), and cetacean tourism is now recognized as a sub-lethal consumptive industry (Neves, 2010; Higham et al., 2016). As such, its management is best based on a precautionary principle (Bejder et al., 2006b) and on analytical frameworks incorporating the ecological and social aspects of the industry, and the multiple threats to cetaceans (Higham et al., 2009). Moreover, animal welfare (i.e., individual effects) is increasingly recommended as a necessary complement to conservation indicators (i.e., population-level effects) (Papastavrou et al., 2017; Nicol et al., 2020). To date, however, priorities and approaches to cetacean tourism research and management have varied significantly at both local and global scales.

New Zealand has a 30-year history of cetacean tourism research and management. Following the establishment of the first dedicated operation in Kaikoura in 1987 (Donoghue, 1996), the industry flourished in multiple locations, each characterized by a unique combination of ecological, social, research and management features (**Figure 1**). The New Zealand evidence- and partnership-based approach to environmental conservation (Ewen et al., 2013) translates in scientific studies often commissioned by the government (Constantine, 1999; Orams, 2004), and in research and management initiatives involving multiple stakeholders, including local *iwi* (Māori tribes; Simmons, 2014) and tour operators. In some cases, these studies have prompted site-specific management actions. Recent longitudinal studies, however, have exposed the inadequacy of past and present management regimes (Hartel et al., 2014; Bennington et al., 2020; Dwyer et al., 2020) and outlined the financial, procedural and institutional barriers to effective marine conservation (Bremer and Glavovic, 2013; Dodson, 2014). Effective management of cetacean tourism in New Zealand continues to be a challenge.

In this review we draw on our personal experiences of extended engagement in marine mammal and cetacean tourism research, advocacy and community outreach, and advisory roles to national and regional governments and organizations in New Zealand and internationally. Where possible, the perspectives of other interested parties (e.g., governmental agencies, tour operators) are included, based on available literature and personal communications.

Building on previous assessments of the industry (Donoghue, 1996; Constantine, 1999; Orams, 2004), we aim to (1) critically review approaches taken in New Zealand to studying and managing tourism pressures via analysis of five case studies, (2) put forward clear and specific recommendations for the future of research and management of cetacean tourism within a national and international context, and (3) highlight the main knowledge gaps, emerging questions, future challenges and opportunities for managing the industry in light of both welfare and conservation considerations. Overall, we aim to initiate a productive dialogue on the future of cetacean tourism industry in New Zealand.

CASE STUDIES OF CETACEAN TOURISM IN NEW ZEALAND

The Department of Conservation (DOC) is the government agency responsible for administering the Marine Mammals Protection Act (MMPA) New Zealand Government, 1978 and the Marine Mammals Protection Regulations (MMPR) (New Zealand Government, 1992). Under the MMPR, DOC issues permits for commercial operators conducting tours to view and/or swim with marine mammals, and regulates human behavior around the animals with site-specific conditions.

Over the past three decades, in response to the significant growth in international tourism (Upton, 2019), cetacean tourism has become an established industry in the country. The permit system provides a legal structure to regulate its proliferation, but has often been used to formalize already existing commercial activity (Allum, 2009), hence in a reactive, rather than proactive fashion. The number of permits issued by DOC to view and/or swim-with cetaceans increased from one in 1987 to 63 by 1997 (Constantine, 1999), and to 76 by 2020 (DOC, pers. comm.). The number of permits, however, is likely to underestimate the actual increase in tourism pressure over time, as operators can increase the number and duration of trips at their discretion. In addition, wild cetaceans have been increasingly exposed to interactions pursued by non-permitted operations and to opportunistic boat encounters. Data on trip number, frequency and duration, and cetacean daily and cumulative exposure to overall pressure, which would have allowed for a more representative description of tourism evolution, are unavailable or sporadic (e.g., Bejder et al., 1999; Green, 2005; Martinez et al., 2011).

As of today, most current permits allow only viewing cetaceans, while 27 permits grant the additional right to swim with dolphins. The level of enforcement is variable and, depending on the region, boat patrols and "mystery shoppers" are used to assess compliance. Site-specific voluntary codes of conduct often complement but may not contradict the MMPR.

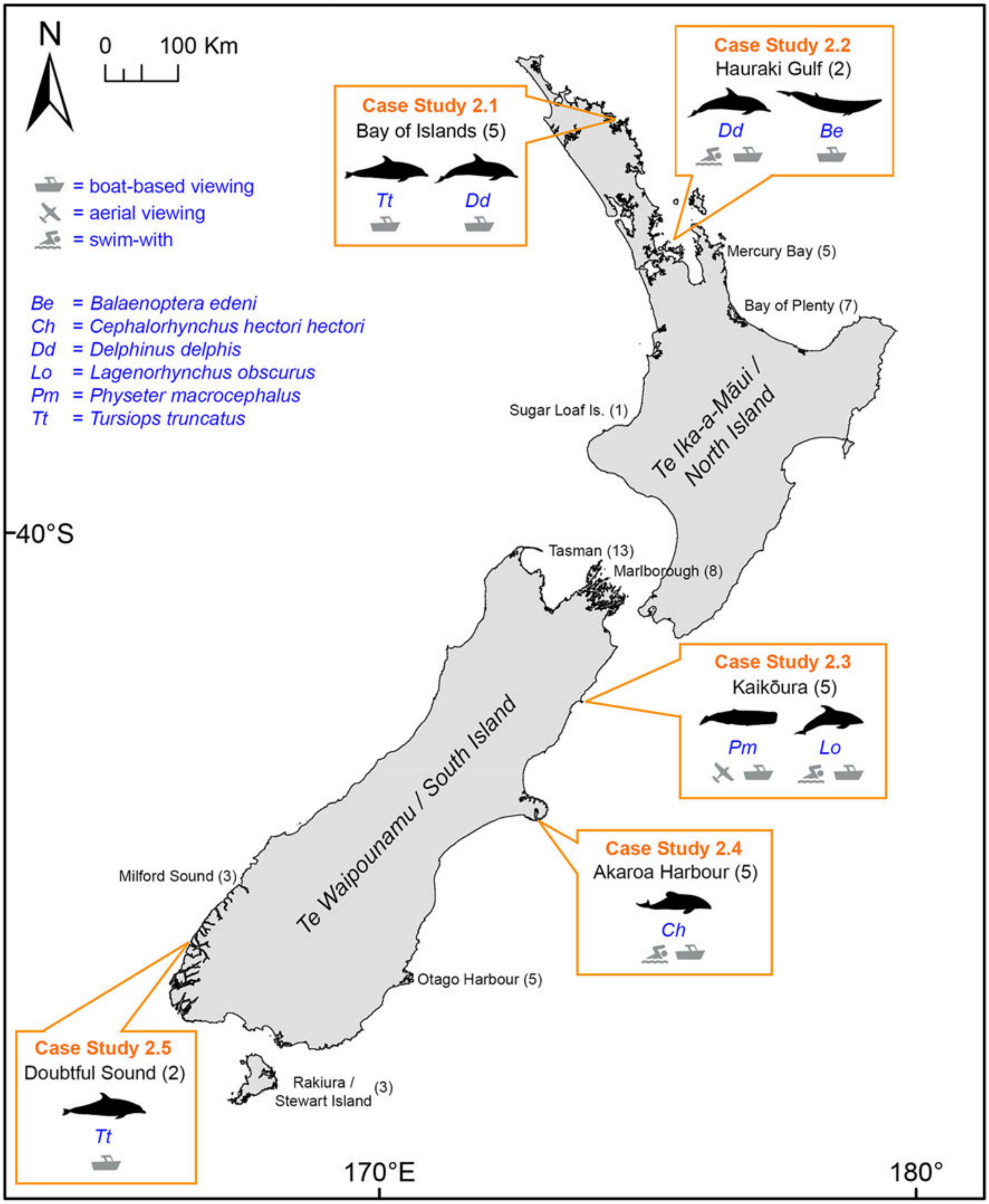

FIGURE 1 | Map of cetacean tourism destinations in New Zealand with permitted operations. For each destination, we report the number of permitted operators (in brackets). For the selected case studies presented in the following sections (boxes), we also indicate species targeted and characteristics of operations.

Commercial activities target predominantly the populations of six species: bottlenose (*Tursiops truncatus*), common (*Delphinus delphis*), dusky (*Lagenorhynchus obscurus*), and the endemic Hector's dolphin (*Cephalorhynchus hectori hectori*), as well as the sperm whale (*Physeter macrocephalus*), and the Bryde's whale (*Balaenoptera edeni brydei*). Substantial research on the effects of tourism on cetaceans has been undertaken at five locations, four of which are the focus of long-term monitoring programs: the Bay of Islands, the Hauraki Gulf, Kaikoura, Akaroa Harbour and Doubtful Sound (**Figure 1**). These are reviewed in detail in this section and in **Tables 1–4**. The literature on cetacean tourism at other destinations in New Zealand is summarized in **Table 5**.

TABLE 1 | Summary of the literature on bottlenose and common dolphin tourism in the Bay of Islands.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1994–95	Behavior of both common and bottlenose dolphins impacted by tourism. Socializing was the behavior most impacted for both species [1]. Documented seasonal shifts in habitat use with both species. Photo-identification studies identified non-resident bottlenose dolphin population [1]. No acoustic response in common dolphins exposed to a controlled series of pass-by and engine start-up. Uncertain evidence for bottlenose dolphins [2]. On-board education significantly improves customer experience [2].	Inclusion of swimmer placement to assess tourism impact. Ethogram describing the dolphins' behavioral responses. Systematic data collection on the operations and effects of the tour vessels on dolphin behaviors. Established methods for population monitoring.	Avoid "in path" swimmer placement [1,3]. Prohibit approaching bottlenose and common when foraging or resting, respectively [1]. Clear definition of "juvenile" [1]. Improve the level of on-board education [2].	Appointed a full-time Marine Mammal Ranger. Recommended swimmer placement to minimize impact. Engaged with tour operators outside of the Bay to ensure lowering potential cumulative impacts. Creation of a Dolphin Care Code and a code of ethics in Paihia.	[1] Constantine and Baker, 1997 [2] Helweg, 1995 [3] Constantine, 2001
1996–2001	Significant change in bottlenose dolphin resting behavior due to increased tourism pressure [1,4,5]. Dolphins sensitized to cumulative effects of swim attempts, with differences in age-class response to swimmers [3]. Identification of preferred resting areas [4]. Estimated 446 dolphins using the Bay. Core users identified. Identified individuals from the Bay in other locations [4,6].	Long-term study on behavioral response to tourism [4,5] Use of CATMOD to determine the interaction effects of dolphin group and vessel/operation variables [5] Habitat use models to identify core habitat and overlap with tour vessel use.	No further permits for dolphin-based tourism [3,4,5]. Creation of dedicated time periods when no vessels should approach dolphins [4,5]. Limitation of the amount of time tour vessels spend with dolphins and number of swim attempts per vessel [4,5].	Creation of "lunch break" to limit all vessel contact time, reduced permitted vessel encounter duration, limit to three swim attempts per permitted tour vessel per trip. Created two new permitted tour vessel exclusion areas based on resting areas. Proposed establishment of a moratorium on new permits. DOC handbook for dolphin tourism operators and outreach materials for the public.	[4] Constantine, 2002 [5] Constantine et al., 2004 [6] Berghan et al., 2008
2003–06	No genetic interchange between bottlenose populations around New Zealand indicates isolation of populations [7]. Annual decline in local abundance of bottlenose of 7.5% (1997–2006). Fewer dolphins used the Bay on a regular basis [8]. Long inter-calf intervals with high rates of calf mortality [9]. Strong association networks with some persisting for almost a decade [10,12].	Population genetics to understand regional connectivity. Genetic identification of individuals to understand population demographics. Long-term dataset for POPAN mark-recapture analysis and assessment of reproductive rates.	Focus on minimizing all anthropogenic impacts [8,9]. Enforcement of tour operators permit conditions [8,9]. Monitoring of demographic and social impacts to determine whether mitigation is effective [8,10]. Urgent conservation action [8,9].	Marine mammal ranger employed to enforce permit conditions, educate non-permitted tour operators and the public.	[7] Tezanos-Pinto, 2009 [8] Tezanos-Pinto et al., 2013 [9] Tezanos-Pinto et al., 2015 [10] Mourão, 2006
2007–12	Significant changes in fine-scale habitat use. The static tourism exclusion zones are rarely used by dolphins [11]. Near-complete abandonment of BOI area by dolphins, evidenced by continued decline in local population size (from 446 in 1994 [4] to 24 in 2012 [12,13]). Fragmented social structure [12].	Spatial ecology tools to reveal habitat shifts. Long-term photo-identification data to determine trends in demographic and social structure.	Replacement of static exclusion zones with dynamic protected areas [11]. Further measures to mitigate impacts [11,12].	Implementation of a 5-year moratorium on new permits. DOC Marine Mammal Handbook updated.	[11] Hartel et al., 2014 [12] Hamilton, 2013
2012–15	Continued high levels of calf mortality and reduction in habitat use. Continued changes in behavioral budgets in the presence of vessels. Poor compliance across all vessel types [13].	Behavioral state transitions.	Greater enforcement of MMPR for all vessels [13]. Adaptive protection measures supported with education.	2019: ban on swimming with dolphins in the Bay of Islands. Encounter time for permitted tour operators further reduced. Voluntary maximum approach distance to pods containing mother calf-pairs.	[13] Peters and Stockin, 2016

TABLE 2A | Summary of the literature on the sperm whale tourism at Kaikoura.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1990–92	Surface intervals and respiratory intervals shorter in presence of vessels, and some evidence for effects on echolocation behavior [1,2]. Outboard-driven tour vessels produce high levels of noise in the frequency range of echolocation buzzes [2].	Serial observations to control for behavioral differences among individuals [1,2]. Passive acoustics [2].	More sensitive boat handling by tourism vessels [1,2]. Use of directional hydrophones to track whales to reduce the need for fast approaches [2]. Continued monitoring to investigate long-term effects of disturbance [2].	Extensive use of hydrophones for tracking. Improved skipper behavior. Shift to waterjet propulsion for new, larger vessels.	[1] MacGibbon, 1991a,b [2] Gordon et al., 1992
1997–98	Diverse demography of visitors. Positive attitudes of local and Māori community toward tourism. Issues and tensions between tourism and locals' aspirations and needs. Significant economic impact of tourism.	Questionnaires, interview.	Develop a comprehensive community-based tourism strategy with strong links to a national tourism strategy. Policy directions: maintain local ownership of key facilities, retain local control in decision making, safeguard carefully tourism's visual impact, and adequately resource and manage key public sites.	None.	Simmons and Fairweather, 1998
1998–2005	Respiratory intervals and time to first echolocation click shorter, surface intervals longer, heading changes at the surface more frequent in the presence of vessels; responses more pronounced for "transient" whales.	Multi-year dataset; shore-based observations; accounting for impact of research vessel; distinction among individual whales. Multi-model inference statistical approach.	No increase to level of permitted activity. Long-term scheme for monitoring behavioral changes required, with cooperation of whale watching companies. Recommendations for improvements in educational material.	10-year moratorium on whale watching permits. In 2005, establishment of Te Korowai o Te Tai o Marokura (the Kaikoura coastal guardians), a volunteer, multi-stakeholder group, to provide leadership about the use and protection of Kaikoura's resources, including in relation to whale watching.	Richter et al., 2003, 2006
2009–11	Respiratory intervals longer in presence of vessels when measured from shore; variance of heading change at surface increased in presence of tour vessels; time to first click and duration of first silence longer in presence of vessels [3]. Decline in the abundance of sperm whales visiting Kaikoura [4].	Research vessel, shore-based observations and platforms of opportunity [3]. Mark-recapture modeling (Cormac-Jolly-Seber) [4].	Current regulations appropriately manage the interactions between tour vessels and whales; continued caution warranted concerning growth of industry [3].	10-year moratorium on whale watching permits.	[3] Markowitz et al., 2011 [4] Van der Linde, 2010
2016–20	Continued decline in abundance, driven by a decrease in numbers during summer [5]. Decline in abundance may be partly driven by oceanographic variability due to climate change [6].	Mark-recapture models (Robust design) [5].	Need to carry out longitudinal study to evaluate impact of tourism on population demography [5,6].	Review of tourism impacts and moratorium due in 2022.	[5] Somerford, 2018 [6] Guerra, 2019

TABLE 2B | Summary of the literature on the dusky dolphin tourism at Kaikoura.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1993–98	Surface activity [1,2], movements [1–3], and group cohesion [1] change in presence of vessels. The number of groups has increased and their distribution is further south since the establishment of tourism [3]. Diverse demography of visitors. Positive attitudes of local and Māori community toward tourism. Issues and tensions between tourism and locals' aspirations and needs. Significant economic impact of tourism [4].	Shore-based theodolite tracking, surface activity levels [1–3]. Questionnaires, observation [4].	Reduce trips between 11 a.m. and 2 p.m.; voluntary or regulated "time off"; no increase in activity, enhance education and enforcement, stricter regulations for private vessels [1]. Comprehensive community-based tourism strategy linked to a national strategy [4].	Adoption of a voluntary summertime midday rest period (11:30–13:30, 1.Dec to 31.March). 10-year moratorium on dolphin watching permits (1999–2009). Guide and skipper course.	[1] Barr and Slooten, 1999 [2] Yin, 1999 [3] Brown, 2000 [4] Simmons and Fairweather, 1998
1998–2008	Resting and socializing decrease in the presence of tourism activities [5,7]. Number of swim drops correlated with behavioral responses [5]. Effects on heading, dispersion, and leaping rate of large groups [7]. Decrease in visits during the rest period (visit/h) [6]. No change in size and location of core area compared to pre-tourism [8]. Importance of education in visitor satisfaction [9].	Shore-based theodolite tracking, boat-based behavioral observation [5–8]. Questionnaires and interviews [9].	Reduce or maintain current level of activity, midday rest period mandatory in October-March, or constant observations, education and encouragement for compliance [6]. Limit the number of swim attempts [5]. Enhance education efforts on tours [5,9].	5-year moratorium on motorized boat-based permits (2009–2014). Mandatory rest period in Nov-Feb, voluntary in March. New limits on swim drops (max. 5/trip) and no. swimmers per boat to reduce no. of vessels In 2005, establishment of Te Korowai o Te Tai o Marokura (the Kaikoura coastal guardians), a volunteer, multi-stakeholder group, to provide leadership about the use and protection of Kaikoura's resources, including in relation to dolphin watching.	[5] Markowitz et al., 2009 [6] Duprey et al., 2008 [7] Markowitz, 2012 [8] Dahood, 2009 [9] Lück, 2003
2008–10	Resting and socializing, and swim speed decrease in the presence of vessels, milling and surface activity increased; number of vessels predict magnitude of changes; change in reorientation rate associated with aircraft [10–13]. The population is relatively resilient to tourism pressure [10].	Theodolite tracking, focal follows. Log-linear analyses of behavioral state transitions; analysis of movements Before-During-After interactions.	Social sciences to update old studies on perceptions, attitudes and desires in local communities and visitors [10,13]. Clarify define regulations; enhance enforcement; define Limits of Acceptable Change; 5-year monitoring and re-evaluation cycle; establish an industry-funded research program integrated within the management scheme [10,13].		[10] Lundquist and Markowitz, 2009 [11] Lundquist et al., 2012 [12] Lundquist et al., 2013 [13] Lundquist, 2014
2011	Tourists on swim-with-dolphin tours displayed high satisfaction rates [14].	Questionnaires	Enhance education and visitors' empowerment		[14] Lück and Porter, 2019

TABLE 3 | Summary of the literature on Hector's dolphin tourism at Akaroa Harbour.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1999–2004	Akaroa dolphin tourism is valued at NZ$1.47 million; swim/tour vessels make up 13.4% of total traffic, but 47.1% of dolphin-boat interactions. Behavioral changes related to vessel presence [1]. Anecdotal evidence of habituation. Doubling of vessel traffic during 1990s [2]. Boat traffic as lethal threat [2].	Theodolite tracking of dolphins and vessels [1,2]. Operator survey questionnaires.	Don't increase tourism activity in Akaroa Harbour. Minimum tour education requirement. Education of recreational boat users. Annual operator workshops.	Informal moratorium on issue of new permits Voluntary code of conduct. Levy on permitted operators to fund research. Review of research [3].	[1] Nichols et al., 2001 [2] Stone and Yoshinaga, 2000; [3] Green, 2005
2005–13	Behavioral changes in response to boats (shift from traveling/diving to milling/socializing) [5–7]. Increased magnitude of effect with additional vessel. Dolphin response to swim encounters varied with swimmer placement, dolphin behavior, and swimmer behavior [7]. Vessels within 300 m of dolphins for 35.2% of observations; 70.4% of dolphin-boat encounters involved commercial vessels [7]. Using sound to attract dolphins associated with sustained and closer encounters [8]. First attempt at standardizing data recording by tour operators in Akaroa Harbour, weaknesses of the 2006–08 operator data collection system using data sheet [9].	Theodolite tracking of dolphins in presence and absence of vessels. Group focal follows. Markov-chain methods on transition probabilities, behavioral budget [7].	Reduce cumulative tourism exposure and/or the number of permits [7]. Establish a moratorium on Hector's dolphin tourism in NZ. Time-area closure systems within the Akaroa Marine Reserve [6]. Ban using sound to attract dolphins [8]. Education of recreational boat users. Annual operator workshops.	Detailed technical report [4]. 2007: Maximum swimming time per trip reduced from 60 to 45 min. 2008: 5-year moratorium on new permits.	[4] Allum, 2009; [5] Martinez, 2010 [6] Martinez et al., 2010 [7] Martinez et al., 2011 [8] Martinez et al., 2012 [9] Martinez and Stockin, 2011
2013–19	Economic impact of tourism in Akaroa estimated at NZ$6–8 million; wider value NZ$22.2–24.9 million in the Canterbury economy, and NZ$27.9–31.3 million nationally [10].			Since 2015: Annual SMART Operator course offered [11]. 2016: 10-year moratorium on new permits. Voluntary reduction in permitted trips from 37 to 34. Tracking systems installed on tour vessels 2019; improved boat ramp signage [12].	[10] Yeoman et al., 2018 [11] Healey, pers. comm. [12] MacTavish, pers. comm.
2020 and ongoing	Analysis of changes in tourism pressures and dolphin habitat use in 1995–2020.	Analysis of existing dataset [1,5] on dolphin distribution related to tourism operations. GPS-based tracking of tour vessels. Automated hillside camera system to quantify vessel traffic, passive acoustic T-POD and SoundTrap monitoring of dolphins an acoustic environment.			University of Otago, in progress

TABLE 4 | Summary of the literature on bottlenose dolphin tourism at Doubtful Sound.

Year	Research findings	Research methods	Management recommendations	Management actions	References
1999–2004	First studies on the short-term effects of tour vessels on dolphins, showing disruption of behavioral budgets [1]. Increased dive intervals with different avoidance strategies in males and females [2]. Increase in some aerial displays and erratic movements [4]. Spatial quantification of critical habitat (areas of high use, including for resting and socializing) [3].	Systematic population surveys and monitoring since 1990, with Photo-ID as core method Development of Markov-Chain methods to quantify impact on behavioral budget [1]. Modeling and controlling for influence of research vessel in assessment of behavioral change due to tour boats [2].	Establish a multi-level marine mammal sanctuary and limit boat traffic where dolphins rest and socialize [3]. Change of tour operator behavior to reduce impact and extent of dolphin interactions.		[1] Lusseau, 2003b [2] Lusseau, 2003a [3] Lusseau and Higham, 2004 [4] Lusseau, 2006
2005–09	Dolphin watching deemed unsustainable [5]. Declines in abundance and calf survival [6,7]. Analysis according to IUCN criteria results in Fiordland bottlenose dolphins being declared critically endangered [8].	Assessment of population trends and conservation status [6–8].	Reiteration of previous recommendations.	2007: public meetings, involvement of external experts. Discussion and consultation document released by DOC outlining options for managing impact of tourism on dolphins [9]. 2008: voluntary Code of Management (CoM) established by committee including DOC, tour operators and researchers [10].	[5] Lusseau et al., 2006 [6,7] Currey et al., 2007, 2009a [8] Currey et al., 2009b [9] Williams, 2007 [10] Department of Conservation, 2008
2010–16	Increase in dolphin excursions beyond the fiord (decreased occupancy) [11]. Changes in group cohesion and acoustic behavior in response to vessels and noise [12]. Groups with calves particularly sensitive to vessels and noise [12]. Significant decline in frequency and length of dolphin-boat interactions since implementation of CoM [13]. Slight recovery in calf survival and population abundance [14,15]. Breaches of Dolphin Protection Zones, but compliance improving over time [16].	Combined visual and acoustic data collection [12]. Staged approach to quantify and account for impact of research vessel [12].	Cap the number of tour vessels and trips operating in the area. Reduce vessel speed and shift in vessel design (e.g., water-jet propulsion) to reduce noise [12,13]. Consider turning voluntary CoM into formal legislation [13].	Effectiveness of the CoM to be reviewed after 10 years of its implementation (due 2018).	[11] Henderson et al., 2013 [12] Guerra et al., 2014 [13] Guerra and Dawson, 2016 [14] Brough and Johnston, 2015 [15] Johnston and Bennington, 2018 [16] DOC compliance monitoring reports
2017–19	Core dolphin habitat highly consistent over more than 10 years (2005–2018), but low overlap with Dolphin Protection Zones (<15%) [17]. Continued support for the CoM by stakeholders [18].	Kernel Density Estimation for quantifying core habitat [17].	Multiple options for changes in Dolphin Protection Zones to increase overlap with core habitat [17]. Extend compliance to wider boating community, review extent and location of Dolphin Protection Zones, and considerations to limit vessel activity [18].	Continuation of CoM and compliance monitoring by DOC.	[17] Bennington et al., 2020 [18] McLeod, 2018
2020 and ongoing				Re-evaluation of CoM [19].	[19] Richard Kinsey (Fiordland DOC office), pers. comm.

TABLE 5 | Summary of the research on cetacean tourism at other New Zealand destinations.

NORTH ISLAND

Location **Mercury Bay, Coromandel**

Species **Common dolphins**

Year	Research findings	Research methods	Management recommendations	Management actions	References
1998–2001	Dolphin response change from attraction, to neutral, to avoidance over the course of the encounter; small groups avoid vessels sooner and more frequently than larger groups; interactions more likely to be sustained when involving larger dolphin group and fewer swimmers. No evidence of disturbance on non-resident dolphins, but risk of cumulative effects of tourism exposure at different locations in their distribution.	Boat-based photo-identification, group size, behavioral state and activity budget.	Limit distance and length of approaches. Introduce a site-specific code of conduct.		Neumann, 2001; Neumann and Orams, 2005, 2006

SOUTH ISLAND

Location **Porpoise Bay, Catlins**

Species **Hector's dolphins**

Year	Research findings	Research methods	Management recommendations	Management actions	References
1995–97	No displacement from core use area, dolphin-boat orientation changes from "toward boat" at onset of encounter to away as encounter duration extends; tighter groups with vessels in the bay. No evidence of disturbance but concerns about chronic, cumulative effects.	Theodolite tracking of dolphins, boats and swimmer positions to assess dolphin-boat orientation and pod dispersion.	Do not exceed current disturbance levels. MMPR to include important features of individuals and populations (age, sex, species, habitat use).	Interpretation panels, posters and leaflets for the public with DOC specific guidelines Southland District Council 's Coastal Plan DOC summer warden Voluntary code of conduct	Bejder, 1997; Bejder et al., 1999
2001–03	Compared to 1995–97: no evidence of displacement, similar habitat use, 3-fold increase in exposure, decrease in boat attraction, longer swims, looser groups when vessels in the bay, decreased diving and increased milling and socializing behavior.	As above (Bejder, 1997; Bejder et al., 1999)	Establish a Marine Mammal Sanctuary in the Bay. Establish time closures in the dolphin core use area. Restrict tourism to one permitted operator for 40 min/day; restrict kayaking area and prohibit on-site renting.	Lone permit revoked for non-compliance	Martinez et al., 2002; Green, 2005

Location **Lyttelton Harbour and Timaru Harbour**

Species **Hector's dolphins**

Year	Research findings	Research methods	Management recommendations	Management actions	References
2000–05	Vessel presence affect group swimming speed and grouping behavior. Group behavior toward vessels changed over a period of 7 years from neutral, to vessel-positive, to avoidance. Low-level tourist vessel activity considered to not be placing undue stress on the population.	Theodolite tracking of dolphin positions and behavior.	Further research on impacts of vessels on dolphins.	None	Travis, 2008

(Continued)

TABLE 5 | Continued

Location	Queen Charlotte Sound, Marlborough				
Species	**Hector's, bottlenose, dusky dolphins**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1995–2014	Baseline data on dolphin occurrence and distribution. Swim-with industry is relatively new (since 2004) and mainly targets bottlenose dolphins with active pursuit of interactions. Dolphins show neutral reactions to swim attempts	Vessel logbooks and observations from platforms of opportunity. GAMs and GLMs to investigate dolphin occurrence, distribution and habitat use in relation to environmental variables. Behavioral observation of responses to swimmers.	Protection of periods and regions of high density and predicted density. Coherent management of tourism, marine farming, and vessel traffic effects.		Cross, 2019

Location	Milford Sound, Fiordland				
Species	**Bottlenose dolphin**				
Year	**Research findings**	**Research methods**	**Management recommendations**	**Management actions**	**References**
1999–2002	Resting and socializing behavior are sensitive to boat interactions, dolphins need at least 68 min between two interactions [2]. Dolphins more frequently absent from Milford Sound during months of intense vessel traffic [3]. Marks of physical injuries caused by boat strikes, calf killed by a tour boat in 2002 [1].	Boat-based visual survey, operator boat traffic data, oceanographic parameters to build discrete time Markov chain of dolphin presence/absence [3]; Markov Chain and log-linear analyses of behavioral state transitions [2].	Reduce vessel traffic and boat-dolphin interactions with protected areas [3].	2006 Marine Mammal Viewing Code of Practice (voluntary)	[1] Lusseau et al., 2002 [2] Lusseau, 2004 [3] Lusseau, 2005

The Bay of Islands, Northland

The Bay of Islands (BOI) is a sheltered habitat containing over 144 islands, and numerous inlets, bays and estuaries. Bottlenose dolphins inhabit the BOI year-round, with 1–3 groups of 15–20 individuals usually present at any time (Constantine et al., 2004; Peters and Stockin, 2016). These dolphins are not exclusively resident in the BOI, but range along the northeast coast of the North Island (Constantine, 2002; Berghan et al., 2008; Tezanos-Pinto et al., 2013), and display seasonal inshore and offshore movements (Constantine and Baker, 1997; Hartel et al., 2014; Peters and Stockin, 2016). Common dolphins are also regularly present in the outer BOI (Constantine and Baker, 1997).

Cetacean tourism started in 1991 with a single vessel offering viewing and swim-with tours with common and bottlenose dolphins (Constantine and Baker, 1997; Constantine, 1999). Two additional companies began tours in 1993–1994. In 1995, bottlenose dolphins became the primary focus of tourism operations, as they were easier to locate and often found closer inshore. Concerns raised by the original tour operator and local Māori over the impact of the industry prompted research on population demographics and tourism impacts on bottlenose dolphins in 1993. The research demonstrated clear behavioral effects on the local dolphin population and recommendations were made to limit expansion of the industry (Constantine and Baker, 1997), which, by then, had already grown rapidly and was operating more tours with larger vessels (**Table 1**). Over the 2000s, despite a moratorium on permits since 1998, heightened pressure from permitted operators was compounded by increasing numbers of private boat users and non-permitted operators seeking out interactions with dolphins. In response, DOC implemented further permit restrictions on the number and duration of trips, swim attempts and swimmers, created static exclusion zones, promoted better education, and continued to hire marine mammal rangers to try and resolve the issues (**Table 1**). These measures were insufficient to mitigate impacts on the dolphin population. The dolphins became rapidly sensitized to swimmers (Constantine, 2001) and behavioral states were altered by vessel presence, with dolphin tour vessels having the greatest impact (Constantine and Baker, 1997; Constantine, 2001; Constantine et al., 2004; Peters and Stockin, 2016). Rapid declines in local abundance (Tezanos-Pinto et al., 2013), changes in fine-scale habitat use (Hartel et al., 2014) and decay in social structure (Constantine, 2002; Hamilton, 2013) continued to indicate a highly impacted population (Hamilton, 2013). In 2019, swimming with the dolphins was banned and interaction times were further reduced. Currently, four permitted companies operate one to two trips per day each. However, existing measures (such as trip duration limits and static protected areas; Hartel et al., 2014) are likely ineffective and are often ignored (Peters and Stockin, 2016). A renewal of the moratorium on permits, the institution of adaptive time-area closure systems, stronger and enforceable limitations for all users and operations, and appropriate consultation processes were strongly recommended (Peters and Stockin, 2016) but, as with previous recommendations, have not yet been comprehensively addressed by management.

The BOI offers an example of inadequate management and rapid, dramatic negative consequences of tourism. Stricter mitigation measures to decrease pressures on the dolphins following identification of impacts from the then low levels of tourism in the early 2000s (Constantine and Baker, 1997) could have prevented the rapid decline of the local population (**Table 1**). Despite robust research advice and cultural significance, the welfare of this population has been largely neglected by management authorities.

The Hauraki Gulf, Auckland

The shores of the Hauraki Gulf (hereafter the Gulf) host New Zealand's largest metropolitan area, with shipping, fishing and aquaculture activities based throughout the Waitematā Harbour. Compared to other parts of New Zealand, cetacean tourism in the Gulf remains relatively small scale and stable, with only two permits currently in existence, of which one is actively used. Tourism focuses specifically on common dolphins and Bryde's whales, although regular encounter by the tour boats have offered insights to other species (Berghan et al., 2008; Hupman et al., 2015).

The common dolphin is the species most frequently encountered by operators (O'Callaghan and Baker, 2002; Stockin et al., 2008a; Colbert, 2019). During encounters with vessels, dolphin groups have been shown to reduce feeding and resting behavior (Stockin et al., 2008b), increase vocalization rate (Petrella et al., 2012), change group cohesion (when calves were present; Schaffar-Delaney, 2004), and alter feeding strategies (Burgess, 2006; de la Brosse, 2010). Annual abundance estimates range from 2,478 (95% CI = 1,598–3,615; Hamilton et al., 2018) to 8,632 (95% CI = 7,738–9,630; Hupman et al., 2018), thus vessel effects are likely diluted across a large population. However, photo-identification efforts along the wider northeastern North Island coastline (Neumann et al., 2002; Meissner, 2015; Hupman, 2016) show that individual dolphins may be subject to cumulative tourism impacts across several locations (Meissner et al., 2015).

A small number of Bryde's whales are present in the Gulf year round. Over the period 2004–2013, seasonal abundance estimates ranged from 38 to 74 individuals, with a super population of 100–183 whales using the Gulf overall (Tezanos-Pinto et al., 2017). The whales forage most actively in daylight (Izadi et al., 2018) and sometimes in association with common dolphins and Australasian gannets (*Morus serrator*) (Stockin et al., 2008a; Wiseman et al., 2011), both of which act to increase the whales' detectability by tour operators. Although globally abundant, the Bryde's whale is considered Nationally Critical in New Zealand (Baker et al., 2019) and yet, to date, there has been no investigation of tourism impacts on the species in the Gulf.

Even though bottlenose dolphins are commonly seen in the Gulf, the impacts of tourism registered in the longer-established industry in the Bay of Islands have led to the species being excluded from swim-with permits, and more recently viewing permits in this area.

The Gulf case study provides an example of a cetacean tourism industry embedded in a context of multiple stressors (aquaculture, fishing, commercial shipping, contaminants), and targeting two species with different life history, behavior and ecology. Despite establishment of the Hauraki Gulf Marine Park in 2000 (the only one of its kind in New Zealand), most of the conservation issues affecting the area remain unmitigated (Hauraki Gulf Forum, 2020). The suitability of dynamic marine protected areas, in combination with minimizing encounters at certain times of the day, and avoidance of feeding and nursery dolphin groups should be investigated for the future management of anthropogenic impacts in this region (Dwyer et al., 2020).

Kaikoura, Canterbury

Kaikoura is the longest established cetacean tourism destination in New Zealand, and tourism is the main driver of the local economy (Orams, 2002; Curtin, 2003). Activities are focused around the Kaikoura submarine canyon, a foraging habitat for dusky dolphins and sperm whales (Childerhouse et al., 1995; Benoit-Bird et al., 2004). Since 1991, there have been three boat-based operations, one focusing on viewing of sperm whales and two on viewing and swimming with dusky dolphins, in addition to three air-based operations. This case study focuses on the research and management of sperm whale tourism (**Table 2A**). The history of tourism and research targeting dusky dolphins is summarized in **Table 2B**.

Kaikoura is one of the few places in the world where sperm whales can be seen close to shore year-round. The individuals encountered regularly at Kaikoura are exclusively males (Childerhouse et al., 1995, Jaquet et al., 2000). Some are resident in Kaikoura for many months at a time, and return regularly; others transit through the area (Childerhouse et al., 1995; Somerford, 2018). The effects of tourism on the local population have been investigated in a series of studies commissioned by DOC at ∼10-year intervals starting in 1990. Several effects due to the presence of vessels and aircraft have been detected (**Table 2A**). These have not always been consistent among studies, but have generally included changes in both surface behavior and echolocation. Although responses have been interpreted as of minor consequence overall, variation among individual whales (especially between "residents" and "transients") and between seasons could act to swamp the real effects of tourism activities (Richter et al., 2006; Markowitz et al., 2011). Precautionary management was therefore recommended, and an increase in the number of boat trips and permits strongly discouraged (Richter et al., 2006; Markowitz et al., 2011).

DOC responded to these calls by issuing 10-year moratoria on permits in 2002 and 2012. The monopoly of one company conducting all vessel-based whale watching tours has caused disquiet among others seeking permits (Simmons and Fairweather, 1998; Orams, 2002; Curtin, 2003; Simmons, 2014), but has likely reduced impacts on the whales. Additionally, this company introduced significant changes to its vessels (switching from 6 m outboard-powered rigid-hulled inflatables to 20 m diesel jet-engine catamarans) and its operations (often using directional hydrophones to track whales). These measures reduced underwater noise and the need for high-speed approaches, hence acted to mitigate disturbance to the whales.

Despite these management decisions, longitudinal studies show a significant decline in the number of sperm whales visiting Kaikoura over the past 30 years, especially during summer (Somerford, 2018). It is now essential to understand whether the detected behavioral responses to tourism may have had direct long-term consequences, or whether they add to the suite of other factors affecting this population (e.g., climate change; Guerra, 2019). In particular, there is growing concern about cumulative impacts of chronic, repeated interactions when very few individuals (<3) are present in the area, as happens commonly in early summer (Guerra, 2019), because this could lead to complex physiological, behavioral and/or ecological long-term consequences (Bejder et al., 2009).

Kaikoura could be cited as a reasonable model for management of tourism on sperm whales. The impacts of tourism on sperm whales have been regularly monitored, there is only one boat-based, long-term operator and the regulations are largely followed (Curtin, 2003). Relationships among tourism operators, researchers, local communities and managers are generally positive, and have helped develop cetacean tourism in an orderly fashion. Continued longitudinal study is necessary to monitor the conservation status of this population, to unveil the effects of chronic exposure on resident individuals, and to understand whether the detected behavioral changes resulting from tourism translate to biologically meaningful effects.

Akaroa Harbour, Banks Peninsula

The Hector's dolphin is endemic to New Zealand. The species is Endangered (Reeves et al., 2013), and the population at Banks Peninsula has experienced significant depletion since 1970 (up to 80%; Slooten, 2007) mainly due to bycatch in gillnets and trawls (Dawson, 1991). The Banks Peninsula Marine Mammal Sanctuary (established in 1988), and further protection measures in 2008 led to an increase in adult survival rate (Gormley et al., 2012), but were insufficient to support population recovery (Slooten, 2013).

Akaroa Harbour is the primary focus of tourism on Hector's dolphins, and is a hotspot of dolphin abundance at Banks Peninsula (Brough et al., 2020). Dolphins are present year-round. Their distribution is concentrated close to shore in the summer months (Dawson et al., 2013) coinciding with calving (Slooten and Dawson, 1994) and the seasonal peak in tourism. Beginning with a daily natural history tour in 1985, dolphin tourism grew into a NZ$1.46 million industry by 1999 (Nichols et al., 2001). In addition, recreational vessel traffic more than doubled over the same time period (Stone and Yoshinaga, 2000).

Research on the potential impact of tourism in Akaroa Harbour began in 1999 (**Table 3**). Studies provided evidence of changes in behavioral state and directionality of travel (Nichols et al., 2001), cautioned about calf vulnerability to boat-strike (Stone and Yoshinaga, 2000), and indicated that dolphin response to swim encounters varied with swimmer placement and behavior, dolphin behavior, and possibly the dolphins' previous exposure to tourism (Martinez et al., 2011) (**Table 3**). Researchers lauded operators' compliance with some permit conditions (e.g., swim encounter duration), but cautioned that growth in operations, and the tendency to "hand-over" dolphin groups from one tour boat to the next, could cause the same dolphins to be repeatedly targeted over the course of the day (Nichols et al., 2001; Martinez et al., 2011). Martinez et al. (2011) emphasized that in-water interactions, even when initiated and apparently well-tolerated by dolphins, could have long-term detrimental effects on the dolphin population. Further development of the industry was therefore discouraged. In 2008, after granting two new permits to already existing non-permitted operations (Allum, 2009) (from four to six permits), and allowing permitted operators to increase their number of trips (from 25 to 37 trips/day), DOC issued a 5-year moratorium on new permits, which was later followed by a 10-year moratorium in 2016. Currently, five permitted and multiple non-permitted operators are active in Akaroa Harbour.

Adherence by commercial operators to the MMPR and permit conditions (Martinez et al., 2011), combined with moratoria and voluntary initiatives, has reduced the potential effects of tourism on the local Hector's dolphin population. However, an increased number of visitors and a recent surge in cruise ship tourism have resulted in a longer "peak season," leading to an overall increase in tourism pressures. In addition, recreational boat traffic, predominant in the harbor, is frequently in breach of the MMPR (Martinez et al., 2011).

A 2019 economic assessment revealed the importance of the industry both locally (NZ$6–8 million in direct annual operator income) and regionally, and tied its fate to that of the dolphin population (Yeoman et al., 2018). In 2018, DOC commissioned a new study to investigate changes in dolphin distribution at varying levels of tourism. Such longitudinal studies of behavior, habitat use, and demography provide the best hope of quantifying the consequences of anthropogenic pressures, especially in the context of multiple threats (e.g., permitted tourism, non-permitted and recreational operations, bycatch, cruise ship traffic, and aquaculture), as well as forecast the future of the industry.

Doubtful Sound, Fiordland

Doubtful Sound is one of the most popular nature tourism destinations in New Zealand. The fiord is home to a small (65–71 individuals), isolated, largely closed and resident population of bottlenose dolphins (Currey et al., 2009a; Bennington et al., 2020) currently listed as Critically Endangered by the IUCN (Currey et al., 2013). Researchers have monitored the population in collaboration with DOC almost continuously since 1990 (**Table 4**), when the first boat-based scenic cruise operation was established. Interactions with the dolphins are an iconic feature of scenic cruises, and have been a cause of concern since the early 2000s (Lusseau, 2003a,b; Guerra et al., 2014). As of 2020, two permitted companies operate in Doubtful Sound year-round, offering multiple daily and overnight trips.

Studies conducted between 2000 and 2009 showed a range of behavioral responses to tour vessels, determined the location of critical resting and socializing habitats (Lusseau and Higham, 2004) and detected a worrisome downward trend in calf survival and abundance (Currey et al., 2007, 2008) (**Table 4**). Concerns were voiced that tourism levels were unsustainable for this dolphin population (Lusseau et al., 2006), and DOC released a Threat Management Discussion Paper (Williams, 2007) offering several options for managing tourism operations. In 2008, DOC, in conjunction with tour operators and scientists, developed a voluntary Code of Management (CoM) to leave dolphin encounters to chance, restrict vessel traffic in "Dolphin Protection Zones," and reduce the extent of dolphin-vessel interactions. These "Dolphin Protection Zones" partially and loosely overlapped with the critical habitats identified by Lusseau and Higham (2004). Nevertheless, the implementation of the CoM led to declines in the frequency and duration of dolphin-vessel interactions, suggesting that tourism pressure on the population had eased (Guerra and Dawson, 2016). It also coincided with a reversal of the downward trends in calf survival and abundance recorded in the 1990s and 2000s (Currey et al., 2007, 2008), which had possibly been caused by tourism, demographic stochasticity and/or other impacts (e.g., construction and operation of a power plant) (Henderson et al., 2014; Brough and Johnston, 2015; Brough et al., 2016).

The generalist focus of scenic cruises, the voluntary nature of the CoM, and the close cooperation between DOC, scientists and tour operators in the development of management measures, all seem to have contributed to generally high compliance by tour operators (Guerra and Dawson, 2016). However, continued behavioral reactions to vessels and noise, and vulnerability of groups with calves (Guerra et al., 2014), low compliance among members of the recreational and non-permitted boating community, and the limited extent of the static Dolphin Protection Zones undermine the effectiveness of the plan in protecting this population. The CoM was reviewed in 2018 (McLeod, 2018) prompting a re-evaluation of spatial protection measures, formalization of the CoM, and further limitations on vessel activity.

Doubtful Sound is similar to other case studies in that it experienced an initial phase of management inaction, a failure to fully and promptly integrate science-based management recommendations (e.g., multi-level marine mammal sanctuary; Lusseau and Higham, 2004), and ongoing compliance issues. However, voluntary management measures appear to have contributed to reducing exposure of dolphins to vessels, and overall, the fiord represents an example of relatively successful evidence-based management. The small size, isolation, and history of low calf survival and rapid fluctuations in abundance (Currey et al., 2007, 2009b; Brough and Johnston, 2015) emphasize that continuing monitoring and research, combined with decisive and effective management action, will continue to be critical for the Doubtful Sound dolphin population.

EFFECTIVE RESEARCH STRATEGIES

To ensure a genuinely sustainable industry that safeguards the well-being of cetacean individuals and populations requires rigorous scientific evidence to quantify impacts, develop management options, and evaluate their effectiveness (Bejder and Samuels, 2003). Based on 30 years of research on tourism impacts in New Zealand, and in the light of recent assessments of global research on cetacean tourism (IWC Sub-Committee on Whale Watching, 2019), we outline five key points to consider in the development of research strategies.

Comprehensive Research on Short- and Long-Term Responses

Documenting short-term behavioral responses is the most common approach to evaluating tourism impacts on cetaceans (**Tables 1–4**, **6**). Although they should not be taken as sufficient indicators of detrimental impacts (Corkeron, 2004; Bejder et al., 2006a, 2009), they represent an important first step to identifying tourism effects on animal welfare, forecasting likely biological consequences on populations (Christiansen and Lusseau, 2015; New et al., 2015, 2020; Booth et al., 2020), and designing and monitoring management intervention. A robust approach to research requires baseline knowledge of population biology and ecology, and employs multiple tools, such as the quantification of behavior changes (e.g., Lusseau, 2003a; Meissner et al., 2015), acoustic responses (e.g., Richter et al., 2006, Guerra et al., 2014), patterns of habitat use (e.g., Lusseau and Higham, 2004; Hartel et al., 2014), and health variables (e.g., Rowe and Dawson, 2009; Dwyer et al., 2014). These indicators of change would also be useful to investigate individual well-being through the Welfare Assessment Tool for Wild Cetaceans (WATWC), a framework being developed with the support of the International Whaling Commission (Nicol et al., 2020). The tool is used to characterize consequences of potential welfare hazards to nutrition, environment, health, behavior, and affective state of exposed animals, and to compute a score indicating the severity of harm to the individuals or populations assessed (Nicol et al., 2020). Until the WATWC and welfare frameworks for wildlife are established, key metrics for the computation of welfare risk are the intensity and duration of impacts over the life-span of individuals, and the number of individuals affected (De Vere et al., 2018; Nicol et al., 2020).

Inevitably, however, short-term responses do not provide information on latent effects, those that appear elsewhere or at a lagged time, or on individuals that may already be avoiding the area due to disturbance. Moreover, short-term behavioral responses must be interpreted with caution, as they display significant variation between and within populations, groups and individuals (e.g., due to sex, Lusseau, 2003b; presence of calves, Guerra et al., 2014; previous exposure to disturbances, Constantine, 2001; Bejder et al., 2009; among others).

There is thus a vital need to identify the long-term consequences of tourism disturbance on cetacean populations (e.g., abundance, reproduction and survival rates). Identifying how non-lethal impacts result in population-level consequences has proven a challenge (Lusseau and Bejder, 2007; New et al., 2014; King et al., 2015), but remains an important objective to understand the mechanisms that lead to detrimental effects (e.g., stress, displacement from quality habitat, compromised foraging and resting). Long-term datasets offer precious opportunities to analyze demographic and distribution trends in the context of tourism development and management (e.g., Tezanos-Pinto et al., 2013; Somerford, 2018; Bennington et al., 2020) and shed light on the long-term consequences of tourism disturbance on cetacean populations.

Control Data

One crucial feature of effective research on both short- and long-term responses is the availability of control data (Bejder et al., 1999; Bejder and Samuels, 2003). These data should be gathered at appropriate temporal (before/during/after) and/or spatial scales (control/impact sites) (Bejder and Samuels, 2003), and using research methods unlikely to influence cetacean behavior (e.g., land-based, unmanned aerial vehicles, remote cameras, passive acoustic methods; Lundquist et al., 2013). In the absence of true control data, modeling to factor out the impacts of research activities and platforms is advised (Nowacek et al., 2001; Lusseau, 2003a; Richter et al., 2006; Guerra et al., 2014; Christiansen et al., 2020). Moreover, long-term data covering periods of step-wise changes in tourism (e.g., Constantine et al., 2004; Bejder et al., 2006b), and data from populations exposed to different levels of tourism (e.g., Lusseau, 2004; Fumagalli et al., 2018), have much more explanatory power than short-term data from one site. Lastly, information from benchmark studies at other locations can significantly enhance investigation and management of tourism effects, especially in data-deficient situations. In New Zealand, the research and management experience at the Bay of Islands and Doubtful Sounds influenced permit conditions in Waikato, Marlborough and Bay of Plenty, among others, where the bottlenose dolphin is now excluded from viewing and swim-with activities.

At many locations, where so far it has been difficult to observe cetaceans in the absence of vessels and/or swimmers, the COVID-19 pandemic may be creating unprecedented opportunities to collect control data.

Tourism Within the Context of Additional Pressures

Tourism often co-occurs alongside other potential stressors, such as bycatch, climate change, pollution, shipping, or habitat modification. Even when its impact is considered to be mild, cetacean tourism has the potential to aggravate the combined pressures on wild individuals and populations. Research should therefore aim to assess and manage potential cumulative impacts in unison (Maxwell et al., 2013; New et al., 2014), rather than in isolation. As evidenced by the case studies presented here, complementing tourism research with broader investigations of population exposure and responses to other threats helps gain a comprehensive picture of population conservation status, interpret and contextualize tourism effects. In addition, it can help identify management opportunities, capitalize on existing strategies, and eliminate redundant legislation to optimize governance. Finally, considering tourism within the context of multiple pressures generates the knowledge needed to negotiate management trade-offs between concurring industries affecting the same populations.

Evidence-Based Management Recommendations

Studies with a clear focus and specific research questions can deliver targeted recommendations, which in New Zealand have been particularly useful for the establishment of permit

TABLE 6 | Recommended actions to increase management efficacy of cetacean tourism at national and local destination level in New Zealand.

	Precaution	Adaptation	Holistic Approaches	Multi-Stakeholder Collaboration
National level	• Develop a National Plan for cetacean tourism • Clarify **ambiguous terms** (e.g., define *"juvenile,"* "*sufficient* education") in permit conditions • Address lack of **enforcement** of the permit system (e.g., "on the spot" ticketing for violations) • Enable precaution with **adequate policy tools** (e.g., shift burden of proof) • Devise a sustainable **financial system** to support the necessary long-term science (e.g., tourism levies)	• Enhance legal tools to promptly **reverse and adjust measures** based on the regular assessment and monitoring of management efficacy, compliance and cetacean responses • Add regulations for **revoking** permits and penalties for non-compliance • Early, frequently and regularly **revise management of tourism,** particularly of industries targeting distinct, small, declining populations • Improve and set standards for delivery of effective **educational, conservation-oriented information** on tours	• Regularly assess priorities and update the Marine Mammal Action Plan considering the integrated impacts of **global** and **national** stressors, the scientific information on individual welfare and population-level effects, and public interest and attitude toward cetacean tourism • Use of emerging techniques including **health and welfare assessments** to be incorporated into tourism impact assessments • Facilitate the formation of dedicated **interdisciplinary research** consortia, both nationally and locally	• Strengthen frameworks for **consultation** with recreational and non-permitted operators, tourism agencies and other stakeholders • Enhance **participation in and support of research** (sharing knowledge, data collection) • Establish collaborations with existing agencies and groups (e.g., boating education and certification agencies) to promote **knowledge and compliance to regulations** among the broader boating community • Ensure consistency of conservation and management messages in **marketing** and **delivery** of tourism activities
At each destination	• Extend enforceable obligations to **non-permitted** and **recreational** operations • Assess the suitability of site-specific **time-area closures** to tourism	• Establish the **legal basis** for adaptive management at local and regional level • Shift to **least obtrusive practices** in tourism (e.g., land-based, watching only) and research (e.g., land-based, platforms of opportunity) • Distinguish impacts from different segments of boating public, to articulate **specific management measures for the relevant boat users**	• Support **long-term studies** on behavior, distribution and population biology in partnership with local stakeholders • Identify **control sites or times** for the collection of control data • Assess the suitability of the **WATWC framework**, validate and improve the tool • Launch research efforts to characterize **stakeholders** (operators, researchers, government, visitors, local community) which ought to be integrated in management frameworks • Analyze and conceptualize tourism within relevant local, regional and national threats, and their **cumulative effects**	• Enhance **education and communication** of national and site-specific regulations and conditions
Bay of Islands	• Renew moratorium	• Modify the current static area-closure system • Reduce the number of vessels on the water • Revise regulations regarding the number of trips allowed daily and the practice of "handing over" groups	• Coordinate research and management regionally to protect dolphins exposed to multiple threats	• Enhance education of permitted, non-permitted and recreational users
Hauraki Gulf	• Prevent tourism increase		• Coordinate research and management regionally to protect dolphins exposed to multiple threats • Begin research on the impacts of tourism on Bryde's whales	• Capitalize on the ongoing engagement with the voluntary shipping Transit Protocol to promote science-based and social process in management
Kaikoura	• Renew moratorium • Reduce interactions with individual whales during summer, when whale abundance is particularly low	• Clarify and revise regulations for air-based operations • Consider ceasing dolphin-swimming activities and restrict tours to dolphin-watching	• Combine research on short-term whale responses with studies of long-term population dynamics • Investigate long-term changes in spatial distribution and abundance of dolphins relative to the changing extent of tour operations	• Enhance communication and awareness of risk of decline in whale abundance during summer, and of need to minimize impact from tourism
Akaroa Harbour	• Renew moratorium • Establish regulations for cruise ship traffic and monitor the resulting effects	• Revise regulations regarding the number of trips allowed and the practice of "handing over" groups	• Continue monitoring of the population, at local and regional level, the threats it is exposed to, and their effects on welfare and conservation • Update research on short-term responses to tourism operations, and on long-term population dynamics	• Enhance education of non-permitted and recreational users

(Continued)

TABLE 6 | Continued

	Precaution	Adaptation	Holistic approach	Multi-Stakeholder collaboration
	• Include tourism in the updated Threat Management Plan for the species			
Doubtful Sound	• Renew moratorium	• Review the extent and location of Dolphin Protection Zones • Upgrade voluntary guidelines into formal legislative framework applicable to all vessels and users	• Update research on short-term responses to operations and long-term population dynamics • Design a regional research program incorporating fiords and populations experiencing high, medium and no tourism disturbance	• Enhance communication with the broader boating community to improve compliance with guidelines

conditions and moratoria. Pre-tourism studies should be undertaken, if possible, to assess the impacts of the proposed industry, define initial regulations and establish a baseline for future monitoring (Martinez, 2003; Higham et al., 2009). At the onset of the industry, as well as regularly throughout its development, a main priority is the identification of situations in which cetacean tourism is incompatible with the welfare and conservation of the targeted individuals and populations. For example, there is a moratorium on tourism activities focused on the Critically Endangered and endemic Māui dolphin (*Cephalorhynchus hectori maui*), and it is currently illegal to approach bottlenose dolphins (*Tursiops truncatus*) and southern right whales (*Eubalaena australis*) in several regions. The identification of sensitive habitats is another essential first step in the design of tourism exclusion zones to effectively limit or prevent interactions in critical situations (Constantine et al., 2004; Lusseau and Higham, 2004; Lundquist, 2014).

In many locations, a key impediment to developing effective management strategies is the lack of information on the impacts of different segments of the boating community. For example, it is easy to focus on commercial operators, when they may not be the major source of impact. It is therefore important to quantify the frequency and effects of interactions with different vessel types, including recreational and non-permitted, in addition to permitted tour operators. The assessment of impacts where there are no permitted operations (e.g., Porpoise Bay, New Zealand) can be particularly useful. By understanding what specific activities lead to identifiable negative impacts, regulations can be targeted to specific activities. This will also help to devise measures that apply to the general public in places where the tourism industry does not have a role in managing impacts on cetaceans.

The social sciences and humanities, so far underrepresented in cetacean tourism research, can not only describe the social, economic and political aspects of the industry, explain and predict its evolution, and provide evidence-based recommendations for its advancement, but also facilitate and promote conditions that enable effective partnerships between stakeholders (Orams, 1996; Beausoleil et al., 2018; Whitty, 2018). Such partnerships can help design and implement management measures (Duffus and Dearden, 1990; Higham et al., 2009), and find best strategies to develop more unobtrusive and educational, and yet commercially viable, practices.

New Avenues for Research

The literature on cetacean tourism is substantive. Efforts should now focus on making full use of the existing datasets, and on addressing emerging gaps, new questions and evolving research approaches, rather than continuing to replicate descriptive findings which are now well-understood. The question is no longer *if* tourism can cause detriment, but *how* can we best predict, prepare for, and minimize it.

Beside advancement in the natural sciences, additional opportunities involve the social sciences and humanities (see section Evidence-Based Management Recommendations above), traditional ecological knowledge (*Mātauranga Māori* in New Zealand), animal welfare science (Papastavrou et al., 2017; Beausoleil et al., 2018; Nicol et al., 2020), and new analytical/modeling techniques and technological innovations (Pirotta et al., 2014; Nowacek et al., 2016; Booth et al., 2020; New et al., 2020). In particular, we encourage colleagues with adequate resources and datasets to (1) advance research on early warning signs and strategies to detect thresholds or tipping points in population dynamics (Scheffer, 2010); (2) develop quantitative metrics for animal welfare that, alongside population-level metrics, can guide evidence-based decision making (Papastavrou et al., 2017), validate and enhance emerging frameworks (e.g., WATWC, Nicol et al., 2020), and contribute working toward a common understanding of welfare (see Beausoleil et al., 2018); (3) advance tools and technologies to minimize or eliminate the use of invasive methods in tourism research, which can cause additional disturbances or mask tourism impacts; (4) design more robust protocols for collection and analysis of policy-relevant data from platforms of opportunity and through citizen science (Lusseau and Slooten, 2002; Cheney et al., 2013; Embling et al., 2015; Hupman et al., 2015); and (5) advance research on the human dimension of the tourism industry, in particular the socio-economic drivers of management response and pathways to overcome obstacles to management success in order to achieve more effective protection.

DETERMINANTS OF MANAGEMENT EFFICACY

One key lesson to extract from the New Zealand experience is that it is critical to heed early signs of impacts of cetacean tourism. Early management intervention is more likely to be effective and more easily implemented. Once there are clear indications that cetacean populations are declining, it may be too late to reduce tourism (and other) impacts to sustainable levels. An essential prerequisite of management efficacy is a policy framework that enables decision makers to receive and act upon rigorous scientific information early and decisively (Mangel et al., 1996; Higham and Bejder, 2008). Policies should clearly express what levels of risk and change are tolerated, where possible defining clear, measurable and adaptive management criteria and thresholds (e.g., stopping rules). In practice, management of tourism in New Zealand has ranged from examples based on robust, science-based and actionable policies, to those more influenced by economic and political pressures. We identify four key features of successful interventions: precaution, adaptation, holistic approaches, and multi-stakeholder collaboration.

Precaution

A precautionary approach establishes a framework of protective measures to prevent an activity from inflicting serious or irreversible impact, even if the evidence of such harm is lacking or uncertain (Cooney, 2004). The need for precaution arises from the acknowledgment that cetacean tourism is a non-lethal anthropogenic stressor and a form of consumptive exploitation (Neves, 2010; Higham et al., 2016) whose impacts on a particular population are often unknown, uncertain or ignored.

Precaution calls for tourism on vulnerable, small, isolated, threatened, or resident populations, or in priority habitats, to be minimized or avoided (Constantine and Bejder, 2008; Ross et al., 2011; Johnston, 2014). This is best achieved by confining operations to populations able to sustain tourism pressure (International Whaling Commission, 2006) and by prohibiting tourism in certain areas or times (i.e., temporal and/or spatial closures) (Tyne et al., 2014). One time- and area-based management strategy could involve assigning different spaces to permitted tour operators, non-permitted operators and the public, while ensuring "no-access" zones or times where cetaceans are fully protected (Lusseau and Higham, 2004; Fumagalli et al., 2018).

Maintaining a precautionary approach may require managers to be resolute in the face of demands from industry and the public, and this is why precaution is more effective when formulated as a legal obligation within policy frameworks, planning, and management tools (e.g., the MMPR in New Zealand). It is also important that the burden of proof rests with the proponents of the activity (Bejder et al., 2006b; Constantine and Bejder, 2008) and that regulations are clear, unequivocal, and effectively enforced (Constantine and Baker, 1997; Childerhouse and Baxter, 2010; Lundquist, 2014; Peters and Stockin, 2016). Under some circumstances, voluntary guidelines can provide an effective first step in management (Schaffar et al., 2010) or complement official regulations to further reduce tourism pressure (Guerra and Dawson, 2016).

A clear statement on what level of impact can be tolerated is a necessary step toward more precautionary and effective management strategies. These may include the use of quantitative tools (e.g., risk thresholds) to monitor impact and assess management success (e.g., Limits of Acceptable Change; Duffus and Dearden, 1990; Higham et al., 2009). Setting measurable risk thresholds, however, first requires addressing some critical questions, such as what agencies set the thresholds, how are these set, how thresholds are monitored, and what should be done at sites where there are insufficient data to set thresholds. We suggest that thresholds should require regular validation and adjustment based on emerging information, apply a precautionary approach, and be set only if there is robust evidence of their safety. Where terminology is vague (e.g., "harassment"), unambiguous definitions are required, and should be linked to specific indicators.

Adaptation

It is important that management approaches can adapt to changing conditions and new information to improve protection (Higham et al., 2009, 2014; Hartel et al., 2014). They should allow for careful monitoring of impacts and assessment of management interventions. Furthermore, regulations should be easily modified on the basis of the best available evidence. For instance, welfare concerns could initially prompt gradual reductions in tourism, which would likely be less drastic and costly than those required once a population has already declined or been displaced (Papastavrou et al., 2017). If population-level effects are detected, however, targeted actions should be swiftly implemented.

Tour operations that are more generalist and do not exclusively rely on cetacean tourism (e.g., scenic and wildlife viewing tours) offer more scope for adaptation to changes in management, and should therefore be more resilient. In turn, this may help facilitate compliance with new regulations.

Holistic Approaches

Ideally, science for policy is comprehensive and multi-disciplinary. Defining management strategies requires information on the target species, the tourism operations, and how both have changed over time at the site (Duffus and Dearden, 1990; Higham et al., 2009). Aspects to take into account include (1) the health and ecology of the cetacean population, (2) cetacean exposure to tourism and other threats, (3) the characteristics of tourism activities, (4) policy and governance, and (5) social, economic and political aspects of the community where the tourism activities occur (Higham et al., 2009).

In this context, it is important to realize that impacts of tourism on cetaceans are partly due to a mismatch in the timeframe of social, economic and political processes (e.g., short-term profits, election cycles) and biological factors (sustainability of cetacean populations over a 50–100 year timeframe). Furthermore, data on (1) and (2) above may already indicate what is required for impacts on the target species to be sustainable but, when other layers are added, there is an argument made for compromise. The politics of compromise can be insidious, and undermine actions needed urgently. It is crucial that biological viability remains a core, non-negotiable goal; impacts on the target species should not be trumped by social need. A solid understanding of the social dimension (including tourism dynamics, policies, societal values and stakeholders' attitudes) should help identify the most effective course of management action. There is a risk, however, that a quest for holism may result in complexity and delay, so achievement of this ideal may need to be balanced with the need for urgency.

Information outputs need to be communicated effectively to managers, tour operators, and policy makers to facilitate translation into management action. This requires genuine engagement and continued collaboration, ideally with long-term relationships and working groups integrating four key stakeholders: the management agencies, the biologists, the tourism operators, and the social scientists (Higham et al., 2009). This approach should help to (1) streamline the development of management measures in response to research findings, (2) ensure that the lessons learnt from previous failings and successes extend beyond scientific reflection, and (3) incorporate valuable insights gained by managers, policy makers and tour operators into research considerations.

Multi-Stakeholder Collaboration

The management of cetacean tourism is chiefly about managing human behavior (Forestell and Kaufman, 1993). Understanding and involving the local human component is therefore essential for an effective transition to activities that are lower impact and truly sustainable. It is important for management agencies to collaborate with tour operators, community representatives, and researchers in the development of guidelines and regulations (Higham et al., 2009). Participatory, democratic and transparent forms of governance can contribute to management efficacy (Cooney, 2004) but a balanced oversight is needed to ensure that management remains timely, evidence-based and focused on shared objectives.

Permitted commercial tour operators represent arguably the most important, yet underestimated agency of positive change in the management of cetacean tourism. Studies of visitor experiences when engaging with rare and endangered species in New Zealand have highlighted the potential for commercial operators to contribute positively to conservation outcomes (Higham and Carr, 2003). Although not all operators conduct their businesses sustainably, there are visionary businesses which contribute directly to research programs, and offer leadership in community stewardship and conservation advocacy. The recently established "SMART Operator" program (Sustainable Marine Mammal Actions in Recreation and Tourism Participation), a voluntary collaboration between commercial boat operators and DOC, is providing interested operators with training and certification to operate more responsibly around marine mammals. While researchers need to remain independent of the industry, these operators can become strong allies in seeking positive change.

It is noteworthy that the Tourism Futures Taskforce (TFT) has recently been appointed by the Minister of Tourism to provide advice on rebuilding a sustainable, climate-safe New Zealand tourism industry following the COVID-19 pandemic (Tourism Futures Taskforce, 2020). The TFT seeks a post-COVID focus for tourism that shifts from mass tourism to values-based tourism, is aligned with the aspirations of local communities and measured in terms of net benefits in relation to the Living Standards Framework (LSF) and the four capitals (social, economic, environmental and cultural) (*Te Tai Ohanga* The Treasury, 2019). This move will require tourism operators to fundamentally shift from a depletive, volume-based approach, to a new "regenerative" sustainable tourism paradigm in nature-based tourism.

It is recognized that business models determine how cetacean tourism is practiced (Neves, 2010). In *te ao Māori* (the Māori worldview) the well-being of people cannot be separated from the well-being of the environment (Upton, 2019). *Kaitiakitanga* (guardianship of natural resources) is a concept embedded in the national legislation (Simmons, 2014), whereby cetaceans form part of the identity of a community. Indigenous business models (e.g., Whale Watch Kaikoura) founded on the principles of *kaitiakitanga*, *manaakitanga* (hospitality), and *tino rangatiratanga* (self-determination), seek to achieve long-term ecological integrity, the protection of *taonga* (treasures), cultural renaissance, community well-being and inter-generational wealth creation. These outcomes align with the principles of management efficacy and improved sustainability, and the role of such business models in reshaping cetacean tourism will need to be fully embraced in the emerging tourism paradigm (Upton, 2019; Tourism Futures Taskforce, 2020).

Research and conservation projects that build local expertise, resources and capacity are more likely to be resilient and to continue independently from the principal investigators (Parsons et al., 2017). Moving away from "parachute research" (i.e., foreign scientists conducting research until their funding runs out and then leaving the site; Parsons et al., 2017) is a step toward ensuring conservation in areas where booming cetacean tourism lacks local research and management expertise, as it is often the case in developing countries and emerging destinations.

Working collaboratively, tourism operators, researchers and local communities can shift the essence of the visitor experience from fleeting entertainment, to deep and enduring engagement (Higham et al., 2014; Johnson and McInnis, 2014). Permit regulations currently compel tour operators to provide education and interpretation onboard their tours, however requirements are vague and effectiveness poorly documented. Evidence-based education, advocacy of conservation, awareness of animal welfare needs, and promotion of less obtrusive human-wildlife engagement could ultimately lead to higher compliance with existing regulations (Hoyt, 2012; Orams et al., 2014; Filby et al., 2015; Finkler et al., 2019; Lück and Porter, 2019). Involvement of tour participants in citizen science may also help promote public action (McKinley et al., 2017).

FUTURE CHALLENGES AND OPPORTUNITIES

The successful integration of precaution, adaptation, and community involvement into a more holistic approach to cetacean tourism is an important challenge. While some examples of addressing this challenge have been introduced in previous sections, specific recommendations for further implementation are presented in **Table 6**. At a national level, we encourage improvements in legislation, policies and practice. Among the priority actions listed, we suggest a revision of the current permit scheme and protected areas, a development of a National Plan for cetacean tourism, an update of the 2005–2010 Marine Mammal Action Plan, as well as the issue of more site-specific regulations applying to all users, including non-permitted operators and the public. Long-term multi-disciplinary research programs, research-informed advancement in education and engagement of the public, and ongoing collaboration between research and management are needed at each New Zealand destination. Finally, we report the latest recommendations issued by researchers in the five case studies (**Table 6**).

We emphasize that a prompt intervention to address current management weaknesses is particularly important as increasing anthropogenic threats, and in particular climate change, exacerbate pressures on marine ecosystems and will inexorably have societal repercussions (Hughes, 2000; Hoegh-Guldberg and Bruno, 2010). Health and welfare of cetaceans are already in decline (Gulland and Hall, 2007) and expected to worsen (Simmonds, 2017; Nunny and Simmonds, 2020) due to effects on their habitat and biology (Learmonth et al., 2006; Kaschner et al., 2011, 2019; Schumann et al., 2013). Inevitably, cetacean tourism operations will also be affected (Lambert et al., 2010). We must now use the tools available to identify species and populations most vulnerable to climate change (e.g., Dawson et al., 2011; Silber et al., 2017; Simmonds, 2017; Becker et al., 2019), and act to increase their resilience by mitigating effects of non-climatic threats (including tourism). As environmental conditions continue to change, multi-stakeholder systems need to ensure continued support to cetacean tourism research, conservation and management.

CONCLUSIONS

New Zealand has several destinations with mature cetacean tourism industries, a research community with a long history of engagement in marine conservation, a well-educated population, a strong economy, and a society with a strong connection to natural heritage. These characteristics place the country in a privileged position of advantage to manage tourism impacts well and responsibly. Nonetheless, the history of cetacean tourism is complex. On one hand, New Zealand has a reasonable regulatory base (MMPA and MMPR, site-specific permit conditions), established partnerships for evidence-based management, and long-term studies and monitoring. As evidenced by a few case studies, cetacean tourism can be managed in ways that are economically successful while reducing disturbance to populations (e.g., Doubtful Sound, Kaikoura, Hauraki Gulf). On the other hand, it has largely failed to timely intervene on populations experiencing local declines (e.g., Bay of Islands), there is no national plan for managing cetacean tourism, and no strategy to manage the multiple, co-occurring anthropogenic threats to cetaceans. In most cases, evidence-based recommendations have been ignored or partially implemented. In others, scientific data to guide tourism management is still completely missing.

This review indicates that the availability of robust scientific information, and recommendations to be precautionary are not sufficient preconditions for sustainable management to take effect. Conflicting interests, socio-economic pressures, ambiguity, political power struggles, ineffective scientific guidance, lack of societal vision and momentum, or all of the above, can weaken or stymie management actions. The proximal and ultimate causes of management inefficiency are complex and often difficult to tease apart. It is paramount that proactive collaborations are established between the interested parties, including scientists, managers and tour operators.

A necessary step forward, in New Zealand and elsewhere, is to declare in clear, unambiguous terms what levels of risk to marine mammal individuals and populations we are willing to tolerate. Once this moral, scientific, and societal decision is reached, scientists will be in a much better position to devise appropriate research in support of actionable policies. The research community has also the great responsibility to advocate for, and to help catalyze the transition to more resilient management systems, engaged communities, and research programs causing the least detriment to wild cetaceans, while providing timely and robust information for policy. The majority of current New Zealand permits and moratoria expire in 2022–2026: there is a window of opportunity for comprehensive action on the next generation of permitted operations and the post-COVID scenario. Looking forward, we recommend that stakeholders engage without delay in formulating a clear policy and vision for this industry, and in developing an integrated, holistic and adaptive research and management system to tackle the future of cetacean tourism and conservation in New Zealand.

AUTHOR CONTRIBUTIONS

SD encouraged and initiated the study. MF and MG led the design of the study and the writing of the manuscript with contributions and support from all authors. The preparation of the case studies received significant support from TB and RC (Bay of Islands), TB and KS (Hauraki Gulf), WC and ES (Akaroa Harbour), WR (Kaikoura), SD and JH (Doubtful Sound). WC contributed the artwork. All authors critically reviewed the final manuscript.

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An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years (2000-2015) to Inform Research and Management Programs

by

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An Updated Literature Review Examining the Impacts of Tourism on Marine Mammals over the Last Fifteen Years (2000-2015) to Inform Research and Management Programs

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Abstract:
In 2000, Samuels *et al.* provided a comprehensive review of the scientific literature available at the time, which included 107 references related to the effects "swim-with dolphin" tours have on animals' health and behavior. Over the last fifteen years, opportunities to view marine mammals in the wild have increased through commercial and private vessel-based platforms, in water "swim-with" activities, and land-based observation stations. Additionally, "structured" provisioning programs and illegal feeding interactions with a number of marine mammal species have increased. This current literature review updates and builds upon Samuels *et al.* 2000, by including almost 190 new references from 2000-2015 pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions. The scope has also been expanded to include additional species of cetaceans, pinnipeds, and sirenians. Our updated review highlights the major animal responses to viewing activities in four major themes: (1) behavior, (2) habitat use, (3) health, and (4) reproduction. Reoccurring responses documented in all four interaction themes include changes in animals' behavioral budgets and ranging patterns, habitat displacement, avoidance behaviors, and reduced maternal care. Many studies highlighted the risks and effects associated with interactions, such as increased energetic demands, predation, acoustic disturbance, reduced juvenile survivorship, boat collision, and entanglement injuries. This updated literature review provides a comprehensive analysis of human-marine mammal interactions to date that can help guide future potential research projects and management strategies.

Copies of this report may be obtained by from:
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Introduction

Global tourism targeting marine mammals has grown dramatically over the past 20 years intensifying concerns among scientists and managers about impacts of these activities on animal populations and individuals. For example, in 1998, the whale watching industry included 9 million whale watchers across 87 countries, and generated over $1 billion USD in total expenditure (Hoyt 2001). Ten years later, by 2008, the market grew to 13 million whale watchers across 119 countries and generated a total expenditure of $2.1 billion USD (O'Connor et al. 2009). These numbers are specific only to whale-watching and do not represent the variety of other tourism activities targeting a broader range of marine mammal species. Tourism has expanded from vessel-based observation platforms to in-water "swim-with" activities (e.g., Samuels & Bejder 2004, Lundquist 2007, Lundquist et al. 2008, Courbis & Timmel 2009) and land-based observation stations (e.g., Boren et al. 2002, Cassini et al. 2004, Orsini et al. 2006). Food provisioning to facilitate closer interactions with marine mammals is also expanding. Food provisioning includes "structured" provisioning programs where controlled feeding is allowed (e.g., Mann et al. 2000, Mann & Kemps 2003, Foroughirad & Mann 2013) and illegal food provisioning (e.g., Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Finn et al. 2008, Donaldson et al. 2010, Donaldson et al. 2012).

A great deal of scientific literature has been published on marine mammal tourism impacts. In 2000 and 2003, Samuels et al. provided a comprehensive review of the scientific literature pertaining to swimming with wild dolphins, which included 107 references and found that swim-with activities occur worldwide with more than 20 cetacean species. The literature described four basic categories of cetaceans involved in in-water encounters with humans: (1) lone, sociable, (2) food-provisioned, (3) habituated, and (4) not habituated. In many cases, swim-with activities were disturbing to targeted animals; however, the majority of sources of information were descriptive, anecdotal, and not suitable for management purposes (Samuels et al. 2000, Samuels et al. 2003). At the time, their review highlighted the need for science to better assess the impacts from cetacean-focused tourism and assess the potential long-term effects.

In the years following the Samuels et al. reviews, the marine tourism industry has continued to grow and the potential for disturbance and long term impacts to marine mammals has intensified. Since 2000, research on human-marine mammal interactions has expanded and provided additional scientific findings and recommendations that should be considered in future management decisions. This current literature review updates and builds upon Samuels et al. (2000, 2003) by including almost 190 new references from 2000-2015 pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions. The scope has also been expanded to include additional species of cetaceans, pinnipeds, and sirenians.

This updated review includes four chapters organized by human-marine mammal interaction type: vessel, swimmer, feeding, and land-based interactions. The vessel interaction chapter was further sub-divided into two categories, vessel-based tour interactions and vessel traffic interactions, since animals' response to and impacts from these activities vary. While vessel traffic interactions may not be considered a "tourism" activity, it is not uncommon for vessels to opportunistically sight a marine mammal during transit and then consequently approach for a closer view. The feeding interaction chapter is also structured differently from the other three chapters to accommodate the differences in legal requirements (or lack thereof) associated with feeding marine mammals around the world.

Each chapter in the review is structured to highlight how human interactions impact animal behavior (individual and group), habitat use, health, and reproduction/development. Throughout the literature, different themes for each impact emerged and formed the basis for the subsections (e.g., subsections in vessel interactions may differ from ones in land-based interactions). At the end of each chapter there is a summary of conclusions and risks to both human and marine mammals associated with human interactions. Management recommendations proposed throughout the literature are also summarized at the end of each chapter; recommendations for vessel and swimmer interactions are combined since swim-with activities typically use a vessel to approach dolphins, and therefore management measures are very similar.

The purpose of this review is to provide an updated compilation of research on human-marine mammal interactions that have been documented in the fifteen years following the Samuels et al. (2000) review effort. This review not only provides the most current literature, but also is an expanded effort to include other types of human-marine mammal interactions with other species worldwide. New scientific findings and recommendations have emerged in the last fifteen years that can help guide future potential research projects and management decisions.

Chapter 1. Vessel Interactions

Introduction

Vessel-based tours targeting marine wildlife are the most common type of marine mammal watching activity (Hoyt 2001). These tours are associated with the greatest threats to marine mammals because they repeatedly target specific cetacean communities in easily accessible coastal habitats for prolonged periods (Nowacek et al. 2001, Bejder et al. 2006a). In addition, high densities of vessel traffic utilizing the same environment as marine mammals pose significant threats to the animals' behavior, habitat use, communication, health, reproduction, and survivorship (e.g., Allen & Read 2000, Nowacek et al. 2001, Buckstaff 2004, Bechdel et al. 2009, Jansen et al. 2010, French et al. 2011).

In this chapter, each vessel-based interaction type is broken into a separate sub-section: (a) vessel-based tour interactions, and (b) vessel traffic interactions. "Vessel-based Tour Interactions" includes literature examining animals' behavioral responses to vessels (e.g., commercial tour boats, jet skis, kayaks) that are specifically aimed at viewing wildlife and where the passengers remain onboard. "Vessel Traffic Interactions" includes literature examining behavioral responses and movement patterns of marine mammals within the same habitat as vessels that are not specifically engaged in viewing wildlife (e.g., commercial fishing vessels, freighters, cruise liners, and commercial or recreational whale watching boats in transit). This distinction between the two sub-sections was made in order to discern the direct effects of tourism on marine mammals (i.e., vessel-based tour interactions) from the cumulative effects that vessel traffic, not related to tourism, has on marine mammals (i.e., vessel traffic interactions).

We included 146 scientific papers, dissertations, theses, and workshop reports that focused on vessel-based tours and vessel traffic interactions with 28 marine mammal species. Species include 17 odontocetes (killer, sperm, and short-finned pilot whales, bottlenose, Indo-Pacific bottlenose, spinner, dusky, Commerson's, Burrunan, Irrawaddy, Hector's, pantropical spotted, common, Indo-Pacific humpback, Chilean, Guiana, and Risso's dolphins); 5 pinnipeds (Australian and New Zealand fur seals, South American and California sea lions, and harbor seals); 4 mysticetes (humpback, minke, fin, and gray whales); manatees and dugongs. Vessel interactions were documented worldwide spanning over 30 countries, archipelagos, island nations, and sovereign states. Vessel types include motorized commercial and recreational whale watching boats, jet skis, kayaks, commercial and recreational fishing vessels, freighters, cruise liners, and trawlers.

Part A: Vessel-based Tour Interactions

"Vessel-based Tour Interactions" includes literature examining animals' behavioral responses to vessels (e.g., commercial tour boats, jet skis, kayaks) that are specifically aimed at viewing wildlife and where the passengers remain onboard.

1.1 Behavioral Effects

1.1.1 Behavioral Budgets

Vessel-based tour interactions have been documented to directly or indirectly alter the behavioral budgets of several marine mammal species through acoustic or visual stimuli, or physical contact. Behavioral budgets (also commonly referred to as activity budgets) quantify how much time an animal allocates to various behaviors and are typically used to identify behavioral patterns. The most commonly documented animal responses to vessel-based tourism are decreased foraging or resting activities, and increased travel behavior. For example, Christiansen et al. (2013b) used a novel modeling approach to quantitatively infer activity budgets from minke whale (*Balaenoptera acutorostrata*) behavior to inform the link between behavior and bioenergetics. Using this approach, they showed that the cumulative time minke whales spent foraging and surface feeding decreased from 15.3% to 8.8% during interactions with whale-watching boats. This represents a potential 42% decrease in the proportion of time spent engaged in energy acquiring activities (Christiansen et al. 2013b). For common dolphins (*Delphinus delphis*), foraging behavior was documented to decrease by 11.9% (Stockin et al. 2008) and 12.4% (Meissner et al. 2015) in the presence of a tour vessel. Additionally, common dolphins targeted for tourism were significantly less likely to continue foraging after the approach of a tour vessel (Stockin et al. 2008, Meissner et al. 2015). Lusseau et al. (2009) evaluated the effects of tour vessels on endangered southern resident killer whales along San Juan Island, Washington, USA. When vessels were present, whales decreased the proportion of time spent foraging and increased time spent traveling (Lusseau et al. 2009). Similar to common dolphins (Stockin et al. 2008, Meissner et al. 2015), the likelihood of killer whales to continue foraging when already engaged in foraging behavior significantly decreased when vessels were within 100 to 400 m (Lusseau et al. 2009). General patterns of decreased foraging behavior in the presence of tour vessels have also been documented for bottlenose dolphins (*Tursiops truncatus*) (Samuels & Bejder 2004, Underhill 2006, Yazdi 2007, Arcangeli & Crosti 2009, Scarpaci et al. 2010, Symons et al. 2014, Pirotta et al. 2015); dusky dolphins (*Lagenorhynchus obscurus*) (Coscarella et al. 2003); Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) (Christiansen et al. 2010, Steckenreuter et al. 2011, Steckenreuter et al. 2012); pantropical spotted dolphins (*Stenella attenuata*) (Montero-Cordero & Lobo 2010); Risso's dolphins (*Grampus griseus*) (Visser et al. 2011); fin whales (*Balaenoptera physalus*) (Jahoda et al. 2003); and killer whales (*Orcinus orca*) (Bain et al. 2006, Bain et al. 2014).

Decreased resting behavior has also been documented in response to tour vessels across multiple species, including bottlenose dolphins (Constantine et al. 2003, Constantine et al. 2004, Lusseau 2004, Östman-Lind et al. 2004, Arcangeli & Crosti 2009); common dolphins (Stockin et al. 2008); dusky dolphins (Lundquist 2011, Lundquist et al. 2012); pantropical spotted dolphins (Östman-Lind et al. 2004, Montero-Cordero & Lobo 2010); Risso's dolphins (Visser et al. 2011); and spinner dolphins (*Stenella longirostris*) (Forest 2001, Östman-Lind et al. 2004). For example in the presence of tour vessels, a 34% decrease in resting behavior was documented for bottlenose dolphins in New Zealand (Lusseau 2003a) and a 10% decrease for bottlenose dolphins in Chile (Yazdi 2007). In addition, Australian and New Zealand fur seals (*Arctocephalus sp.)* were documented to decrease the amount of time spent resting as tour boats approached closely to haul-out sites (Shaughnessy et al. 2008, Cowling et al. 2014a).

Generally, marine mammals travel more in the presence of tour vessels, likely as a type of avoidance tactic, which is further discussed in subsequent sections. Indo-Pacific bottlenose dolphins were found to cease resting behavior and shift to traveling behavior when tour boats approached (Stensland & Berggren 2007, Christiansen et al. 2010, Steckenreuter et al. 2011, Steckenreuter et al. 2012). One study found Indo-Pacific bottlenose dolphins increased travel behavior by 28.8% when tour vessels were near (Steckenreuter et al. 2012). Southern right whales in Argentina that were traveling prior to a disturbance, showed a significant increasing tendency to continue traveling instead of starting to rest, as a result of a vessel approach (Vermeulen et al. 2012). Other species documented to increase their traveling behavior in the presence of tour vessels include bottlenose dolphins (Lusseau 2003a, 2004, Underhill 2006, Arcangeli & Crosti 2009); common dolphins (Stockin et al. 2008, Meissner et al. 2015); dusky dolphins (Coscarella et al. 2003); Commerson's dolphins (*Cephalorhynchus commersonii*) (Coscarella et al. 2003); Hector's dolphins (*Cephalorhynchus hectori*) (Nichols et al. 2001); fin whales (Jahoda et al. 2003); and killer whales (Bain et al. 2006). Increased milling behavior is also a commonly documented response to vessel-based tours among species, and is typically seen in conjunction with increased travel behavior (Stockin et al. 2008, Lundquist 2011, Lundquist et al. 2012, Steckenreuter et al. 2012).

The majority of literature on vessel-based interactions report similar conclusions on changes in animals' behavior and behavioral budgets. However, the literature also suggests various factors that may affect animals' behavioral responses to vessels, such as age class or sex, as well as the number of vessels, type of vessel, distance of vessel, and methods of vessel approach. Factors such as age class play a role in the resting behavior of New Zealand fur seals; juvenile seals rested less than adult seals when vessels approached (Shaughnessy et al. 2008, Cowling et al. 2014a). The juvenile age class tends to be more skittish than adults and more likely to flee to the water. Juveniles may also be more rambunctious and curious of their environment, resulting in decreased resting behavior compared to adults (Shaughnessy et al. 2008, Cowling et al. 2014a). Symons et al. (2014) found sex-based differences in bottlenose dolphin foraging behavior in New Zealand. Females increased the frequency of foraging dives, but decreased dive duration, perceiving a risky situation with the vessel nearby; however, males performed fewer, but longer foraging dives under the perception of decreasing risk. Males opt for a riskier, but energetically less expensive option in order to reserve energy for competition for female resources. Females, on the other hand, choose the more risk-averse foraging strategy due to high potential costs, such as death of herself or her calf. Despite these gender differences, the literature shows that, in general, both males and females achieve a lower net energy gain from a foraging bout when a vessel is present and behaving intrusively. Vessel characteristics (i.e. number of vessels, type of vessel, distance vessel approaches animal, and method of approach) have also been documented to affect how much time animals spend foraging, traveling, and resting (Nichols et al. 2001, Lusseau 2003a, Constantine et al. 2004, Underhill 2006, Cowling et al. 2014a).

Changes to behavioral budgets may also differ across species due to natural variations in life history patterns. For example, dusky and spinner dolphins exhibit different onshore and offshore diurnal movement and feeding patterns. Dusky dolphins in Argentina rest at night and feed during daylight hours on pelagic schooling fish, whereas dusky dolphins in New Zealand and spinner dolphins in Hawaii forage offshore at night in the pelagic layers and return inshore during the day to rest (Würsig et al. 1991, Coscarella et al. 2003, Dans et al. 2008, Dans et al. 2012). As a result, dolphin-watching in Argentina disrupts dusky dolphin foraging behavior (Coscarella et al. 2003, Dans et al. 2008, Dans et al. 2012), while dolphin-watching in New Zealand and Hawaii disrupts resting behavior for dusky dolphins and spinner dolphins (Forest 2001, Danil et al. 2005, Lundquist 2011, Lundquist et al. 2012, Symons 2013, Tyne 2015, Tyne et al. 2015).

1.1.2 Avoidance

1.1.2.1 Horizontal Avoidance

Horizontal avoidance tactics are defined as a change in the animal’s heading or swim pattern and are one of the most common methods marine mammals (other than pinnipeds) use to evade tour boat pressure. Horizontal avoidance has been documented in bottlenose dolphins (Latusek 2002, Lusseau 2004, 2006, Yazdi 2007, Machernis 2014); Indo-Pacific bottlenose dolphins (Bejder et al. 2006a, Lemon et al. 2006, Steckenreuter et al. 2012); Indo-Pacific humpback dolphins (*Sousa chinensis*) (Piwetz et al. 2012); Hector’s dolphins (Martinez et al. 2011); spinner dolphins (Delfour 2007, Timmel et al. 2008); dusky dolphins (Lundquist 2011, Lundquist et al. 2012); Guiana dolphins (*Sotalia guianensis*) (Filla & Monteiro-Filho 2009); humpback whales (*Megaptera novaeangliae*) (Scheidat et al. 2004, Morete et al. 2007, Schaffar et al. 2009, Stamation et al. 2009, Schaffar et al. 2013); fin whales (Jahoda et al. 2003); killer whales (Williams et al. 2002a, Williams et al. 2002b, Bain et al. 2006, Williams et al. 2011); sperm whales (*Physeter microcephalus*) (Richter et al. 2006); and West Indian manatees (*Trichechus manatus*) (Nowacek et al. 2002). Killer whales, in particular, are a good example of how cetaceans modify their swim pattern to avoid vessels on two spatial scales (1) deviation and (2) direction. Increased deviation is reflected by a less predictable swim path from one surfacing event to another, and decreased directedness is reflected by a less predictable path on the scale of an entire observation session. Killer whales have been documented to increase total swim effort to horizontally avoid vessels, but display different avoidance tactics in response to varying numbers of tour vessels and approach distances (Williams et al. 2002a, Williams et al. 2002b, Williams & Ashe 2007). For example, as the number of vessels increased, killer whales maximized path directedness; however, when fewer vessels were around, the whales were observed to swim in a more zigzag pattern (Williams & Ashe 2007, Williams et al. 2009). An endangered population of humpback whales on their breeding ground in New Caledonia exhibited similar decreased swim path directedness when boats were present within 1000 m of the animals (Schaffar et al. 2009)

Another horizontal avoidance tactic marine mammals use to avoid vessel-based tours is altering their swim speed. Minke whales increased their swim speeds from 1.62 m/s to 2.64 m/s during whale watch interactions in Faxaflói bay, Iceland, accounting for a 4.4% increase in estimated energy expenditure (Christiansen et al. 2013b, Christiansen et al. 2014). Humpback whales increased their swim speeds over 50% when approached by tour vessels in Brazil (Morete et al. 2007) and manatees exhibited short bursts of increased swim speeds when moving away from vessels in Belize (Nowacek et al. 2002). In contrast, large groups of dusky dolphins have been observed to decrease swim speeds as multiple boats approached closely (Lundquist 2011, Lundquist et al. 2012, Lundquist et al. 2013). Slower swims speeds exhibited by this species may be a response to the reduced ability to communicate and coordinate pod movements, due to increased background noise from vessel motors (Lundquist 2011, Lundquist et al. 2012, Lundquist et al. 2013).

Factors related to both the vessels (vessel type, number of vessels, approach method) and the animals (group size, sex) play a role in determining the type of avoidance behavior displayed. Fast and unpredictable vessels, such as motor boats and jet skis, tend to elicit horizontal avoidance responses in bottlenose dolphins (Mattson et al. 2005, La Manna et al. 2013). Northern resident killer whales displayed different avoidance tactics in response to motorized vessels and kayaks; the whales were not observed trying to outpace kayaks as they did with motorized vessels, since kayaks are unable to keep up with the whale's swim speed (Williams et al. 2011). The number of vessels can affect the type of avoidance strategy marine mammals display. For example, killer whales displayed a more tortuous swim pattern when there were only a few vessels (1-3), but adopted a straighter swim path as vessel number increased (>3) (Williams & Ashe 2007). The authors hypothesized that an irregular path may be a useful avoidance tactic with a single vessel, but ineffective when vessel numbers increase. In a multiple-vessel scenario, a dive that takes a whale further from one vessel may bring it closer to another (Williams et al. 2002b). In terms of approach method, vessels that attempt to "leapfrog" marine mammals by positioning in the animals' predicted path or approach "head on," often elicit horizontal avoidance responses, as exhibited by Burrunan dolphins (*Tursiops australis*) (Filby et al. 2014), gray whales (*Eschrichtius robustus*) (Heckel et al. 2001), and killer whales (Williams et al. 2002a). Williams et al. (2002a) reported northern resident killer whales increased their path deviation and reduced their swim path directness when a vessel was "leapfrogging," reflecting an increase of 17% in the distance a whale would have to swim to cover 100 m of straight-line distance.

Differences in animals' group size and sex have also played a role in avoidance responses. Common dolphins, for example, typically form larger groups to provide better protection from predation and other threats such as vessel interactions (Neumann & Orams 2005), thus they display less avoidance behavior than species traveling in smaller groups (Tseng et al. 2011, Filby et al. 2014). In addition, sex-differences in avoidance techniques have been noted in northern resident killer whales, such that females swam faster and increased the angle of deviation between surfacings, while males maintained swim speed, and chose a smooth, but less direct path compared to females (Williams et al. 2002b).

1.1.2.2 Vertical Avoidance

In some instances, marine mammals exhibit vertical avoidance behaviors by altering dive patterns, dive times, and respiration rates. We found no recent literature regarding pinnipeds and vertical avoidance behaviors. Rather, the majority of literature focused on cetaceans and found that altering dive times, often measured by inter-breath intervals (IBI) is the most commonly used vertical avoidance tactic. Studies have documented species to either increase or decrease their IBI in response to the circumstances of the disturbance source. Marine mammals documented to exhibit this type of avoidance tactic include bottlenose dolphins (Lusseau 2003b, Underhill 2006, Symons et al. 2014); Indo-pacific bottlenose dolphins (Stensland & Berggren 2007); Irrawaddy dolphins (*Orcaella brevirostris*) (Stacey & Hvenegaard 2002); humpback whales (Schaffar et al. 2009, Stamation et al. 2009); fin whales (Jahoda et al. 2003); killer whales (Bain et al. 2006); sperm whales (Richter et al. 2006); and minke whales (Christiansen et al. 2014). For example, bottlenose, Indo-Pacific bottlenose, and Irrawaddy dolphins increased their IBI presumably to avoid close vessel approaches or underwater acoustic disturbance from vessels (Stacey & Hvenegaard 2002, Lusseau 2006, Stensland & Berggren 2007). Minke whales and killer whales, however, responded by decreasing IBI when disturbances, such as tour vessels, were on the whales' foraging grounds, or when there were greater than 12 tour vessels in the surrounding area (Bain et al. 2006, Christiansen et al. 2013a).

An animal's sex is also a factor in determining dive patterns and respiration rates when vessels are present. Lusseau (2003b) observed that male bottlenose dolphins increased their mean IBI when vessels were greater than 400 m away, whereas females only did so when boats were within 400 m and potentially impeding the movement of a group of dolphins. Lusseau (2003b) suggests this phenomenon may be due to differences in metabolic rates between males and females. Males have increased energy stores so they are able to absorb the energetic costs of vertically avoiding vessels, whereas females have less energy stores, compared to males, especially when reproductively mature. Thus, females only increase their mean IBI when the risk of incurring injury from a vessel is high (Lusseau 2003b).

1.1.3 Surface Active Behavior

The literature largely supports the finding that surface active behaviors (e.g., spy hops, breaches, tail slaps, flipper slaps) and aerial displays by cetaceans typically increase in response to vessel-based disturbances (Forest 2001, Bain et al. 2006, Morete et al. 2007, Courbis & Timmel 2009, Noren et al. 2009, Stamation et al. 2009, Kessler et al. 2013). Surface active behaviors may be a general indicator of disturbance, or may serve as agonistic acts towards boat approaches. For example, spinner dolphin aerial displays were observed most frequently midday, coinciding with peak tourism hours during dolphin resting periods (Courbis & Timmel 2009). Interrupting rest periods can significantly increase rates of predation and diminish foraging efficiency (Forest 2001, Courbis & Timmel 2009). Southern resident killer whales' surface active behaviors increased by 70% when boats were as far as 224 m away (Noren et al. 2009). Williams et al. (2009) noted that killer whales were less likely to perform surface active behaviors as vessel numbers increased, but more likely to exhibit these behaviors as vessels got closer to the whale (Williams et al. 2009). Some surface active behaviors, such as breaches, slaps, and fluke lifts, may be used as a threat display when vessel traffic is close, but not close enough to elicit an avoidance response. Half of humpback whale groups in Tonga showed increased surface active behaviors when vessels approached closer than 30 m, even though recommended viewing guidelines are set at 10 m (Kessler et al. 2013). Although less commonly documented, in some vessel-based interaction studies, animals' surface active behaviors decreased. For example, Hawaiian spinner dolphins decreased aerial displays entering and exiting their resting bay, which may have been an avoidance strategy from being seen and targeted by nearby tour vessels (Forest 2001). Similarly, Morete et al. (2007) observed decreased rolling behaviors from humpback whale calves in the presence of vessels, possibly inhibiting important social and developmental skills, such as motor skills and coordination. While there are different theories explaining the purpose and timing of surface active behaviors in response to vessel tours, all of these activities have additional energetic costs associated with them (Williams et al. 2009). No literature regarding surface active behaviors for pinnipeds has been documented.

1.1.4 Acoustics

Noise from vessel engines is problematic for a variety of reasons, such as causing a startle response, masking natural sounds, impacting hearing, and potential injury. Acoustic masking is a growing concern; it interferes with or obscures communication by limiting the range at which signals can be heard, or reduces the quality of information being sent (Erbe 2002, Jensen et al. 2009, Albuquerque & Souto 2013, Guerra et al. 2014). For endangered Southern resident killer whales, vessels idling within 200 m from whales do not interfere with the soundscape or reduce the active space of echolocation signals. However, in accordance with the "Be Whale Wise" guidelines, vessels can power up to normal cruising speeds within 400 m of whales. At this range and speed, Holt (2008) estimated the horizontal detection range of a 50 kHz echolocation signal is reduced by as much as 360 m relative to ambient conditions (400 m under ambient conditions, 40 m under masked conditions). Interference with communication can have significant biological effects, especially if it impacts an animal's ability to forage, socialize, navigate, or communicate for group cohesion purposes (Foote et al. 2004, Holt et al. 2008, Albuquerque & Souto 2013, Pirotta et al. 2015). In response to increased ambient noise, some species alter their communication by changing their whistle structure, clicks, or call duration. For example, bottlenose dolphins and killer whales are known to increase repetition rates, call duration, and call amplitude by 1 dB for every 1 dB increase in ambient noise level (Foote et al. 2004, Holt et al. 2008, Hawkins & Gartside 2009a). In New Zealand, dolphin groups with mothers and calves increased their whistle rates, producing shorter and higher-frequency whistles around fast moving and loud tour boats, compared to groups with no calves (Guerra et al. 2014). This demonstrates the need for vocal contact with calves outweighs the costs of whistling more and may help to restore group cohesion (Guerra et al. 2014). Australian fur seals also altered their vocalizations by changing their pattern of calls and barks in response to high levels of motor boat noise (Tripovich et al. 2012).

Increased noise associated with the distance and speed of a vessel may also influence the received sound levels and a marine mammal's acoustical response. When comparing a fast zodiac at 51 km/h with a slow zodiac at 10 km/h, Erbe (2002) recorded stark differences in detection distance, masking distance, behavioral response, and temporary threshold shifts (TTS) for killer whales in Haro Strait, British Columbia. Temporary threshold shifts occur when an animal is exposed to intense sound, so that their hearing threshold becomes elevated, but returns to pre-exposure level after a period of time (Finneran et al. 2001). In Erbe's (2002) comparison between killer whales' responses to fast boats versus slow boats, she reported that: (1) killer whales detected fast boats 16 km away versus slow boats 1 km away; (2) behavioral responses were elicited when fast boats were 200 m away versus slow boats that were 50 m away; (3) fast boats masked calls at 14 km whereas slow boats masked calls at 1 km; and (4) TTS occurred at 5 dB for 30-50 mins when exposed to fast boats within 450 m compared to slow boats that were 20 m away.

1.1.5 Vigilance/Flushing/Haul Out/Aggression

Vigilance and flushing behaviors are characterized in pinnipeds by general alertness, upright or head-up posture, and fleeing to the water (Andersen et al. 2012). These behaviors are observed in response to vessels across a wide geographic range from species including: Australian fur seals (Shaughnessy et al. 2008, Stafford-Bell 2012, Tripovich et al. 2012); harbor seals (*Phoca vitulina*) (Henry & Hammill 2001, Johnson & Acevedo-Gutiérrez 2007, Fox 2008, Jezierski 2009, Andersen et al. 2012, Osinga et al. 2012, Hoover-Miller et al. 2013, Young et al. 2014); New Zealand fur seals (Boren et al. 2002, Shaughnessy et al. 2008, Cowling et al. 2014a);

and South American sea lions (Pavez et al. 2011, Pavez et al. 2014). These behavioral responses are significantly impacted by spatial/seasonal differences (breeding vs non-breeding haul-out sites) and animal age/sex class. For example, molting and breeding seasons are energetically taxing times for pinnipeds. During these times, seals are likely to conserve energy and remain on land, explaining the increased vigilance and decreased flushing behaviors observed during vessel approaches (Henry & Hammill 2001, Boren et al. 2002, Andersen et al. 2012). As for spatial and age/sex class factors, responses and rationale vary. For example, New Zealand fur seal pups tend to be more alert and shift their behavior from resting to vigilance when vessels approach their haul-out sites (Cowling et al. 2014a). This reaction from seal pups may be explained by their inexperience around vessels and uncertainty regarding the threat they might pose (Cowling et al. 2014a). During a study conducted in Chile, Pavez et al. (2014) documented South American female sea lions at a non-breeding haul-out site exhibited a larger response to tourism disturbance likely because they did not have newborn pups to care for or protect, thus were not constrained to remaining on land. In contrast, females at the breeding site typically remained on land during vessel disturbances to tend to their newborn pups. Sub-adult males, no matter what site (breeding or non-breeding), displayed a more noticeable response to disturbance. Sub-adults do not effectively compete in reproduction such that they do not need to defend females or territories, and are usually on the periphery of the colony trying to abduct females or pups (Pavez et al. 2014). Lastly, adult males displayed greater disturbance behavior at the non-breeding site, where they were not constrained to land in order to defend females and territories.

In some studies, vigilance and flushing responses were complex and varied depending on species, vessel approach distances, and vessel type. Australian fur seals moved to the water when a vessel approached within 40 m of a haul-out site (Shaughnessy et al. 2008), whereas South American sea lions had a much higher tolerance for approach distance and flushed when vessels were less than 25 m (Pavez et al. 2011). Similarly, California sea lions increased alertness when boats approached within 20 m (Labrada-Martagón et al. 2005). When evaluating disturbance response among vessel types (i.e. motorboat vs. kayak/canoe), harbor seals in particular appeared to be more sensitive to close approaches by motorboats than by kayaks. In Washington State, disturbed harbor seals retreated to the water when motor boats stopped within 190.5+/-124.8 m of their haul-out location, compared to when kayaks stopped within 91+/-36.3 m (Johnson & Acevedo-Gutiérrez 2007). Similarly, harbor seals in Canada flushed to the water when boats were greater than 200 m of their haul-out site, and flushed when kayaks were within 100-140 m (Henry & Hammill 2001). Although seals appear to be less sensitive to kayaks than motor boats, kayaks likely still elicit a predator-prey response since they are quiet, close to the surface of the water, and less conspicuous, thus mimicking the characteristics of a predator and inducing flushing behavior (Henry & Hammill 2001, Fox 2008, Jezierski 2009, Hoover-Miller et al. 2013).

Increased aggression between animals has also been observed as a result of tour-vessel disturbance. The average number of displays of territorial disputes increased between Australian fur seals as the number of recreational vessels within 200 m of the haul-out site increased (Stafford-Bell 2012), and also in response to increasing motor boat noise (Tripovich et al. 2012). These responses may be due to increased stress levels and a heightened sense of emotion from the threat of approaching vessels and their associated motor noise (Stafford-Bell 2012, Tripovich et al. 2012).

1.1.6 Physiological Responses

Measuring behavioral responses alone may not be the only indicator of an animal's level of disturbance, and in fact may underestimate it. Measuring changes in heart rate have also been used to characterize the "unseen" physiological responses to disturbance. For example, harbor seal heart rate increased by 5 bpm upon initiation of vigilance behavior when experimentally approached by vessels in Southeast Alaska (Karpovich et al. 2015). After responding to vessels by entering the water, seals exhibited a lower heart rate while in the water, and a higher heart rate of 6 bpm during the next haul out, with the elevated heart rate persisting for at least 180 minutes (Karpovich et al. 2015). This physiological response indicates that vessel disturbance has a prolonged influence on the energetic balance of harbor seals, which could result in decreased opportunities to forage or care for young, and translate into longer term implications.

Respiration rates may also be used as a proxy for oxygen consumption to estimate energy expenditure in larger cetaceans. On minke whale feeding grounds in Faxaflói bay, Iceland, whale watching boat interactions resulted in increased respiratory rates from 0.88 breaths/min to 1.12 breaths/min, suggesting that vessel presence elicited a stress response (Christiansen et al. 2014). This increase in respiratory rates corresponds to an overall 23.2 % increase in estimated energy expenditure (Christiansen et al. 2014).

1.1.7 Neutral

There is very little literature that documents a neutral response (i.e., showing no apparent response to a stimulus) by animals to tour vessel interactions. In areas of low-level tourism in Patagonia, Argentina and Mercury Bay, New Zealand, a neutral response to vessel presence was reported for Commerson's and common dolphins (Failla et al. 2004, Neumann & Orams 2005, Neumann & Orams 2006). This neutral response is likely due to very low levels of tourism resulting in less behavioral, physical and acoustic disturbance (i.e. Failla et al. 2004).

1.2 Group Behavior Effects

1.2.1 Group Size, Cohesion, and Acoustics

Some studies focused on group behavior of marine mammals in response to tour-vessel interactions. Results from these studies varied and documented how groups became more compact, spread out into smaller sub-groups, or increased in size. All of these responses likely indicate avoidance strategies by the animals. For example, increasing group compactness during vessel encounters may serve as a tactic to better track other group members' movement patterns and respond more quickly in the context of a presumed threat (Bejder 2005, Bejder et al. 2006a, Steckenreuter et al. 2011, Steckenreuter et al. 2012). In other cases, bottlenose dolphins in Australia and Chile spread out into smaller sub-groups in response to vessel encounters (Yazdi 2007, Arcangeli & Crosti 2009), which resulted in as much as 27% more groups with a 12% decrease in group size (Arcangeli & Crosti 2009). Dividing into smaller sub-groups may make movement patterns less predictable to a perceived threat (Yazdi 2007). In many cases, cohesion between mother and calf pairs increased as did overall group size when calves were present among the group during a disturbance event (Latusek 2002, Mattson et al. 2005, Scarpaci et al. 2010, Steckenreuter et al. 2012). This was likely used as added protection for the calf or other animals when the number of tour vessels increased, or distance between tour vessel and animals decreased. Conversely, Guerra et al. (2014) documented significantly less cohesiveness and coordinated movement for bottlenose dolphin groups with calves during and after a vessel disturbance. Simultaneous with the disturbance event, the researchers also recorded elevated whistle rates. The increased whistle rate is likely a method to compensate for masking effects of vessel noise and to restore group cohesion after the passage of a vessel (Guerra et al. 2014).

The increase of whistle production to restore group cohesion has also been documented for a resident inshore bottlenose dolphin population in Port Phillip Bay, Australia (Scarpaci et al. 2000). Whistle production was significantly higher in the presence of tour boats while animals were engaged in traveling, feeding, and socializing behavior. Since these behaviors typically require more coordination through acoustic signals, the authors suggest that increased whistle production was a result of disrupted group cohesion from either the physical separation of individuals in a group or from masking effects (Scarpaci et al. 2000).

1.3 Habitat Use Effects

1.3.1 Displacement

Tour vessel interactions can displace marine mammals from their preferred habitat and affect their distribution and abundance. In 2006, Bejder et al. (2006b) published a landmark study that clearly documented habitat displacement of bottlenose dolphins in Shark Bay, Australia as a result of tour vessel interactions. Specifically, the average dolphin abundance decreased by 14.9% when the number of tour boats increased from zero to two vessels over several years of monitoring (Bejder et al. 2006b). In contrast, dolphin abundance increased by 8% in an adjacent bay less frequented by vessels. This finding provides strong support for the long-term shift in habitat use from an area of high tourism to one with fewer disturbances (Bejder et al. 2006b). Similarly in Hawaii, there is strong evidence suggesting that spinner dolphins were temporarily displaced from their most important resting bay to a previously less-used secondary resting bay due to increased pressure from tour boats (Östman-Lind et al. 2004). More recent work has estimated a reduction in the Hawaiian Island stock population of spinner dolphins (Tyne et al. 2014). The genetic distinctiveness of this stock and the ease of human access into their preferred habitat make this stock more vulnerable to negative impacts from human disturbance (Tyne et al. 2014). In Fiordland, New Zealand, Lusseau et al. (2006) reviewed the effects of tourism on bottlenose dolphins in Milford Sound and Doubtful Sound and also documented habitat displacement in response to tourism pressure. Specifically in Milford Sound during peak tourism season, dolphins spent less time within the heavily trafficked fjord compared to other seasons, and when they did visit, the dolphins spent more time at the entrance of the fjord in the "no boat" zone (Lusseau 2005).

1.3.2 Ranging Patterns

Tour vessel interactions have been documented to influence animals' ranging patterns. For example, differences in ranging patterns were found between conditioned (illegally provisioned animals) and non-conditioned bottlenose dolphins in Panama City, Florida (Samuels & Bejder 2004). Conditioned animals remained within less than one nautical mile from where boats, jet skis, and swimmers congregated and interacted with (i.e., illegally fed) the animals. Conversely, non-conditioned dolphins traveled up to several nautical miles away from the interacting vessels along the coastline or into a nearby bay (Samuels & Bejder 2004). In another area of Florida, Sarasota Bay, a few routinely provisioned animals were only sighted in an unnaturally small portion of the bay, at the southern extent of the normal population range, where boating and tourist traffic is high (Cunningham-Smith et al. 2006). In both studies, it is important to note that the animals were so heavily conditioned to being fed by people that it was difficult to discern the effects of vessel interactions on animals' ranging patterns alone.

1.4 Health Effects

1.4.1 Contaminant Exposure

Only one study modeled the potential health effects of exhaust emissions from whale watching boats on southern resident killer whales in British Columbia (Lachmuth et al. 2011). A pollution dispersion model was run and incorporated data on whale and vessel behavior, atmospheric conditions, and exhaust emissions from whale watching vessels. The model suggested that during average-case whale watching scenarios (i.e., 20 vessels maintaining the 100 m viewing distance guideline, mixed wind speeds, and average mixing height) the World Health Organization's Air Quality Guidelines for carbon monoxide (CO) and nitrogen dioxide (NO_2) were occasionally exceeded depending on environmental factors; however, they were always exceeded when 20 or more vessels violated the viewing distance guideline and were closer than 100 m. Whales' exposure to airborne contaminants is highly dependent on environmental factors as exemplified and accounted for in the model. Acute and chronic exposure to engine exhaust emissions can have different health effects depending on concentration and duration, but overall can result in asthma, respiratory infection, and changes in pulmonary function, arterial vasoconstriction, and mortality, as seen in other mammals (Lachmuth et al. 2011). While Lachmuth et al. (2011) highlight the potential for health effects from exposure to vessel exhaust, there is no evidence to date that southern resident killer whales suffer from health issues directly related to CO and NO_2 emissions.

1.5 Reproductive Effects

1.5.1 Reproductive Rate/Survivorship

Studies in the literature have documented a negative correlation between vessel exposure, and both female reproductive rates and juvenile survivorship. For bottlenose dolphins in Shark Bay, Australia, between 1993 and 2004, females chronically exposed to tour vessel interactions exhibited a reduced ability to produce and successfully rear offspring (Bejder 2005). The majority of calves born to females exposed to high vessel pressure did not survive to weaning, likely as a result of malnutrition, increased disease susceptibility, or increased predation (Bejder 2005). French et al. (2011) found California sea lions' reproductive rates decreased in response to the presence of vessels within 50 m; however at the same time, pups' growth rates increased. In this particular case, the increase in growth rates is likely a result of the reduction in reproductive rates, which allows for more available resources for the remaining pups to utilize (French et al. 2011). Although it was not specified in the study that the vessels were specifically targeting the sea lions for tourism purposes, the close approach distance of 50 m is likely a means to actively view the animals from a closer distance. Juvenile survivorship and fitness were also jeopardized for West Indian manatees (King & Heinen 2004) and Indo-Pacific bottlenose dolphins (Stensland & Berggren 2007) due to decreased time spent nursing in the presence of tour-vessels.

1.5.2 Neutral

There are two studies that document neutral impacts to marine mammal reproduction from vessel-based interactions. Weinrich & Corbelli (2009) found humpback whale calving and calf survival rates did not change because of exposure to whale watching tours in the Gulf of Maine. Neither the length of exposure to tours nor the number of interactions between vessels and whales affected calf production or survival (Weinrich & Corbelli 2009). Christiansen et al. (2015) estimated that the cumulative time minke whales spend near whale watching boats on feeding grounds in Faxaflói Bay, Iceland was 0.2%, or 7.13 hours. This constitutes only a 0.66% energy loss from blubber storage for pregnant females. The authors concluded that the impacts of whale watching on minke whale fetal growth is negligible (Christiansen et al. 2015).

Part B: Vessel Traffic Interactions

"Vessel Traffic Interactions" includes literature examining behavioral responses and movement patterns of marine mammals within the same habitat as vessels that are not specifically engaged in viewing wildlife (e.g., commercial fishing vessels, freighters, cruise liners, and commercial or recreational whale watching boats in transit). Throughout the literature, there is no common understanding of how various terms (i.e., vessel, boat, ship, vessel traffic, etc.) are used to describe a situation. Due to this inconsistency, it can be very challenging to decipher an animal's response to either vessel-based tour interactions or vessel traffic interactions. This section highlights papers that may include a mix of vessel types, but are primarily non-targeted vessel traffic. However, it is not uncommon for a recreational vessel, for example, in transit to opportunistically sight a marine mammal and then move closely to approach and get a better viewing. While this may not be considered a "tourism" activity, this section emphasizes the impact non-tourism based vessels have on marine mammals and provides a baseline of impacts animals experience without additional anthropogenic pressures from tourism.

1.6 Behavioral Effects

1.6.1 Behavioral Budgets

Vessel traffic interactions have been documented to alter an animal's behavioral budget. The most commonly cited behavioral changes include decreased foraging, resting or socializing, and increased traveling behaviors. For example, Williams et al. (2006) documented decreased foraging and increased traveling by killer whales in the presence of vessel traffic. The Williams et al. (2006) study was one of the first to suggest vessel traffic affects killer whale foraging, reducing energy acquisition by 18%. A similar result was found for dugongs in Australia, which decreased foraging in a heavily trafficked zone when vessels passed within 50 m (Hodgson & Marsh 2007). The decreased time spent foraging resulted in an overall energy deficit of 0.8-6% (Hodgson & Marsh 2007). Bottlenose dolphins in Florida and Italy also have been found to decrease foraging and increase traveling in the presence of vessel traffic (Bechdel et al. 2009, Papale et al. 2011). In addition to changes in foraging and traveling behavior, socialization patterns were observed to change in response to vessel traffic. For example, killer whales were observed spending 14% less time rubbing their bodies on pebble beaches in the presence of vessel traffic, which is typically an important component of their socializing repertoire when not disturbed (Williams et al. 2006).

1.6.2 Avoidance

1.6.2.1 Horizontal Avoidance

Horizontal avoidance is one of the most commonly observed avoidance tactics used by marine mammals, other than pinnipeds, especially in busy traffic conditions and in narrow channels. Typical avoidance behaviors include a change in heading, away from traffic, accompanied by increased swim speed. Horizontal avoidance behaviors in response to vessel traffic have been documented for bottlenose dolphins (Gregory & Rowden 2001, Nowacek et al. 2001, Latusek 2002, Papale et al. 2011); Chilean dolphins (Ribeiro et al. 2005); Indo-Pacific humpback dolphins (Ng & Leung 2003); Irrawaddy dolphins (Kreb & Rahadi 2004); killer whales (Smith 2008); humpback whales (Smith 2008); and the West Indian manatee (Miksis-Olds et al. 2007). For example, in Core Sound, North Carolina, bottlenose dolphins swam in more direct paths in the presence of high vessel traffic; however, when no boats were in the study area, the animals changed heading in between surfacings and were able to utilize their environment without vessel restrictions (Latusek 2002). Bottlenose dolphins and manatees have also been observed to increase swim speeds to evade vessel traffic (Nowacek et al. 2001, Miksis-Olds et al. 2007, Papale et al. 2011).

Horizontal avoidance tactics are often affected by vessel type and vessel speed. In general, marine mammals tend to avoid vessels moving at high speeds such as jet skis, personal watercraft, motorboats, and ferries (Ng & Leung 2003, Goodwin & Cotton 2004, Miksis-Olds et al. 2007, Baş et al. 2014). Irrawaddy river dolphins in Brazil surfaced significantly less in the presence of motorized canoes, speedboats, and actively changed direction to avoid tugboats that occupied over three quarters of the river width (Kreb & Rahadi 2004). Bottlenose dolphins in Cardigan Bay, Australia avoided kayaks over 50% of the time, often traveling up to distances 200 m away, possibly due to a startle response from a kayak's relatively silent movement compared to motor boats (Gregory & Rowden 2001).

1.6.2.2 Vertical Avoidance

Several species of dolphins utilize vertical avoidance strategies to evade high densities of vessel traffic. Specifically, animals have been documented to increase dive duration, increasing their IBI, so that the amount of time spent at the surface is limited. Increased time underwater to evade vessel traffic has been documented for bottlenose dolphins (Nowacek et al. 2001, Hastie et al. 2003, Goodwin & Cotton 2004, Papale et al. 2011, Rako et al. 2012, Baş et al. 2014); Indo-Pacific humpback dolphins (Ng & Leung 2003); Irrawaddy dolphins (Kreb & Rahadi 2004); and killer whales (Williams et al. 2009). Similar to horizontal avoidance tactics, vertical avoidance behaviors are elicited by high speed boats and an increased presence of vessel traffic.

1.6.3 Surface Active Behaviors

Humpback whales' surface active behaviors (i.e., spy-hopping, tail slapping, or breaching) have been documented to be affected by vessel traffic. Humpback whales in Australia were observed to decrease their surface active behaviors by almost 50% when the number of vessels increased from zero boats to 1-3 boats (Smith 2008).

1.6.4 Flushing

Harbor seals exhibit a flushing response to vessel traffic (Jansen et al. 2010). In Alaska, harbor seals flushed in response to the passing of cruise ships at different distances (Jansen et al. 2010). Harbor seals were 25 times more likely to flee into the water when cruise ships passed within 100 m than when ships passed within 500 m (Jansen et al. 2010).

1.6.5 Physiological Responses

Harbor seals showed a 4 bpm increase in heart rate with each additional vessel present in a fjord in southeast Alaska while hauled out (Karpovich et al. 2015). The observed heart rate could be attributed to the seals becoming more alert and aware of vessels in the area and potentially experiencing stress. Vessel size also had an impact on seals' heart rate. Smaller vessels (i.e. skiffs, inflatables, kayaks) comprise approximately 23% of vessel traffic in two neighboring fjords. Karpovich et al. (2015) found that these smaller vessels had the largest impact on harbor seals' heart rates, likely due to their unpredictable movement patterns and ability to closely approach haul-out sites.

1.6.6 Neutral

Two studies did not report any significant behavioral changes by dolphins in response to vessel traffic (Gregory & Rowden 2001, Failla et al. 2004). In Bahia San Julian, Argentina, Commerson's dolphins have been documented to have a neutral response to vessels when there is a low frequency and intensity of vessel traffic (Failla et al. 2004). In Cardigan Bay, Australia, bottlenose dolphins were also documented having a neutral response to vessel traffic 62% of the time (Gregory & Rowden 2001). Authors suggest this neutral response may be a result of conditioning to vessel traffic; however, they did note that dolphins exhibit avoidance behavior when kayaks were nearby, suggesting that response may be a factor of vessel type (Gregory & Rowden 2001).

1.7 Group Behavior Effects

1.7.1 Group Cohesion and Acoustics

Several studies document how vessel traffic affects different species of dolphins and humpback whales' group cohesion, respiratory rates, and communication. For example, group cohesion became tighter with increased boat traffic for bottlenose dolphins in Sarasota, Florida (Nowacek et al. 2001) and Chilean dolphins in Chile (Ribeiro et al. 2005), likely as a means to help coordinate movements among group members. Dolphins also exhibit increased breathing synchrony in response to high vessel traffic. Thirty and a half percent of a bottlenose dolphin group in Moray Firth, Scotland, synchronized their breathing, likely as an antipredator tactic from the perceived threat of vessels (Hastie et al. 2003). Dolphin species also utilize their acoustic abilities to help establish group cohesion. For example, bottlenose dolphins' whistle rate in Sarasota, Florida, increased prior to the passing of vessels, likely as a result of heightened arousal or an attempt to establish group cohesion before the disturbance (Buckstaff 2004). In contrast, Indo-Pacific humpback dolphins in Australia increased their whistle rate after vessels passed within 1.5 km, with mom/calf pairs exhibiting the highest whistle rate, likely to re-establish cohesion (Van Parijs & Corkeron 2001). Acoustic disturbance also has general impacts on species' foraging and social behavior. Bottlenose dolphin call rates and creaks associated with foraging and social behavior decreased in the presence of various types of vessels in Portugal (Luís et al. 2014). In Brazil, the number of individual humpback whale singers decreased in the presence of high vessel traffic, indicating that they either stopped singing in response to the traffic, or possibly moved out of the recording range (Sousa-Lima & Clark 2008).

1.8 Habitat Use Effects

1.8.1 Habitat Preferences

In many cases, dolphins prefer certain habitats for protection while engaged in specific behaviors, like foraging. High densities of vessel traffic have the potential to disturb animals and alter their habitat use. There are three publications that examine bottlenose dolphin habitat use in response to vessel traffic. Two papers document a shift in habitat usage and the other did not. Allen & Read (2000) documented bottlenose dolphins in Clearwater, Florida shifting away from primary foraging habitats during periods of high boat density (Allen & Read 2000). During weekdays with less boat traffic, the dolphins strongly preferred foraging in the channel and spoil island habitats; however, on weekends, with more vessel traffic, the animals did not exhibit strong patterns of habitat selection (Allen & Read 2000). The authors suggest the dolphins shifted their foraging habitat preference to directly avoid vessel traffic, or in response to the movement of prey influenced by vessel traffic (Allen & Read 2000). Select habitats also provide protection from predators and anthropogenic impacts. Bottlenose dolphins in Core Creek, North Carolina, prefer the deeper waters of the Intercoastal Waterway and were observed to spend 85% of their time there when vessel traffic was low (Latusek 2002). However, as vessel traffic increased, animals were observed occupying the shallower waters outside of the Intercoastal Waterway and reduced the time spent in their preferred habitat by 17% (Latusek 2002). Lastly, La Manna et al. (2010) examined the relationship between bottlenose dolphin distribution in the Straits of Italy and the type and number of vessels present. The authors did not observe any disruptions in habitat preference. These results may be explained by the ecological importance of the area with high prey availability and plentiful foraging opportunities (La Manna et al. 2010).

1.8.2 Displacement

Short-term and localized habitat displacement has been documented for bottlenose dolphins in Croatia in response to high boat traffic conditions (Rako et al. 2012, Rako et al. 2013). In Croatia, Rako et al. (2012) documented a significant decrease in bottlenose dolphin sightings in areas of high anthropogenic pressure. The authors suggest that localized displacement from critical habitat may be occurring as a result of a large number of high speed boats, which increase underwater noise (Rako et al. 2012, Rako et al. 2013). Continued short-term avoidance strategies may result in long-term displacements from preferred habitat.

1.9 Health Effects

1.9.1 Mortality

High volumes of vessel traffic within marine mammal habitats can increase the risk of boat collision injuries and mortalities. In the Indian River Lagoon, Florida, from 1996 to 2006, Bechdel et al. (2009) reported 43 bottlenose dolphins, or 6% of the population, exhibited scars indicative of boat collisions. Two counties within the Indian River Lagoon, St. Lucie and Martin, have the highest number of registered boats per square kilometer of habitat. The highest rates of dolphin boat collision coincided with these two counties (Bechdel et al. 2009). Confirmed collisions have also been identified for other small cetacean and large whale species worldwide (Van Waerebeek et al. 2007). Among large whale species, vessel-caused mortality and traumatic injuries have been documented primarily for southern right, humpback, and Bryde's whales, but also include sperm, blue, sei, and fin whales (Van Waerebeek et al. 2007). Secondary deaths as a result of vessel strike have also been documented (e.g., an orphaned calf died three weeks after its mother was killed by a boat) (Bechdel et al. 2009). The risk of vessel-strike mortality is also increased for species that do not appear to leave areas with high levels of vessel traffic and for animals that become habituated to vessels. For example, two Hector's dolphin calves were found dead in Akaroa Harbor, New Zealand, an area known for increasing competitive use between humans and marine mammals (Stone & Yoshinaga 2000). One calf was confirmed dead from propeller wounds and the other was most likely a result of vessel collision. The authors suggest that vessel strikes will increase as the high volume of vessel traffic in the harbor is expected to increase over time, potentially resulting in serious consequences for the Hector's dolphin population (Stone & Yoshinaga 2000).

2.0 Reproductive Effects

2.0.1 Reproductive Rate/Juvenile Survivorship

One paper looking at general vessel traffic exposure documented a decline in harbor seal pup survivorship. In response to vessel traffic in Alaska, 77% of harbor seals flushed into the water when cruise ships passed within 200 m (Jansen et al. 2010). Pups, with little insulating blubber, are likely to incur energy deficits if they spend more than 50% of their time in the water, such that a flushing response to cruise ship traffic may decrease their chance of survivorship (Jansen et al. 2010).

Conclusions and Summary of Risks from Vessel Interactions

There are recurring themes throughout the published literature on marine mammal responses to tour based interactions and vessel traffic. One common finding is the effect of tour vessels and vessel traffic on marine mammal activity budgets, such as decreased foraging and resting, and increased time traveling (e.g., Lusseau 2004, Williams et al. 2006, Stockin et al. 2008, Arcangeli & Crosti 2009, Steckenreuter et al. 2012, Christiansen et al. 2013b, Meissner et al. 2015). These changes in behavior can have short-term effects resulting in decreased prey acquisition, increased energy expenditure from additional travel, and increased predation from lack of rest. Changes in short-term behavioral patterns may alter long-term survival and reproduction at the individual and population level (e.g., Bejder 2005, Lusseau 2005, Lusseau & Bejder 2007, Currey et al. 2009, French et al. 2011, Peters et al. 2013). In addition, when certain behaviors are disrupted by vessel presence, it takes a significantly longer time for an animal to return to the previous state it was engaged in prior to the disturbance, exacerbating the effects of the disturbance (e.g., Meissner et al. 2015).

Horizontal and vertical avoidance techniques were also commonly documented among marine mammals to evade the pressure of tourism and vessel traffic. The biological effects from these behavioral responses include both long and short-term habitat displacement (e.g., Allen & Read 2000, Lusseau 2005, Bejder et al. 2006b, La Manna et al. 2010). The area an animal occupies is not arbitrary; rather, it is driven by habitats that provide optimal feeding, resting, and calving opportunities, as well as protection from predation. However, when vessels create disturbance in these critical habitats, animals may avoid those areas, potentially compromising their refuge to engage in biologically significant behaviors (e.g., Allen & Read 2000, Lusseau 2005, Lusseau et al. 2009, Rako et al. 2013). In some cases, the availability of suitable habitat elsewhere to retreat to is not available, so marine mammals remain in the same location, despite the disturbance (Gill et al. 2001).

Responses to disturbance can put marine mammals at risk for potential illness, injury, or death. Vessel interactions increase animals' risk of boat collision injuries or mortalities, predation, and may reduce juvenile survivorship (e.g., Currey et al. 2009, Jansen et al. 2010). Slow moving animals, such as manatees, are often unable to evade high speed vessels or heavily trafficked zones and risk injury from boat collision (Nowacek et al. 2002). Dolphin calves and juveniles are less experienced around vessels and have been documented alive and dead with propeller scars across their bodies (e.g., Nichols et al. 2001, Kreb & Rahadi 2004, Lusseau 2005). Vessel interactions may result in habitat avoidance or mother-calf separation, which increases animals' risk of predation (Van Parijs & Corkeron 2001, Lusseau 2005). Vessel traffic and tour boat interactions have also been documented to elicit flushing among pinniped species, in which incidences of stampeding to the water have resulted in death, especially for pups (Pavez et al. 2011, Andersen et al. 2012, Osinga et al. 2012).

Behavioral studies on mysticetes (Christiansen et al. 2015, Christiansen & Lusseau 2015) and odontocetes (Richter et al. 2006, Bain et al. 2014) have documented that short-term behavioral responses do not always translate into long-term consequences. Christiansen et al. (2015) measured the effects of behavioral disturbances caused by whale watching in Iceland on minke whale fetal growth. Although feeding activities were disrupted and energy expenditure increased, as capital breeders that only eat during a foraging season and fast the rest of the year, the energetic disturbance constituted less than 1% of the animal's overall energy requirement, resulting in a negligible impact on fetal growth. Similarly for odontocetes, Bain et al. (2014) concluded that southern resident killer whales are only affected by the whale watching industry 25% of the year, resulting in energetic consequences on the order of 3-4%. Authors of these studies acknowledge that despite these results, behavioral disturbance is not absent. However, when the pressure from tourism or vessel interactions is seasonal, due to specific whale watching seasons, or accounted for in species' life history patterns, the long-term consequences may be less severe.

Other studies have documented how short-term avoidance and behavioral responses can lead to long-term biologically significant effects for individuals and populations (e.g., Bejder 2005, Lusseau 2005, Bejder et al. 2006a, Bejder et al. 2006b, Lusseau 2006, Lusseau et al. 2006, Williams et al. 2006). Changes in individual marine mammal energy budgets in response to tourism pressure and vessel traffic are commonly reported. When changes in energy budgets begin to reduce the survival and reproduction probability of individuals, the consequences become exaggerated as the population declines and tourism and vessel traffic pressure remains constant (Lusseau et al. 2006). Short-term shifts in habitat use from areas of high to low disturbance may eventually result in long-term habitat displacement (Lusseau 2005, Bejder et al. 2006a, Bejder et al. 2006b, Lusseau et al. 2006).

Throughout the literature, terminology used to describe disturbance can be problematic, specifically with regard to the terms tolerance and habituation, and how they are both used and interpreted. Misuse of terms or a misunderstanding of the range of factors that influence animals' responsiveness to disturbance could give the false impression that human interactions have neutral or benign consequences (Bejder et al. 2009). Habituation is a longer term process and requires sequential measures recorded from the same individuals over time; most studies, however, are restricted to measuring short-term behavioral responses. If a study is short-term in nature, there is a need to collect and consider the range of factors that may influence an animals' response in order to accurately define biological relevance of observed short-term effects (Higham & Shelton 2011). This is an important idea to keep in mind as some papers document a neutral response to vessel interactions, implying that the interaction is resulting in no negative effect on the target species. While this may be the case, especially in low tourism areas, it may not necessarily be true if considered out of context or over a very short time period.

Tour-based interactions and vessel traffic elicit a variety of responses that impact the overall behavior, habitat use, health, and reproduction of marine mammals. Typically, there are several factors associated with the nature of these interactions, such as vessel approach type, number of vessels, or vessel approach distance, which may influence an animal's response. The location of interactions and the extent of anthropogenic pressure also play a large role in recorded behavioral responses. Each response is also dependent on the species, life history patterns, biology, and social structure of animals involved. However, in general, the literature suggests that marine mammals tend to most commonly exhibit horizontal or vertical avoidance strategies or shift locations in response to vessel pressures. These responses to disturbance affect the animals' energetics, however the specific long-term repercussions to the animal's health and survival is still undetermined for most species.

Chapter 2. Swimmer Interactions

Introduction

For this literature review, we characterize swimmer interactions as any activity between a human swimmer(s) in the water and a marine mammal(s). Swimmer interactions are typically associated with commercial or recreational vessels but are occasionally land-based. The majority of literature available (2000-2015) and presented in this review focuses on swim-with tourism from commercial boats. These types of tours vary how they conduct swimming with marine mammals and may allow passengers to either free-swim, snorkel, or hold onto a line attached to a boat called a "mermaid line", or something similar to keep swimmers close to the tour vessel. In some studies, the authors measure animals' response to both vessels and swimmers, but separately analyze and document the results from each type of interaction. Thus, there are overlapping references to papers cited in this chapter and Chapter 1. However, this chapter specifically summarizes animals' responses to swimmer presence.

We included 38 scientific papers, dissertations, theses, and workshop reports that document effects of swimmer interactions on 15 marine mammal species. Species include 8 odontocetes (bottlenose, Indo-Pacific bottlenose, common, spinner, Burrunan, and Hector's dolphins, short-finned pilot whales and beluga whales); 3 pinnipeds (Australian and New Zealand fur seals, and California sea lions); 3 mysticetes (minke, dwarf minke, and southern right whales); and manatees. Swim-with activities are primarily documented in the United States, New Zealand, and Australia, with some literature from Argentina, East Africa, Canary Islands, Canada, and Mexico. However, this is not an exhaustive list of all the species or geographic areas where swim-with activities take place. After conducting an extensive web search, Rose et al. (2005) found that swims with humpback and minke whales are most common among whale species, and occur primarily in the Dominican Republic, Tonga, and Great Barrier Reef. Swim-with activities are known to occur with even more species (e.g., killer whale, bowhead whale, blue whale, gray whale, fin whale, sei whale, southern right whale, and sperm whale); however, the impacts from those interactions have not been well-documented in the published scientific literature, and are therefore not included in this review.

2.1 Behavioral Effects

2.1.1 Behavioral Budgets

It is well established throughout the literature that swim-with activities alter the natural behavioral budgets of many marine mammal species including spinner dolphins (Forest 2001, Östman-Lind et al. 2004, Danil et al. 2005, Courbis & Timmel 2009, Symons 2013, Johnston et al. 2014, Tyne 2015), common dolphins (Neumann & Orams 2006, Meissner et al. 2015), bottlenose dolphins (Constantine et al. 2003, Samuels & Bejder 2004, Peters et al. 2013), Hector's dolphins (Nichols et al. 2001), Indo-Pacific dolphins (Stensland & Berggren 2007), Burrunan dolphins (Filby et al. 2014), southern right whales (*Eubalaena australis*) (Lundquist 2007, Lundquist et al. 2008), and manatees (King & Heinen 2004).

Swimmer interactions alter natural behavior by changing the amount of time an animal spends engaged in essential activities necessary for their survival, such as foraging, resting, mating, and socializing. The changes in activity budgets caused by swimmers are similar to changes in activity budgets associated with vessel interactions. The most frequently documented behavioral changes are decreased time spent resting and foraging and increased time spent traveling and milling. For example, southern right whales in Argentina spent one-third less time resting and socializing in the presence of swimmers and increased their time spent traveling during the interaction by 22% (Lundquist 2007, Lundquist et al. 2008). Spinner dolphins in Hawaii rest inshore during the day and forage offshore at night; daytime access to shallow, sandy bottom coves and bays are essential for the animals to rest and avoid predators (Würsig et al. 1991, Norris et al. 1994, Thorne et al. 2012). However, these resting bays have become targets for swim-with tours since they are easily accessible to the public. Johnston et al. (2014) observed vessels and/or swimmers within 150 m of dolphins in over 75% of their sampling events. As a result of swimmer disturbances, Danil et al. (2005) documented spinner dolphins departing bays much earlier in the afternoon than expected, depriving them of rest and shelter. Tyne et al. (2015) further document the importance of these resting bays by illustrating that resting spinner dolphins displaced from these areas are unlikely to engage in resting behavior elsewhere.

In Florida, West Indian manatees decreased the amount of time they spent foraging when swimmers were in close proximity (King & Heinen 2004). Numerous studies have also documented increased milling behavior in response to swimmers by bottlenose dolphins (Constantine et al. 2003, Peters et al. 2013); West-Indian manatees (King & Heinen 2004); and Burrunan dolphins (Filby et al. 2014), suggesting that marine mammals are being disrupted from crucial feeding, socializing, and resting behaviors. Swim-with interactions continue to alter bottlenose dolphins' behavioral budgets long after swimmers have exited the water and vessels have departed the study area (Peters et al. 2013).

2.1.2 Avoidance

Throughout the published literature, horizontal avoidance tactics such as changes in swim speed, direction, or movement patterns were used by marine mammals to avoid swimmer interactions. Such tactics have been documented in Indo-Pacific bottlenose dolphins (Stensland & Berggren 2007); spinner dolphins (Delfour 2007, Timmel et al. 2008); southern right whales (Lundquist 2007, Lundquist et al. 2008); humpback whales (Kessler et al. 2013), and manatees (King & Heinen 2004). In most cases, the species have been documented increasing swim speed and changing swim direction more frequently as the number of swimmers increased.

Certain aspects of swimmers' presence play a role in marine mammals' responses, including swimmer placement, swimmer behavior, and also animal group composition. In general, bottlenose and Hector's dolphins exhibited less avoidance behavior when swimmers were placed parallel to the path of an animal or group of animals in the water (Constantine 2001, Constantine et al. 2003, Martinez et al. 2011), and more prominent avoidance behavior was observed when swimmers were placed in the path of the animals (Martinez et al. 2011). In Tonga, humpback whales departed significantly earlier from an area when approached by splashing swimmers compared to quiet, calm swimmer approaches (Kessler et al. 2013). In Argentina, animal group composition plays an important role in southern right whale's responses to swimmers. Mother-calf pairs and juveniles increase swim speed and adopted less linear swim paths in the presence of swimmers, while mixed adults/juvenile groups showed no significant changes in movement or behavior (Lundquist 2007, Lundquist et al. 2008).

There is little documentation on vertical avoidance behaviors. One study off the south coast of Zanzibar documented that Indo-Pacific bottlenose dolphins increased their proportion of active dives in the presence of swimmers (Stensland & Berggren 2007).

2.1.3 Surface Active Behaviors

Hawaiian spinner dolphins are well-known for surface active behaviors (e.g. leaping, spinning), which can indicate disturbance depending on the intensity, time of day and context (Forest 2001, Delfour 2007, Courbis & Timmel 2009). Courbis & Timmel (2009) documented in 2002 that spinner dolphin aerial displays were reduced in the early morning and late afternoon as animals entered and exited their resting bays. In contrast to this study, between 1993-1994, Forest (2001) indicated in her study that spinner dolphins displayed a bimodal distribution of aerial behavior with higher rates of activity before 7 am and after 3 pm. Similarly, the frequency of aerial activities have been documented to decrease from 2.23 per hour in the 1970s (Würsig et al. 1991, Norris et al. 1994) to 0.750 per hour in the 2002 study (Courbis & Timmel 2009). Courbis & Timmel (2009) suggest for their 2002 study that the diminished aerial behavior could indicate newly adopted cryptic behaviors used to avoid being seen and targeted by vessels engaged in swim-with activities (Courbis & Timmel 2009). Forest (2001) also suggested less aerial behavior entering and exiting the bay may be indicative of diminished energy levels.

2.1.4 Haul out

Only one study reports pinnipeds hauling out as a response to swimmer presence. Stafford-Bell (2012) observed that Australian fur seals hauled out initially when one or two swimmers entered the water. However, over time, the rate of hauling out generally decreased as the number of swimmers increased. In some instances, seals interacted with swimmers and even mimicked their underwater actions, which led authors to conclude that Australian fur seals are becoming habituated to the presence of swimmers in Port Phillip Bay, Australia. Habituation in this study was defined as a reduction in responses to an ongoing stimulus that is not a result of fatigue or adaptation (Stafford-Bell 2012).

2.1.5 Initiation

Some studies reported marine mammals, such as dwarf minke whales (*Balaenoptera acutorostrata*), Hector's dolphins, bottlenose dolphins and southern right whales, initiated interactions with swimmers (Birtles et al. 2002, Lundquist 2007, Lundquist et al. 2008, Martinez et al. 2011, Peters et al. 2013). An interaction is often defined as an animal approaching a vessel, which results in swimmers entering the water to begin an "in-water" interaction, or when an animal approaches swimmers already in the water (Birtles et al. 2002). Interactions are also characterized by the distance between an animal and a swimmer and the length of time they remain within that distance (i.e., remain within 5 m for a minimum of 10 seconds) (Martinez et al. 2011). Authors suggest that animals engaged in milling behavior (Martinez et al. 2011), larger group sizes (Neumann & Orams 2006, Peters et al. 2013), and younger age classes (Constantine 2001, Lundquist 2007, Lundquist et al. 2008) are more likely to initiate an interaction with swimmers in the water.

A handful of studies documented an interaction-neutral-avoidance response to swimmers (Neumann & Orams 2006, Boren et al. 2009, Cowling et al. 2014b). At the beginning of an interaction, animals are likely curious about swimmers in the water and initiate a close approach (Neumann & Orams 2006, Cowling et al. 2014b). This is then followed by a period of lost interest towards the swimmers and neutral behavior, eventually resulting in avoidance of the vessels and swimmers (Neumann & Orams 2006, Cowling et al. 2014b).

2.1.6 Aggressive/Threatening Behavior

In a review of self-initiated behaviors of free-ranging cetaceans directed towards human swimmers, aggressive or threatening behaviors were mainly reported for food-provisioned and lone, sociable dolphins, likely responding to inappropriate human behaviors (Scheer 2010). Samuels & Bejder (2004) reported individual bottlenose dolphins slapping their fluke on the surface of the water when swimmers were in close proximity, leaping over swimmers, and displaying open mouth behavior to threaten swimmers during non-feeding swim-with events. In Tenerife, Canary Islands, short-finned pilot whales were reported to headshake (i.e., an individual rhythmically shakes its head and adjacent body part from left to right with the melon directed towards the swimmer) (Scheer et al. 2004). Frohoff et al. (2000) observed numerous aggressive and threatening behaviors displayed by beluga whales (*Dephinapterus leucas*) in Eastern Canada during swimmer encounters: head jerking (quick movement of an individual's head to avoid physical contact with a human), hitting (forceful contact with a part of its body), jaw slapping (abrupt opening and closing of its jaw underwater producing a slapping noise), open mouth behavior, and pushing (shoving or nudging a swimmer forcefully with its rostrum) (Frohoff et al. 2000). Dwarf minke whales in the northern Great Barrier Reef, Australia were observed displaying open mouth behavior during swimmer interactions (Birtles et al. 2002).

2.2 Habitat Use Effects

2.2.1 Displacement

Habitat displacement as a result of swimmer disturbances has been documented for spinner dolphins in Hawaii. Danil et al. (2005) documented that spinner dolphins in Hawaii spend less time in their primary resting habitat due to high levels of swim-with tours. As the number of swimmers increased, dolphins departed their resting bay earlier than they did if fewer to no swimmers were present (Danil et al. 2005). In the presence of one to five swimmers, dolphins departed the bay around four to five o'clock in the evening. As the number of swimmers increased to greater than 15, dolphins were recorded departing the bay as early as noon to one o'clock (Danil et al. 2005). Should dolphins be displaced from their resting bays, it is unlikely that they will engage in resting behaviors outside of those areas (Tyne et al. 2015). Östman-Lind et al. (2004) provide a similar example of short-term displacement and area avoidance in Makako Bay, Hawaii. They observed two swim-with tour vessels follow a group of spinner dolphins into Makako Bay, where they were joined by two other vessels and spent an hour following the dolphins with 10 or more people in the water. The dolphins then exited the bay and milled offshore for approximately a half hour until the boats and swimmers left, at which time the dolphins re-entered the bay (Östman-Lind et al. 2004). Östman-Lind et al. (2004) have also documented evidence of long-term habitat displacement in Hawaii. Makako Bay was the most frequently used resting bay from 1989-1992, but in the 2004 study, the dolphins were utilizing a different bay to the north much more frequently. The authors attributed this to the higher levels of tourism in Makako Bay and the lower levels of tourism in the bay to the north.

2.2.2 Ranging Patterns

Swim-with tour interactions, similar to vessel-based tour interactions, have been documented to influence animals' ranging patterns. In Panama City, Florida, Samuels & Bejder (2004) reported the ranging patterns for bottlenose dolphins engaged in swim encounters with humans were much smaller than those of animals that did not. Dolphins engaged in swim encounters remained within less than one nautical mile from the area where boats, jet skis, and swimmers routinely congregated for interactions with the animals. However, it is important to note that the animals engaged in swim encounters were conditioned to take food items from people, so their altered ranging patterns could have been confounded with the effects of people feeding them rather than just swimmer interactions alone.

2.3 Development and Reproductive Effects

2.3.1 Reproductive Rate/Juvenile Development

French et al. (2011) found California sea lions' reproductive rates decreased in response to the presence of swimmers/divers within 50 m; however, at the same time, pups' growth rates increased. In this situation, the increase in growth rates is likely a result of the reduction in reproductive rates, which allows for more available resources for the remaining growing pups (French et al. 2011). Although it was not specified in the study that the swimmers/divers were specifically targeting the sea lions for tourism purposes, the close approach distance of 50 m is likely a means to actively view the animals from a closer distance.

Juvenile bottlenose dolphins are more likely to interact with swimmers than adult dolphins (Constantine 2001). The interactions between juveniles and swimmers could be a form of play, similar to those between conspecifics, however, these misplaced interactions could interfere with the development of necessary foraging and social skills (Constantine 2001). In New Zealand, Constantine (2001) documented adult dolphins interacting with swimmers during 26.7% of observations compared to 67.5% for juveniles. In addition, when juveniles were engaged in a sustained interaction with swimmers, they were not observed in close proximity with an adult (Constantine 2001). In Panama City, Florida, a juvenile dolphin was put at risk once every 12 minutes from human interactions, either from vessels or swimmers (Samuels & Bejder 2004).

2.3.2 Nursing

Swimmer presence also results in decreased nursing behavior (King & Heinen 2004, Stensland & Berggren 2007). Manatee calves significantly reduced the amount of time they spent nursing in the presence of swimmers (King & Heinen 2004). Indo-Pacific female dolphins increased their travel time as swim-with tourism activities increased; thus, the authors hypothesized that females would have less available time to nurse their calves, thereby jeopardizing the fitness of the population (Stensland & Berggren 2007).

Conclusions and Summary of Risks from Swimmer Interactions

The primary risks to marine mammals from swimmer interactions include habitat displacement, energetic implications from behavioral changes, increased avoidance and disturbance behavior, and the potential risks to both humans and animals associated with aggressive and threatening behavioral displays and habituation.

Habitat displacement is well documented in the literature as a result of swimmer interactions (e.g., Östman-Lind et al. 2004, Danil et al. 2005). For spinner dolphins, in particular, long-term studies have documented habitat displacement from a favored resting bay that has high tourism pressure, to another less frequently visited bay with less swim-with dolphin tourism pressure (Östman-Lind et al. 2004). Habitat displacement increases the risk of predation as animals abandon their primary habitat and move into unfamiliar and presumably less safe areas (Danil et al. 2005, Bejder et al. 2006b). This new habitat might not provide the essential features (e.g. depth, benthic substrate) that play a key role in performing essential life functions, such a foraging, socializing, or resting (Thorne et al. 2012, Tyne et al. 2015).

Swimmer interactions can also place additional energetic stress on animals as a result of altered activity budgets and increased avoidance tactics. For spinner dolphins, decreased resting time from intense tourism exposure may result in an energetic deficit affecting the fitness of those animals. Using a theoretical model to calculate resting requirements for spinner dolphins based on consumption requirements, the model predicted that spinner dolphins must spend 40-60% of their day resting to be in a positive energetic balance (Symons 2013, Johnston et al. 2014). Based on actual observations, it appears that the resident population is likely meeting their rest requirements; however any increase in tourism exposure may push them over the threshold (Symons 2013). Spinner dolphins also exhibit aerial disturbance behaviors, such as leaping and spinning, that have greater energetic costs than resting behavior would in the absence of swimmers (Forest 2001). The effects of increased energy expenditure are exaggerated for animals that utilize a habitat solely for resting, such as spinner dolphins in Hawaii (e.g., Danil et al. 2005, Courbis & Timmel 2009, Symons 2013, Johnston et al. 2014, Tyne et al. 2015), or for breeding and calving, such as southern right whales in Argentina (Lundquist 2007, Lundquist et al. 2008). When marine mammals expend additional energy in response to swimmers during critical periods, this may interrupt social interactions and foraging opportunities, which could have long-term health and reproductive effects on the population.

Lastly, species such as dwarf minke whales, New Zealand fur seals, and spinner dolphins have been documented to be habituated to swimmers during interactive tours (e.g., Birtles et al. 2002, Timmel et al. 2008, Cowling et al. 2014b). These types of interactions between swimmers and animals in the wild are not natural and pose significant threats to both the animal and human involved. Habituated animals display less avoidance behavior towards vessels and swimmers (Stone & Yoshinaga 2000). They become emboldened to closely approach people and vessels, exposing them to physical risks from boat propellers and health risks from food handouts. Samuels & Bejder (2004) determined juvenile bottlenose dolphins are at risk once every 12 minutes from human interactions. Swimmers interacting with marine mammals in the water may be exposed to aggressive or threatening behaviors from animals during encounters (reviewed in Nichols et al. 2001, Scheer 2010). Headshakes, pushing, hitting, and jaw slaps are just a few examples of high risk behaviors short-finned pilot whales, belugas, and bottlenose dolphins have displayed during swimmer interactions (Frohoff et al. 2000, reviewed in Nichols et al. 2001, Scheer et al. 2004). Biting and open mouth behaviors can be a part of conspecific play behavior; however, when accidentally or intentionally directed towards a person in the water, it could result in serious risk of injury (reviewed in Nichols et al. 2001). Swimmers who are not familiar with or able to recognize threatening behaviors may not know when to terminate an interaction, and therefore, increase their chances of sustaining an injury.

In comparison to vessel interactions, there is significantly less literature documenting swimmer-marine mammal interactions. However, marine mammals' response to swimmers and vessels are similar considering that a vessel transports swimmers to engage in a swim-with interaction. Patterns of habitat displacement, area avoidance, changes in behavioral budgets, and increased risks for humans and animals have been documented in response to swimmer interactions.

Management Recommendations for Vessel and Swimmer Interactions

Management plans designed to regulate vessel and swimmer interactions with marine mammals are typically similar in structure given that vessels are the primary platform for swim-with tours and it is impossible to manage one without considering the interactions of the other. For this reason, the management regimes recommended and discussed in scientific papers, dissertations, and reports have been combined for both interaction types. Reoccurring recommendations highlighted throughout the literature include: (1) increase enforcement of guidelines and regulations, (2) revisit viewing distance and vessel speed guidelines, (3) increase education and awareness, (4) redesign management systems, and (5) implement time-area closures or marine protected areas.

One of the most commonly cited recommendations to reduce harassment from vessels and swimmers is to promote adherence to and increase enforcement of existing guidelines and regulations (e.g., King & Heinen 2004, Delfour 2007, Tosi & Ferreira 2008). Federal and State wildlife viewing guidelines are typically based on scientific research or common sense principles. When these guidelines are responsibly followed by tour operators and participants, the impact from tour boats and swimmers are less harmful. For example, in New Zealand, one study found negligible impacts from swimmers and tour boats on common dolphin behavior, likely because there was a high rate of compliance to the New Zealand Marine Mammals Protection Regulations in this area (Neumann & Orams 2006). Cowling et al. (2014b) reported similar results for New Zealand fur seals when regulation compliance was nearly 100%. In general, when vessels and swimmers adhere to established guidelines or regulations, people often enjoy a higher quality viewing experience because the targeted animals are less likely to avoid the area. For example, tourists have had increased viewing times with humpback whales, Indo-Pacific bottlenose dolphins, and Guiana dolphins when tour vessels were responsible and approached parallel to the animal (Filla & Monteiro-Filho 2009, Hawkins & Gartside 2009a, Stamation et al. 2009).

In most locations where viewing guidelines or regulations exist, compliance is low due to a lack of enforcement. An increase in enforcement personnel on the water would likely serve as a financial incentive for compliance. For example, in the United States, violations of the Marine Mammal Protection Act (MMPA) can be prosecuted civilly or criminally depending on the severity of the offense. Harassment cases most often result in fines. To demonstrate the effectiveness of enforcement, harassment of dolphins significantly decreased when law enforcement vessels were present on the water during a docent program in Sarasota, Florida

(Cunningham-Smith et al. 2006). Enforcement could also improve through self-regulation within a community of users targeting marine mammals in the same area (Heenehan et al. 2015). If a community can build trust and reciprocity to hold one another accountable to follow guidelines or regulations, this might lessen the need for official monitoring and enforcement from agencies (Heenehan et al. 2015).

Another management recommendation to reduce disturbance is to revisit viewing distance guidelines. Animal responses to vessel approaches can be dependent on a variety of factors including: species type, vessel type, animal group composition, presence of a calf, mating/breeding season, and behavioral state. All these factors should be considered when developing effective viewing distance guidelines (e.g., Boren et al. 2002, Johnson & Acevedo-Gutiérrez 2007, Yazdi 2007, Steckenreuter et al. 2012). Most recommendations for viewing distance guidelines fall between 100 and 300 m (Jahoda et al. 2003, Scheidat et al. 2004, Morete et al. 2007, Lusseau et al. 2009, Noren et al. 2009, Schaffar et al. 2013). However, disturbance has been recorded at further distances (e.g., Schaffar et al. 2009, Andersen et al. 2012, Young et al. 2014). It is necessary to continue scientific research in order to update guidelines. For example, Noren et al. (2009) found that the existing guidelines that request vessels not to approach within a 100 m radius of whales and slow down to less the 7 knots within a 400 m radius were not sufficient to prevent disturbance to southern resident killer whales and recommended extending the viewing distance based on scientific evidence. Thereafter, in 2011 NOAA Fisheries announced new vessel regulations to prohibit vessels from approaching any killer whale closer than 200 yards and from parking in the path of whales (76 FR 20870, 14 April 2011). The effectiveness of these regulations were evaluated by comparing trends between the 5 years leading up to the regulations (2006-2010) and the 5 years following the regulations (2011-2015) (Ferrara et al. 2017). It was concluded that overall, the vessel regulations seem to have provided some benefit to the whales, but additional time may be needed to ensure that the regulations are sufficient in providing the whales adequate protection (Ferrara et al. 2017). In general, species-specific viewing distance guidelines may be the most effective way to address all the variables discussed above.

Reducing vessel speed can also help minimize human impacts on marine mammal behavior, acoustic impacts, and mortality (Williams et al. 2002a, Ng & Leung 2003, Goodwin & Cotton 2004, Laist & Shaw 2006, Smith 2008, Bechdel et al. 2009, Jensen et al. 2009, Rako et al. 2013). For example, it has been suggested that a boat cruising at 10 km/h and making a slow approach within 50 m of killer whales will have less acoustic and behavioral impacts, than if a boat was approaching faster and closer (Erbe 2002, Jelinski et al. 2002). However, in the absence of or non-compliance to vessel speed guidelines, animals have been recorded to change swim path directness and deviate when motor boats and jet skis speed pass (Williams et al. 2002b, Goodwin & Cotton 2004). Faster vessels also increase sea ambient noise, which has been documented to result in habitat displacement, masking, and temporary threshold shifts for marine mammals (e.g., Erbe 2002, Rako et al. 2013). Preliminary results have shown positive results of implementing and enforcing year-round, slow-speed regulations in Brevard County, Florida to help reduce boat-strike mortalities to manatees (Laist & Shaw 2006). In the 42 months prior to the new rules, there were 2.34 manatees deaths per year, compared to the 0.29 deaths per year following when the rule went into effect (Laist & Shaw 2006).

Another common recommendation is to increase education and outreach efforts with tour operators, recreational boat users, and the general public to mitigate human-wildlife interactions. While tour boat operators are sometimes aware of the guidelines and regulations for marine mammal viewing activities, enhanced outreach efforts can help clarify any issues to help decrease disturbance (e.g., Higham & Carr 2003, Christensen 2007, Morete et al. 2007, Stockin et al. 2008, Stamation et al. 2009, Heenehan et al. 2015). Keane et al. (2008) and Tyne (2015) propose that to achieve a successful management plan, rules and regulations must be supplemented with educational and enforcement programs. In New Zealand, dolphin tour operators must include an educational component to their dolphin-watching tours as a condition of obtaining a cetacean-watching permit (Carlson 2009). Increased education efforts may be particularly beneficial in areas of high density boat traffic, such as the Indian River Lagoon, Florida, where bottlenose dolphin boat collision injuries coincide with the highest number of registered boats per square kilometer (Bechdel et al. 2009). Increasing education efforts among the recreational boating community using pamphlets, signage, and workshops may help facilitate awareness resulting in compliance (Neumann & Orams 2005). An example of successful education and outreach efforts resulting in decreased harbor seal disturbance was documented in Kenai Fjord National Park, Alaska (Hoover-Miller et al. 2013). Through a series of operator workshops, orientations, and collaborations, seal disturbance rates from interactions with motor boats and kayakers decreased by 60% (Hoover-Miller et al. 2013).

Redesigning management systems is one way to reduce the number of boats or commercial tour operators around an individual or group of animals (Bejder et al. 2006b, Martinez et al. 2011, Papale et al. 2011, Steckenreuter et al. 2012, Lundquist et al. 2013, Tyne et al. 2014). Licensing or permitting systems are two ways to accomplish this if the legal framework is in place. In the United States, permits under the MMPA can authorize the “take” of marine mammals for only a limited set of activities, such as scientific research, documentary filming, public display, and commercial fishing operations. The MMPA does not provide a permit mechanism to “take” marine mammals for wildlife viewing or other similar recreational purposes; therefore, those activities must be conducted in a manner that does not harass or injure the animals. Vessel-based and swimmer interactions with marine mammals often cause behavioral changes, which is considered harassment. Behavioral changes can be a consequence of human activities, or it can be argued that they are changes due to natural shifts in activity. Tyne et al. (2015) point out a “need for an enforcement policy to make legislation more easily understood, less ambiguous and more fairly enforced.”

Licensing and permitting systems have been implemented or suggested in locations such as New Zealand, New Caledonia, and Australia (e.g., Constantine et al. 2003, Stockin et al. 2008, Scarpaci et al. 2010, Schaffar et al. 2013). These systems are only likely to be successful if the framework provides management agencies sufficient authority to change or revoke an operator's license should numerous violations occur (Bejder et al. 2006b, Higham et al. 2008, Tyne et al. 2014, Tyne 2015). Other factors that play into the success of reducing disturbance through a licensing/permit system are: the number of quotas or permits issued, the frequency of tour operating schedules, targeting the same group of animals as previous tours, and vessel compliance to viewing guidelines (Constantine et al. 2003). The permitted tourism industry that has developed at the Great Barrier Reef in Australia for swimming with dwarf minke whales has resulted in a 91% increase in the number of whales encountered over six seasons (2003-2008) (Curnock et al. 2013). Although the number of permitted operators has remained capped since permits were introduced in 2003, increased encounter rates have resulted from a shift in effort to target minke whale "hotspot" sites. In addition, endorsements to conduct swim –with tours are fully transferable, which has highlighted a substantial latent capacity in the industry (Curnock et al. 2013). Additional longitudinal and controlled studies are helpful to identify whether permits or quotas are effective, and if so, help define an ideal number of permits/quotas to issue to successfully reduce disturbance.

Spatial management through tools like Marine Protected Areas (MPAs) and time-area closures is another technique scientists have recommended to reduce cumulative exposure to human activity within specific marine mammal habitats. MPAs can limit or exclude vessel, swimmer, and other anthropogenic activities from occurring in important marine mammal habitats. Not only can this alleviate tourism pressure on marine mammals, but it can also provide an excellent opportunity to conduct controlled experiments on marine mammal behavior in the absence of human activity (Williams et al. 2006, Smith et al. 2008, Williams et al. 2011). Time-area closures, even as short as a few hours a day, could provide diurnal animals, such as Hector's and spinner dolphins, and non-diurnal animals, like Risso's dolphins, protection from vessel and swimmer pressure during critical resting periods (Martinez et al. 2011, Visser et al. 2011, Gormley et al. 2012, Tyne 2015). Other measures, such as seasonal closures, may be better suited to help relieve anthropogenic pressure during times when environmental variables, such as increased water temperatures or depleted prey resources, increase energetic demands for marine mammals (Lusseau 2003a). In Brazil, the delineation of a coastal reserve to control boat traffic has been successful in reducing impacts on Guiana dolphins (Tosi & Ferreira 2008). Similar suggestions of creating sensitive areas, protection zones, and area closures have been made to protect a number of species around the world (e.g., Stone & Yoshinaga 2000, Lusseau et al. 2006, Bain 2007, Hodgson & Marsh 2007). It is important after any management action is implemented to continue research and monitoring to evaluate the efficacy of the protections put in place (Hartel et al. 2014).

Using the best available science, numerous management techniques have been recommended to reduce disturbance from human-marine mammal interactions. These recommendations are a representative compilation of common themes throughout the scientific literature. They are not all feasible or applicable in each location where interactions occur. Rather, management decisions should be based on the unique characteristics of the location, the specific interaction/disturbance, and the species' behavior and life history patterns. However, given the rapidly evolving nature of tourism, scientists and managers are challenged to continually develop studies with appropriate temporal and spatial scales that quantify the population dynamics of tourism-exposed cetacean and pinniped populations (Tyne et al. 2014). Obtaining current estimates of population size, critical habitat, and baseline population parameters, coupled with behavioral responses to tourism activities, will help to identify when and which populations are most vulnerable and how best to revise and/or develop the most effective management plans (Tyne et al. 2014).

Chapter 3. Feeding Interactions

Introduction

Feeding interactions are characterized by humans intentionally feeding or attempting to feed marine mammals in the wild. Feeding of marine mammals, typically dolphins, occurs worldwide and can have broad behavioral and physical consequences on the animals. The literature in this chapter is divided into one of two sub-sections, "Legal Provisioning Programs" or "Illegal Feeding" to accommodate and highlight differences in the legalities (or lack thereof) of feeding marine mammals around the world. Each sub-section is followed by its own conclusions. The "Legal Provisioning Programs" sub-section describes examples of formal provisioning programs where dolphins are legally fed by park rangers or visitors. The "Illegal Feeding" sub-section highlights documented sites where dolphins are fed illegally by commercial dolphin tours or recreational boaters or fishermen. Feeding wild animals can result in a form of operant conditioning in which animals learn associations between human-related stimuli, their behaviors in response to the stimuli, and a food reward (Samuels & Bejder 2004). These animals are referred to as "conditioned" and can often be recognized by performing solicitous gestures (e.g., head up, beg, following a vessel) when there are human-related stimuli present or suspected of being present (Samuels & Bejder 2004, Donaldson et al. 2012).

We included 18 scientific papers, dissertations, theses, and workshop reports on feeding interactions with common bottlenose, Indo-Pacific bottlenose and tucuxi dolphins. Feeding occurs with other marine mammal species (e.g., manatees and pinnipeds), and there are numerous anecdotal examples of these interactions in social media, the news, and advertising. However, although these activities do occur, they are not scientifically documented. For the purposes of this review, only data and conclusions from scientific, peer-reviewed manuscripts, dissertations, theses, and workshop reports are included.

The effects from legal provisioning programs have been scientifically described in two locations in Australia: Monkey Mia and Tangalooma. The effects from illegal feeding are described in five locations worldwide: Cockburn Sound, Australia; Southeastern Brazil; Panama City Beach, Florida; Sarasota Bay, Florida; and Savannah, Georgia.

Part A: Legal Provisioning Programs

3.1 Monkey Mia in Shark Bay, Australia

Monkey Mia is the longest running dolphin provisioning site in the world. Although feeding dolphins was banned in Western Australia in 1998, Monkey Mia was included in a grandfather clause to continue provisioning bottlenose dolphins. Feeding dolphins in Monkey Mia has a long, evolving history beginning in the 1960s with fishermen tossing bait or unwanted catch to dolphins. In the 1970s, tourists began purchasing buckets of fish to feed dolphins while standing in the water (Mann & Kemps 2003). In 1989, the Department of Conservation and Land Management introduced regulations that limited feeding to specific matrilines of dolphins, and monitored the amount of fish fed to the dolphins monthly. Under this management regime, calf mortality rates increased and dolphin behavioral patterns changed (e.g., decreased maternal care and increased mother-calf separation) (Mann et al. 2000, Foroughirad & Mann 2013). For example, in March 1994, a tiger shark attacked a calf, left unattended by its provisioned mother, while she was being fed at the beach (Mann & Barnett 1999). As a result of this specific incident and increased calf mortality rates, new feeding policies were instituted in 1994 which included: (1) minimizing feeding to three times a day between 8:00-13:00 to allow dolphins time offshore to participate in natural behaviors; (2) restricting adult females to 2 kg of fish per day; (3) restricting feeding to non-calf females within one of the three matrilines, and (4) excluding feeding males to reduce the potential for aggressive displays (Mann & Kemps 2003). Fish quality and handling protocols became stricter and each of the feeding sessions began with an educational session (Mann & Kemps 2003).

Prior to a feeding session, tourists are permitted in the water where dolphins arrive and swim freely among tourists within viewing and touching distance (Smith et al. 2008). When feeding time begins, tourists step back and rangers bring out buckets of fish and provisioned animals approach the ranger's station (Smith et al. 2008). One at a time, a tourist is called over to feed the animal and then return to their position nearshore so the next person can be called (Mann & Kemps 2003). The last fish to each dolphin is fed simultaneously and the tourists are asked to step out of the water. The provisioned dolphins typically leave within five minutes after the feeding session ends (Mann & Kemps 2003).

To evaluate the efficacy of the 1994 management changes, two studies were conducted to investigate factors leading to risky interactions (i.e., potentially injurious to the human or dolphin) and reevaluating calf survivorship (Smith et al. 2008, Foroughirad & Mann 2013). Researchers found that risky interaction rates increased with longer wait times to feeding sessions, but also depended on the individual dolphin (Smith et al. 2008). Foroughirad & Mann (2013) found that calves born to provisioned mothers after 1994 exhibited higher calf survivorship than those born to provisioned mothers before the 1994 management changes; however, there were still marked differences in mother and calf activity budgets. Provisioned mothers provided less maternal care to their offspring compared to their non-provisioned counterparts (Mann & Barnett 1999, Foroughirad & Mann 2013). When mothers were at the provisioning beach near people, calves were unable to attain nursing position and were forced to wait upwards of half an hour before mothers left the beach and calves could regain nursing position (Foroughirad & Mann 2013). Calves of provisioned mothers foraged more than calves of non-provisioned mothers, likely as a way to compensate for decreased milk intake and increased energy expenditure needed to travel to the beach on a daily basis (Foroughirad & Mann 2013). Notably, five offspring born to provisioned mothers after 1994 survived infancy, but did not survive past the juvenile period. Particularly, four of the five offspring were born to one provisioned mother who consistently spent more time in the provisioning area and begging from boats offshore. The low juvenile survivorship is likely due to compromised developmental and social learning skills and insufficient hunting experience due to maternal neglect during the pre-weaning period (Foroughirad & Mann 2013).

3.2 Tangalooma, Moreton Island, Australia

Similar to Monkey Mia, Tangalooma has a long history of feeding interactions between dolphins and humans. In 1989, three methods to establish a regular feeding station at Tangalooma were attempted, but none were successful (Orams 1995). In 1992, another effort was initiated, this time proving successful and by the end of the year, three dolphins regularly visited the resort and accepted hand-held fish. This number grew to approximately six to eight dolphins regularly visiting by 1994.

In 1994, a management regime was established, which included (1) obtaining a reliable source of fish; (2) designating a specific dolphin feeding zone; (3) establishing a regular feeding time; (4) restricting the amount of fish offered to an estimated one third of dolphins' daily food intake; and (5) establishing strict procedures for tourists feeding dolphins. When the dolphins arrive, three to four guests enter the water and one at a time, hold the fish underwater for the dolphins to take. After a fish is taken, the group leaves the water and the next group enters. This "shallow water feeding system" differs from Monkey Mia, such that people are not permitted to remain in the water during the entire time dolphins are in the provisioning zone. This system has reduced the "pushy" and aggressive behaviors dolphins exhibited during feeding times and allows dolphins to spend more time interacting with each other than with humans (Hawkins & Gartside 2009b).

Over the 15 year history of the program, eight calves have participated in the provisioning program. Two calves belonged to mothers who were not provisioned at the time of giving birth, but were subsequently fed at Tangalooma; five calves were born to mothers who were provisioned at the time of birth (one subsequently became orphaned); and one orphaned calf was found adjacent to the provisioning area and began accepting fish from the program (Neil & Holmes 2008). Neil & Holmes (2008) suggest possible explanations for the unusually high calf survival rate (100%) at Tangalooma, considering two calves were orphaned and two were first-borns, which typically experience high mortality rates. Some of these explanations include the location of the provisioning area; Tangalooma is located on an island with boat access only, limiting the potential for unregulated human-dolphin interactions. Neil & Holmes (2008) also point out that the northeast part of Moreton Bay, where the provisioning area is located, has the best water quality from tidal flushing and is remote from sources of pollution. In addition, the authors suggest that the provisioning program may help reduce the risk of predation from foraging-related, mother-calf separation scenarios. Neil & Holmes (2008) further hypothesize that provisioning programs have the potential to help lactating mothers meet their energetic demands without expending as much energy to independently forage in the wild. Lastly, the management regime consisting of short, fixed feeding times, improved fish handling protocols, higher quality of fish, and prohibiting extended contact of hand-feeding may also contribute to 100% calf survivorship at Tangalooma (Neil & Holmes 2008).

Conclusions for Legal Provisioning Programs

The legal provisioning programs at Monkey Mia and Tangalooma are very similar, with the one main difference being the “shallow-water feeding system” at Tangalooma, where there are strict limitations for people entering the water with the dolphins. Despite the programs’ similarities, conclusions from research studies at both sites are significantly different. Although calf and juvenile survivorship at Monkey Mia increased significantly after the implementation of new management protocols in 1994, behavioral budgets of provisioned dolphins remained altered. Calves of provisioned mothers received less maternal care compared to calves of non-provisioned mothers, consequently compromising calves’ development of social and foraging skills (Foroughirad & Mann 2013). In comparison, calf survival rate was 100% over the 15 year history of the Tangalooma program (Neil & Holmes 2008). The authors suggest that the geographic location, characteristics of the feeding site, and revised management regime in this area may contribute to high survival rates by reducing predation risk and lowering energy expenditure for lactating mothers.

In comparing the research results at Tangalooma and Monkey Mia, it is important to consider the temporal scale. Monkey Mia is the longest running provisioning program, operating since the 1970s. In comparison, Tangalooma was successfully launched in 1994 after two previous attempts. The evolution of the dolphin feeding program and its effects on animals has been documented for a longer period of time at Monkey Mia and likely more accurately depicts the long-term effects of provisioning. Baseline and longitudinal studies of the general population, apart from the provisioned dolphins that participate in the program, are needed to quantify survival rates and statements regarding the success of the provisioning program in Tangalooma, especially given the contradictory evidence from the Monkey Mia program.

Part B: Illegal Feeding

3.3 Cockburn Sound, Australia

From 1993 to mid-1997, Cockburn Sound, Australia has a resident community of 74 bottlenose dolphins that have been exposed to illegal feeding primarily from recreational fishers since 1993 (Donaldson et al. 2010). The sound supports a number of commercial and recreational fishers and has a growing recreational tourism industry. As these anthropogenic pressures increase, studies have examined the growing number of provisioned animals (Finn et al. 2008), physical effects from interactions with humans (Donaldson et al. 2010), and possible factors that may contribute to dolphins becoming conditioned (Donaldson et al. 2012).

Long-term research has discovered that the number of conditioned dolphins in Cockburn Sound has increased from one animal in 1993 to 14 animals in 2003 (Finn et al. 2008). The majority of conditioned animals are adult males that approach recreational boats and appear to frequently utilize areas where recreational fishers are found such as seagrass beds, boats ramps, and shore-based fishing sites. These behavioral patterns suggest that dolphin's ranging patterns are becoming altered by provisioning. Not only has the number of conditioned dolphins increased since 1993, but so has the frequency at which they have been observed. The conditioned status of these animals is sustained through food handouts by recreational fishers, with anecdotal accounts suggesting other sources as well (Finn et al. 2008). Social learning has also been proposed as a propagation factor for the increased number of conditioned dolphins in this environment (Donaldson et al. 2012).

Illegal feeding increases the risk of injury to conditioned dolphins. Between 1993-2004 there were 12 reported incidences of injured animals in Cockburn Sound, three of which resulted in death (Donaldson et al. 2010). Three of the 14 conditioned animals had scars that were indicative of a boat strike; none of the other 60 dolphins in the resident community displayed boat-strike scars. In addition, two of the 14 conditioned animals became entangled in recreational fishing gear; one became entangled while engaged in feeding interactions (Donaldson et al. 2010). There are also additional examples which emphasize the importance of preventing feeding interactions considering the suite of anthropogenic activities that already exist and put these animals at risk of injury or mortality. For example, over 7 years (1996-2003), five non-conditioned calves became entangled in active or discarded fishing line (Donaldson et al. 2010). In addition, another injury, although not involving a conditioned dolphin, was the result of deliberate harm from what was suspected to be a spear-gun (Donaldson et al. 2010).

3.4 São Paulo estuarine waters, southeastern Brazil

The São Paulo State estuarine waters in southeastern Brazil serve as an important nursing area for tucuxi dolphins (*Sotalia fluviatilis*). The animals typically remain close to shore along estuarine bays and beaches to prey on fishes. In July 1996, a tucuxi mom-calf pair was observed close to a local fisherman's wooden trap to capture mullet (Santos et al. 2000). The adult female was then observed accepting hand-fed mullet from tourists who were aboard the fisherman's boat, an event that had been anecdotally reported since the end of the 1980s. Santos et al. (2000) documented that hand-feeding mullet to dolphins occurs in this community and through photo-identification, have been able to identify multiple dolphins participating in feeding interactions. As the numbers of tourists that come to this region to view tucuxi grow, there have been indications that other local fishermen have interest in conducting feeding tours. Although specific impacts to the tucuxi dolphins have not been documented, Santos et al. (2000) suggests that changes in natural foraging and social behavior, conditioning, and risk of injury or ingestion of contaminated food are all possible.

3.5 Panama City Beach, Florida, USA

For over two decades, Panama City Beach, Florida has been the most significant hotspot in the southeastern United States for illegal feeding and harassment of bottlenose dolphins. Currently, there are approximately 25 vessel-based and swim-with tour operators in the area, as well as a large recreational fishing presence (Machernis 2014). Participants on commercial dolphin tours, commercial tour operators, recreational fishermen, and the general public engage in dolphin feeding (Samuels & Bejder 2004). In 2004, seven dolphins were identified as having chronic interactions with humans (i.e., repeatedly observed to make close approaches to vessels and to display behavior indicative of human interaction). These animals were calculated to be fed once every 39-59 minutes (Samuels & Bejder 2004). During observations, conditioned dolphins spent 77% of their time engaged in human-interaction behaviors (i.e., remain close to vessel/swimmer, head up, beg, lunge at vessel, follow vessel, accept food). Conditioned dolphins may also be offered or teased with human food or non-food items that could be hazardous to their digestive system and further increase their risk of injury, illness, or death. There were marked differences in the ranging patterns between conditioned and non-conditioned animals, with conditioned dolphins spending the majority of time within less than one nautical mile of "Interaction Beach," where dolphin viewing and swim-with tours congregate and the majority of feeding occurs. Samuels & Bejder (2004) also concluded that juveniles are at increased risk of becoming conditioned as a product of social learning and uncontrolled food provisioning. In addition, illegal feeding of wild dolphins increases the risk of humans incurring injuries inflicted by dolphins from aggressive behavioral displays, such as tail-slapping or biting (Samuels & Bejder 2004).

3.6 Sarasota Bay, Florida, USA

Sarasota Bay, Florida is home to approximately 150 resident bottlenose dolphins (Cunningham-Smith et al. 2006). Some individuals in the population are food provisioned or depredate (dolphins taking fish from fishing lines) from recreational fishers (Cunningham-Smith et al. 2006, Powell & Wells 2011). Illegal feeding was documented in 1990, when a distinctively marked male dolphin, known as "Beggar" was observed begging and being fed regularly by boaters (Cunningham-Smith et al. 2006). Subsequently, seven other members from the Sarasota dolphin community were observed begging from vessels, likely due to social transmission, and consequently, there were an increasing number of dolphin bite reports. To address this problem, a three-phase study was initiated to characterize the types and frequency of boater-dolphin interactions and evaluate the efficacy of boater education and enforcement (Cunningham-Smith et al. 2006). Results of this study documented that of the 1,797 human interactions observed, most interactions involved Beggar; 26% involved humans splashing, teasing, and touching him, and 11% involved feeding him. Dolphin bites to eight people were also observed. Harassment towards and feeding of Beggar decreased when law enforcement increased their presence on the water, educating boaters on the harms of feeding wild dolphins and taking punitive actions. However, all illegal feeding and harassment behaviors were observed to increase again once law enforcement was no longer on the scene (Cunningham-Smith et al. 2006). In 2012, Beggar was found dead in Sarasota Bay. A necropsy was performed and while no definitive cause of death could be pinpointed, there were a number of indications that his interaction with humans was likely the leading cause of his death. Findings of the necropsy included several healed boat and puncture wounds, multiple broken ribs and vertebrae, fishing hooks and small pieces of line in the stomach, internal injuries from two stingray barbs, underweight, and dehydration – likely from not eating a normal dolphin diet (Wells et al. 2013)

Human interactions prompted by associations with Beggar may have also contributed to the death of a four-year old male calf in 2000 (Cunningham-Smith et al. 2006). The young calf and his mother were documented associates of Beggar. The calf stranded alive near Beggar's home range, and died shortly afterward, displaying evidence of human interactions, including emaciation, fishing gear entanglement, and lacerations from propeller wounds (Cunningham-Smith et al. 2006).

Powell & Wells (2011) described interactions observed between dolphins and recreational anglers. Their study was prompted by five stranded dolphins in 2006, four of which were recovered entangled in fishing gear and one that had a history of angler interactions. Powell & Wells (2011) found that increased incidences of depredation and other types of angler interactions were more prevalent after red tide events, when prey resources were depleted, and during peak tourist season, when the number of boaters and anglers were at their highest. Dolphins that engaged in depredation and other interactions with anglers had significant shifts in behavior; spending less time traveling and foraging and more time milling and interacting with boats (Powell & Wells 2011).

3.7 Savannah, Georgia, USA

Perrtree et al. (2014) investigated the prevalence of human interactions (begging, depredating, patrolling, provisioning, and scavenging) with bottlenose dolphins in Savannah, Georgia. When compared to other hotspots such as Cockburn Sound, Australia and Panama City Beach and Sarasota, Florida, dolphins in Savannah exhibited the highest rate of human-interaction behaviors (Perrtree et al. 2014). Begging was the most frequently observed dolphin behavior, comprising 22.4% of sightings, while other behaviors observed included patrolling, scavenging, and provisioning (Perrtree et al. 2014). Perrtree et al. (2014) only observed two instances of provisioning, both with commercial shrimp trawlers; however, the authors hypothesized that the reason they did not observe more instances was possibly due to the presence of their research vessel. Documentation of human-dolphin interactions spanned an area of 272 km^2, the largest to date. A high rate of interactions occurring over a large geographic range may be a key factor in the high rates of entanglement, human-induced injuries, altered behavioral budgets, and aggression that have been documented for dolphins in Savannah, Georgia (Perrtree et al. 2014).

Conclusions for Illegal Feeding Interactions

Locations in Australia and the southeastern United States are hotspots for illegal feeding of bottlenose dolphins (Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Powell & Wells 2011, Perrtree et al. 2014). The number of conditioned dolphins in these areas has increased over time and, through social learning, conditioning has been passed down to younger generations (Samuels & Bejder 2004, Cunningham-Smith et al. 2006). Provisioning reinforces the association between people and food for dolphins. Oftentimes, these close interactions lead to dangerous consequences for both the dolphin and human involved (Samuels & Bejder 2004, Cunningham-Smith et al. 2006). Illegal feeding has been shown to alter dolphins' activity budgets (in particular, decreased time spent foraging and socializing), alter ranging patterns, and increase the risk of entanglement or injury (Samuels & Bejder 2004, Cunningham-Smith et al. 2006, Donaldson et al. 2010, Powell & Wells 2011). Illegally feeding dolphins puts the human at risk for injuries (i.e., biting), and disease transmission (Samuels and Bejder 2004). Additionally, depredation is a growing concern in areas where illegal feeding occurs and there is a large community of active anglers (Donaldson et al. 2010, Powell & Wells 2011). Depredation by dolphins introduces increased risk of fishing gear entanglements, as well as injury or mortality from fisher retaliation (Donaldson et al. 2010, Powell & Wells 2011). While illegal feeding continues to persist, scientific documentation of these interactions and their impacts on dolphins is essential to help develop effective management strategies and guide future decision-making.

Management Recommendations for Illegal Feeding Interactions

Illegally feeding wild marine mammals, in particular bottlenose dolphins, is a widespread problem. A diversity of user groups engage in illegal feeding, including dolphin-view tour operators, tourists, recreational boaters, and commercial and recreational fishermen. Consequently, targeted management efforts are very challenging. There are a couple of recommendations suggested throughout the literature offering solutions to help curtail illegal feeding activities, such as increasing targeted education and enforcement and continuing longitudinal research studies. The recommendations cited here mostly pertain to bottlenose dolphins; however, many of the same approaches can be applied to illegal feeding with other marine mammal species.

Increased education and outreach efforts create awareness for the impacts feeding has on dolphins' natural behavior, health, and survival (Cunningham-Smith et al. 2006, Donaldson et al. 2010). In an increasingly urbanized world, there is a growing demand for seeking out interactions with wildlife (Orams 2002). During these interactions, people often forget that feeding marine mammals, or engaging in activities that can lead to potential changes in their natural behavior (i.e., harassment), is illegal in the United States and a violation of the MMPA that can be civilly or criminally prosecuted. Increased signage with well-publicized punitive actions may help deter people from engaging in such activities (Cunningham-Smith et al. 2006). Educating people may also help prevent feeding and harassment of wild animals, as well as reduce associated injuries to both people and dolphins. Cunningham-Smith et al. (2006) documented 18 instances of "Beggar" (the notorious Sarasota, Florida dolphin) biting people when they tried to touch or tease him. For the safety of both the dolphin and the human, it is necessary to target education efforts to all users on appropriate actions they should take when around dolphins (Powell & Wells 2011). Given that education and outreach efforts can be costly, timely, and require an adequate number of personnel, Finn et al. (2008) recommend adopting the "hotspot" approach where efforts are targeted towards popular feeding interaction locations.

Increasing enforcement efforts is another common recommendation to reduce illegal feeding of wild dolphins. The regulatory framework prohibiting feeding interactions is already in place in the United States; however, it is advised that there should be stricter enforcement of these regulations (Cunningham-Smith et al. 2006). Simply the presence of a marked law enforcement vessel reduces illegal activities; while in their absence, violations persist (Cunningham-Smith et al. 2006). When no visible marked enforcement is present, the public perceives the risk of being caught for a feeding violation as small. In the United States, there are limited numbers of enforcement personnel, who are required to spend their time spread across a wide territory to regulate all federal fishing and protected species actions. While increasing the presence of law enforcement is effective in deterring illegal feeding, the financial and physical resources required to do so are considerable, making this a difficult management strategy to implement.

Lastly, in order to document seasonal and long-term impacts of illegal feeding on an individual dolphin or population, continued longitudinal research projects are warranted (Samuels & Bejder 2004, Finn et al. 2008, Powell & Wells 2011). The systematic behavioral methodology used by Samuels & Bejder (2004) to describe dolphin behavior allowed for comparisons between individuals' behavior, socialization, and ranging patterns in the presence and absence of swimmers and vessels. A long-term data set collected with a similar methodology would further illuminate the impacts illegal feeding may have on specific age classes or sexes, activity budgets, habitat use, survival, or reproductive conditions. Longitudinal studies provide a baseline of behavior so that changes or responses to anthropogenic or environmental factors can be parsed and examined over time.

Chapter 4. Land-Based Interactions

Introduction

The pinniped-viewing industry provides people the opportunity to view seals, sea lions, or fur seals in their natural habitat by approaching them on land or anchoring boats near haul-out beaches. Management of the pinniped-viewing industry varies from site to site; some sites have established viewing distance boundaries (e.g., Andersen et al. 2012), while in other locations, tour companies provide guided walks for people who want to view pinnipeds (e.g., Boren et al. 2009). However, most sites are unregulated and tourists can independently approach pinnipeds on land (e.g., Cassini 2001, Boren et al. 2009). Pinniped responses to all forms of land-based approaches depend on a variety of factors that are discussed in this chapter.

Sixteen scientific papers, dissertations, theses, and workshop reports were reviewed that focus on land-based interactions with six pinniped species. The species involved in these interactions include: South American and New Zealand fur seals; Southern elephant, Weddell, and harbor seals; and Australia sea lions. Studies document interactions in ten countries, along beaches, rocky coastlines, and seal reserve sites.

4.1 Behavioral Effects

4.1.1 Vigilance/Flushing/Move on Land

Across the literature, most pinnipeds' first response to land-based approaches by people is to become alert, by exhibiting a head-up, upright posture (Engelhard et al. 2002, Orsini et al. 2006, van Polanen Petel et al. 2008, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012, Granquist & Sigurjonsdottir 2014). For example, harbor seals (*Phoca* sp.) hauled out on sandbanks in the Dollard Estuary of the Wadden Sea, Germany displayed vigilant behavior 72% of the time when approached on land by people (Osinga et al. 2012). Similarly, harbor seals in the Netherlands displayed vigilant behavior 70% of the time when approached (Groothedde 2011). Vigilance behavior is typically followed by physical avoidance, such as moving away from the source of disturbance, either on land or flushing into the water (Mathews 2000, Cassini 2001, Cassini et al. 2004, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012). Vigilance and flushing behaviors often occur when a person's approach crosses a threshold distance of perceived safety. Threshold distances for both vigilance and physical retreat vary among species and other various factors. For South American and New Zealand fur seals (*Arctocephalus* sp.), the threshold distance before retreat was approximately 10 m (Cassini 2001, Boren et al. 2002). Harbor seals initiated a flight response when pedestrians were within 165-260 m (Andersen et al. 2012). Responses are largely dependent on the animals' sex and reproductive stage, age class, group size, previous exposure to humans, and tourists' behavior and group size.

When measuring pinniped disturbance, animal sex and reproductive stage is an important variable in determining responses. The breeding season and its related activities (i.e., pupping, nursing, and mating) is a sensitive time for pinniped species. Andersen et al. (2012) observed female harbor seals in Denmark were more reluctant to flee to the water during close approaches by humans during the breeding season than any other time of the year. If seals did flush to the water, they were observed returning to the haul-out site immediately after the disturbance. During these sensitive periods, animals have a close association to land and conserve energy by increasing their vigilance and decreasing their flushing threshold distances (Andersen et al. 2012). Boren et al. (2002) drew similar conclusions on the importance of site function, reproductive stage, and sex. At a breeding colony in New Zealand, disturbances resulting in females and pups fleeing to the water have greater consequences on pup body condition and survival during the pupping-mating season than at any other time of the year (Boren et al. 2002). Boren et al. (2002) also observed that male New Zealand fur seals were more likely to remain on land during close approaches by humans at this breeding site. This finding is also supported by breeding male grey seals in Scotland that conserve energy through non-active behaviors in the presence of human disturbance (Bishop et al. 2015). At breeding locations, males invest a considerable amount of time and energy in obtaining and defending territories, females, and the resources females use within those territories (Boren et al. 2002). Therefore, when approached, males are more likely to stand their ground and conserve the energy they invested rather than expend it.

Pinniped age class and group size also play a role in how animals respond to disturbances and perceive habitat suitability. Younger sea lion age classes (i.e., pups and juveniles) have been observed displaying increased vigilance compared to adults in Australia (Orsini et al. 2006). Juveniles have less experience and exposure to disturbance than adults and, therefore, may be less able to judge the risk of harmful stimuli. The size of the group at a haul-out site also contributes to the type of behavioral response. For example, smaller groups of South American fur seals in Peru displayed high rates of vigilance behavior when disturbed by humans, likely because they perceived increased vulnerability being in a smaller group (Stevens & Boness 2003). In larger groups, the vulnerability of individuals to predators may be reduced by the “dilution effect,” such that larger groups have lower energy expenditure per individual to perform vigilance behaviors and predator detection (Stevens & Boness 2003). The level of perceived vulnerability associated with group size also results in differences in an animal’s assessment of habitat suitability. When grouped in low densities, seals may chose a less suitable habitat for rearing pups (i.e. rocky, uneven surfaces, not optimal for thermoregulation) that are more difficult for humans to access, while larger groups are more likely to breed in more suitable rearing habitats, despite the ease of access for humans (Stevens & Boness 2003).

Previous exposure to human presence is a strong determining factor in pinniped response to human-interactions (Boren et al. 2002, van Polanen Petel et al. 2008). Beaches in Kaikoura and Whakamoa Bay, New Zealand are two highly used haul-out sites by New Zealand fur seals. The haul-out beach in Kaikoura is also a popular tourist destination, whereas Whakamoa is rarely frequented by visitors and was used as the control site in the study (Boren et al. 2002). During controlled approaches, New Zealand fur seals on Whakamoa beach displayed increased vigilance, avoidance, and aggressive behavior, when compared to hauled out seals on Kaikoura beach (Boren et al. 2002). This reduced disturbance response by fur seals on Kaikoura beach may indicate that fur seal behavior has been modified by tourist activities and that habituation may be occurring in areas with high levels of tourism (Boren et al. 2002). A similar conclusion was reported by van Polanen Petel et al. (2008) for Weddell seals (*Leptonychotes weddellii*) in East Antarctica. The percentage of vigilant seal behavior (e.g., looking up at the source of disturbance) over 10 approaches decreased linearly from 67% to 18%, as did time spent looking at the source of disturbance (van Polanen Petel et al. 2008). Repeated and consistently benign approaches to lactating seals resulted in diminished behavioral responses over a two-hour time period (van Polanen Petel et al. 2008). Comparatively, when seals were approached infrequently over the course of 3-4 weeks in a location where all animals in that area had been previously flipper tagged, animals showed no signs of becoming accustomed to humans (van Polanen Petel et al. 2008). The previous, presumably unpleasant experience of being flipper tagged may have led Weddell seals to perceive humans as a threat that required constant monitoring (i.e., vigilant behavior), irrespective of how frequently they had been exposed (van Polanen Petel et al. 2008).

Lastly, tour group size and tourists' behaviors when viewing pinnipeds affect the type of responses they elicit. Harbor seals typically exhibit a greater disturbance response to larger tour group sizes (5-10 people), compared to smaller ones (Groothedde 2011). Pinnipeds in general were observed to display increased avoidance behavior in response to larger groups of 7-9 people in New Zealand (Boren et al. 2009). Additionally, when tourists behave in a disturbing manner (i.e., yelling, clapping, imitating seal sounds, throwing stones), pinnipeds are more likely to avoid the group (Cassini 2001). In most cases, larger group sizes are associated with more disturbing tourist behaviors, which may create the most disturbances to pinnipeds (Granquist & Sigurjonsdottir 2014).

4.2 Habitat Use

4.2.1 Haul-out Utilization

Land-based disturbances affect how pinnipeds utilize a haul-out site, the location at which they haul out, and the recovery time post-disturbance (Mathews 2000, Granquist & Sigurjonsdottir 2014). Harbor seals in Iceland utilize the natural landscape to increase the distance between themselves and tourists (Granquist & Sigurjonsdottir 2014). There is a natural water barrier between seal haul-out sites on skerries (i.e., small rocky islands) and viewing zones on land. When the number of tourists on land increased, harbor seals hauled out onto skerries farther away from the land-based viewing zones (Granquist & Sigurjonsdottir 2014). This demonstrates that the seals changed their haul-out site selection based on the presence of tourists (Granquist & Sigurjonsdottir 2014).

In Glacier Bay National Park, harbor seals rarely flushed to the water when disturbed by vessel wakes, and when they did, the seals re-hauled out after a short period of time (Mathews 2000). Comparatively, when vessel disturbance was accompanied by land-based disturbance from people at nearby camping sites, seals responded by flushing to the water and not re-hauling at the same site out until more than 52 hours later (Mathews 2000). These findings provide additional evidence for the negative effect human disturbance can have on pinniped habitat utilization (Mathews 2000).

Conclusion and Summary of Risks for Land-Based Interactions

Pinnipeds are most disturbed when hauled out on land and approached by pedestrians. Most often pinnipeds respond to disturbance by first increasing their vigilance and then flushing to the water (e.g., Mathews 2000, Cassini 2001, Cassini et al. 2004, Jezierski 2009, Groothedde 2011, Andersen et al. 2012, Osinga et al. 2012). Across the pinniped literature, disturbance responses vary depending on the animals' sex and reproductive stage, age class, group size, previous exposure to humans, and tourists' behavior and group size. Breeding seasons are energetically demanding times. Males on breeding colonies are less likely to flee from an established territory they spent a lot of time and energy obtaining and defending (Boren et al. 2002). Similarly, females and pups are more sensitive during the breeding season and have been observed to conserve energy during close approaches by increasing vigilance and decreasing flushing behaviors (Boren et al. 2002, Andersen et al. 2012). Additionally, younger, less experienced pinnipeds and smaller haul out groups tend to flee or show increased vigilance when disturbed (e.g., Orsini et al. 2006). Larger haul out groups have added protection from the "dilution effect," which shapes their response type (Boren et al. 2002, Stevens & Boness 2003, Orsini et al. 2006). Prior experience and continued exposure to human approaches are also factors in how pinnipeds respond to human presence; continued, benign approaches have been shown to result in a habituated response (van Polanen Petel et al. 2008). Lastly, tourist group size and behavior are factors in pinniped disturbance responses (Osinga et al. 2012, Granquist & Sigurjonsdottir 2014). Larger and more boisterous tourist groups tend to create the most disturbances to animals they are observing.

In general, these disturbances pose a risk to animals' health and survival. Vigilance and flushing behaviors have energetic consequences (Stevens & Boness 2003, Orsini et al. 2006, Jezierski 2009, Andersen et al. 2012, Osinga et al. 2012). Some pinniped life stages, such as molting, lactating, and gestation, are already energetically demanding times. The added stress that comes from human disturbances can interfere with and jeopardize these life stages (Orsini et al. 2006). Disturbances can also have significant effects on juvenile survivorship (Osinga et al. 2012). If mothers and pups are constantly flushing to the water, the amount of time pups have on land to nurse is reduced. Also, the experience of flushing among large groups of pinnipeds can result in the stampeding and killing of pups, as well as lead to mother-pup separation (Osinga et al. 2012). For example, in the Netherlands, yearly numbers of orphaned pups fluctuate between 13 and 24 pups due to flushing from disturbance (Osinga et al. 2012). Disturbances can also cumulate into potential habitat displacement (Stevens & Boness 2003, Cassini et al. 2004, Orsini et al. 2006, Boren et al. 2009). Human presence may reduce the quality or quantity of time pinnipeds spend in their preferred habitat, driving them away to seek potentially less suitable haul-out sites (Orsini et al. 2006).

Land-based interactions with pinnipeds and swim-with interactions with dolphins stimulate similar discussion regarding tolerance to disturbance versus habituation. Some research has supported the idea that with repeated exposure to land-based activities, pinnipeds become habituated to human presence and therefore are only likely to be affected by human activities until they reach the point of habituation (van Polanen Petel et al. 2008, Granquist & Sigurjonsdottir 2014). Similar to points discussed in dolphin swim-with interaction literature, there is some misuse of the term habituation. It is argued that a positive factor for habituated animals is that they are able to conserve energy and reduce stress by not responding to stimuli that are perceived as non-threatening (Boren et al. 2002). However, for animals to become habituated, they must go through a series of behavioral modifications before reaching the point of habituation, such that over time, habituation has altered natural behaviors and may ultimately reduce long term survival (Boren et al. 2002). Truly habituated animals may lose their natural wariness of people and not respond appropriately to negative interactions. There may also be other behavioral or physiological long-term effects truly habituated animals experience that have not yet been discovered (Bejder et al. 2009).

Management Recommendations for Land-Based Interactions

One of the most commonly recommended management strategies throughout the pinniped literature to reduce disturbing land-based interactions is to implement guided walking tours and enhance educational programs (e.g., Orsini et al. 2006, Boren et al. 2009, Jezierski 2009, Andersen et al. 2012). The presence of a guide during land-based tours has been found to significantly reduce the amount of vigilance and flushing behavior displayed by pinnipeds (Orsini et al. 2006, Boren et al. 2009, Jezierski 2009). Guides or rangers are effective in teaching tourists how to appropriately behave while viewing wild animals (Boren et al. 2009); inappropriate behaviors, such as running, shouting, clapping, and throwing objects towards seals, can be curtailed. Guided tours can also help regulate the number of people who participate, keeping group sizes smaller and promoting adherence to viewing distance guidelines (Orsini et al. 2006, Granquist & Sigurjonsdottir 2014).

The construction of fences around colony's haul-out sites has also been found to be an effective management tool (Cassini et al. 2004, Groothedde 2011). The presence of a fence forms a physical boundary between animals and tourists and is a simple and affordable means to reduce negative interactions. Cassini et al. (2004) found that after the implementation of a fence, the most disturbing human behaviors (i.e., close approaches, intrusive behavior) and fur seal disturbance responses (i.e., flushing, threat displays, and aggressive behavior towards tourists) were reduced. Cassini et al. (2004) recommended that fences are constructed in conjunction with educational programs to enhance tourists' perceptions and attitudes towards wildlife. One risk of fence construction is resource and space limitations. If fenced areas are not large enough to support an expanding population, animals may abandon the site. However, this can potentially be avoided through population growth models and proper spatial planning (Cassini et al. 2004).

Seasonal site closures and the designation of colonies for tourist activities have also been suggested to reduce human disturbance on pinnipeds. Mating, pupping, and lactation seasons are energetically demanding times, such that disruption by tourists is especially problematic as it causes additional energy spent on vigilance and flushing behaviors. Osinga et al. (2012) recommend closing off pedestrian foot traffic during pupping and mating seasons and constructing an observation platform to observe pinnipeds from a distance. Van Polanen Petel et al. (2008) proposed two very different strategies to help minimize human impact on seals: 1) spread land-based visitation by humans amongst many pinniped colonies at irregular time intervals to avoid cumulative impacts, and 2) target one colony for land-based visitation to reduce the cumulative number of individual pinnipeds being disturbed, although risking potential behavioral changes and conditioning of animals in the visitation colony.

Each management regime is faced with its own host of challenges. The high level of variance among behavioral responses and the differences in human behavior that elicit those responses makes a "one size fits all" management strategy unfeasible and ineffective. Factors such as site function (breeding vs. haul-out site), size of the colony, location and geographical features, ease of human access to a site, and tourist popularity of a site should all be considered in the development of ecotourism management plans for pinniped land-based viewing.

Conclusions

Scientific literature reviews are an important conservation tool that collate and summarize pertinent themes from literature that scientists and managers can then reference and apply to the development of management strategies and new research ideas. The need to update and expand the literature review conducted by Samuels et al. (2000) highlights how much the marine mammal tourism industry has developed over the last 15 years and the necessity to keep up-to-date with existing research. This literature review includes almost 190 new references pertaining to swim-with activities, as well as vessel, land-based, and feeding interactions with odontocetes, mysticetes, pinnipeds, and sirenians.

The marine mammal tourism industry plays a large socioeconomic role in many small, coastal communities throughout the world. All forms of tours have the potential to provide valuable educational opportunities to the public, bringing people closer to animals in their natural habitats and learning first-hand about life history patterns and behaviors. However, as the scientific literature in this review depicts, the marine mammal tourism industry can have individual and population level impacts on target species, as well. It has been well documented across literature that disturbance to marine mammals from vessel, swim-with, feeding, and land-based interactions have short-term behavioral effects that can lead to long-term consequences.

One of the main concerns about tourism is its effect on marine mammal health and survival. Repeated exposure to disturbance may alter an individual animal's behavioral budget, resulting in increased energy expenditure and decreased energy acquisition. Over time, many scientists have argued that these behavioral modifications could ultimately affect the population, through reduced fitness, reduced survival, and long-term habitat displacement (e.g., Östman-Lind et al. 2004, Samuels & Bejder 2004, Christiansen et al. 2010, Christiansen et al. 2013a, Tyne et al. 2014). As research and analysis methodologies have evolved, models have begun to evaluate long-term population consequences of disturbance. Some papers highlighted in this review suggest that while behavioral disruptions from tourism activities are substantial, the cumulative exposure and energetic impact to disturbed individuals is low; at least for certain species and locations (Lusseau 2004, Bain et al. 2014, Christiansen et al. 2014, Christiansen et al. 2015). Nonetheless, the evaluation of long-term consequences of human disturbance is on an upward trajectory in the scientific community. Through the development of different models and scientific frameworks, scientists are taking a population level approach to evaluate anthropogenic impacts on marine mammal populations.

The research conducted over the last fifteen years, collated into this review, provides a thorough background of human interactions and impacts to marine mammals from tourism for scientists to build upon and develop future potential research projects. This review also provides comprehensive information to assist managers in the development of management and conservation strategies. This review highlights that many of the behavioral responses observed are due to inappropriate human behavior; thus, rather than regulate animal behavior, human behavior change and control should be the focus of management regimes.

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Effects of Tourism on the Behaviour of Sperm Whales Inhabiting the Kaikoura Canyon

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Kaikoura Sperm Whales and Tourism Research Project

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Contents

Chapter 1

SUSTAINABILITY AND MANAGEMENT OF WHALE WATCHING

Christoph Richter, Tim M. Markowitz, and Jonathan Gordon

The history of the relationship between humans, oceans and the organisms living within them is a long one and is punctuated by marked changes in perception and attitudes. After centuries characterized by fear and awe (Ellis 1994), humans soon discovered that oceans are a rich source of resources (Norse 1993). Finally, after decades of exploitation, we recognized that oceans are not limitless and worthy of sustainable management and their protection into the future (Safina 1997). This general pattern holds true for our relationships with such disparate groups of organisms as fish (Safina 1997) and whales (Whitehead et al. 2000).

After centuries of sometimes intense whaling spanning the globe (Whitehead *et al*. 2000), public opinion is now, in most countries, firmly on the side of conservation (Peace 2010). Whaling highlighted the risks from direct exploitation for these slow breeding animals. There are also new and continuing threats to cetacean populations from a variety of sources. For instance, incidental bycatch in fishing gear remains a significant problem for many coastal species (Lewison *et al*. 2004; Read *et al*. 2006). Similarly, (Read *et al*. 2006) global climate change is predicted to impact cetacean populations through alteration in prey distribution and ocean currents (Simmonds and Isaac 2007; MacLeod 2009). Like climate change, noise pollution is a factor that is increasingly influencing whale populations (Richardson *et al*. 1995; NRC 2005; Firestone 2007; Scott 2007; Azzellino *et al*. 2011).

There are numerous under-water sources of anthropogenic noise with an equally wide range of characteristics (Richardson *et al*. 1995; NRC 2005; Nowacek *et al*. 2007). Sounds can be caused by activities related to fishing practices, such as high-frequency fish finders, which are relatively localized in their impacts (Richardson *et al*. 1995). Other sounds may spread over large areas (kilometers to hundreds of kilometers), such as noises from oil exploration and production, or ship traffic (Richardson *et al*. 1995). The latter has been increasing ever since the first engine-powered ships more than a century ago (NRC 2003).

Noise pollution is of particular concern for marine mammal conservation since many marine mammal species rely on acoustics for communication, navigation and foraging (Berta *et al*. 2006). Any change in the natural soundscape these species inhabit can be expected to impact any or all of these three functions. For instance, bottlenose dolphins (*Tursiops truncatus*) suffered temporary hearing loss after exposure to high intensity sonar (Mooney *et al*. 2009). The same species also changed its vocalisation behaviour in response to vessel traffic (Buckstaff 2004). Harbour porpoise (*Phocoena phocoena*) increased their distance to a sound source playing windmill noises, and increased their acoustic activity when windmill sounds were projected (Koschinski and Culik 2003).

Whale watching is often cited as a means of educating the public about marine mammals in general, and conservation concerns related to them in particular. While the educational effect of whale watching is being debated (Orams 1996; Orams 2000; Russell and Hodson 2002; Andersen 2006; Kessler and Harcourt 2010), there is no question about its socioeconomic impacts around the world (Cisneros-Montemayor *et al*. 2010). It is now one of the largest ecotourism industries and is expected to expand its role even further in the next few years (O'Connor *et al*. 2009). Whale watching activities bring in substantial amounts of money for local, regional and national economies (O'Connor *et al*. 2009). A prime example is Kaikoura, on the east coast of New Zealand's South Island, a community shaped by marine mammal watching (Butcher *et al*. 1998; McAloon *et al*. 1998). For instance, approximately 30% of the local jobs depend directly or indirectly on the tourism industry (Butcher *et al*. 1998). Nationally, whale watching and other marine mammal tourism enterprises contribute significantly to the economy (O'Connor *et al*. 2009). Consequently, economic, social and educational considerations argue for the sustainable management of this industry.

One of the major issues in managing whale watching activities is the detection, interpretation and management of impacts of the anthropogenic activities on the focal species. Interestingly, while the development of the industry has been rapid and is predicted to continue at this pace, scientific research to assess the potential impacts of whale watching has not kept abreast with this development. The current knowledge of whale watching impacts is patchy and difficult to interpret. For example, Erbe (2002) used an acoustic modeling approach to estimate that killer whales (*Orcinus orca*) would suffer temporary theshold shifts when within 450 meters of whale watching vessels for more than 50 minutes, and permanent threshold shifts when within 1km for more prolonged daily exposures over years. Erbe argued that such exposure levels are realistic in the every-day operations of killer whale watching (Erbe 2002). In contrast, Au *et al.* (2000), studying acoustic output of whale watching vessels off Maui, considered the recorded noise levels as too low to significantly effect humpback whales (*Megaptera novaeangliae*). Off Ecuador, however, humpback whales did change their spatial behaviour when they were accompanied by whale watching vessels (Scheidat *et al*. 2004). Sperm whales (*Physeter macrocephalus*) off the Azores also react in a variety of ways to whale watching vessels (Magalhaes *et al.* 2002).

Most importantly, even when statistically significant impacts are detected, it is often difficult, if not impossible, to assess the biological importance of these effects (Richter *et al.* 2006; Lusseau and Bejder 2007). For instance, Weinrich and Corbelli (2009) detected no effects of whale watching exposure on long-term population characteristics, such as calving rate and female survival.

SPERM WHALES OFF KAIKOURA

Off Kaikoura, sperm whales occur throughout the year (Jaquet *et al*. 2000). Individuals seen in that area are almost exclusively males (Childerhouse *et al*. 1995) and, based on their size, are thought to be subadults or adults. They exhibit behaviours consistent with foraging activities (Jaquet *et al.* 2000), and little or no social behaviour (Lettevall *et al*. 2002).

The presence of a productive deep water canyon extending to within 1 nautical mile from shore (Lewis and Barnes 1999), brings the whales close enough to local harbours to allow a thriving whale watching industry focused on sperm whales to operate. This is only one of two places in the world where sperm whales are the main focus of a year-round whale watching industry carrying out short trips. In New Zealand whale watching is regulated by the New Zealand Department of Conservation (DOC), which issues permits for limited number of boats and/or trips per time. As a consequence of the last project assessing whale watching impacts (Richter *et al*. 2003), DOC decided upon a 10-year moratorium on further whale watching permits. The approaching end of this moratorium has necessitated an updated assessment of current impacts.

Kaikoura not only offers tourists the rare opportunity to view sperm whales from boats, it is also one of the few places to watch whales from the air. Tourists are brought to the whales in dedicated boats as well as fixed-wing planes and helicopters. The impact of these platforms on sperm whale behaviour has been the subject of two previous substantial investigations (Gordon *et al*. 1992; Richter *et al.* 2003). However, since the last study approximately a decade ago, the boats being used for trips have changed. The outboard engine powered vessels used in the past have been replaced by hydrofoil-assisted catamarans powered by onboard diesels with water jet propulsion. In addition, the use of directional hydrophones for locating diving sperm whales has become much more wide-spread. In fact, both of these were recommendations from earlier studies (Gordon *et al*. 1992; Richter *et al*. 2003). The use of passive acoustic tracking with directional hydrophones means that whale watching vessels are usually close to whales when they surface and this avoids the need for fast approaches to whales. The boats can approach the eventual surfacing position of a whale over a longer time period and at slower speed.

RESEARCH GOALS

The current study aims to assess current impacts of whale watching activities on sperm whales off Kaikoura. We have attempted this using three platforms: a small quiet boat, a shore based lookout station and the tour vessels themselves. Each of these platforms have their distinct and complementary advantages and disadvantages (Bejder and Samuels 2003). By using all three in this study (see Chapters 2-4), we can capitalize on their strengths and hopefully address their weaknesses.

Surface behaviour can be readily observed and recorded, and statistical tests can reveal whether any differences are statistically significant. What is ultimately important though is the biological significance of any effects and it is therefore desirable to be able to measure behaviors which are likely to have a direct biological significance (NRC 2005). Sperm whales come to Kaikoura to feed and feeding efficiency is likely to be of prime biological significance for these animals. Sperm whale feeding occurs at depths of hundreds of meters and has never been directly observed. However, sperm whales echolocate to find their prey and as we come to understand their echolocation behaviour better we can begin to infer their underwater behaviour, including their foraging rates, by analysing acoustic recordings made at the surface. This is a much more involved process than simply logging simple surface behaviours. However, in this project we attempt to get at this crucial question by comparing measures of acoustic behaviour associated with feeding success with and without the presence of whale watching platforms.

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Chapter 2

SHORE-BASED MONITORING OF SPERM WHALES IN KAIKOURA CANYON: BEHAVIOUR, DISTRIBUTION AND INTERACTIONS WITH TOUR VESSELS

Ophélie Sagnol, Tim M. Markowitz and Wendy J. Markowitz

Whale watching has been described as a sustainable use of marine resources offering an economic alternative to whaling. However, in at least some cases research has found tour vessels to be a nuisance to whales and dolphins, with the potential to reduce the biological fitness of wild cetacean populations. Previous studies of sperm whales at Kaikoura have focused on boat-based research. The consistent occurrence of sperm whales near land combined with high vantage points on shore provides a rare opportunity to monitor these large-brained, deep-diving giants from a "perfect research blind," providing data on whale distribution and behaviour in both the presence and absence of vessels. Theodolite tracking has been used effectively in a number of studies to examine the effects of anthropogenic noise, habitat alteration and tourism on cetaceans. In this study, regular monitoring of sperm whales and whale watching vessels was undertaken using a surveyor's theodolite linked to a laptop computer running the tracking program Pythagoras. In parallel, we used a linked digital video camera-binocular system to confirm our observations. In order to assess the distribution and habitat use of sperm whales, location fixes (estimated longitude latitude positions based on horizontal and vertical angles) collected with the theodolite were imported into ArcGIS 10. Observations were made during 212 days between April 2010 and June 2011. A total of 2,717 surfacings were recorded using the theodolite and 1,204 surfacings using the digital video-binocular system. Both surface behaviour and distribution of whales varied seasonally. Blow interval and surface time peaked in summer, while swimming speed, distance from shore and water depth peaked in spring, when whale use of the Kaikoura Canyon area also appeared to decrease. Whales observed from shore were generally accompanied by tour vessels less than half the time. The greatest level of visitation occurred in the afternoon and during the summer months, when the number of whale surfacings accompanied by vessels slightly exceeded the number of whale surfacings unaccompanied by vessels. GIS analysis of whale and tour vessel distribution showed whale sightings were most tightly clustered in summer and autumn when the degree of overlap between areas where whales were accompanied and unaccompanied by boats peaked at 78-93%. There was a significant difference in ventilation rate (blow interval) for whales in the presence versus absence of whale watching vessels, but no difference in surface behaviour with number of vessels present. Swimming speed did not vary with vessel presence.

INTRODUCTION

BACKGROUND AND JUSTIFICATION

During the past few decades, sperm whales off Kaikoura have been the focus of both scientific investigation and the whale watching industry (Gordon *et al.* 1992, Childerhouse *et al.* 1995, Dawson *et al.* 1995, Jaquet *et al.* 2000, Richter *et al.* 2003). These studies have focused on boat-based research, although some shore-based monitoring of sperm whales has also been undertaken (Richter et al. 2006). In New Zealand, shore-based monitoring has been used more commonly in studies of tourism effects on dolphins, including Hector's dolphins at Porpoise Bay (Bejder et al. 1999) and Banks Pensinsula (Martinez et al. 2011), and dusky dolphins off the Kaikoura coast (Barr and Slooten 1997, Würsig et al. 2007, Markowitz et al. 2010).

Land-based monitoring of whales is uncommon because few populations of whales reliably reside or migrate close to shore (Forney 2009). However, shore station platforms have proven useful for examining effects of human activities on whales in the near shore environment in a number of settings. For example, shore-based monitoring has been used to examine the effects of oil exploration on grey whales in Russia (Gailey et al. 2007) and near shore construction projects on beluga whales in Alaska (Funk et al. 2005, Markowitz and McGuire 2007). Shore-based studies have previously been used to examine the effects of tourism on Southern right whales in Argentina (Lundquist et al. 2006) and grey whales in the calving lagoons of Baja, Mexico (Ollervides 1997). In New Zealand waters, shore-based monitoring of whales has included research on southern right whales in the Auckland Islands (Pateneude 2000) and humpback whales in Cook Strait (Gibbs and Childerhouse 2000; www.doc.govt.nz/about-doc/news/media-releases/cook-strait-whale-count-on-again/).

From a land-based research platform, the behaviour of cetaceans can be observed without disturbing them, effectively providing a perfect research blind (Würsig *et al.* 1991, Barr and Slooten 1999). In addition, it is less likely that whale watch tour operators will alter their behaviour because they know they are being observed than when they have scientific observers onboard (Chapter 3) or are in the presence of a research vessel (Chapter 4). The Kaikoura peninsula is an ideal place to install a land-based whale tracking station, with the existence of an elevated vantage point and individual whales close enough to shore to be reliably monitored. This provides a non-disturbing and inexpensive compliment to vessel research.

As part of a research effort focused mainly on boat-based data collection, Richter et al. (2003, 2006), examined blow rates of sperm whales at Kaikoura using high powered binoculars. In the current study, we build on this work by adding a digital video system linked to binoculars and increased theodolite tracking effort. Since the 1970s, surveyor's theodolites have been used in many studies to examine cetacean behaviour, movement patterns and habitat use, and also to assess the effects of human activities on marine mammals (Barr and Slooten 1999, Harzen 1998, Harzen 2002, Latusek 2002, Williams *et al.* 2002, Morete *et al.* 2003, Scheidat *et al.* 2004, Lundquist *et al.* 2006, Bailey and Thompson 2006, Schaffar and Garrigue 2008,). At Kaikoura, theodolite tracking has been used to monitor dusky dolphins and examine the effects of tourism on them for over 20 years (Cipriano 1992, Yin 1999, Barr and Slooten 1999, Würsig et al. 2007, Markowitz et al. 2009). Given the demonstrated utility of theodolite tracking in other studies of cetacean interactions with tourism, we decided to utilize this tool in a shore-based investigation of sperm whale-vessel interactions at Kaikoura.

RESEARCH OBJECTIVES

A shore-based monitoring programme was initiated to investigate the behaviour and distribution of sperm whales, current levels of interaction with tour vessels, and any measurable effects of tourism traffic on the whales. Specific objectives of this research were to:

1. ***Describe the behaviour and distribution of sperm whales in the Kaikoura submarine canyon area,***
2. ***Assess the level of interaction between sperm whales and tour vessels at Kaikoura, and***
3. ***Examine the effect of whale watching on the behaviour and distribution of the sperm whales.***

HYPOTHESES

In fulfilling these objectives, we tested the following hypotheses:

1. ***The distribution of sperm whales varies seasonally.***
2. ***Sperm whale behaviour is altered by the presence of whale watching vessels.***
3. ***Habitat use of sperm whales varies depending on the presence of whale watching vessels.***

WHALE INTERACTIONS WITH VESSELS

In order to address these objectives and hypotheses, we monitored sperm whales at Kaikoura in the presence and absence of vessels. While the boat-based research team made every effort to minimize their effect on the sperm whales (see Chapters 4-5), it is not possible to monitor sperm whales in the absence of vessels from a vessel. GPS data loggers (see Chapter 3) provided detailed GPS tracks of tour vessels and aircraft whether or not scientific observers were onboard; however, these data provided only information on the vessels, not on the interactions between the whales and vessels. Only the shore-based monitoring presented in this chapter provides information on sperm whale behaviour and distribution in the absence as well as in the presence of vessels and aircraft. By conducting the largest shore-based monitoring effort examining interactions between sperm whales and tour vessels at Kaikoura to date, we sought to fill an important gap in the available scientific information, comparing sperm whale behaviour in the presence and absence of vessels. To accomplish this goal, focal whale observations were classified as follows with respect to vessel interactions:

Whale only-	No vessel or aircraft near whale (<500m).
Whale watching tour vessel-	Presence of at least one whale watching tour boat (<300m).
Research vessel-	Presence of the research boat (<300m).
Aircraft-	Aircraft circling over whale (<300m).
Whale watching vessel and aircraft-	Presence of at least one whale watching boat and at least one aircraft (<300m).

METHODS

STUDY AREA

A shore station was established on a hill situated at the east end of the Kaikoura Peninsula (S 42°25’47.1’’ E 173°41’54.6’’) (Figure 2.1), providing a good vantage point overlooking a study area encompassing the Kaikoura Canyon, centre of the whale watching industry. The height of the station was surveyed using a surveyor’s theodolite (Sokkia Set 4000) and methods detailed by Würsig *et al.* (1991) at 99.88 m (±0.04m).

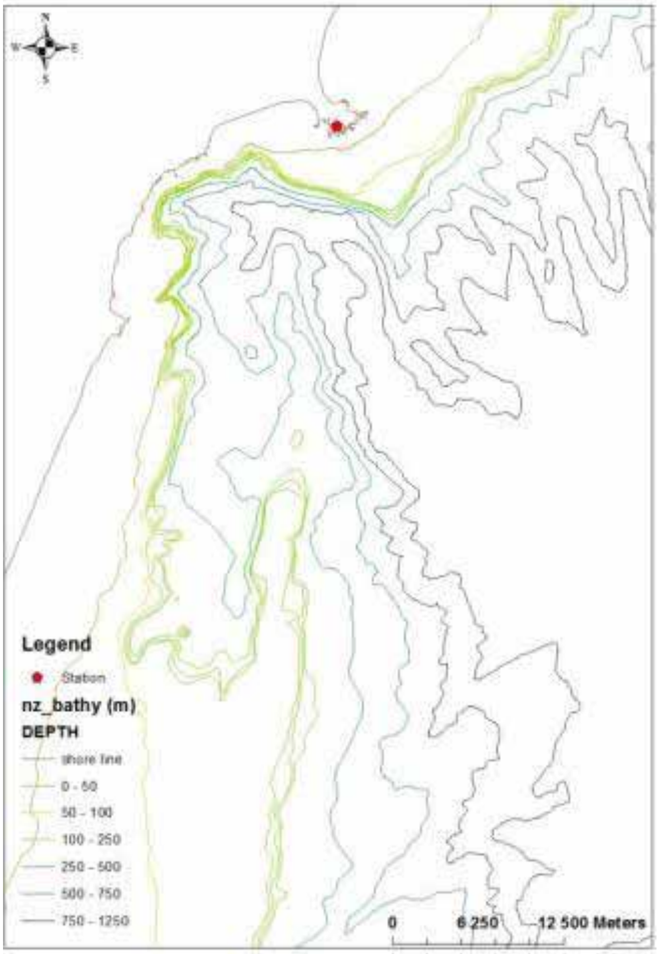

Figure 2.1. The Kaikoura Canyon study area is shown, including isobaths (water depth in meters) and location of the shore station (Red dot).

DATA COLLECTION

Positions and movements of sperm whales and tour vessels were measured using a theodolite Sokkia Set4000 and a system using binoculars and digital video (Figure 2.2).

Theodolite

A theodolite measures horizontal and vertical angles (Würsig *et al.* 1991, Gailey and Ortega-Ortiz 2002). The horizontal angle is zeroed relative to a reference point visible from the shore station. The theodolite was connected to a laptop running the tracking program Pythagoras (Gailey and Ortega-Ortiz 2002) set up with the theodolite eyepiece height, the station height and the GPS position of the station. The software transformed theodolite readings into latitude and longitude coordinates in real time with corrections built in accounting for curvature of the Earth and tide level (Gailey and Ortega-Ortiz 2002). Date and time stamped whale positions and behaviours, vessel tracks, environmental parameters, and other shore station data were logged into Pythagoras (Figure 2.3).

Figure 2.2. The research team tracks whales from the shore station. From left to right: theodolite operator, data logger (laptop), note taker and digital video binocular system operator.

During data collection, the study area was scanned constistently with the help of 20x80 binoculars and a 15-60x monocular spotting scope. Environmental conditions recorded included Beaufort sea state, swell height and direction, percent cloud cover, estimated wind speed and wind direction. From these data a visibility score was assessed of 0 to 4 (4 = perfect visibility). The location track for each whale began when the whale was spotted and finished with the fluke up dive of the focal whale. The same individual was tracked through a complete surfacing; from the first blow spotted until the fluke up. Theodolite fixes were taken on each blow and this also served as a record of blow time. Other behaviours observed during the surface period (Table 2.1) were recorded together with an estimated location by the theodolite.

Table 2.1. Behavioural events recorded during focal whale tracks (after Whitehead & Weilgart 1991).

Behavioural Event	Definition
Fluke up	Whale tail above the water surface; this usually initiates a long dive.
Shallow Dive	Sperm whale dives without showing fluke.
Lobtail	Whale slaps the tail at the surface of the water.
Spyhop	Whale head partially or completely above water surface.

Positions of whale watching boats, the research vessel or recreational boats approaching or around the whales were measured as often as possible to document vessel action, designated as: approaching, stationary and departing.

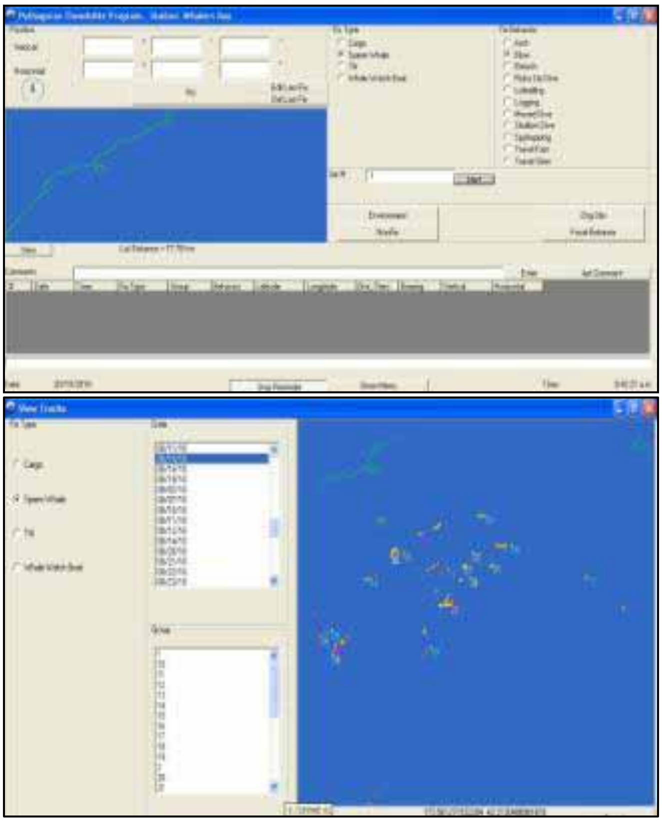

Figure 2.3. Screen captures show the data input (top) and track output (bottom) in Pythagoras tracking software. The violet point on the left represents the shore station and the lines represent all the whale tracks of the day (14 June 2010).

Digital Video-Binocular System

In parallel with the theodolite, a video-binocular range system (figure 2.4) was used to monitor and track the whales and vessels. Like the theodolite, the system provides the range and the position of the whale after analysis of the video using the software PAMGUARD. The video system provided a digital video record of whale behaviour and vessel activities that could be more readily reviewed and re-sampled post-hoc.

The video camera and binoculars were co-aligned so that the view the researcher sees in the binoculars is the same as what is recorded on the video camera. The aligned binoculars (20x80) and the video camera (Canon HV20) were fixed on top of a pole mounted on a seat so that the observer could use them comfortably. The video system requires both the whale and the horizon or a known shoreline to be in the same frame (Leaper and Gordon 2001). During whale tracking the whale was centred on the screen and a running verbal commentary was recorded to help with future analysis of respiration rate, time at surface, vessel interactions and behavioural sequences. Every time the system was moved to follow the whale movement the bearing was recorded using a handheld compass mounted on the video/binocular frame. Theodolite and video were usually used to follow the same whale.

Figure 2.4. Video system. Digital video binocular system is used to monitor and track whales and vessels.

RESEARCH EFFORT

Sperm whales and vessels were tracked on 212 days from April 2010 through June 2011, encompassing a total of 1162 hours of effort. Scanning effort by season is described in table 2.2.

Seasonal differences in research effort were a result of weather conditions at both the data collection platform (shore station) and on the water. The number of days of effort was reduced in winter months due to deteriorated weather conditions. During spring 2010, sperm whales were absent from the study area from mid-October to the beginning of November.

To describe changes in whale distribution and behaviour throughout the year, a seasonal scale was used. Seasons were defined as follows:

Autumn March, April and May
Winter June, July and August
Spring September, October and November
Summer December, January and February.

Table 2.2. Total shore station monitoring effort.

Season	Effort (h:m:s)	# Days
Autumn 2010	244:57:11	36
Winter 2010	124:52:42	26
Spring 2010	175:05:48	42
Summer 2010-11	283:05:44	49
Autumn 2011	240:50:24	41
Winter 2011	93:50:00	18
Total	**1162:41:49**	**212**

Theodolite tracking effort

Sperm whales were successfully tracked with the theodolite for a total of 226 hours corresponding to 2717 surfacing events (surfacing = more than one theodolite location recorded for the same whale). Effort by tracking and number of tracks by season are described in table 2.3. The increased number of tracks during summer 2010-11 and autumn 2011 is explained by the presence of more sperm whales in the study area.

Table 2.3 Theodolite tracking of sperm whales.

Season	Whale Theodolite Track Duration (h:m:s)	Number of Surfacings
Autumn 2010	46:54:40	472
Winter 2010	17:36:20	241
Spring 2010	14:24:24	177
Summer 2010-11	57:18:04	607
Autumn 2011	59:08:37	797
Winter 2011	31:23:40	423
Total	**226:45:45**	**2,717**

Video system effort

Sperm whales were successfully tracked with the video system for a total of 117 hours corresponding to 1204 surfacing events. Effort by tracking and number of tracks by season are described in table 2.4. Use of the video system decreased as the project progressed because the theodolite was found to be the more effective system.

Table 2.4. Digital video records of sperm whales.

Season	Digital Video Recording Duration (h:m:s)	Number of Surfacings
Autumn 2010	70:38:04	677
Winter 2010	31:05:33	365
Spring 2010	10:26:10	120
Summer 2010-11	2:58:56	18
Autumn 2011	2:37:51	24
Total	**117:46:34**	**1,204**

DATA ANALYSIS

Surface Behavior

For analysis of surface behavior, we included only encounters during which the fluke up was spotted. Brief surfacings (<5 blow intervals) or surfacing with double or missing blows (determined by blow intervals <5sec or >50 sec) were excluded from analysis. This totalled 1088 surfacings recorded with the theodolite (Autumn 2010=226, Winter 2010=104, Spring 2010=42, Summer 2010-11=192, Autumn 2011=341 and Winter 2011=183) and 515 with the video system (Autumn 2010=364, Winter 2010=83, Spring 2010=64 Summer 2010-11=4) used for analysis. Surface duration recorded for whales are based on duration from the first blow detected. This is not necessarily representative of the entire time whales spent at the surface (see results). Rather, it is an indication of the time the observer spent following a whale. For more accurate estimates of surface time, see Chapter 4. Leg speed (the distance between locations divided by time between locations), was calculated by the tracking software Pythagoras. A maximum swim speed filter of 30km/hr was applied to the data. Video system data presented here were collected in parallel with the video record. A second observer recorded observations made by the video system in conjunction with the recording.

GIS Analysis

Data sorting, statistical analyses and figure production were performed in Microsoft Excel 2007, Microsoft Xlstat Pro 7.5, Microsoft Access 2003 and ArcGIS 10.

In ArcGIS 10, all map features (coastline map, bathymetric chart and data layers) were initially imported using the coordinate system WGS 84. To increase accuracy, the data frame was then transformed to NZ UTM 59S. All the data imported in ArcGIS 10 with the coordinate system WGS 84 were then exported using the same coordinate system as the data frame.

Sperm whale and vessel positions (longitude and latitude) were overlaid onto a coastline base map and a bathymetric chart supplied courtesy of the National Institute of Water and Atmospheric Research, New Zealand (NIWA) using ArcGIS 10. The bathymetric chart used was graduated by an increment of 10m at shallow depths (<200m) followed by an increment of 50m at depths >200m. In order to limit replication during analysis only one position per surfacing (Longitude-Latitude) for each sperm whale was plotted. Data layer shape files (points) were then joined by spatial proximity to the bathymetric shape file, such that each point was assigned a depth equal to the nearest isobath. As a result, a single depth estimated by the nearest isobath was assigned to each sperm whale surfacing.

The study area was delimited using a buffer polygon of 20 km around the shore based station. To limit the effect of distance on the theodolite accuracy only data within 20km have been considered in the analysis that follows.

To examine the distance of sperm whales from the coastline, spatial proximity analysis was performed in ArcGIS 10, determining the distance from each feature in the sperm whale shape file from the coastline shape file To measure the geographic distribution of sperm whales and whale watching boats, standard deviation ellipse analysis was performed in ArcGIS 10, summarizing the spatial characteristics as the dispersion (area km²) and the mean centre (Longitude Latitude) of the geographic feature.

RESULTS

SEASONAL CHANGES IN BEHAVIOUR

Figures 2.5-2.7 compare the surface behaviour of sperm whales within the submarine canyon by season. For each surfacing (theodolite n=1088 and Video system n=515) mean blow interval (time difference between two blows in seconds) was calculated. Mean blow interval of sperm whales varied significantly between seasons based on theodolite location recordings (ANOVA n=1088, F=4.145, p=0.001) as well as digital video records (ANOVA, n=515, F=4.412, p=0.004), although the seasonal pattern was most apparent in the video records (Figure 2.5). Post-hoc pairwise comparisons (Tukey HSD) showed significant differences between summer and autumn 2010-2011 (P = 0.035) and between autumn 2010 and autumn 2011 (P =0.002) for theodolite data; and differences between summer and both autumn (P=0.01) and winter (P=0.02) for digital video records.

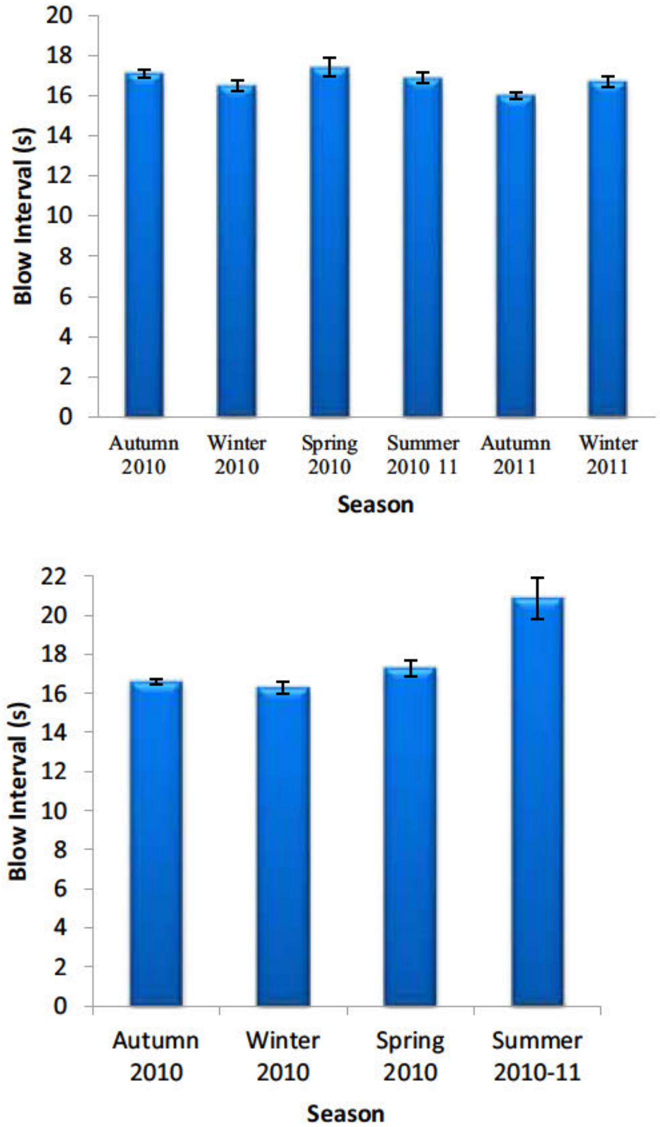

Figure 2.5. Blow interval (seconds) of sperm whales tracked from shore is compared by season using two research methods (theodolite- top, digital video-bottom). Bars represent mean values with standard errors.

Estimated surface time (time the whale was tracked at the surface from first observation to fluke up) was compared by season using the two shore-based methods. Surface time varied significantly between season based on both theodolite locations (ANOVA n=1088, F=5,870, p=<0.0001) and digital video records (ANOVA, n=515, F=3.930, p=0.009). Post-hoc pairwise comparisons (Tukey HSD) showed significant differences in surface time between autumn and winter 2010 (p=0.002), autumn 2010 and autumn 2011 (p=0.004), summer 2010-2011 and winter 2010 (p=0.002) , and summer 2010-11 and autumn 2011 (p=0.006).

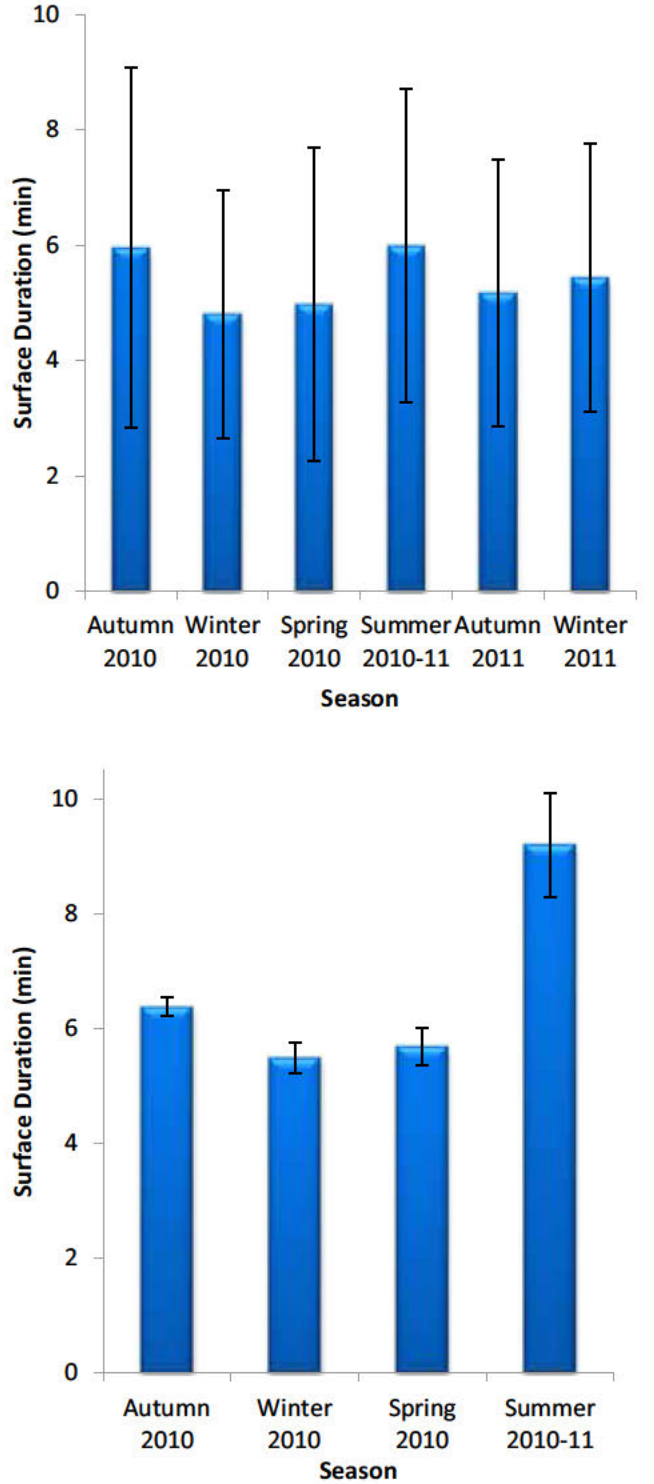

Figure 2.6. Mean surfacing duration (minutes) of sperm whales tracked from shore are compared by data collection method (theodolite- top, digital video-bottom). Bars represent mean values with standard errors.

Estimated Swimming Speed of Whales

The estimated swimming speed of sperm whales at the surface varied significantly between seasons (ANOVA, n=1036, F=6.351, p=<0.0001), peaking in the spring (Figure 2.7), the same season when the whales were most scarce (Table 2.5) and found furthest from shore (Figure 2.8) in the deepest water (Figure 2.9). Mean leg speed (distance between successive locations /time between locations) of whales was significantly faster in spring than in autumn (Tukey p=0,010), winter (Tukey p=0.0002), and summer (Tukey p=0018 and Tukey p=0.009).

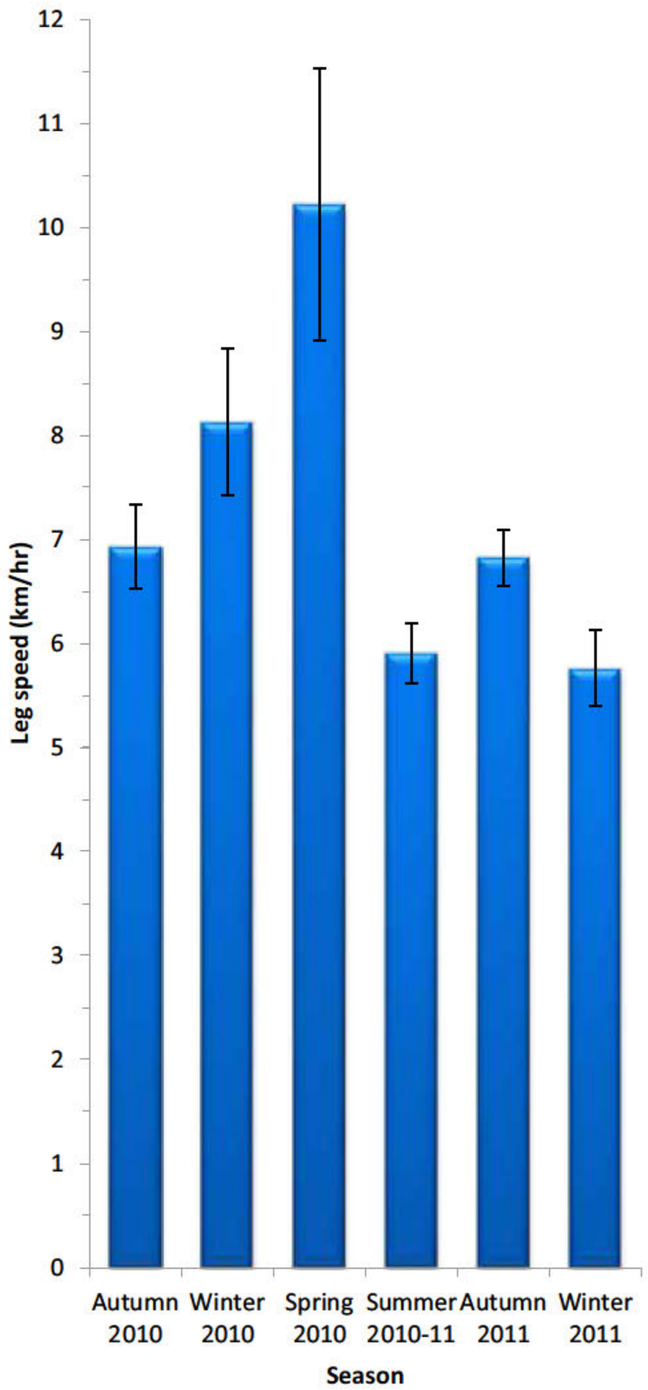

Figure 2.7. Leg speed (km/h) of sperm whales tracked from shore with a surveyor's theodolite is compared by season. Bars represent standard errors. Bars represent mean values with standard errors.

HABITAT USE AND DISTRIBUTION

Distance from Shore

Distance of sperm whales from shore and mean water depth at which sperm whales were sighted varied seasonally, peaking in spring and summer (Figures 2.8, 2.9). Distance of sperm whale sightings from shore varied significantly between seasons (ANOVA F=58.198, p<0.0001), with the whales located significantly further offshore in spring and summer than in other seasons (Tukey HSD p<0.0001). Distance from shore peaked in the spring (Figure 2.14), with the whales leaving the study area altogether for a couple of weeks during spring months (figure 2.8).

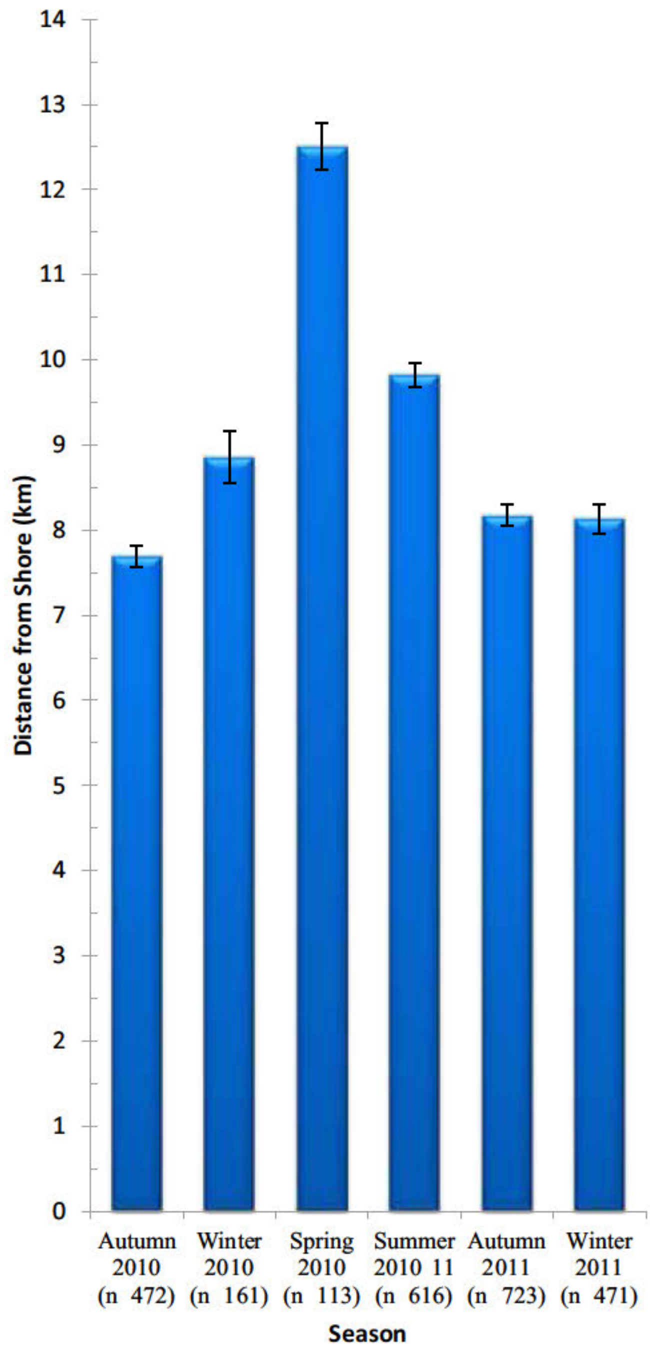

Figure 2.8. Distance from shore (km), estimated by longitude and latitude position of sperm whales from shore using a surveyor's theodolite. Bar represent standard errors.

Water Depth

Estimated mean water depths at which whales were located (figure 2.9) varied significantly between seasons (ANOVA, n=2556, F=42.301 p<0.0001). Post-hoc pair wise comparisons revealed similar findings to those for distance from shore, with sperm whales tracked at significantly greater water depths in spring and summer than in other seasons (Tukey HSD, p<0.0001). For autumn and winter months, there was no significant inter-annual variation in the mean water depths at which sperm whales were located between years (ANOVA, F=0.003, ns and F=0.068, ns).

Overall, sperm whales were most often found in water depths ranging from 1050-1250 m (table 2.5). Only 6.8% of total sightings of sperm whales occurred at depths <500m (Table 2.5). No whales were found in waters less than 500m deep in the spring (Figure 2.10).

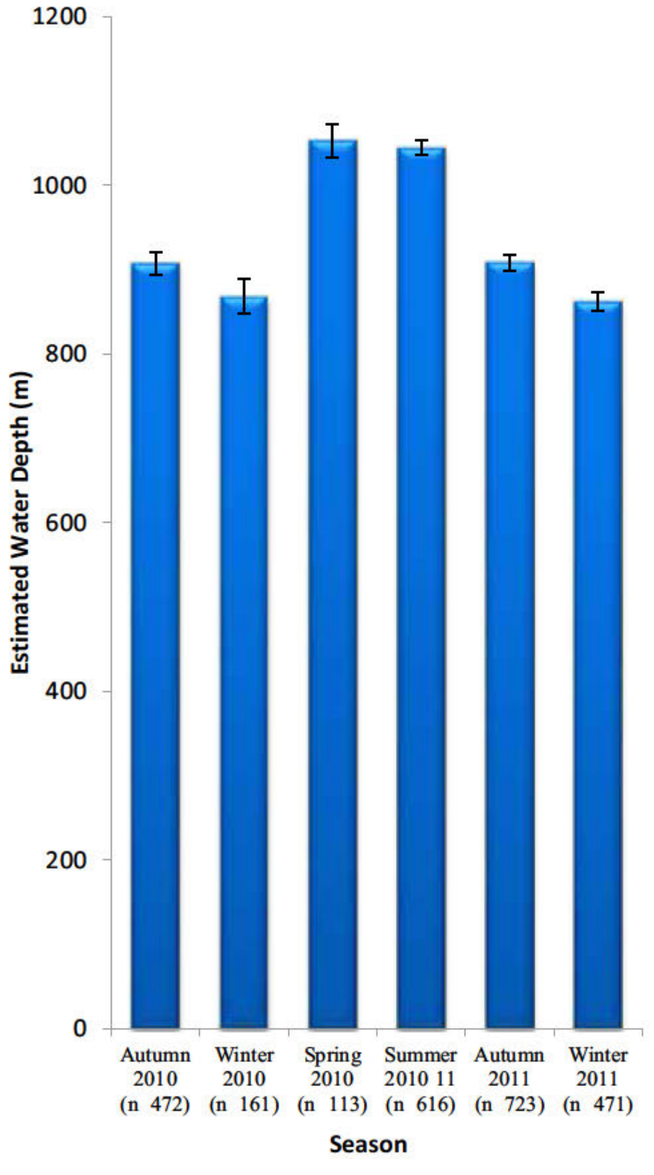

Figure 2.9. Water depth, estimated by longitude-latitude position of sperm whales tracked with a surveyor's theodolite, is compared by season. Bars represent mean water depths with standard errors.

Table 2.5. Number (top) and percent (below) of whale sightings at various water depths (m) are compared by season.

Season	<300	300-500	550-800	850-1000	1050-1250	>1250	Total
Autumn 2010	22	24	112	128	171	15	472
	5%	5%	24%	27%	36%	3%	
Winter 2010	3	16	45	47	45	5	161
	2%	10%	28%	29%	28%	3%	
Spring 2010	0	0	20	30	43	20	113
	0%	0%	18%	27%	38%	18%	
Summer 2010-11	1	11	91	146	302	65	616
	0%	2%	15%	24%	49%	11%	
Autumn 2011	13	39	208	205	222	36	723
	2%	5%	29%	28%	31%	5%	
Winter 2011	7	38	163	136	116	11	471
	1%	8%	35%	29%	25%	2%	
Total	46	128	639	692	899	152	2556
	2%	5%	25%	27%	35%	6%	

Colour bars indicate relative number of sightings by depth from high (red) to low (green).

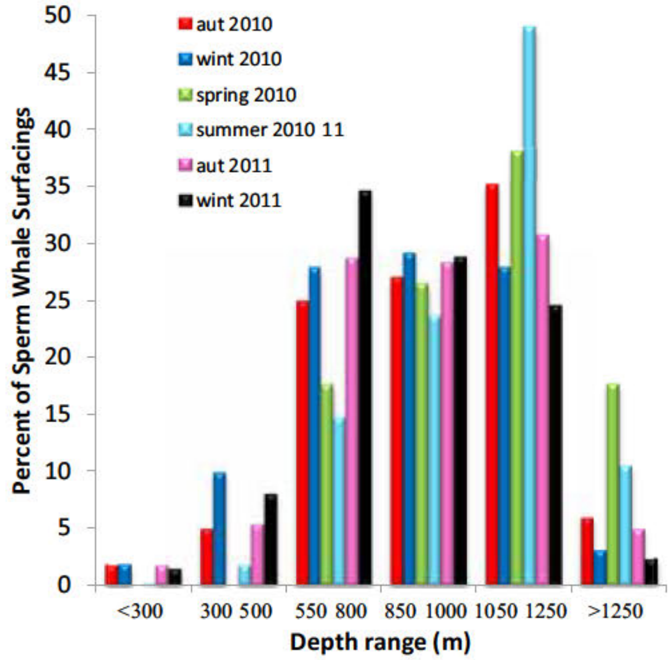

Figure 2.10. Percent of sperm whale surfacings in different water depth bins is compared by season (water depths estimated by longitude-latitude position from theodolite fixes).

Overall Distribution

The distribution of sperm whales estimated from shore-based theodolite tracking showed seasonal variation (figure 2.11). Examination of standard deviation ellipses indicated that the distribution of sperm whales was most scattered in winter 2011, and tightest in autumn 2010 and summer 2011 (Table 2.6). Whales ranged not only further offshore but were also tracked further to the north on average during the spring (Figure 2.12).

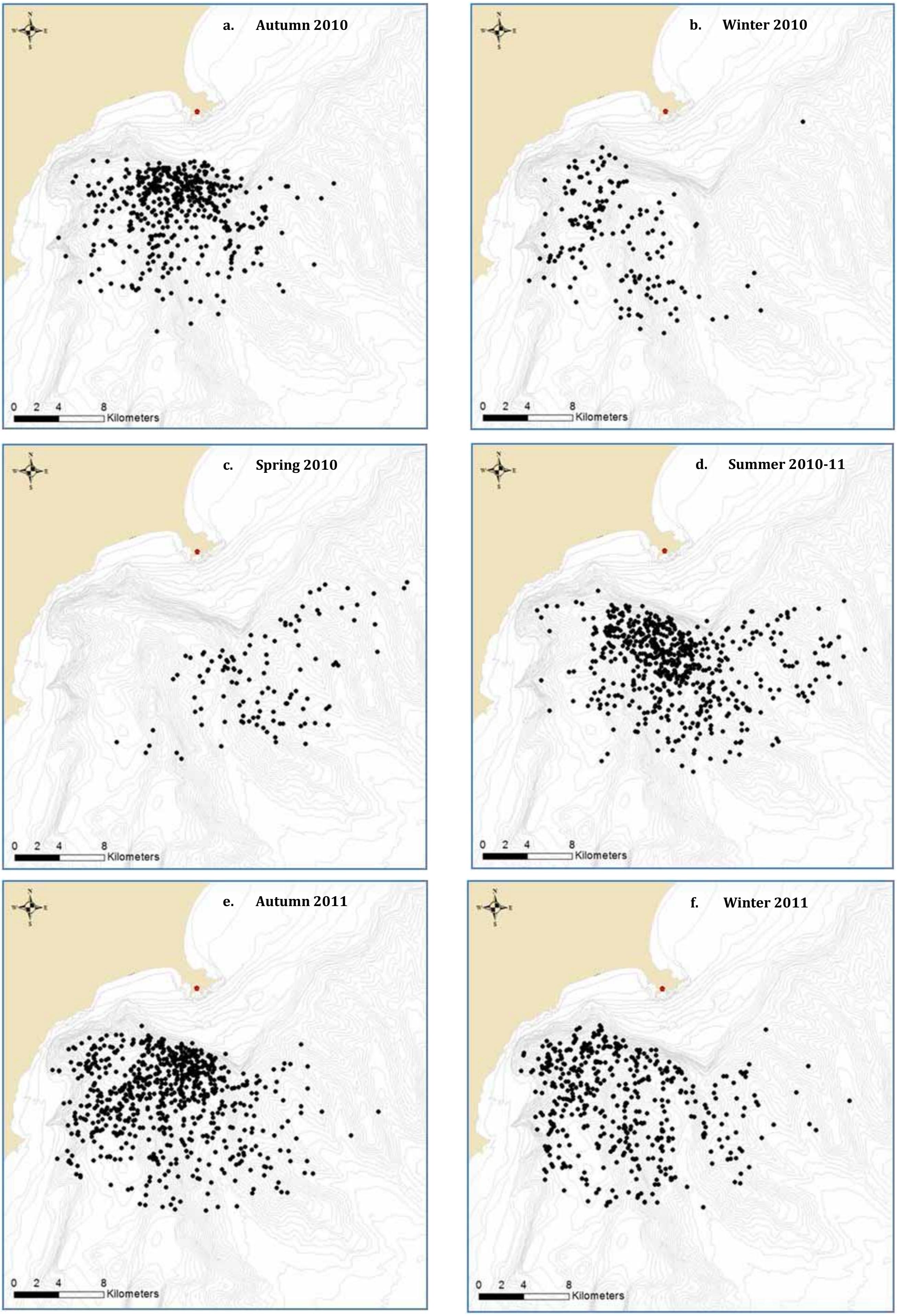

Figure 2.11. Sperm whale locations are compared by season. (Red dot= shore station, black dot= sperm whale location from theodolite record).

Table 2.6. Area of standard deviation ellipses and mean centre location for sperm whale locations are compared by seasons.

Season	Area (km²)	Longitude	Latitude
Autumn 2010	73.3	173.6790	42.5077
Winter 2010	102.3	173.6477	42.5312
Spring 2010	107.8	173.7746	42.5282
Summer 2010-11	93.6	173.7132	42.5200
Autumn 2011	105.2	173.6698	42.5180
Winter 2011	125.8	173.6579	42.5213

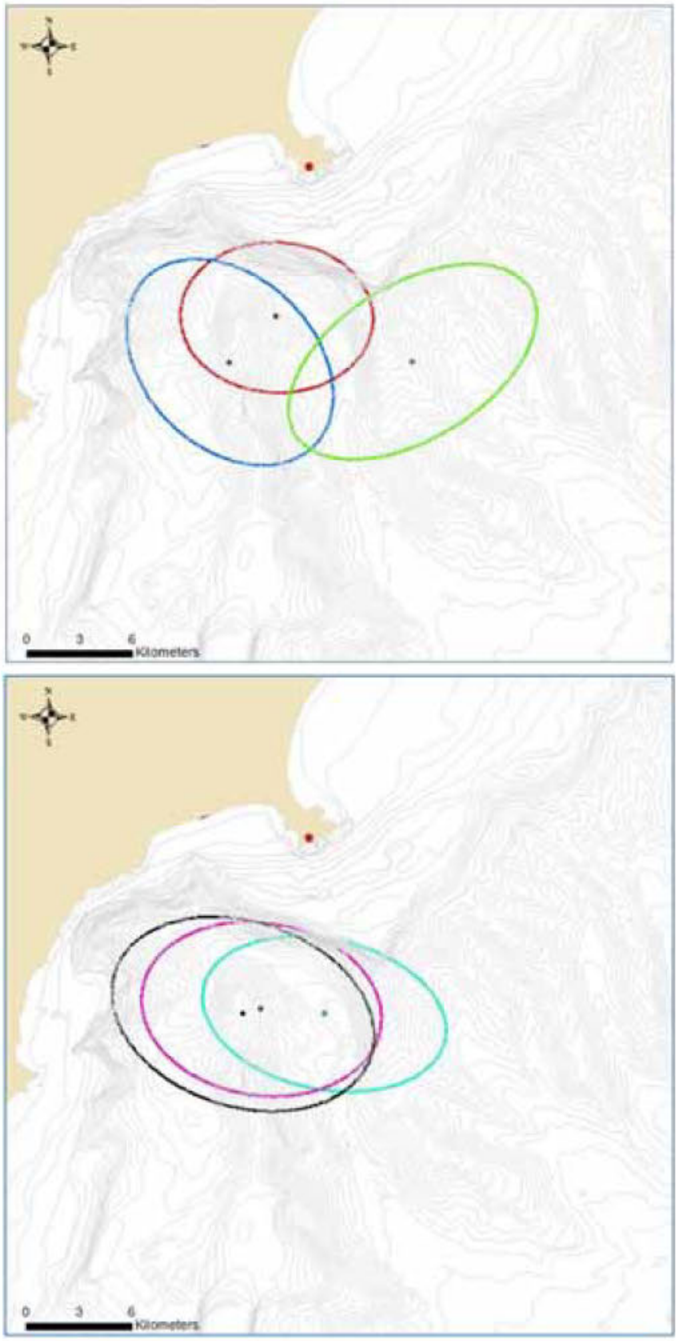

Figure 2.12. Area of standard deviation ellipses and mean centre location for sperm whales locations are compared by season. On top red : autumn 2010, blue : winter 2010 and green : spring 2010. On the bottom: blue summer 2010-11, pink: autumn 2011 and black winter 2011.

WHALE INTERACTIONS WITH VESSELS

Interactions by Time of Day

In order to assess level of interaction between sperm whales and tour activities, we examined the proportion of surfacings during which whales were accompanied by various boats and aircraft by time of day and season. Overall, whales were accompanied by vessels during less than half of all surfacings (Figure 2.13), and were least likely to be visited by either boats or aircraft during the morning hours (before 12:00 pm).

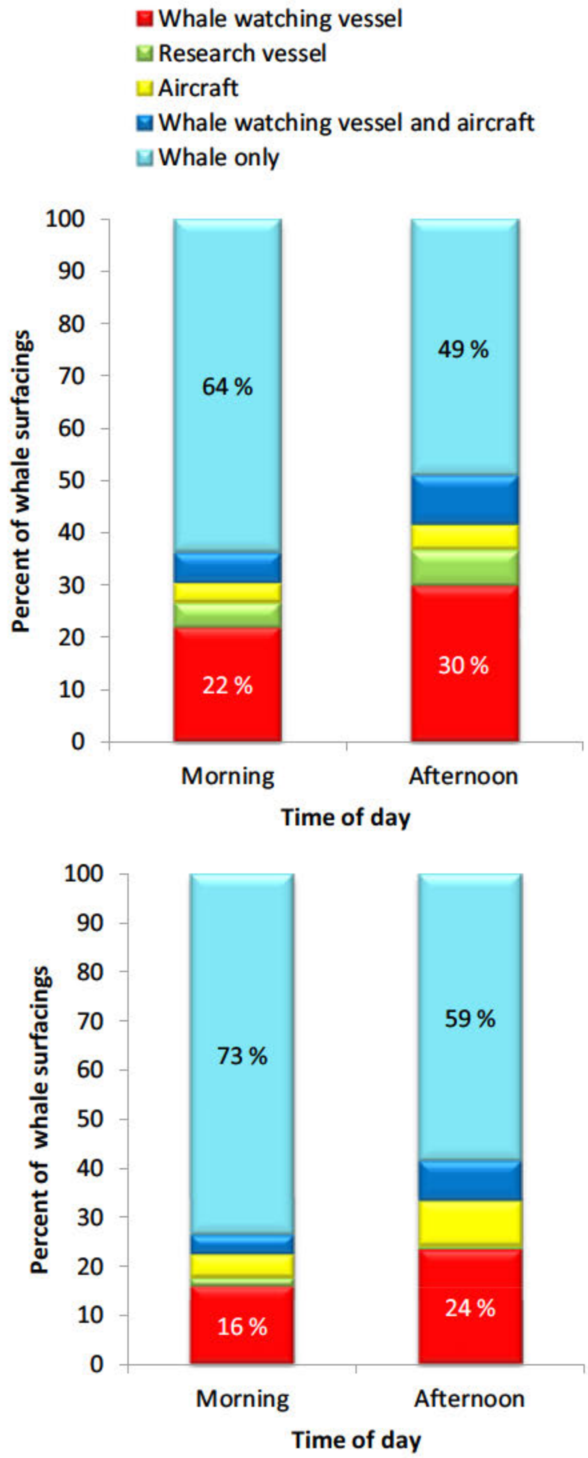

Figure 2.13. Percent of type of encounter is compared by time of the day monitored by theodolite (top) and digital video record (bottom). Data labels show percentages for the two largest categories, whales alone (black text) and whales accompanied by whale watching tour boats (white text).

Interactions by Season

A summary of interactions of whales with vessels and aircraft by season is provided in figure 2.14. A total of 703 surfacings of whales associated with whale watching vessels was recorded. For both methods, the dataset included considerably more instances of whales surfacing without vessels or aircraft than with vessels or aircraft A decrease in vessels and aircraft trips during autumn and winter meant that a smaller proportion of observed surfacings had whale watching platforms present. In summer, the proportion of surfacing with whale watch vessels present was highest, probably due to an increase in whale watching trips during the peak tourism season (Figure 2.14). Most interactions occurred with whale watch tour boats, particularly during the summer and autumn (Figure 2.15).

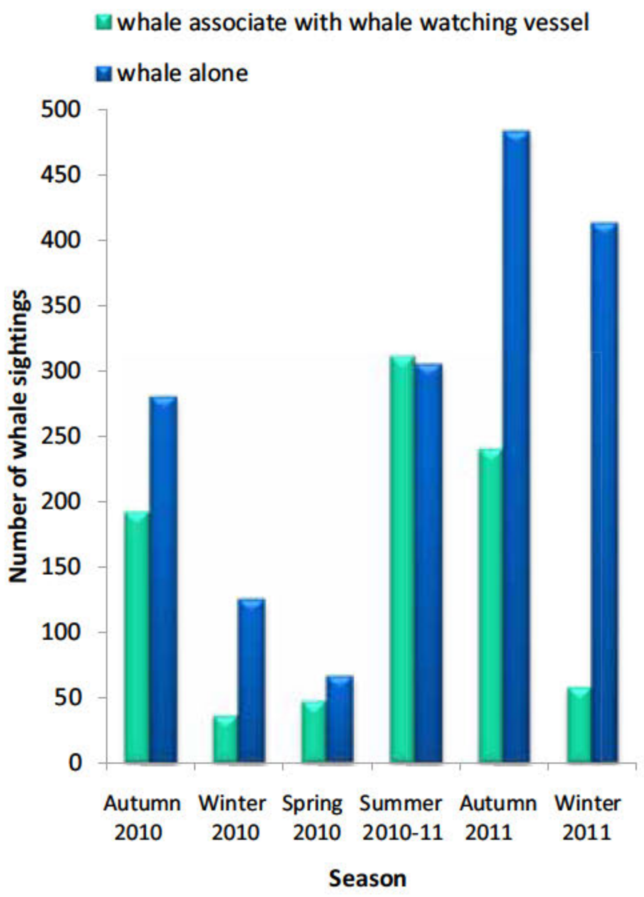

Figure 2.14. Number of sightings of whales alone versus whales accompanied by one or more vessels is compared by season.

Figure 2.16 compares the distribution of whale watching tour vessels with the distribution of whales by season. The distribution of sightings of whales alone and whales associated with whale watching vessel is compared in figure 2.17. Whale distribution and interaction with tourism activity varied seasonally. Whether in shore or offshore, most whale sightings and whale watch tour interactions occurred over the relatively deep water of Kaikoura Canyon. Thus the distance from shore of whales alone and whales accompanied by vessels showed greater seasonal variability than the water depth (Figures 2.20 and 2.21).

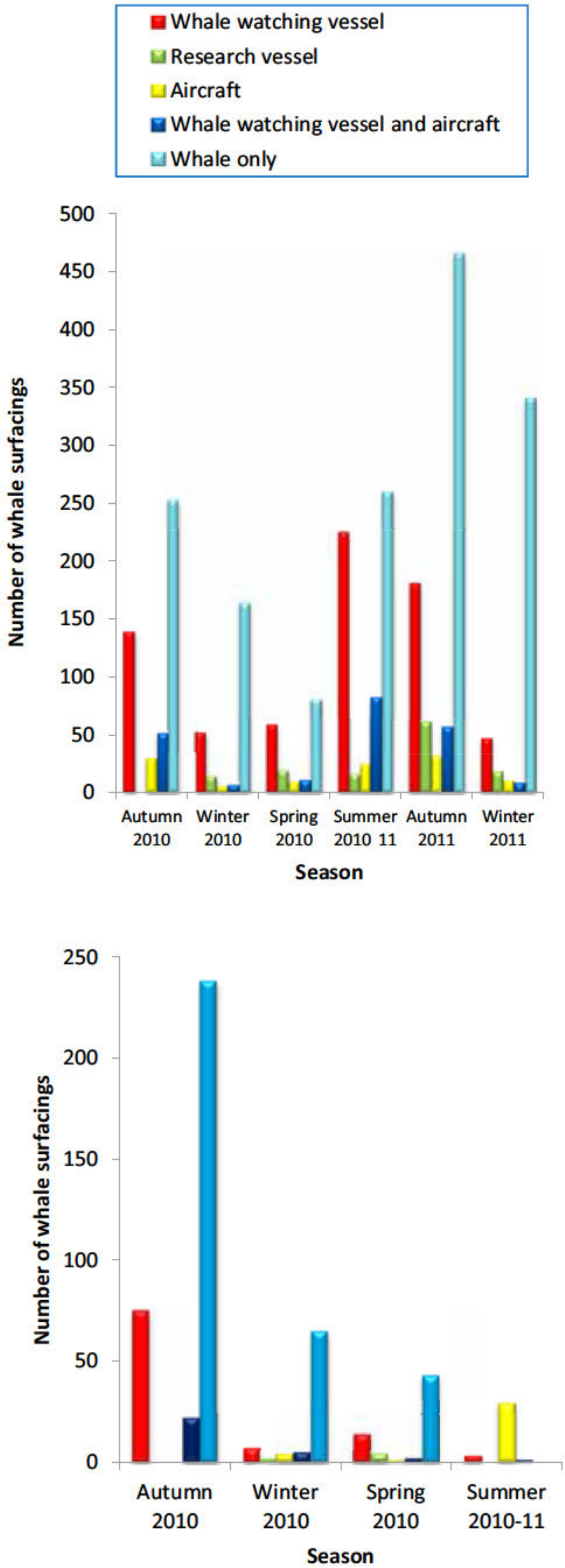

Figure 2.15. Seasonal type of encounter for theodolite locations (top) and video system track (bottom).

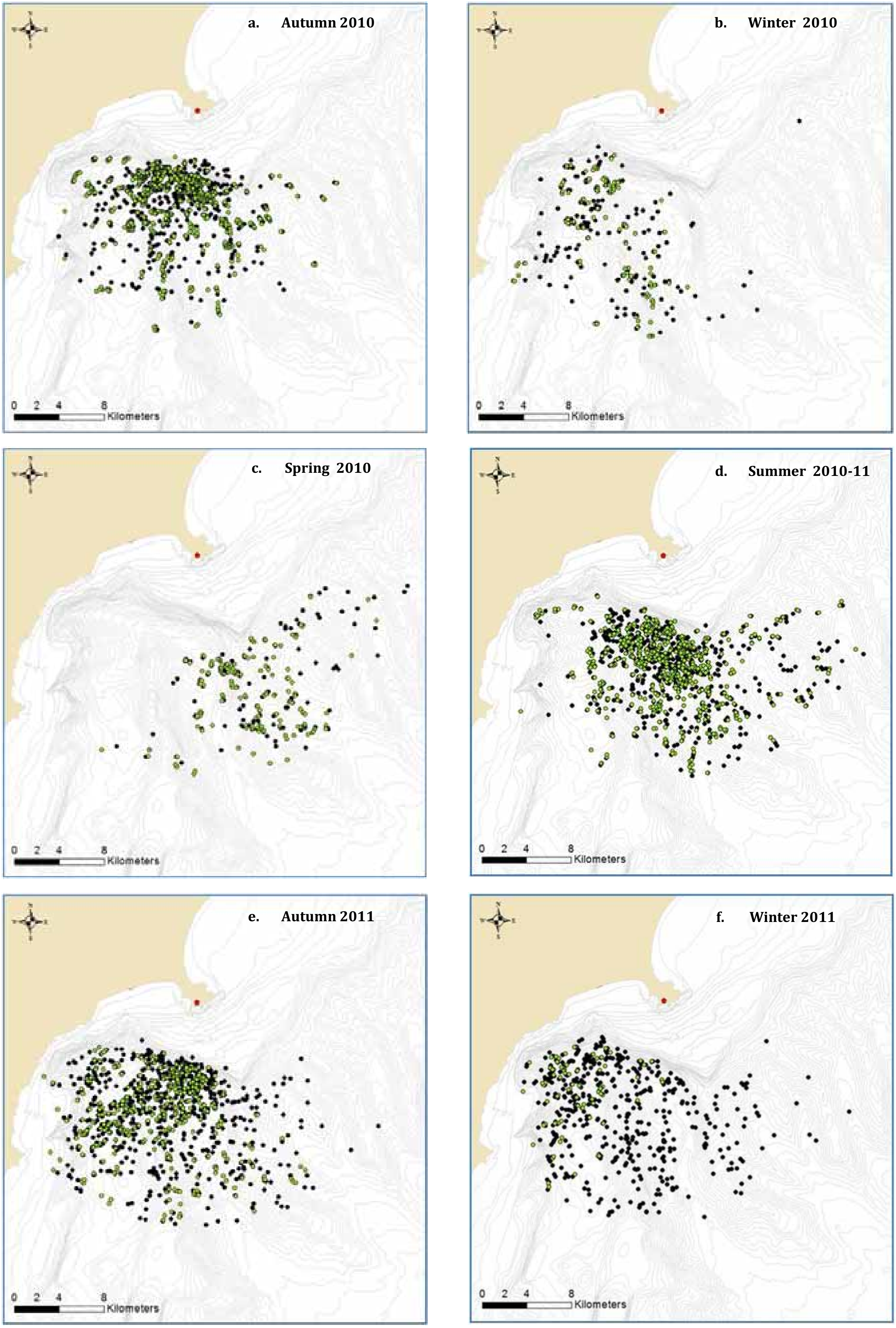

Figure 2.16. Sperm whale locations and whale watching vessel locations are compared by season. (Red dot= shore based station, black dot= sperm whale, green dot= whale watching vessel).

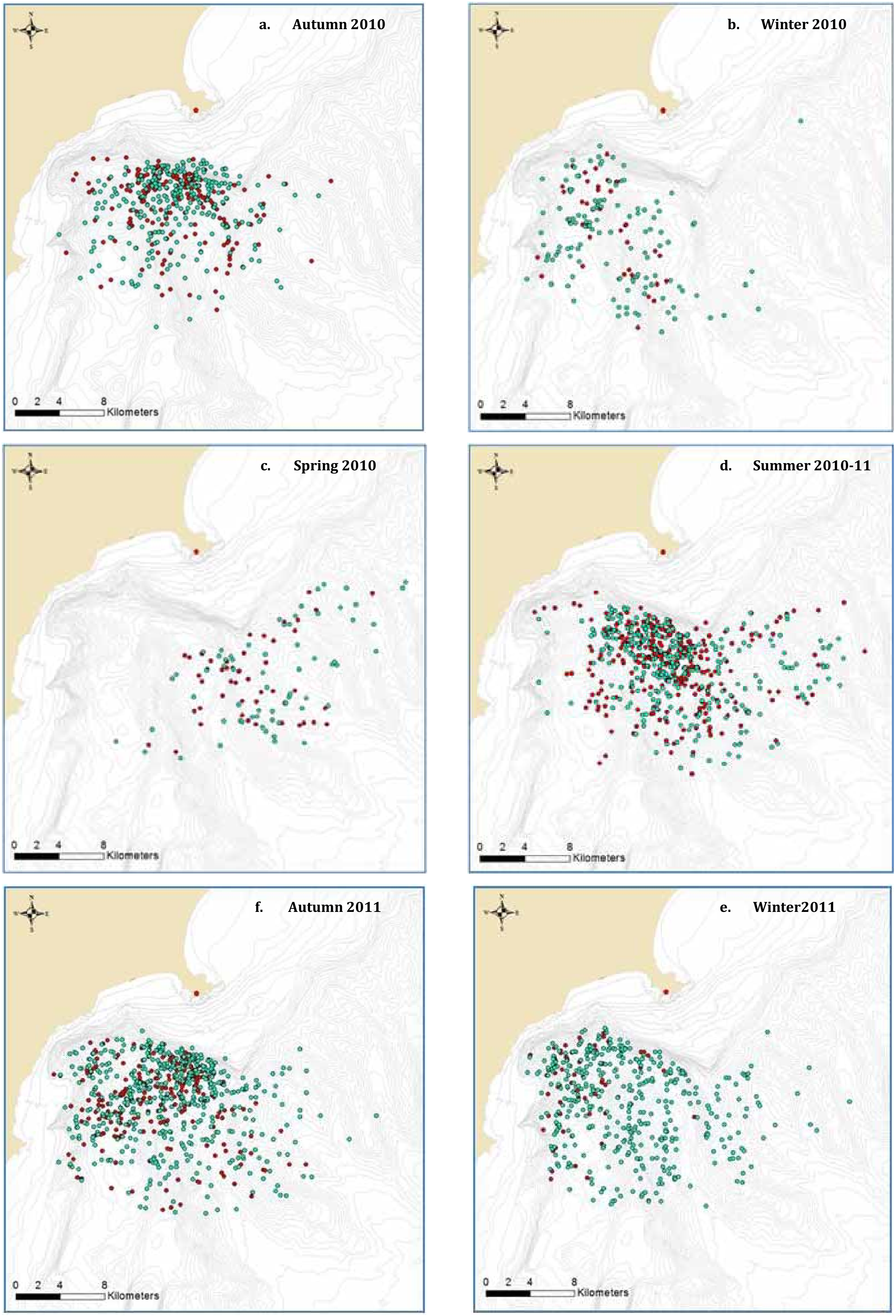

Figure 2.17. Locations of sperm whales alone and sperm whales associated with whale watching vessels are compared by season. (Red dot= whale associated with whale watching vessel, blue dot= sperm whale alone).

Comparison of standard deviation ellipses (Tables 2.7 and 2.8, Figures 2.18 and 2.19) revealed that the area where whale watching tours operated is significantly different from the area of the sperm whale distribution (ANOVA n=12, F=9.135, p=0.013). The mean central location did not vary significantly between whales accompanied by vessels and those not accompanied by vessels.

Table 2.7. Area and mean centre (Longitude-Latitude) of standard deviation ellipses for whale watching locations are compared by seasons.

Season	Area (km^2)	Longitude (°E)	Latitude (°S)
Autumn 2010	64.4	173.6753	42.5037
Winter 2010	83.3	173.6388	42.5225
Spring 2010	78.3	173.7568	42.5364
Summer 2011	82.5	173.7041	42.5183
Autumn 2011	87.8	173.6583	42.5179
Winter 2011	49.6	173.6588	42.5190

Whale watching vessels ranged as far in search of whales in winter as in other seasons (Table 2.7), but interaction with vessels took place over a smaller proportion of the sperm whale distribution during winter than in other seasons (58% and 48%, Table 2.8). In summer and autumn interactions occurred over the greatest proportion of the whales' range (78-93%, Table 2.8).

Table 2.8. Area (km^2) calculated for standard deviation ellipse is compared by season for sperm whales accompanied with and without whale watching boat.

season	Area (km^2) with boats	Area (km^2) without boats	%
Autumn 2010	69.6	74.5	93
Winter 2010	64.5	110.8	58
Spring 2010	85.0	118.5	72
Summer 2011	85.1	101.0	84
Autumn 2011	87.7	113.0	78
Winter 2011	61.1	127.0	48

Standard deviation ellipses for whale watch vessel locations monitored from shore indicate that whale watching tours were conducted furthest offshore in spring (Figure 2.18 top, green) and summer (Figure 2.18 bottom, blue). Whale watch tours found closer to shore in autumn and winter followed the contours of the Kaikoura Canyon, generally staying in the deepest water (Figure 2.18).

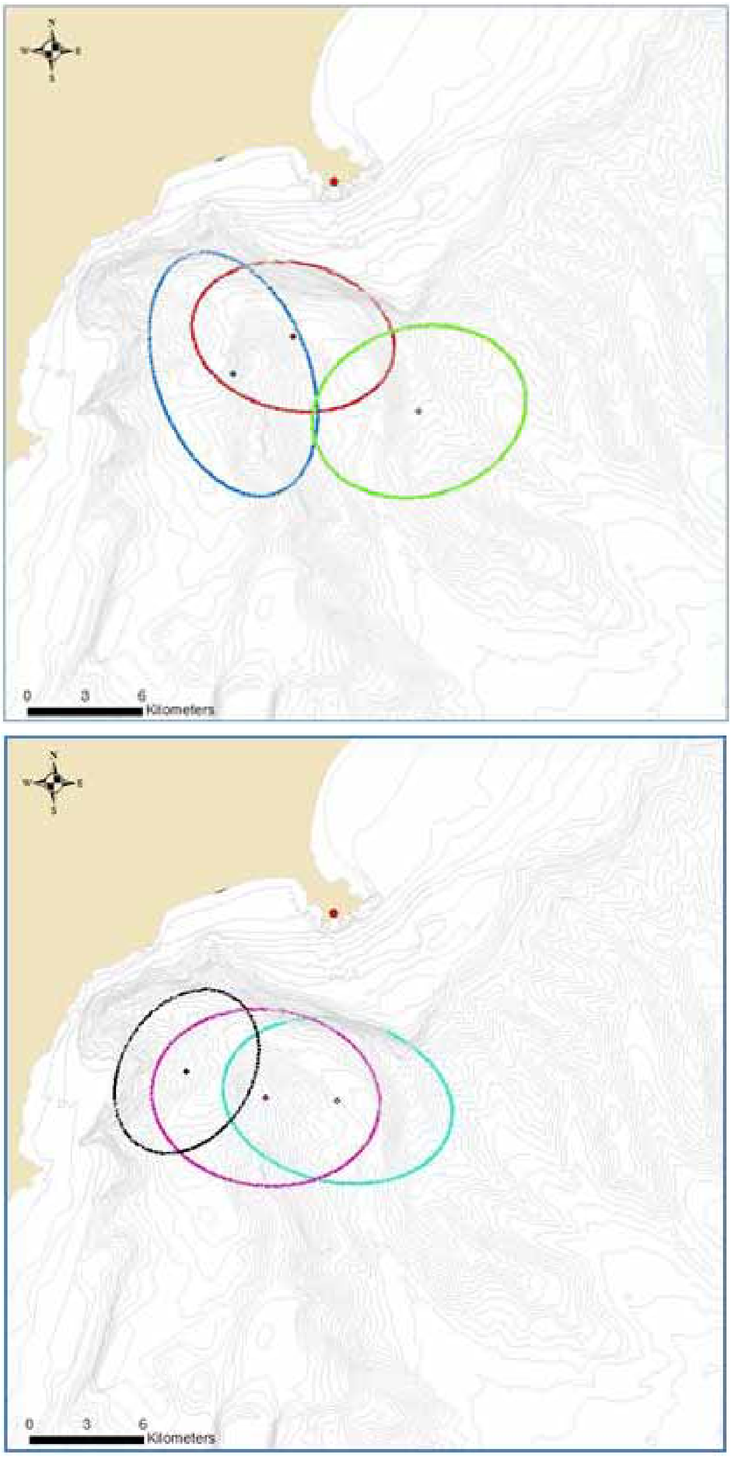

Figure 2.18. Area and mean centre (Longitude Latitude) of standard deviation ellipses for whale watching vessel locations are compared by seasons. On top red : autumn 2010, blue : winter 2010 and green : spring 2010. On the bottom: blue summer 2010 11, pink: autumn 2011 and black winter 2011.

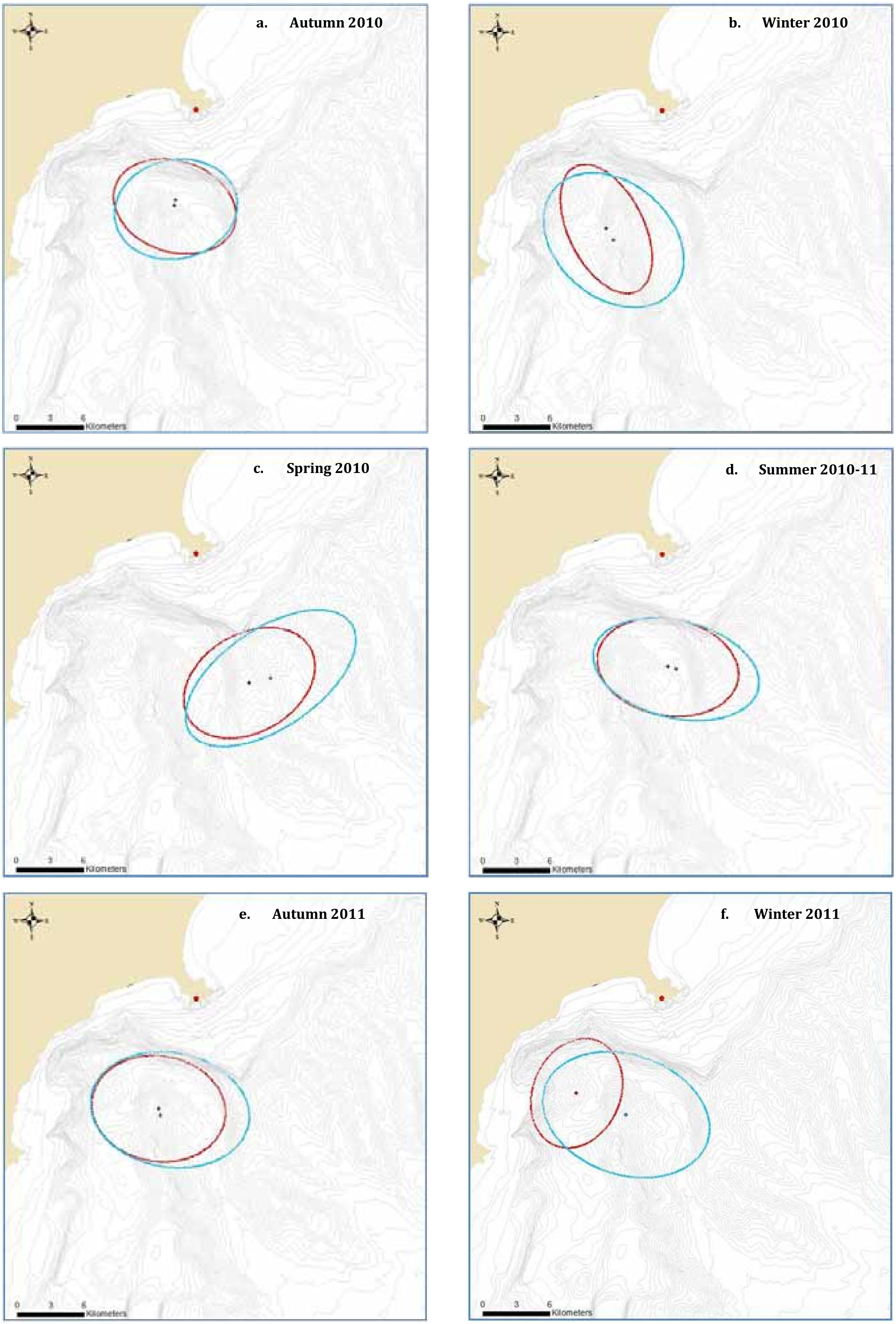

Figure 2.19. Area and mean centre (Longitude-Latitude) of standard deviation ellipses for sperm whales alone (blue) and sperm whales associated with whale watching vessels (red) are compared by season.

During summer 2010-11 and winter 2011, distance from shore of sperm whales alone and sperm whales associated with whale watching vessels (Figure 2.20) was significantly different (ANOVA, n=616, F=5.236,p=0.022 and ANOVA n=471, F=42.119, p<0.0001).

The water depths at which sperm whales were fixed alone and associated with whale watching vessels (Figure 2.21) varied significantly in autumn 2010 (ANOVA, n=472, F=12.502, p=0.0004) and in winter 2011 (ANOVA, n=471, F=6.951, p=0.009).

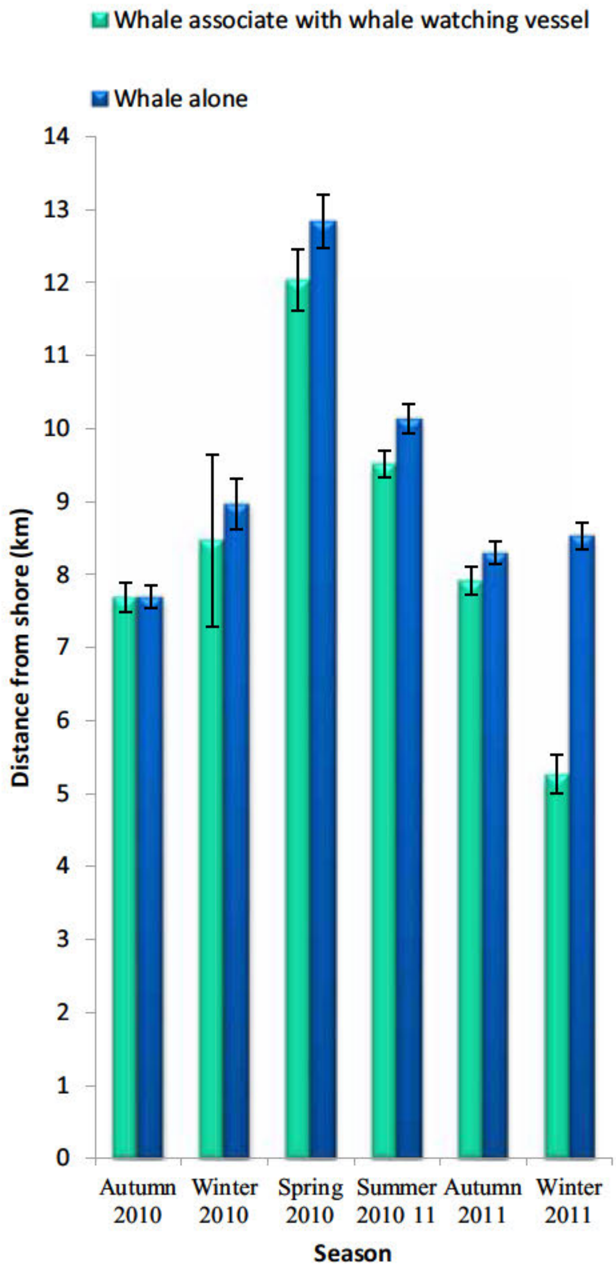

Figure 2.20. Distance from shore (km) of sperm whales alone is compared to the distance from shore of sperm whales associated with a whale watching vessel. Distance from shore was estimated by drawing the shortest straight line between the shoreline and the whale theodolite locations assigned to the on nearest isobaths on a bathymetric chart. Bars represent means values with standard errors.

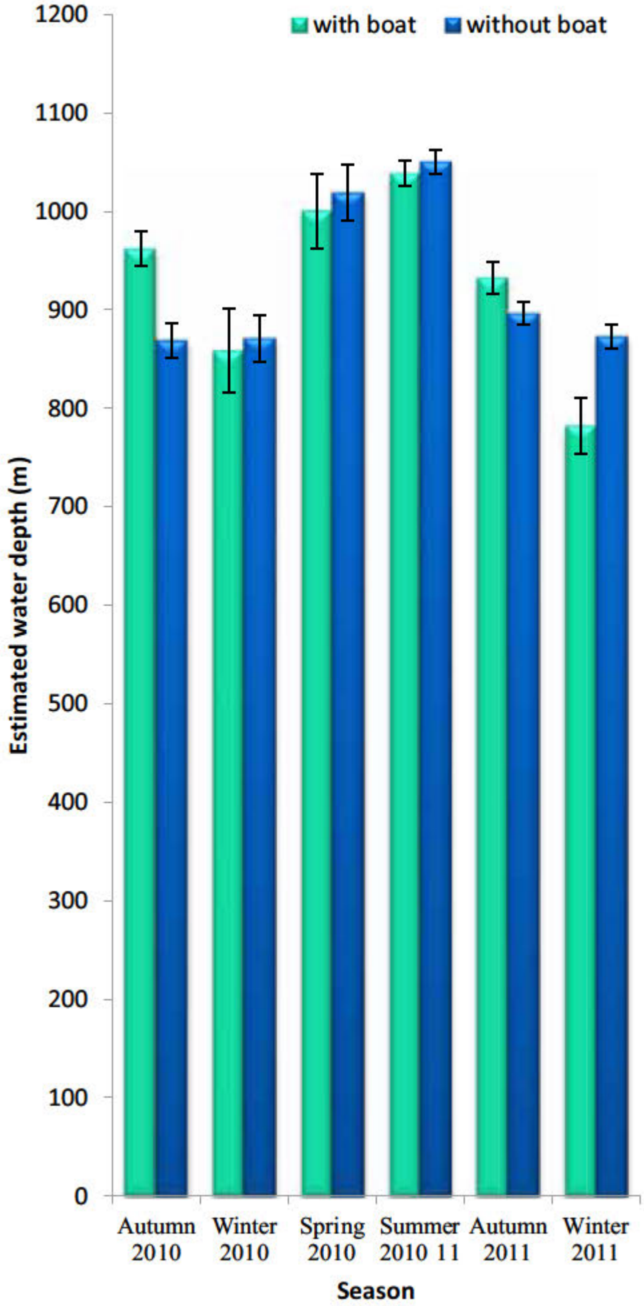

Figure 2.21. Estimated water depth (m) of sperm whales alone is compared to the estimated water depth of sperm whales associated with a whale watching vessel. Depth was estimated by theodolite locations assigned to the on nearest isobaths on a bathymetric chart. Bars represent means values with standard errors.

EFFECTS OF VESSELS ON WHALE BEHAVIOUR

Surface behaviour of sperm whales was compared by type of vessel encounter. Ventilation rate (blow interval) varied significantly with type of encounter (Figure 2.22, ANOVA, n=1088, F=6.614, p<0.0001). Whales associated with whale watching vessels and with whale watching vessels and aircraft had significantly longer mean blow intervals than whales alone (Tukey p=0.027; Tukey p=0.001) or whales associated with the research vessel (Tukey p=0.020; Tukey p=0.001). There was no significant difference in leg speed with type of encounter (ANOVA, n=1036, F=2.100, ns).

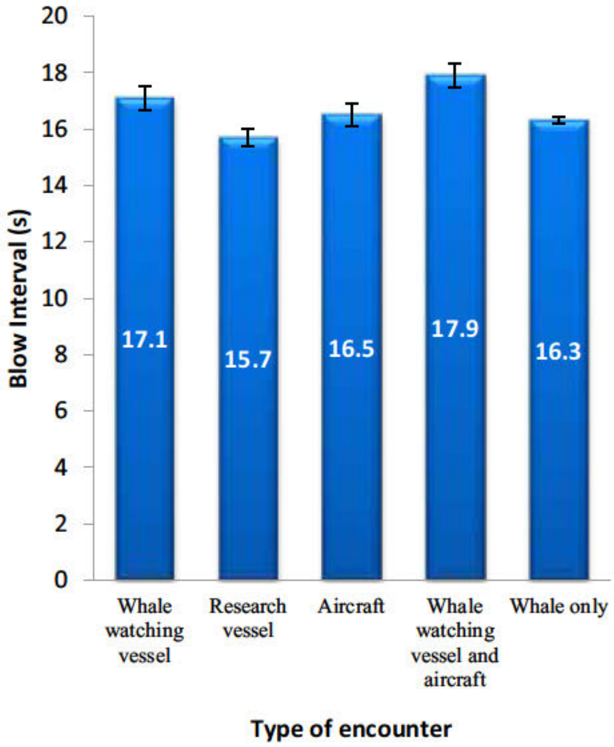

Figure 2.22. Mean blow interval (s) of sperm whales tracked from shore are compared by data collection method. Bar represent standard errors.

Interactions by Season

Whales not associated with vessels and aircraft had significantly different mean blow intervals by season (ANOVA n=626, F=3.176, p=0.008, figure 2.12). Effectively, ventilation patterns of whales associated with whale watching vessels (ANOVA n=275, F=1.620, ns), with research vessel (ANOVA n=62, F=1.781, ns), with aircraft (ANOVA n=44, F=1.496, ns) and with whale watching vessel and aircraft (ANOVA n=81, f=1.065, ns), showed no statistical difference between seasons. This result suggests the effect of interactions with vessels and aircraft on blow interval supersedes any effect of season on this behavioural parameter. The impact of season on mean blow interval for whales alone was no longer apparent in the presence of vessels and aircraft. This significant difference appeared to occur only for ventilation patterns in autumn (2010, 2011, Tukey, p=0.043). Data collected with the video system confirmed that ventilation patterns of whales associated with whale watching vessels (ANOVA n=99, ns), the research vessel (ANOVA n=6, F=6,438, ns), aircraft (ANOVA n=34, F=0,964, ns), whale watching vessels and aircraft (ANOVA n=30, F=1,135, ns) showed no statistical difference between seasons.

Interactions by time of day

Time of the day (figure 2.13) does not appear to be a factor influencing the mean blow interval of sperm whales in the Kaikoura Canyon. If we look closely at all types of encounters, whales associated with whale watching vessels (ANOVA n=275 F=0.039, ns), the research vessel (ANOVA n=62 F=1.112, ns), Aircraft (ANOVA n=44 F=0.012, ns), whale watching vessels and aircraft (ANOVA n=81 F=0.041, ns) and whales only (ANOVA n=626 F=0.209, ns) showed no statistical difference with time of day.

Results of mean blow interval were similar for data collected using the video system. Whales associated with whale watching vessels (ANOVA n=99 F=0.298, ns), the research vessel (ANOVA n=6 F=0.858, ns), aircraft (ANOVA n=34 F=0.744, ns) whale watching vessels and aircraft (ANOVA n=30 F=3.804, ns) and whales only (ANOVA n=346 F=0.005, ns) showed no statistical difference with time of day.

As was found with ventilation patterns, time of day is not a factor influencing mean leg speed of sperm whales. No statistical differences were found for whales associated with whale watching vessels (ANOVA n=262 F=0.268, ns), with the research vessel (ANOVA n=60 F=0.0003, ns), with aircraft (ANOVA n=44 F=3.054, ns), with whale watching vessels and aircraft (ANOVA n=76 F=0.04, ns), and whales only (ANOVA n=594 F=0.185, ns).

Number of whale watching vessels

The surface behaviour of sperm whales did not vary significantly with the number of whale watching vessels present ANOVA n=275 F=1.188, ns). During the majority of surfacings in which whales interacted with whale watching vessels, whales were associated with only one boat (n=192). Whales were associated with two boats during 72 surfacings and with three whale watching boats during only 11 surfacings. Whales were visited by the greatest number of vessels in summer, followed by autumn (Figure 2.23).

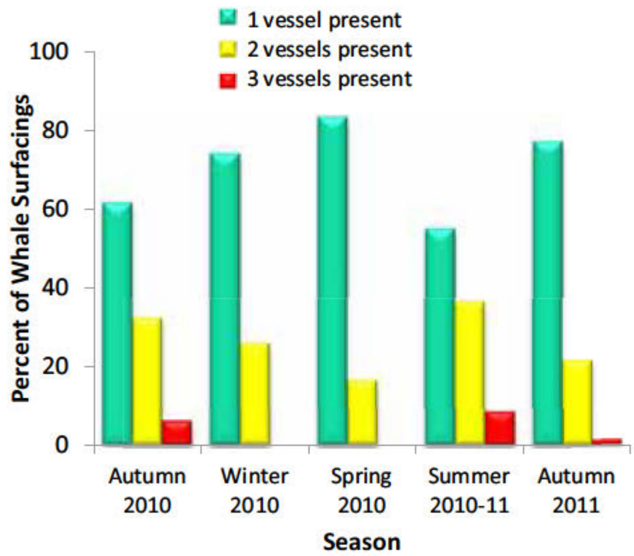

Figure 2.23. The number of whale watching vessels accompanying whales is compared by season. Bars indicate the percent of surfacing whales accompanied by one, two, and three vessels.

DISCUSSION

This chapter presents information on the behaviour and distribution of sperm whales within the Kaikoura submarine canyon. The behaviour and distribution of sperm whales associated with whale watching vessels, aircraft and the research vessel, was compared with whales not interacting with vessels.

In general, the factor most influencing sperm whale behaviour and distribution appears to be season. Similar results were reported by Richter *et al.* (2003). Seasonal changes were detected in blow interval (longest in spring and summer, shortest in winter), time whale was tracked at surface (an indication of surface time, highest in summer), and mean leg speed (highest in spring).

Habitat use also varied seasonally, with whales found further offshore in spring and summer than in autumn and winter. Vessel positions recorded with the theodolite from the shore station showed a narrower distribution than those based on GPS data loggers (Chapter 3). This is likely because shore-based monitoring focused on vessels in the vicinity of whales (not all vessel tracks), and was limited by distance from shore (due to reduced visibility of vessels further from the station).

Changes in water depth by season were not as great as changes in distance from shore because whales moving inshore stayed inside the canyon where the water was deepest. Whales were found at the deepest mean water depths (over 1km) in spring and summer. In general, whales were most prevalent in the 850-150m depth range. Only rarely did they occur in water <500m deep.

The seasonal distribution reported by Jaquet *et al.* (2000) is comparable to the results in this chapter, with sperm whales found closer to shore in winter months. The absence of sperm whales within the canyon during October was also previously noted by Jaquet *et al.* (2000). Overall, the mean water depth at which sperm whales were sighted in this study agrees with the findings reported by Jaquet *et al.* (2000) ,between 500 to 1500m, although fewer whales were sighted at depths exceeding 1250m.

Interactions with vessels occurred during less than half of all monitored surface intervals. Interactions were most common in the afternoon and in the summer months.

Although the distribution of whale sightings varied between instances when whales were observed at the surface alone and instances when they were accompanied by tour vessels, these findings do not appear to indicate habitat displacement. Whale interactions with tour vessels generally occurred in a narrower range, closer to shore than the range of whale sightings in the absence of vessels (Figures 2.19 and 2.20). While we cannot rule out the possibility that some whales moved offshore to avoid vessel interactions, the most parsimonious explanation for these findings is that the differences were due to tour vessels approaching and interacting more often with those whales closest to port.

We found a difference in ventilation patterns for whales alone versus whales accompanied by whale watching vessels. The finding that blow interval varied between surfacings where whales were accompanied by vessels and those where they were not may indicate an effect of whale watch tourism with the potential to influence sperm whale foraging efficiency and energy budgets. The mean blow interval documented in this study from the theodolite station (16.6 sec) was similar to that reported by Richter *et al.* (2003, 16.7 sec). Moreover, our studies of whale distribution showed that the whales were found in deeper water around the peak summer tour season. While it is not possible to measure sperm whale energy use (nor indeed food consumption), it seems likely that the whales are particularly energetically challenged in the spring and summer when they are found in the deepest water. If tour vessels are reducing the oxygen intake of the whales, this could be a cause for concern. The effect of vessels on ventilation rate appeared to supersede the effect of season on the same variable, as seasonal differences disappeared in the presence of tour vessels.

The research vessel had no measurable effect on the whales' surface behavior, including their breathing rate. While it is almost certain the whales are aware of the presence of the research vessel, this finding suggests that the research vessel provides a reasonable independent platform from which to monitor whale interactions with tour vessels unobtrusively (Chapter 4). Aircraft by themselves also had no effect, and the combined effect of aircraft and whale watch vessels on ventilation rate was no greater than that of the whale watch vessels by themselves. This suggests that aerial tours may have less of an effect on the behavior of sperm whales than boat tours, a finding similar to that in a recent study of dusky dolphin interactions with boats and planes off Kaikoura (Markowitz et al. 2009).

One shortcoming of this research was that individual whales could not be identified and tracked over time through their dive cycles. Chapters 4 and 5 of this report describe photo-identification and acoustic tracking research conducted from a vessel which was able to collect these data. A strength of shore based observation is that it provides ability to collect true no vessel control data to compare with those from whales with vessels present. This strength, combined with a broader vantage from which to observe whale interactions with tour vessels across the Kaikoura Canyon area may explain why we were able to detect some differences in the behaviour and distribution of whales interacting with tour vessels that were not detectable from either the research vessel or the tour vessel (most notably ventilation rate).

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Chapter 3

REMOTE TRACKING AND ONBOARD MONITORING OF WHALE WATCHING ACTIVITY AT KAIKOURA, NEW ZEALAND

Ophélie Sagnol and Tim M. Markowitz

This chapter examines whale watching tourism at Kaikoura using the tour vessels and aircraft themselves as research platforms. Although this approach does not provide an independent vantage from which to monitor sperm whale interactions with tours, it does provide an opportunity to gather detailed information on the tours themselves. The objectives of this chapter were to document levels of whale watching tourism activity, areas in which whale watching vessels operate, and interaction of vessels with sperm whales. To address these research objectives, we utilized two methods: remote tracking by GPS data logger systems and direct monitoring by scientific observers onboard tour vessels and aircraft. The research effort onboard whale watching boats occurred year round during 94 trips, peaking in Autumn. The distance between whale watch tour vessels and whales during an encounter averaged 75 $\pm$ 1.8m (mean $\pm$ se). Sperm whales changed heading >10° during 75% of interactions with whale watch vessels. Neither heading changes nor blow intervals varied significantly with distance of whales from the whale watch vessels. To obtain general data on vessels, GPS data loggers were deployed onboard whale watching vessels and aeroplanes from Spring 2009 through Winter 2011. Additional data for aerial tours were downloaded from online GPS track logs. GPS tracks showed less activity in winter than other seasons, with summer and autumn the busiest seasons. Tours ranged furthest offshore and alongshore in spring, when the sperm whales were relatively scarce. Tours occurred across the narrowest ranges in winter.

INTRODUCTION

This portion of our study evaluated tourism off Kaikoura, New Zealand from whale watch tour vessels. This platform provides for detailed study of a "focal tour" examination of tour vessel movements, speeds, and interactions with animals. To obtain as much information as possible on vessel activity given the large number of boat and aerial tours, we utilized remote tracking in the form of onboard GPS data loggers. In addition, we deployed scientific observers onboard tours to document vessel-whale interactions in more detail. Because they are performed from the tour vessel, observations of whale behaviour from this platform cannot provide the same quality of information as data collected from an independent platform (e.g., research vessel, shore station). However, to gather data on what the vessel is doing (e.g., areas visited, distance from whales during an encounter, speed of movement), the ideal place to be is onboard. Remote tracking was used so that we could continue to have onboard monitoring, even when scientific observers could not be present.

Whale watching began in Kaikoura in the late 1980s and has grown considerably since that time, as the number of passengers and vessel sizes increased (Te Korowai 2008). Whale watching platforms operated by local companies include aircraft (both fixed wing planes and helicopters, Figure 3.1) and Whale Watch Kaikoura tour vessels (five 17-18m catamarans with jet engines, Figure 3.2). Tours operate year round, so long as weather permits and whales are in the area.

Figure 3.1. Aircraft monitored in this study included helicopters and fixed wing aeroplanes. Helicopters (left) were fitted with GPS data loggers to track their movements. Fixed wing planes (right) were either fitted with GPS data loggers (Kaikoura Aeroclub) or used their own GPS logging system which could be downloaded by researchers (Wings Over Whales). Onboard observers also collected data on some fixed wing flights.

Boat tours typically last 2-2.5 hours, while aerial tours are typically about 30 minutes. Both aerial and boat tours typically take visitors to see a number of other attractions in addition to whales (e.g., scenery, dolphins, fur seals, birds). Thus, while whales are the focus of the tour, the actual time spent with whales is a relatively small fraction of the total tour. Whale watch skippers often stop to listen with a directional hydrophone to locate whales during dives, especially on tours early in the day.

The use of a tour vessel as a research platform from which to measure the effects of the same tour vessel inherently introduces confounding factors in studies of cetacean responses to tourism (Bejder and Samuels 2003). Nevertheless, such a platform has been used with some success by researchers examining dolphin responses to tourism (e.g., Constantine 2001, Dans et al. 2008). An advantage of the use of tour vessels is that it allows systematic sampling of details related to vessel operation and tour activity (Bejder and Samuels 2003, Markowitz et al. 2009).

RESEARCH OBJECTIVES

The objectives of this research were to:

1. Document whale watching tour activity from both aircraft and boats, comparing it by platform and season;
2. Examine interactions of whale watching tours and sperm whales from the vantage point of the tour vessels, measuring vessel distance and speed concurrently with whale behavior; and
3. Note any apparent changes in whale behavior in the course of encounters with tour vessels.

a. Aoraki

b. Paikea

c. Tohora

d. Te-Ao-Marama

e. Wawahai

Figure 3.2 Five vessels used by Whale Watch Kaikoura over the course of the two year investigation. Vessel movements were monitored by GPS data loggers and vessel activities were monitored by onboard observers.

METHODS

MONITORING BY GPS DATA LOGGERS

GPS loggers (Figure 3.3) were deployed in four whale watch tour boats and four aircraft (three loggers in helicopters, one logger in an aeroplane operated by Kaikoura Aeroclub). GPS data from another aerial tour, Wings over Whales, were downloaded directly from their web-based tracking system. GPS loggers were powered directly by the electrical system onboard whale watching vessels. Logger's onboard aircraft ran on an independent battery power supply that needed to be changed once per week.

Figure 3.3. GPS data loggers such as this one were used to monitor movements of tour vessels over a two year period.

The GPS loggers collected GPS positions (GMT time, Longitude and Latitude) every 15 seconds. The data from the GPS loggers were downloaded from all platforms every two months. Tracking data downloaded from the GPS loggers were extracted using Data log Data Downloader and stored in a folder named by the platforms name. The next step was to convert the data, previously in an .nmea format into a .csv format using JDatalog in order to be able to import this data into a Microsoft Access database.

GPS locations, flight speeds, and altitudes from Wings Over Whales flights were logged every minute and downloaded from the tracplus website for analysis (http://www.tracplus.com/). Data from takeoff and landing (determined by examining daily logs for flight speed and altitude) were excluded from analyses.

To examine the position (Longitude and Latitude) of the whale watching vessels, GPS positions imported into Microsoft Access were extracted by platform (whale watching boats and aircraft) and by seasons, then exported into ArcGIS 10. As detailed in Chapter 2, GPS positions were imported using the WGS 84 coordinate system onto a coastline base map and a bathymetric chart supplied by the National Institute of Water and Atmospheric Research (NIWA). For more accurate estimates, the data frame was changed to NZ UTM 59S, and a buffer of 1000m around the coastline base was created, removing vessel positions not related to whale watching.

To examine variability in the areas where whale watching companies operated, standard deviation ellipses were examined in ArcGIS 10. The best fit area (km²) and the central point (Longitude and Latitude) were then determined in ArcGIS. The area data did not follow a normal distribution, so they were transformed using y=ln(y). Central location followed a normal distribution so no transformation was necessary.

MONITORING BY ONBOARD OBSERVERS

Whenever possible, scientific observers were sent onboard whale watching vessels (Figure 3.4).

Figure 3.4. A whale watching vessel follows a sperm whale.

Vessel data collected on these trips included vessel approach time and bearing, range of the whale from the boat using a Bushnell laser range finder, and the presence plus position of other vessels (within 300m) relative to the whale. Whale data collected on these trips included heading (estimated by compass), blow rate, behaviour (e.g., breaching, tail slapping), and fluke photographs for identification of individual whales (see Chapter 4). To examine changes in the heading of the whale we subtracted the last heading record of an encounter from the first heading of the encounter.

Observations were made onboard whale watching vessels on 94 trips. During two trips no whales were found by the whale watching crew. The number of whale watching trips varied seasonally due to research team logistics and availability of space on whale watch vessel tours (Figure 3.5).

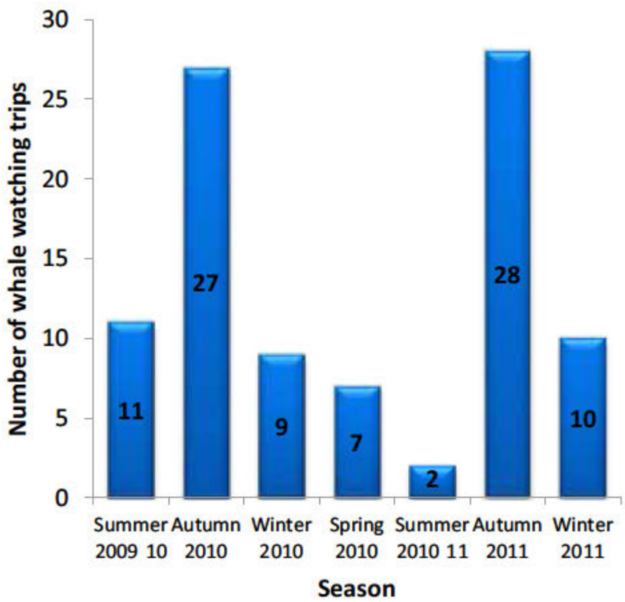

Figure 3.5. The number of whale watching trips monitored by onboard observers is compared by season.

Aerial whale watch tours (Wings Over Whales) were monitored by onboard observers on eight occasions. Data collected included altitude, length of time circling, presence of other vessels and any noteworthy behaviours of sperm whales.

RESULTS

COMPARING TOUR VESSELS AND AIRCRAFT

Seasonal variation of whale watching activity was evident from GPS data logger tracks of all vessels and aircraft. Based on standard deviation ellipses (Figure 3.6), the different tour companies utilized similar areas (ANOVA, n=23, F=0.860, ns). However, seasonal and interannual variation in the area in which the companies operated was significant (ANOVA, n=23, F=13.519, p<0.0001, Table 3.1).

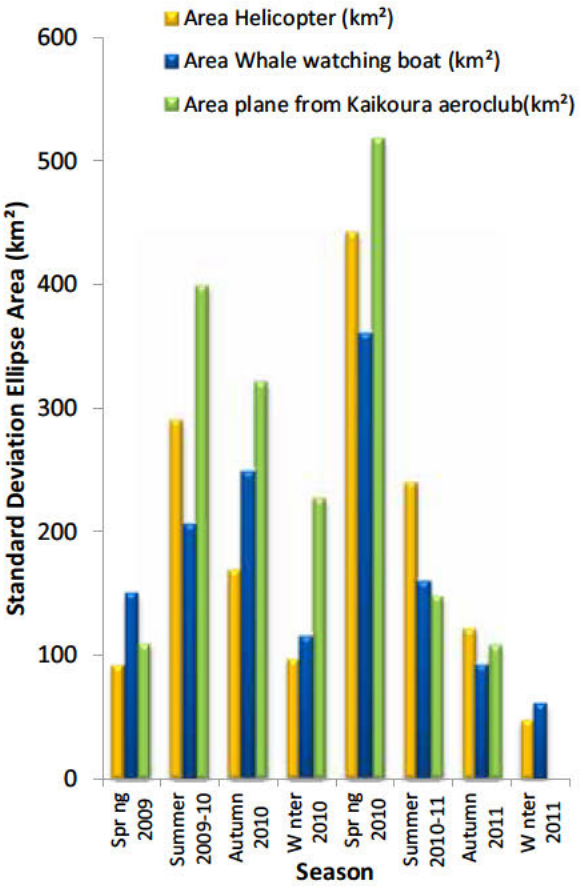

Figure 3.6. Areas of standard deviation ellipses based on GPS tracks are compared by whale watching platforms and season.

Table 3.1 Tukey HSD pairwise post-hoc comparisons of seasonal variation in area utilised by tour companies.

Season	Year	Comparisons			
Spring	2010	A			
Summer	2009-2010	A	B		
Autumn	2010	A	B	C	
Summer	2010-2011		B	C	
Winter	2010		B	C	
Spring	2009			C	D
Autumn	2011			C	D
Winter	2011				D

The central location in which whale watching companies operated (table 3.2) did not significantly vary between platforms (Longitude ANOVA, n=23, F= 0.196, ns; Latitude ANOVA, n=23, F=0.874, ns). But central location varied significantly between seasons (Longitude ANOVA, n=23, F= 15.756, p<0.0001; Latitude ANOVA, n=23, F=8.698, p=0.0002).

Table 3.2. Central location (Longitude and Latitude) are compared by platforms and seasons. Tabular values presented are minutes of longitude and latitude (All central locations were found within the same degrees, 173° East Longitude and 42° South Latitude). There were no GPS data logger tracks for the aeroclub plane during winter 2011

Season		Spring 2009	Summer 2009-10	Autumn 2010	Winter 2010	Spring 2010	Summer 2010-11	Autumn 2011	Winter 2011
Boats	173°E Long	41.9'	41.0'	39.7'	38.5'	44.4'	41.5'	37.6'	36.0'
	42°S Lat	30.4'	30.9'	30.9'	30.7'	31.7'	30.8'	30.6'	30.3'
Planes	173°E Long	41.9'	41.6'	39.9'	39.4'	43.7'	39.5'	39.9'	
	42°S Lat	30.4'	31.8'	31.4'	31.7'	32.7'	30.7'	30.2'	
Helicopters	173°E Long	41.3'	43.2'	40.1'	37.1'	45.2'	42.8'	39.9'	36.8'
	42°S Lat	30.4'	31.7'	30.5'	30.8'	32.5'	30.7'	30.6'	30.2'

WHALEWATCH BOATS

Information Extracted from GPS Data Logger Tracks

For whale watch boats, GPS data logger tracks showed clearly that summer and autumn were the busiest seasons, with less activity in winter (Figures 3.7 and 3.8). Examination of standard deviation ellipses showed whale watch tour boats generally ranged furthest offshore and alongshore in search of whales during the spring and tracks were limited to the smallest near shore area in winter (Figure 3.9).

The mean speed calculated from GPS data logger tracks for all whale watch boats was 23.8 $\pm$ 0.07 km/h (12.8 $\pm$ 0.04 knots). This includes movement of vessels in transit (top speeds exceeding 40 km/h) as well as approaching and following whales and dolphins (speeds of 0-15 km/h).

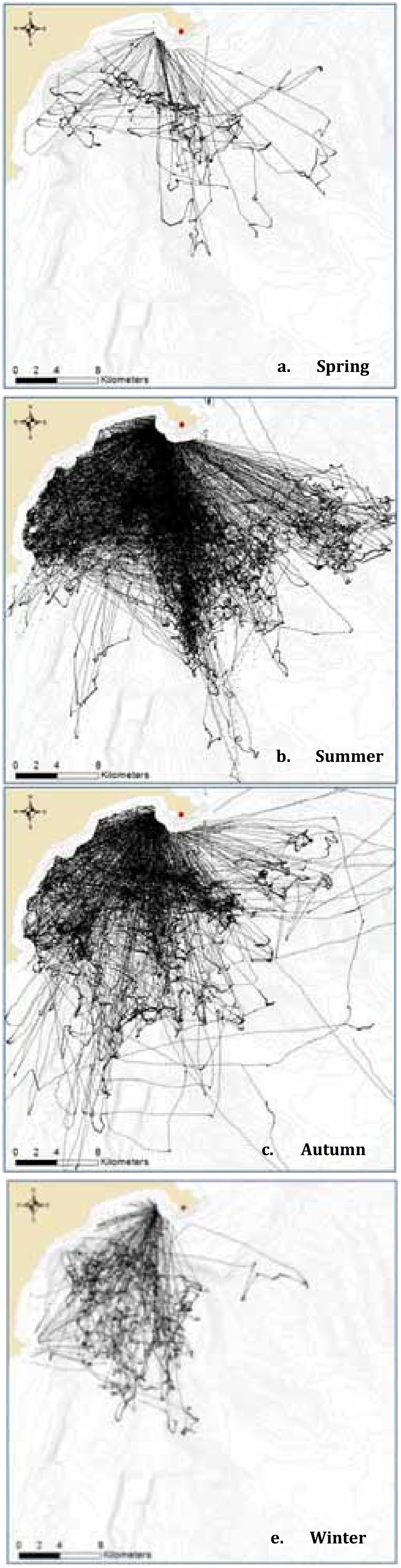

Figure 3.7. GPS positions extracted from GPS loggers onboard Whale watch boats are compared by seasons (2009 10).

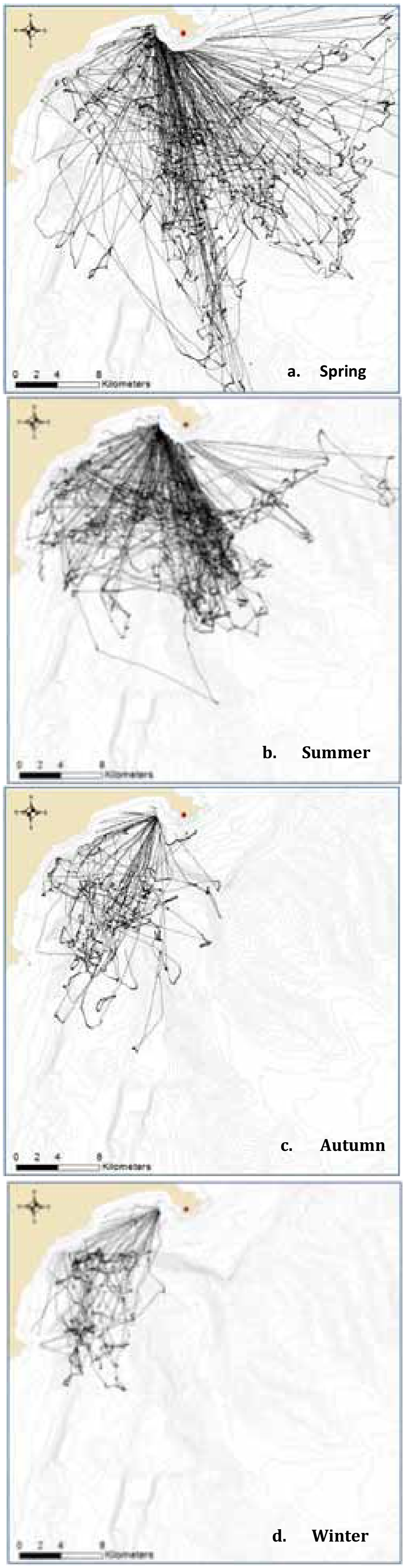

Figure 3.8. GPS positions extracted from GPS loggers onboard Whale watch boats are compared by seasons (2010 11).

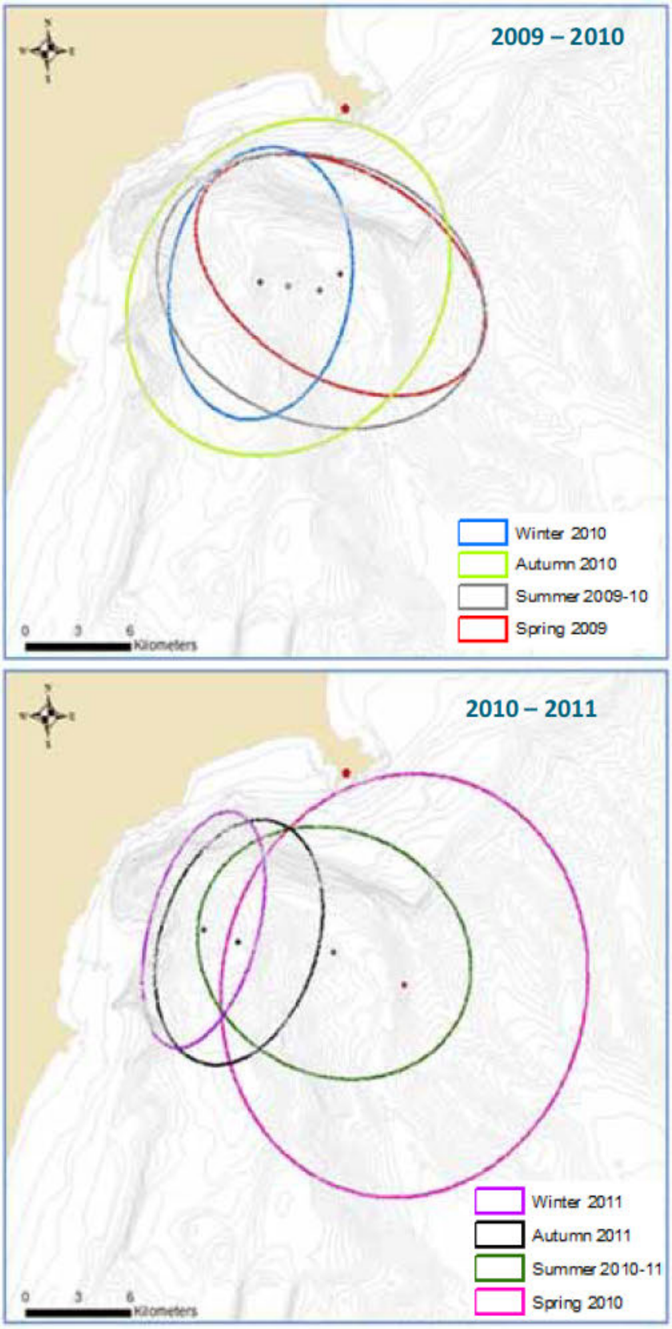

Figure 3.9. Area and mean centre (Longitude-Latitude) of standard deviation ellipses for GPS positions extracted from GPS data loggers onboard whale watching vessels is compared by season for the two year study (Top: 2009-2010, Bottom: 2010-2011).

Onboard Monitoring from Whale Watch Boats

A total of 187 whale encounters were recorded during 94 whale watching trips. The number of encounters observed (Figure 3.10) followed a similar pattern to the number of trips (Figure 3.5).

The distance of the whale watching vessel from the whale was estimated 127 times using a laser range finder. The distance between the vessel and the whale during an encounter averaged 75 $\pm$ 1.8m (mean $\pm$ standard error). A whale watching boat approached within 50m of a whale on only one occasion (32m). Most interactions occurred at distances of 50-90m (Figure 3.11).

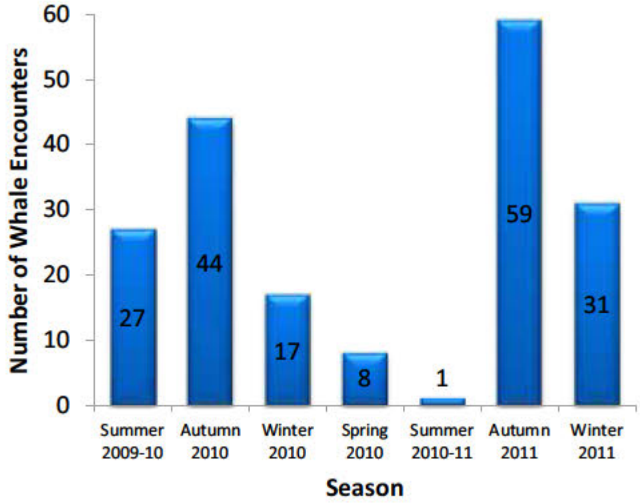

Figure 3.10. Number of sperm whale encounters monitored by scientific observers onboard whale watch tour boats by season.

To examine sperm whale behaviour, we focused our analyses on encounters ending with a fluke up dive. Whales submerged without fluking up on 11 occasions (5.9%). For those encounters where whale heading could be reliably and consistently determined (n = 95 encounters), whales changed heading >10° from the beginning to the end of the encounter 75% of the time (71 encounters). Distance of whale watching vessels from the whales did not appear to influence changes in whale heading. There was no significant difference in the distance of whales from vessels that changed heading versus those that did not (Kruskal Wallis,n=25, χ^2=3.841, ns, Figure 3.12).

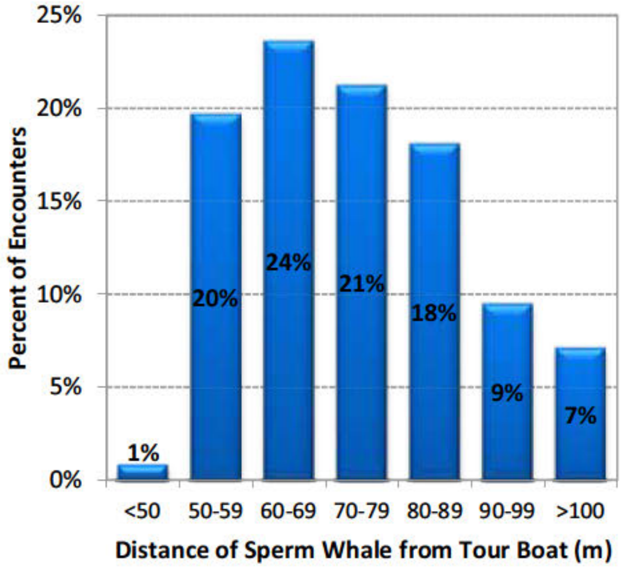

Figure 3.11. This frequency distribution shows the percent of sperm whale interactions with tour vessels that occurred at distances of <50, 50-59, 60-69, 70-79, 80-89, 90-99, and >100 m measured from the tour vessel with a laser range finder (n =127).

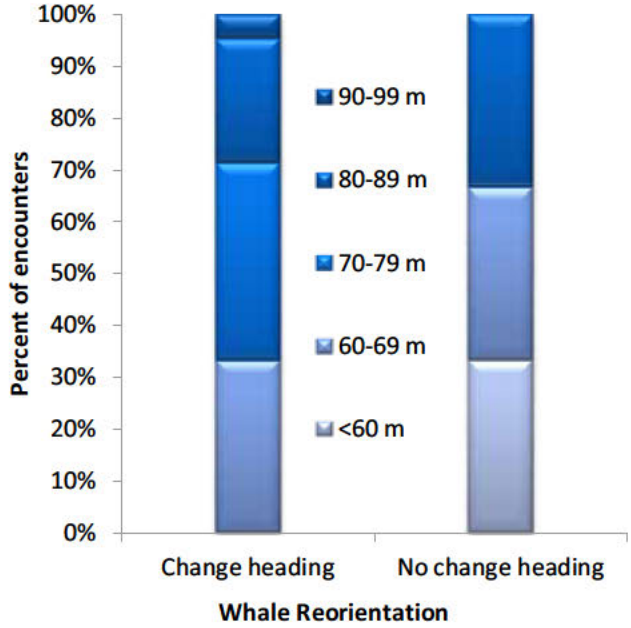

Figure 3.12. Distances between the whale watch tour boat and sperm whales (m) are compared for whales that changed heading during encounters (> 10°) versus those that did not.

Neither the length of encounters between whale watch vessels and whales at the surface (ANOVA, n=187, F=1.185, ns) nor the number of whale blows per encounter (ANOVA, n=131, F=1.451, ns) varied significantly between seasons. The time the whale watch vessels attended a whale at the surface prior to a fluke up dive ranged from 4.2 to 7.9 minutes (median = 6.8 minutes). The number of blows per encounter ranged from 9 to 27 as the first blows were never sighted. These are not true estimates of whale time or number of breaths at the surface because whale watch tour vessels generally approach whales after they have already surfaced (i.e., after the first blow of the surface interval). The first blow following surfacing was never spotted during all 94 trips. Thus, the values reported here document time the whales were accompanied at the surface by the vessel, a fraction of their total time at the surface. Based on the focal follow data from the independent research vessel, surface time averaged 10 minutes in the presence of whale watch vessels (see Chapter 4). Combining these two analyses, it appears that whale watch vessels which approached a whale generally attended that whale for more than half the time it was at the surface (68% on average).

In order to calculate the blow interval (a measure of ventilation rate during the encounter), only whale encounters without missing or double blows (described as interval blow <5sec and >50sec) were used. A total of 92 encounters were analysed and compared by seasons (Figure 3.13). Mean blow interval was normalized using ln(y). Blow interval of sperm whales collected onboard the whale watching vessel did not vary significantly with the distance of the whale from the boat (ANOVA, n=56, F=1.962, ns), but did vary significantly between seasons (ANOVA, n=92, F=2.716, p=0.025).

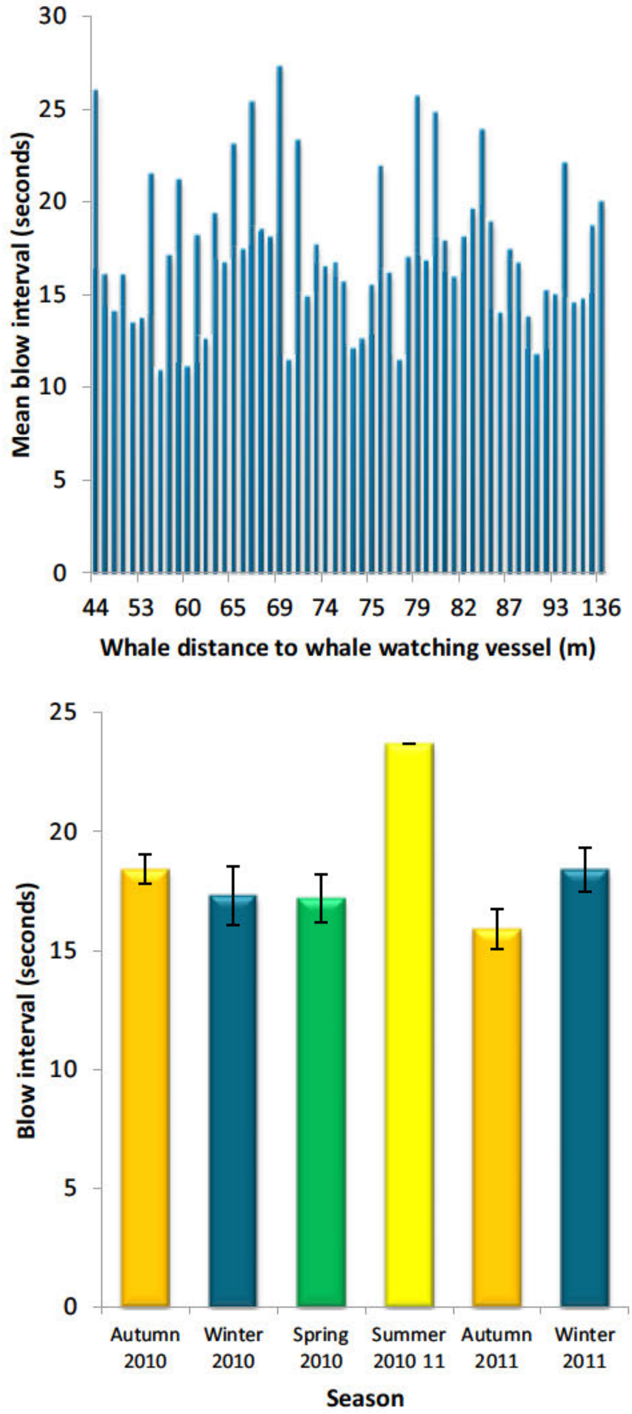

Figure 3.13. Blow intervals of sperm whales attended by whale watch vessels are compared by distance from the vessel (top) and by season (bottom). Bars represent means with standard errors.

AERIAL WHALE WATCHING TOURS

Helicopter Tours

Seasonal variability in aerial tour activity was evident in GPS data logger tracks from the helicopters (Figures 3.14 and 3.15). Generally, helicopter tour activity was least in winter months and peaked in summer and autumn (with some interannual variability (Figures 3.14 and 3.15).

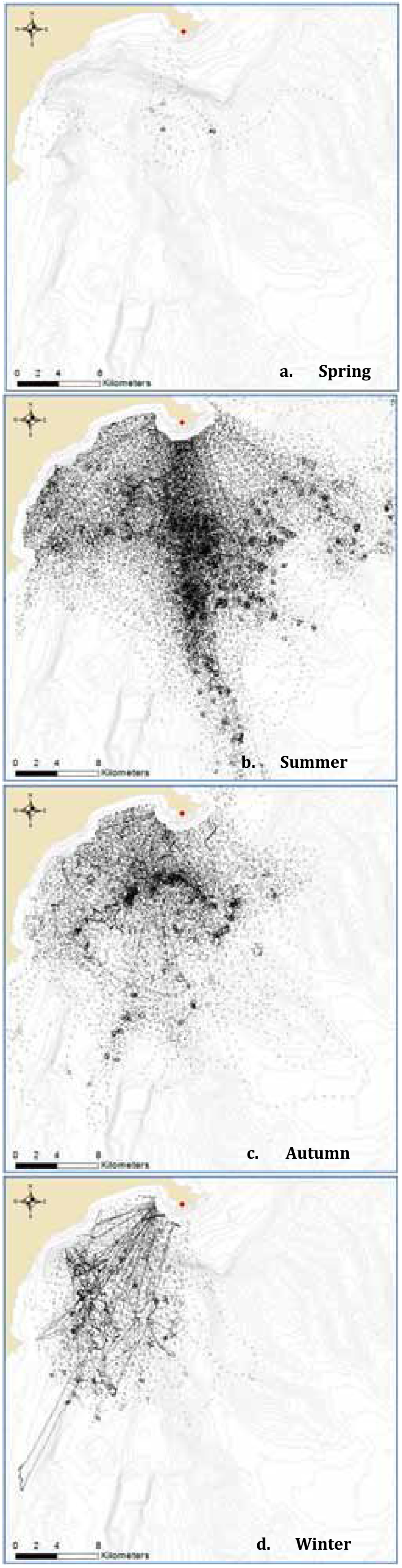

Figure 3.14. GPS positions extracted from GPS loggers onboard helicopters during 2009-10 are compared by season.

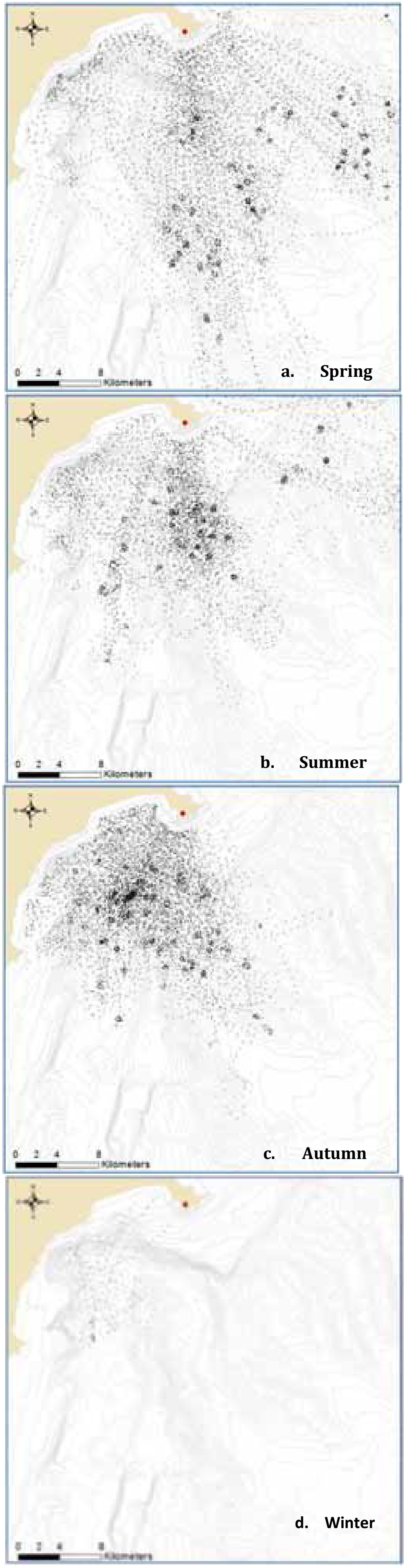

Figure 3.15. GPS positions extracted from GPS loggers onboard helicopters during 2010-11 are compared by season.

Analysis of standard deviation ellipses for helicopter tours showed tours ranging further offshore and alongshore in spring and summer, and across a narrower range closer to shore in autumn and winter (Figure 3.16). Some interannual variability was evident, with tours taking place across the widest range in summer during 2009-2010, and in spring during 2010-2011. In both years, helicopter tours were conducted over the narrowest range in winter, with intermediate ranges in autumn (Figure 3.16).

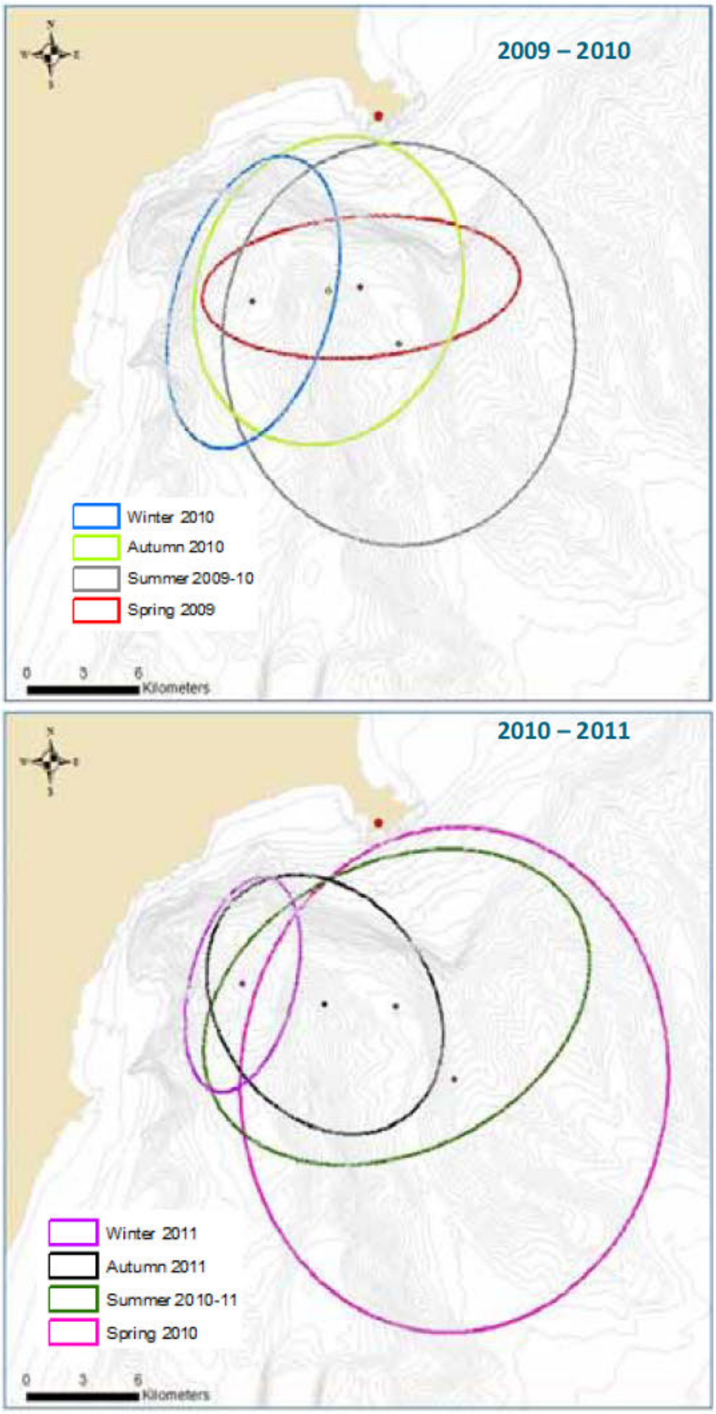

Figure 3.16. Area and mean centre (Longitude-Latitude) of standard deviation ellipses for GPS positions extracted from GPS loggers onboard helicopters is compared by season for 2009-2010 (top) and 2010-2011 (bottom).

Aeroplane Tours

The most consistent aeroplane tours were run by Wings Over Whales. According to GPS track logs archived and downloaded online, Wings Over Whales operated flights in the Kaikoura area on 83% of days. Amount of aerial tour activity varied seasonally (Figure 3.17), with the highest number of days and hours operating in late spring and summer (November through February) and the lowest amount of tour activity in late autumn and winter (May through August). Seasonal variability in areas visited by fixed wing aircraft tours was evident in GPS data tracks from both tour companies (Figures 3.19 — 3.22).

Wings Over Whales tours were flown at an average (mean ± standard error) flight speed of 189 ± 4.2 km/h (102 ± 2.2 knots) and altitude of 234 ± 4.0 m (766 ± 13.1 ft). Records taken by observers onboard Wings Over Whales flights based on the plane's altimeter while circling over the whale showed a similar average altitude of 221 ± 23.4 m (726 ± 76.8 ft), with a range of 143 to 305 m (Figure 3.18 left). There was no significant difference between average flight altitude and altitude while circling whales (Mann-Whitney, U= 62380, ns), although this may be due to limited power (n=8 flights with onboard observers). Mean altitude of Wings Over Whale flights did show some seasonal variation ($F=60.299$, $df=3$, $P < 0.001$), with planes flying lowest on average during the peak summer tourism season (Tukey, $P < 0.05$, Figure 3.18 right).

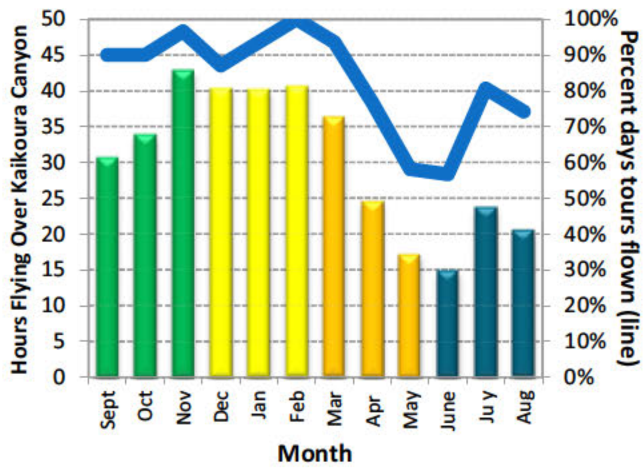

Figure 3.17. Amount of aerial tour activity is compared by month for fixed wing aircraft tours run by the Wings Over Whales company based on data downloaded from online flight logs.

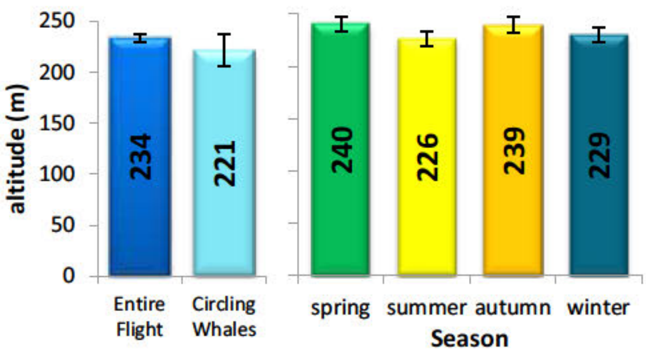

Figure 3.18. Altitudes of whale watch tour planes (Wings Over Whales) are compared: for the entire flight versus the time circling whales (left) and by season (right). Bars represent means with standard errors.

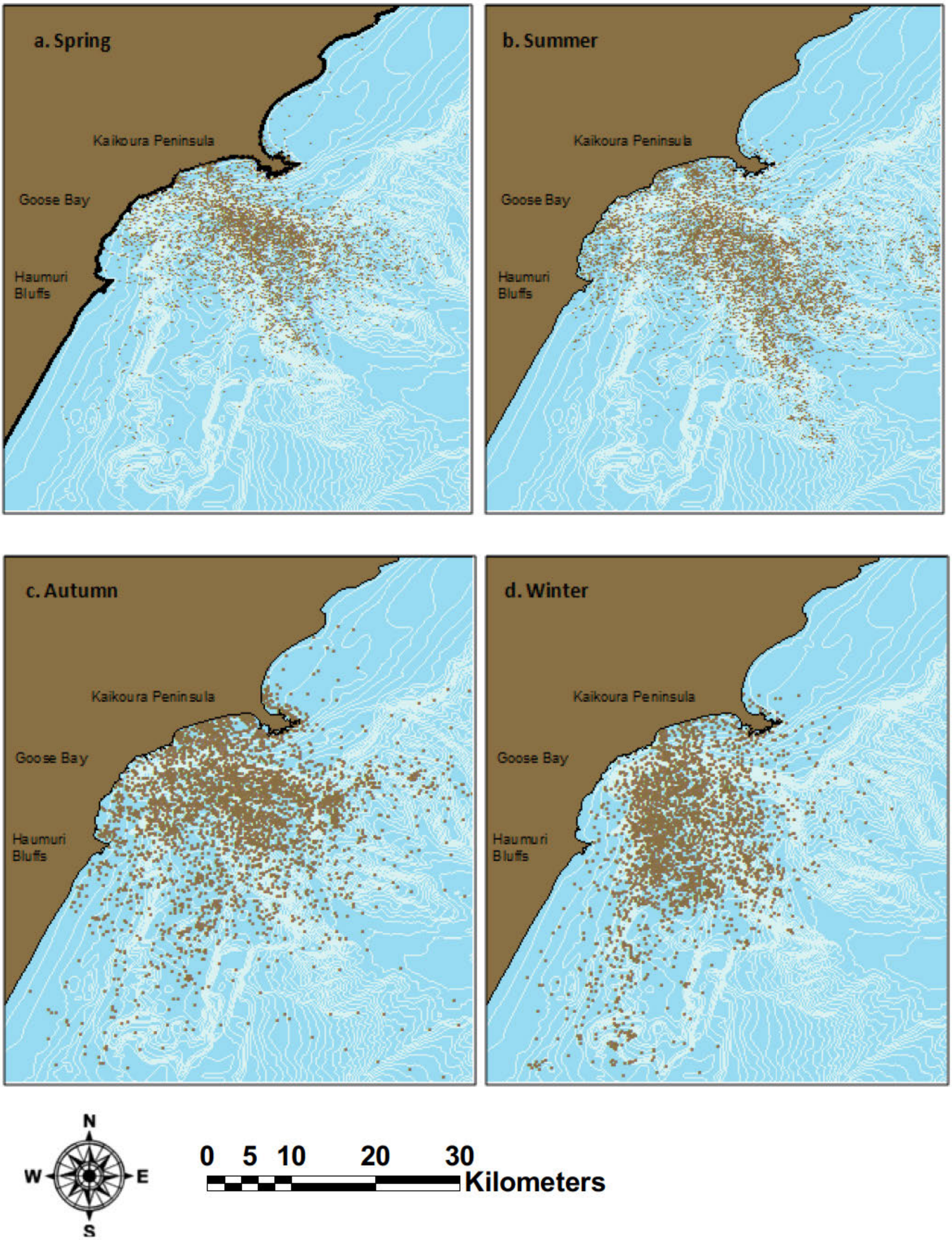

Figure 3.19. GPS positions downloaded from daily online flight logs for Wings Over Whales aerial tours are compared by season. Positions were logged at one-minute intervals (data downloaded from www.tracplus.com, courtesy of John MacPhail).

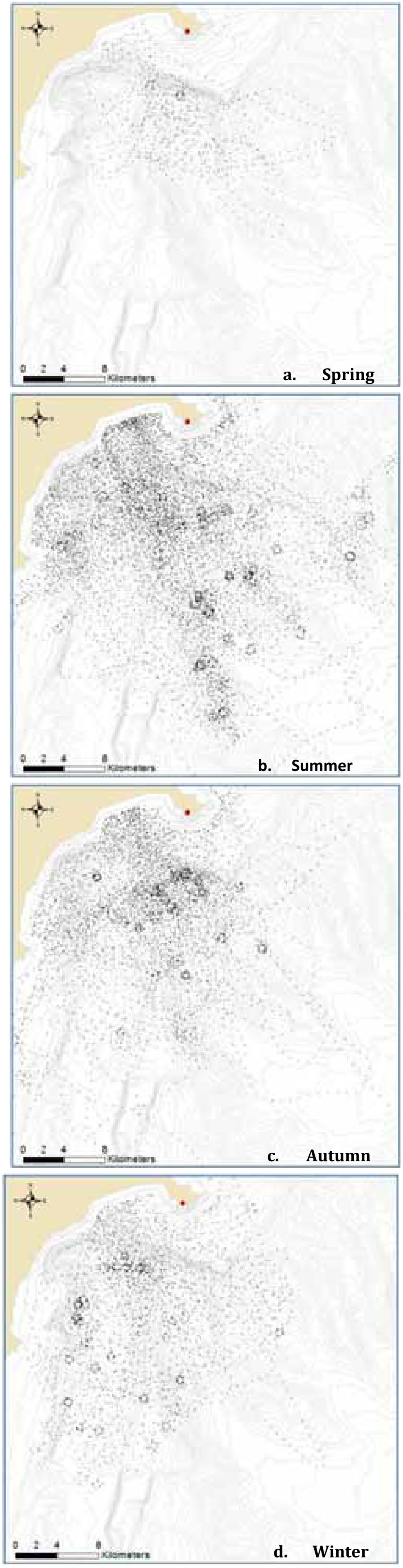

Figure 3.20. GPS positions extracted from GPS loggers onboard plane from Kaikoura aeroclub are compared by season (2009 10).

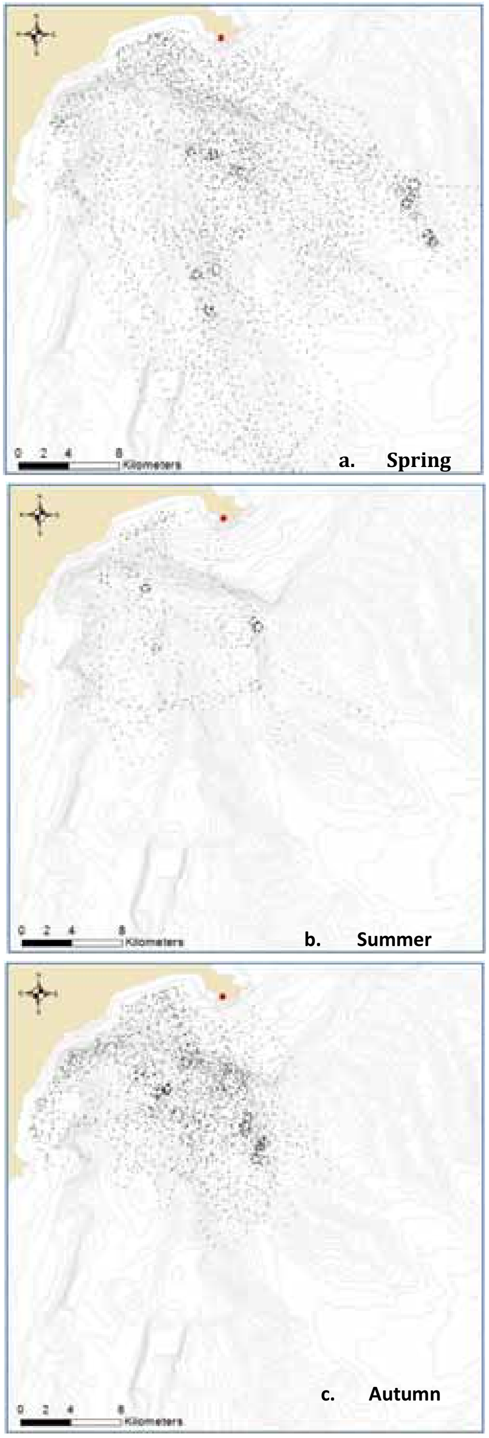

Figure 3.21. GPS positions extracted from GPS loggers onboard Kaikoura aeroclub plane are compared by season (2010-11).

The view from the air (Figure 3.22) provided observers with a good vantage for observing behaviors often missed from boat-based observations, including defecation which was noted on two occasions. However, space and logistical limitations resulted in a small sample size for onboard observations during aerial tours.

Figure 3.22. Picture of a sperm whale from a Wings Over Whales plane during a tour.

DISCUSSION

Onboard Monitoring from Whale Watch Boats and Aircraft

This chapter presents data collected onboard whale watching vessels and aircraft in order to examine the interaction of vessels with sperm whales. Season was the factor which most influenced the ventilation pattern of sperm whales. Similar results were reported in chapter 2.

Distance from the tour vessel to the whale was recorded 127 times by onboard observers with a laser range finder, averaging 75m. Our findings confirm that the whale watching vessels are generally following the regulations (99.2% of the time), staying >50m away from the whale in all but one instance (32m).

We observed an apparent effect of vessels on the directional heading of the whales. On all the encounters with whale watching vessels, whales changed heading 75 % of the time. Similar results regarding heading change recorded from a research vessel were reported by Richter *et al.* (2003) and in Chapter 4 of this report.

Observers on aircraft documented an average altitude of 221m when planes were circling over sperm whales at the surface, with a range of 143m to 305m. One limitation of this research was the small sample of data collected from aeroplanes. For this reason, we lacked power for statistical comparison of mean flight altitude with altitude while circling over whales.

Information Extracted from GPS Data Loggers and Online GPS Tracking Logs

The data extracted from the GPS data loggers provided information on whale watch tour operating areas and seasonal effort for both vessel and aircraft tours.

As expected, seasonal variation of whale watching activity was documented. Summer and autumn were the busiest seasons, with an increase in whale watching activity. Different companies used similar areas. Regular communication between vessel and aircraft tours facilitates information sharing regarding whale position and dive times. This coordination serves to increase the sighting success for the companies. It also likely increases the number of visits to those particular whales first spotted by the companies.

The seasonal and interannual variation in the area in which the companies operated was significant; this is correlated with findings in chapter 2 showing seasonal variability in the distribution of sperm whales.

The information from GPS data loggers provides a valuable measure of whale watching activity throughout the year. However, due to logistical challenges, there were some missing records. While data loggers onboard whale watch vessels had an onboard power supply, GPS data loggers onboard helicopters and the plane from Kaikoura Aeroclub ran on battery power packs that lasted a maximum of one week. Consequently, some periods with tour activity may have been missed. GPS data loggers onboard whale watching boats were at times unplugged, so data were lost. GPS tracks from Wings Over Whales tours downloaded from their online records provided fairly consistent coverage, allowing us to estimate the proportion of days and number of hours these aerial tours operated by time of year. These records showed flights most days of the year, but also a clear seasonal effect with twice the flight hours in summer as in winter.

Although remote tracking for both vessels and aircraft provided a good general gauge for inferring the level and extent of tour activity, the data gathered do not provide direct information on sperm whale interactions with tours. Some more detailed information on whale-tour interactions was collected by observers onboard whale watching tours, providing higher quality information about vessel and aircraft activity during encounters with sperm whales. The best vantage for gathering data on the behaviour of whales during these interactions as well as in the absence of tours was generally from either the shore station for a broad view (Chapter 2), or from the independent research vessel platform for a narrower, focal whale view (Chapter 4).

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Chapter 4

EFFECTS OF VESSEL TRAFFIC ON THE SURFACE BEHAVIOUR OF INDIVIDUALLY IDENTIFIED SPERM WHALES FORAGING IN THE KAIKOURA CANYON

Christoph Richter, Manuel Fernandes and Saana Isojunno

Surface behaviour links to biologically important aspects of a whale's physiology and is readily observable, and thus potentially useful as a management tool. This chapter investigates the effects of whale watching vessels on the surface behaviour (blow rates, surface time, spatial behaviour) of male sperm whales off Kaikoura. Respiratory parameters were not affected by the presence of whale watching vessels. Differences between individuals and seasons were the most consistently important factors. In the analyses of spatial behaviour, only the variance of heading changes increased in the presence of vessels. These results indicate that sperm whales seem not to react to the presence of whale watching vessels with changes in respiratory and most spatial behaviours. However, the small proportion of transient whales in our sample, and the fact that there are reactions, leads us to interpret this lack of response cautiously.

INTRODUCTION

BACKGROUND AND JUSTIFICATION

Concern about the impact of human activities on marine mammals has been increasing recently (Reynolds *et al.* 2009). Both the activities and their potential impacts vary widely (e.g. Lemon Blewitt and Cato 2008; Krahn *et al*. 2009; Azzellino *et al*. 2011). Generally, impacts are possible because marine mammals happen to visit or occupy the areas in which anthropogenic activities take place. Consequently, a potential solution to minimize or prevent impacts is to separate, spatially or temporally, anthropogenic activities from whale habitat. For example, moving shipping lanes can significantly reduce the probability of ship strikes and reduce noise exposure (Schick *et al.* 2009).

Whale watching, on the other hand, necessarily relies on whales and vessels sharing the same space and time. Therefore whale watching is dependent on the very organisms it may be impacting with its activities. An interest in reducing potential impacts and ensuring that whale watching is carried out in the most sustainable way should be a natural interest of the industry (Higham *et al*. 2008). This becomes even more important considering the global economic potential of whale watching, which is estimated to potentially grow to more than US$ 2.5 billion annually and providing 19,000 jobs (Cisneros-Montemayor *et al.* 2010).

Managing whale watching sustainably then requires minimizing the potential impacts on whales of ships, their associated noises, and any other activities associated with this activity (Higham *et al*. 2008). In contrast to the whale watching industry, which has grown rapidly over the last decades (O'Connor *et al*. 2009), our knowledge of potential impacts is generally increasing only slowly. For instance, whale watching began in Greenland in the early 1990s (O'Connor *et al*. 2009), but reactions of humpbacks to the unregulated activities have only been studied in 2010 (Boye *et al*. 2010). Although responses of humpback whales to whale watching activities have been studied elsewhere (e.g. Au and Green 2000; Scheidat *et* al. 2004; Corbelli 2006; Weinrich and Corbelli 2009) results are not always easily transferable. Similarly, dolphin watching activities off Zanzibar commenced in 1992 and were only studied more than a decade later (Stensland and Berggren 2007; Christiansen *et al*. 2010).

There are, of course, exceptions to this general pattern. For Kaikoura – and for New Zealand as a whole – whale watching (and similar activities centered around dolphins, birds and seals) is economically vital (O'Connor *et al*. 2009). Due to this economic importance, the industry is being monitored regularly. Gordon and colleagues (1992) detected shorter surface periods and altered acoustic patterns in transient individuals when vessels were present. Similarly, Richter et al. (2003; 2006) determined that transient whales responded stronger to boat activities than whales seen more than once off Kaikoura. As a consequence of these latest reports, the Department of Conservation instituted a 10-year moratorium on new whale watching permits in 2002.

RESEARCH OBJECTIVES

This project aims to reassess and update potential impacts. This chapter examines the surface behaviour of sperm whales in the presence and absence of whale watching vessels (boats, fixed-wing plans and helicopters).

Specific objectives of this research were to:

1. ***Record surface of sperm whales in the presence and absence of whale watching vessels***
2. ***Assess which factors are important determinants influencing surface behaviour***
3. ***Determine whether whale watching vessels are influencing surface behaviour of sperm whales.***

METHODS

EQUIPMENT

We used a dedicated research vessel (RV) for behavioural observations. The boat was a 6m, aluminium monohull (Stabicraft 2050 Supercab), powered by a 100 hp four-stroke Yamaha engine. Observations were recorded on a mini laptop running Logger software. The computer also logged the position of the boat every 15 seconds from a button USB GPS. Logger had been configured to work as an event recorder. The time of certain key presses were recorded allowing the time of certain common behaviours to be recorded automatically. Other keys prompted for data to be entered manually.

The boat was fitted with a raised observation platform behind the main cabin, which allowed observers an unobstructed 360˚ view. Observers on this platform recorded events through a keyboard connected to the mini computer running Logger inside the cabin. The event recorder program played back the identity of the behaviour or activity associated with each key through headphones to help the operator ensure accuracy. Logger also recorded a few seconds of data before and after each key press so that the voice of the operator speaking the observed behaviour was captured to allow later error checking. An observer inside the cabin, seated directly at the computer, entered additional information and checked for completeness of records.

Sperm whales were tracked throughout their dives with a custom-built omnidirectional, towed hydrophone array, which was connected to a dedicated 12V computer running PAMGUARD software and a directional hydrophone. For further details on the acoustic equipment refer to Chapters 5 and 6.

We took identification photographs with a Nikon D300 camera and a AF-S VR 70-300mm f/4.5-5.6 Nikkor lens. We measured distance with a Bushnell Yardage range finder.

RESEARCH TEAM

The team consisted of a skipper, responsible for driving the boat and assisting in spotting whales, and three to four research personnel (Figure 4.1). One person was situated in the cabin, entering data into the mini computer and monitoring the PAMGUARD display on the acoustic computer while tracking. The other team members were situated on the observation platform, with one person taking ID photos and the second person entering behaviour information. The third person was tasked with obtaining distance, bearing and heading information. If present, a fourth person assisted with observations on the platform.

Figure 4.1. Surface behavioural data were entered using a remote keyboard and voice recordings from an elevated platform with a headset (left), and logged on a mini-computer in the cabin (middle). Whales were tracked during dives with a towed hydrophone array, and bearings confirmed by directional hydrophone (right).

EFFORT

Effort was divided into passage, search and tracking and photo-identification. Passage effort was noted when travelling to and from offshore areas where we encountered whales or when moving between study areas during the day. Once over the canyon, we switched effort to search. Two observers took positions on the platform and searched for blows or other visual signs of sperm whales, while a third person listened for clicks with a custom-built directional hydrophone. We usually deployed the towed hydrophone during this time as well. If we were not able to detect sperm whales visually or acoustically, we moved further offshore until we saw or heard a sperm whale. Switching effort to track and photo-identification, we followed the whale using a combination of the PAMGUARD software and towed hydrophone and the hand held directional hydrophone. This allowed us to position ourselves close to where the whale eventually surfaced, avoiding the need to use high speed to get into our standard observation position behind the whale. Throughout the time the whale spent at the surface, we maintained our position approximately 100m behind the whale. Once the whale fluked, we chose to either follow the same whale through its dive using passive acoustics or leave that particular individual and find a different whale.

We followed whales throughout dives with the towed hydrophone and PAMGUARD software. Once the whale fluked and began clicking, the observer in the cabin kept track of the clicks while the boat moved slowly in the direction the whale had fluked. The skipper then kept the boat on a consistent heading and slow speed. When the PAMGUARD click bearing display indicated that we were either falling behind the whale or had overtaken him, we stopped the boat, obtained a precise indication of direction to the whale with the hand held directional hydrophone, and then corrected the travel direction of the boat accordingly.

We generally stayed on the water for approximately eight hours, depending on weather conditions. When conditions were too bad to reliably track and/or obtain high quality identification photos (sea states higher than Beaufourt 3), we either did not go out, or, when the weather deteriorated to this condition and improvement seemed unlikely while we were on the water, we stopped tracking, switched effort to passage and returned back to shore.

PHOTO-IDENTIFICATION

A dedicated observer took a series of photos of the fluke during fluke-up with the lens set to maximum focal length (Figure 4.2). After downloading the photos to a laptop, photos were first rated for quality following Arnbom (1987; fluke in focus, size of fluke is large enough to recognize small characteristics, and orientation is as horizontal and parallel to the photo plane as possible), and then visually compared with previous photos. Matched flukes were given the same identifier name (comparisons with the existing Kaikoura catalogue were not possible). If no match was made, the whale was recorded as a new individual.

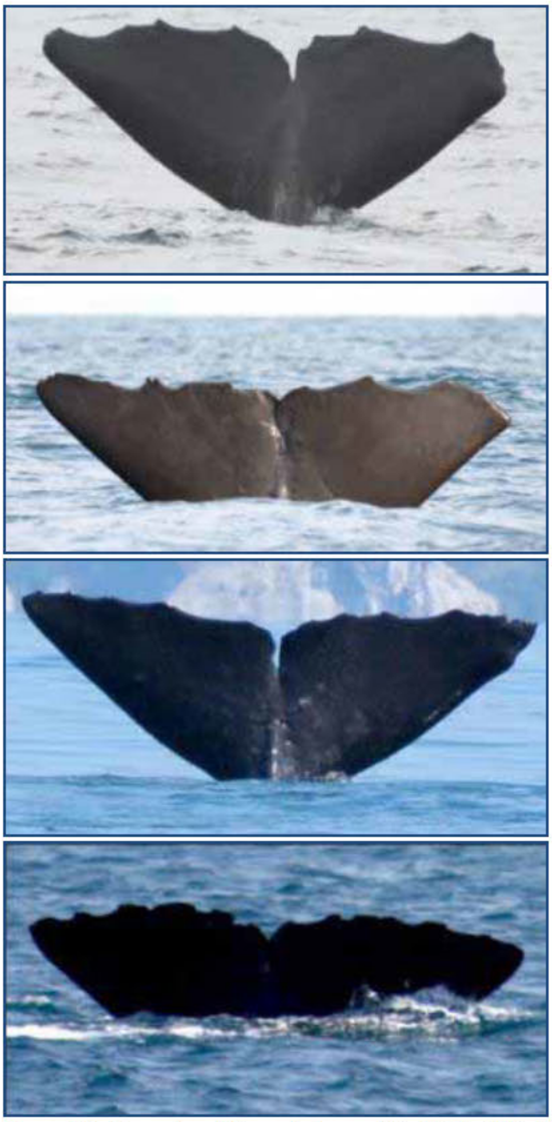

Figure 4.2. Examples of four photographically identified individual whales monitored off Kaikoura.

BEHAVIOURAL OBSERVATIONS

Blow rate

The observer positioned at the keyboard on the observation platform began recording blows immediately after the initial blow was spotted. The time of each blow was recorded by pressing a dedicated button on the keyboard, which Logger recorded on the laptop in the cabin. The observer also called out "blow" to indicate that the blow was spotted and recorded. If the whale was obscured by another boat, another button press was used to indicate this. Similarly, if the observer was unsure whether a blow was spotted, for example due to low contrast light conditions, a "missed"-button was pressed to indicate the likelihood of a missed blow around the time of the button press.

At the end of the encounter, observers recorded whether the first recorded blow coincided with the whale's surfacing, early or late in the surfacing, and how many blows were missed from the first observed blow until event data recording commenced. Mean blow rates where then calculated by dividing the number of blows during an encounter by the corresponding surface time (i.e. the time from the first blow or first indication of the whale's presence at the surface, to the time of fluke-up).

Surface Time

The surface time is the period from being spotted at the surface to the fluke disappearing under water. Surfacing times usually started with the first blow or when a body part of the whale, commonly the head, was seen before a blow. In either case, the observer at the outside keyboard pressed a button to record the beginning of an encounter. Once the whale fluked, another button recorded the end of the encounter. If the encounter ended due to the whale being lost, it diving without fluke-up, or any other reason, observers noted that the encounter did not end with a fluke-up.

Spatial behaviour at surface

Throughout the surface time, we recorded distance and bearing from the boat to the whale and the heading of the whale. Distance was measured by an observer on the platform with a laser range finder (Bushnell Yardage Pro.l). Measurements were taken during approaches and every time the distance changed markedly (more than 20 metres). Heading and bearing were measured with binoculars equipped with a compass (Fujinon 7x50) and were recorded whenever we took distance readings, or when the whale changed its heading. We recorded final distance, bearing and heading measurements at fluke-up. The team member in the cabin entered this information into customised forms in the Logger throughout the encounter.

STATISTICAL ANALYSES

This was an observational study with the explicit goal of determining whether whale watching vessels impact sperm whale behaviour. Consequently, analyses using the standard hypothesis-testing framework are inappropriate. Instead, we employed a modelling-approach, the goal of which was to develop a minimum adequate model (Crawley 2007). This model should be as simple as possible, i.e. contain as few factors and interaction terms as possible, while explaining the observed data sufficiently well (Anderson 2007). Therefore, we began analyses with a full model (including all factors and interaction terms), and then removed non-significant terms in a step-wise process until only significant terms remained. Models were first removed based on complexity (four-way interactions before three-way interactions before two-way interactions, etc), and then by magnitude of p-values (those terms with higher p-values were removed first). The residuals of this model were then checked visually for heteroscedascity, normality of residuals, and undue leverage of single data points. Where necessary, data were transformed as appropriate.

Finally, we calculated the Akaike's Information Criterion (AIC) values for each of the models produced in this process and chose the model with the smallest value as the minimum adequate model. AIC tables in this chapter are structured consistently by listing the four best models in order of increasing AIC value followed by the full model at the bottom. Since absolute AIC values are less important than the difference of AIC values between models, we also calculated the difference of each model's AIC value from the best model to indicate the improvement in explanatory power.

The factors that we included in the full models were:

- ***Year (2009, 2010, 2011; as discrete variable)***
- ***Season (winter, summer, spring)***
- ***Identity of whale (ID),***
- ***Presence of whale watching vessels within 300 m (vessel).***

For this report, we paid particular attention to the inclusion of vessel presence in the minimum adequate model. If the minimum model included vessel presence, we then reanalysed the data set with a factor that differentiated between vessel type (boat, helicopter, fixed-wing plane) and number.

Due to heteroscedasticity in the heading data, we could not use the same analysis framework. Instead, we investigated whether the distribution of absolute heading values differed in mean and variance between encounters with and without vessels with Wech two-sample tests and variance tests, respectively. In addition, we determined whether the frequency of positive or negative heading changes was dependent on vessel presence with Fisher exact tests.

Throughout our seasons, we attempted to follow the same whale through several consecutive dives in order to obtain observations of the same individual with and without whale-watching vessels. While we were able to follow whales throughout multiple dives, we recorded only few such series of dives with changing vessels presence. (This was because whale watching vessels were also adept at following the same whale so that an individual was likely to have vessels with it repeatedly.) We compared differences between pairs of consecutive encounters during which vessel presence changed with differences between pairs during which no change in vessel presence occurred. For this, we first determined whether absolute mean differences between pairs with and without vessel change differed significantly, using a one-way ANOVA. We then determined whether the frequency of increasing or decreasing differences varied between series with and without vessel change using a Fisher's exact test. Analyses were carried out with JMP version 8 (SAS Institute, 2009) and R version 2.13.2 (http://www.r-project.org/).

RESULTS

EFFORT

We carried out six field seasons. Effort varied considerably from season to season (Table 4.1). This variability was due to weather conditions during the particular seasons.

Table 4.1: Spatial and temporal effort over six field seasons is shown by distance in nautical miles and time (hours: minutes).

Field Season	Unknown/ off effort	Directed travel	Search	Passage	Tracking photo ID	Total
1 Spring Aug-Nov 2009	21.8 (3:16)		59.6 (12:34)	114.7 (12:45)	170.5 (67:55)	**366.5 (96:32)**
2 Summer Dec 2009-Feb 2010	28.9 (3:17)	11.4 (00:52)	135.0 (19:30)	355.3 (48:06)	244.3 (93:02)	**774.9 (164:49)**
3 Winter May-June 2010			15.0 (4:09)	67.4 (7:31)	41.3 (18:15)	**123.8 (29:56)**
4 Spring Aug–Oct 2010			211.8 (47:44)	393.6 (44:32)	168.2 (77:04)	**773.7 (169:21)**
5 Summer Nov 2010–Mar 2011		30.8 (4:11)	133.7 (29:06)	368.2 (46:57)	295.7 (142:19)	**828.4 (222:34)**
6 Winter April-June 2011		18.2 (2:55)	90.5 (15:20)	347.6 (31:56)	358.9 (162:11)	**815.2 (212:24)**
Total	**50.7 (6:33)**	**60.4 (7:58)**	**645.6 (128:23)**	**1646.8 (191:47)**	**1278.9 (560:46)**	**3682.5 (895:36)**

Effort also varied with respect to the number of encounters with and without whale-watching vessels. During half of the seasons, most of our encounters were with whale-watching vessels (Fig. 4.3). Both winter seasons, in contrast, featured more encounters without vessels. This is not surprising, given the smaller number of trips carried out by fewer whale-watching vessels during those periods. Due to the low number of encounters with planes and helicopters, we did not analyse them separately, but included them in order to maintain the largest sample sizes possible. Therefore, when referring to whale watching vessels, the term "vessel" refers to boats, planes and helicopters.

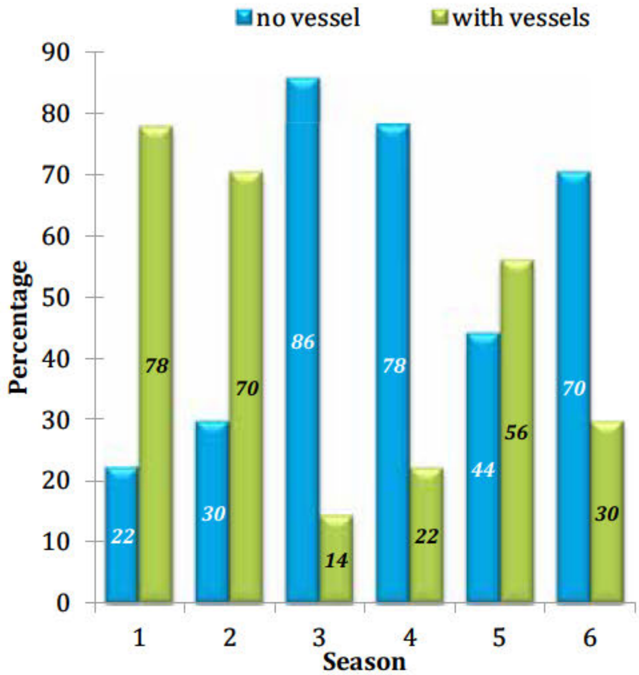

Figure 4.3. Proportion of encounters with and without whale-watching vessels are compared by field season (For details of seasons refer to Table 4.1).

SIGHTING RATE

Most individually identified whales were seen on less than seven separate days (Figure 4.4). We defined whales seen on only one day as transient, and those seen on more than one day as residents (Jaquet *et al.* 2000). Using this criterion, 18 of the 56 identified whales were transients (32%).

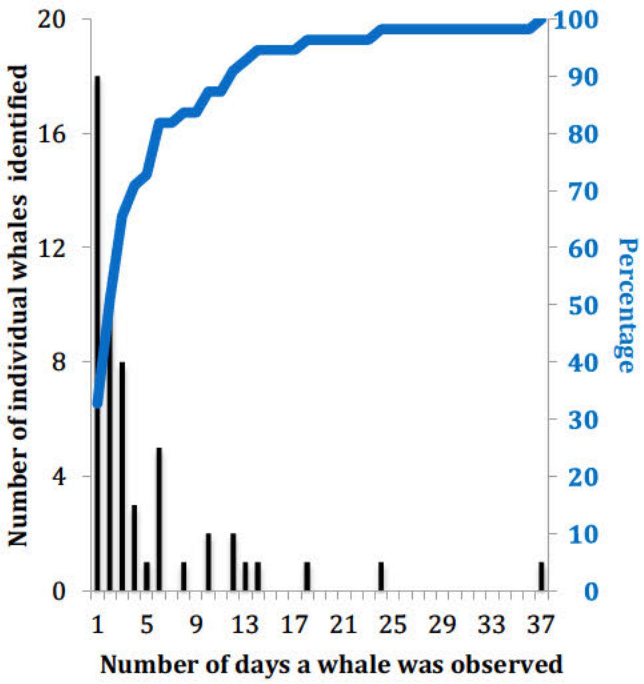

Figure 4.4. Sighting rate across all field seasons. Bars frequency with which individual whales were sighted on different days; the line displays a discovery curve of the cumulative percentage of identified individuals.

BLOW RATE

Two different data sets were analyzed for blow rates. The first data set included all blow rates from encounters during which the whale was not obscured and/or we did not miss blows for any other reason. The second set was more restrictive by further excluding all encounters during which we did not observe the first blow. Thus, this second set analysed blow intervals from encounters of complete surfacing intervals only. Sample sizes for blow rate analyses are summarised in Table 4.3.

Table 4.3. Summary of sample sizes for analyses of blow rates.

			Vessel Presence				Total
			No whale watching vessels		With whale watching vessels		
Data Set	Year	Season	Resident	Transient	Resident	Transient	
Unobscured encounters	2009	Spring	3	0	8	0	11
		Summer	3	0	6	0	9
	2010	Spring	64	3	13	1	81
		Summer	26	3	46	5	80
		Winter	6	1	1	0	8
	2011	Summer	23	1	32	0	56
		Winter	124	0	49	0	173
		Total	**249**	**8**	**155**	**6**	**418**
Unobscured complete encounters	2009	Spring	2	0	7	0	9
		Summer	1	0	3	0	4
	2010	Spring	19	1	7	0	27
		Summer	9	0	19	0	28
	2011	Summer	6	0	17	0	23
		Winter	54	0	29	0	83
		Total	**91**	**1**	**82**	**0**	**174**
Grand Total			**340**	**9**	**237**	**6**	**592**

Blow rates from unobscured encounters

The least adequate model for this analysis included the factors year, season and ID. Blow rates did not differ between encounters with and without whale-watching boats (Table 4.4 and Figure 4.5). All three of the remaining factors were significant (Table 4.5).

Table 4.4. Results of model fitting process for blow rate analysis using unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	Year+ season+ID	50	986.87	0
2	Year+season+ID+vessel	51	988.16	1.29
3	Year*vessel+season+ID	53	990.34	3.47
4	Year *ID* vessel+season	69	1000.56	13.69
5	Year*season*ID*vessel	108	1045.97	59.1

*(+ indicates no interaction, * indicates inclusion of interaction terms; models 3 and 4 include 2-way interactions only)*

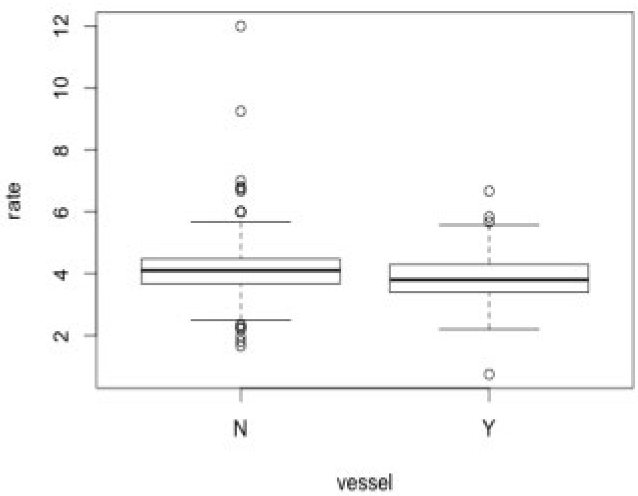

Figure 4.5. Box plot showing the difference in blow rates (rate: blows/min) for encounters without (N) and with (Y) whale watching vessels. The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

Table 4.5 Results of analysis of variance of minimum adequate model to explain blow rates from unobscured encounters.

	df	Sum of squares	F	p
Year	2	4.40	3.81	0.023
Season	2	4.83	4.18	0.016
ID	44	133.57	5.25	>0.001
Residuals	361	208.80		

Blow rates from complete unobscured encounters (Encounters with recorded first blow)

The least adequate model for this analysis included the factors year, season and ID. Blow rates did not differ between encounters with and without whale-watching boats (Table 4.6 and Figure 4.6). All three other factors were significant (Table 4.7).

Table 4.6. Results of model fitting process for blow rate analysis using complete, unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	Year+ season+ID	31	291.73	0
2	Year+ season+ ID+vessel	32	293.37	1.64
3	Year+season+ID*vessel	46	296.67	4.94
4	Year+season*ID*vessel	55	299.69	7.96
5	Year*season*ID*vessel	62	306.12	14.39

*(+ indicates no interaction, * indicates inclusion of interaction terms; models 3 and 4 include 2-way interactions only)*

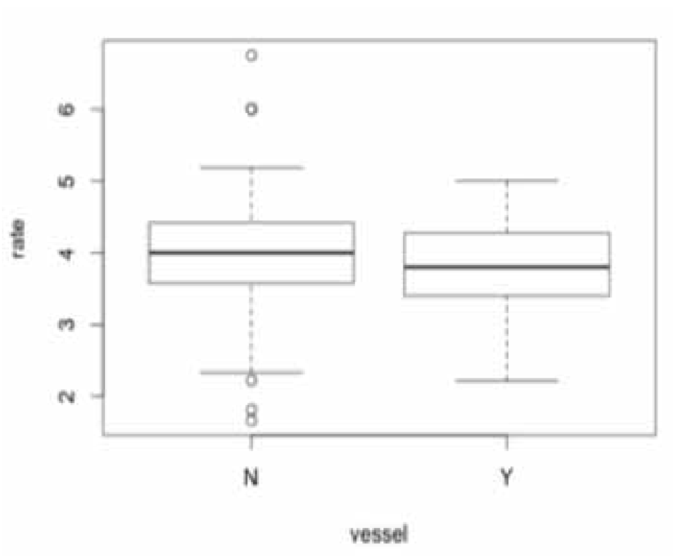

Figure 4.6: Box plot showing the difference in blow rates (rate: blows/min) for encounters without (N) and with (Y) whale watching vessels. The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

Table 4.7. Results of analysis of variance of minimum adequate model explaining blow rates from complete, unobscured encounters.

	df	Sum of squares	F	p
Year	2	2.98	5.62	0.005
Season	2	2.02	3.82	0.024
ID	25	48.96	7.39	>0.001
Residuals	144	38.15		

SURFACE TIME

Only encounters during which we observed the first blow and the whale remained in unobstructed view throughout the surfacing were used in this analysis. This ensured that only information from full-length, complete encounters were analysed. Sample sizes for this analysis are summarized in Table 4.8.

Table 4.8. Sample sizes used in analyses of surface time.

		Vessel Presence				Total
		No whale watching vessels		With whale watching vessels		
Year	**Season**	**Resident**	**Transient**	**Resident**	**Transient**	
2009	*Spring*	2	0	7	0	**119**
	Summer	1	0	3	0	**4**
2010	*Spring*	19	1	7	0	**27**
	Summer	9	0	19	0	**28**
	Winter	4	1	0	0	**5**
2011	*Summer*	6	0	17	0	**23**
	Winter	54	0	29	0	**83**
	Total	**95**	**2**	**82**	**0**	**179**

The minimum adequate model for surface time included only season and ID, year was not required (Tables 4.9 and 4.10). Once again, vessel was also not a required factor, although surface times with vessel(s) were approximately one minute longer than when no additional vessels accompanied the whale (Figure 4.7).

Table 4.9. Results of model fitting process for surface time (first blow/sighting to fluke-up) using complete, unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	Season+ID	30	874.20	0
2	Year+ season+ ID	32	876.71	2.51
3	Year+season+ID+vessel	33	876.99	2.79
4	Year*ID+season+vessel	42	878.42	4.22
5	Year*season*ID*vessel	66	880.69	6.49

*(+ indicates no interaction, * indicates inclusion of interaction terms; model 4 includes 2-way interactions only)*

Table 4.10. Results of analysis of variance of minimum adequate model to explain surface time from complete, unobscured encounters

	df	Sum of squares	F	p
Season	2	137.78	10.43	>0.001
ID	26	390.38	2.274	0.001
Residuals	150	990.42		

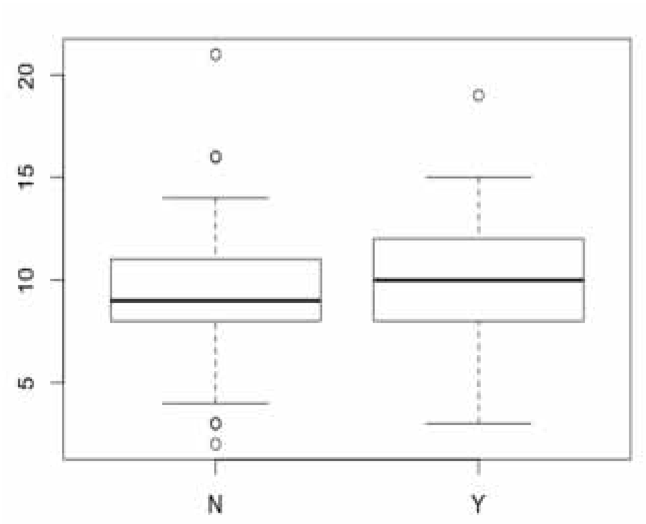

Figure 4.7. Box plot showing the difference in surface time (min) for encounters with (Y) and without (N) whale watching vessels. The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

SPATIAL BEHAVIOUR AT SURFACE

We recorded the heading of whales at first sight and, during an encounter, when either our distance to the whale, or the whale's heading itself, changed. In addition, we measured the whales' heading again at fluke-up. We analysed these data using two separate response variables: the absolute amount of heading change (degrees) and the direction of the heading change (positive or negative).

Amount of heading change

We initially began analysing these data with the same step-wise modelling approach employed for the respiratory data. The following factors were included:

- **Year (2009 – 2011)**
- **Season (winter, summer, spring)**
- **Identity of whale (ID)**
- **Whale watching vessel within a 300m of whale (yes, no)**
- **Code (reason for heading measurement: fluke-up, distance measurement, heading change of whale).**

However, the final, minimally adequate model suffered from strong heteroscedasticity and thus was not appropriate. Instead, we determined whether mean and the variance of heading change differed between encounters with and without vessels.

To begin, we checked that our reasons for heading measurements did not differ depending on vessel presence (Fisher's Exact test, $p = 0.317$). Mean absolute heading changes did not differ depending on vessel presence (no vessel: 27.38 degrees, 95% CI = 21.035 – 33.725; with vessels: 23.26 degrees, 95% CI: 18.808 – 27.719; Welch 2-sample test: $t = 1.045$, $df = 542.36$, $p = 0.297$). However, variances differed significantly between encounters with and without vessels (no vessel: variance = 2028.50, with vessel: variance = 2982.57; F-test, $F = 1.47$, $df = 286, 394$, $p < 0.0001$). During encounters without additional vessels, whales changed headings less strongly than in the presence of additional vessels (Fig. 4.8)

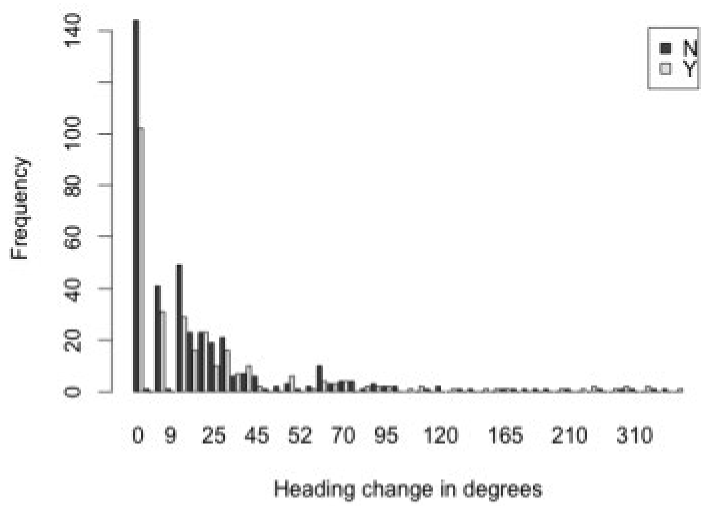

Figure 4.8. Frequency of heading changes (degrees) without additional vessels (N, black bars) and with whale watching vessels (Y, white bars).

Direction of heading change

Additional vessels did not influence whether whales changed directions more to the left or right during an encounter (Fisher's Exact test, $p = 0.92$).

FOCAL FOLLOWS

For these analyses, we included 17 series of consecutive encounters involving 11 different whales. Those series contained only six cases in which an encounter without additional vessels (before) was followed by one with (during), and then by one without again (after), in order to allow before-during-after comparisons. However, none of those series consisted of complete encounters only (i.e. encounters with first blows) and thus were not used to analyse surface times.

Blow rates

We used two data sets in this analysis, similar to the blow rate analysis above: blow rates from encounters during which we could observe the whale throughout without obstructions, and a more limited set that excluded encounters during which we did not observer the first blow, or were not certain that we had seen it. From both sets, we first selected all pairs of encounters during which vessel presence changed (additional vessels were present during the first or second encounter, and not during the other). We then selected other pairs of encounters during which only our research vessel was present or all encounters were with whale watching vessels, i.e. no change in vessel presence occurred. These were chosen to be from the same whale and as close to the time of pairs with vessel change in order to minimize potential effects of other uncontrolled factors such as whale ID, time of day, distance from shore and water depth. Consequently we analysed the difference between those pairs and the direction of change for effects of vessel presence.

Blow rates from unobscured encounters

Neither mean blow rates (Welch two-sample test, t = 0.795, df = 17.31, p = 0.473; Figure 4.9), nor variances (variance test, F = 1.358, df = 10, 22, p = 0.525) varied between encounters with and without change in vessel presence. Similarly, change in vessel presence did not influence whether whales increased or decreased their blow rate during consecutive encounters (Fisher's exact test, p = 0.2458).

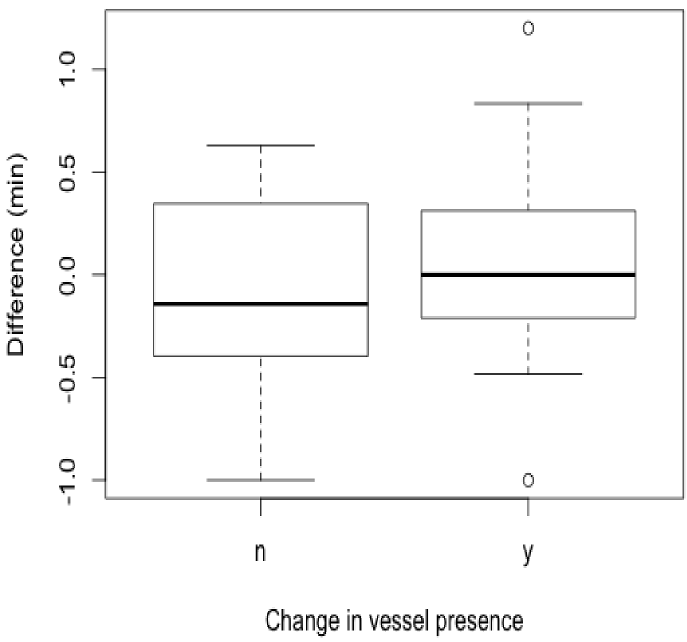

Figure 4.9. Differences in blow rates from unobstructed encounters, between consecutive encounters with the same whale, depending on presence of whale watching vessels (n = no whale watching vessels, y = with whale watching vessels). The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

Blow rates from unobscured, complete encounters (including first blow)

With only two consecutive encounters including a change in vessel presence the sample size is too small for meaningful statistical analysis. However, patterns are similar to those seen in the previous section (Figure 4.10).

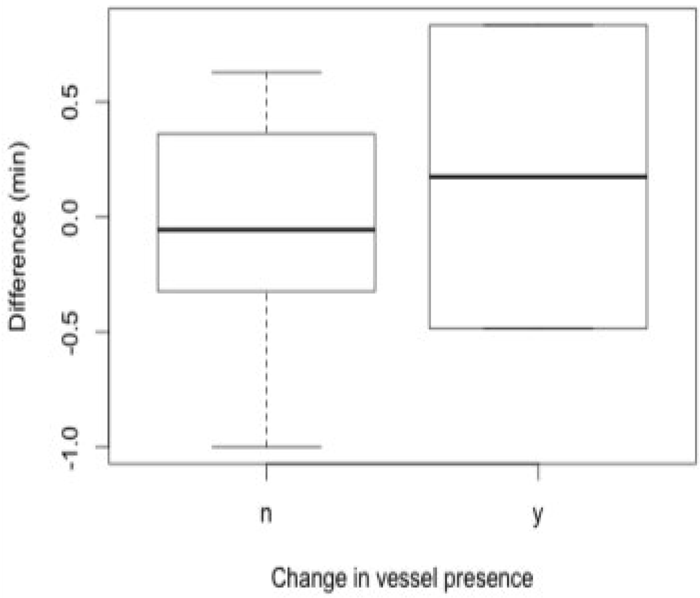

Figure 4.10. Differences in blow rates from complete, unobstructed encounters, between consecutive encounters with the same whale, depending on presence of whale watching vessels (n = no whale watching vessels, y = with whale watching vessels). The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

Blow intervals

Blow intervals were analysed with the same framework as blow rates. We investigated effects on mean blow interval as a measure of central tendency, and coefficient of variation (CV) as a measure or spread. Sample sizes available for blow interval analyses are summarized in Table 4.11.

Blow intervals from unobscured encounters

The minimum adequate model for mean blow intervals only required year and ID (Tables 4.12 and 4.13). However, the AIC values did not differ very much for the three best models, two of which included vessel presence. Vessel presence was never a significant factor in those models (Figure 4.11).

The minimum adequate model for the CV of blow intervals was more complicated and included year, season, ID and interactions between year, season and ID (Tables 4.14 and 4.15).

Table 4.11 Sample sizes used in analyses of blow intervals.

Data Set	Year	Season	No whale watching vessels: Resident	No whale watching vessels: Transient	With whale watching vessels: Resident	With whale watching vessels: Transient	Total
Unobscured encounters	2009	*Spring*	3	0	8	0	11
		Summer	3	0	6	0	9
	2010	*Spring*	64	3	13	1	81
		Summer	25	3	45	5	78
		Winter	6	1	1	0	8
	2011	*Summer*	23	1	32	0	56
		Winter	120	0	49	0	169
	Total		**244**	**8**	**154**	**6**	**412**
Unobscured complete encounters	2009	*Spring*	2	0	7	0	9
		Summer	1	0	3	0	4
	2010	*Spring*	19	1	7	0	27
		Summer	9	0	17	2	28
		Winter	4	1	0	0	5
	2011	*Summer*	6	0	17	0	23
		Winter	52	0	29	0	81
	Total		**93**	**2**	**80**	**2**	**177**
Grand Total			**337**	**10**	**234**	**8**	**589**

Table 4.12: Results of model fitting process for blow interval analysis using unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	Year+ID	49	3419.23	0
2	Year+season+ID+vessel	52	3419.88	0.65
3	Year+ID+vessel	50	3420.35	1.12
4	Year*season+ID+vessel	55	3420.87	1.64
5	Year*season*ID*vessel	113	3480.22	60.99

*(+indicates no interaction,*indicates inclusion of interaction terms)*

Table 4.13. Results of analysis of variance of minimum adequate model to explain blow intervals from complete, unobscured encounters.

	df	Sum of squares	F	p
Year	2	3597.00	8.563	>0.001
ID	45	16405.00	1.736	>0.001
Residuals	364	76449.00		

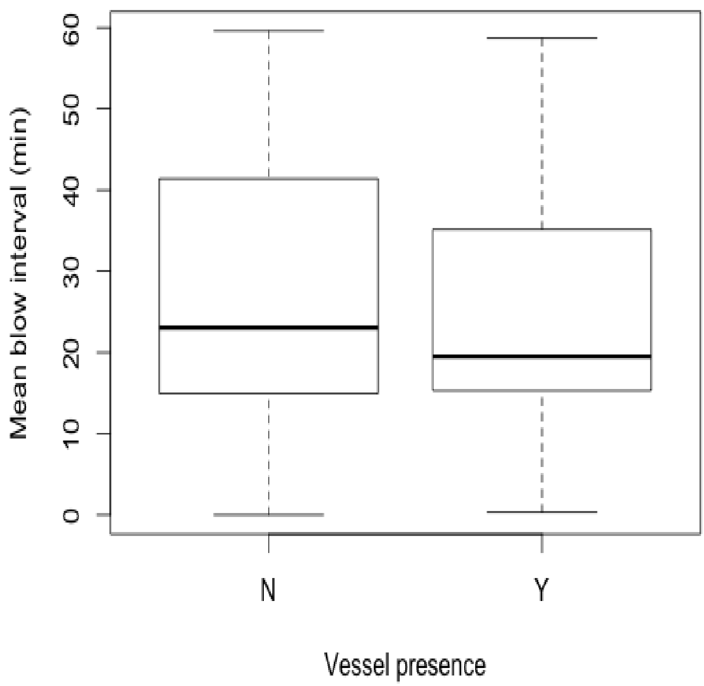

Figure 4.11. Mean blow intervals from unobstructed encounters, depending on presence of whale watching vessels (N= no whale watching vessels, Y = with whale watching vessels). The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

Table 4.14. Results of model fitting process for CV of blow interval analysis using unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	Year*season*ID	78	1448.69	0
2	Year*season*ID+vessel	79	1448.84	0.15
3	Year*season*ID*vessel	83	1449.50	0.81
4	Year*season*ID*vessel	81	1450.00	1.31
5	Year*season*ID*vessel	113	1480.81	32.12

*(+ indicates no interaction, * indicates inclusion of interaction terms, models 2-4 include two-way interactions only; model 4 included only one interaction term with vessels, model 3 two)*

Table 4.15. Results of analysis of variance of minimum adequate model to explain CV of blow intervals from unobscured encounters.

	df	Sum of squares	F	p
Year	2	563.15	169.66	>0.001
Season	2	57.12	17.208	>0.001
ID	45	430.28	5.761	>0.001
Year*season	2	21.98	6.622	>0.001
Year*ID	17	53.07	1.881	0.019
Season*ID	8	106.04	7.987	>0.001
Residuals	335	555.98		

Blow intervals from complete unobscured encounters

Only ID was required to model the blow intervals from complete unobstructed encounters (Tables 4.16 and 4.17) .

Table 4.16. Results of model fitting process for blow interval analysis using complete, unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	ID	27	918.83	0
2	Year+ID	29	919.47	0.64
3	Year+ID+vessel	30	921.32	2.49
4	Year+season+ID+vessel	32	924.11	5.28
5	Year*season*ID*vessel	66	959.95	341.12

*(+indicates no interaction, *indicates inclusion of interaction terms)*

Table 4.17. Results of analysis of variance of minimum adequate model to explain CV of blow intervals from unobscured encounters

	df	Sum of squares	F	p
ID	25	1399.7	6.34	>0.001
Residuals	152	1342.8		

Again, the minimum required model for the CV was more involved, including year, season, ID and interactions between year and season as well as year and ID (Tables 4.18 and 4.19)

Table 4.18. Results of model fitting process for CV of blow interval analysis using complete, unobscured encounters.

Model number	Model	df	AIC	Difference from best model
1	ID*year*Season	42	-314.38	0
2	ID*year*Season+vessel	43	-312.38	2.00
3	ID*year*Season*vessel	45	-311.56	2.82
4	Year+season+ID+vessel	48	-309.78	4.6
5	Year*season*ID*vessel	66	-294.68	19.7

*(+ indicates no interaction, * indicates inclusion of interaction terms, models 2 and 3 include two-way interactions only, model 4 three way interactions)*

Table 4.18: Results of analysis of variance of minimum adequate model to explain CV of blow intervals from complete, unobscured encounters

	df	Sum of squares	F	p
Year	2	0.064	3.978	0.021
Season	2	0.066	4.137	0.018
ID	25	0.889	4.431	>0.001
Year*season	2	0.176	10.98	>0.001
Year*ID	9	0.174	2.407	0.015
Residuals	136	1.092		

Surface time

We first selected all pairs of surface times during which vessel presence changed (additional vessels were present during the first or second encounter, and not during the other). We then selected pairs of surface time during which only our research vessel was present, i.e. no change in vessel presence occurred. These were chosen to be from the same whale and as close to the time of pairs with vessel change in order to minimize potential effects of other uncontrolled factors such as whale ID, time of day, distance from shore or water depth.

The mean difference between pairs of encounters did not change depending on presence of additional vessels (one-way ANOVA, df = 1, 26; F = 0.21, p = 0.651, Fig. 4.10).

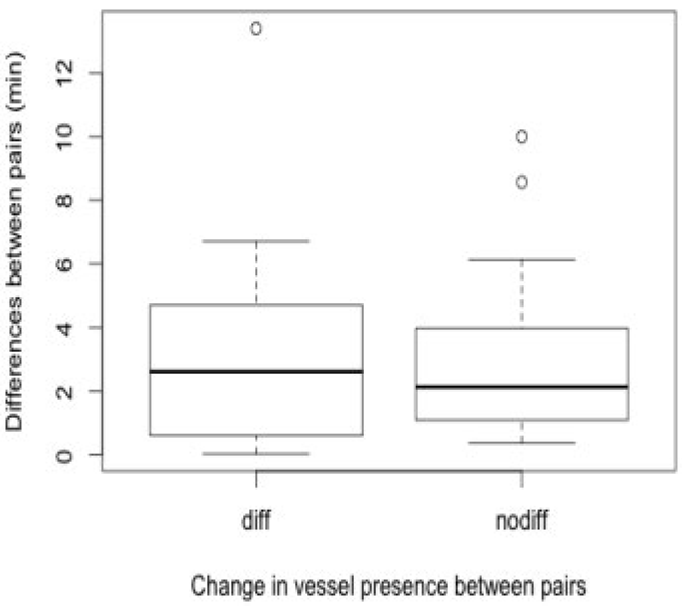

Figure 4.12. Box plot showing the difference (minutes) between pairs of consecutive encounters with (diff) and without (nodiff) vessel change. The thick line indicates the mean, the boxes comprise the interquartile range (i.e. from 25th to 75th percentile) and the whiskers stretch to 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

We also analysed whether vessel presence influences the direction of changes, i.e. whether whales preferentially increase or decrease surface times when vessel presence changes. We did not detected such a preference in the frequency of positive or negative differences based on vessel presence (Fisher's exact test, p = 0.81).

DISCUSSION

Sperm whales did not appear to alter their respiratory behaviour in the presence of whale watching vessels. None of the analyses on overall blow rates, blow intervals, and surface times required vessel presence as factor in minimum adequate models. Similarly, vessel presence did not impact changes in blow rates or surface time on consecutive encounters. In contrast, previous reports described whales changing their respiratory behaviour in the presence of vessels (Gordon *et al.* 1992, Richter *et al*. 2003; 2006).

There is a range of possibilities that could explain not only why we didn't detect effects on whale behaviour, but also the difference to previous results. The most obvious one is that indeed whales may not have responded to whale watching vessels. While possible, it is also important to remember that "the absence of evidence is not evidence of absence" (p. 3) (Crawley 2005). Nevertheless, some lines of evidence may point to the fact that whales may respond less to whale watching boats than they did in the past (in the available time it was not possible to match our whale identification photos with existing catalogues). Statistically, vessel presence was not an influential factor in any of the models, indicating that, at least compared to the other factors in our analysis, whale watching vessels did not influence respiratory behaviour. Moreover, the differences between encounters with and without vessels were small. Richter et al (2003; 2006) also described small effects of vessel presence, however the direction of differences was not always the same. For example, surface time declined in the presence of whale watching vessels in Richter *et al*. (2003, 2006) whereas we observed an increase. On the other hand, blow rates increased (significantly in some analyses) in Richter *et al.* (2003, 2006) and (not significantly) in our study. Finally, this was the first study during which no whale watching boats with outboard engines were used anymore. Given their lower noise levels (see Chapter 5), this may have contributed to a decrease in reactions to vessel presence.

It is also possible that differences in statistical methods and sample size contributed to some of the discrepancies with previous research. Gordon *et al*. (1992) employed non-parametric tests on single factor comparisons. For example, they detected a significant decrease in surface time using a Mann-Whitney U test (Gordon *et al*. 1992). Richter *et al*. (2003, 2006) used a modelling approach similar to our current methods for most analyses. For instance, surface time was best modelled by inclusion of year, season, ID, whale watching vessel presence, and interactions. In their analyses, presence of whale watching vessels also reduced surface time significantly (Richter *et al*. 2003) despite differing statistical analyses. In contrast, our current analysis of surface time did not require the inclusion of whale watching vessel presence. This difference in statistical results may be explained by lack of statistical power in the current analyses because of smaller sample sizes. Gordon *et al*. (1992) had 242 encounters in their analysis, and Richter *et al.* (2003, 2006) included 281 data points. The analysis in this report was based on only 179 encounters. However, this sample size allows detection of the current difference in surface time between encounters with and without whale watch vessels (1.07 minutes) with sufficient power (>90%). Given that this difference is larger than the one described by

Richter *et al*. (2003, 0.3 min), and is in the opposite direction (i.e. vessel presence increases surface time rather than decreasing it) indicates that lack of power was not an issue at least for the analysis of surface time.

Another reason may be the importance of differences between individual whales. As in Richter et al.'s (2003; 2006) analyses, whale identity was the most consistently important factor. Such differences are rarely explicitly included in whale watching impact analyses (e.g. Scheidat *et al*. 2004; Sousa-Lima and Clark 2008; Noren *et al*. 2009, but see Weinrich and Corbelli 2009). This is not surprising given that inclusion of individual differences makes results difficult to interpret and compare between projects. We likely observed only some of the whales that had been part of Richter *et al*.'s (2003, 2006) previous study based on the fact that average residency time is approximately 42 days (Lettevall *et al*. 2002) and the time between these studies spans two decades. It is therefore not surprising that it is difficult to point a uniform picture when comparing our results with those from Gordon *et al*. (1992) and Richter *et al*. (2003; 2006). On the other hand, we argue that it is crucial to recognize that whales react in different ways, and that this recognition needs to be included in sensitive statistical analyses and management decisions.

Individual differences could also explain our results in a final and different way. Richter *et al*. (2006) pointed out that effects were generally small, even when significant. In addition, similar to Gordon *et al*. (1992), they found that resident individuals were less responsive to vessels than transients. Given that we had only few sightings with transient individuals, it is possible that the dominance of resident individuals in our data set explains the lack of significant vessel effects.

It is not immediately obvious why the vast majority of our encounters were with residents. The definition of resident/transient whales was the same as in Richter *et al*. (2003, 2006) and the methods for finding whales were also comparable. It is possible that the spatial distribution of whales has changed with transients moving further offshore and thus becoming less likely to be detected visually or acoustically.

Season and year were also important factors in respiratory analyses. This confirms results from Richter *et al.* (2003; 2006), which may reflect seasonal changes in diet (Childerhouse *et al.* 1995; Jaquet *et al*. 2000). Our values for seasonal surface times (summer: 10.8 min., Winter: 8.8 min.) correspond well with those from Jaquet *et al.* (2000) (summer: 9.3 min., winter: 8.8 min.) and Richter *et al*. (2003) (summer: 9.2 min., winter: 8.3 min.). This might indicate consistent relationships between season and surface time over at least a decade. However, without information on prey distribution and availability off Kaikoura it is difficult to specify what that relationship may be. Recent evidence of surface feeding on fish by a sperm whale off Kaikoura (J. Orme, http://news.bbc.co.uk/earth/hi/earth_news/newsid_8549000/8549998.stm, accessed on Oct. 26, 2010) indicates that there is at least some flexibility in prey choice, as reported by Gaskin and Cawthorn (Gaskin and Cawthorn 1967).

In contrast to the results from the analyses of respiratory behaviour, whales did show reactions to vessel presence in their spatial behaviour. Whales showed a larger variance in heading change when whale watching vessels were present. Richter *et al.* (2003; 2006) also found changes in the spatial behaviour of whales in the presence of whale watching vessels. Gordon *et al.* (1992) on the other hand did not find changes in heading due to whale watching vessels.

In summary, most analyses did not detect an effect of whale watching vessels on the surface behaviour off sperm whales off Kaikoura. This may be due to low sample sizes for some analyses, a change in boat propulsion compared to previous research, the overarching importance of individual differences and seasonal effects, or in fact a lack of responses by the whales. These findings should be interpreted cautiously, however, since we only observed few transients, which were the most responsive individuals in previous reports (Gordon *et al*. 1992; Richter *et al*. 2003, 2006).

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Chapter 5

MEASUREMENTS OF UNDERWATER NOISE FROM WHALE WATCHING VESSELS OPERATING IN NEW ZEALAND

Jonathan Gordon and Jamie Macaulay

Sound travels well in water and underwater noise can affect deep-diving marine mammals. While no direct measurements of sperm whale hearing sensitivity have been made, research suggests sperm whales are likely to be most sensitive in a frequency band between 10 and 20 kHz. There are few studies of the noise produced by relatively small, fast-moving vessels such as those typically used by whale watch tourism companies. Past research at Kaikoura showed vessels with jet propulsion systems were substantially quieter than those with propellers. Following this work, the whale watching company at Kaikoura switched to larger vessels propelled by water jet drives. The purpose of this current study was to examine the level of underwater noise produced by whale watch tour vessels under typical operating conditions. Recordings, using five hydrophones, were made in the deep water of Kaikoura Canyon during both regular vessel transit and controlled vessel passes. Underwater recordings were made continuously during passes, while the speed and distance of the whale watch vessel was obtained from an onboard GPS data logger and laser range finding binoculars. Source levels were calculated for 1/3 octave frequency bands and two wider bands, one of which was the band in which sperm whales may be more sensitive. For such large, powerful vessels, the jet propelled catamarans used by whale watch tours at Kaikoura were remarkably quiet, especially when making the sort of manoeuvres required to stay with whales at the surface. Favourable noise characteristics of the newer jet propelled vessels may be contributing to reduced levels of disturbance among sperm whales at Kaikoura, despite vessel sizes having increased since previous studies.

INTRODUCTION

Sound travels much more efficiently through seawater than does light, or indeed any other form of radiated energy, making it the preferred medium for long range sensing and communication underwater, both for many marine animals and man. Of all animal groups, marine mammals show the most extreme adaptation for exploiting underwater acoustics, combining both sensitive hearing and the ability to produce a wide range of sounds. Toothed whales, such as the sperm whales, make loud vocalisations for echolocation, utilising active as well as passive acoustics to sense their environment. It is thus very likely that in most cases whales will be aware of, and possibly disturbed by, boat-based whale watching activity through the noise produced by those vessels. In Kaikoura, and other whale watching locations, it might be useful to consider two types of influence. Vessels will produce noise as they transit, often at high speed (see Chapter 3) between their harbours and areas in which whales might be encountered. During these periods, like many other water users, they contribute to the background noise in the area. Most likely, this affects submerged deep diving whales. It may influence their underwater behaviour and could affect their foraging efficiency. When whales are at the surface whale watching vessels approach them closely, usually at slow speed, and may then drift with engines running but no propulsion, or making slow manoeuvres to maintain favourable positions in relation to the whale. It is noises made at these times, often at shorter range, which might be considered most likely to cause short term behavioural effects at the surface or soon after diving.

During the first substantial DOC funded assessment of the effects of whale watching on sperm whales in Kaikoura in 1991 measurements of vessel noise from whale watching boats and some other comparable vessels were made in the waters off Kaikoura by Gordon et al. (1992) while a series of careful measurements from similar vessel were also made on a naval range)(Anon 1992; Marrett 1992),

Both of these reports found the vessels tested which had jet drive systems were substantially quieter than those with conventional propeller drives, including the outboard motor powered vessels used for whale watching at that time. One recommendation in Gordon et al. (1992) was that the industry should consider expanding by utilising larger vessels powered by quieter water jet propelled drive systems. In the intervening years the industry has been moving in this direction. Vessel based whale watching in Kaikoura is now all carried out by one company (Whale Watch Kaikoura) using a fleet of four 17m aluminium catamarans powered by Hamilton water jets. The purpose of the work reported here was to make quantitative underwater sound measurements to determine the underwater noise output from the current whale watching vessels under typical operating conditions.

The concern in this case is primarily the effect that under water noise might have on the target for whale watching in Kaikoura, the sperm whale. No direct measures of hearing sensitivity have been made in this animal which has never been maintained in captivity. However, it is believed, largely on the basis of their anatomy, that their best hearing sensitivity is lower than that of dolphins but is not as good at low frequencies as that of baleen whales (Ketten, 1992; Ketten, 1997) It is likely that sperm whales have good sensitivity to the dominant frequencies in their own vocalisations. Recent work has shown that sperm whale produce powerful and highly directional clicks which they use of echolocation (Mohl et al., 2003; Mohl et al., 2000). The sperm whale clicks typically picked up with hydrophone in the vicinity of sperm whales, such as those used by whale watchers and researchers to find and follow sperm whales, are usually off the axis of the sperm whale's main forward facing beam and have a broad band frequency component. However, on axis clicks described by Mohl et al. (2000) are both extremely powerful (223 dB re 1 µ Pa peRMS @ 1m) and relatively narrow band, with centroid frequencies of around 15 kHz. We might therefore expect sperm whales to have best hearing sensitivity close to this frequency. (In this report we propose a "sperm whale suggested high sensitivity band" between 8.9– 22.4kHz incorperating four of the 1/3 octave bands used for analysis.This might also be a frequency at which masking effects could have the greatest effect on foraging success. In qualitative terms we should probably consider sperm whales as being more sensitive at high frequency than humans.

There are surprisingly few published studies on boat noise from relatively small fast boats such as those often used for whale watching. In fact, the DOC funded studies mentioned above (Anon, 1912; Marrett, 1992) still stand out as being amongst the most comprehensive. These trials, carried out at a naval vessel characterisation range, compared source levels and 1/3 octave spectra for four different vessels. An 8m outboard powered rigid hulled inflatable (Rhib; twin 150 Hp outboards), a 6m monohull with jet drive propulsion, a 9m catamaran with two 180 Hp outboard engines, and a monhull with 2 150hp diesel inboards (see Table 5.1). Received levels were measured over over a range of speeds and source levels calculated/. Generally, vessels were noisier at higher speeds. If we consider the band from Vessels source levels were generally lower in the frequency band considered most significant for sperm whales (10-20kHz approx.) than at lower frequencies. The Catamaran was noisiest at lower frequencies with a peak 1/3 octave level of ~135 dB re 1µPa @ 1m at 2kHz. At mid frequencies, ~7kHz, the Naiad Rhib was the noisiest vessel with a peak of 130dB re 1µPa @ 1m. The jet driven vessel was the quietest vessel tested with a source level of ~125dB re 1µPa @ 1m at 2kHz and ~118dB @ 7kHz.

Table 5.1. Summary of vessels tested during the original DOC trials in 1991 (Anon 1992).

Vessel	Description	Motive power	Maximum speed tested (knots)
Aotea	8m Naiad RHIB	twin 150hp outboards	33-35
Rangitoto Ranger	6m aluminium mono-hull	jet boat	15-21
Cougar Wildcat	9m catamaran	twin 180hp outboards	21-25
Hauturu	mono-hull displacement vessel	twin 150hp inboard diesels	9-10

As part of an assessment of the effects of underwater noise from whale watching boats on killer whales Erbe (2002) made recordings of vessel noise from a series of outboard powered inflatables and rigid hulled inflatable boats (rhibs) used by the whale watching industry in British Colombia (Canada) and Washington State (USA). She found that there was no consistent relationship between noise levels and boat speed. (Planing boats like these do seem to be particularly noisy when they are “straining” to get on the plane and quieter when they start planing which may explain this observation.) At high speeds of around 50km/h the zodiac has a source levels of around 162dB re 1µPa @ 1m in a frequency band between 100Hz and 10kHz, while motor boats with internal engines were slightly less noisy with source levels of 159dB re 1µPa in the same frequency band. Jensen et al.(2009) also made field recordings of small fast vessels typical of those used for whale watching and used these to explore potential effects of vessel noise on delphinid communication. They found that boat speed was a good predictor of noise output. In the frequency band between 2 and 12.5kHz they measured RMS source levels of 132 and 146 dB for a 6 m aluminium vessel powered by a 135 HP outboard engine at 5 and 10 knots respectively and of 134 and 144 dB for a 5m aluminium hulled vessel with a 4 stroke 80 horse power outboard engine at 5 and 10 knots. They also measured the peak to peak source levels of the strong transients that occur during gear shifts. These often seem to be the sounds that are most likely to disturb cetaceans in the field. They calculated source levels ranging from 173-193 dB re 1µPa $_{pp}$ and SEL levels for 130-149 dB re 1µPa^{2}s.

METHODS

Recordings were made in deep water in the Kaikoura Canyon (approx. location latitude -2˚ 27.8’ S, Longitude 173˚ 41.2’E) between 08/03/2011 23:00 and 09/03/2011 01:00 GMT. Recordings were made from the DOC research vessel Titi while she was shut down and drifting as a quiet ship, with no equipment running. Runs made past the vessel opportunistically by whale watching vessels travelling between South Bay and whale watching areas were recorded but the most useful recordings were made during a series of controlled passes by one vessel, Aoraki reported here. Five hydrophones were used for recording.

Signals from hydrophones H1 Cal , H2 and H3, were recorded at 270kHz using an NI USB 6251 Digital acquisition card. H1Cal. (a Reson TC4033-1) was the only independently calibrated hydrophone available. It had a 20m cable length and was deployed to a depth of 10m. Signals were amplified using a Reson VP2000 preamplifier. H2 was a High Tech Inc HTI-96-Min hydrophone with preamp. The stated frequency response of this unit is 2-30kHz with a sensitivity of -165dB to -240dB re 1V/µPa. This was deployed at a water depth of 1m, a depth similar to that of a sperm whale’s ear when at the surface. A third hydrophone, H3, was a mono towed hydrophone on loan from DOC. This unit was weighted and deployed to a depth of 30m. The element in this hydrophone was a Benthos AQ4 element linked to a Magrec HP01 preamplifier which gave 29dB of gain. This had a better low frequency response than the other towed hydrophone and should have a near flat response between 50Hz and 15kHz. Signals from hydrophones 2 and 3 were conditioned using a Magrec HP27 ST preamplifier.

The final two hydrophone elements, H4 and H5, were the pair of units in the 100m towed hydrophone used routinely throughout the main project to find whales and make recordings of sperm whales (Chapter 6). These were two Magrec HP-03 elements mounted 0.5m apart in a streamlined streamer section made up of a 35mm diameter oil filled polyurethane tube. The HP-03 units comprised spherical ceramic elements, which should be close to being omni-directionally sensitive, and a 29dB HP-02 preamplifier with a low cut filter set to give -6dB signal reduction at 100Hz. These elements were conditioned using a Magrec HP27 filter/amplifier unit before being a sample rate of 192kHz using a RME Fireface 400 sound card. The towed hydrophone streamer incorporated a depth sensor which was read and logged by PAMGUARD. Comparison of the depth sensor readout, the cable length and the direction that the boat was drifting in the wind provided a reasonable indication of hydrophone geometry during recording (Figure 5.1). Because the whale watch boats were asked to pass directly upwind of the recording vessel, the towed hydrophone should be in a sector under the whale watching vessel and would give a good indication of the noise received from transiting boats by a diving whale. Figure 5.1 is a diagram indicating the approximate locations of the hydrophones during the passing trials while Table 5.3 summarises the recording setup.

Before the trials, recordings of vessel noise were made with all five hydrophones deployed at the same depth. These recordings could be used to cross-calibrate the other hydrophones against the independently calibrated Reson system. However, we found this rather ad-hoc approach gave inconsistent results so instead we calculated a sensitivity for the non calibrated hydrophones based on the manufacturers’ specifications.

Extended recordings of ambient noise with no vessels within three nautical miles and no identifiable noise sources on the record were made before and after the trials.

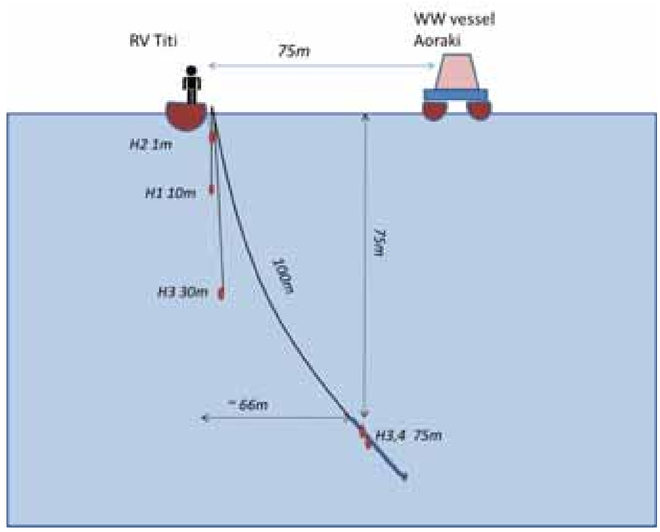

Figure 5.1. Diagram (not to scale) showing geometry of the recoding hydrophones, research vessel Titi and whale watching vessel Aoraki during passing trials

Table 5.2 Summary of hydrophones, conditioning and digitisation used during noise measuring trials.

	Hydrophone	Preamp/ Filter	High Pass Hz	Low Pass Hz	Gain	Digitiser	Depth
H1 Cal	Reson TC4033 1	Reson VP 2000	10	100k	30	NI USB 6251	10m
H2	HiTech HTI 96	Magrec HP27 ST	10	100k	39	NI USB 6251	1
H3	Aq4+ Magrec HP 01 preamp	Magrec HP27 ST	50	100k	39	NI USB 6251	30
H4/H5	Magrec HP03	Magrec HP27 ST	200Hz	100Hz	59	Fireface 400	75

During trials the whale watching vessel was asked to make several passes upwind of the recording vessel at a range of approximately 75m and at a series of speeds typical of whale watching vessel operations. These were, maximum speed, typical cruising speed (an efficient speed for travelling between harbour and whale watching grounds), no wake speed (used for final approach to the whales). In addition, the vessel undertook a series of manoeuvres representative of those performed during encounters with whales at the surface including moving slowly ahead and astern, changing from ahead to astern and cycling (when the engines and jets are running but providing no effective propulsion). Details of ranges and boat speeds during noise trials are shown in Table 5.3.

Underwater recordings were made continuously during passes. The speed of the whale watching vessel was obtained by analysing data from a GPS logging device (Chapter 3) carried by the whale watch vessel and that had been set to log a location every second. The range between the recording vessel and the whale watch vessel could be measured by comparing GPS data from the research vessel (recorded by PAMGUARD) and from the GPS logger on the whale watch vessel. In addition, accurate ranges were taken using laser range finding binoculars (Leica Geovid). Video recording showing the whale watching vessel were also made during passes. The sound track of these picked up a general commentary on the recording vessel and the ranges called out by the field worker using the laser binoculars. To accurately synchronise the underwater recordings with times on the video, a distinctive series of knocks were made on the metal boarding ladder of Titi at least once during each video sequence. These could be picked up on both the video sound channel and the underwater acoustic recordings and acted as "clapper board" for synchronising the two.

During analysis, the video and underwater recordings were coordinated so that recording sequences at known and closest ranges could be edited out for analysis. Similarly, sound sections while the boat was undertaking specific manoeuvres could be identified with the help of the synchronised video.

Videos were viewed and timed using MPEG Video Wizard software, sound files were edited with Adobe Audition, and sound levels in 1/3 octave bands were calculated using PAMGAURD. The 1/3 octave bands used in this analysis are provided in Table 5.3.

RESULTS AND DISCUSSION

A variety of issues related to electrical and boat noise limited the recordings that could be analysed. The recordings from the 1m hydrophone, H2 were too contaminated by noise from waves on the hull of the recording vessel and electrical noise to allow analysis. We also decided to discard data below .5kHz which appeared to be contaminated by significant levels of noise. Four of the of seven passes were sufficiently well recorded for reliable analysis and these covered the full range of vessel speeds tested. The deep hydrophones H4 and H5 were not operating during the vessel manoeuvring session. Table 5.3 summarises key information for these trials. Figure 5.2 a to c show calculated RMS source levels in 1/3rd octave bands for hydrophones H1, H3 and H4 for the passing trials at top speed, fast cruising speed and no wake speed, while Figure 5.3 a and b show similar data for the manoeuvring trials.

It would be wrong to equate these somewhat ad-hoc measurements made from a drifting vessel with only a single calibrated hydrophone supplemented by other less well characterised sensors in poorly defined locations, with the more rigorous characterisations that can be undertaken at dedicated facilities, such as a naval range (e.g. Anon, 1992). Thus, we caution that the sound pressure source levels presented here should be taken as indicative only (especially from the non-calibrated hydrophones) and comparisons between plots may be more useful than giving attention to absolute levels.

Table 5.3. One third Octave Bands used for this analysis. Bands included in Erbe's .1-10kHz band and 10-20kHz sperm whale high sensitivity band are indicated

Frequency Band (kHz)	Center Frequency (kHz)	Erbe (2002) 0.1-10kHz	Sperm Whale High Sensitivity
0.13975-0.2215	0.180625	√	
0.2215-0.2795	0.2505	√	
0.2795-0.3505	0.315	√	
0.3505-0.4435	0.397	√	
0.4435-0.559	0.50125	√	
0.559-0.701	0.63	√	
0.701-0.887	0.794	√	
0.887-1.118	1.0025	√	
1.118-1.403	1.2605	√	
1.403-1.774	1.5885	√	
1.774-2.236	2.005	√	
2.236-2.806	2.521	√	
2.806-3.5496	3.1778	√	
3.5-4.5	4	√	
4.5-5.6	5.05	√	
5.6-7.1	6.35	√	
7.1-8.9	8	√	
8.9-11.2	10.05	√	√
11.2-14.1	12.65		√
14.1-17.9	16		√
17.9-22.4	20.5		√
22.4-28.1	25.25		
28.1-35.5	31.8		
35.5-44.7	40.1		
44.7-56.1	50.4		
56.1-71.0	63.55		
71.01-89.4	80.205		
89.4-111.8	100.6		

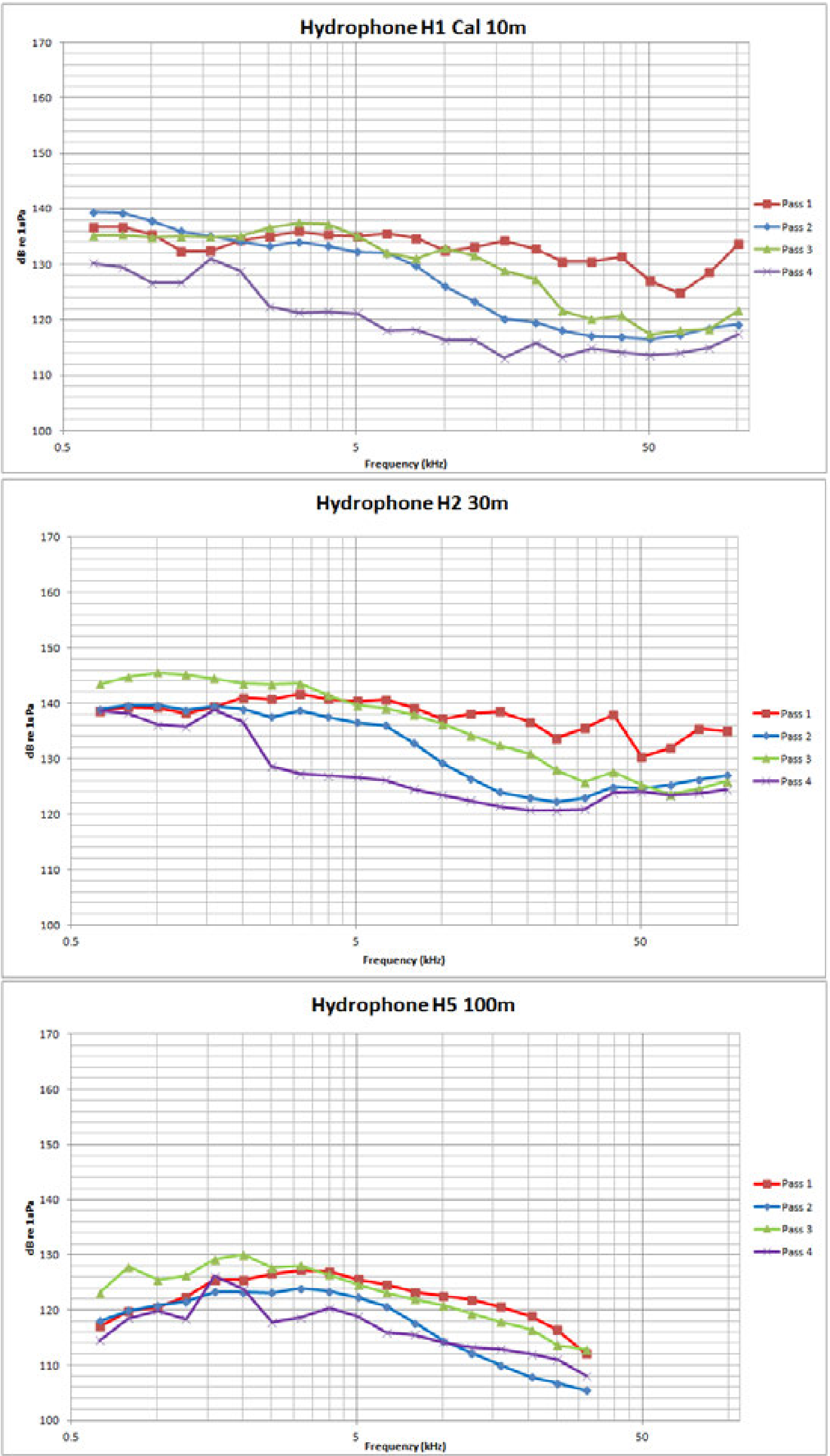

Figure 5.2 One third octave band source sound pressure levels for four passes at different speeds on three hydrophones at different depths. See Tables 5.3 and 5.4 for further details.

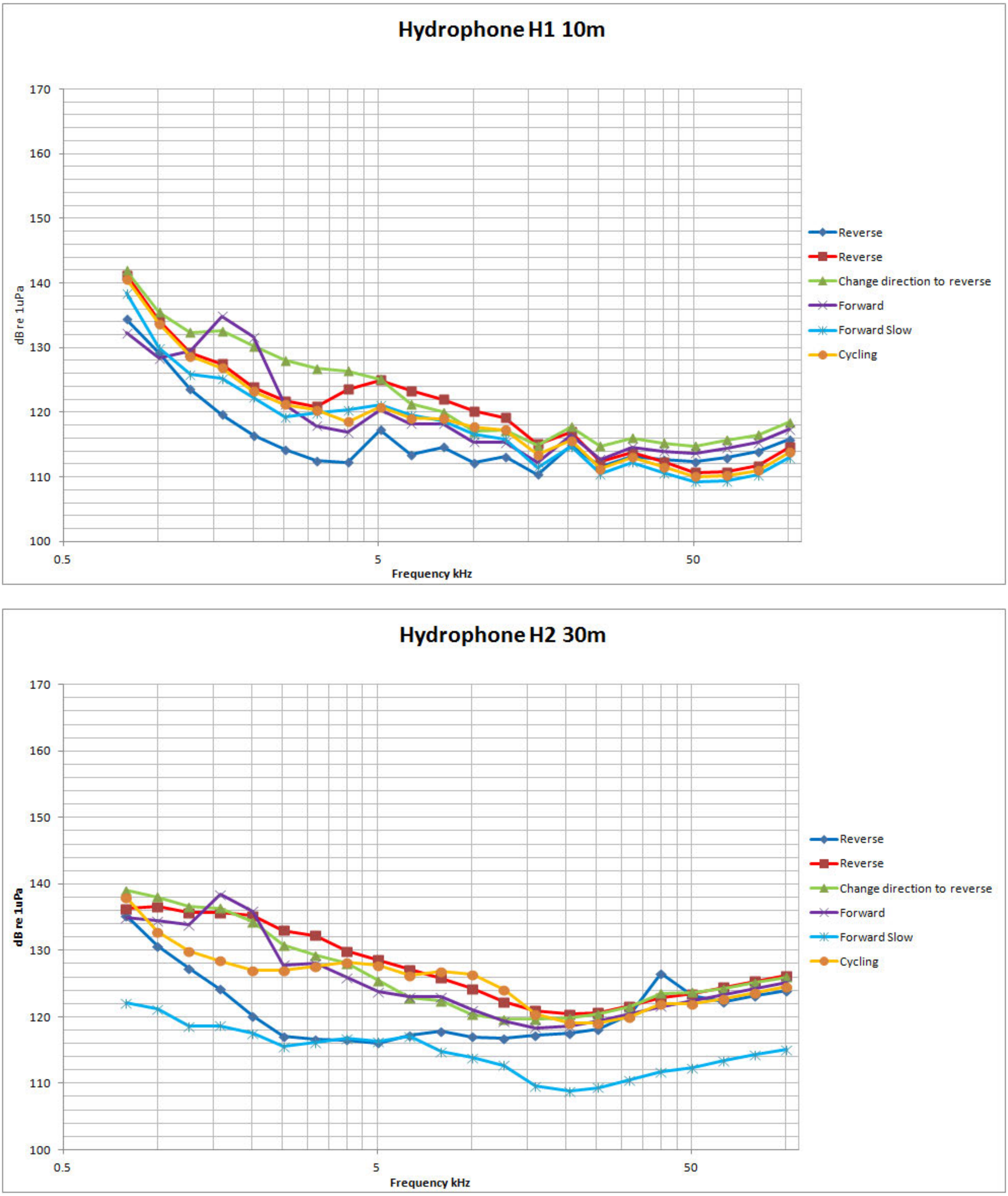

Figure 5.3 One third octave band sound pressure source levels for whale watching vessel performing a range of different manoeuvres typical of those preformed close to whales at the surface during whale watching operations . Reverse, Change in direction from ahead to reverse, Forward, forward slow, cycling (no propulsion).

Table 5.4. Summary of vessel passes, RMS Source levels are calculated for two frequency bands, .56-22.4kHz and 9.0-22.4kHz

Run #	Category	Speed	Revs RPM	Passing Range m	RMS Source level (.56-22.4kHz) dB re 1µPa @	RMS Source level (8.9-22.4kHz) dB re 1µPa @ 1m
1	Max Speed	28.1	3000	40	159	145
2	Fast Travel	23.5	3000	83	157	134
3	Fast Travel	20.7	2100	54	158	142
4	No Wake	7.3	1300	55	148	127
5	Change of Direction To reverse			74	155	129
6	Cycling			70	152	128
7	Forward			66	149	127
8	Reverse			55	146	124
9	Reverse			75	153	130
10	Slow Forward			65	150	127

Figure 5.3 a-c indicate that spectral sound levels decreased quite gradually as frequency increased and the distribution of acoustic energy within the spectra was similar for hydrophones deployed at different depths. Source levels were highest at maximum speed and lowest at no wake speed. In the 8.9 to 22.4 kHz frequency band (likely to cover the range over which sperm whales are most sensitive) source levels ranged between 145dB at maximum speed to 127dB at no wake speed. The pass at maximum speed (28.1 knots) was 11dB higher than the next fastest pass, number two, which at 23.5 knots was only 4.6 knots slower. However, levels for pass 3 (20 knots) were slightly higher than for pass 2 (23.5 knots). This seems to support Erbe (2002)'s observation that sources levels do not always increase directly as boat speed increases. The spectral levels recorded at maximum speed @10kHz in this study were some 15-20 dB higher than those reported by Anon (1992) for a jet driven vessel which was considerably smaller than the Aoraki The source level at maximum speed in the broader frequency band .56 – 22.5, 159dB, was towards the lower end of the range of source level for a range of much smaller vessels traveling at that speed reported by Erbe (2002) 158- 162dB (by examination of Figure 4 in Erbe, 2002) One feature of these vessels that was immediately evident from listening to them in the field as well as from the analysis of these recordings, was how quiet they were when making the types of manoeuvres required to stay with whales at the surface. There were no loud transients, as reported by Jensen et al. (2009), even when the vessel went from ahead to astern. In our experience, this is an operation usually guaranteed to disturb whales at the surface. Figure 5.3 shows 1/3 octave source levels for noise events identified in the recordings during these manoeuvres and Table 5.3 provides source levels over the broader frequency bands.

CONCLUSION

For such large powerful vessels, the jet propelled catamarans used as whale watching platforms in Kaikoura seem remarkably quiet. This is largely borne out by analysis of field recordings presented here, especially in the frequency bands above 1 kHz.

The most marked difference compared to other vessel types is the noise output during slow movements and manoeuvres required to remain in an appropriate position close to sperm whales at the surface for whale watching. Sound levels remained low, and when changing from forward to reverse, and vice versa, there were no indications of the high level transients typical of conventionally powered vessels, which so often seem to frighten whales during close encounters.

We suggest that the favourable noise characteristics of these jet propelled vessels have played a major role in the reduced levels of behavioural disturbance, indicated by results elsewhere in this report, in spite of an increase in vessel size and visitor numbers.

The observation that source levels at 23 knots were lower than at 20 knots is intriguing. If a more extensive series of measurements indicated that there are "cruising speeds" that produce less noise while still being practical, then the whale watching fleet might consider adhering to these speeds on passage to reduce their acoustic footprint.

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Chapter 6

EFFECTS OF WHALE WATCHING ON UNDERWATER ACOUSTIC BEHAVIOUR OF SPERM WHALES IN THE KAIKOURA CANYON AREA

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Foraging is likely the most biologically significant activity for sperm whales that are the focus of whale-watching at Kaikoura. Foraging success is therefore a key behaviour to monitor changes that have direct impact on the whales' fitness in the area. We are now able to measure foraging effort and prey detection rates using passive acoustics. In this chapter, we measure the acoustic foraging behaviour of whales before, during and after viewing by different numbers and types of whale-watching vessels. We found no differences in parameters that we believe are most closely related to prey encounter rates and feeding success that could be attributed to vessel interactions. There were slight changes to the initial search pattern of dives following whale-watching boat encounters: whales delayed their first click and descended for longer before stopping for their first silence, which was also extended. However, the effects appeared small relative to high individual variability and were within the range of behaviours predicted by their spatial and temporal environment.

INTRODUCTION

Male sperm whales migrate across ocean-basins to forage in productive high-latitude habitats such as Kaikoura. In these areas, males forage in loose bachelor groups becoming increasingly solitarily with age (Whitehead, 2003). Sperm whales are highly sexually dimorphic (Cranford, 1999) and presumably larger males are more successful. Males are much larger than females and spend their first 20 years attaining full size before taking an active role in breeding (Whitehead, 2003). Their foraging success in feeding areas is therefore likely to be important for their future breeding success and survival. Feeding is a key behaviour to measure in any impact study. In Kaikoura, successful foraging is likely the most biologically significant activity for whales that are the focus of whale watching activities.

Sperm whales feed at depth, spending more than 70% of their time in foraging dive cycles (Watwood *et al.* 2006). They return to the surface for 4-10 minutes to recover oxygen supplies to allow the next feeding dive that can last up to an hour. Direct observation of feeding is nearly impossible at the typical foraging depths of 200-900 metres (e.g., Watkins *et al.* 1993, Watwood *et al.* 2006). The submarine canyon in Kaikoura is one of the most productive benthic habitats known in the deep sea (De Leo *et al.* 2010).

Sperm whales are highly vocal animals producing powerful clicks for much of their dives which can be monitored reliably using hydrophones at the surface. It has long been proposed that the function of these clicks is echolocation (Gordon, 1987; Jaquet *et al.* 2001) though see Fristrup and Harbison (2002) for a dissenting view. Gordon (1987) and Jaquet *et al.* (2001) also proposed that characteristic sequences of rapid clicks, “creaks” were echolocation runs made during prey capture and on this basis Gordon *et al.* (1992) measured creak rates as a proxy for foraging during an earlier study of whale watching impacts in Kaikoura. Since then, studies using dTags (passive acoustic recording tags which also record an animal’s depth and orientation) have provided strong evidence that sperm whales do use echolocation to detect prey both at long- and short-range (Madsen *et al.* 2002; Miller *et al.* 2004) and that “creaks” are associated with prey capture. As we learn more about the underwater behaviour of sperm whales from studies like this we can be more confident in using analysis of echolocation clicks recorded at the surface as indicators of sperm whale behaviour, including their foraging behaviour.

Broadly speaking, sperm whales emit two types of directional echolocation clicks:

1. ‘Regular’ or ‘usual’ clicks. These are regularly spaced clicks (~0.5-1.5s) whose high source levels and low repetition rate maximise range for detecting prey and scanning the environment (Mohl *et al.* 2003; Watwood *et al.* 2006). Regular clicks can be interpreted as being produced for broad scale orientation and searching for prey or prey schools at long range.

2. ‘Creaks’ or ‘buzzes’. These are rapid series of clicks, whose repetition rate can be as high as 60 clicks per second. These trains are much quieter than regular clicks and hence harder to detect. There is strong evidence that creaks can be interpreted as the detection of prey at close range, similar to the terminal echolocation phase in other toothed whales (Miller *et al.* 2004, Johnson *et al.* 2004, 2008). Unfortunately, there is, as yet, no means of detecting successful prey capture.

This chapter investigates the acoustic behaviour of sperm whales while diving, with a focus on quantifying creak production as an indicator of foraging. Sperm whale creak rates have been found to vary greatly between individuals and on different measurement occasions (Miller *et al.* 2009). As they are received at lower levels on surface hydrophones than regular clicks, and may be more directional, their detection probability will be lower than that of regular clicks (Madsen *et al.* 2002). Our general research approach was to follow individual whales through several dives while making continuous acoustic recordings to measure changes in individual acoustic behaviour before, during and after they have been with whale-watching vessels at the surface. In this way, factors that were likely to have affected acoustic behaviour, such as individual identity, time and location, were controlled for, allowing for the effects due to whale-watching to be detected more reliably.

RESEARCH OBJECTIVES

We aimed to quantify:

1. ***any changes in individual acoustic behaviour between pairs of dives with and without whale-watching in the preceding surfacing***
2. ***any relationships between spatiotemporal environmental parameters and acoustic behaviour of diving whales***
3. ***any relationships between surface behaviour and acoustic behaviour of the subsequent dive***
4. ***any relationships between presence of whale-watching and acoustic behaviour of the subsequent dive***

METHODS

Data collection

Our aim in the field was to acoustically track individual whales through complete dive cycles before, during and after being encountered by whale-watching (ww) vessels. Whales were first localised using a combination of towed hydrophones, a hand-held directional hydrophone, and radio communication with ww-operators in the area and our own land based observers. An omni-directional towed hydrophone was deployed once the research vessel was in the vicinity of a surfaced or diving whale. The towed hydrophone was used to make continuous stereo recordings.

Acoustic equipment

Two types of acoustic systems were used on the research vessel, Titi. First, there were a couple of simple hand-held directional hydrophones and headphone amplifiers used to localise sperm whales. The second was a towed hydrophone, and associated, signal conditioner, digitiser and computer used both as a means of finding and tracking sperm whales and for making continuous recordings throughout entire dives.

The directional hydrophones were essentially a hydrophone element mounted within a reflective bowl. We used two of these over the course of the project. One was built for us by Dr Steve Dawson of Otago University. The second was assembled by Ecologic UK. It comprised a High Tech Inc HTI-96-Min hydrophone capsule mounted on shock cord within a stainless steel bowl covered in polyurethane foam and mounted on a pole. A Magrec HP/24 waterproof monitoring unit provided a high pass filter and amplification.

The towed hydrophone was built by Ecologic UK and was based on their standard configuration. It consisted of a streamlined sensor unit (made up of 5m of 35mm oil filled polyurethane tube) towed on 100m of Kevlar strengthened cable. Within the sensor unit, and separated by 1m, were two Magrec HP-03 spherical hydrophones with associated preamplifiers. These preamplifiers provide 29dB of gain and had low cut filters set at 100Hz to reduce low frequency flow noise. The streamer section also contained a Keller 10bar 4-20mA pressure sensor to provide information on hydrophone depth.

Signals from the hydrophone were amplified and conditioned on the vessel with a Magrec HP27ST stereo amplifier/filter unit and digitised by a RME Fireface 400 sound card at 96 or 192kHz. The sound card was controlled by an Aeon Boxer fan-less 12v computer which ran PAMGUARD software to both carry out real time detection and to display sperm whale clicks, allowing real time tracking in the field, and to make continuous recordings to hard drive. A USB GPS allowed PAMGUARD to collect location information and display tracks and detections on a real time map. The regulated 4-20mA current from the pressure sensor induced a voltage over a 47 ohm resistor which was measured by a Measurement Computing USB-1208 digital acquisition unit and converted to a depth reading, to be displayed and stored by PAMGUARD.

The complete PAMGUARD system was 12v powered and we found that a single 100Ah deep cycle battery could keep the system operating continuously through a complete working day.

At the surface, whale behaviour, such as heading, timing of blows, time of fluke up and occurrence of any other identifiable behaviours, was recorded using the Logger software (see Chapter 4 for details). The number and relative positions of ww-boats were recorded, as well as the number of helicopters and aeroplanes viewing the whale. At the end of the surfacing, a series of photos of the whale's flukes were taken for individual identification. Further details on effort and surface data collection is provided in Chapter 4.

Once the whale dove, we aimed to follow it as closely as possible, usually staying slightly behind its location underwater. The whale was tracked using its heading at fluke up as an initial guide, and the bearing to received clicks calculated and displayed in real time by PAMGUARD software. This program detected sperm whale clicks on digitised channels from each of the two hydrophones located 1m apart in the hydrophone streamer, towed 100m behind the vessel. Time of arrival differences for each click were processed to provide relative bearings to vocalising whales but with left-right ambiguity. These were displayed as a plot of bearing against time (e.g., Figure 6.1). By monitoring this display the course of the research vessel could be adjusted to maintain close contact with the diving animal. To correct left-right ambiguities, when necessary, we would stop and take a bearing to the whale using the hand-held directional hydrophone.

Acoustic data processing

In the field, continuous recordings were made to external hard drives. These raw data were reanalysed in the lab to provide detailed data. We identified occasions when the same identified whale had been the subject of long focal follows during which there were surfacing occasions with and without whale watching vessels. Sequences of sound files made during these follows were processed with PAMGUARD with a click detection module configured to automatically detect and localise clicks. The click detector doesn't classify the clicks to distinguish between those made by the focal whale clicks and clicks from other whales and other sources. Further, automatic detections often included false positives, especially as the thresholds were set low to detect as many quieter creak clicks as possible. We therefore carried out a second stage of analysis during which clicks of the focal whale were identified and marked with significant manual supervision and input using the Rainbow Click program (IFAW).

Automatically detected clicks were stored as "click files" by PAMGUARD and these files were further analysed using Rainbow click. Rainbow Click has a bearing display similar to PAMGUARD (Figure 6.1) and click train identification algorithms that identify clicks likely to be from the same individual based on their bearing and spectral characteristics. The operator's task was to review and edit these trains as necessary and link trains that were believed to come from the focal whale. The first clicks of dives (which are often characteristic in being loud and slow) were identified using the fluke up times noted in the visual dataset. Each surface start and end time was matched with the appropriate location in the respective sound files. Whales usually start regular clicking about 30-60 seconds after fluking and typically stop clicking some minutes before surfacing. They may emit a few slow clicks before and sometimes during surface periods (e.g., Figure 6.3).

To speed up analysis, we didn't listen to complete files; instead we carefully inspected the detected click trains visually and listened carefully to gaps in regular clicking to check for creaks. We also checked on unusual/slow-looking regular clicks and when uncertain, used aural monitoring to assess the total number of whales.

Clicks from focal whale were classified as being regular clicks, slow clicks, or creak clicks. Clicks were marked as slow if they had an unusually long interclick interval (ICI, 4-8s), were louder or sounded more metallic than previous/following regular clicks (Figure 6.3). Clicks were marked as creak clicks when the ICI was less than 100 ms and when the click train sounded continuous (i.e. the ear could not distinguish a click from another).

The automated click detector detected nearly 100% of regular clicks; however, its performance was much poorer for creak clicks. When gaps in clicking were carefully monitored by ear it was clear that a significant portion of creak clicks and even entire creak trains went undetected by the click detector. Thus, for consistency, we marked the last and first regular clicks before and after a creak, respectively (Figure 6.1, Figure 6.4) and called this pause in regular click train a 'creak interval'. From acoustic tagging we know that creaks often end in a short pause, before regular clicking is resumed. Thus creak intervals do not provide the exact start and end times of creaks. If a creak was not heard, the pause was assumed not to contain creaks, and scored as a "silence".

Regular click trains and creaks produced by other whales were marked as individual click trains where possible. When these trains could not be linked with near certainty they were grouped or linked to each other with a "confidence" score of 0-<100. This procedure ensured that the total number of animals heard at any given time was recorded while retaining as many click patterns as possible.

Summarising acoustic behaviour

A set of acoustic parameters were chosen to characterise the acoustic behaviour of the whale while diving (Table 6.1). Most of the parameters are directly comparable to those used in a previous whale-watching impact study in Kaikoura (Gordon *et al.* 1992).

Not all dives could be tracked successfully. For example, a dive became incomplete when the click train of the focal whale was so similar in bearing and amplitude to those of other whales that we lost track of it. The summary parameters that could be extracted for a dive depended to some extent on the period over which the focal whale's acoustics output could be followed. Parameters that summarise the initial phase of clicking (time from fluke to first clicks, duration of first bout of clicks, duration of first silence, ICIs of the initial bouts) could be extracted in all cases where clicks could be detected until the second bout of clicks into the dive. For parameters that required longer analysis duration, we discarded the shortest analysed periods. These were creaks that typically occurred much later in the dive (10-30 minutes), and parameters that were used to describe the search phase (regular clicking) of the dive. After inspecting the respective parameter distributions, we chose a 30-minute threshold for analysing the number of creaks (creak activity, creak rate and proportion of time spent creaking), and a 20-minute threshold for overall ICI (median ICI, proportion of clicks within 0.1 seconds of median ICI and proportion of time spent silent).

Covariate data

A set of environmental variables and parameters measured in the field and from published data (e.g., bathymetry) were used to explain the acoustic behaviour in the subsequent dive (Table 6.2). Year and month of observation were also included in the models.

Measuring change in acoustic behaviour

We term 'a dive exposed to whale-watching' as a dive made directly after a surfacing where ww-vessel(s) were present. To compare with the previous study (Gordon 1992), we first tested pairs of consecutive exposed and non-exposed dives using Wilcoxon matched-pairs signed-rank tests (package MASS in statistical computing software R 2.13.2, www.r-project.org).

To capture some of the natural variability in the acoustic parameters, they were modelled as a function of surface covariates, year and month, as well as the number and type of ww-vessels (Table 6.2). We used generalised additive models (GAM, package mgcv in r), which allow for more flexible non-linear responses to explanatory covariates. We restricted the complexity of all the estimated relationships by setting the maximum number knots to 5.

Whale-watching may influence the following dive behaviour through a direct effect or less directly as a consequence of changes in whale behaviour during the previous surfacing. If the surface behaviour is not influenced by whale-watching, the natural surface behaviour may still influence the following dive behaviour. We therefore applied three models:

Null model fit only to non-exposed dives, including all covariates but whale-watching. This model can inform us how the year, time of year, the spatial environment and surface behaviour may be related to the acoustic parameters.

WW model fit to all data, including all covariates except surface behaviour. This model tests if the acoustic behaviour is different after whale-watching presence during the previous surfacing, given the spatial and temporal environment.

Full model is fit to all data, including all covariates in Table 6.2. This model tests if the acoustic behaviour is different after whale-watching presence during the previous surfacing*, given surface behaviour*, and the spatial and temporal environment.

Autocorrelation was measured so that serial correlation within a whale follow could be accounted for. The autocorrelation structure assumed independence between followed whales, and that subsequent dives were equally correlated.

Shrinkage smoothers were used as a means of automated model selection (Wood, 2006). In other words, variables retained by shrinkage were judged to be important in capturing the variability in the response data.

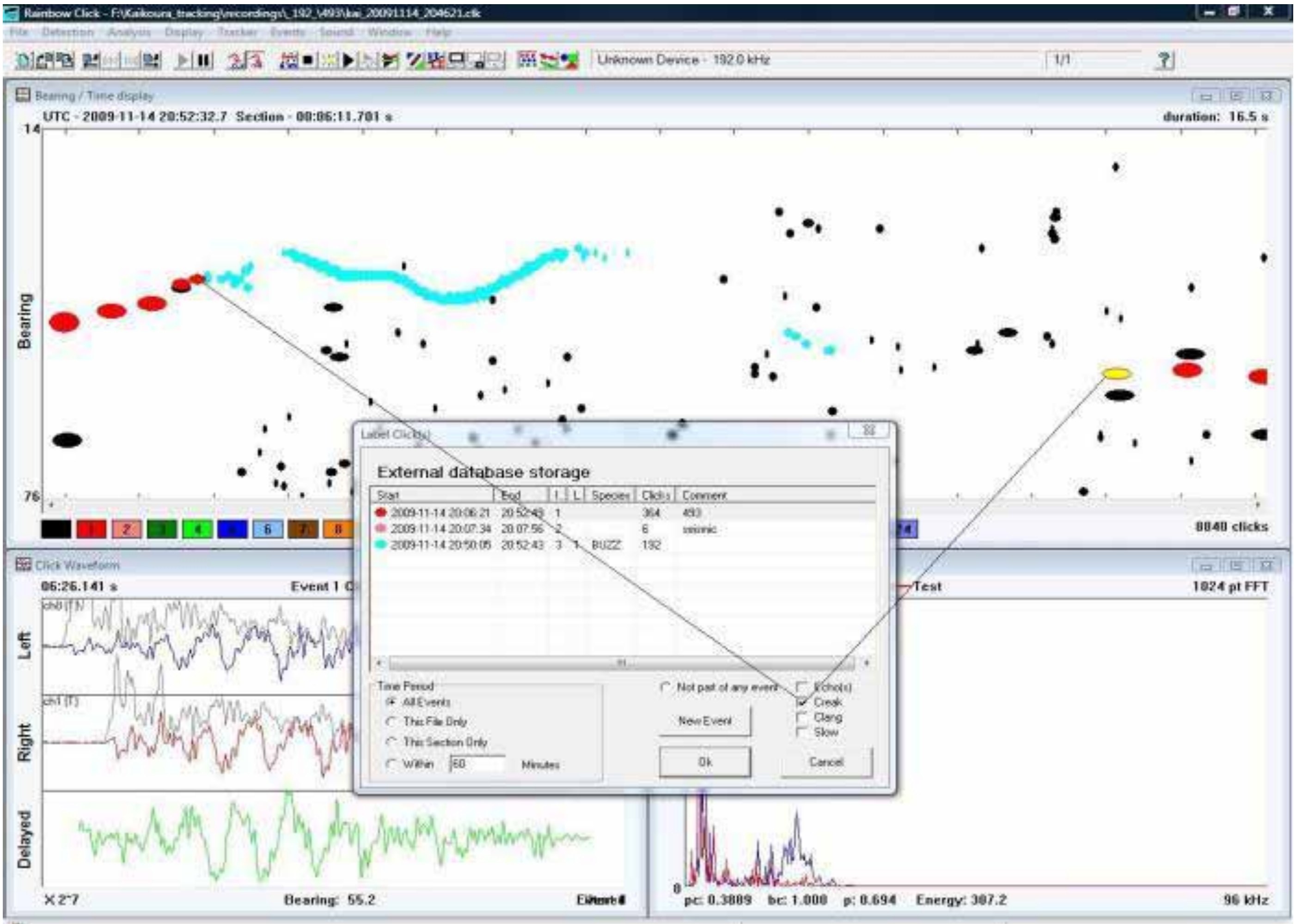

Figure 6.1. Rainbow click bearing display showing marking of a creak produced by the followed whale. X-axis is time and Y bearing from the direction of travel. Dots show automated click detections. The regular clicks by the followed whale have been marked red and creak clicks blue. Dot size is proportional to their received level. The last and first regular click in either side of the creak were marked to show the gap in regular clicking that contained the creak, i.e. 'creak interval'.

Table 6.1. Parameters summarising acoustic behaviour underwater. The first column lists the names used as response variables in the model. "Min dur" is the minimum analysis duration since fluke-up.

Variable	Explanation	Min dur
First ClickTime	**Time from fluke to first clicks**	**0**
First BoutDur	**Duration of first bout of clicks**. The bout was considered broken by a silence when the interclick interval was greater than five times the previous interclick interval.	**0**
First PauseDur	**Duration of the first silence**, after the first bout of clicks.	**0**
ICI First5	**Initial mean click interval.** The mean interclick interval between the first six clicks.	**0**
ICI Last5	**Mean interclick interval at the end of first bout**. The mean interclick interval between the five clicks immediately prior to first silence.	**0**
ICI Change	**Change in interclick interval during first bout**. The difference between initial mean interclick interval and mean interclick interval at the end of first bout.	**0**
First CTime	**Time from fluke to first creak**	**0**
Creak act	**Creak activity** – defined as the number of creaks heard divided by the time for which data were analysed after fluke.	**30**
Creak rate	**Creak rate from first creak**. The number of creak heard divided by the time for which data were analysed following the first creak.	**30**
% Creak	**Proportion of time creaking.** Total duration of creak intervals divided by analysis time.	**30**
ICI Med	**Median interclick interval.**	**20**
% ICI Med	**Proportion of clicks within 0.1 seconds of the median interclick interval.**	**20**
% Silent	**Proportion of time spent silent. Total duration of gaps in regular clicking where no creaks were detected, divided by analysis time.**	**20**

Table 6.2. Covariate data.

Variable		Explanation
Spatial	x, y	**The location of the whale's fluke-up** was calculated using the research vessel's GPS position and the range and bearing estimates to the whale at fluke-up, corrected with ~22 degrees of positive magnetic variation.
	depth	**Sea bottom depth at fluke-up.** Depth values were extracted by overlaying the fluke-up coordinates on a 250 m resolution depth made available by NIWA online at http://www.niwa.co.nz/our science/oceans/bathymetry/download?sid=415
	slope, aspect	**Slope (0-90°) and aspect (180-180°) of the sea bottom at fluke-up.** Slope and aspect were computed from the depth surface using a 3-by-3 window of grid cells in Manifold GIS software (www.manifold.net).
Temporal	Year	**Year 2009-2011**
	month	**Month 1-12**
Surface behaviour	surfDur	**Surface Duration. Only for surfacings where the first or early blows and fluke-up were observed**
	blowRate	**Number of blows per minute.**
	surfSpeed	**Speed over ground during surfacing. Measured between the first and last observation of the whale at surface.**
	HChange	**Change in heading during surfacing. The difference in estimated heading between the beginning and end of surfacing. When the heading was estimated at ranges > 600 metres, we used the travelling heading of the preceding/following dive computed between the fluke-up and surface location, where available.**
Whale-watching	boats	**Number of ww-boats**
	copters	**Presence of ww-helicopters**
	planes	**Presence of ww-aeroplanes.**
	vessels	**Types of ww-vessels present. 0 – no ww-vessels, 1 – only ww-boats present, 2 – only ww-helicopters or aeroplanes present 3 – both ww-boats and ww-flights present**

RESULTS

Extracted data

Clicks were extracted from 76 different dive cycles (surfacing and following dive) of which 46 were complete dives (whale followed acoustically from fluke up to surfacing). Whale watching vessels were present for 36 of the surfacings preceding the dives (Table 6.3, Figure 6.2). See Figures 6.3 and 6.4 for example extractions.

Table 6.3. Number of surfacings (N), number of follow occasions (Follows) and reliably identified whales broken down by presence of whale-watching vessels. Left column shows all data, and complete dive cycles on the right.

		All analysed data	Complete dive cycles
No ww-vessels	N	40	**23**
	Follows / identified	16 / 9	**14/9**
Only ww-boats present	N	21	**13**
	Follows / identified	16 / 9	**10/5**
Only ww-flights present	N	4	**2**
	Follows / identified	4 / 3	**2/2**
Both ww-boats and ww-flights present	N	11	**8**
	Follows / identified	6 / 3	**5/3**
Total	N	76	**46**
	Follows / identified	**22 / 11**	**18/10**

Acoustic behaviour before, during and after exposure to whale-watching boats and flights

We first compared acoustic behaviour between dives for the same tracked individuals that were 1) not exposed to any whale-watching, 2) only viewed by whale-watching boats and 3) only viewed by aeroplanes or helicopters in the preceding surfacing.

There were no apparent differences in the means between non-exposed dives and dives exposed to whale-watching boats alone; all differences in means were small compared to their standard deviations, creak parameters especially so (Table 6.4, Table 6.5, Appendix 1). There were not enough data to show any differences between non-exposed dives and dives exposed to ww-flights alone.

To control for variation, we tested differences between pairs of subsequent dive cycles (surfacing + following dive) with and without whale-watching exposure. All pairs were sampled from different follow occasions. None of the parameters were found to follow normal distribution, so non-parametric signed-rank tests were used. Three types of tests were carried out for each pair:

1. non-exposed dive vs. subsequent exposed dive
2. exposed dive vs. subsequent non-exposed dive
3. previous non-exposed dive vs. subsequent non-exposed dive, with an exposed dive in between

The three tests were carried out separately for boats and flights. To increase sample size, we considered the presence/ absence of ww-boats and flights, regardless whether the other was present or not, i.e. surfacing with only ww-flights present would score as an absence of ww-boats. Event then, we did not have enough data to carry out the Type 3 test for the presence of ww-flights (Table 6).

The only significant test result ($P<0.05$) was the duration of the first pause. The duration was increased by a median of 2.53 s for comparisons between dives with ww-boats absent in the first and present in the second preceding surface period (Type 1 test, $p=0.008$, $n=8$ pairs). Similarly, duration of the first pause was decreased by a median of 3.89 for comparisons between dives with ww-boats present in the first and absent in the second preceding surfacing (Type 2 test, $p=0.054$, $n=11$, Table 6.6). This is consistent with the slightly higher mean duration for all dives after they were viewed by ww-boats alone on the surface (11.20, sd=5.40), compared to dives that were not exposed to any ww-vessels (8.87, sd=4.65, Table 6.4).

Although there was considerable variability in first pause duration between follows, the pattern appeared consistent within the follows. There was only one follow where the whale increased, rather than decreased its first pause duration in Type 2 test (exposed dive vs. subsequent non-exposed dive, Figure 6.5). There appeared to be another small increase in pause duration after two consecutive surfacings with boats present (Figure 6.5), but paired testing did not show this to be significant ($p=0.96$, $n=12$).

Also the duration of the first bout of clicks was increased between no-exposure and exposure (median difference +10.75 s, Type 1 test), and decreased after (-39.5 s, Type 2 test), but the p-values of the tests did not reach significant levels ($p=0.31$ and 0.24, respectively, Figure 6.6).

No significant differences could be detected in first pause duration, or any acoustic parameter, between previous non-exposed and subsequent non-exposed dives, probably due to the small sample size (three pairs).

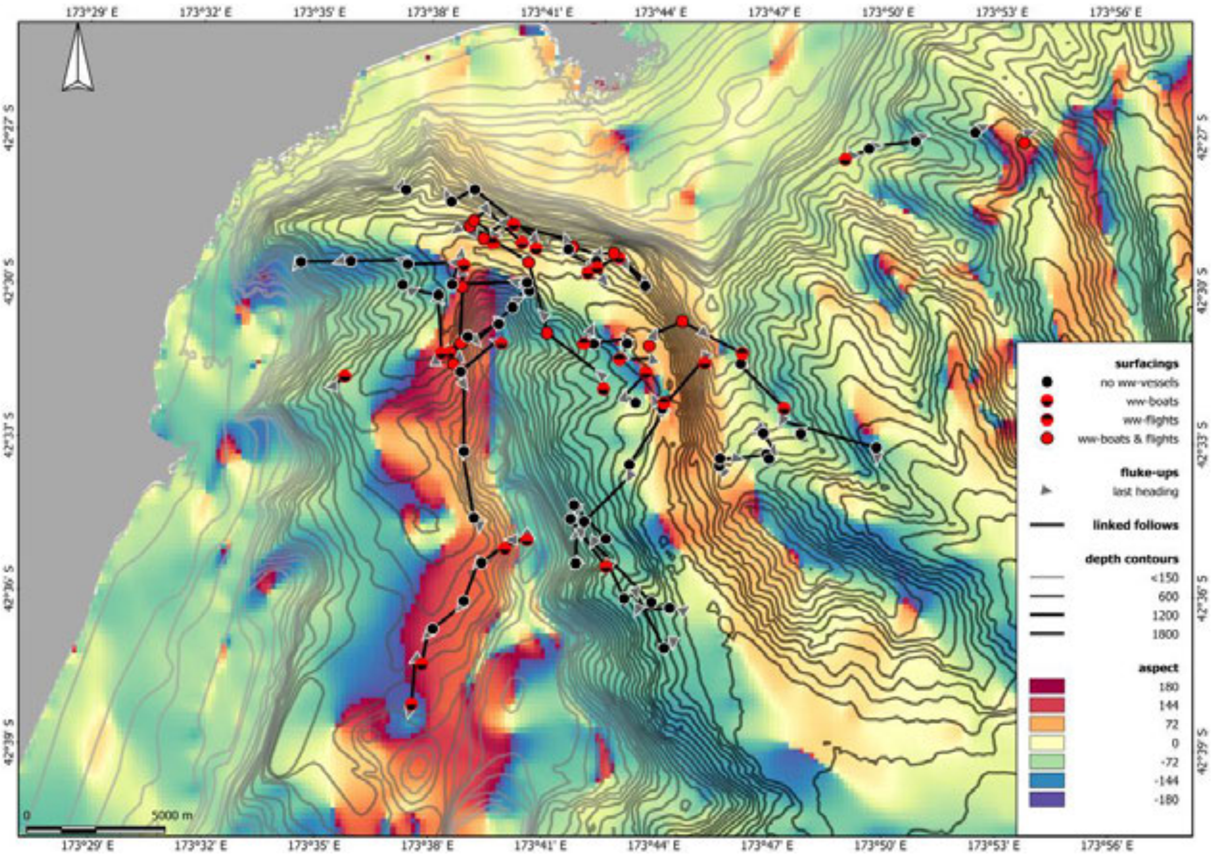

Figure 6.2. Map of surfacings and focal follows for which acoustic data was extracted. Black lines link surfacings that were confirmed to be the same whale.

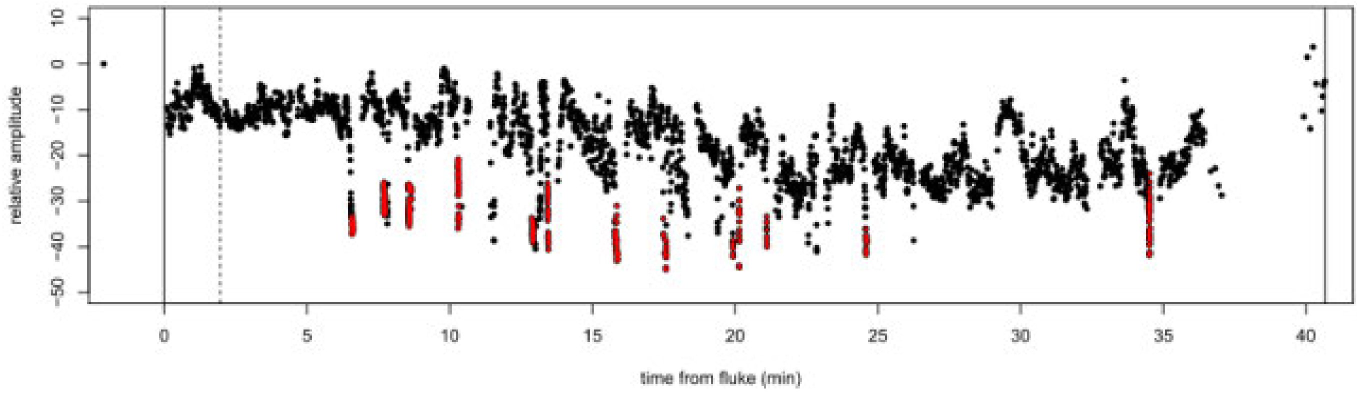

Figure 6.3. Example of an extracted dive cycle. Black dots show regular clicks, and red detected creak clicks. Solid lines show fluke and surfacing time; dashed line the start time of the first pause. Amplitude is shown in dB relative to that of the first click of the dive cycle (in this case, at the surface). Note the slow clicks produced at the end of the dive. This whale was viewed by three whale-watching boats and one aeroplane.

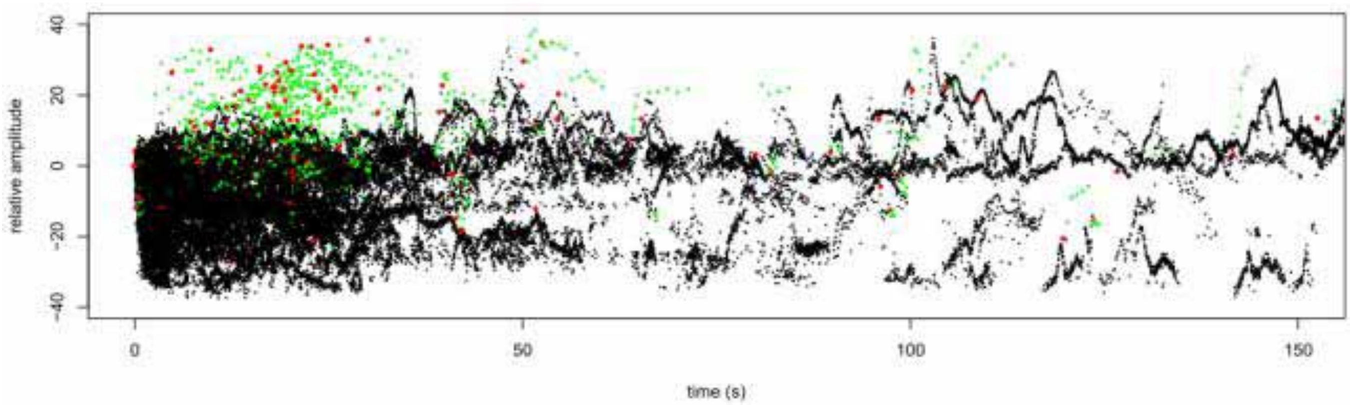

Figure 6.4. Detected creak trains (black) overlaid as a function of time (s) since last regular click. Red dots show the last and first regular clicks (hence marking the start and end of a 'creak interval'), and green dots the following five regular clicks. Amplitude is given relative to the last regular click before the creak train.

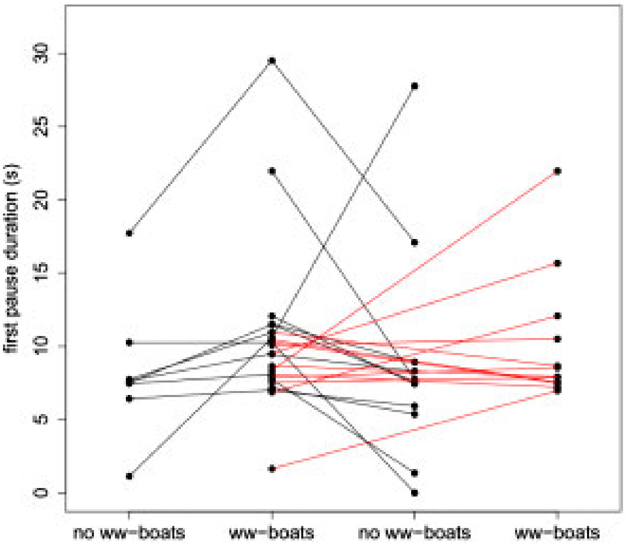

Figure 6.5. First pause duration (s) in dives before exposure to ww-boats, dives after surfacings with ww-boats present, and subsequent non-exposed dives. Red lines show pairs of dives that were both exposed.

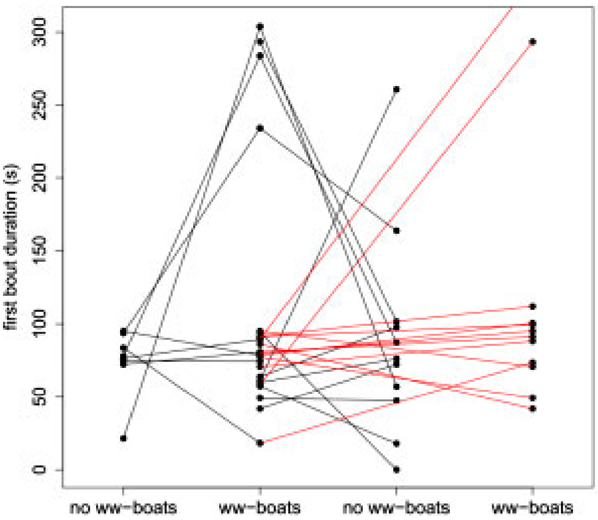

Figure 6.6. First bout duration (s) in dives before exposure to ww-boats, dives after surfacings with ww-boats present, and subsequent non-exposed dives. Red lines show pairs of dives that were both exposed.

Model selection and modelled data

Generalised additive regression models (GAMs) were used to model the acoustic parameters as a function of environmental variables, surface behaviour and whale-watching (Table 6.2). The regression models were additive, meaning that the each of the explanatory covariates were assumed to contribute to the value of the acoustic response parameters independently from each other. Smoothing functions were applied to each explanatory covariate to allow for more flexible responses:

$$\eta = s_1(x_1) + s_2(x_2) + \ldots$$

Where η is the linear predictor, s_i is a smoothing function and x_i an explanatory covariate. The linear predictor is transformed to the scale of the response variable by a link function (e.g., identity or log). We restricted the complexity of the smooths by setting their knots to maximum five for all covariates.

We fit three models in order to explore relationships between surfacing and following dive behaviour, account for variability in the environment and to detect any whale-watching effects: 1) **null model** fit only to non-exposed dives and thus excluding whale-watching covariates, 2) **ww model** fit to all data, but excluding surface covariates and 3) **full model** including all data and all covariates (see Methods: measuring change in acoustic behaviour). Individual was included as an explanatory factor covariate in the whale-watching and full model, but there was not enough data to include individual in the null model. A first-order autocorrelation structure (AR1) was estimated for each model to account for any serial correlation within focal follow occasions.

For those initial click parameters that could be measured in all of the analysed data, all three models were fit to each parameter. Explanatory variables that captured a significant portion of the data were then automatically selected using shrinkage smoothers implemented in the mgcv library in r (Models 1-17 in Table 6.7).

For the parameters that described creaks and click intervals throughout the dive, there were insufficient data to fit the three models (Models 18-24 in Table 6.7). Because we were unable to fit all the covariates in a model, there was no full model to exclude unimportant covariates from. We therefore required other means for selecting covariates. Unfortunately, step-wise model selection is not a reliable alternative in the mgcv library in R because the complexity of each response ('smooth') is estimated as part of model fitting and thus models are not nested within each other. Instead, we modelled each parameter in turn with just one covariate, without an autocorrelation structure, and tested their importance in the model using Wald tests for parametric terms, and Bayesian 'p-values' for the smooths (anova.gam function in mgcv library in r). Covariates that were important at the 90% confidence level were included in a 'full' model that we then used in the automatic model selection by shrinkage. Using a lower confidence level we were more conservative in excluding covariates for the full model. The disadvantage of this approach is that any covariates that did not explain variability in the response data alone (at the 90% confidence level) were excluded from further analysis.

Appropriate model distributions and link functions were investigated for each parameter based on their information criteria (gcv score), model convergence and resulting residual distributions. Residual distributions and model checking are given in Appendix 2. Quasi-likelihood was used for proportions (Models 21, 23 and 24) and variables with over-dispersed distributions (Models 4-9 and 19, i.e. duration of first bout of clicks, duration of first silence and creak activity, Table 6.7). ICI was best described as a Gaussian process; however, Gaussian models failed to converge for mean interclick interval at the end of the first bout. The Tweedie distribution was used instead, which is implemented in mgcv as a mixed compound Poisson-Gamma distribution. Tweedie also performed well for time to first click, whose distribution has positive mass at zero. Time to first creak was the only response variable that could be modelled as pure 'waiting time' Gamma distribution. Full model for the change in the initial ICI did not converge with any of the tested distributions (Gaussian, Quasi or Tweedie).

Table 6.4. Descriptive mean and range statistics for each acoustic parameter measured during diving (all analysed data included), broken down by the presence of whale-watching vessels in the preceding surfacing. Both number of surfacings and number of follows are given as sample size (N).

	First ClickTime (s)	First BoutDur (s)	First PauseDur (s)	ICI First5 (s)	ICI Change (s)	First CTime (min)	Creak Act (-h)	Creak Rate (-h)	% Creak	ICI Med (s)	% ICIMed	% Silent
No ww-vessels												
N	40/16	40/16	40/16	40/16	40/16	32/15	23/14	23/14	23/14	30/14	30/14	30/14
Individual ids	9	9	9	9	9	9	9	9	9	9	9	9
Mean	8.71	102.42	8.87	1.13	0.00	13.17	8.02	11.70	9.6	1.05	21.0	14.1
Sd	7.75	82.11	4.65	0.26	0.32	6.46	6.65	8.35	9.3	0.17	15.3	7.2
Min	0.13	6.67	1.13	0.72	-0.80	2.53	0.00	0.00	0.0	0.72	2.7	4.4
Max	30.79	389.82	27.77	1.67	0.71	29.29	21.25	27.69	38.7	1.37	69.0	34.9
Only ww-boats												
N	21/16	21/16	21/16	21/16	21/16	11/9	14/11	14/11	14/11	13/11	13/11	14/11
Individual ids	9	9	9	9	9	7	6	6	6	7	7	7
Mean	8.19	125.02	11.20	1.10	0.13	10.48	6.18	8.51	9.0	1.07	25.6	12.8
Sd	7.45	98.09	5.40	0.31	0.53	5.40	6.26	7.76	14.4	0.24	14.7	6.0
Min	0.07	18.13	6.86	0.52	-0.70	4.86	0.00	0.00	0.0	0.84	7.3	4.7
Max	22.23	335.45	29.51	1.54	1.20	19.06	20.09	24.29	50.7	1.53	51.4	27.1
Only ww-flights												
N	4/4	4/4	4/4	4/4	4/4	2/2	2/2	2/2	2/2	3/3	3/3	3/3
Individual ids	3	3	3	3	3	2	2	2	2	3	3	3
Mean	10.25	49.89	5.00	0.93	-0.06	6.22	2.19	2.52	5.4	0.94	33.2	7.9
Sd	7.01	39.12	3.39	0.67	0.43	-	-	-	-	-	-	-
Min	0.00	0.00	0.00	0.00	-0.68	5.35	0.00	0.00	0.0	0.79	26.4	0.0
Max	15.24	95.10	7.45	1.54	0.30	7.09	4.39	5.04	10.8	1.16	40.8	16.4

Table 6.5. Descriptive mean and range statistics for parameters measured for complete dive cycles, broken down by the presence of whale-watching vessels in the preceding surfacing. Both number of surfacings and number of follows are given as sample size (N), e.g., 23/14: 23 surfacings, 14 follow occasions.

	Dive duration (min)	Speed over ground (kt)	Dir change (deg)	Creak activity (-h)	Creak Rate (-h)	Time spent creaking (%)	Median regular ICI (s)	Clicks at median ICI (%)	Time spent Silent (%)
No ww-vessels									
N	23/14	23/14	23/14	19/14	19/14	19/14	21/14	21 /14	21/14
Individual ids	9	9	9	9	9	9	9	9	9
Mean	35.30	0.66	55.19	6.79	10.30	9.0	1.06	20.4	14.2
Sd	6.97	0.28	44.18	5.44	6.87	9.6	0.17	16.7	7.9
Min	19.77	0.10	1.79	1.35	1.97	0.6	0.72	2.7	4.4
Max	49.62	1.20	154.95	18.90	23.92	38.7	1.37	69.0	34.9
Only ww-boats									
N	13/10	13/10	11/9	10/9	10/9	10/9	11/9	11/9	12/9
Individual ids	5	5	5	5	5	5	5	5	5
Mean	34.01	0.80	54.66	6.58	8.32	11.2	1.09	25.1	11.7
Sd	10.23	0.44	52.28	7.18	8.57	16.7	0.26	13.7	4.7
Min	11.82	0.30	4.82	0.00	0.00	0.0	0.84	7.3	4.7
Max	44.77	2.01	159.98	20.09	24.29	50.7	1.53	51.4	19.3
Only ww-flights									
N	2/2	1/1	2/2	1/1	1/1	1/1	1/1	1/1	1/1
Individual ids	2	1	2	1	1	1	1	1	1
Mean	27.58	0.27	30.51	4.39	5.04	10.8	1.16	26.4	16.4
Min	0.48		27.88						
Max	54.68		33.14						

Table 6.6. Wilcoxon matched-pairs signed-rank tests. Number of pairs tested, test statistic (sum of negative signed ranks) and p values are given in columns N, V and p, respectively. 'Sign' is the sign of the maximum total rank, and can be interpreted as increase or decrease in the values. Also the median pair-wise difference is given for each acoustic parameter.

	Type 1: No-boat encounter vs subsequent boat encounter					**Type 2:** Boat encounter vs subsequent no-boat encounter					**Type 3:** Prev ous encounter vs subsequent encounter				
	N	V	p	s gn	med an d ff	N	V	p	s gn	med an d ff	N	V	p	s gn	med an d ff
F rst C ckT me	8	14	0 641	+	3 53	11	37	0 765	-	-0 01	3	0	0 250	+	2 79
F rst BoutDur	8	10	0 313	+	10 75	11	47	0 240	-	-39 50	3	0	0 250	+	35 76
F rst PauseDur	8	0	0 008	+	2 53	11	55	0 054	-	-3 89	3	2	0 750	+	0 08
C F rst5	8	11	0 383	+	0 19	11	30	0 831	+	0 14	3	2	0 750	+	0 53
C Last5	8	12	0 461	+	0 23	11	42	0 465	-	-0 02	3	2	0 750	+	0 18
C Change	8	15	0 742	+	0 07	11	41	0 520	-	-0 05	3	3	1 000	+	0 10
F rst Ct me	4	4	0 875	+	2 43	3	0	0 250	+	3 32	1				
Creak Act v ty	3	1	0 500	+	4 74	4	3	0 625	+	1 65	0				
Creak Rate	3	1	0 500	+	6 25	4	1	0 250	+	4 58	0				
% Creak ng	3	1	0 500	+	4 73	4	2	0 375	+	3 76	0				
C Med an	6	15	0 438	-	-0 05	4	8	0 375	-	-0 14	1				
% C Med an	6	16	0 313	-	-8 49	4	6	0 875	-	-2 91	1				
% S ent	6	10	1 000	+	2 34	4	3	0 625	+	3 46	1				

	Type 1: No-f ght encounter vs subsequent f ght encounter					**Type 2:** F ght encounter vs subsequent no-f ght encounter				
	N	V	p	s gn	med an d ff	N	V	p	s gn	med an d ff
F rst C ckT me	5	12	0 313	-	-18 58	3	0	0 250	+	3 24
F rst BoutDur	5	10	0 625	-	-10 42	3	0	0 250	+	22 10
F rst PauseDur	5	10	0 625	-	-0 32	3	3	1 000	+	-0 75
C F rst5	5	9	0 813	-	0 05	3	0	0 250	+	0 31
C Last5	5	6	0 813	+	0 16	3	0	0 250	+	0 19
C Change	5	5	0 625	+	0 08	3	4	0 750	-	-0 03
F rst Ct me	2	3	0 500	-	-8 07	0				
Creak Act v ty	3	1	1 000	+	0 00	0				
Creak Rate	3	1	1 000	+	0 00	0				
% Creak ng	3	1	1 000	+	0 00	0				
C Med an	3	5	0 500	-	-0 15	0				
% C Med an	3	2	0 750	+	0 01	0				
% S ent	4	0	0 125	+	0 10	0				

Impact of the research vessel

To assess whether the research vessel itself could have influenced acoustic behaviour, we used estimated minimum distance to the whale during surfacing as a covariate. We were not able include the covariate in the three full models due to small sample size. Instead, we fitted two models for each acoustic parameter: one with minimum distance as a sloe non-linear covariate, and the other the minimum distance as a non-linear covariate and presence of whale-watching boats as a factor covariate. We also checked if the research vessel could explain any of the remaining variability in the data once all the covariates in the three full models had been included; in other words, we modelled the residuals of each model as a function of the minimum distance to the research vessels.

The minimum distance ranged from 25 to 1000 metres, with 64% of the data between 200-400 metres. When fitted alone, the minimum distance to the research vessel did not explain enough data (at 90% significance level) in any of the acoustic parameters. Minimum range did not explain variability in any of the model residuals (at 95% confidence level) either. When the minimum distance was fitted together with presence of boats, minimum range appeared to be important in the models for creak activity and proportion of time spent creaking. We fit both these models with and without whale-watching boats that had little support in the two-covariate models (Wald tests p = 0.408 and 0.518, respectively), as well as with and without aspect and depth that were supported by model selection (Table 6.8 a).

The model for creak activity appeared to be driven by the highest response value in the set, 20.1 creaks per hour that was measured after minimum range of 60 metres at the surface. Fitting without this point changed the fit so much that minimum range was no longer supported when fitted with presence of boats (Wald test, n=29, p=0.377) and no longer converged in a model with aspect. This indicates that there was no real increase in creak activity with proximity to the research vessel and that the model for creak activity was over-fitting to the small sample size.

Presence of ww-boats was not supported in the models for the proportion of time spent in creak intervals (Wald tests p > 0.5), but both depth and minimum range captured a significant amount of the data (Wald test, p < 0.001, n=30). The model with depth and minimum range of the research vessel captured a large proportion of the data (adjusted R-square 63.62%) and it didn't appear to be driven by few data points or over-fit the data. Given mean depth, proportion in creak interval was predicted to increase by a factor of 2.7 from a minimum range from the research vessel of 400 to 150 metres (Figure 6.7).

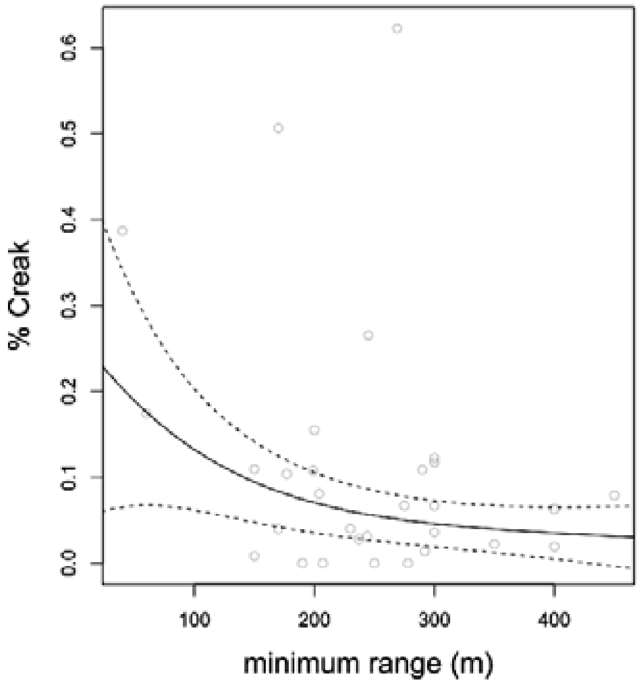

Figure 6.7. Predicted proportion time in creak intervals as a function of minimum range to the research vessel, given mean depth. Dashed lines show confidence intervals assuming t-distribution. Grey circles show data.

Table 6.7. Fitted models.

Model no	Response variable	short name	Model type	Distribution	Link	Var	N	Rsq %	Autocorr (Phi)	Min Resid	Max Resid	Min Fitted	Max Fitted	Min Observed	Max Observed
1	First ClickTime	firstRCTime	null	Tweedie(1.1)	mu^0.1		33	26.98	0.67	-4.01	3.51	1.50	25.29	0.13	30.79
2			ww	Tweedie(1.1)	mu^0.1		59	37.12	0.49	-3.97	3.54	0.43	26.21	0.13	30.79
3			all	Tweedie(1.1)	mu^0.1		56	43.30	0.48	-3.88	3.20	0.68	25.90	0.13	30.79
4	First BoutDur	firstRCTrainDur	null	quasi	log	mu	33	56.44	-0.53	-12.90	9.90	32.03	384.35	12.22	389.82
5			ww	quasi	log	mu	59	51.87	-0.29	-8.65	11.99	23.33	273.19	12.22	389.82
6			all	quasi	log	mu	56	51.52	-0.75	-11.53	12.36	32.04	345.62	12.22	389.82
7	First PauseDur	firstPauseDur	null	quasi	inverse	mu	33	0.00	-0.11	-3.20	5.20	8.54	8.54	1.13	27.77
8			ww	quasi	inverse	mu	59	7.40	-0.19	-3.26	5.54	4.91	22.02	1.13	29.51
9			all	quasi	inverse	mu	56	8.28	-0.20	-3.27	5.54	4.90	22.28	1.13	29.51
10	ICI First5	first5ICI	null	gaussian	identity		33	60.58	0.00	-0.38	0.29	0.80	1.39	0.73	1.65
11			ww	gaussian	identity		59	75.81	-0.14	-0.25	0.27	0.72	1.55	0.52	1.65
12			all	gaussian	identity		56	75.21	-0.13	-0.25	0.27	0.73	1.55	0.52	1.65
13	ICI Last5	last5ICI	null	Tweedie(1.1)	mu^0.1		33	16.91	-0.17	-0.46	0.41	0.94	1.32	0.66	1.64
14			ww	Tweedie(1.1)	mu^0.1		59	18.15	-0.29	-0.39	0.36	0.87	1.55	0.66	1.66
15			all	Tweedie(1.1)	mu^0.1		56	57.32	-0.08	-0.26	0.30	0.72	1.69	0.66	1.66
16	ICI Change	ICIChange	null	gaussian	identity		33	25.71	-0.33	-0.52	0.58	-0.28	0.30	-0.80	0.71
17			ww	gaussian	identity		59	40.01	0.06	-0.63	0.54	-0.49	0.80	-0.80	0.92
18	First CTime	firstCTime		Gamma	log		25	13.68	0.78	-0.88	0.92	7.19	16.81	4.93	29.29
19	Creak act	CIFAct		quasi	inverse	mu	30	18.46	0.59	-4.61	2.52	5.53	11.51	0.00	20.09
20	Creak rate	CIFRate		quasipoisson	log		30	0.00	0.50	-4.59	3.62	10.52	10.52	0.00	24.29
21	% Creak	durCI		quasi	log	mu	30	45.04	0.58	-0.50	0.48	0.02	0.60	0.00	0.62
22	ICI Med	medICIRC		gaussian	log		38	85.57	-0.44	-0.13	0.13	0.68	1.52	0.61	1.53
23	% ICI Med	propMedICIRC		quasi	identity		41	45.15	-0.80	-0.20	0.21	-0.01	0.57	0.03	0.58
24	% Silent	durPauseRC		quasi	log	mu	42	34.69	0.39	-0.23	0.26	0.09	0.23	0.04	0.26

Table 6.8 a. All models with the retained covariates. NA:s show covariates that were fitted in each full model, but were then excluded by shrinkage model selection. Columns EDF/df, F, and p values show (estimated) degrees of freedom, Wald test statistic and p-value, respectively.

	response	model	depth			slope			aspect			year			month		
			EDF	F	p	EDF	F	p	EDF	F	p	EDF	F	p	EDF	F	p
1		null	NA	NA	NA	NA	NA	NA	0.861	5.280	0.034	1.199	6.530	0.012	0.906	8.499	0.008
2	First ClickTime	ww	NA	NA	NA	NA	NA	NA	0.938	7.898	0.008	NA	NA	NA	NA	NA	NA
3		all	NA	NA	NA	0.517	0.865	0.286	0.946	8.673	0.006	NA	NA	NA	0.683	2.345	0.138
4		null	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.710	22.365	0.000	NA	NA	NA
5	First BoutDur	boat	2.440	5.767	0.004	NA	NA	NA	0.830	3.807	0.065	NA	NA	NA	NA	NA	NA
6		all	1.069	22.664	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7		null	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	First PauseDur	ww	0.852	3.554	0.072	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9		all	0.849	3.623	0.070	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10		null	1.046	18.123	0.000	NA	NA	NA	1.009	14.563	0.001	0.749	2.470	0.131	NA	NA	NA
11	ICI First5	ww	1.564	75.353	0.000	0.920	5.950	0.021	NA	NA	NA	NA	NA	NA	0.964	22.633	0.000
12		all	1.507	69.427	0.000	0.905	5.448	0.028	NA	NA	NA	NA	NA	NA	0.962	21.772	0.000
13		null	NA	NA	NA	NA	NA	NA	0.939	7.642	0.011	NA	NA	NA	NA	NA	NA
14	ICI Last5	ww	1.930	1.840	0.173	NA	NA	NA	0.760	2.537	0.124	NA	NA	NA	NA	NA	NA
15		all	3.777	7.298	0.000	NA	NA	NA	0.996	13.153	0.001	NA	NA	NA	NA	NA	NA
16	ICI Change	null	0.995	13.655	0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17		ww	1.110	15.972	0.000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	First CTime								0.632	1.560	0.208						
19	Creak act								0.859	4.788	0.042				NA	NA	NA
20	Creak rate								NA	NA	NA						
21	% Creak		0.941	4.781	0.043	NA	NA	NA									
22	ICI Med		NA	NA	NA										0.884	6.171	0.024
23	% ICI Med		1.034	15.280	0.001	NA	NA	NA	1.041	22.878	0.000				NA	NA	NA
24	% Silent		NA	NA	NA	1.091	29.952	0.000	NA	NA	NA						

Table 6.8 b. All models with the retained covariates. NA:s show covariates that were fitted in each full model, but were excluded by shrinkage. Columns EDF/df, F, and p values show (estimated) degrees of freedom, Wald test statistic and p-value, respectively.

	surfDur			blowRate			surfSpeed			HChange			Boats			as.factor(vessel)			as.factor(individual)			
	EDF	F	p	EDF	F	p	EDF	F	p	EDF	F	p	EDF	F	p	df	F	p	df	F	p	no sig levels
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.749	2.716	0.117										
2													NA	NA	NA	3	2.331	0.088	11	2.779	0.008	5
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.889	4.860	0.037	NA	NA	NA	3	3.538	0.023	10	3.586	0.002	8
4	NA	NA	NA	1.167	33.842	0.000	NA	NA	NA	NA	NA	NA										
5													NA	NA	NA	3	2.865	0.048	11	7.816	0.000	4
6	NA	NA	NA	1.077	12.364	0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	3.217	0.033	10	17.143	0.000	5
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA										
8													NA	NA	NA	3	1.128	0.348	11	1.327	0.243	1
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	1.080	0.368	10	1.416	0.208	0
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA										
11													NA	NA	NA	3	0.366	0.778	11	5.520	0.000	7
12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3	0.346	0.792	10	5.730	0.000	6
13	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.559	1.185	0.244										
14													NA	NA	NA	3	1.783	0.165	11	2.825	0.008	1
15	2.015	5.207	0.011	NA	NA	NA	NA	NA	NA	2.333	4.377	0.016	NA	NA	NA	3	2.973	0.046	10	3.630	0.002	2
16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA										
17													NA	NA	NA	3	0.279	0.840	11	0.675	0.754	0
18							NA	NA	NA				0.909	5.575	0.030							
19																						
20																						
21																			9	0.831	0.597	2
22	NA	NA	NA				NA	NA	NA	0.816	2.691	0.119				3	2.466	0.089	10	24.453	0.000	5
23	1.062	8.930	0.006	0.934	6.622	0.018													11	15.379	0.000	8
24																						0

Table 6.9. Estimated coefficients for each vessel factor

response	modelNo	Vessel factor	Estimate	Std Error	t-value	p-value
	2	Intecept	1.115	0.045	24.764	0.000
First ClickTime		ww-boats	0.037	0.020	1.875	0.068
		ww-flights	0.085	0.061	1.393	0.171
		both	-0.001	0.047	-0.015	0.988
	3	Intecept	1.051	0.054	19.309	0.000
		ww-boats	0.048	0.019	2.523	0.016
		ww-flights	0.135	0.060	2.249	0.030
		both	0.051	0.050	1.019	0.314
First BoutDur	5	Intecept	3.813	0.237	16.121	0.000
		ww-boats	0.520	0.178	2.920	0.006
		ww-flights	0.423	0.465	0.910	0.368
		both	0.497	0.340	1.462	0.151
	6	Intecept	4.163	0.189	21.972	0.000
		ww-boats	0.241	0.137	1.753	0.087
		ww-flights	0.337	0.343	0.985	0.331
		both	0.766	0.256	2.991	0.005
	8	Intecept	0.118	0.021	5.625	0.000
First PauseDur		ww-boats	-0.026	0.016	-1.688	0.099
		ww-flights	0.000	0.057	0.006	0.996
		both	0.003	0.038	0.086	0.932
	9	Intecept	0.118	0.021	5.533	0.000
		ww-boats	-0.026	0.016	-1.649	0.107
		ww-flights	0.000	0.059	0.008	0.994
	9	both	0.004	0.039	0.094	0.925
	11	Intecept	1.406	0.093	15.085	0.000
		ww-boats	0.001	0.048	0.018	0.985
		ww-flights	0.013	0.114	0.114	0.910
		both	-0.071	0.092	-0.770	0.446
	12	Intecept	1.402	0.096	14.620	0.000
		ww-boats	0.001	0.049	0.026	0.979
ICI First5		ww-flights	0.014	0.117	0.118	0.907
		both	-0.070	0.094	-0.742	0.463
ICI Last5	14	Intecept	1.007	0.009	113.861	0.000
		ww-boats	0.003	0.007	0.477	0.636
		ww-flights	0.019	0.017	1.151	0.256
		both	0.029	0.013	2.264	0.029
	15	Intecept	1.001	0.008	121.586	0.000
		ww-boats	0.005	0.006	0.906	0.372
		ww-flights	0.027	0.013	2.042	0.049
		both	0.028	0.010	2.870	0.007
ICI Change	17	Intecept	-0.026	0.130	-0.203	0.840
		ww-boats	0.028	0.100	0.278	0.782
		ww-flights	0.137	0.238	0.575	0.569
		both	0.159	0.175	0.908	0.369
ICI Med	22	Intecept	-0.121	0.055	-2.224	0.037
		ww-boats	0.069	0.035	1.988	0.059
		ww-flights	0.140	0.064	2.169	0.041
		both	0.117	0.058	2.013	0.056

Models describing the first bout of clicks

Time to first clicks. Time to first click was 1 s or less in 28% of the modelled data, with a median of 7.25 s and maximum of 30.79 s. There was high between-individual variability with strong support for individual both in the ww-vessel and full models (Wald tests p < 0.01, Table 6.8 b). The full model explained 43.30% of the data, an increase of 6.18 units from the ww-vessel model which excluded surface covariates.

The aspect of seabed at fluking was an important predictor for time to first clicks, increasing with positive aspect (more west-facing slopes) in all three models (p<0.04, Wald test for Models 1-3, Table 6.8 a, Figures 6.8, 6.9). Water depth at fluke location was not retained in any of the three models, while bathymetric slope had weak support in the full model (Wald test, p=0.289, Table 6.8 a).

There was good support for heading change in the full model (Wald test, estimated df =0.89, n=59, p=0.037), but it failed to capture a significant amount of variability in the null model, probably because of much smaller sample size (n=33) and exclusion of the individual factor. 160 degree change in heading was predicted to approximately half the time to first click (Figure 6.8).

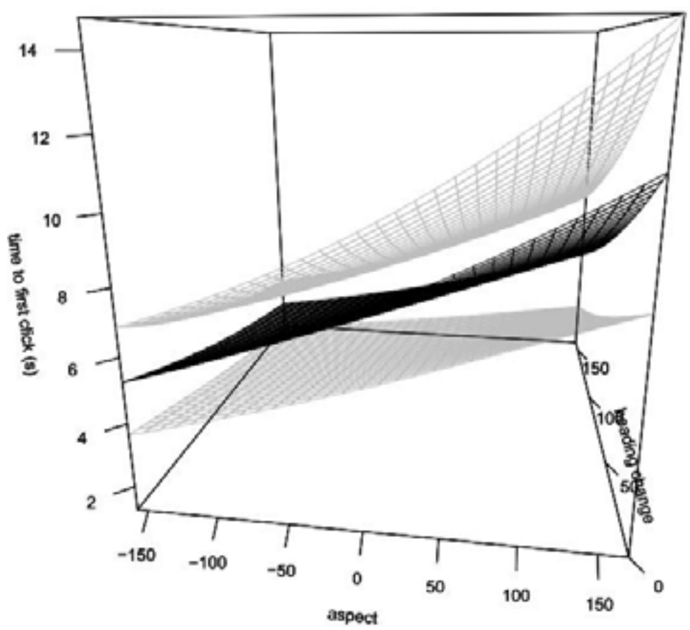

Figure 6.8. Predictions for time to first click as a function of aspect of sea bottom and heading change of the whale at surface under Model 3. Black surface shows mean, and grey +/- standard errors.

Year and month were retained only in the null model, probably capturing variability that was explained by individual factor in the ww-vessel and full models.

There was more support for the vessel covariate in the full model (Wald test, df=3, n=56, p=0.023) than in the ww-vessel model (n=59, p=0.088). Time to first clicks was significantly longer after encounters with boats or helicopters alone (p=0.015 and p=0.030, respectively Table 6.9); however, no such difference was detected after encounters with both boats and helicopters (p=0.314, Table 6.9, Figure 6.9, 6.10). Given mean values for all other covariates, no individual animals could be predicted to increase their time to first clicks after encounters with either boats nor flights due to wide confidence intervals (95%, Figure 6.10).

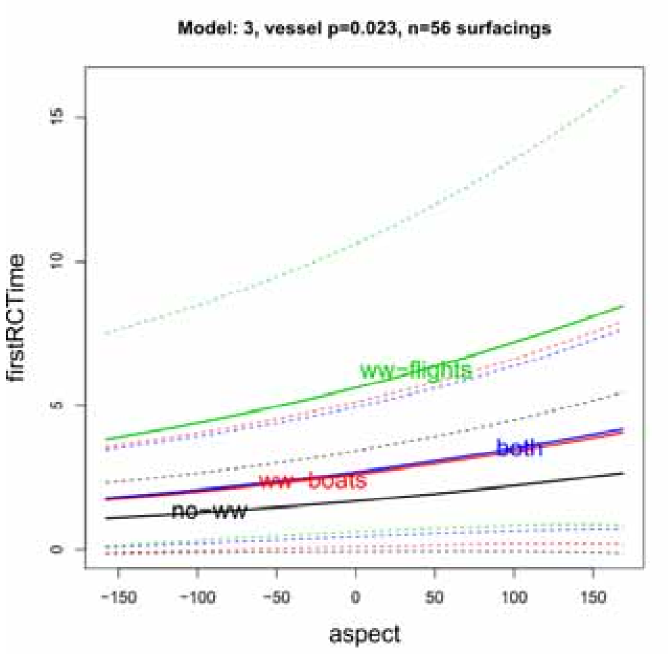

Figure 6.9. Predicted time to first click (s) after encounters with different whale-watching vessels as a function of sea bottom aspect at fluking, given mean values for all other covariates and individual factor fixed to its intercept under Model 3 (Table 6.8 a). Dashed lines show 95% confidence intervals assuming t-distribution.

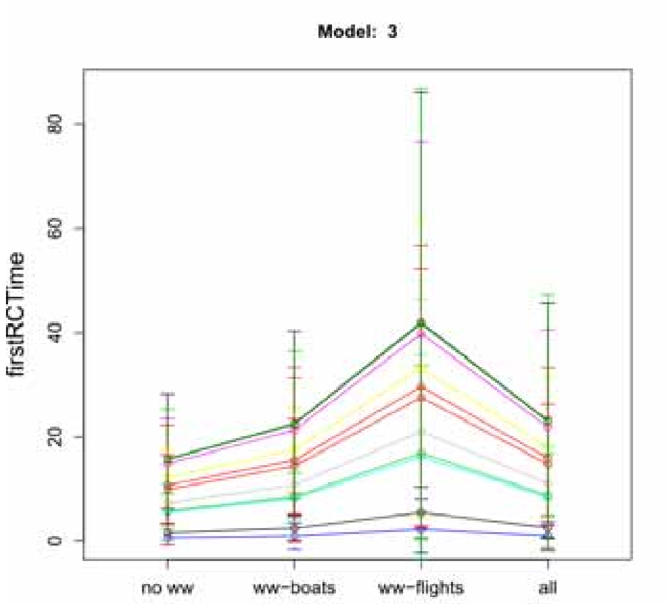

Figure 6.10. Predicted individual time to first click after different whale-watching encounters (no ww-vessels, ww-boats only, ww-flights only, and both flights and boats), given mean values for all other covariates under Model 3 (Table 6.8). Individuals are shown in different colours. Crossbars show 95% confidence intervals assuming t-distribution.

Duration of first bout of clicks. The duration of the first bout of clicks was highly over-dispersed, with 67.11% of the data between 50 and 100 s, median of 80 seconds and maximum of 390 s (Figure 6.11). The models accounted for this variation by estimating variance as a function of the mean (Table 6.7). The range of fitted values matched well with the range of the response values, and adjusted R-squares were over 50% for all three models (Table 6.7). There was strong support for an effect due to individual in both the ww-vessel and full models (p<0.001, Table 6.8 b).

Depth explained a significant amount of the data in the vessel and full model (p<0.001, Table 6.8 a), but was not retained in the null model, probably due to smaller sample size and not including individual as a factor. Duration of first bout of clicks increased in deeper fluking depths in both models, with a predicted difference of 43 seconds between 600 and 1200 metres, given the whale did not encounter vessels and mean values for all other covariates (Figure 6.12 a).

The blow rate (blows per minute) captured a significant amount of data in both the null and full models (p <0.001, Wald tests Table 6.8 b). Higher blow rates were associated with an increase in the duration of first bout of clicks in both models, however, prediction intervals were too large to predict beyond blow rates of 4.5 (Figure 6.12 b).

WW-boat presence was an important factor both in the ww-model and the full model (p<0.004, Table 6.8 b). Presence of boats alone was more important in the ww-model (t=2.920, p=0.006) than in the full model (t=1.753, p=0.087), while the presence of both boats and flights was more important in the full model (t=2.991, p=0.005, Table 6.9). Neither model could show differences between no vessels and ww-flights, possibly due to small sample size. Not a single individual could be predicted to increase their time to first clicks after encounters with neither boats nor flights due to wide confidence intervals (95%, Figure 6.14).

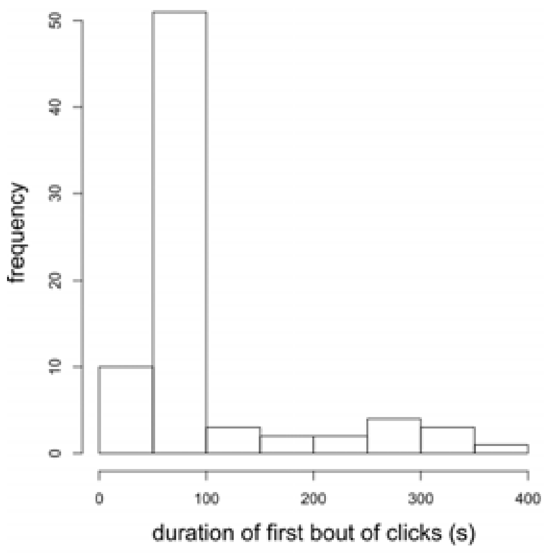

Figure 6.11. Histogram of the duration of first bout of clicks

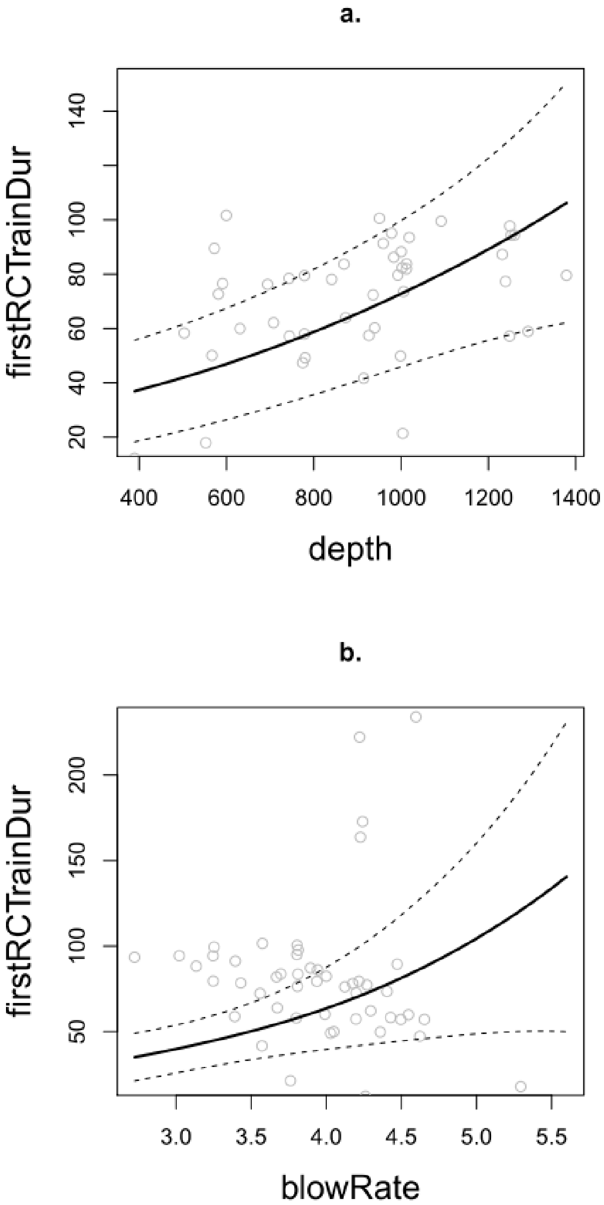

Figure 6.12. Predicted duration of first bout as a function of fluking depth (a) and blow rate (blows per minute, b) given no whale-watching vessels, individual fixed to its intercept and all other covariates fixed to their means (mean depth 885 m) under Model 6. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

Duration of first silence. The null model for duration of first silence did not retain any covariates and hence explained no data in the response data. When individual was included in the vessel and full models, only fluking depth was retained with some support for the covariate (p=0.07, Wald tests, Table 6.8 a), but the adjusted R square of both models remained low (7.40 and 8.28%, Table 6.7). There was little evidence that the presence of vessels explained a significant amount data in the model (Wald test in Model 9, n=56, p=0.368, Table 6.8 b).

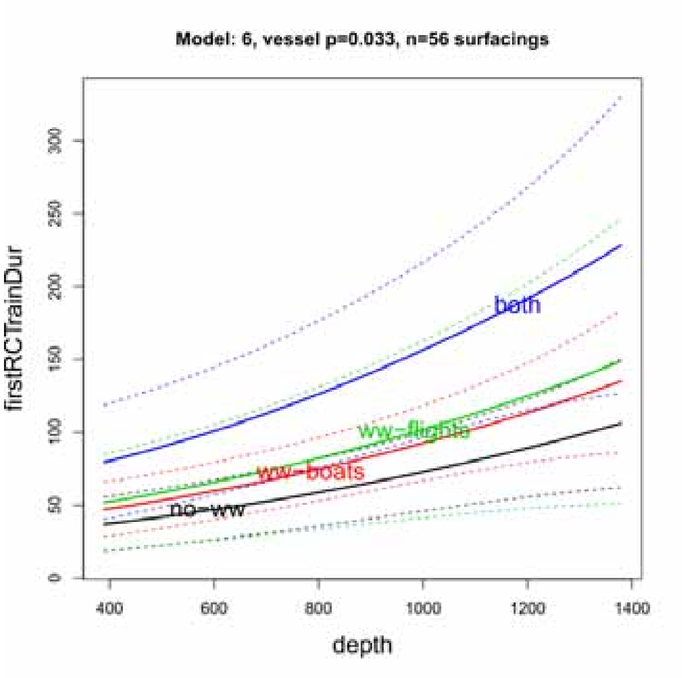

Figure 6.13. Predicted duration of first clicking bout (s) after encounters with different whale-watching vessels as a function of fluking depth (m), given mean values for all other covariates and individual factor fixed to its intercept under Model 6 (Table 6.8 a). Dashed lines show 95% confidence intervals assuming t-distribution.

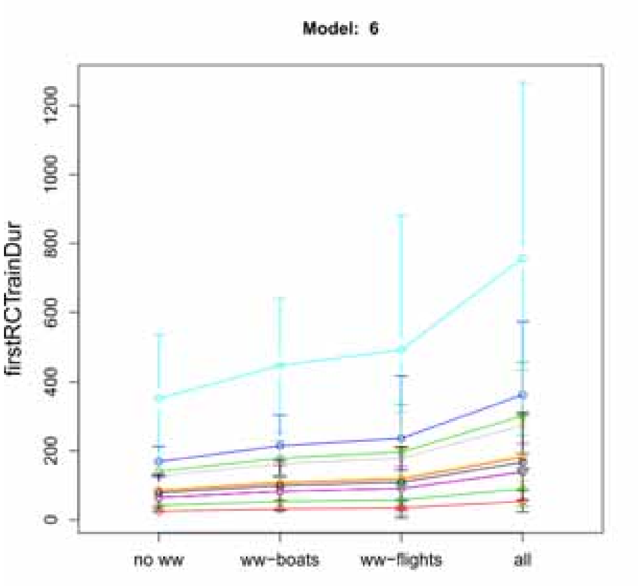

Figure 6.14. Predicted individual duration of first bout of clicks after whale-watching encounters (no ww-vessels, ww-boats only, ww-flights only, and both flights and boats), given mean values for all other covariates under Model 6 (Table 6.8). Individuals are shown in different colours. Crossbars show 95% confidence intervals assuming t-distribution.

ICI of the first 5 clicks. Models for the initial ICI had the largest adjusted R-squares in the set (61-76%). The mean initial ICI appeared normally distributed, with a mean of 1.12 s, minimum of 0.73 and maximum of 1.65 s.

Water depth at fluke location was the most important covariate for the initial clicks in all three models (p<0.001, Table 6.8 a). A 0.12 second increase was predicted for every 100 metre increase in fluking depth (Figure 6.15, 6.16a). Also slope was retained in the vessel and full model with good evidence that it explained the response data (Wald test p<0.03, Table X). A much smaller effect on initial ICI was revealed (compared to that of water depth) with about 0.1-0.2 second increase between flat and steep sea bottom at fluking (Figure 16 b, d). In the null model, sea bottom aspect was retained instead of slope (Table 6.8 a).

There was strong support for month and individual in the ww-vessel and full models (Wald tests p < 0.001, Table 6.8 a). Initial ICI was predicted to be slightly longer in winter (May/August) than in spring (Sept-Nov); however, such increase was not obvious in the raw data (Fix 6.15 c). The relationship was estimated as being linear due to lack of data for summer months of December-January, and only a few data points for February. These predictions should therefore be interpreted with caution. There was no evidence for vessel effects (p>0.3, Table 6.8 b, Table 6.9, Figure 6.15).

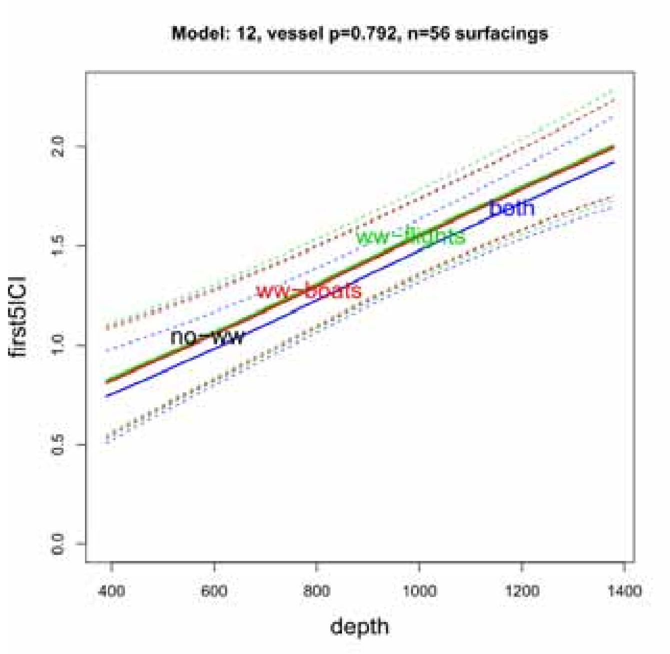

Figure 6.15. Predicted mean ICI (s) after encounters with different whale-watching vessels as a function of depth (m), given mean values for all other covariates and individual factor fixed to its intercept under Model 12 (Table 6.8 a, Table 6.9). Dashed lines show 95% confidence intervals assuming t-distribution.

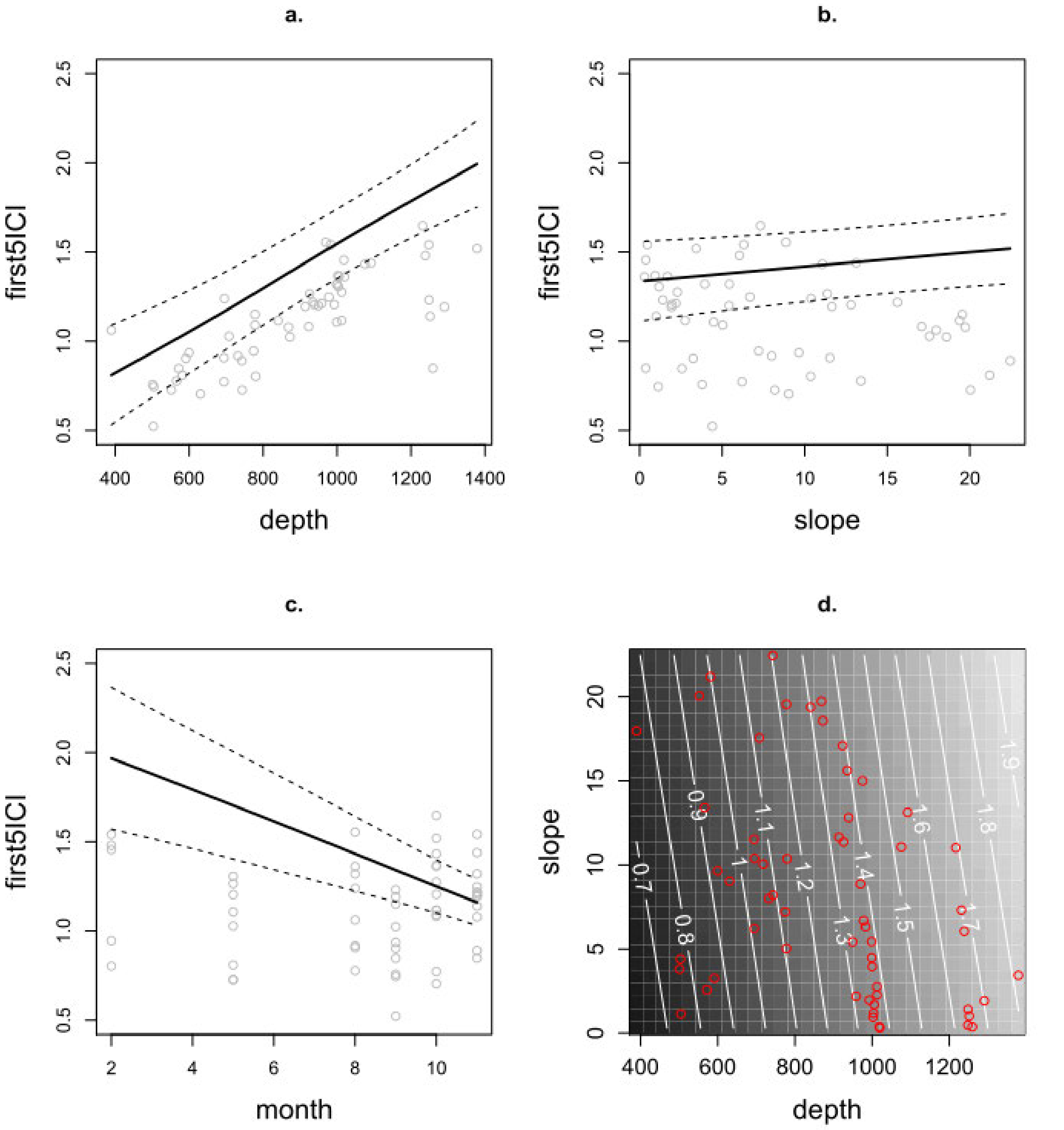

Figure 6.16. Predicted mean initial ICI as a function of depth (a), slope (b) and month (c) given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means (mean depth 885 m) under Model 15. Dashed lines show 95% confidence interval assuming t-distribution. In plot (d), predicted mean initial ICI is given as a function of both depth and slope with all other covariate values fixed. Grey and red circles show data.

ICI at the end of the first bout of clicks. The full model explained much more of the response data than the vessel and the null model (adjusted R square 57.32, 18.15 and 16.91%, respectively, Table 6.7). This is probably due to the model attempting to over-fit in small data set where there is little actual signal. Indeed, the predicted relationships for fluking depth, heading change and surface duration appeared implausibly complicated in the full model (Figure 6.17 a.), with the greatest changes predicted at the edges of the data. These predictions are therefore unreliable. Similarly the impact of vessel presence cannot be interpreted in the full model. There was little support for vessel presence in the ww-vessel model (p=0.165, Table 6.8 b).

Aspect was retained in all three models (Table 6.8 a). In all three models, the mean ICI at the end of the first bout was predicted to decrease with positive aspect (e.g., Figure 6.17 b); however, the prediction intervals may be artificially narrow in the full model due to the over-fitting of data by the other covariates.

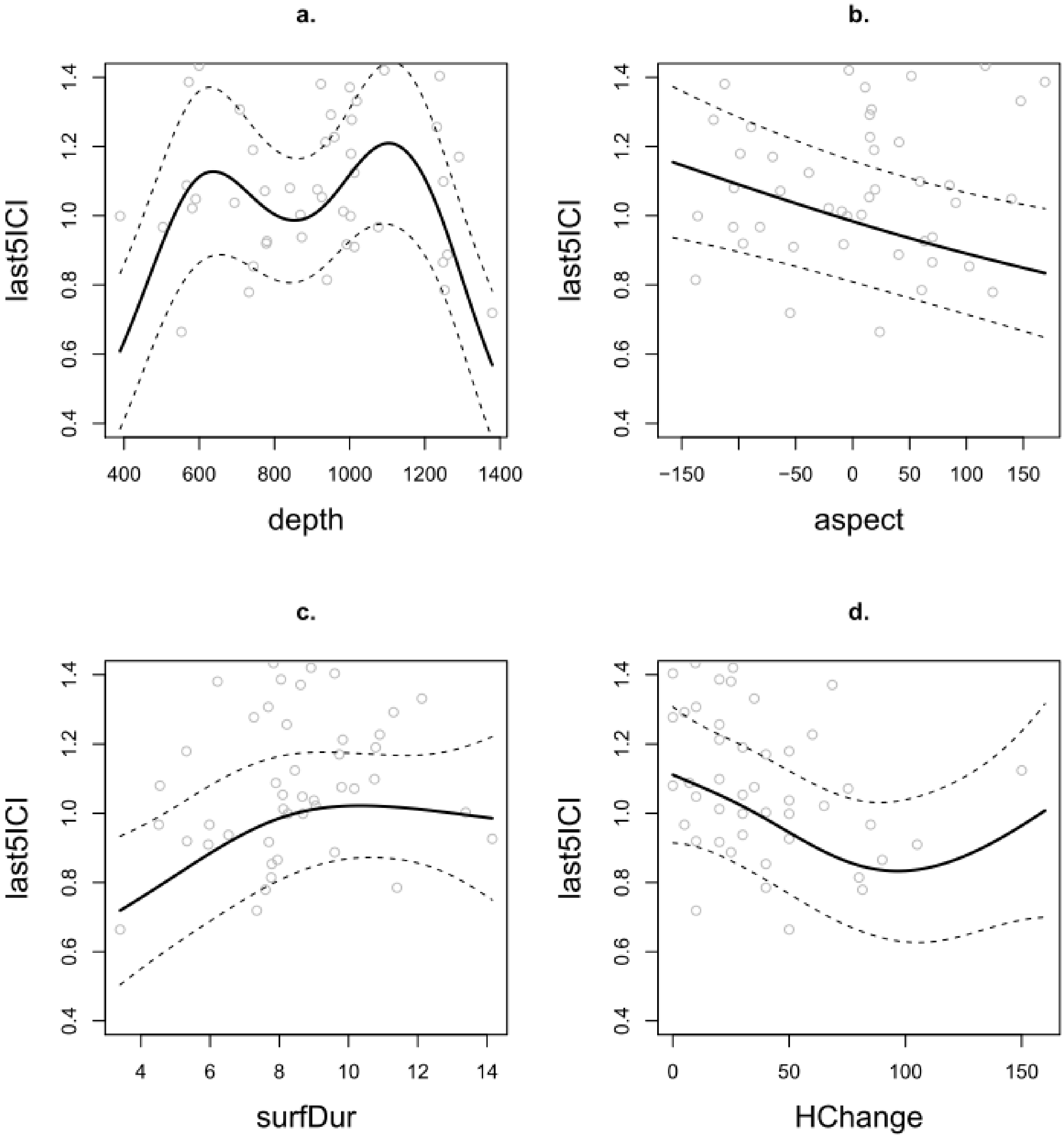

Figure 6.17. Predicted mean ICI at the end of the first bout as a function of fluking depth (a), sea bottom aspect at fluking (b), surface duration (c) and heading change (d), given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means (mean depth 885 m) under Model 15. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

Change in ICI in the initial bout. The full model for change in ICI did not converge with any distribution or link function that we explored. In the null and vessel model, there was strong support for water depth at fluking, but no other covariate ($p < 0.001$, Wald tests in Table 6.8 a). Change in ICI was predicted positive in shallower, and negative in deeper waters (Figure 6.18).

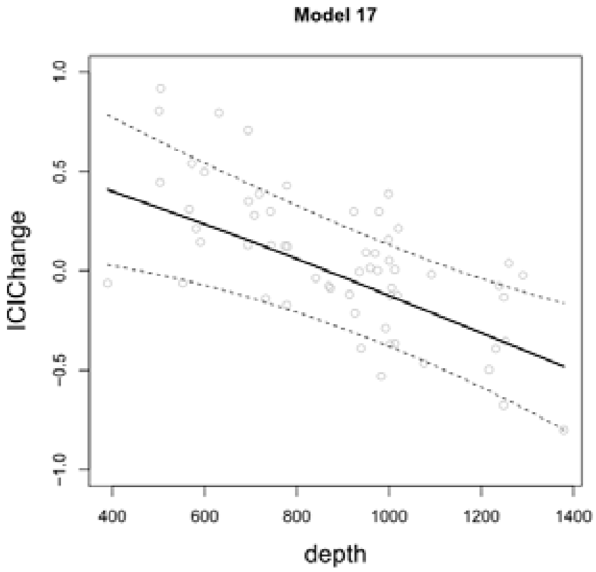

Figure 6.18. Predicted change in ICI during the first bout as a function of fluking depth, given no whale-watching vessels, individual fixed to its intercept and all other covariates fixed to their means under ww-vessel Model 17. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

Models describing creaks

Time to first creak. The sample size used to fit the model was small (n=25), and the model explained only 13.68 % of the data (R-sq, Table 6.7). Sea bottom aspect at fluking position and number of encountered boats were retained in the model with weak support for aspect (p=0.208) and good support for number of boats (p=0.030, Wald tests, Model 18 in Table 6.8). Time to first creak appeared to decrease with number of boats. However, confidence intervals were too large and the model explained too little of the variation for reliable prediction.

Creak activity. Only sea bottom aspect was retained in the model, explaining 18.46% of the variation in the data (n=30, Model 19, Tables 1, 2 a). The model fitted considerably smaller and narrower range of values than what was observed (5.53-11.51 and 0-20.9 creaks per hour, respectively). According to the model, creak activity (-h) increased with positive sea bottom aspect (Figure 6.19).

Creak rate. Only sea bottom aspect explained enough variability in the response data to be included in the full model, but it was not retained further by shrinkage. We therefore found no covariates that explained creak rate.

Proportion of time spent creaking. Depth and individual explained 45.04% of the data and fitted values matched well with the observed proportions 0-0.62 (Table 6.7). Only depth appeared to capture significant amount of the response data (p=0.043, Table 6.8a). For prediction, we retained individual in the model. Proportion of time spent creaking appeared much higher in deeper waters, but confidence intervals were large and the fit appeared to be driven by few unusually high proportions at the deeper range of the data (Figure 6.20).

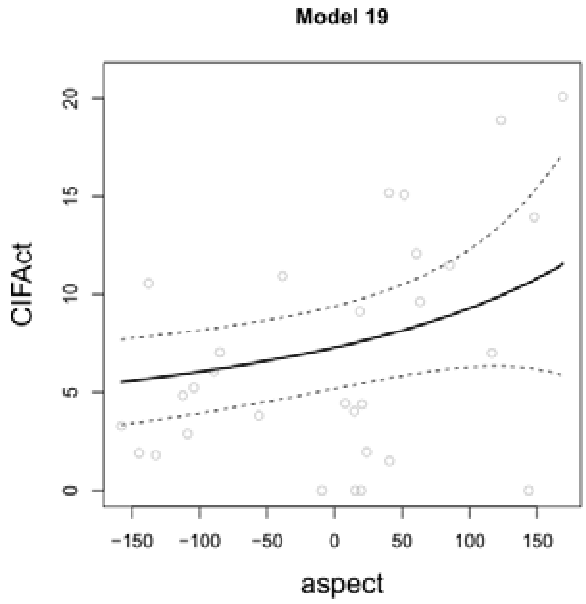

Figure 6.19. Predicted change in creak activity as a function of sea bottom aspect, given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means under Model 19. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

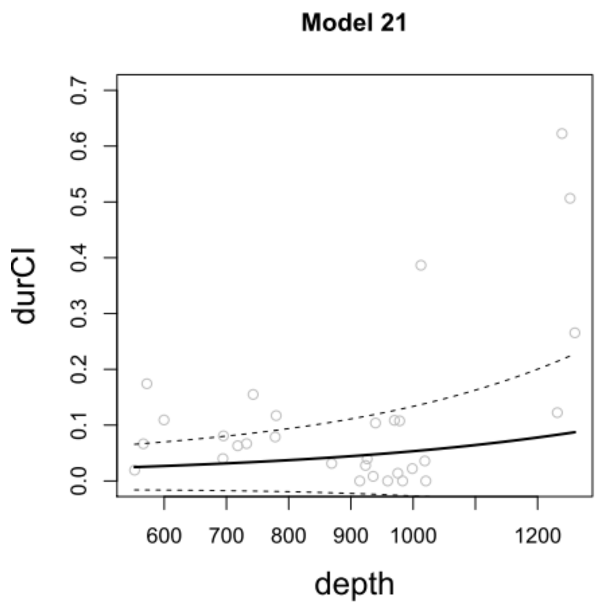

Figure 6.20. Predicted change in proportion of time spent creaking as a function of fluking depth, given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means under Model 21. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

Models describing search click intervals

Median ICI. The distribution of median ICI appeared normal with a mean of 1.04, minimum of 0.61 and maximum of 1.53 s (n=38). The fitted values of the model matched almost exactly the observed range, explaining 85.57% (R-squared, Table 6.7) of the data. This is probably due to the ability of individual (p<0.001) to capture the variability.

Month, heading change and vessel presence were also included in the model with good support for month (p=0.024) and weaker support for presence of vessels (p=0.089) and heading change (p=0.119, Table 6.8 a,b).

Median ICI was predicted to increase by 0.1 seconds from April to October, given mean values for all other covariates and no vessels present. The relationship was predicted linear as there was no data for December-January. Presence of vessels was predicted to increase median ICI by another 0.12 seconds, averaging across individuals and vessel factors (Figure 6.21).

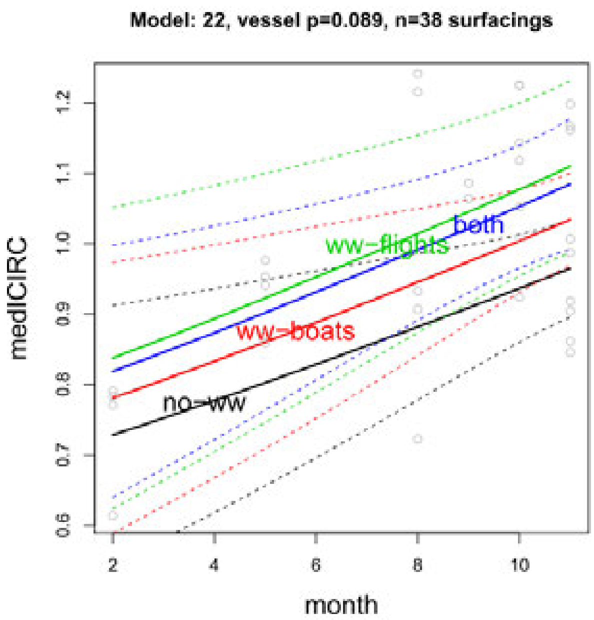

Figure 6.21. Predicted median ICI (s) after encounters with different whale-watching vessels as a function of month, given mean values for all other covariates and individual factor fixed to its intercept under Model 22 (Table 6.8 a). Dashed lines show 95% confidence intervals assuming t-distribution. Grey circles show data.

Proportion of clicks in the median ICI. 51% of the proportions were less than 0.2, with a maximum of 0.6 (n=41). The model fit well to the data, with the range of fitted values matching the observed range of 0-0.6.

Fluking depth, sea bottom aspect, surface duration, blow rate and individual were retained in the model, explaining 45.15% of the data (R-squared, Table 6.7). Depth, aspect and individual were the most significant explanatory variables (p<0.001, Table 6.8 b), but there was also good support for surface duration and blow rate (p=0.006 and p=0.018, Wald tests, Table 6.8 a).

Nearly linear relationships were estimated for each of the covariate, with proportion of clicks in the median ICI increasing with deeper fluking depths, longer surface durations and higher blow rates; the proportion was predicted to decrease with positive sea bottom aspect (Figure 6.23 b).

Proportion of time spent silent. The only covariate retained in the model was sea bottom slope at fluking, with strong evidence that it explained variability in the data (p<0.001, Table 6.8 a). Proportion of time spent silent was predicted to increase when fluking at steeper slopes (Figure 6.22).

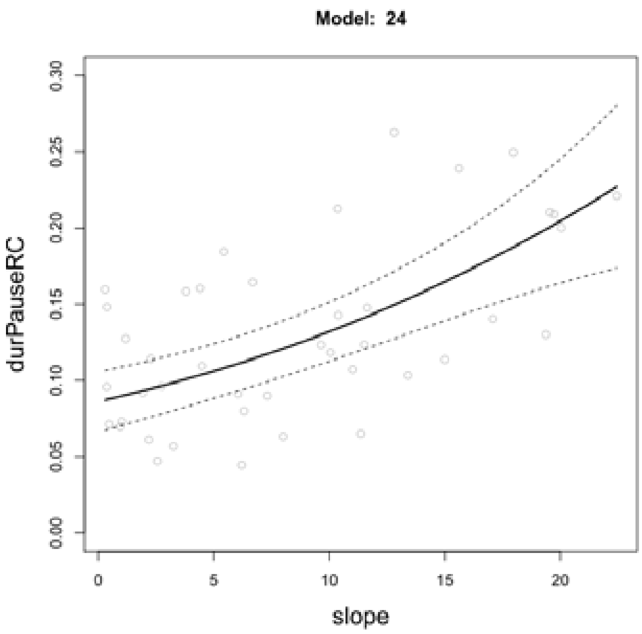

Figure 6.22. Predicted proportion of time spent silent as a function of sea bottom slope at fluking, given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means under Model 24. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

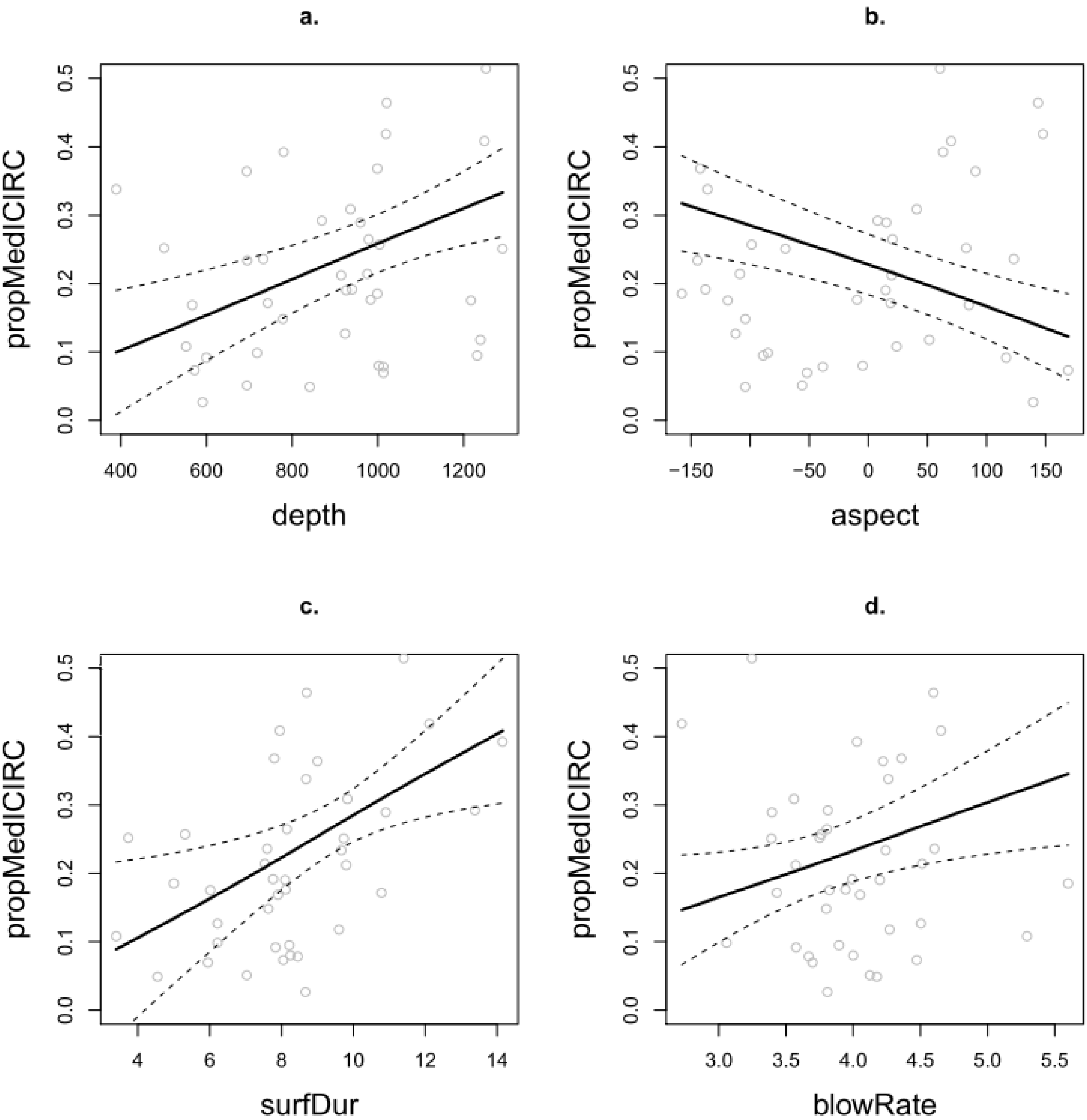

Figure 6.23. Predicted proportion of clicks in median ICI as a function fluking depth (a), sea bottom aspect (b), surface duration (c) and blow rate (d) given no whale-watching vessels in the previous surfacing, individual fixed to its intercept and all other covariates fixed to their means under Model 23. Dashed lines show 95% confidence interval assuming t-distribution. Grey circles show data.

DISCUSSION

By analysing acoustic behaviour we hoped to be able to explore changes in subsurface behaviour of whales that are likely to be of biological significance, foraging success in particular. The challenge is to separate potential whale-watching effects from natural variability that is related to the measurement occasion: for example due to individual, environment, location, season and year. We first made pair-wise comparisons between dives for the same whale before and after they encountered whale-watching boats at the surface. These might be considered simple natural experiments. We used non-parametric statistical tests that do not assume any theoretical distribution for the parameters. However, the requirement for sequential encounters of the same individual both with and without whale-watching limited our sample size. To allow a greater proportion of the collected data to be included in the analyses, we also used an approach which modelled each of the acoustic parameters as a function of whale-watching and environmental variables, as well as the individual whales. The disadvantage of this approach was that not all acoustic parameters fit well to statistical distributions. The strengths and weakness of the two approaches are therefore somewhat complimentary.

Our ability to detect change was limited by high variability between individuals and follow occasions and the relatively small sample size. Acoustic parameters related to number of creaks were particularly variable, and because they occurred later in dives, could only be analysed for a small portion of the data (25-30 dives, Table 6.7). Full models describing creaks and search click intervals were only fit with covariates that could predict the response data in the absence of other covariates (Models 18-24, Table 6.7). In other words, because we were not able to fit all the explanatory covariates in the full model, we might have omitted some features of the environment that could have explained smaller (but significant) amount of the response data, once other variability was accounted for. This is a disadvantage of the type of flexible model fitting we used for which step-wise selection of covariates is not appropriate. For example, only aspect was retained in the model for creak activity (Model 19, Table 6.8). We can assume bathymetric aspect captured a significant amount of the variability in creak activity, but not that it was the only one of the covariates that would have explained the data. It is possible that for example that season would have captured a small amount of variability in creak activity once in a model with aspect. In contrast, for acoustic parameters describing the initial bout of clicks we can assume that the retained covariates were the only covariates capturing a significant amount of the data (Models 1-17, Table 6.8). Therefore we have more confidence in a negative ‘no whale-watching effect’ result for the initial bout of clicks (Models 1-17) than for parameters describing creaks or search click intervals (Models 18-24). There is little difference between the two sets of models for any positive result.

Not all model predictions were considered reliable. Models for the ICI at the end of the first bout of clicks appeared to be over-flexible with respect to the small sample size (Models 13-15 in Table 6.7). This is a likely consequence of an over-flexible model fixing individual levels so that any residual variability can be fitted with the non-linear explanatory covariates. The predictions of the full model were implausibly complicated explaining nearly 60% of the data. However, a more positive bathymetric aspect was predicted to decrease the ICI in all three models. Given that the three models were fit to slightly different data sets, we have added confidence in this result.

Models for change in ICI during the initial bout did not converge well with any distribution, and although we could fit the null and ww-watching models (Models 16 and 17 in Table 6.7) with a Gaussian distribution, the full model did not converge. This indicates that the Gaussian distribution may not describe the distribution of ICI Changes very well, and we therefore interpret this model with caution.

Any differences found between different seasons should be interpreted with caution. There were no data for December-January, and the models predicted nearly linear relationships between months (2-11) and the response variables, which seems unrealistic.

Due to the small sample size, we were restricted to investigating whale-watching effects on the dive immediately following the whale-watching encounter. The models were not informed about exposure to whale watching vessels on earlier dives. Similarly, the pair-wise tests only compared dives before and after encounters.

The detection of creaks can be uncertain when monitoring sperm whales remotely using a towed hydrophone. When we monitored creaks aurally, it was apparent that some portions of creak trains were inaudible. In some cases it seemed that we could hear the beginning and end of the creak train, but not creak clicks in between. The apparent silences are likely due to the whale changing the direction of the sound beam away from the hydrophone. Creak trains were typically preceded by faster regular clicks, but such faster regular clicks also lead to silences. This indicates that entire creak trains may have gone undetected. It is possible that features of the regular clicks could be used as an indicator of prey encounter rate, such as mean and variance of click rate.

Impact of the research vessel

The research vessel ‘Titi’ gave priority to whale-watching boats to view whales during surfacings, but approached the whale from behind within the code of conduct to better collect surface data and photo-identification. Unlike whale-watching boats, we attempted to track individual whales at very low speed during diving, and this could potentially be disturbing to the whales. We have no data on the distance between Titi and the diving whale, but there was great variability in the estimated distance to the whale at surface: minimum distance ranged from 25 to 1000 metres in the analysed data. Ranges less than 100 metres were measured on a few occasions (4 surfacings in the analysed data) when the whale surfaced next to the research vessel or swam towards the stationary vessel.

The only relationship that we found between the acoustic parameters and the minimum distance between Titi and the whale during the previous encounter was a slight increase in the proportion of time spent in creak intervals with closer proximity to the whale at surface. This is likely due to variability in our ability to detect creaks, rather than a real increase in the terminal echolocation of the whale. Observations of whale heading at fluke up and the fluking location were used to determine the initial course of the research vessel when tracking a diving whale. These estimates were likely to be less reliable at greater observation distance. The whale's relative location was monitored with the towed and directional hydrophones, but it is possible that when the initial heading estimate was poor, we spent more time further away from the diving whale. Coupled with the directionality of the creaks, this could have degraded our ability to detect them.

Overall, our results indicate that there were no obvious changes in the acoustic behaviour related to the research vessel's proximity to the whale at surface. However, we were not able to fit minimum distance in the full models and therefore cannot rule out smaller effects. We therefore assume the impact of the research vessel was a small and relatively constant effect during all encounters.

Acoustic behaviour in the environment

Most of the analysed data was collected within the Kaikoura Canyon and the northern part of Conway Trough. The Kaikoura Canyon is 60 km long and u-shaped in profile, joining Conway Trough at the head of the canyon only some 500 metres from shore (Lewis and Barnes, 1999). The proximity of the canyon to land and the substantial sediment input may contribute to the Kaikoura Canyon being one of the most productive benthic habitats described so far in the deep sea (De Leo *et al.* 2010). The canyon sediments are mostly mud, with the major gravel-sand-silt turbidity currents originating in the head of the canyon near Kahutara and Kowhai rivers (Lewis and Barnes 1999). Kaikoura Canyon also benefits from the subtropical convergence zone and nearly year-round upwelling of nutrient-rich waters. In winter, coastal upwelling of warm water is caused by mixing of river inputs and subtropical waters intruding into the canyon from southward flowing East Cape current (Houtman 1965). In summer, upwelling of cold water occurs when the north-flowing Southland Current converges with the more saline subtropical East Cape current against the continental shelf (Garner 1961, Heath 1971).

The oceanographic features of the Kaikoura Canyon and the surrounding waters parallel those used to describe sperm whale foraging habitat around the world's continental slopes and ridges: high bottom relief (e.g., Jaquet and Whitehead 1996, Hooker and Whitehead 1999, Pirotta *et al.* 2011), coastal upwelling of cold nutrient rich waters (Rendell *et al.* 2004), thermal fronts (Griffin 1999) and high primary productivity (Jaquet and Whitehead 1996). These features are thought to result in concentrations of sperm whales' prey, mainly meso- and bathypelagic cephalopods, fish being more important regionally (Clarke 1996, Whitehead 2003).

We found that bathymetric features - depth, slope and aspect - were important in shaping the acoustic foraging behaviour of sperm whales in Kaikoura. Bathymetric features were retained in all full models related to the first bout of clicks, creak activity, proportion of time spent in creak intervals, proportion of clicks in median inter-click-interval (ICI) and proportion of time spent silent (Table 6.7, Table 6.8 a).

The echolocation behaviour in the beginning of the dive was related to the depth of the sea bottom. The mean ICI of the first five clicks was shown to increase by 0.12 s with every 100 m increase in water depth at the fluking location. Echolocators often click soon after they receive the echo of their target or the most distant large reflector (Au 1993). With sperm whales, one can often hear the animal click soon after the arrival of the main bottom echo. A change in water depth of 100m would increase the travel distance for a click's echo by 200m. If we assume speed of sound of 1520 m/s, the travel time would increase by 0.13 s per 100m, very similar to the 0.12s observed. Similarly, the initial ICI was close to the two-way travel time of sound to the bottom or slightly above depending on the individual and season. As slope steepness increased, there was a small increase in ICI. This could be explained if greater bottom depths were within the beam of ensonification than the depicted depth at that location (180x180m grid cell bathymetric resolution). ICI should be determined by the delay for echoes from the most distant substantial target within the beam, not the closest. Mean initial ICI was a median of 0.03 seconds shorter than expected by the two-way travel time. These results suggest that in the beginning of the dive, the whales listened to the returning echoes near the bottom before emitting another click. Jaquet *et al.* (2001) had also found a correlation between fluking depth and the ICI of the first 10 clicks in Kaikoura, suggesting that the first clicks function to detect the sea bottom.

Similarly, we found the first pause was slightly delayed in deeper waters. It has been suggested that pauses occur when air is recycled for sound production (e.g., Madsen *et al.* 2002 b). The duration of the first bout, before the first pause, was predicted by the model to increase by about 7 seconds (or by 7-14 metres assuming a descent rate of 1-2m/s; Gordon 1987), for every 100 metre increase in sea bottom depth, given mean values for all other covariates (Figure 6.12 a). This could result from a faster descent rate, whereby increased compression of air might allow for clicking longer before recycling the air.

Clicks were more regular (higher proportion of clicks near median ICI) after longer surface durations, higher blow rates and in dives that started in deeper waters. Together with the delayed onset of the first silence, these results indicate that the whales undertook a different foraging strategy, possibly attempting to localise a deeper prey layer in deeper waters. The importance of longer surface duration and higher blow rate suggest that these dives are associated with an increased need to recover oxygen stores. Little evidence has been found for an increased need for recovery after longer or deeper dives (Watkins *et al.* 2002, Drouot *et al.* 2004, Watwood *et al.* 2006, Davis *et al.* 2007). This could be due to little correlation between dive duration and energy consumption, or that the studied whales did not routinely reach their aerobic dive limits. However, Jaquet (2001) found a weak but statistically significant correlation between dive duration and both the preceding and following surface duration in Kaikoura. In the same study, the correlation matched with a seasonal pattern: whales stayed longer at surface (+0.5 min) and made longer dives (+5.3 min) in the summer than winter. This coincided with whales congregating within the canyon, in relatively deep waters (>1000 m) during summers in 1990-1994. Similarly, Richter *et al.* (2003) documented longer surface durations during summer, but unlike Jaquet *et al.* (2001), preference for the deepest part of the canyon in autumn and winter in 1994-2001. Unfortunately, we had little data to detect seasonal changes in acoustic behaviour.

We found some indication that the initial ICI was longer in February-May and shorter in September-October (Figure 6.16 c) than expected based on depth and slope alone. Similarly to Jaquet (2001) and Richter *et al.* (2003), we hypothesise that there are seasonal changes in distribution and selection of prey that drive the observed changes in foraging strategy. Sperm whales are found in Kaikoura year-round and are likely to exploit a range of available prey species. Sperm whales have been described as a generalist feeder (Whitehead 2003). For example, Clarke (1996) found that sperm whales take advantage of aggregations of terminally spawning cephalopods. In Kaikoura, there are also reports of occasional surface feeding by the whale-watching operators.

Regular clicks are typically faster before terminal echolocation (a creak, e.g., Jaquet *et al.* 2001). More irregular usual clicking may therefore co-vary with creak rates. In our data, we found that slopes facing west (positive aspect) were associated with both irregular clicking and higher creak activity (Figures 6.19, 6.23 a, 6.24). Similarly, the mean ICI at the end of the first bout was shorter when fluking over a sea bottom with a west facing slopes. These results indicate that the whales were detecting more prey at the coast-facing slope of Conway trough and south-west facing slope of the Kaikoura Canyon. This is likely related to the local water flow conditions at the shelf slope rather than the orientation of the slope itself. The dominant current in the study area is the Southland current flowing northwards through the Conway Trough, branching offshore south of the Kaikoura Peninsula (Heath 1971). West and south-west facing slopes therefore orientate nearly parallel to the current. The south-west facing slope of the Kaikoura coincides with the major route of sand-gravel-silt turbidity current flowing offshore from the head of the canyon (Lewis and Barnes 1999) and the summer congregations of sperm whales described by Jaquet *et al.* (2000). Also Pirotta *et al.* (2011) found aspect to capture more variability in the sperm whale distribution data than slope, in contrast to other studies where steepness of the slope was deemed important (e.g., Praca and Gannier 2007). These apparently contradictory results may be explained by differential importance of flow conditions, as well as the limited range of each study area that may encompass only a few combinations of slope and current.

Slope explained 34.7% of the proportion of time spent silent, with up to a two-fold increase in silent time between flat and steep sea bottom (Table 6.7, Figure 6.22). This could be due to the whale spending more time listening passively to conspecifics or prey, especially if steep bottom relief altered sound paths to the whale.

We detected a much smaller number of creaks per dive (mean=4.17, sd=3.86, n=46 complete dives) than documented in the literature; for example Drouot et al (2004) detected an average 24.8 creaks per dive. However, comparisons of creak rates across studies should be interpreted with caution because different studies might define creaks differently. We defined a creak start and end with a 100 ms threshold on ICI, but considered creaks joining with other creaks with few slower creak clicks as one.

Time to first click was 8.28 seconds on average (sd=7.27), considerably shorter and more variable than previously reported at Kaikoura (31.9 seconds by Gordon *et al.* 1992 and 25 seconds by Jaquet *et al.* 2001). The first click was delayed by 1-2 seconds with more positive aspect. This may be a reflection of the different foraging tactics the whales employ along different parts of the canyon's slopes. The model predicted a decreased time to first click with increased heading changes at surface, possibly related to an increased need to update information on bathymetry. This is supported by our field observations, which showed that whales appeared to follow bathymetric contours up until a point where they would either turn back to follow the same contour line or cross other bathymetric features.

Acoustic behaviour and whale-watching

Duration of the first silence was the only acoustic parameter that showed significant and consistent differences with whale watching vessel presence in the non-parametric paired comparisons. The duration increased by a median of 2.53 seconds for dives made after being viewed by ww-boats, and decreased by a similar amount of 3.89 after a surfacing with no ww-boats. In the model for duration of first silence, however, all covariates failed to explain a significant amount of the data; bar weak support for depth (p=0.07, Table 6.8 a). The poor model fit could be explained by an inappropriate choice of distribution for the response; however, none of the tested distributions could find signal in the data and the residual distributions appeared good for the quasi model (Appendix 2). Another possibility is that the individual captured enough variability in the response for any other explanatory covariate to become unimportant in the model. Duration of first silence is also the parameter that showed the strongest association with vessels in Gordon *et al.* (1992). We tentatively suggest that some individuals may be silent for longer during this first pause when ww vessels are present because they are listening passively to the vessels above them, perhaps assessing the directions in which they are moving away.

Vessel presence was a significant predictor of time to first clicks, along with individual, aspect of the sea bottom and the whale's heading change at surface. Presence of whale-watching boats and flights appeared to increase time to first click, more significantly after accounting for the heading change. Similarly, Richter *et al.* (2003) found a 50% increase in time to first clicks, but only for transient animals; residents decreased their time to first click in the presence of whale-watching boats. It is possible that some whales delayed clicking until sufficiently far from any engine noise to start echolocation at ambient noise levels, or that they used this time to listen to the vessels moving off at surface.

Interestingly, Richter *et al.* (2003, 2006) also found greater and more frequent heading changes in the presence of whale-watching platforms. Greater heading changes decreased time to first click in our data, an opposite effect to the presence of whale-watching boats alone. If this reflected a need to click sooner after changing heading direction, possibly to update their orientation in relation to bathymetry, it could explain why the more habituated transient animals in Richter *et al.* (2003) study appeared to decrease their time to first click after encountering ww-platforms.

The duration of the first bout of clicks was predicted by the model to increase after encountering whale-watching boats, along with depth and higher blow rates (Models 5 and 6 in Table 6.8 b). However, the duration of first bout was highly variable across individuals and individual differences were predicted to be more than an order of magnitude greater than the average change after encountering whale-watching boats. The ww-vessel covariate remained important when accounting for blow rate, suggesting that whale-watching influenced the duration of the first bout directly, rather than as a consequence of any impact on blow rate. Previous studies have documented small decreases in mean blow interval with whale-watching vessel presence (Gordon *et al.* 1992, Richter *et al.* 2003, 2006). The authors have suggested a stress response. It is possible that some whales attempted to descend further before stopping for their first pause, perhaps to be further away from boat noise or perceived risk.

Note that higher blow rates increased the duration of the first bout, regardless of whale-watching. Higher blow rates and longer surface duration (but not ww-vessel presence) also predicted more regular clicking throughout the dive, which could mean lower prey encounter rate. These results could either indicate an effect of the research vessel (although see discussion above), or relate to a foraging tactic such as navigating across to a different foraging area while searching for prey opportunistically.

Time to first creak appeared to decrease with number of boats viewing the whale at surface. Along with aspect, however, the model explained a very small amount of the small sample (14% in the data of 25 surfacings), and confidence intervals were too large for prediction. Whale-watching vessel presence was not an important predictor of any other creak related variable.

Conclusions

We did not find any changes in parameters related to prey encounter rates that could be attributed to whale-watching; however, we were constrained by relatively small sample size. We were unable to reliably assess the impact of whale-watching flights on any of the acoustic parameters due to small sample size.

We did find changes to the initial echolocation behaviour after encountering whale-watching boats: whales delayed their first click and appeared to descend for longer before stopping for their first silence, which was also extended. However, the effects appeared small relative to high individual variability and were within the range of behaviours predicted by their spatiotemporal environment.

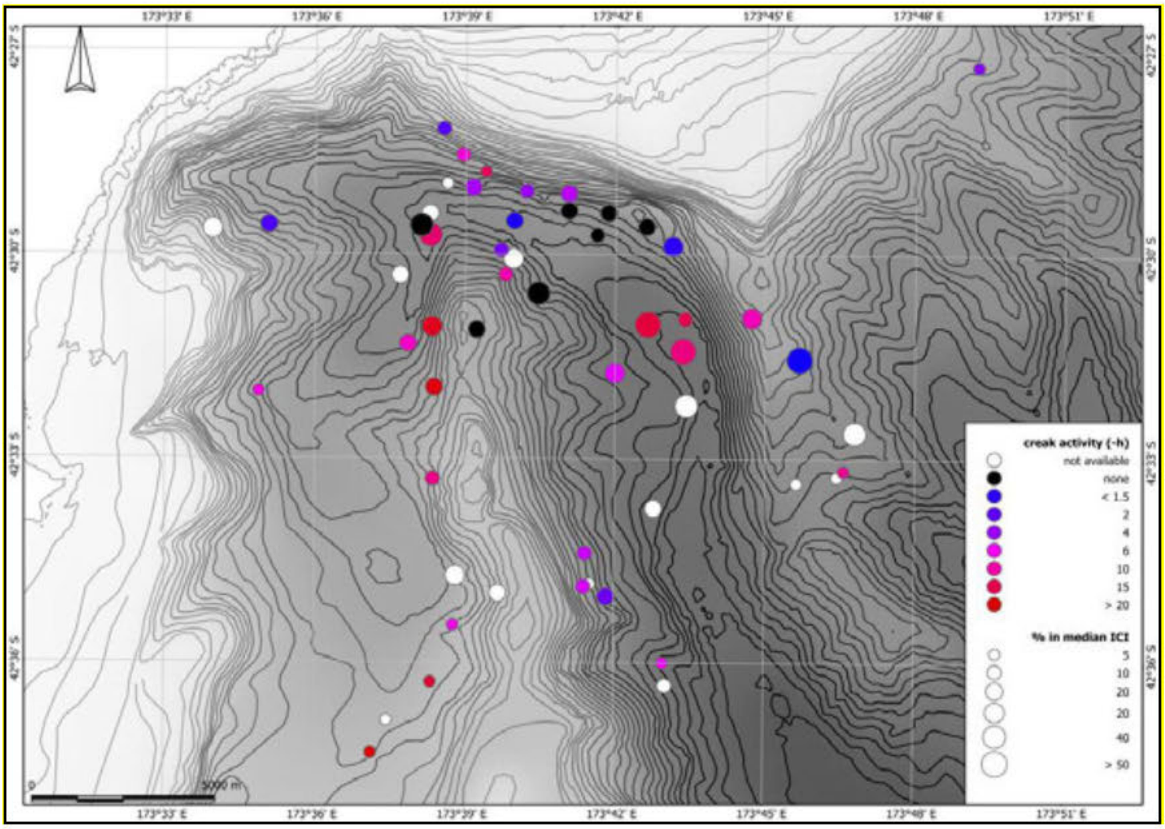

Figure 6.24. Distribution of data on creak activity (creaks per hour of analysed data) and proportion of clicks near the median ICI.

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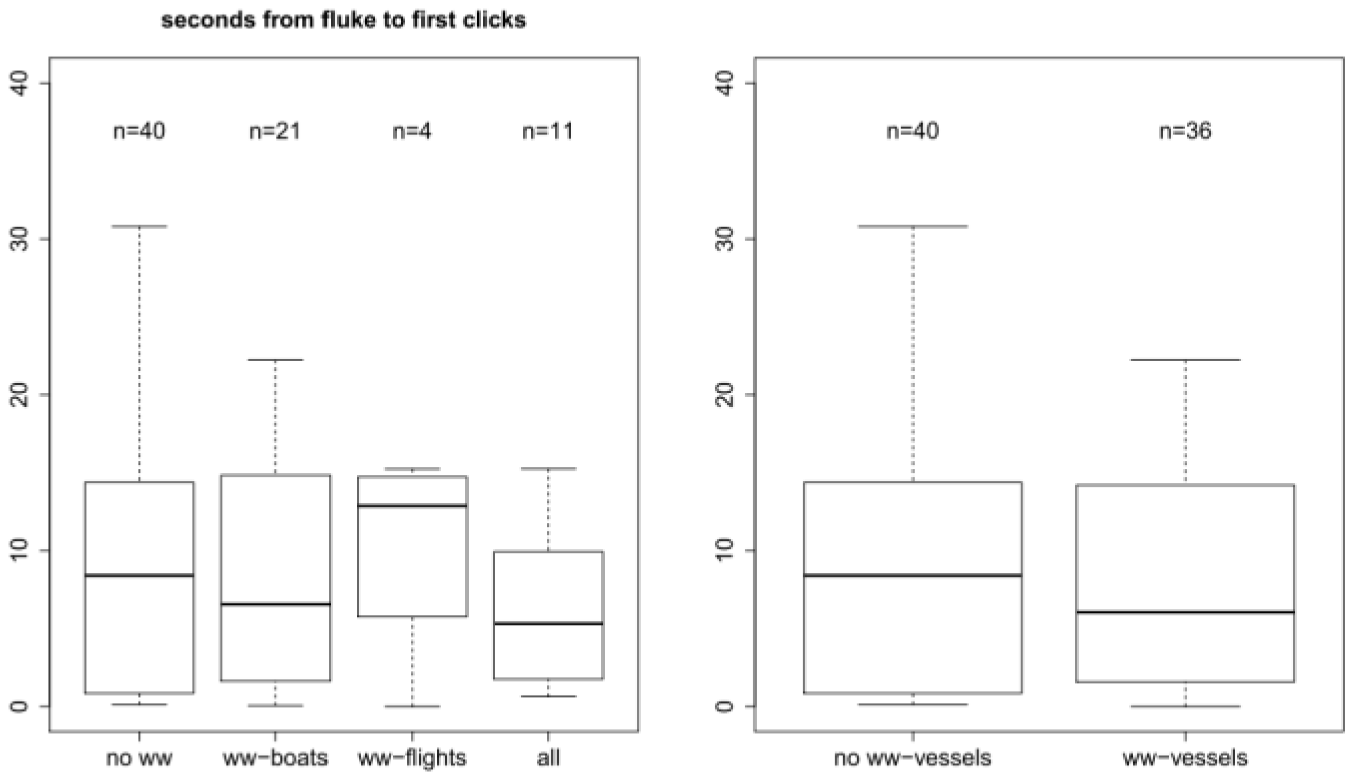
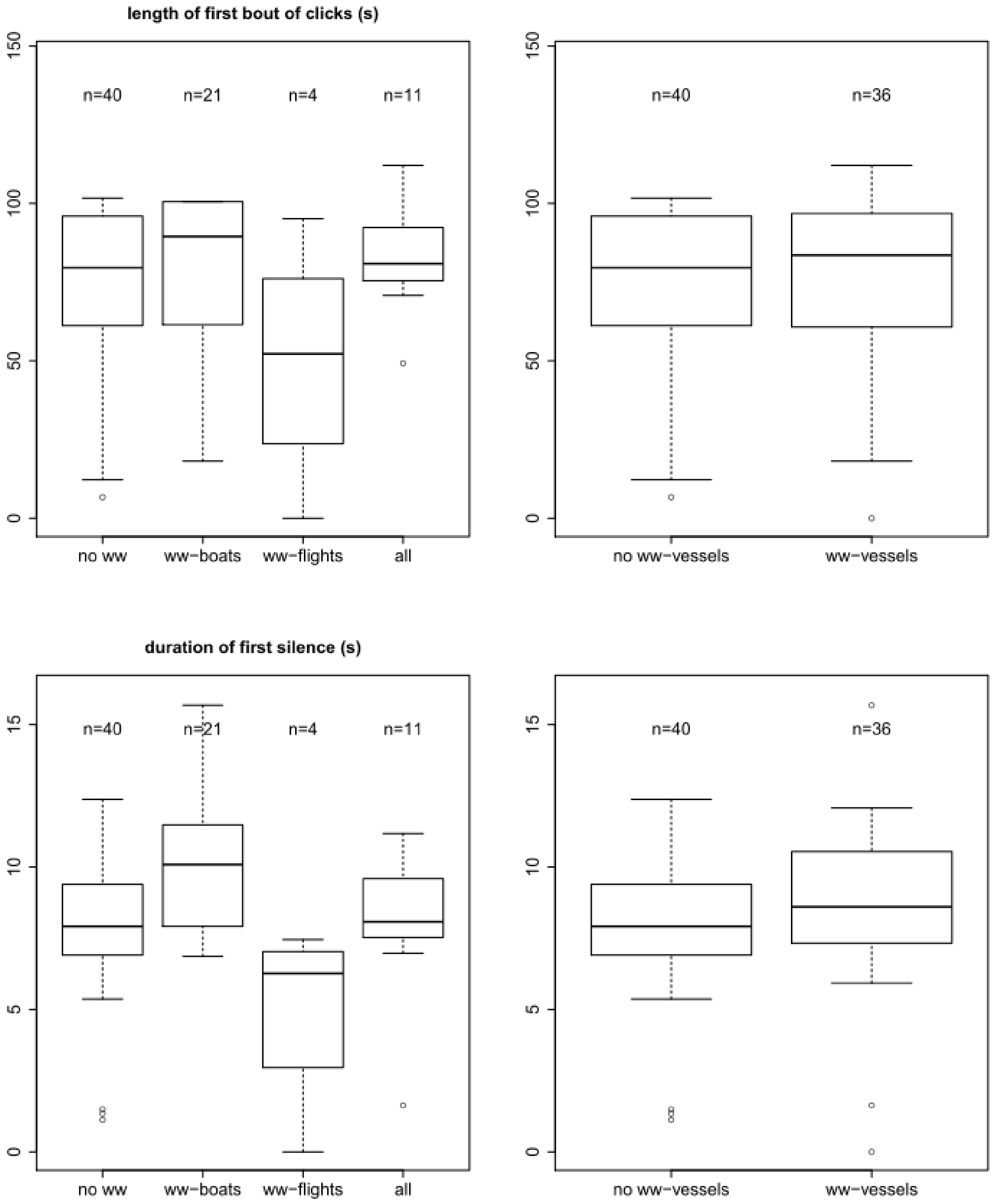
APPENDIX 1

ACOUSTIC PARAMETERS IN PRESENCE AND ABSENCE OF WHALE WATCHING

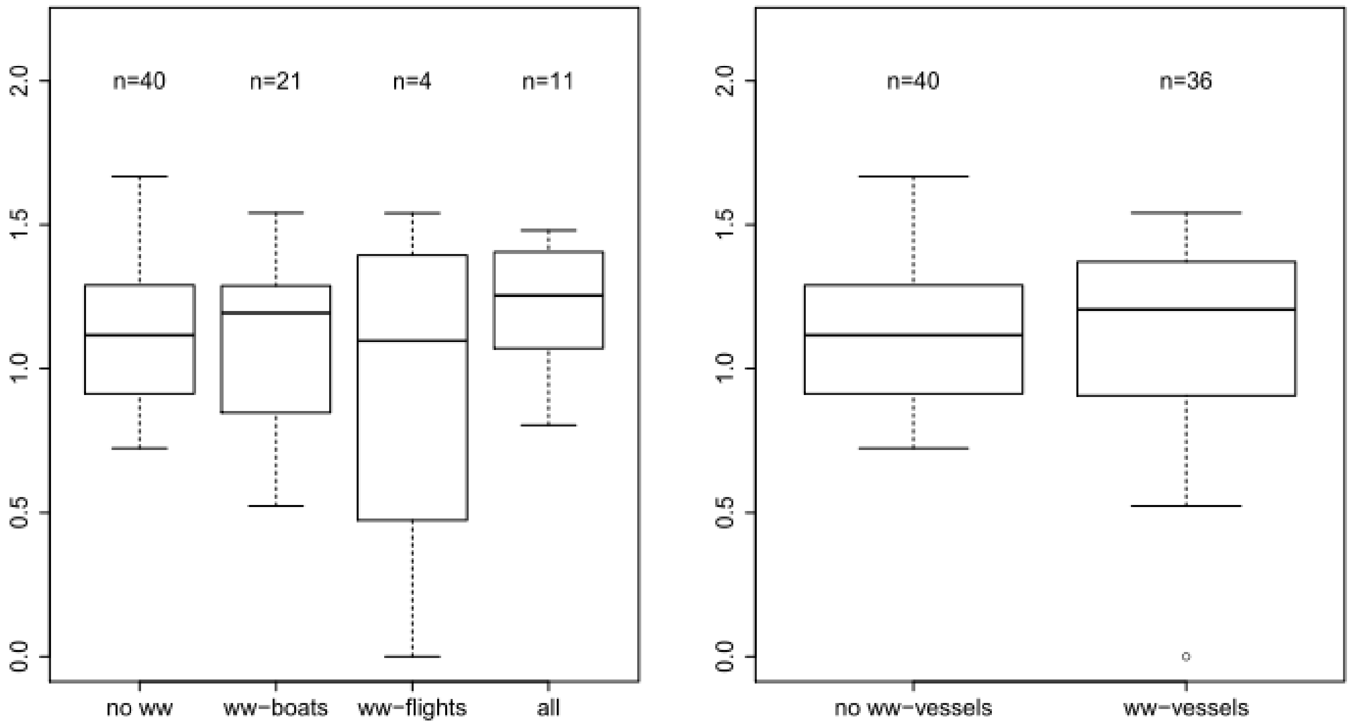
The following boxplots show all acoustic parameters grouped by presence of whale-watching vessels in the preceding surfacing: no whale-watching vessels (no ww), only whale-watching boats (ww-boats), only whale-watching helicopters or aeroplanes (ww-flights), and both ww-flights and ww-boats (all). Sample size (n) gives the number of surfacings. Data include dives that were not complete, but include at least first regular click train and the following pause.

In the boxplots, the boxes contain the 25 to 75 percentiles. The middle line shows the median and whiskers stretch 1.5 times the interquartile range. Circles denote values beyond 1.5 times the interquartile range.

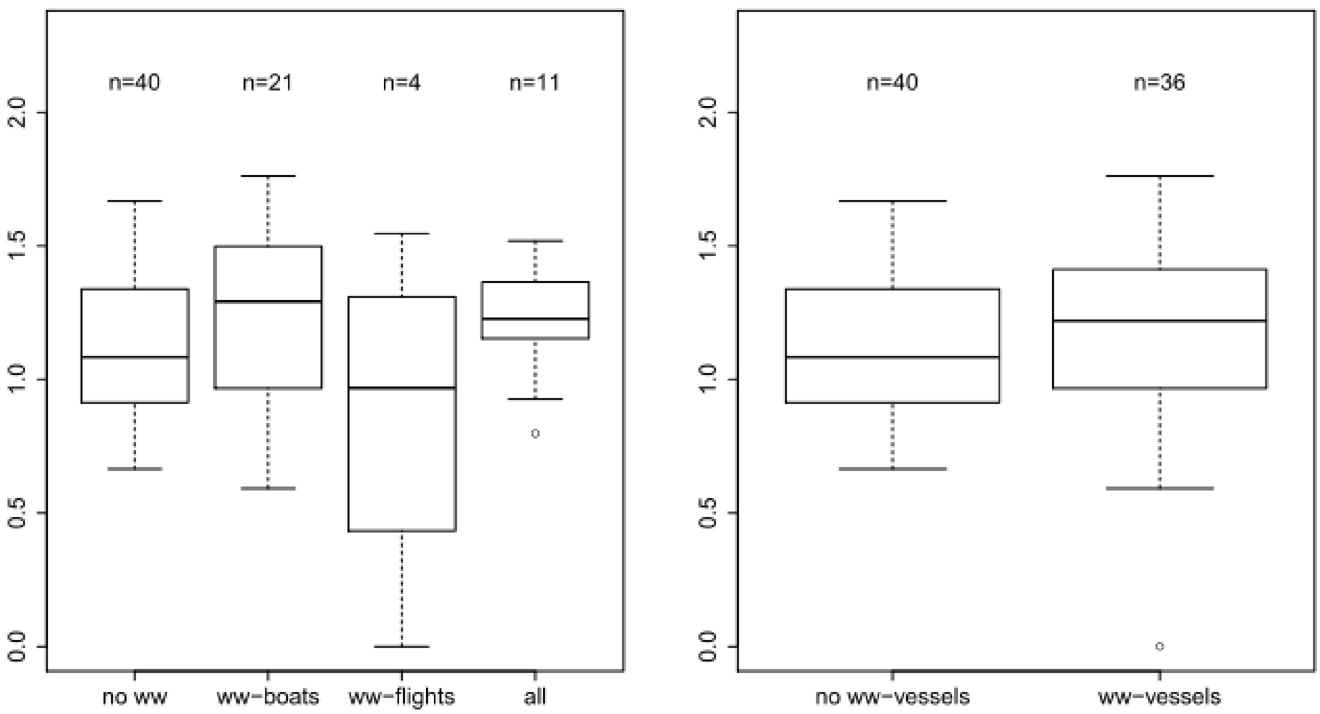



length of first bout of clicks (s)
n=40
n=21
n=4
n=11
n=36
no ww
ww−boats
ww−flights
all
no ww−vessels
ww−vessels
duration of first silence (s)
0
50
100
150
5
10
15

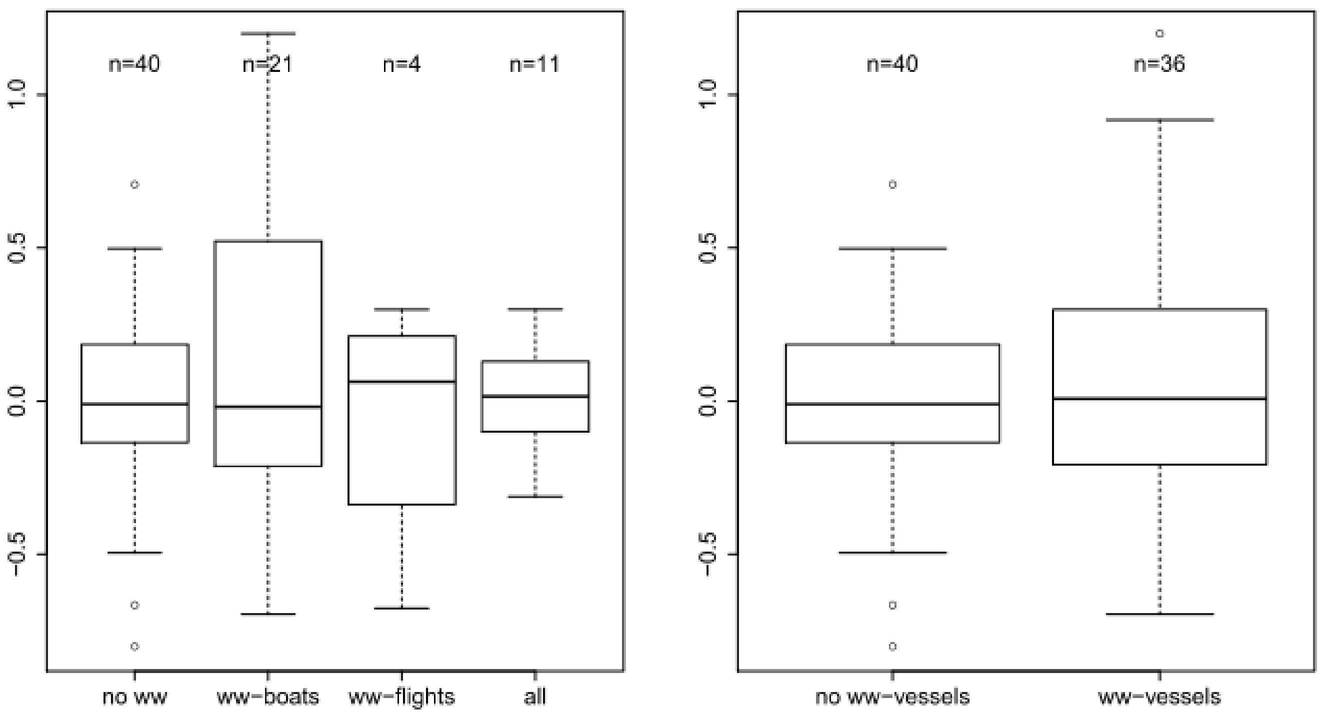
initial mean ICI (s)



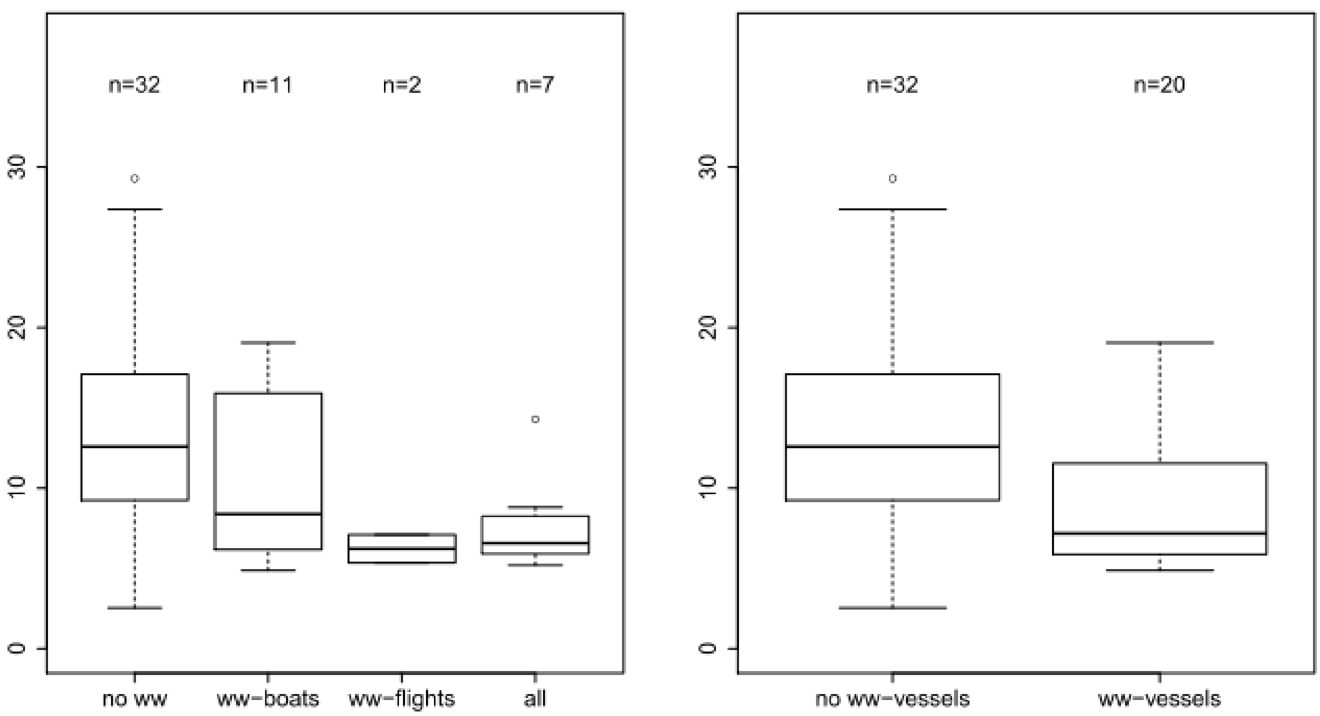
mean ICI at the end of first bout (s)

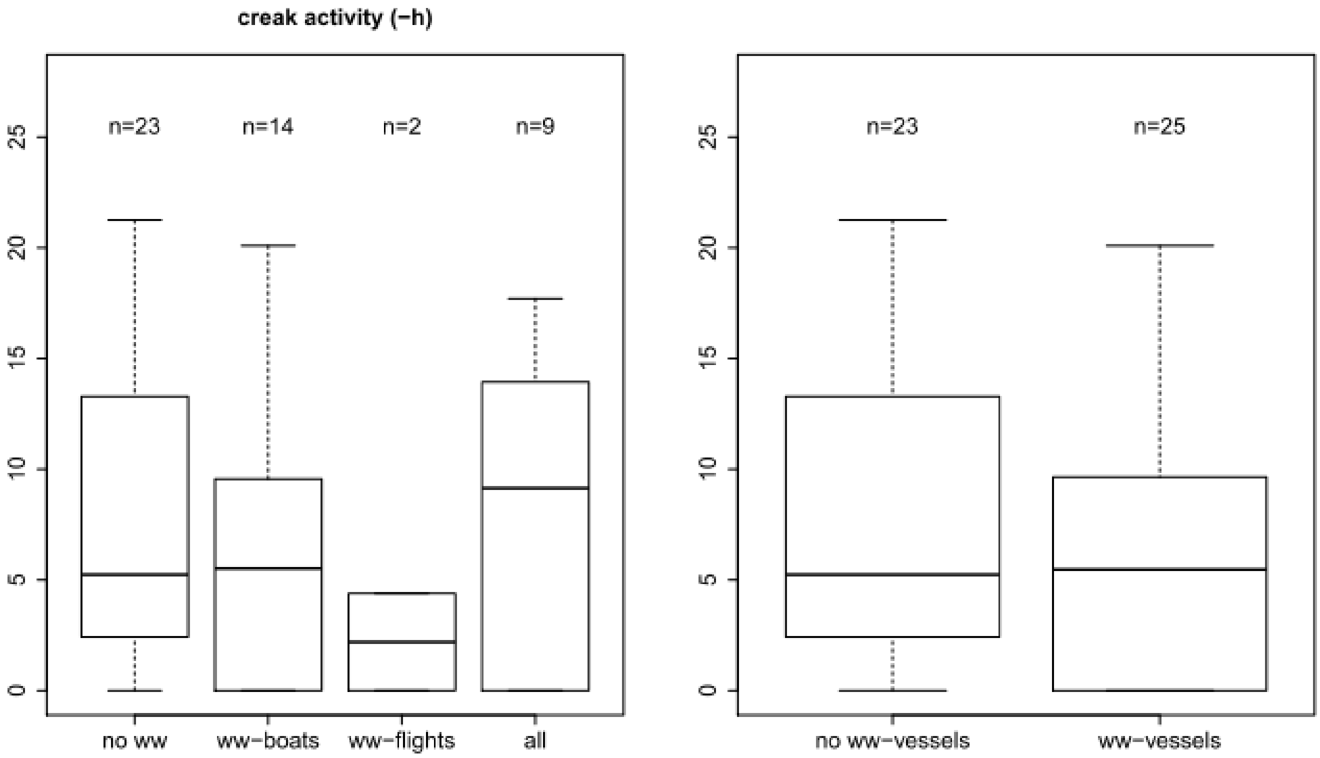


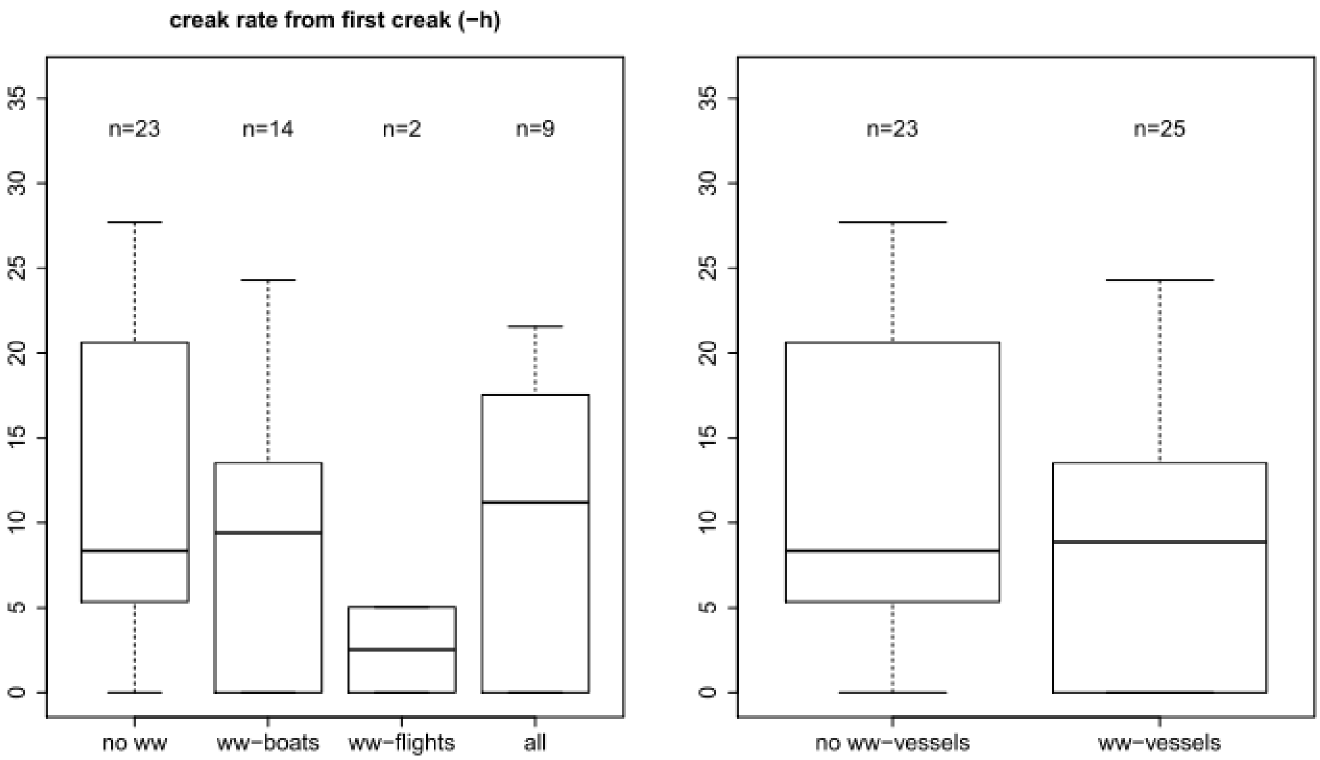
change in ICI during first bout (s)

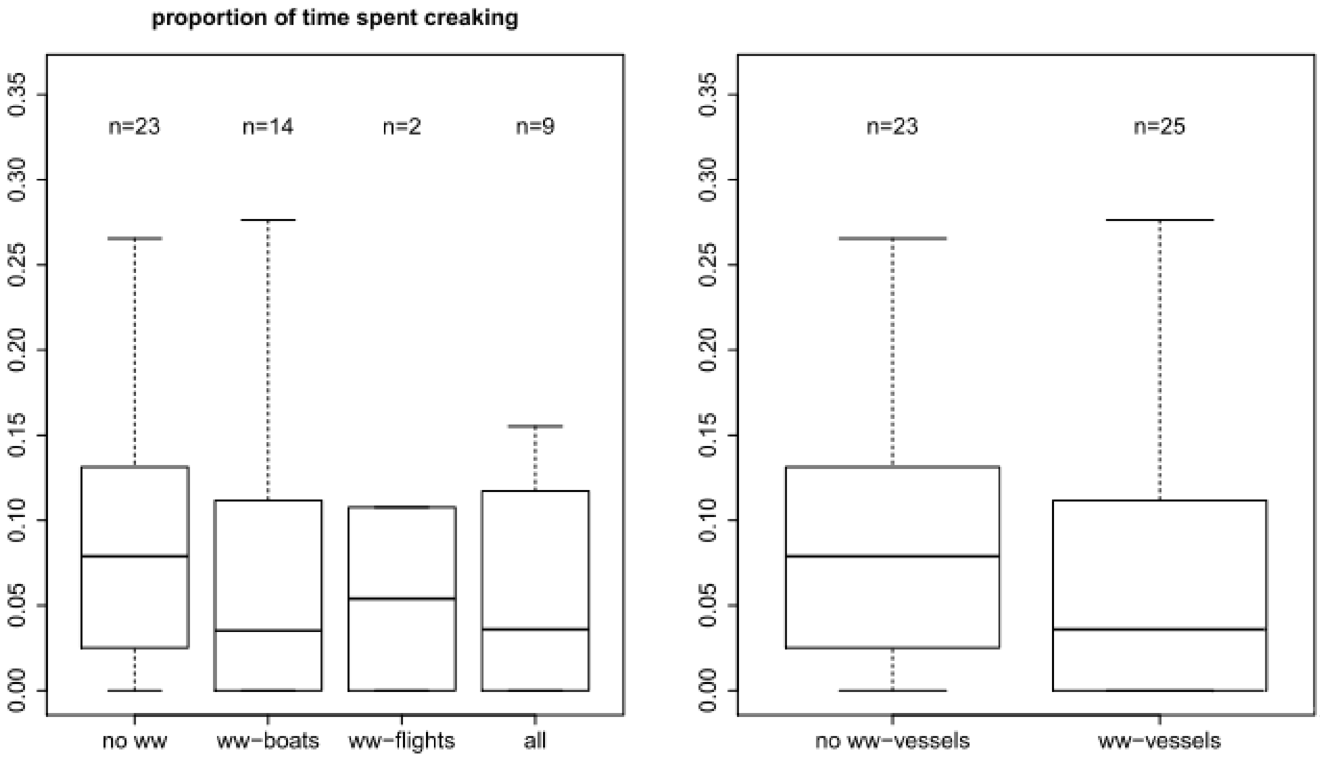


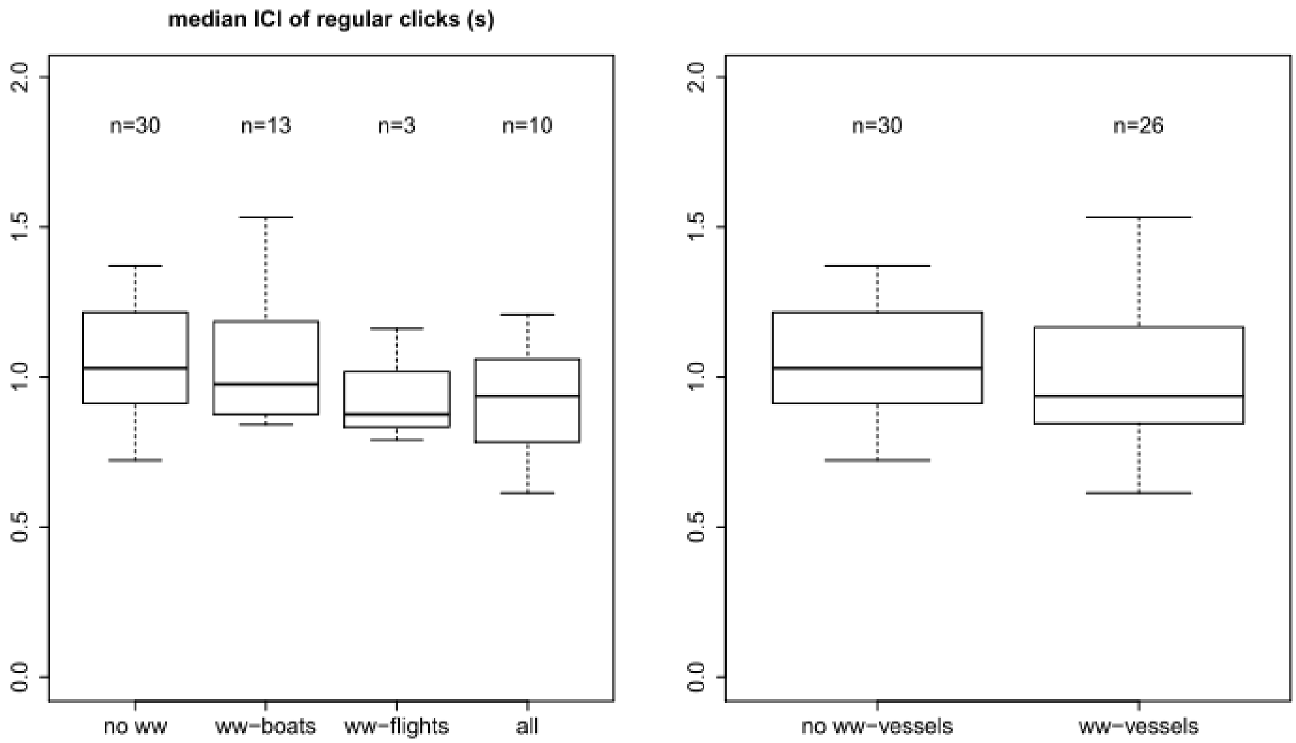
seconds from fluke to first creak (min)



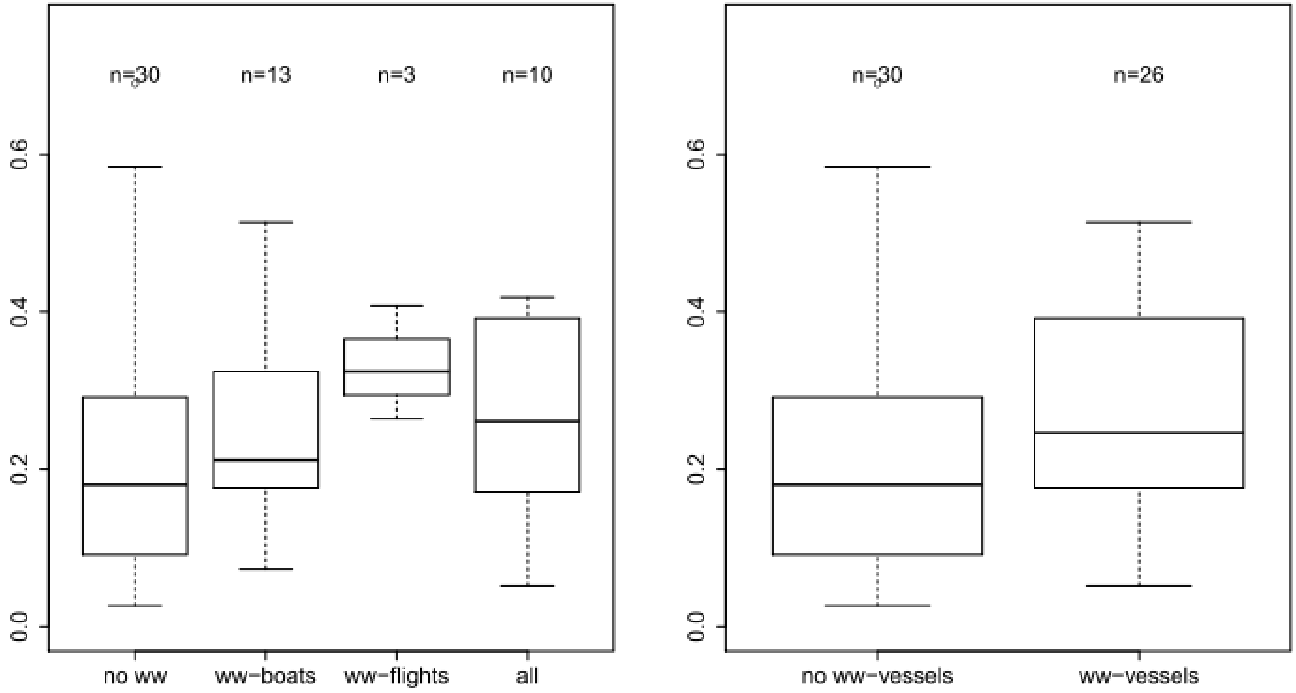

creak activity (−h)
n=23
n=14
n=2
n=9
n=23
n=25
0
5
10
15
20
25
no ww
ww−boats
ww−flights
all
no ww−vessels
ww−vessels


creak rate from first creak (−h)
n=23
n=14
n=2
n=9
n=23
n=25
0
5
10
15
20
25
30
35
no ww
ww−boats
ww−flights
all
no ww−vessels
ww−vessels

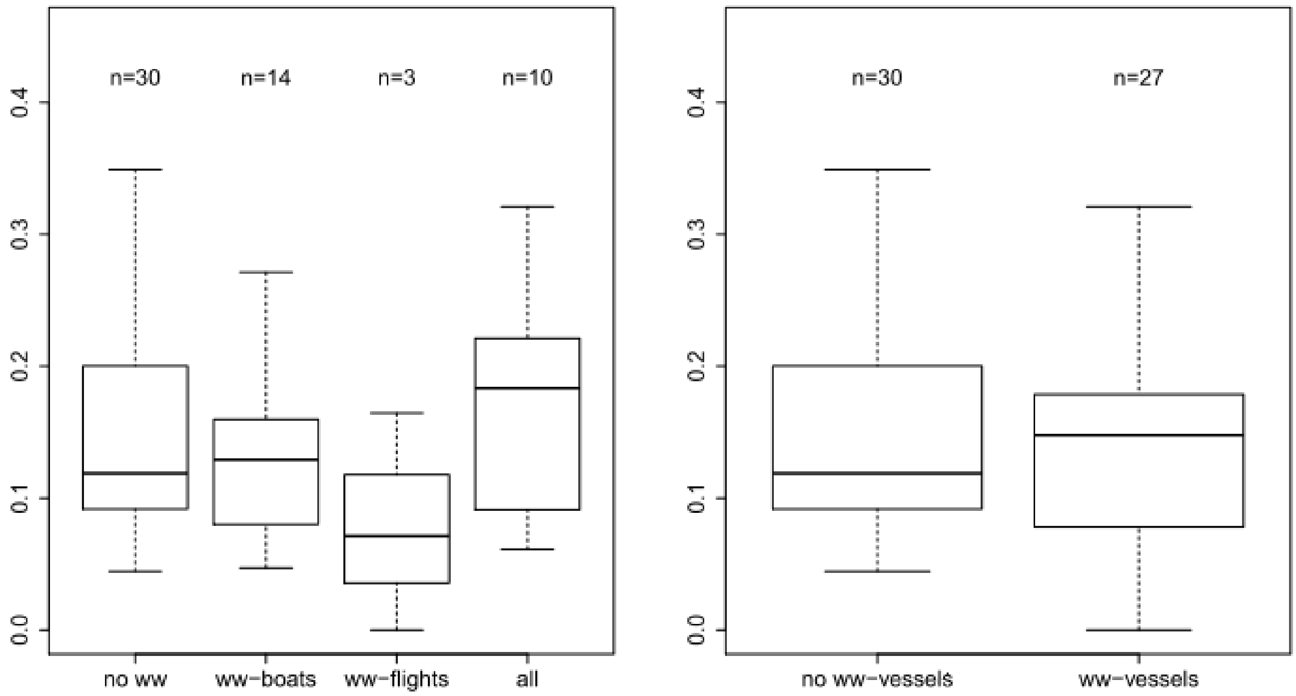

proportion of time spent creaking
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
n=23
n=14
n=2
n=9
no ww
ww-boats
ww-flights
all
n=23
n=25
no ww-vessels
ww-vessels


median ICI of regular clicks (s)
2.0
1.5
1.0
0.5
0.0
n=30
n=13
n=3
n=10
no ww
ww-boats
ww-flights
all
n=30
n=26
no ww-vessels
ww-vessels

proportion of clicks within 0.l seconds of median



proprtion of time spent silent



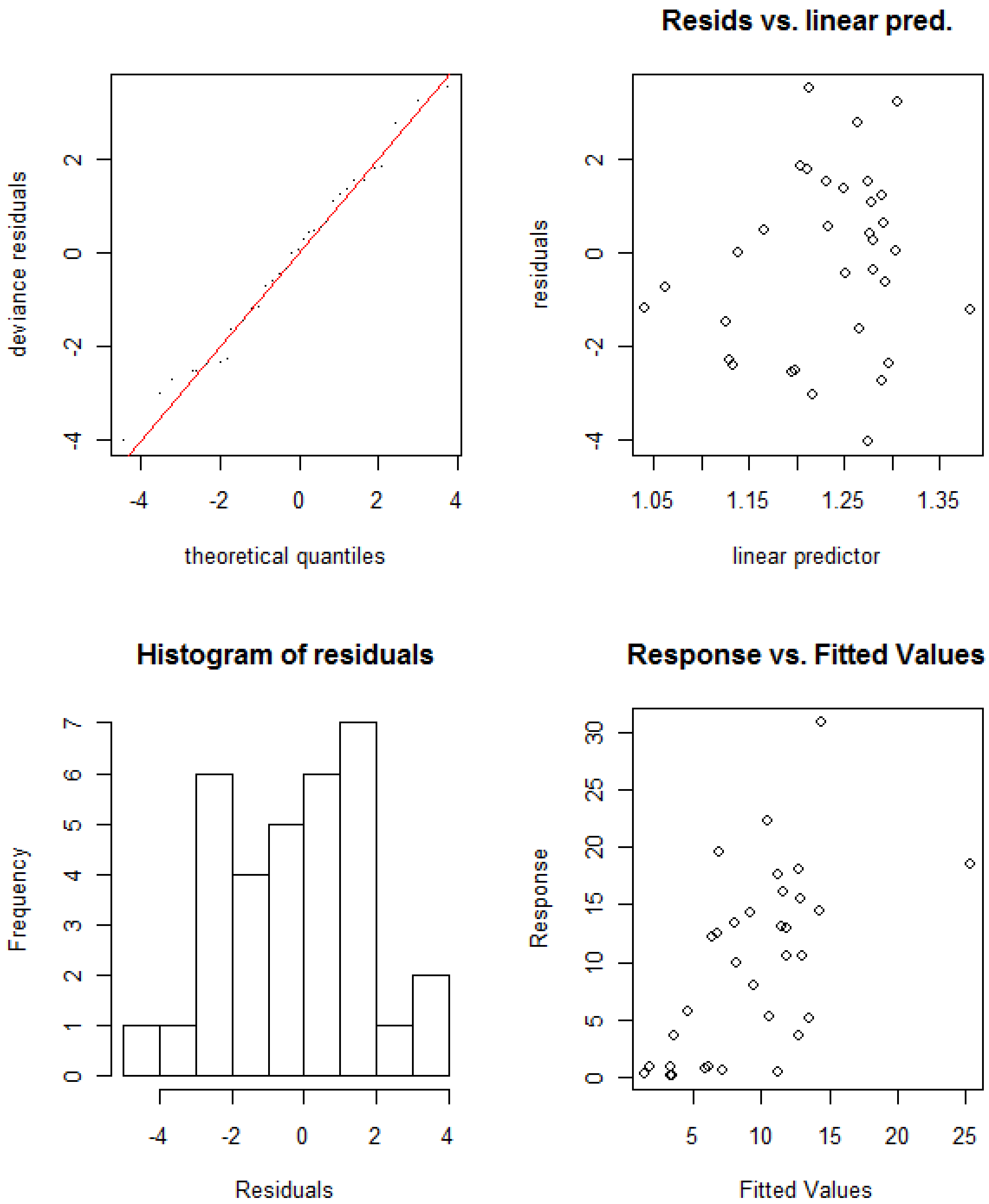
APPENDIX 2

MODEL RESIDUAL PLOTS

The following plots are:

1. Deviance residuals as a function of their theoretical quantiles (simulated from the assumed distribution, QQ-plot). Deviances from the 45 degree line indicate over- or underfitting.
2. Deviance residuals as a function of the linear predictor, i.e. response values transformed using the link function. These residuals should be spread evenly across the linear predictor, if not, the data may be under/over dispersed or influenced by an un-modelled factor in the data.
3. Histogram of deviance residuals. The distribution should have mass in the centre and balanced tails, if not, the model could be under- or overfitting.
4. Response values as a function of the predicted values. Describes model fit.

Captions give the model number in Table 6.7, name of the response variable, assumed distribution, link function, sample size and adjusted R-square as a percentage.



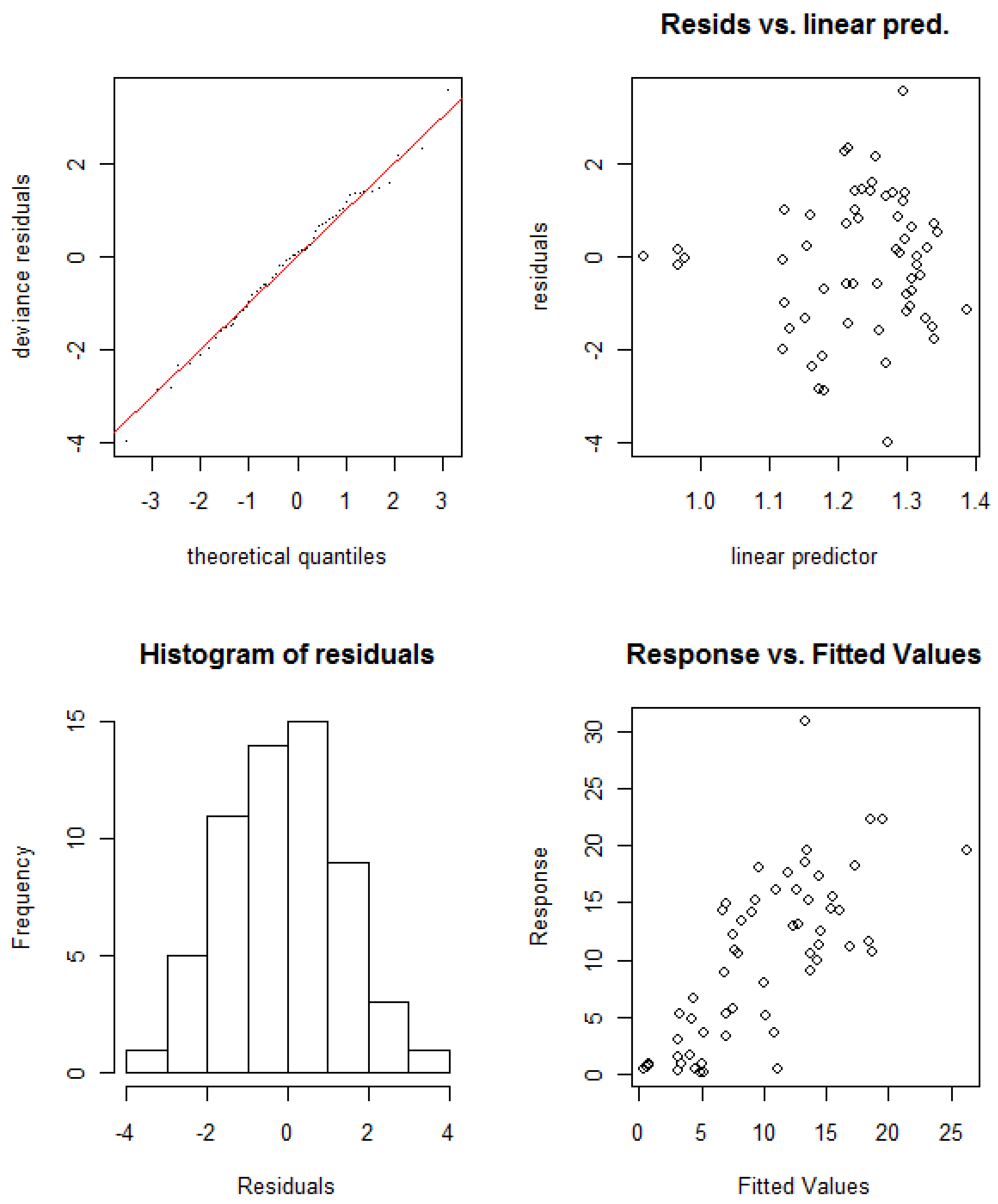
Model 1 Time to first click

Family Tweedie(1.1)

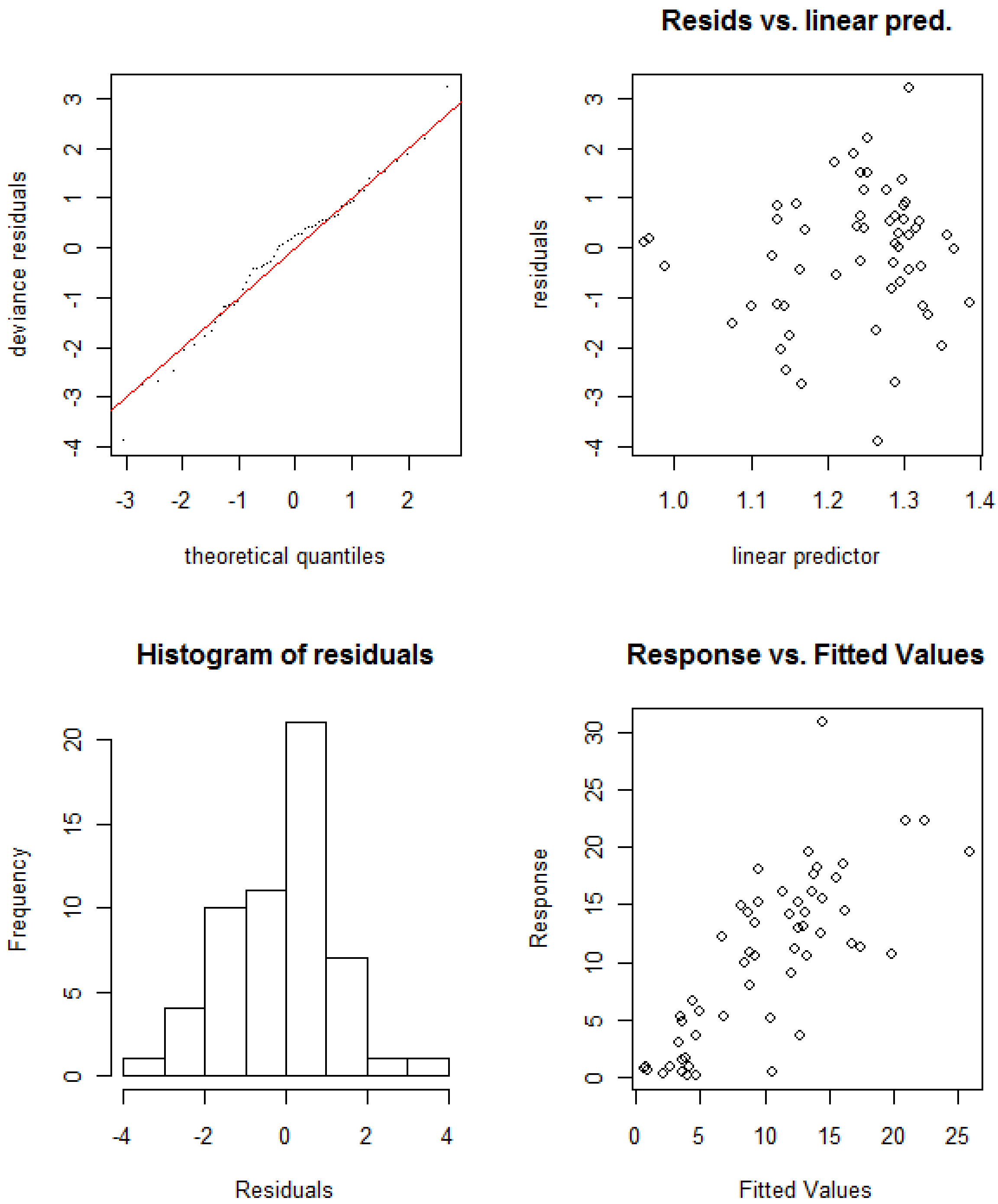
Link mu^0.1

N 33

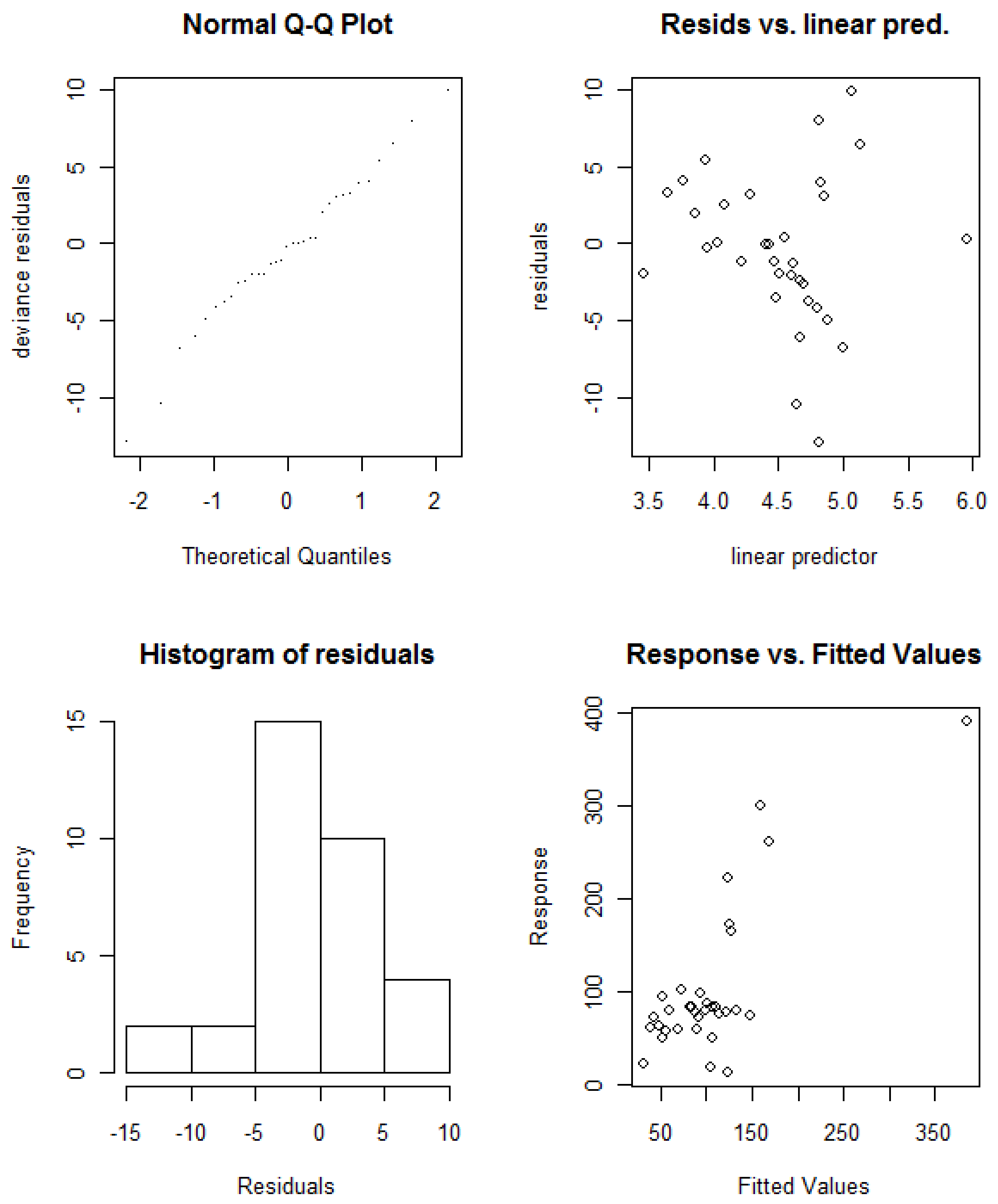
r-sq 26.98%



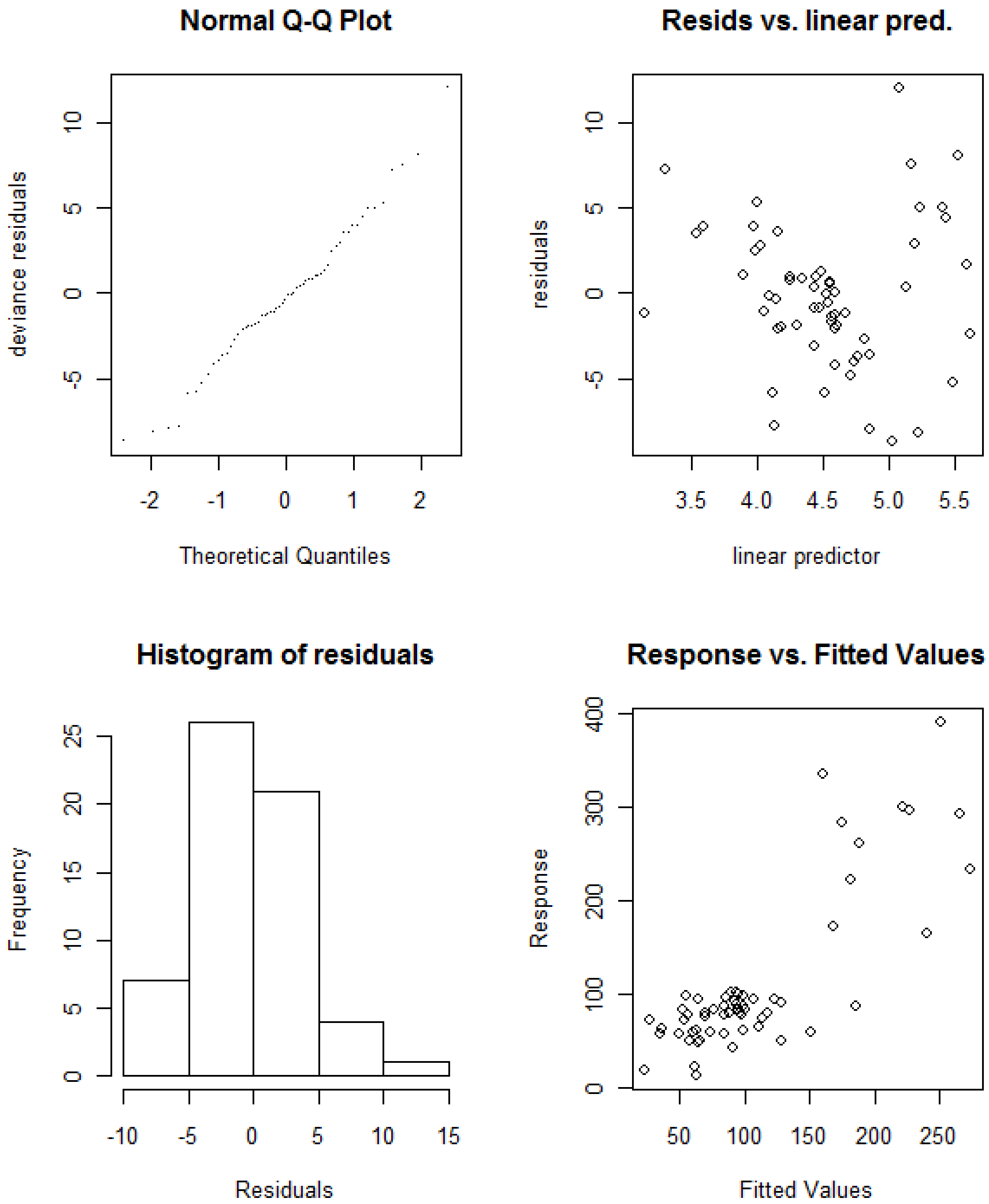
Model 2	***Time to first click***
Family	*Tweedie(1.1)*
Link	*mu^0.1*
N	*59*
R-sq	*37.12%*



Model 3	***Time to first click***
Family	*Tweedie(1.1)*
Link	*mu^0.1*
N	*56*
R-sq	*43.30%*

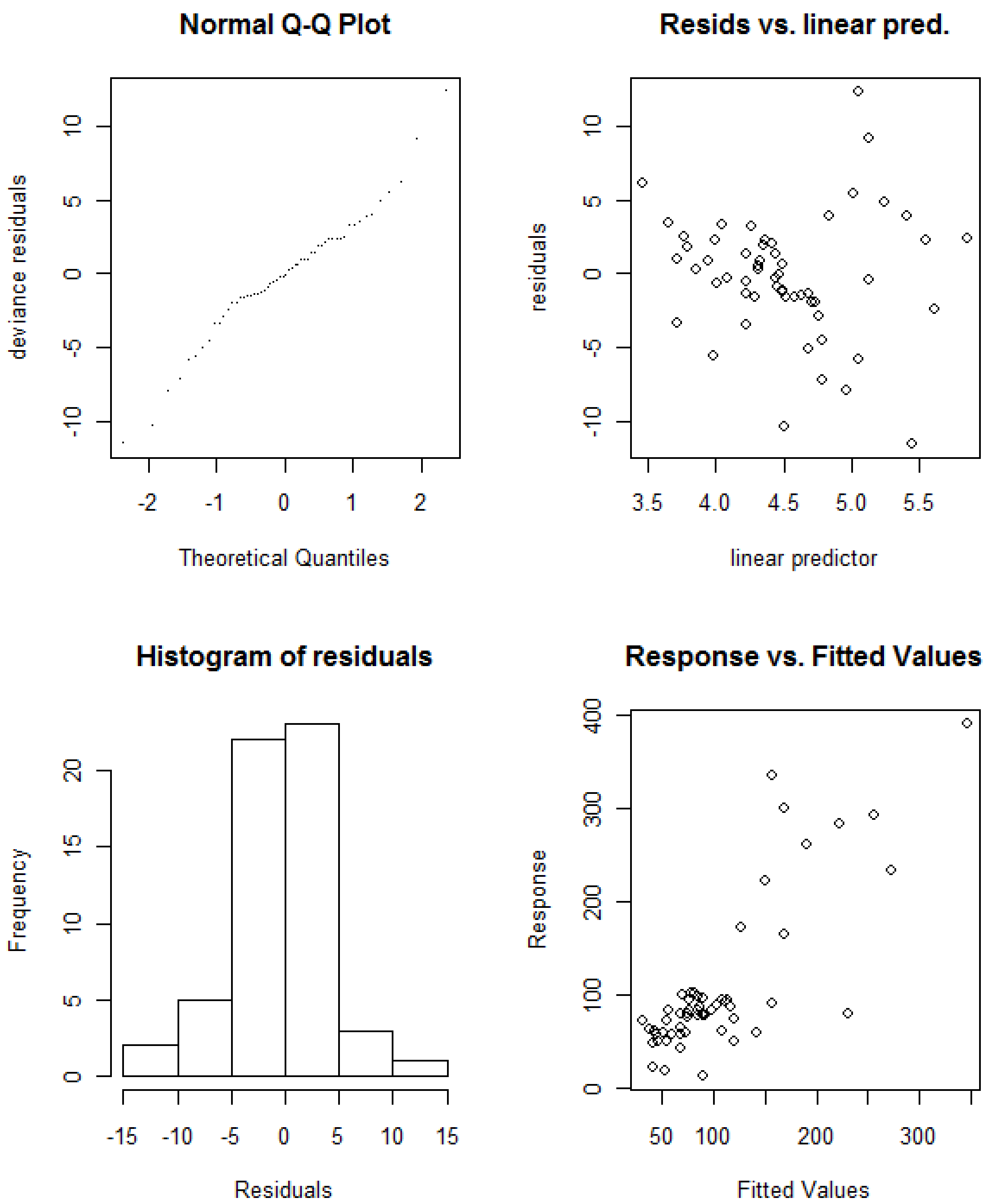


Model 4	***Duration of first bout of clicks***
Family	*quasi*
Link	*log*
N	*33*
R-sq	*56.44%*



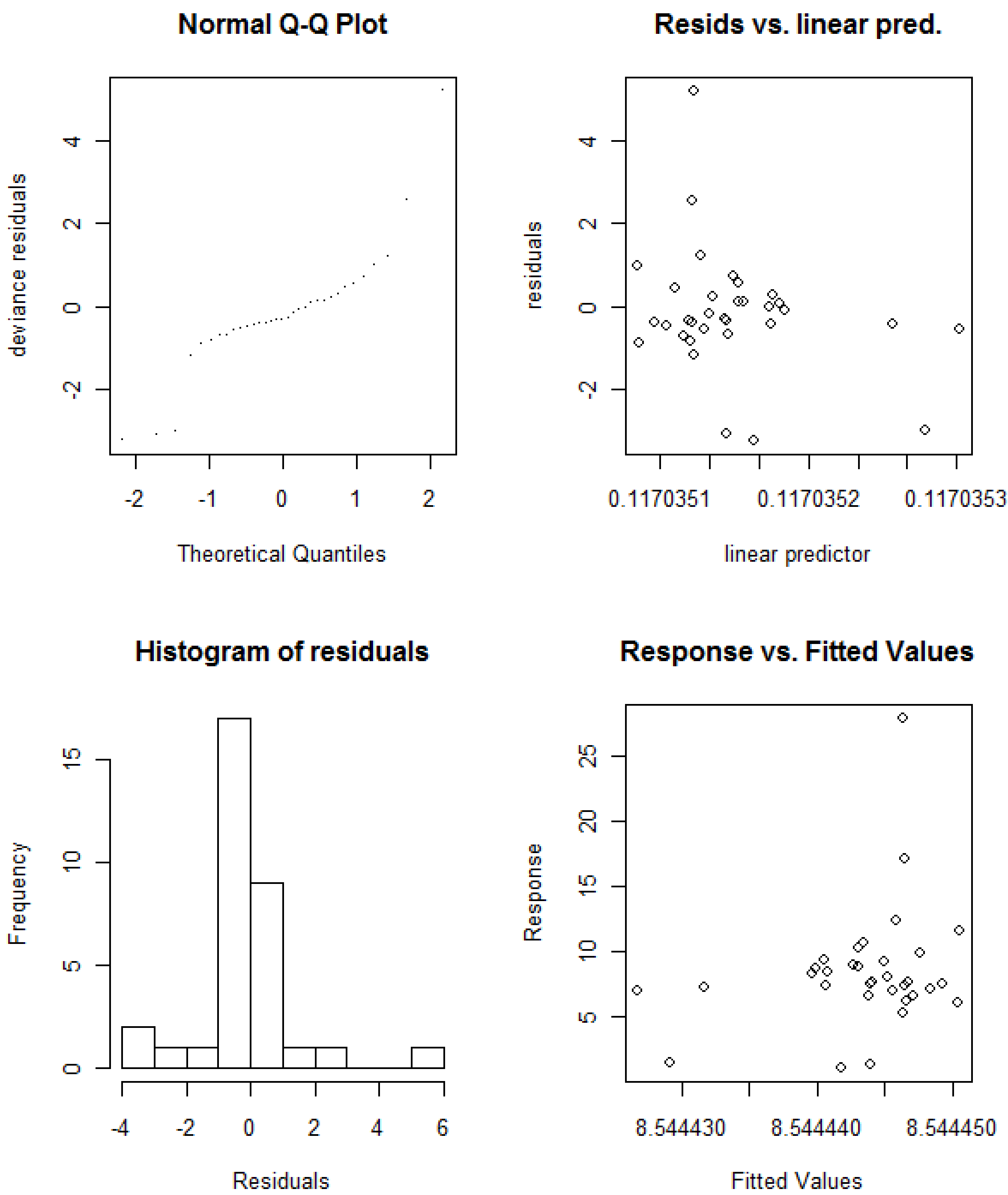
Model 5 Duration of first bout of clicks

Family	*quasi*
Link	*log*
N	*59*
R-sq	*51.87%*



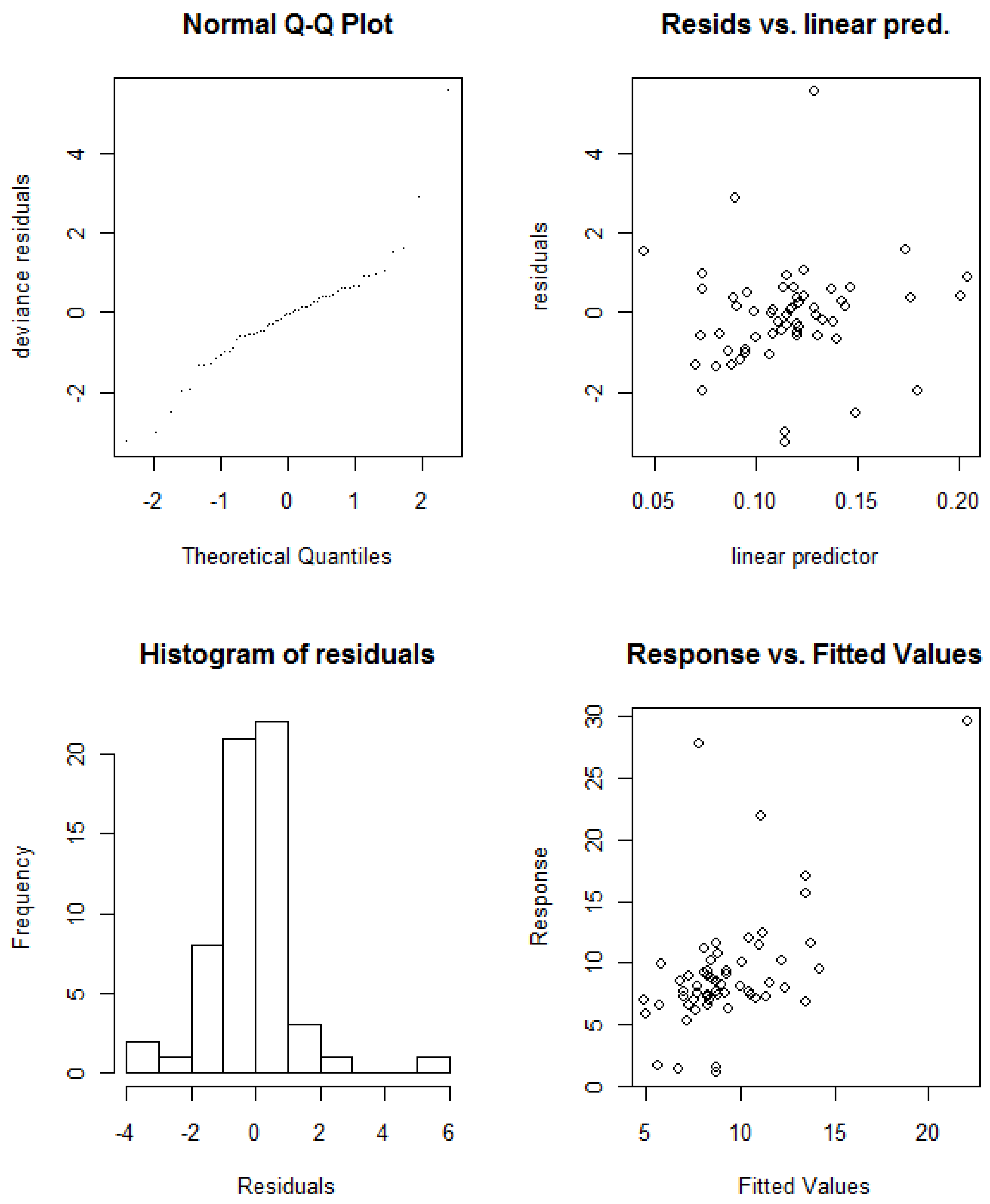
Model 6 Duration of first bout of clicks

Family	*quasi*
Link	*log*
N	*56*
R-sq	*51.52%*



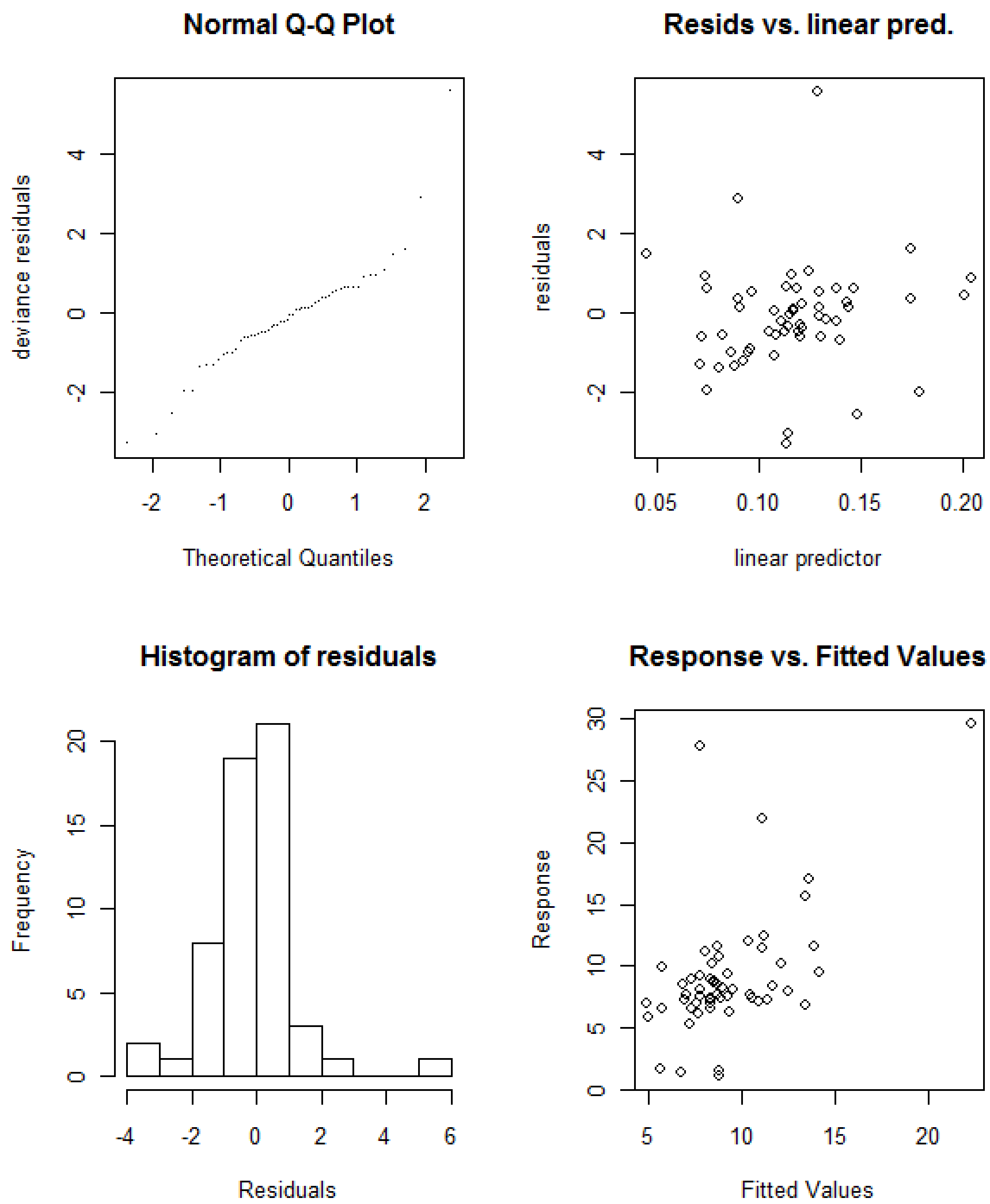
Model 7 Duration of first silence

Family	*quasi*
Link	*inverse*
N	*33*
R-sq	*0.00%*

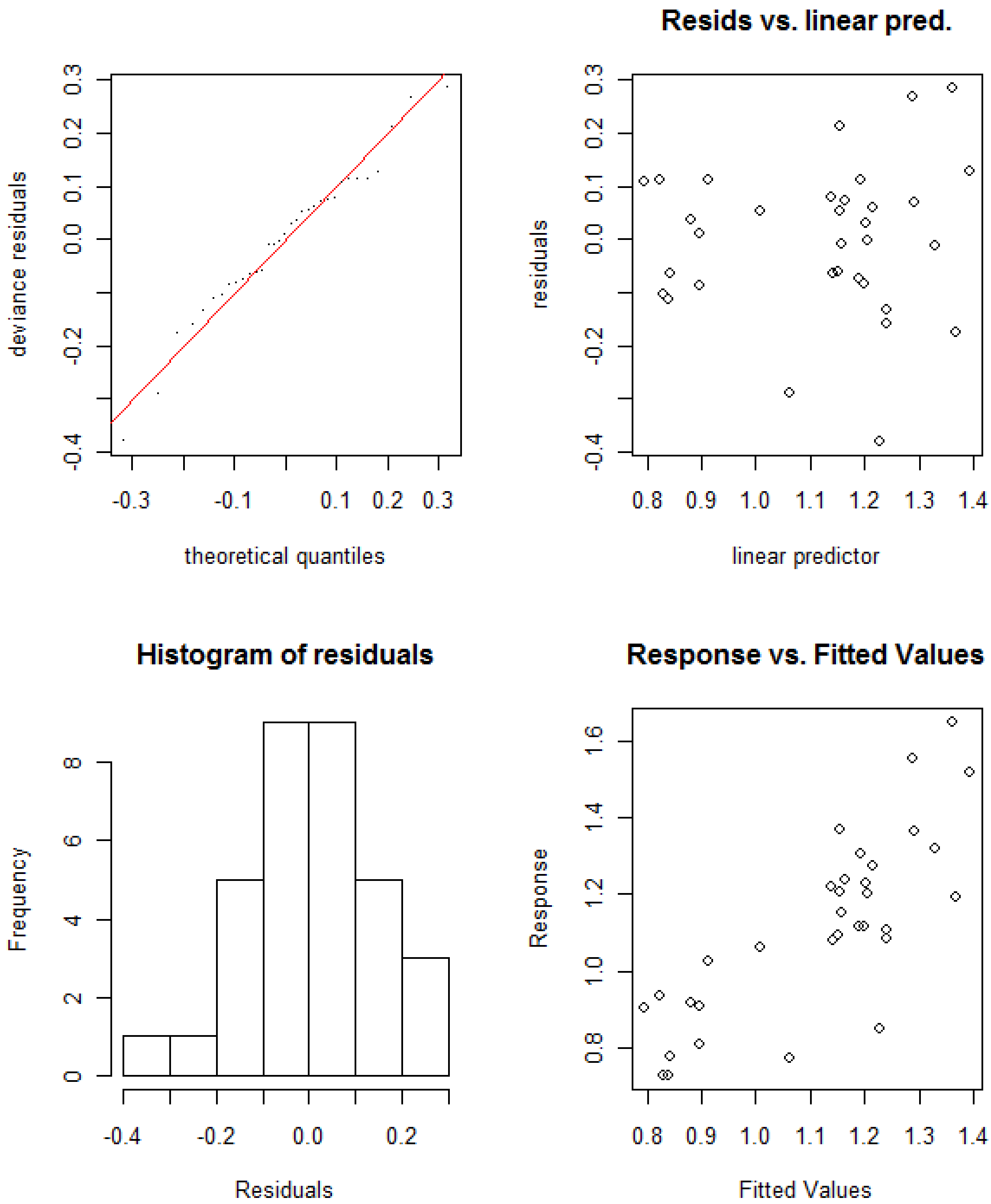


Model 8 Duration of first silence

Family	*quasi*
Link	*inverse*
N	*59*
R-sq	*7.40%*

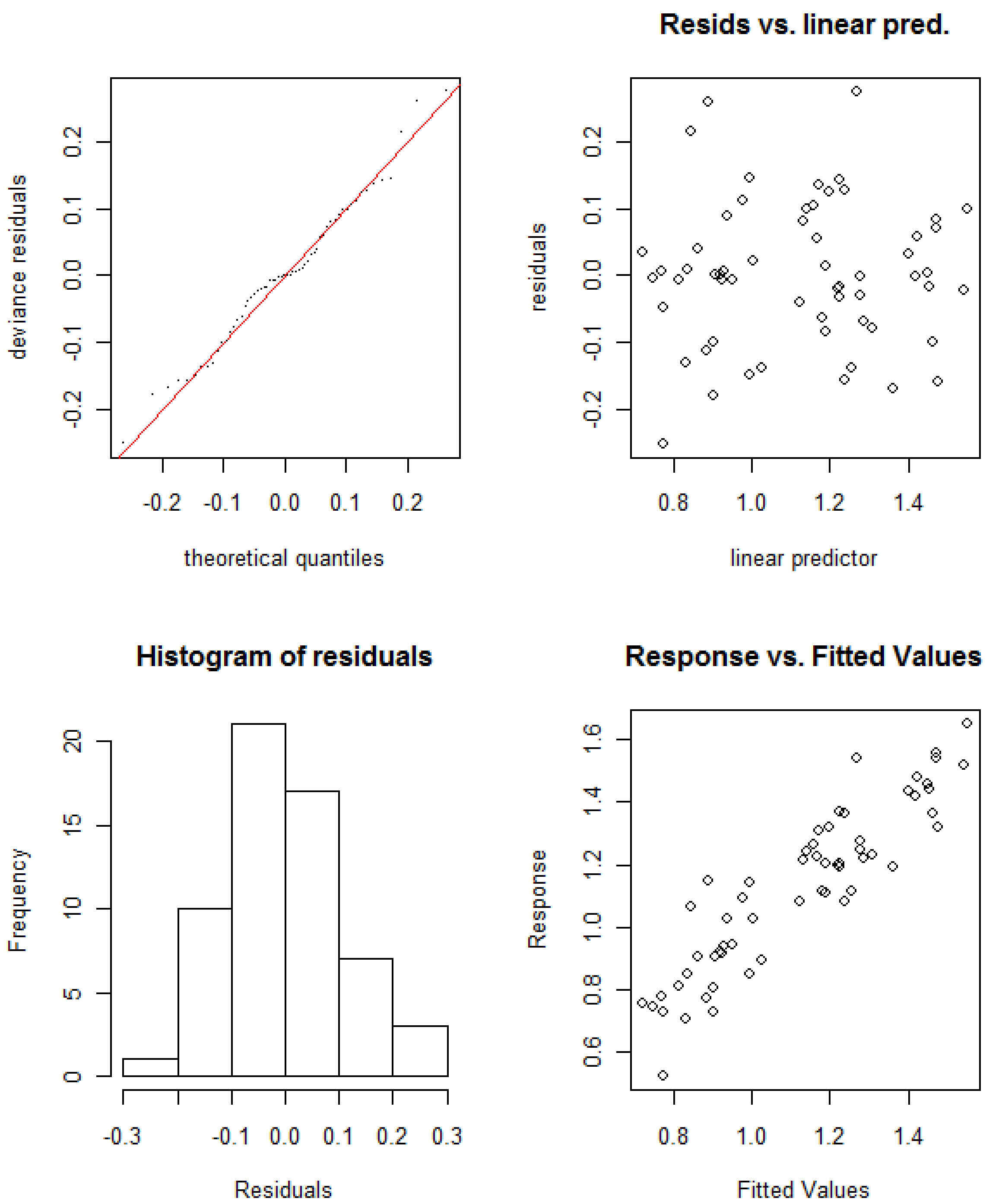


Model 9	***Duration of first silence***
Family	*quasi*
Link	*inverse*
N	*56*
R-sq	*8.28%*



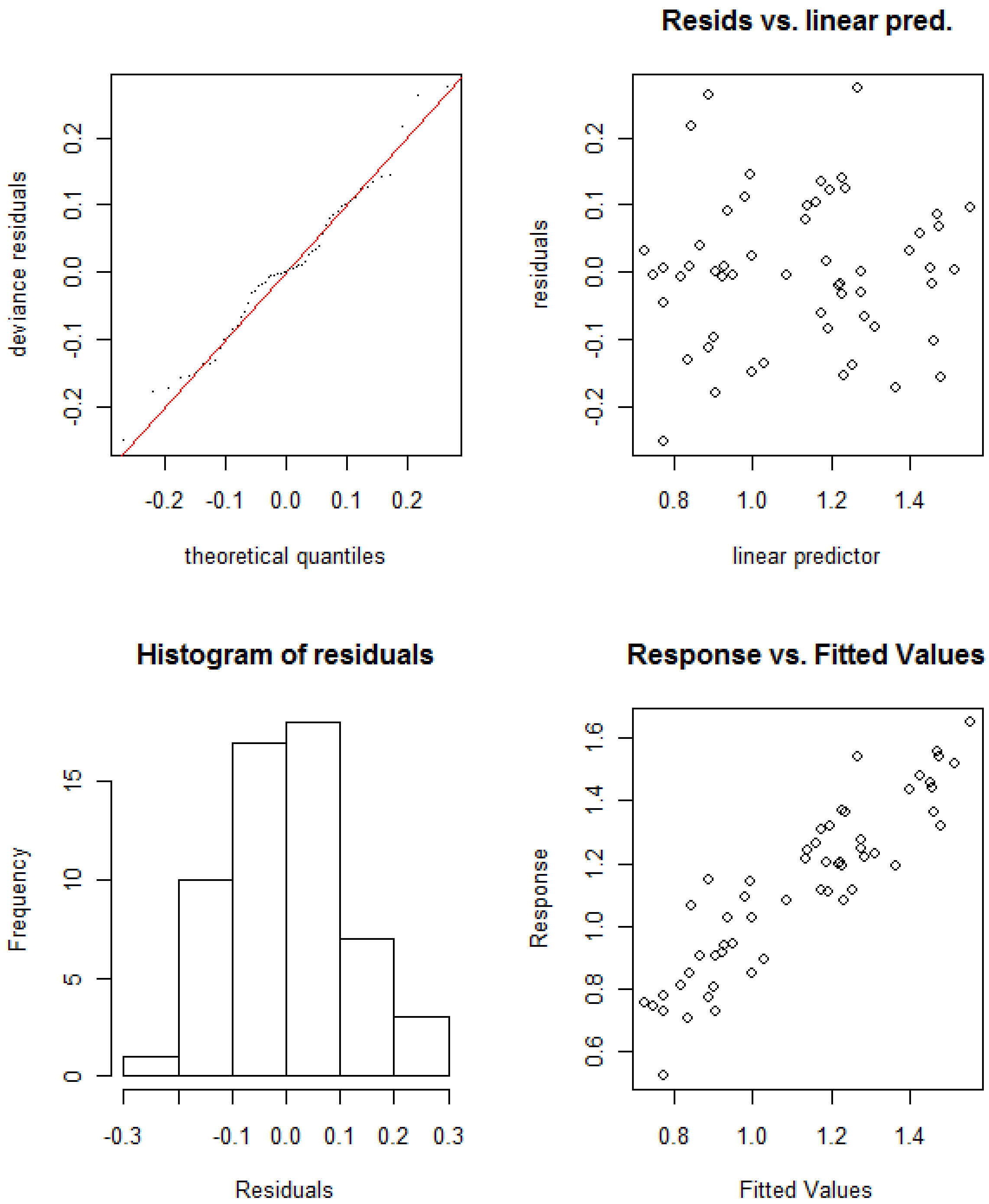
Model 10 ICI of the first five clicks

Family	*Gaussian*
Link	*identity*
N	*33*
R-sq	*60.58%*



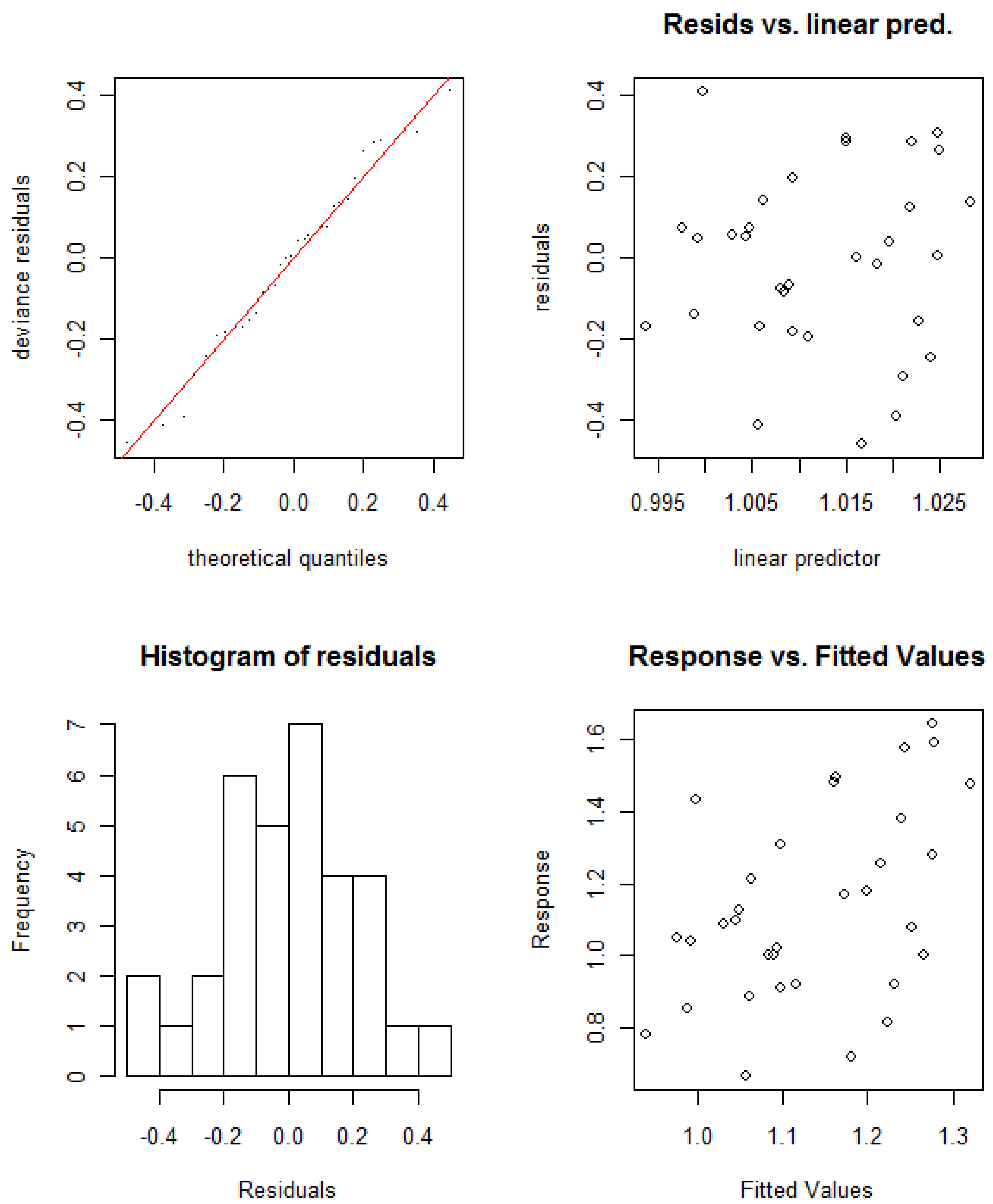
Model 11   ICI of the first five clicks

Family	*Gaussian*
Link	*identity*
N	*59*
R-sq	*75.81%*



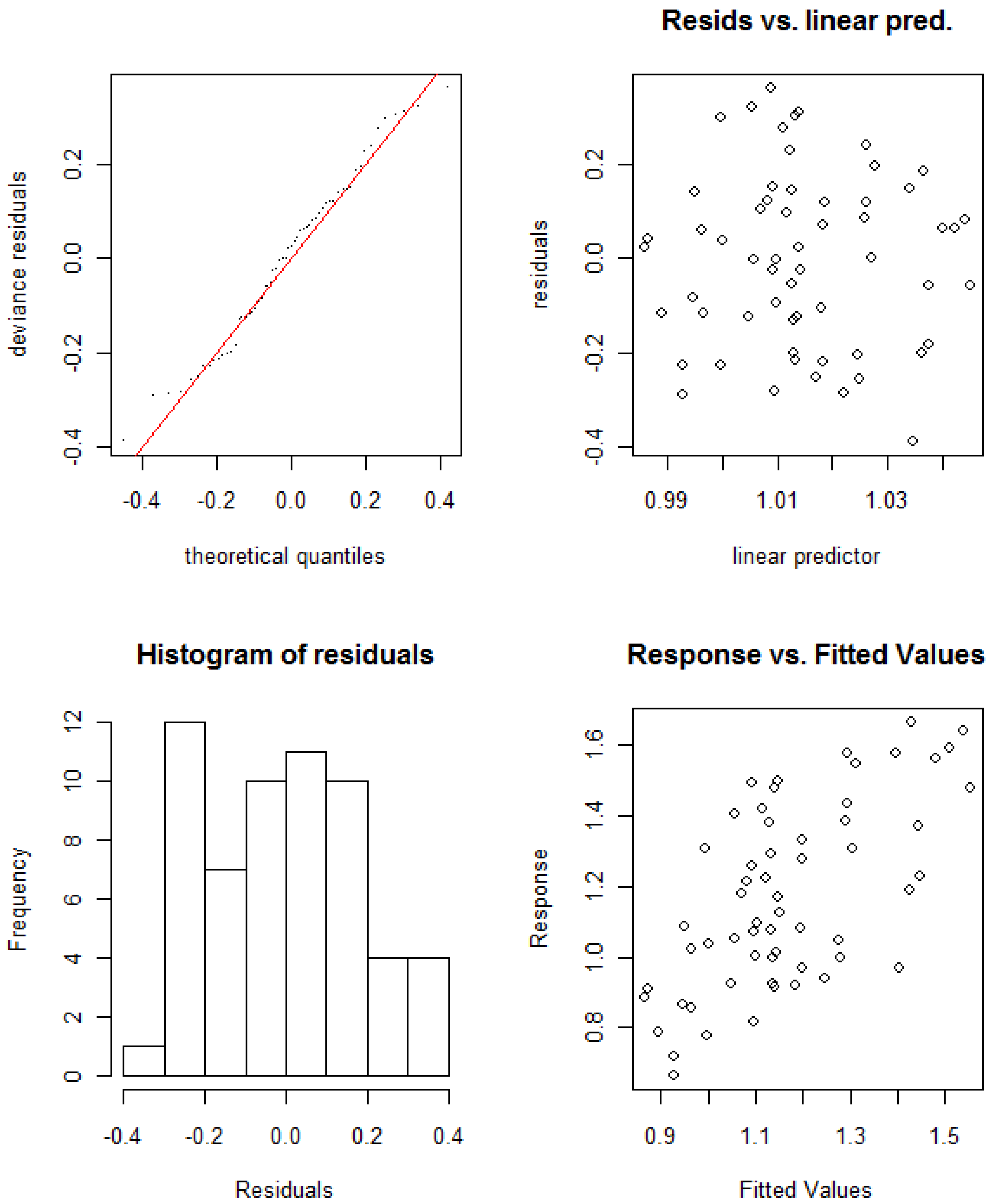
Model 12 ICI of the first five clicks

Family	*Gaussian*
Link	*identity*
N	*56*
R-sq	*75.21%*



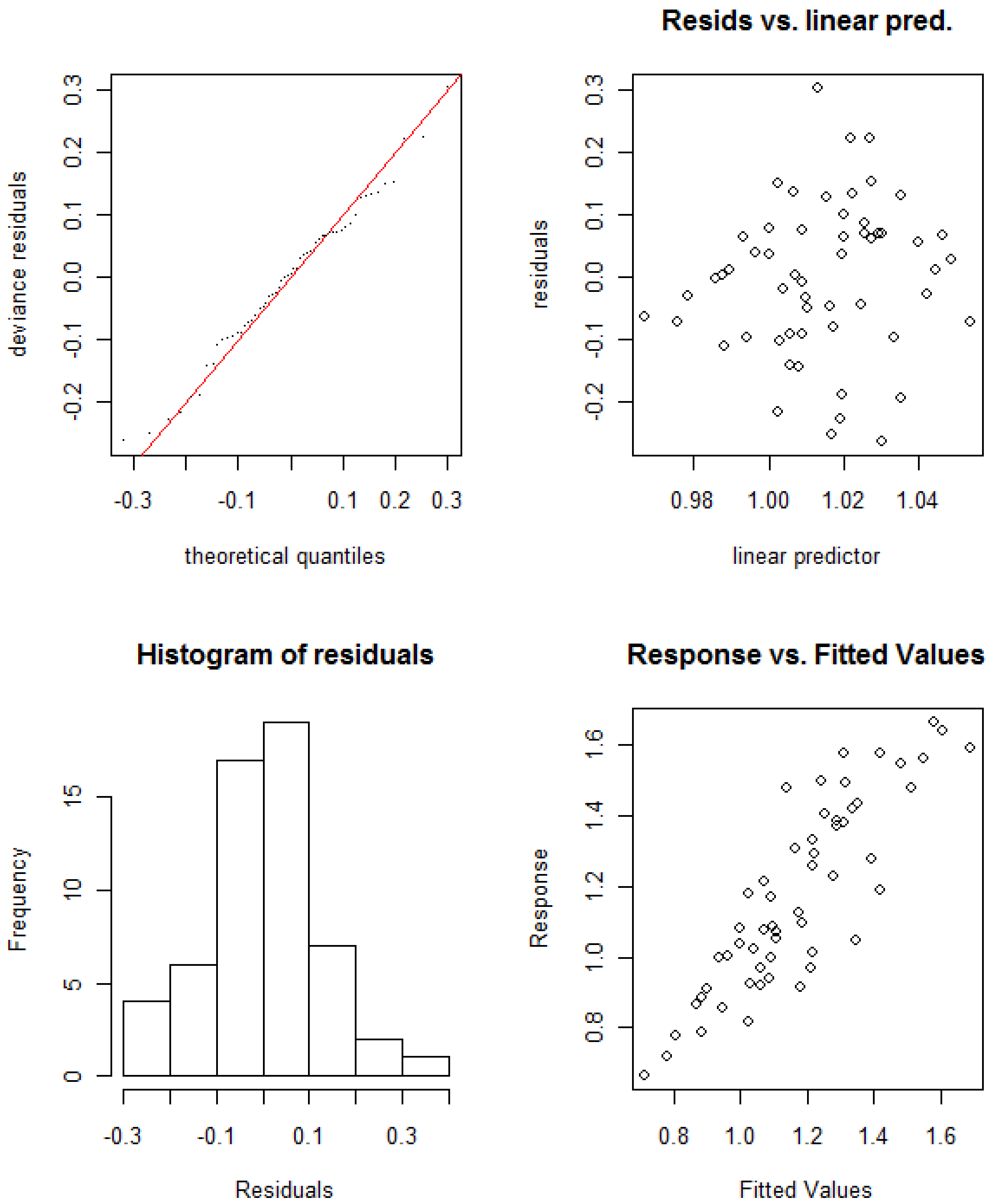
Model 13 ICI of the last five clicks of the first bout

Family	*Tweedie(1.1)*
Link	*mu^0.1*
N	*33*
R-sq	*16.91%*



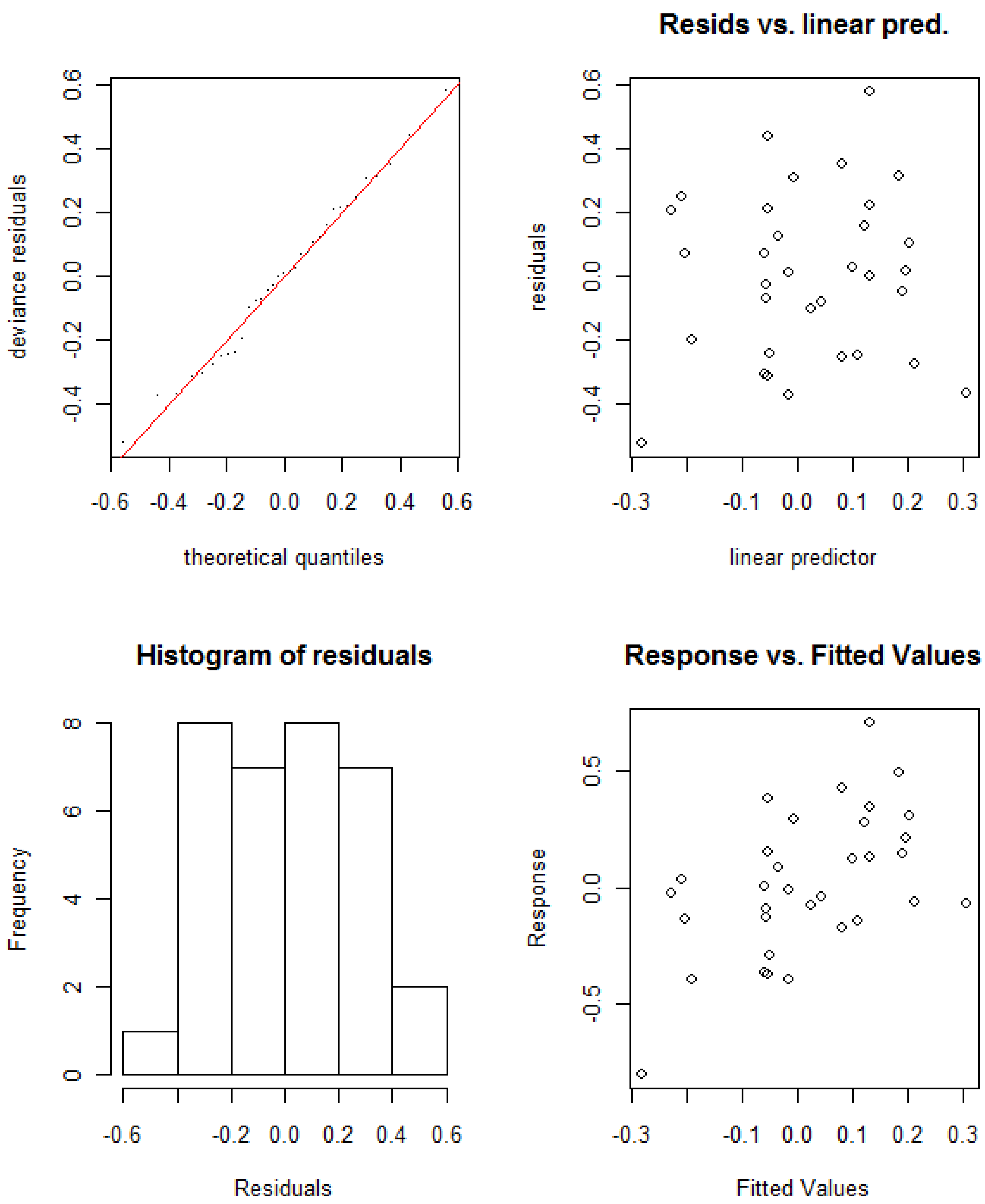
Model 14 ICI of the last five clicks of the first bout

Family	*Tweedie(1.1)*
Link	*mu^0.1*
N	*59*
R-sq	*18.15%*



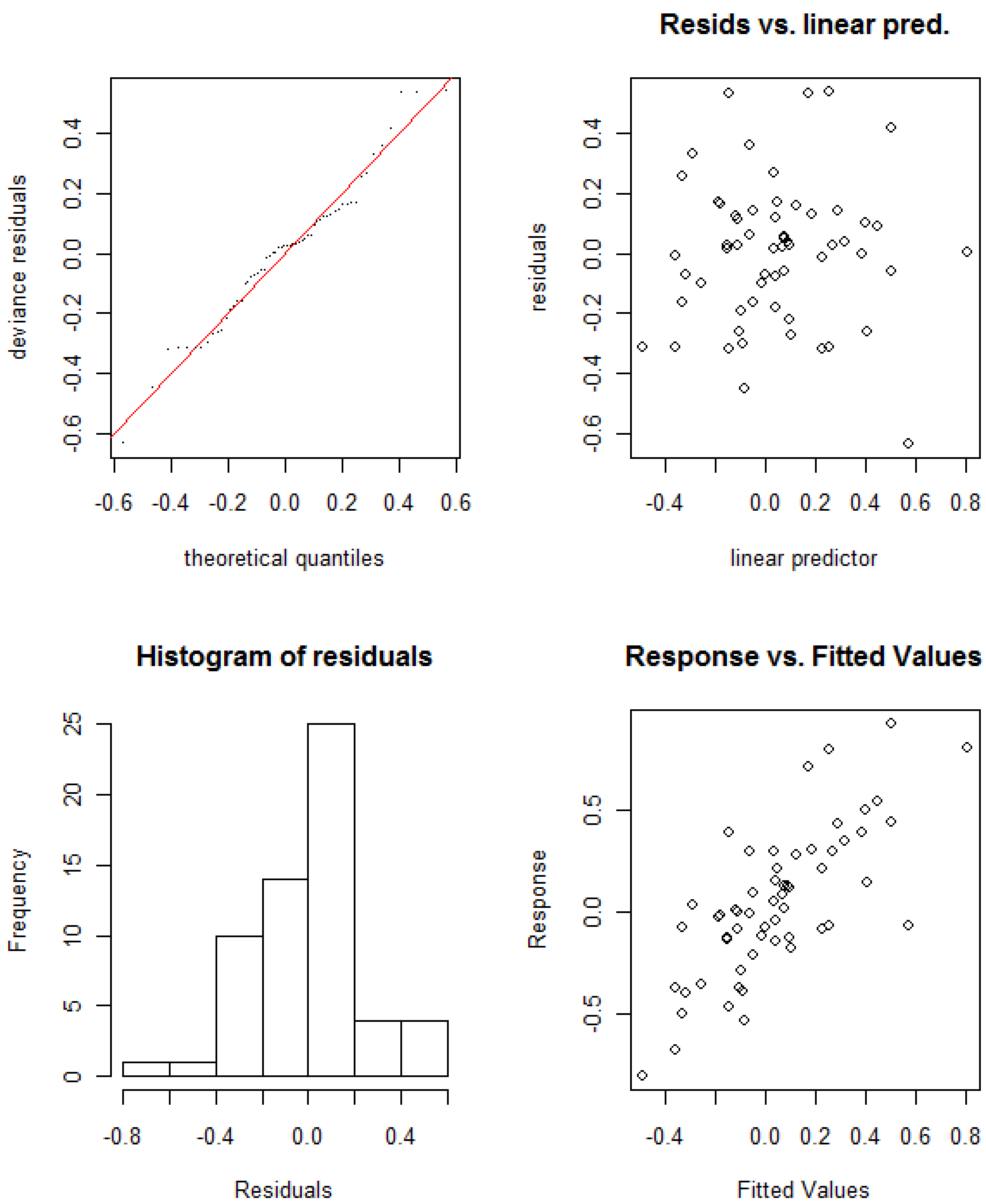
Model 15 ICI of the last five clicks of the first bout

Family	*Tweedie(1.1)*
Link	*mu^0.1*
N	*56*
R-sq	*57.32%*



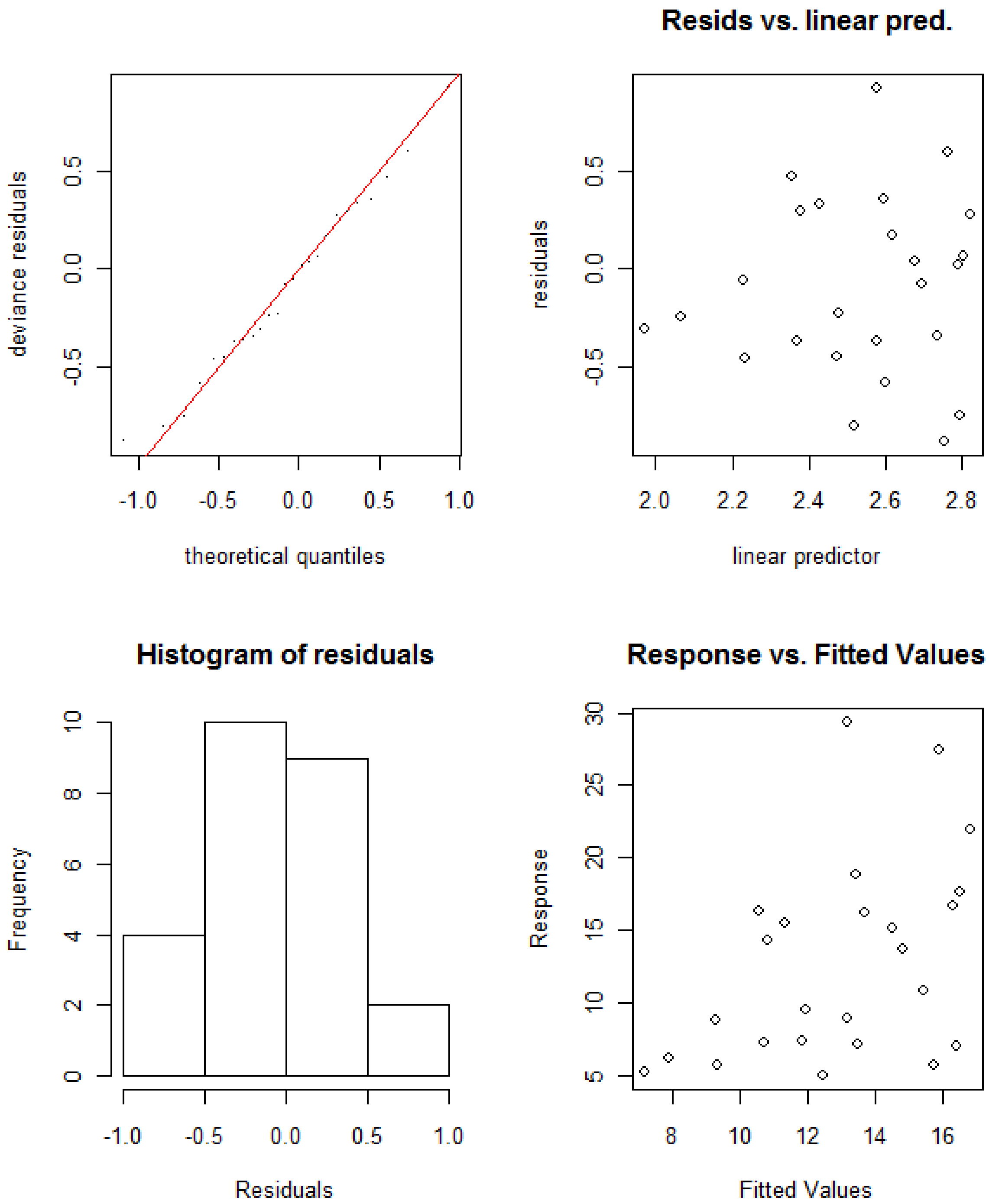
Model 16   Change in ICI during the first bout of clicks

Family	*Gaussian*
Link	*identity*
N	*33*
R-sq	*25.71%*



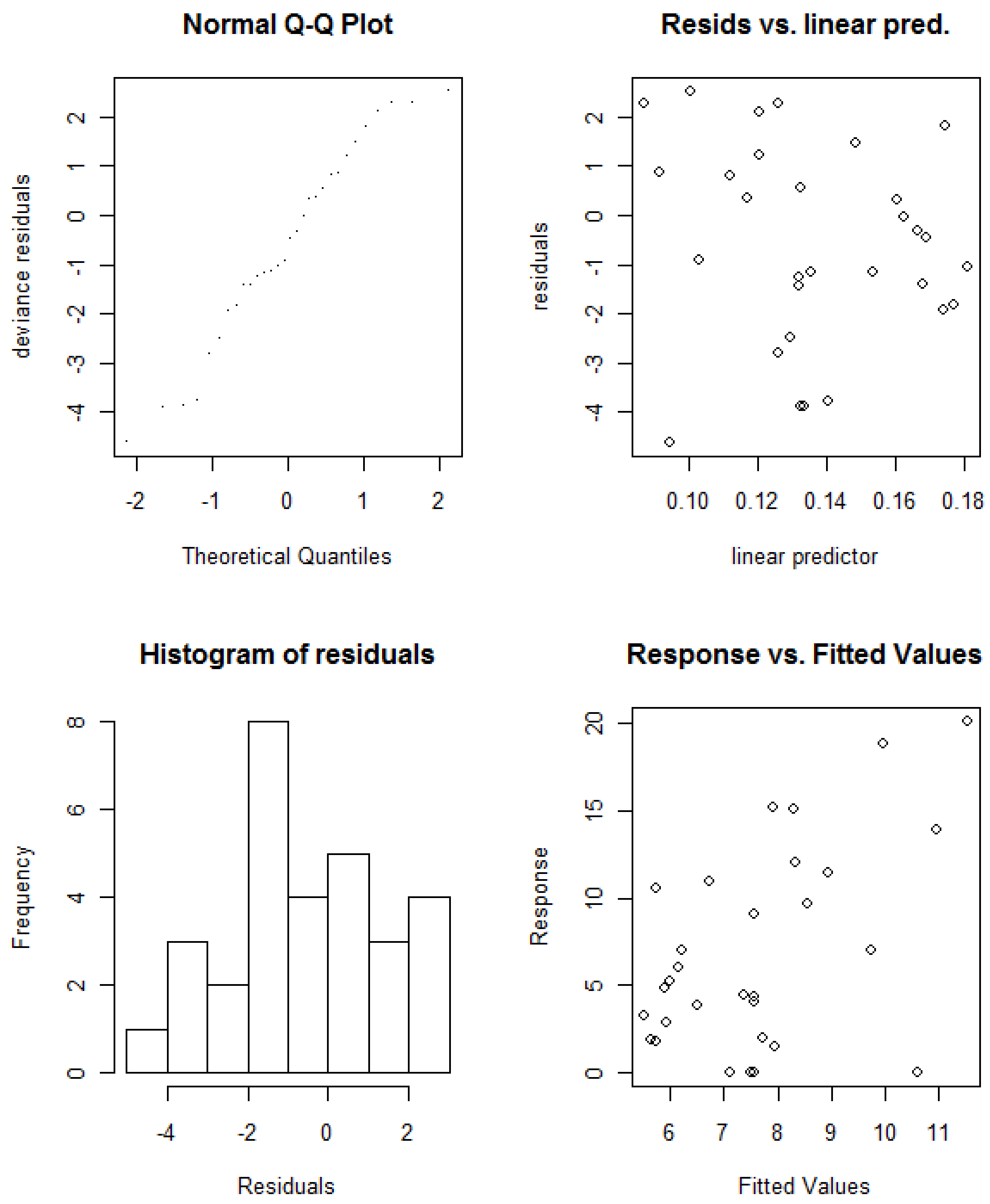
Model 17 Change in ICI during the first bout of clicks

Family	*Gaussian*
Link	*identity*
N	*59*
R-sq	*40.01%*



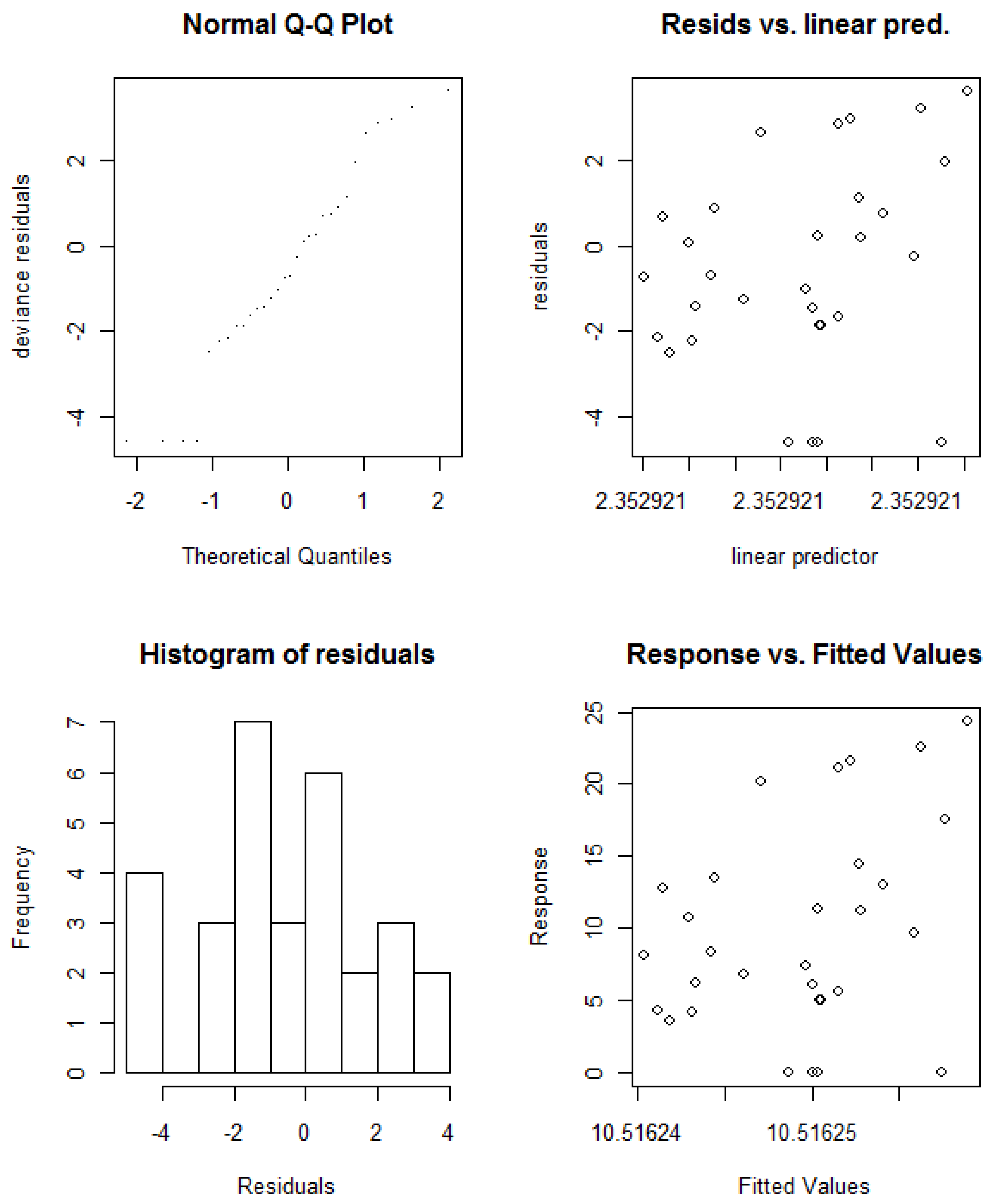
Model 18 Time to first creak

Family	*Gamma*
Link	*log*
N	*25*
R-sq	*13.68%*



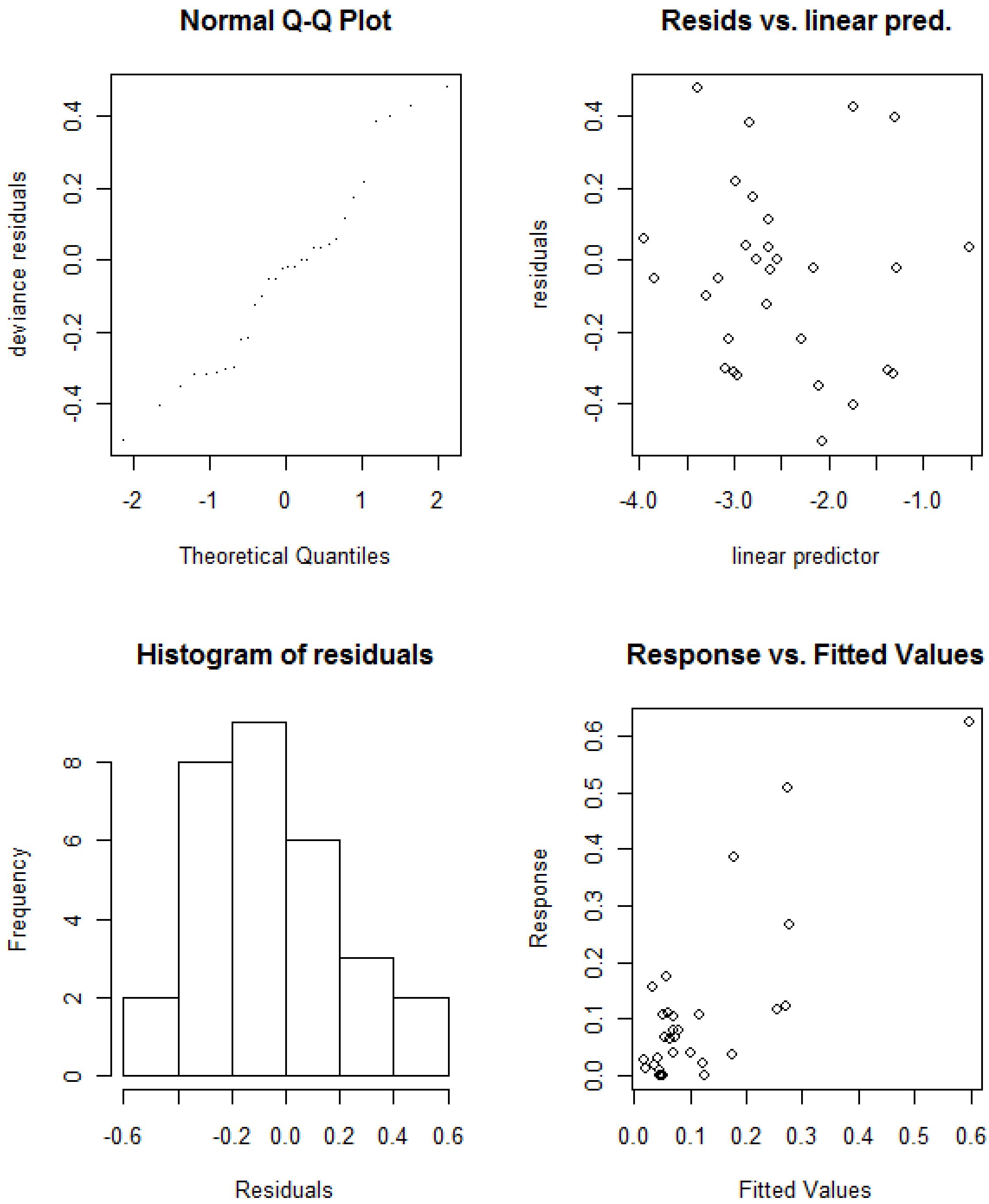
Model 19 Creak activity

Family	*quasi*
Link	*inverse*
N	*30*
R-sq	*18.46%*



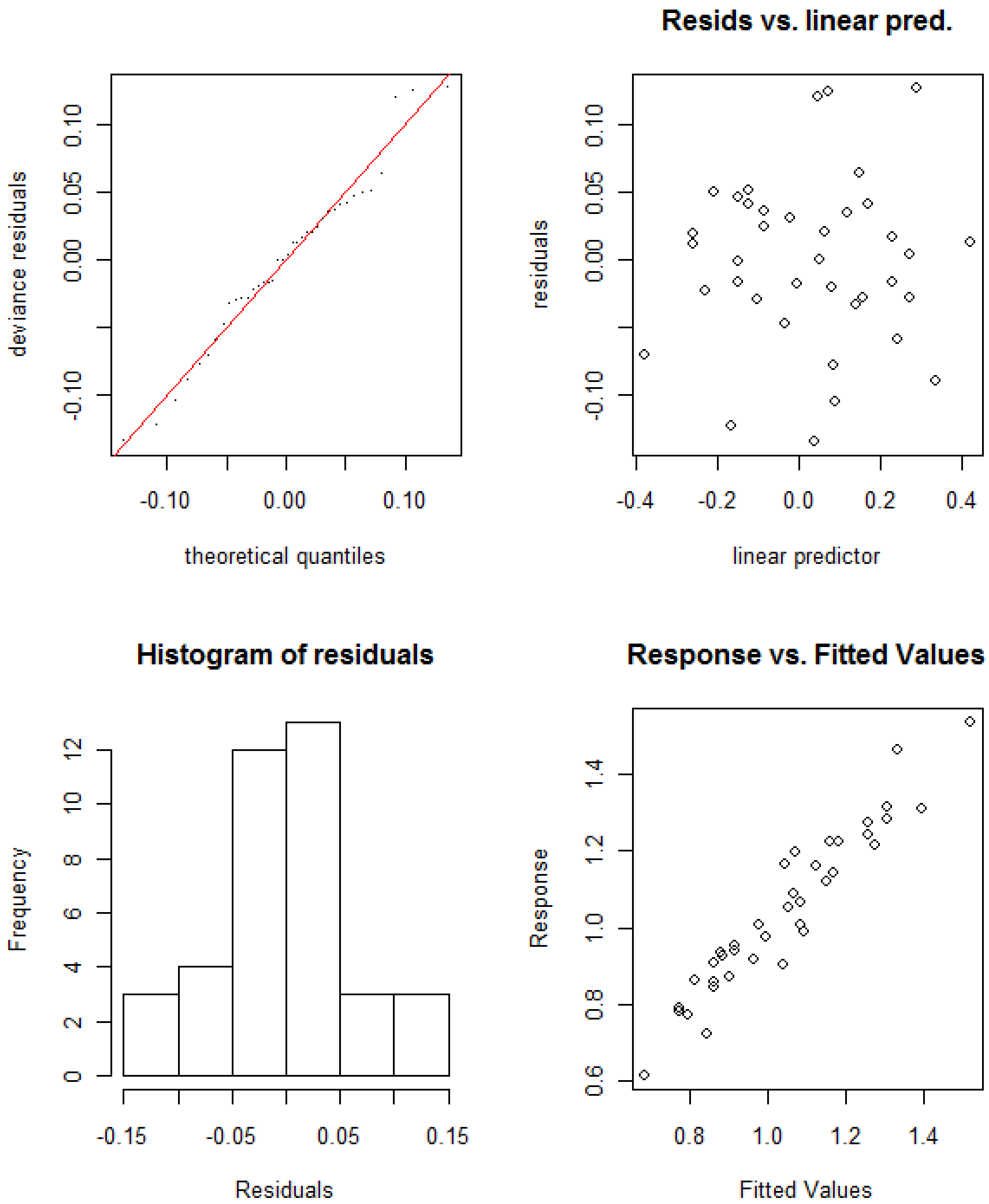
Model 20 Creak rate

Family	*quasipoisson*
Link	*log*
N	*30*
R-sq	*0.00%*



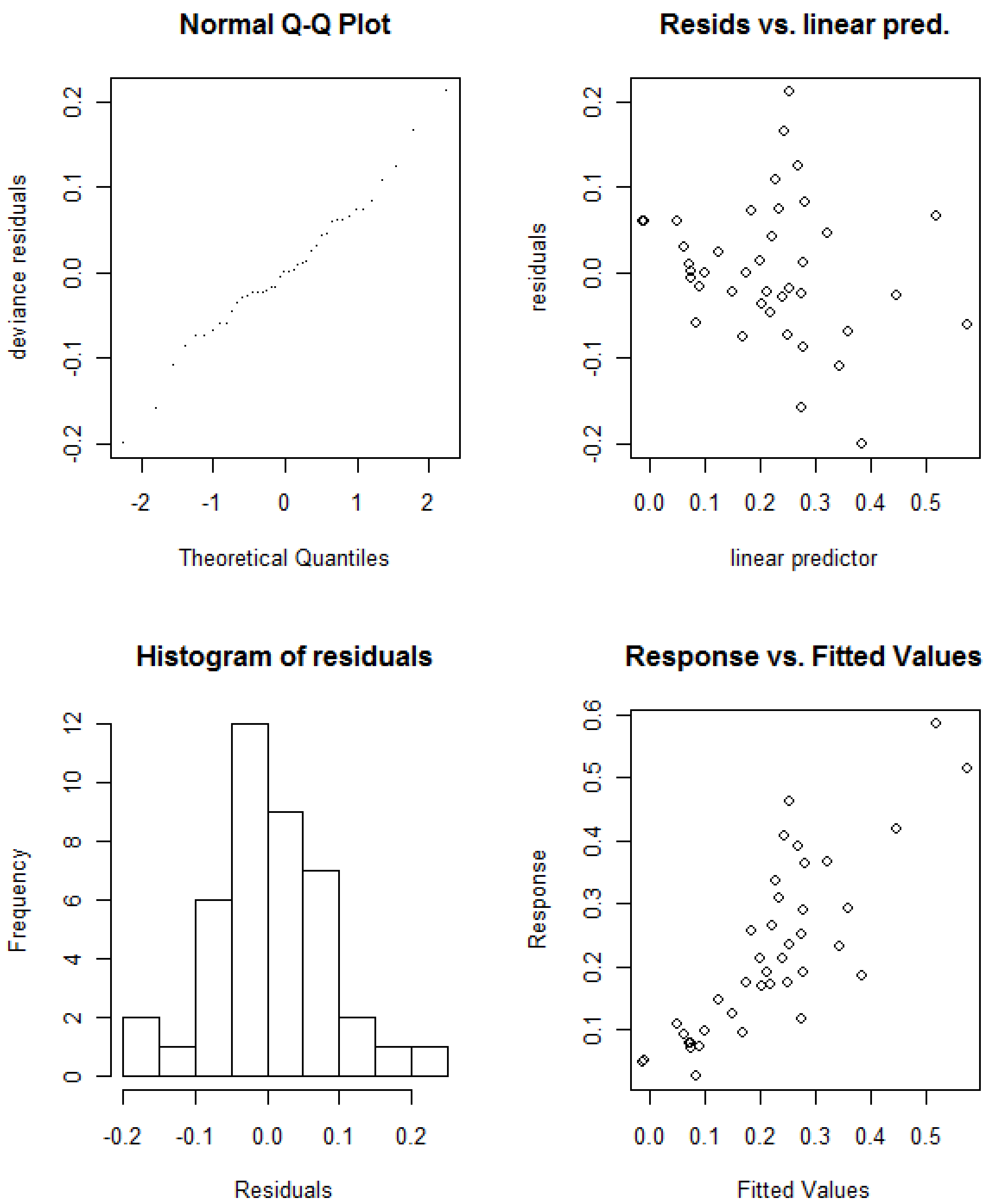
Model 21 % Time spent creaking

Family	*quasi*
Link	*log*
N	*30*
R-sq	*45.04%*



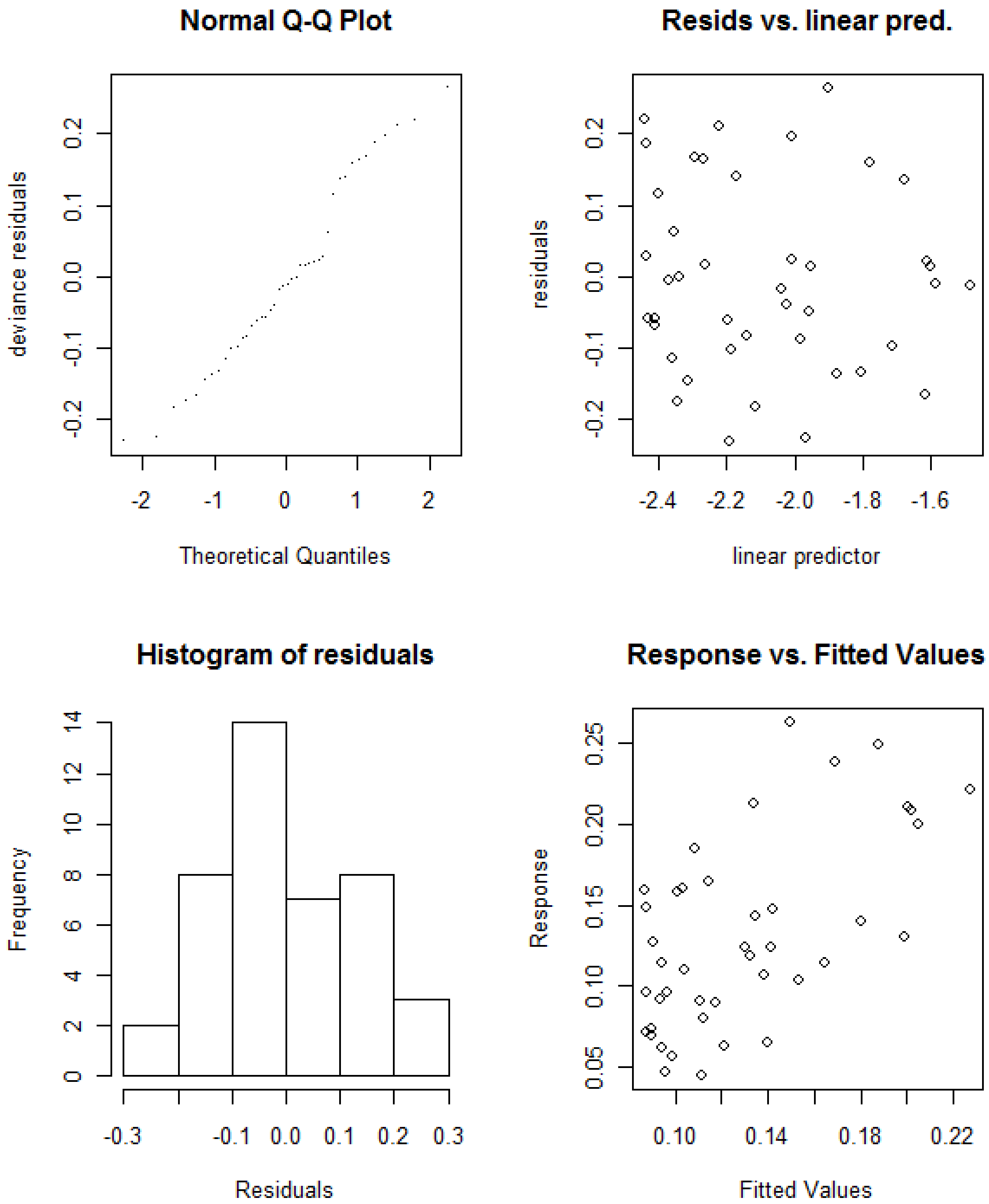
Model 22 Median ICI

Family	*gaussian*
Link	*log*
N	*38*
R-sq	*85.57%*



Model 23 % Regular clicks in median

Family	*quasi*
Link	*identity*
N	*41*
R-sq	*45.15%*



Model 23 % Regular clicks in median

Family	*quasi*
Link	*identity*
N	*42*
R-sq	*34.69%*

Chapter 7

SPERM WHALE INTERACTIONS WITH TOUR VESSELS AT KAIKOURA: RESEARCH CONCLUSIONS AND FUTURE DIRECTIONS

Tim M. Markowitz and Jonathan Gordon

REVIEW OF FINDINGS

BEHAVIOURAL ECOLOGY AND SEASONAL PATTERNS

Both surface behaviour and distribution of whales varied seasonally. Blow interval and surface time peaked in summer, while swimming speed, distance from shore and water depth peaked in spring, when whale use of the Kaikoura Canyon area also appeared to decrease. Observations of focal whales tracked through dive cycles by the research vessel indicate that dive duration follows a similar seasonal pattern to water depth (Table 7.1). GIS analysis of whale and tour vessel distribution showed whale encounters with whale watching vessels were most tightly spatially clustered in summer and autumn when the degree of overlap between areas where whales were accompanied and unaccompanied by boats peaked at 78-93%.

Table 7.1. Seasonal changes in habitat use and dive behaviour by sperm whales in the Kaikoura Canyon area.

Parameter	Spring	Summer	Autumn	Winter
Distance from Shore (km)	12.5	9.8	7.9	8.5
Water Depth (m)	1,053	1,044	908	865
Dive Duration (min)	39.1	44.7	34.2	36.0

INTERACTIONS WITH VESSELS

Whales observed from shore were generally accompanied by tour vessels less than half the time. The greatest level of visitation occurred in the afternoon and during the summer months, when the number of whale surfacings accompanied by vessels slightly exceeded the number of whale surfacings unaccompanied by vessels. Measurements with a laser range finder from onboard tour vessels showed tour vessels maintained an average distance of 75 m from whales. Measurements of vessel noise collected from the research vessel showed that the newer jet propulsion engines of the whale watch vessels are relatively quiet, particularly when vessels are manoeuvring as they would during "whale watching encounters”. Thus, limited rates of interaction, careful vessel handling and use of modern, quiet vessels appears to be effective in mitigating most effects on the whales.

EFFECTS ON SPERM WHALES

Some statistically significant changes in behaviour were observed when whale watching platforms were present. Data collected from both the research vessel and the tour vessel indicated that whales changed heading in response to whale watch vessels. There was also a significant difference in ventilation rate (blow interval) for whales in the presence versus absence of whale watching vessels. Neither the number of vessels nor the presence of aircraft or the research vessel appeared to further influence these behaviours. Presence of one or more whale watch vessels appeared to be the main factor.

Other than some minor changes during the first part of dives, the acoustic behaviour of the whales, particularly those parameters related to foraging success, did not appear to be affected by interactions with tour vessels.

Changes in blow rate, surface times and vocal behaviour are indicators of changed dive behaviour which could affect foraging efficiency. Thus, although they seem minor, the observed changes are a point of caution. The project benefited from using multiple and complimentary research approaches. For example, the shore station provided control data without any vessels present and a broader view of many interactions. The research vessel provided a more detailed record of the behaviour of focal individuals throughout the day, while acoustic monitoring gave us a handle on the whales’ underwater behaviour and foraging. The potential effects of tourism on sperm whale foraging in Kaikoura Canyon likely warrants continued monitoring and further investigation in the future, especially if the industry develops further. Low cost methods, such as tracking vessel activities with GPS loggers and shore based visual observations could provide affordable monitoring, useful for alerting managers to any changes, between more extensive dedicated research projects. As tools, methodologies and models for examining the behaviour of deep diving sperm whales improve, so will the resolution with which we can address questions relating to whale watching impacts. Based on our current analysis, the effects of tour vessel traffic on the whales appear to be minor, but they cannot be discounted and should continue to be monitored.

OUTLOOK FOR THE FUTURE

Current regulations including existing limits on permitted tours and the three vessels within 300m rule appear to appropriately manage the level of interaction between tour vessels and whales while still allowing operators to provide tourists with a rewarding experience. Such regulations minimize effects of the vessels on sperm whales, promoting a sustainable whale watching industry at Kaikoura. Looking forward, it would appear that whale watching tourism at Kaikoura is on the right track, with growth and development that is good for the community and does not appear to impact the animals. For example, the newer, larger vessels operated by whale watch can carry more passengers and make less noise. While marine mammal eco-tourism will no doubt continue to expand at Kaikoura, we suggest that continued caution is warranted with respect to the rate of growth and the sort of growth to ensure both a healthy tourism business and a healthy sperm whale population for generations to come.

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WHY DOLPHINS MAY GET ULCERS: CONSIDERING THE IMPACTS OF CETACEAN-BASED TOURISM IN NEW ZEALAND[1]

MARK ORAMS

Coastal–Marine Research Group, Massey University at Albany, North Shore MSC, New Zealand

The growth of tourism based upon cetaceans (whales, dolphins, and porpoises) has been relatively recent—but spectacular. Thus, these marine mammals have now become valuable as a tourism resource. Accompanying this growth are concerns regarding the potential impacts on "target" species. In New Zealand, marine mammal tourism has grown rapidly and a variety of studies have shown that dolphins and whales are affected by these activities. However, these impacts vary greatly with the species, location, and type of tourism activity. Thus, these studies show, not surprisingly, that generic management regimes are seldom appropriate. It can be concluded from what has been learned in the New Zealand situation that sound management of marine mammal tourism must be based on solid research that provides information regarding the needs and sensitivities of specific species and particular locations. A conservative approach is essential given the difficulties in accurately assessing the long-term implications of this growing industry for cetaceans.

Key words: Cetaceans; Dolphins; Whale watching; Ecotourism; Stress

Introduction

The rapid growth of whale and dolphin watching as a tourism activity over the past decade has been widely reported in the literature (e.g., Baxter, 1993; Beach & Weinrich, 1989; Duffus, 1996; Duffus & Dearden, 1993; International Fund for Animal Welfare, 1995; Orams, 1997a). Whale and dolphin watching now takes place in every continent and from countries as diverse as Argentina, South Africa, Japan, Norway, New Zealand and Tonga. Hoyt's (2000) review of the industry illustrates its spectacular growth. He claims that in 1983 whale and dolphin watching occurred in only 12 countries, but by 1995 it had expanded to 295 communities and 65 countries and that by 1998 nearly 500 communities and almost 100 countries or territories were involved in dolphin and whale-based tourism. He also estimates that the worldwide economic impact derived from whale- and dolphin-watching activities in 1998 totaled more than US$1 billion. As a consequence, there appears to be widespread optimism about the

[1]Title derived from Robert Sapolsky's (1994) *Why Zebras Don't Get Ulcers. A Guide to Stress, Stress Related Diseases, and Coping*.
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future potential of this industry and predictions are that it will continue this rapid growth rate (Hoyt, 2000).

Many view whale and dolphin watching as viable, sustainable "ecotourism" and a more desirable "use" of these animals than the lethal harvesting of them for products (International Fund for Animal Welfare, 1995). However, there is widespread concern about the impacts that tourism activities have on whales and dolphins (Beach & Weinrich, 1989; Forestell & Kaufman, 1990; Jeffery, 1993; International Fund for Animal Welfare, 1995; Phillips & Baird, 1993). Many of the species of whales and dolphins that are popular for tourism are classified as endangered, and the potential for disturbance of their natural behavioral patterns has attracted much research effort in recent times. Examples include Baker and Herman (1989), Briggs (1991), Corkeron (1995), DeNardo (1996), and Gordon, Leaper, Hartley, and Chappell (1992). Some of this research has suggested that close approach by tourist boats for watching and, in some cases, swimming with dolphins and whales, has altered the behavior of the animals and it has been suggested that this could be detrimental (Beach & Weinrich, 1989). This has lead to the view that the "use" of whales and dolphins as a tourist attraction could be seen as another form of harmful exploitation of these marine mammals (Orams, 1999).

While whale watching worldwide has a history that dates back to the 1960s, the growth of whale watching in New Zealand is relatively recent. Watching sperm whales in Kaikoura (the only location where exclusively whale-based tourism operations exist in New Zealand) did not start until 1987 (Donoghue, 1996). The 1990s saw the advent of dolphin watching and swimming with dolphins at a wide variety of locations in New Zealand. Internationally, dolphin-based tourism has been less significant and has a shorter history than whale watching. New Zealand, however, has been at the forefront of the development of this new tourism industry. The first permit was issued in the late 1980s and by June 2001 75 permits had been issued (Neumann, 2001). The New Zealand Tourism Board (1996) estimated that 14% of visitors to New Zealand (currently estimated at 2 million visitors per annum) participated in dolphin-watching and -swimming activities. Similarly, there are now large numbers of private recreational boats operated by New Zealanders who seek to watch and interact with dolphins in the wild (personal observation). Thus, in New Zealand, there is an "ecotourism" industry that has grown rapidly and that potentially can cause significant impacts on the natural attraction. More significantly, as Constantine (1999a) points out:

> We know little about the long-term, or even short term, effects of humans interacting with marine mammals in the wild. More specifically, issues such as the impacts of noise produced by vessels, boat handling practices, numbers and proximity of boats and humans, effects of swimmers in the water, continual disturbance versus sporadic disturbance, differences in responses of different species, age classes, sexes, individuals, or seasonal changes are not known. Research, therefore, has an important role in the future management of this industry. (p. 8)

Unfortunately, as is often the case in the development of ecotourism, research on impacts has occurred after the industry has become established. Recently, however, there have been a number of important studies completed that have provided valuable information regarding the impacts of tourism practices on specific species in New Zealand. This article will provide a brief review of these studies and consider the implications of their results for management. This review is preceded by a consideration of the challenges inherent in the study of small cetaceans. This is necessary to understand the context of the findings of impact studies and has important implications for the future research and management priorities proposed later in this article.

Research on Impacts

Challenges in Studying Cetaceans

The key challenge in studying cetaceans in the wild is that they are wide ranging and that they spend the great majority of their lives under water. In addition, cetacean populations are complex and dynamic; individuals are usually difficult to recognize; and their behavior is often subtle and always multifaceted and contextual (Mann, 2000). An accurate analogy is that cetacean behavioral ecologists are attempting to create or visualize a complete picture from only a few small pieces of the puzzle. When you add the considerable challenges provided by weather, waves, and working from small boats (often far from shore), this kind of research requires considerable determination. Fortunately, there have been a number of individuals who have persisted despite these challenges and who have contributed to a growing understanding of accepted research protocols and methods that render useful results (Mann, Connor, Tyack, & Whitehead, 2000). However, while methods have advanced significantly over the past three decades and understanding of the behavioral ecology of a variety of species has increased (Perrin, Würsig, & Thewissen, 2002), difficulties in interpreting what is observed remains. With regard to assessing the impacts of tourism, one of the greatest problems is determining cause and effect.

Cause and Effect Issues

Because cetacean behavior is complex and dynamic, and also because observation of behavior is difficult, determining the causal factors that drive observed behavior is problematic. Most often researchers infer or make an estimate of the probable cause on the basis of experience with the species (both their own and others reported in literature), and on the basis of context and repetition. Thus, for example, if repeated and coordinated movement away from a vessel that is attempting to approach dolphins closely is observed, it is inferred that dolphins are attempting to flee from the vessel and that the vessel is the cause of this behavior. However, most observable behavior is seldom as obvious or uniform. Movement, for example, is not always coordinated amongst a group. Within a group of dolphins, some individuals may flee an approaching boat, others may be attracted to it to "bow-ride" for a period, while others may appear unaffected by the boat's presence. In another circumstance, coordinated movement away from an area where a boat is present could be due to the presence of a predator (such as a large shark) or some other factor undetected by researchers and not due to the presence of a vessel at all. Thus, it is difficult for researchers to draw conclusions about the cause of behavior with absolute confidence. This is, of course, problematic when researchers are attempting to assess the impact of tourism activities. The question, seldom able to be answered with absolute certainty, is whether the observed change in behavior would have occurred irrespective of the presence of tourism activity. These issues are further complicated by the fact that most (but not all) research on small cetaceans is carried out from a vessel—and thus the researchers themselves may influence behavior.

These challenges are not always insurmountable, however. With careful experimental design and comparison of the normal behavioral repertoire (such as through a comparison of activity budgets) with behavior when tourism activities are under way, inferences can be made regarding the impacts of those tourism activities. A growing number of studies are being reported in the literature (see later examples, this article) that demonstrate cetacean-based tourism can and often does affect the behavior of the animals targeted. However, it is important to recognize that a change in behavior as a result of tourism is not necessarily harmful.

Is Impact Always Detrimental?

Findlay (2001) draws the important distinction between a "response"—when an animal shows a reaction to the presence of vessels or swimmers (e.g., rapid movement away from a vessel), an "impact"—the resultant effect of the response (e.g., increased respiration rate), and "disturbance"—an assessment that the impact is detrimental (e.g., an observed injury resulting from a boat strike). This classification is helpful because it counters the common conclusion that any observed response by animals targeted by tourism activities is detrimental. This is often not the case. Dolphins and whales have been exposed to human activities for centuries (but at no time more so than at present). They are extremely adaptable organisms, as evidenced by the wide variety of habitats and situations where they survive in close proximity to human activities. Thus, in many situations, cetaceans have become "habituated" to human activities (i.e., they have adapted to and become tolerant of human influence) (Lockyer, 1990; Orams, 1999). Therefore, responses observed to tourism activities may be adaptive, but not necessarily detrimental.

Despite the significant challenges associated with research on wild cetaceans and tourism, a number of studies in New Zealand have recently been completed. This research provides valuable insights into the potential impacts of tourism on cetaceans. While this work seldom provides absolute answers to questions surrounding the issue of impacts, these reports represent an important first step towards improving management of this growing industry in New Zealand.

A Brief Review of Impact Studies in New Zealand

Bottlenose Dolphins (Tursiops truncatus)

Bottlenose dolphins are the most well-studied and understood cetacean (Connor, Wells, Mann, & Read, 2000). They are also the most frequently studied cetacean with regard to tourism: over half of published studies focus on this species (Richter, 2002). They are present in New Zealand in what appears to be several discrete areas: the northeast coast of the North Island (Constantine, 2002), the northern and northwestern coasts of the South Island (including the Marlborough Sounds) (Brager & Schneider, 1998), and Fiordland (southwest of the South Island) (Schneider, 1999).

Constantine's work from the Bay of Islands (1995; 1999b; 2001; 2002) has a number of important findings with regard to the impacts of tourism. First, she found that the method of placement of swimmers into the water had a significant influence on dolphin responses. When swimmers were placed in the water directly in the path of the dolphins' travel, or directly within the dolphin group while they were "milling," significantly higher rates of "avoidance" were observed than when swimmers were placed "line-abreast" (adjacent to the dolphins' path of travel). Another important finding has been that Bay of Islands' bottlenose dolphins appear to have become "sensitized" to swimmers in the water. That is, they have shown increasing levels of avoidance behavior as tourism levels have increased over time (Constantine, 2001).

Lusseau's recent work (Lusseau, 2003; Lusseau, in press; Lusseau & Higham, in press) on bottlenose dolphins in Doubtful Sound (Fiordland) also reveals disturbance as a result of tourism operations. In particular, Lusseau found that the dolphins resident in the Sound were sensitive to disturbance from vessels when the dolphins were resting or socializing.

Dusky Dolphins (Lagenorhynchus obscurus)

In New Zealand, dusky dolphins are typically found in large aggregations close to shore off the Northeastern coast of the South Island (Würsig et al., 1997). They are most reliably sighted off the town Kaikoura where the continental shelf is found close to the coast (Orams, 2002).

At Kaikoura, Yin (1999) found that dusky dolphins' "whistle rate" (underwater vocalizations) increased when swimmers entered the water close by. In addition, she reported that dusky dolphins were more active and traveled more when boats were present during the early afternoon, a time period usually used for resting by the dolphins. Barr (1997) also carried out research on dusky dolphins' reaction to tourism activities at Kaikoura. She found that they were accompanied by vessels during 72% of her observations (daylight hours, summer seasons). She observed an increase in aerial activity when vessels were present and also noted that the dolphins formed "tighter" groups (distance between individuals reduced) when boats were present during the early afternoon time period when dusky dolphins often rested.

Hector's Dolphins (Cephalorhyncus hectori)

Hector's dolphins are endemic to New Zealand and are distributed in several discrete areas, primarily around the coast of the South Island at Porpoise Bay, Southland, around the Banks Peninsula in Canterbury, and in a number of places off the West Coast. Because Hector's are a small, near-shore dwelling dolphin they do not appear to move great distances (Bejder et al., 2002). As a consequence, there appears to be little genetic interchange between these geographically separated populations (Pichler et al., 2001). Recent research has revealed that the small (<100 individuals) populations found off the West Coast of the central North Island are genetically distinct from all others and they have been designated as a separate species that is vulnerable to extinction (Dawson, Pichler, Slooten, Russell and Baker, 2001; Pichler, 2002).

Bejder's (1997) research on Hector's dolphins at Porpoise Bay, Southland, found that the dolphins used a preferred area less frequently when swimmers were present. He also found that the presence of vessels and swimmers increased the probability of the dolphins being observed in "tighter" groups (i.e., swimming in closer proximity to one another). However, dolphins were not displaced from the area due to the presence of boats. In fact, initially they were attracted to boats (for bow-riding) but after 50–70 minutes their behavior did not appear affected by the presence of vessels.

Nichols, Stone, Hutt, Brown, and Yoshinaga (2001) found that Hector's dolphins increased their active swimming behavior with increasing numbers of boats in the Akaroa Harbour area. In the same location, Stone (1999) observed short-term changes from interacting with conspecifics (one another) to interacting with boats. Stone and Yoshinaga (2000) also reported on a potential increase in boat strike on calves that could be correlated with increasing tourism and interest in Hector's dolphins in this area.

Common Dolphins (Delphinus delphis)

Common dolphins are typically a pelagic species found in large aggregations far from shore (Gaskin, 1992). However, in New Zealand they can be found relatively close to shore off the northeastern and central eastern coasts of the North Island (Neumann, 2001) and off Kaikoura in the northeast of the South Island (Würsig et al., 1997).

Common dolphins have been examined from a tourism impact perspective for the Bay of Islands (Constantine, 1995), the Hauraki Gulf (Leitenberger, 2001), and the east coast of the Coromandel Peninsula and Bay of Plenty (Neumann, 2001). Neumann found that common dolphins typically showed patterns of initial attraction to vessels (for bow-riding) for around 10 minutes, followed by around an hour of "neutral" response (neither attracted or avoided), then avoidance. Smaller groups of dolphins exhibited avoidance behavior earlier than larger groups. Interaction with swimmers was in all cases brief (around 2 minutes) and dolphins maintained a "safety distance" (greater than 3 meters). He also found that larger groups (more than 50 dolphins) were more likely to interact with swimmers than smaller groups.

Sperm Whales (Physeter macrocephalus)

In New Zealand, sperm whales are only reliably sighted off Kaikoura (northeast coast of the South Island). At this location the continental shelf is close to shore and a bathymetric feature known as the "Kaikoura canyon" is a favored foraging location for the species (Jacquet, Dawson, & Slooten, 2000). Sperm whales at Kaikoura are almost exclusively males; there is little social interaction, and a reasonable predictable surfacing, reoxygenation, and diving pattern exists for the whales (Richter, 2002). This predictability and near shore location has formed the basis of a considerable whale-watching industry in the area (Orams, 2002).

MacGibbon (1991) found that sperm whales off Kaikoura responded to the presence of whale-watching boats by having shorter respiratory intervals (less time between blows) and by spending less time at the surface. He also noted that sudden changes in boat speed, high-speed approaches, and proximity to whales all produced responses from the whales—usually by submerging without "fluking" (conducting a short shallow dive, presumably to avoid the boat). Gordon and colleagues (1992) showed that individual whales responded differently to the presence of whale-watch vessels; some were tolerant, others not. Richter (2002) showed that "resident" sperm whales (those that were regular visitors to Kaikoura) were more tolerant of vessels than "transients" (whales not recorded more than once at Kaikoura). He also found that respiratory intervals were decreased in the presence of vessels, and an increase in the frequency and amount of heading changes (direction the whale was swimming) in the presence of boats. There was also a decrease in time to "first click" (first echolocation signal) after the whale had dived.

Other Species

While the above species of cetaceans are those explicitly targeted for tourism in New Zealand, there are a number of other species that are encountered opportunistically or, in some cases, periodically, that form part of the "tourism attraction" on a variety of marine tours (including those specifically focused on marine mammals but also including other more general marine tours). There are no currently completed studies that assess the impacts of tourism on these species. There are, however, a number of studies that have addressed more fundamental questions surrounding the species distribution, abundance, biology, and behavioral ecology of these species in New Zealand waters. Species and studies include: humpback whales (Gibbs & Childerhouse, 2000), killer whales (Visser, 2000), southern right whales

(Patenaude, 2000), North Island Maui's (Hector's) dolphins (Russell, 1999), Brydes whales (O'Callaghan & Baker, 2002), and a variety of species of beaked whales (Dalebout, 2002). Species that are sometimes encountered but for which no studies have been currently completed include minke whales and pilot whales (see Childerhouse & Donoghue, 2002, for a summary of cetacean research in New Zealand).

While the findings of all the above reviewed studies identify some impact and disturbance as a result of tourism activities, in many cases (but not all) the behavioral changes reported are not statistically significant (at the alpha = 0.05 level). While scientists dwell excessively on this issue of statistical significance, the issue of greater relevance here (as Richter, 2002, quite rightly points out) is whether such behavioral changes are *biologically* significant. This is extremely difficult to assess given the wide-ranging behavior, habitat, and situational-specific issues that exist in cetacean-based tourism scenarios. What appears logical is that recorded responses and impacts are considered in terms of the known biological parameters of a species at a certain location. Thus, a fundamental understanding of the biology and behavioral ecology of a species is essential in making judgments regarding "disturbance" resulting from tourism activities. A related and extremely important issue, not addressed in any detail in any of these studies, is the issue of stress.

The Important Issue of Stress

It is well recognized that stress has a significant influence on the physical health of human beings. For example, Sapolsky (1994) states that "stress can make us sick, and a critical shift in medicine has been the recognition that many of the damaging diseases of slow accumulation can either be caused or made far worse by stress" (p. 3). It is also being increasingly recognized that other social mammals show similar physiological responses to long-term stress (Moberg & Mench, 2000). Recently, there has been much attention given to issues surrounding the ethics of animal welfare including the influence of stress (Broom & Johnson, 1993; Moberg & Mench, 2000). Examples of long-term captive animals that exhibit what is described by staff as "depression" when a companion dies illustrate a growing understanding that social and psychological phenomena can impact an animal's physiological health. It is also well understood that "intellectual" stimulation, activity, and social relationships are critical to the long-term health and survival of captive marine mammals (Goldblatt, 1993; Kleiman, Allen, Thompson, & Lumpkin, 1996). Thus, the potential effects of stress are relevant when considering the impacts of tourism on marine mammals, including cetaceans.

In his consideration of human stress and stress-related diseases, Sapolsky (1994) divides stress into three main types. The first is acute physical stress, such as that induced by immediate threats to life. The second is chronic stress, such as that produced by long-term difficulties and challenges like famine, disability, or parasite infestation. The third is psychological and social stress, those things that are perceived to be challenges or difficulties and for which the human body reacts as if they were. Acute physical stressors have been well studied in humans and other species and the physiological responses (such as the release of the hormone adrenalin in humans) are widely understood.

Sapolsky's important point is that the body of humans, and other animals, is well adapted to handling acute stressors. Homeostasis, or physiological balance, is reattained quickly after such "acute" events with little or no long-term impact on an animal's health and functioning. This is why "Zebras Don't Get Ulcers" (the title of Sapolsky's book): simply put, they don't spend their days thinking about what the lion might do to them, they only react when the lion is trying to do something to them. It is when an animal continually turns on the "physiological stress response" over an extended period in reaction to a situation (or even in anticipation of a situation) that long-term physiological problems can occur. [It should be noted that acute stress has been shown to be fatal in some circumstances with regard to small cetaceans. For example, Bearzi (2001) reported that a common dolphin died after a strike from a small biopsy dart.]

Long-term chronic problems can occur in mammals because physiological responses are adapted to maximize an animal's chances of survival in a short-term acute stress situation (e.g., escaping the pursuing lion). In this situation, a mammalian body rapidly mobilizes energy from storage sites (and inhibits further storage); heart rate, blood pressure, and breathing all increase in order to transport nutrients and oxygen to muscles; digestion, growth and the immune system are inhibited; reproduction is curtailed, sex drive decreases, pain is blunted, and perception sharpened. All of these physiological responses are adaptive to short-term "life-threatening" scenarios.

When these physiological responses to stress occur continuously over long periods, health problems result. The fact that there is widespread concern in modern human societies regarding issues such as high blood pressure, elevated heart rates, depressed immunity, peptic ulcers, etc., illustrates that it is now understood that stress has a significant impact on human health. Simply stated, if humans continually "turn on" the stress response they significantly increase their chances of getting sick.

An important question is whether the psychological and social stress that so clearly has health impacts in humans is also manifested in other animals. There is strong evidence to support this contention with regard to highly social mammals such as dolphins (Thomson & Geraci, 1986). Long-term captive situations show that dolphins can experience stress of a social nature and that physiological responses result (McBain, 1999). The measurement of "stress"-related hormones from blood samples is now standard husbandry practice in dolphinaria (Dierauf & Gulland, 2001). However, this kind of physiological indicator of stress is seldom available in the study of wild populations. The great majority of cetacean–tourism impact studies focus, almost exclusively, on observed changes in behavior over relatively short time frames. Thus, any conclusion that wild dolphin-based tourism has little impact on dolphins because there are few observed changes in behavior may well be incorrect. Many long-term impacts may indeed occur as a result of low-level, long-term chronic stress that an animal or group of animals may be experiencing but that is not able to be detected from observational studies. This long-term stress could potentially reduce reproductive rates, reduce immunity, and thus increase mortality and morbidity, and it could reduce the biological viability of an individual or group of cetaceans (Broom & Johnson, 1993; Lay, 2000). There have been no studies on New Zealand cetaceans that have addressed this (nor were they able to) and there has been no explicit acknowledgement of this issue, other than admitting the short-term nature of studies and by advocating the use of the precautionary principle.

There are, therefore, significant challenges in quantifying impacts of tourism activities on cetaceans, particularly with regard to the potential detrimental effects of long-term chronic stress. As a consequence, there is a need for a management regime that recognizes this potential and provides opportunities for managers to take a conservative approach in managing the industry. New Zealand's legal framework for protecting marine mammals is considered one of the strongest in the world; nevertheless, challenges remain in implementing the protective intent of the legislation. It is worthwhile reviewing the management regime utilized in New Zealand because it is often held up as a "model" for the industry worldwide (Baxter, 1993) and because the variety of completed studies reviewed above allows for a consideration of the "model's" effectiveness in managing the industry.

Management of Marine Mammal Tourism in New Zealand

Marine mammals in New Zealand waters are afforded complete protection under the Marine Mammals Protection Act (New Zealand Government, 1978). Marine mammal tourism is regulated under the Marine Mammals Protection Regulations (New Zealand Government, 1992). Responsibility for administering these laws and regulations falls to the Department of Conservation (DoC). DoC's primary mechanism for doing this is via the issuing of marine mammal tourism permits. A permit is required for any commercial enterprise wishing to offer and promote interaction opportunities (observing, swimming, snorkeling, etc.) with marine mammals. Permits can have a variety of conditions attached to them; however, all permits require the operator to have no significant adverse effect on the species targeted, to be in the interests of conservation, management or protection of marine mammals, and to have sufficient educational value. Operators are also required to have experience with marine mammals and the local area. These explicit requirements go beyond any other nation's legal framework for managing cetacean-based tourism and allow for DoC to set additional permit conditions.

In a number of situations DoC has set conditions of a permit to require an operator to provide support for research, in terms of a direct financial contribution or, in some cases, by providing a "platform" (i.e., passage onboard a boat) for research activities. The flexibility provided in the permitting and related permit condition procedures has allowed DoC to "tailor make" management regimes to suit particular locations, species, and, in some cases, vessel types. A variety of conditions have been utilized including restrictions on species targeted, animal status (such as no approaches for mothers with calves), locations, minimum depths, minimum approach distances, maximum number of vessels within a specified range, vessel types, vessel speed, vessel propulsion types, time spent with animals, and maximum number of trips.

A real advantage has been the ability to require operators to provide support for research. The majority of marine mammal tourism impact studies conducted in New Zealand to date have received support via this mechanism and many have been published in DoC's "Science for Conservation" series (see http://www.doc.govt.nz/Publications/004~Science-and-Research/index.asp). Furthermore, the permit renewal procedures have allowed DoC to update permit conditions when research has revealed the need for differing approaches to reduce potential impacts.

The system is not without criticism, however. Many marine mammal tourism permit applicants find the application procedure frustrating and too long (personal observation) and some operators find the conditions arduous. Probably of greater significance is that DoC has, at times, found it difficult to enforce permit conditions as a result of ambiguous wording in the regulations (e.g., what is "sufficient educational value"?) or when transgressions of regulations or permit conditions are difficult to prove (e.g., in assessing minimum approach distances). Also of relevance is the large number of permits that have been issued in New Zealand (as of June 2001 there were 75 issued for cetacean-based tourism) while the long-term impacts of such operations is not known. Of particular concern must be the issue of stress and its long-term implications, especially for endangered species such as the Hector's dolphin, an endemic animal that currently supports significant tourism activity. While the regulation is clear that tourism based on marine mammals is "to have no significant adverse effect," accurately establishing whether such adverse effect could or has occurred is difficult.

An additional challenge provided by such a flexible system is the lack of consistency around the country. While permitted operators are aware of, and for the most part obey, permit conditions, nonpermitted marine tour operators and private recreational vessels are seldom aware of such restrictions. As a consequence there is, understandably, considerable frustration amongst permitted operators who do the best they can to minimize impacts, provide educational services, and support research (as per their permit conditions) while some nonpermitted operators and private "boaties" flout such conventions and impose themselves on the animals in an inappropriate way (personal observation). Thus, there is considerable scope for DoC and permitted operators (and other interested parties) to educate the public about appropriate codes of conduct when in the proximity of marine mammals.

Priorities for the Future

In New Zealand, there has been a rapid and widespread growth of cetacean-based tourism (particularly based on dolphins). There is also a framework that attempts to provide a mechanism for the careful and sustainable management of the industry. However, a number of studies have identified that tourism activity is having a variety of impacts on the targeted cetacean populations. What is frustrating (but not unusual) is that "despite the obvious need, no New Zealand cetacean population has received detailed study before being targeted by commercial whale or dolphin-watching operations" (Bejder & Dawson, 1998, p. 2) and thus, "before and after" comparisons have not been possible. It is also extremely difficult (and too early) to reach conclusions regarding the long-term effects of tourism on dolphins and whales in New Zealand.

As a result of the above review of completed studies and a consideration of pertinent issues surrounding the effects of stress, cause and effect determination and impact assessment, the following research priorities and approaches are suggested for the future.

1. That understanding the fundamental behavioral ecology of a species at a specific location is a prerequisite for any impact assessment.

2. Control and experiment design formats are often useful, allowing comparisons of data collected in the presence of tourist (and other) vessels with data collected in the absence of vessels.
3. It is important for researchers to identify parameters that are both relevant to the species and location and that are measurable from a practical standpoint. Parameters could include: respiration rates, interanimal distance (separation), animal swim heading and speed, behavioral states (e.g., traveling, resting, foraging, socializing, milling), behavioral events (e.g., breach, leap, tail-slap, head-slap, spy-hop, blowhole "chuff", etc.), and acoustic activity.
4. Activity budgets can be a useful tool to measure and compare in the presence and in the absence of vessels.
5. Attention needs to be given to observing and measuring potential indicators of stress. These indicators could include, changes (elevation) in respiration rates, boat avoidance behavior, erratic and unpredictable behavior, decreased interanimal distance (separation), increased prevalence of external parasites, decreased reproductive rates (calf number decrease), change in activity budget (less time feeding, resting, socializing; more time milling and traveling), increased stranding rates, and increased mortality.
6. Particular attention and a careful approach needs to be given to those species/locations where the population is already under stress and/or is small in number. For example, North Island Hector's (Maui's) dolphin, South Island Hector's dolphin, Fiordland bottlenose dolphins, and Hauraki Gulf Bryde's whales.

It is recognized that the above list is rather general and not comprehensive; however, research into the impacts of tourism on cetaceans is in its infancy. A good start has been made over the past decade, but more work is needed. All species of cetaceans targeted for tourism in New Zealand live for over 10 years (some much longer); it is possible that detrimental impacts may not become apparent for some generations. Thus, a long-term, continued careful approach to research and management is essential if the worthy requirement of the New Zealand Marine Mammals Protection Regulations of "no significant adverse effect" is to be met.

Conclusion

All interested parties hope that marine mammal tourism can be a sustainable economic activity with few adverse effects on the targeted animals. Also, perhaps through experiencing marine mammals in the wild and by learning about them tourists can be changed to become more environmentally responsible citizens (Orams, 1997b). Certainly, the marine mammal tourism industry provides an economic value to these animals that adds an incentive to ensure that healthy and abundant populations exist into the future. This appears to be the aim of the New Zealand marine mammal management approach. However, significant challenges exist in its implementation. In particular, the issue of long-term tourism-induced stress deserves much greater attention in terms of research and more careful consideration in terms of management. While the legal framework that provides the base for managing the industry in New Zealand has been (quite rightly) applauded, the application and enforcement of the system has been difficult. In addition, the growth of the industry has naturally induced an increase in attention from private recreational "marine tourists." This group appears to be growing rapidly in some areas popular for commercial marine mammal tourism, and management of these activities is a significant challenge for the future. What is certain is that research has a critical role to play in the long-term sustainability of the marine mammal tourism industry in New Zealand.

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Biographical Note

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Review

Are we killing them with kindness? Evaluation of sustainable marine wildlife tourism

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ABSTRACT

The increasing popularity of marine wildlife tourism (MWT) worldwide calls for assessment of its conservation outcomes and the development of appropriate management frameworks to ensure the conservation of the species and habitats involved as well as the long term sustainability of this industry. While many studies have examined the positive and/or negative implications of particular forms of MWT, few have attempted to identify factors of concern shared across different types of marine tourism, or examine their implications for sustainability in a broader perspective. We reviewed the existing literature to highlight common impacts on animal behaviour, health and ecology, and to identify successful cases based on minimal negative affects and/or lack of chronic/irreversible impacts on target species or habitats. To ensure the achievement of both economic and ecologic objectives, the following steps should be integrated in MWT management: 1) Increase of research on the biology and ecology of target species/habitat and application of relevant information for the development of suitable policies, frameworks and management strategies; 2) Structured enforcement of existing policies and enhancement of ecological awareness of visitors through active education; 3) Application of an adaptive management framework to continuously improve the codes of conduct employed; 4) Involvement of different stakeholders and local communities in the development and improvement of the MWT activity. Combining these strategies with the extrapolation of frameworks and policies from cases where adverse ecological impacts have been addressed and successfully resolved can further contribute in ensuring the long term health and conservation of the species/habitats involved in MWT activities.

Contents

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1. Introduction

Wildlife tourism, the practice of observing wild animals in their natural environment has been steadily increasing along with human population growth, with the number of participants estimated to be between 79 and 440 million (International Ecotourism Society, 2000; Moorhouse et al., 2015) and projected to double over the next 50 years (French et al., 2011). If conducted responsibly, wildlife tourism can provide substantial financial benefits to local communities (Ballantyne and Packer, 2013; Gallagher and Hammerschlag, 2011; O'Malley et al., 2013) while at the same time contributing to conservation efforts. The protection of the species and habitats involved in this practice (Troëng and Rankin, 2005; Wilson, 2003) and the conversion to a more environmentally focused use of ecological resources (Ballantyne and Packer, 2013, Brunnschweiler, 2010, Landry and Taggart, 2010) are primary objectives of wildlife tourism. However, it is also imperative that wildlife tourism itself is managed efficiently to ensure negative impacts do not outweigh the positives gained. Environmental impacts range from changes in behaviour, health or ecology of specific species involved (e.g. Clarke et al., 2013; Haskell et al., 2015; Orams, 2002) to broader scale ecosystem changes, such as habitat alterations (e.g. Green and Higginbottom, 2001; Tisdell and Wilson, 2005a).

At present it is still unclear whether wildlife tourism is truly succeeding in achieving its conservation objectives, or if the direct and indirect effects on the environment counter its ecological benefits. Additionally, while the success of a tourism operation is evaluated for its 'ecological sustainability', a clear or commonly agreed on definition of this term has not yet been developed (Harding, 2006; Hardy et al., 2002; Swarbrooke, 1999). This leaves room for loose interpretations, misunderstandings and general lack of clarity in determining the conservation benefits of individual wildlife tourism operations and the industry as a whole. In the context of this paper we define an ecologically sustainable activity as one that does not result in chronic or irreversible detrimental changes. This includes long term negative changes in behaviour, physiology, fitness and population dynamics of the organisms involved and alteration of the habitat structure or ecosystem functions. For example, despite the detection for different shark species of short term behavioural changes linked to provisioning events, feeding operations do not appear to drive their long term movements (Brunnschweiler and Barnett, 2013; Huveneers et al., 2013; Laroche et al., 2007; Meyer et al., 2009). This suggests a limited level of impact of this particular tourist activity on the animals involved, as no long term or irreversible effects on their behaviour were observed.

To assess ecological sustainability of marine wildlife tourism in general, we reviewed the published scientific literature on marine wildlife tourism activities to (1) compare and contrast the environmental impacts and potential trends between the different forms of marine wildlife tourism (MWT; see Box 1 for definitions), (2) highlight key examples of sustainable MWT to derive successful management frameworks, (3) identify common hindrances to the achievement of ecologically sustainable MWT, and (4) discuss core elements and management strategies that can been employed at local or international level to maximize ecological benefits and minimize negative impacts of MWT practices.

Box 1
Terminology. Definitions of terms associated with wildlife tourism derived from the literature covered in this review.

Marine wildlife tourism (MWT) A form of non consumptive tourism that focuses on the observation of marine species and habitats, and in some cases even direct human animal interaction.
Megafauna watching The practice of observing large wild marine animals from the shore or using operator manned vessels, without directly interacting with them.
Swim with megafauna The practice of observing large wild marine animals in the water through regulated snorkelling/SCUBA diving activities.
Provisioning The practice of using food to attract target marine species increasing the chances of observing them, or to promote a direct interaction between tourists and animals in a controlled situation by means of feeding.
Ecological sustainability Ensuring that the tourist practices performed don't have chronic or irreversible ecological changes when compared to the existing baseline information collected through scientific research or local historical records.

2. Methods and results

Search engines Google Scholar, Web of Science and Science Direct were used to obtain peer reviewed publications related to marine wildlife tourism. A first selection was made with the use of the following keywords and combinations of these words: marine wildlife tourism, marine ecotourism, sustainable tourism, whale watching, SCUBA diving, shark diving, provisioning, sea turtle tourism, pinniped watching, marine bird watching and tourism management. This preliminary search led to over 90.000 results, the majority of which however resulted to be not relevant to this review as focusing on topics not related to MWT ecological impacts and management. Grey literature e.g. unpublished theses, conference proceedings and non peer reviewed publications were also excluded. A further selection was then carried out by sorting the publications obtained using the following criteria: the study should have as main focus MWT related research, monitoring, management and/or sustainability. This led to a total of 396 publications with a wide geographical range, extending from Arctic to the tropics. Each study was then sorted in one or more categories based on the different types of MWT discussed, focusing on those most commonly studied in the literature (see Box 1).

Whale watching was the most investigated topic, with 121 studies (30.5% of the 396 publications selected) focusing on evaluating direct and indirect impacts of whale watching practices on different species and analysing/proposing management strategies. 63 publications (15.9%) addressed the topic of SCUBA diving (or 'reef' diving) in relation to environmental impacts, compliance to policies and current management practices or codes of conduct. 56 studies (14.1%) focused on elasmobranch tourism (mainly shark species), 30 (7.6%) on sea turtles. And 19 studies each (4.8%) for both pinniped and shorebird watching.

Management frameworks, achievement of set conservation goals and socio economic implications were addressed in almost all papers examined, either by merely acknowledging their importance for the improvement of MWT or conducting thorough analyses of current status from a local case specific to a global scale. Despite the fact that the majority of the publications examined focused on or even just mentioned the concepts of 'ecologically sustainable (tourism)' and 'sustainability', no comprehensive definition of the terms was presented, and only few papers acknowledged this fact (1.7%) or provided a contex tual definition (3.6%).

3. Discussion

Through the review of the papers selected we identified information relevant to address the focal topics highlighted in the introduction: assessing the current status and sustainability of MWT around the globe and provide insight on different perspectives and approaches to overcome its conservation and management issues.

The information is presented in the sections below following these major themes:

1) Assessment of marine wildlife tourism: underlying approaches, perspectives and obstacles.
2) Observed impacts of MWT on the different species/habitat involved.
3) Recorded 'sustainable' cases of MWT and shared characteristics.
4) Recurring issues hindering sustainable MWT.
5) Proposed strategies for effective management of MWT and achieve ment of ecological conservation objectives.

Additional data files that contain information directly supportive of the topics presented in this work are provided as Appendices.

3.1. Assessing marine wildlife tourism

Wildlife tourism (WT) impacts the environment, even if marginally, as the mere presence of humans is sufficient to affect a habitat's compo sition or a species' behaviour/physiology (e.g. Burger et al., 1995; Fowler, 1999). Thus, the issue is to assess if the level of impact is accept able for the tourism operation to be considered ecologically sustainable. While acknowledging that a consistent definition of this term is current ly not available, a series of criteria that are commonly presented in the literature as indicators of success or as essential elements associated to an economically and ecologically sustainable practice can be employed to evaluate each MWT practice on a case by case basis, as well as generically. These criteria include: 1) increased awareness and/or conservation effort relating to the marine species involved (Orams and Hill, 1998; Tisdell and Wilson, 2005a; Zeppel and Muloin, 2007), 2) limited/no negative effects on their behaviour, ecology and physiology (Birtles and Mangott, 2013; Smith et al., 2014), 3) an organised and adaptable management of the marine resources that prioritises the welfare of the habitat/species involved (Higham et al., 2008; Landry and Taggart, 2010), and 4) direct and active involvement of local communities and relevant authorities in the management of the MWT activity (Brunnschweiler, 2010; Scheyvens, 1999). By assessing whether these criteria are met when evaluating a MWT practice, it is possible to highlight key elements in research and management that require to be addressed and/or improved to ensure the achievement of the conservation goals set for this practice.

Evaluating whether a MWT practice meets these criteria is however just a first step toward the improvement of its ecological sustainability. The understanding of the different ecological impacts caused by MWT on the environment (at local and international scales) and their specific cause is fundamental for the development of suitable strategies for the improvement of MWT policies focusing on species and habitat conservation.

3.2. Impacts of marine wildlife tourism

As shown in the extensive records and literature present, the most popular and widespread forms of marine wildlife tourism are cetacean watching, shark watching, provisioning, SCUBA diving/ snorkelling, marine bird watching and observing pinniped and sea tur tles on land and in water. These tourism practices have been considered socio economically successful and ecologically sustainable in the short term (Burgin and Hardiman, 2015) based on loose definitions and contextual goals. However, there is considerable controversy now sur rounding many of these ventures because of their impacts on habitat and/or species involved (Silva, 2015). Although the changes observed are often classified as case specific or temporary (Apps et al., 2015; Barker et al., 2011a), the continuous presence and cumulative effect of such negative impacts is likely to have long term consequences (Barker et al., 2011b) such as decrease in health or reproductive fitness (e.g. Burger et al., 1995; Orams, 2002), population alterations (e.g. Brunnschweiler et al., 2014; Clarke et al., 2013) and habitat shifts (e.g. Bravo et al., 2015; Hawkins et al., 1999).

Despite the overall lack of long term studies investigating the ex tended ecological impact of MWT, the existing evidence on the topic has highlighted the alteration of the behaviour, ecology and physiology of several target species (Table 1a b; Appendix 1).

3.2.1. Human presence

Most of the impacts observed are involuntary and/or secondary con sequences of the presence and conduct of tourists and operators. High boat/human density and unpredictable maneuvering have been report ed as immediate causes of stress and alteration of behaviour, population dynamics and distribution of the many species involved in MWT activ ities. The review of the literature showed 14 elasmobranchs, over 40 species of teleosts, 5 cetaceans, 8 pinniped species, over 10 species of shorebirds, 3 marine reptiles, and over 20 species of anthozoa and ben thic organisms being affected by the presence and behaviour of humans during MWT activities (Table 1a; Appendix 1). The presence of humans in proximity to wild animals often causes disruption of diel activities such as feeding (Christiansen et al., 2013), nesting (Anderson and Keith, 1980), nursing of youngs (Andersen et al., 2012; Kovacs and Innes, 1990), communication (Jensen et al., 2008), and leads to an in crease in avoidance behaviours (Andersen et al., 2012; Blane and Jaakson, 1994; Haskell et al., 2015), alert signals (Cubero Pardo et al., 2011), and threatening/aggressive displays (Stafford Bell et al., 2012). In some cases, lack of coordination between vessels or reckless driving has led to accidental injury of the target animal (Araujo et al., 2014; Bryant, 1994; Denkinger et al., 2013). There is also concern that over crowding of divers/snorkelers and high number of boats at popular sites could even lead to the abandonment of that location (Barker et al., 2011b; Burger et al., 1995), a significant issue when considering spe cies with feeding/breeding site fidelity, such as cetaceans, pinnipeds, sea turtles and shorebirds. The presence of humans can also affect repro ductive rates, breeding success and caring for young (Burger and Gochfeld, 1993; French et al., 2011).

The handling and riding of marine animals still occurs (e.g. sharks in the Bahamas), as reported both by the literature (e.g. Gallagher et al., 2015; Tisdell and Wilson, 2005a) and social media. Some operators do so in front of customers to increase the excitement in the experience, but there is little information on the effects that this may have on animal health. For example, sharks being handled and placed into tonic immobility (a trance like state) may suffer from negative physiological/ biochemical effects and increased stress (Brooks et al., 2011; Davie et al., 1993; Gallagher et al., 2015). The practice of handling/touching marine fauna is however becoming rarer as many operators have worked on developing/applying appropriate management frameworks and ensuring the enforcement of regulations and codes of conduct aimed at the conservation of the local marine species and habitats (Barker and Roberts, 2004; Camp and Fraser, 2012; Fabinyi, 2008; Luna et al., 2009).

3.2.2. Provisioning

Marine tourism often involves provisioning wildlife (see Box 1 for definition) to concentrate animals such as elasmobranchs, teleosts and

Table 1a
Summary of documented consequences on target organisms/habitats of human presence and activities linked to MWT practices around the world. (see Appendix 1 for details concerning the species involved, case studies and related publications).

Activity/disturbance	Observed consequence	Number of cases recorded for each group
Presence of humans and/or excessive proximity	Disruption of activities or altered behaviour	Elasmobranchs: 11 Teleosts: 1 Cetaceans: 6 Pinnipeds: 10 Shorebirds: 8
	Disruption of communication between individuals	Cetaceans: 2
	Vocalization changes	Pinnipeds: 1
	Alert signals	Elasmobranchs: 1 Pinnipeds: 1 Marine reptiles: 1
	Aggressive behaviour displays	Pinnipeds: 1
	Increased predation susceptibility	Elasmobranchs: 1
	Habituation	Elasmobranchs:1 Cetaceans: 1 Pinnipeds: 1
	Evasive behaviour or site abandonment	Elasmobranchs: 7 Cetaceans: 3 Pinnipeds: 6 Marine reptiles: 1 Shorebirds: 6
	Alteration of spatio-temporal movements and patterns	Elasmobranchs: 3 Cetaceans: 2
	Change in species composition/abundance	Cetaceans: 1
	Changes in population structure/dynamics	Elasmobranchs: 1 Teleosts: 1 Pinnipeds: 2
	Decrease in reproduction rate	Pinnipeds: 1
	Alteration of nesting distribution or abundance	Shorebirds: 7
	Decrease in nesting success (loss of egg and young; nest abandonment; trampling)	Shorebirds: 5
	Alteration of pup/chick behaviour	Pinnipeds: 1 Shorebirds: 3
	Physiological stress (alteration of corticosterone levels or other stress indicators)	Pinnipeds: 1 Shorebirds: 1
High density of vessels and/or uncoordinated maneuvering	Physical injury to animals	Elasmobranchs: 5 Marine reptiles: 1
Divers' contact with bottom/reef	Physical damage of benthic flora/fauna (breakage; abrasion; sedimentation)	Benthic flora/fauna: 19
	Increased susceptibility to disease or other stressors	Anthozoa: 2
	Change in benthic structure, species composition/dominance	Benthic flora/fauna: 3
Divers interaction with fauna	Alteration of behaviour	Elasmobranchs: 5
Photography	Stress of target species	Shorebirds: 1 Anthozoa: 1
	Damage of the surrounding habitat to access the target species	Anthozoa: 3
Inappropriate tourist' behaviour	Alert signals	Pinnipeds: 1
	Disruption of activities or altered behaviour	Pinnipeds: 1
	Aggressive behaviour	Cetaceans: 1
Anchoring	Physical damage to the benthic habitat and reef	Anthozoa: 4
Pollution	Decreased habitat health	Benthic flora/fauna: 4

dolphins for reliable viewing by visitors. Of the 48 provisioning studies reviewed, 89.5% have highlighted how these practices can affect behaviour, with changes that range from minor short term disturbances to long term modifications of activities and conditioning to feeding events, even causing dependency and habituation (Table 1b; Appendix 1). In some cases, constant human animal interaction increases risk of injury for both tourists and animals (e.g. Cunningham Smith et al., 2006; Holmes and Neil, 2012), and can also lead to inter /intra species competition (e.g. Brunnschweiler et al., 2014; Clarke et al., 2013) or aggression (e.g. Clua et al., 2010; Orams, 2002; Smith et al., 2008) (Table 1b; Appendix 1). For example, cases of restlessness and 'pushy' behaviour toward tourists caused by delay in food delivery or undesired physical contact can occur during the provisioning of wild dolphins (e.g. Holmes and Neil, 2012; Cunningham Smith et al., 2006; Orams et al., 1996).

Aside from affecting the behaviour of the animals, provisioning also has the potential to negatively influence their health, particularly when inappropriate/artificial food is used (Newsome et al., 2004) (Table 1b; Appendix 1). Despite the ever growing popularity of MWT provisioning practices, there is only minimal information available on its effects on animal health (sometimes with contradictory results) and detailed long term studies have yet to be carried out (Burgin and Hardiman, 2015; Gallagher et al., 2015). For example, elasmobranch tourism occurs in approximately 85 countries (Gallagher et al., 2015), yet the effects of tourism activities on animal behaviour and/or health have only been studied to some degree for 19 species (17 species in provisioning studies) in 18 locations (Table 1b). The literature clearly shows that tourism can affect elasmobranch behaviour (Table 1a b; Appendix 1), but little is known about adverse effects on long term health. Although some studies acknowledged possible health issues (e.g. Clua et al., 2010; Fitzpatrick et al., 2011; Barnett et al., 2016), evidence thus far would suggest that the Grand Cayman Island provisioning of southern sting rays *Dasyatis americana* is the only operation with a definitive negative effect on the health of the target species (Corcoran et al., 2013; Semeniuk et al., 2007; Semeniuk et al., 2009).

The nature of the provisioning site (temporary or permanent) may play a role in influencing the long term health of animals as much as the intrinsic characteristics of each species (Araujo et al., 2014; Barnett et al., 2016; Laroche et al., 2007).

Table 1b
Summary of documented consequences on target organisms/habitats of provisioning and activities linked to MWT practices around the world. (See Appendix 1 for details concerning the species involved, case studies and related publications).

Activity/disturbance	Observed consequence	Number of cases recorded for each group
Provisioning wildlife	Change in species composition/abundance	Elasmobranchs: 16 Teleosts: 18
	Alteration of animal's behaviour	Elasmobranchs: 12 Teleosts: 17 Cetaceans: 5
	Decrease in care for the offspring	Cetaceans: 1
	Change in offspring's behaviour	Cetaceans: 2
	Alteration of spatio-temporal movement and patterns	Elasmobranchs: 8 Teleosts: 17 Cetaceans: 1
	Habituation, conditioning and/or dependency on humans	Elasmobranchs: 6 Teleosts: 15 Cetaceans: 3
	Increased predation and alteration of the local trophic structure	Elasmobranchs: 2 Teleosts: 12
	Inter- and intra-specific competition	Elasmobranchs: 18 Teleosts: 14 Cetaceans: 3
	'Pushy' behaviour	Cetaceans: 4
	Physical injury to animals	Elasmobranchs: 4 Cetaceans: 1
	Decrease in animal's health	Elasmobranchs: 3 Cetaceans: 1
	Changes in diet and energetic intake	Elasmobranchs: 4 Cetaceans: 1
	Increased parasite density	Overall: 2
	Nutrients-induced alteration of water quality	Overall: 1

Provisioning can also directly and indirectly affect trophic dynamics, structure and health of local habitats by altering species composition and/or abundance, variations in the size structure and trophic structure of the marine community (Table 1b). For example, given that bottom feeding batoids are highly influential in structuring benthic communities (Hines et al., 1997), the increased residency resulting from tourism at stingray city in Grand Cayman Island suggests that predation (>160 stingrays) more than likely modifies and then regulates the structure of the benthic community at and around the feeding site (Corcoran et al., 2013).

3.2.3. Habitat alteration

Habitat degradation and physical damage are other consequences associated with the development of MWT, particularly with regard to SCUBA diving (Di Franco et al., 2009; Hasler and Ott, 2008) or vessel dependent activities (Jameson et al., 1999; Saphier and Hoffmann, 2005). The behaviour of both operators and tourists is the major determining factor in the alteration of benthic structures and water quality: carelessness in movements (Camp and Fraser, 2012; Gil et al., 2015; Hasler and Ott, 2008), touching the different sessile plant and animal species (Uyarra and Côté, 2007; Wilkinson and Souter, 2008), pollution from both littering and vessels (Danovaro et al., 2008; Dearden et al., 2007) are responsible for the gradual decline in habitat health or benthic species composition (Table 1a). The stress on the local environment caused by MWT increases the susceptibility of benthic communities to disease (Vignon et al., 2010), predation (Corcoran et al., 2013) and/or possibly contributes to a habitat shift toward more opportunistic and resilient species (Hawkins et al., 1999; Lloret et al., 2006; Nugues and Roberts, 2003; Schleyer and Tomalin, 2000). Pollution and increased nutrients due to frequent and large scale provisioning are also factors likely to alter the structure and health of the local marine ecosystem (Dearden et al., 2007; Saphier and Hoffmann, 2005; Turner and Ruhl, 2007; Wilkinson 2008). Coastal habitats/ecosystems are also subjected to other forms of tourism, leisure activities, development and industries (Davenport and Davenport, 2006; Hall, 2001). The consequences recorded for MWT are thus further enhanced by the combined and cumulative effect of several anthropogenic activities, which lead to a critical need for the development and enforcement of policies and management frameworks aiming at the conservation of marine/coastal ecosystems. However few studies have focused on the effects of MWT activities on local habitats: of the 396 papers reviewed only 20 (5%) have addressed the topic. More information can be found related to the habitat effects of tourism in general, rather than MWT specifically, a fact that highlights a knowledge gap that needs to be urgently addressed, particularly given the relevance of habitat health on the wellbeing of all organisms inhabiting an area (Rosenberg et al., 2000).

3.3. Sustainability of marine wildlife tourism

There are cases where the combination of scientific based knowledge, appropriate policies, enforcement of regulations and regular monitoring have allowed MWT to be considered ecologically sustainable, as detailed in Section 3.1 (Table 2). Such cases present reported evidence of lack of chronic/irreversible changes in the ecology of the species involved or in the ecosystem. Unfortunately the published scientific literature documenting such 'successful' cases is quite sparse (4.3% of the MWT literature analysed). Nevertheless, the evaluation of successful cases can provide valuable information for the development of best practices and strategies for sustainable MWT. We present as example three case studies which meet all the criteria of success detailed in Section 3.1, and have been able to contribute to the preservation of the species involved while allowing the development of a touristic activity.

Table 2
Studies documenting ecologically successful cases of MWT around the globe, and common management features shared by them with regards to target species conservation.

Documented 'successful' cases of marine wildlife tourism		
MWT activity	Species	References
Shark-watching	Grey Nurse Shark (*Carcharias taurus*) Whale Shark (*Rhincodon typus*)	Apps et al., 2015; Barker et al., 2011a; Mau, 2008; Smith et al., 2010; Smith et al., 2014
Whale-watching	Dwarf Minke Whale (*Balaenoptera acutorostrata*) Humpback Whale (*Megaptera novaeangliae*)	Arnold and Birtles, 1999; Birtles et al., 2002a, 2002b; Birtles et al., 2005; Birtles et al., 2008; Birtles et al., 2014, Wilson, 2003
Turtle-watching	Atlantic Green Turtle (*Chelonia mydas*) Hawksbill Sea Turtle (*Eretmochelys imbricata*) Leatherback Sea Turtle (*Dermochelys coriacea*) Loggerhead Sea Turtle (*Caretta caretta*)	Meletis and Harrison, 2010; Tisdell and Wilson, 2002a, 2002b; Tisdell and Wilson, 2005b
SCUBA-diving	N/A (reef ecosystem)	Lee, 2013; Rosales, 2006
Shared management features*		
Presence of official policies to ensure species/habitat's conservation		
Strict limitations in sites accessibility: time, areas, licenses, number of tourists allowed		
Structured management		
Clear education of operators and tourists on existing policies		
Monitoring of compliance with policies		
Enforcement of regulations and fining or reporting to competent authorities in case of breach		
Prohibition of behaviour/objects that might be a source of stress or damage for the animal		
Monitoring of animal's behaviour to detect signs of stress/disturbance		
Adaptive management approach		
Environmental assessments and strategic planning prior to and following the establishment of the MWT activity		
Involvement of local communities in decision making		
Promotion of scientific research on ecology/physiology of target species		
Operators' involvement in scientific research on target species		
Enhancement of tourists' ecological awareness through education		

* Detailed information on the policies developed and enforced for each 'successful' case of MWT is reported in Appendix 3.

3.3.1. EXAMPLE 1 grey nurse shark (Eastern Australia)

Detailed guidelines/codes of conduct (see Box 1 for definitions), together with the almost complete compliance from divers, led to the gradual development of tourism interactions with the critically endangered grey nurse shark (*Carcharias taurus*) in Eastern Australia (Smith et al., 2014). Monitoring studies have reported the absence of significant changes in behaviour or occurrence/density of grey nurse sharks, despite the regular and frequent encounters with divers (Barker et al., 2011a; Smith et al., 2010). The integration of scientific data on the ecology of these sharks with information gathered on participants' perception and behaviour has allowed to improve shark divers interactions through the development of an adaptive management framework (Apps et al., 2015) with strict regulations aimed at protecting the sharks from being disturbed while allowing tourist activities (Barker et al., 2011a; Smith et al., 2010).

3.3.2. EXAMPLE 2 minke whale (Northern Australia)

In the Northern sections of the Great Barrier Reef (GBR) Marine Park, Australia, whale watching organizations have developed an effective system for swimming with dwarf minke whales (*Balaenoptera acutorostrata*) with minimum or no observed negative impact on the presence and behaviour of the cetaceans (Birtles et al., 2002a; Birtles and Mangott, 2013). The animals were found to voluntarily approach slow moving/stationary vessels and swimmers (Birtles and Mangott, 2013), which would indicate a lack of disturbance from this tourism ac tivity and even interest or curiosity on behalf of the cetaceans involved (Birtles et al., 2002a; Birtles et al., 2014). Limited vessel presence (a maximum of 6 permits per year are released), highly managed swimmer behaviour and strict regulations concerning the duration of the encounters as well as speed, direction and distance from the whales, allow for the animals to carry on with their activities and dictate the terms of the interaction (Birtles et al., 2002a; Birtles et al., 2014). Despite the lack of information about the biology and ecology of these animals, the measures described above and the prevention principle employed at the early stages of development of this particular activity have allowed for the development of a popular and successful MWT that does not appear to negatively affect the health of the animals involved (Birtles et al., 2002a).

3.3.3. EXAMPLE 3   sea turtles (Costa Rica, Australia, etc.)

A multi location example of sustainable MWT is sea turtle tourism. The site specific habitat use patterns of sea turtles (i.e. predictable use of nesting beaches and foraging grounds) means that turtle human interaction rates can be high. The highest volumes of people interacting with sea turtles normally occur at nesting beaches, where tourists observe female turtles laying eggs. This activity is practiced in several locations around the globe with regulations developed and enforced to ensure the safety and wellbeing of the turtles and the eggs, e.g. Tortuguero in Costa Rica (Meletis and Harrison, 2010) and Mon Repos in Australia (Wilson, 2003). Because of the existence of strict guidelines and codes of conduct based on scientific information and adjusted on direct observations from operators, this form of tourism has been refined over time to minimize impact on the behaviour and health of the animals involved (Meletis and Harrison, 2010; Wilson, 2003).

Although there is not much information published in primarily liter ature (Landry and Taggart, 2010; Wilson, 2003), many sea turtle tourism ventures employ similar codes of conduct. Online searches for “turtle watching guidelines” show a plethora of locations that have comparable set guidelines.

3.4. Recurring issues in marine wildlife tourism

Regardless of the existence of positive examples such as those highlighted previously, our review identified several common issues among MWT practices that can hinder the proper development of an ecologically sustainable tourism. These include knowledge gaps, poor management frameworks, and lack of enforcement and implementa tion of best practices.

3.4.1. Lack of background information and baseline data

Comprehensive knowledge on the biology, ecology and behaviour of a particular species or population is not always available, due to reasons that can range from mere lack of baseline/long term data to logistical difficulties associated with the collection of information (e.g. species that move over large ranges or unknown habits) (Birtles and Mangott, 2013; Clarke et al., 2011). Information on species' biology and ecology is essential for a timely detection of signs of negative impacts such as al teration of health, behaviour, distribution, and population dynamics. With such knowledge it is possible to develop best courses of action to eliminate the source of disturbance through timely intervention and ap propriate policies/management frameworks and ensure increased con servation benefits for the species and habitat involved (Birtles and Mangott, 2013; Gallagher et al., 2015; Schaffar et al., 2009). For many species and locations, best practices and codes of conduct are however generated by operators based on their experience and personal obser vations, or on management tools employed in similar MWT practices, but they often lack the required scientific grounding (Birtles and Mangott, 2013; Clarke et al., 2011; Landry and Taggart, 2010). While such regulations might be a first step in establishing a correct manage ment plan for a MWT activity, the lack of specific information on the target species as well as lack of long term monitoring of the effects of tourism might lead to the implementation of ineffective guidelines and measures, thus deviating from the long term sustainability goal of MWT.

3.4.2. Lack of physiological data

The lack of physiological information is one of the biggest gaps in un derstanding and managing the impacts from tourism, and probably one of the hardest issues to address. Of the 396 studies reviewed, only 10 focused on physiology. Behavioural studies have provided important evidence of the existence of negative impacts of MWT on marine species (e.g. Cubero Pardo et al., 2011; Granquist and Sigurjonsdottir, 2014; Quiros, 2007) (Table 1a). However, there are instances where such information is not sufficient or might even be misleading. Changes in behaviour do not necessarily indicate poor health, and there are also cases where the health of the individual is negatively affected but there are no visible signs or behavioural manifestations to indicate it (Beale and Monaghan, 2004; Bejder et al., 2009; Gill et al., 2001). The few physiological studies conducted so far have contributed to deter mine whether the health of the animals and overall population fitness are compromised (e.g. French et al., 2011) (Table 1a). In the long term this could possibly lead to selection against sensitive individuals (Bejder et al., 2006; IWC, 2006; Lusseau and Bejder, 2007), a topic of particular concern considering the ‘threatened’ or ‘endangered’ status of some of the species involved (Hoyt, 2001; Quiros, 2007). Collecting data on the physiology of the target animals can be extremely difficult due to the nature of the sampling procedures and often lack of baseline data to use as reference. However, knowledge of physiological thresh olds and indicators of health for the species involved in MWT are essen tial for the detection of negative impacts at individual and population level, and resolve if evident behavioural changes result in detrimental flow on effects to health. Integrating such information in MWT manage ment is a fundamental step toward the development of suitable policies and monitoring frameworks to reduce as much as possible negative health implications on the target species and ensure proclaimed conser vation benefits are realistic.

3.4.3. Poor management and frameworks

The sole presence of extensive scientific knowledge is not however sufficient for the sustainable development of marine tourism. Inadequate frameworks and guidelines (e.g. excessive vessel allowances, underesti mate of the limit distance from the animals, unsupervised behaviour of the tourists, etc.) coupled with lack of enforcement are also responsible for the several negative impacts of MWT on target species (Constantine et al., 2004; Parsons, 2012; Sitar et al., 2016; Wiley et al., 2008).

The maximum capacity of a particular habitat, the tolerance limits of the species involved and the long term impacts of a MWT activity can sometimes be overlooked (intentionally or not) during the develop ment of the management frame, sometimes simply to give priority to the socio economic goals (Bearzi, 2007; Steckenreuter et al., 2012; Van Waerebeek et al., 2007).

The presence of unclear regulations or the discontinuity between international, national and local policies is also likely to result in the decreased efficacy of such management tools. Conflicts of interest, over lapping of jurisdiction, the existence of several codes of conduct and lack of coordination between different stakeholders are also issues that indirectly contribute to the downsides associated with MWT (Garrod and Fennell, 2004; Parsons, 2012; Wiley et al., 2008).

Moreover, the contrast between the different interests and priorities of the stakeholders involved in the development/management of a MWT, coupled with a lack of clear terminology (i.e. definitions of ‘successful’, ‘ecologically/environmentally sustainable’, etc.), are likely contributors to the divergence of goals and ineffectiveness of manage ment strategies, particularly those aiming at ensuring the long term health and conservation of MWT species and ecosystems (Adams et al., 2003; Newsome et al., 2005; Swarbrooke, 1999).

3.4.4. Lack of proper implementation and enforcement

Good management plans and guidelines have no value if they are not adequately implemented (Parsons, 2012; Pavez et al., 2015; Sitar et al., 2016; Wiley et al., 2008). Large scale monitoring of visitors' behaviour and enforcement of regulations are not always feasible due to logistic and economic constraints, and in many cases the management and implementation of guidelines/restrictions takes place at a smaller, local scale (Allen et al., 2007; Constantine et al., 2004; Dobson, 2006). Unfortunately, lack of coordination between operators, lack of compliance from the different stakeholders including the operators themselves (Parsons, 2012; Pavez et al., 2015; Wiley et al., 2008) and a greater interest in the economic exploit of the resource rather than in its conservation (Parsons, 2012; Steckenreuter et al., 2012; Van Waerebeek et al., 2007) are not infrequent, and hinder greatly the development of ecologically successful MWT practices. These factors coupled with ignorance of the consequences of tourists' actions and unmanaged behaviour of both visitors and operators frequently leads to chronic disturbances and stress on the environment (Garrod and Fennell, 2004; Shaalan, 2005; Zeppel, 2009).

3.4.5. Lack of consideration of the social context of MWT destinations

Engaging locals as stakeholders in tourism development is essential to ensure sustainability in nature based tourism as well as maintain consideration of the values and needs of the local communities and increase awareness/engagement for the conservation of the species and habitats involved in MWT (Agardy, 1993; Wilson, 2003). The potential for rapid or unregulated tourism development to lead to social impacts on local populations and to destination decline has been well documented in the broader tourism literature (e.g. Butler, 1980; Diedrich and García Buades, 2009). However, the local social dimension receives surprisingly little attention in the MWT literature. Rather, MWT studies tend to focus on evaluating the satisfaction or characteristics of tourists (e.g. Ballantyne et al., 2009, Catlin and Jones, 2010) or on mitigating impacts on marine wildlife (e.g. Bravo et al., 2015, Cassini et al., 2004). While these factors are undeniably important, failure to consider the existing socio economic and cultural context of the destination where MWT is occurring could lead to negative repercussions in the local population as well, which, in turn, can have negative impacts on marine wildlife and on tourists. For example, in fishing dependent communities, tourism can create conflict and resentment for conservation measures associated with MWT sustainability among local people if they feel they are losing control and access to natural resources (e.g. Bennett and Dearden, 2014). Tortuguero National Park in Costa Rica is well known for its success in balancing MWT and marine turtle conservation; but several violent conflicts have occurred between foreign volunteers and illegal poachers, which has negatively impacted its reputation as a tourism destination (The Washington Post, 2013). The desirable alternative is that MWT, through its associated benefits, will generate alternative livelihoods and reduce harvest/consumption of marine resources, thus promoting local awareness and support for conservation measures (e.g. Diedrich, 2007; Wilson, 2003).

3.5. Strategies for effective management of marine wildlife tourism

The combination of socio economic and ecological knowledge is essential for the development of adequate management frameworks that aim at the long term ecological sustainability of MWT in addition to a profitable income. Several recommendations and possible directions for management and research have been proposed and introduced in the literature, many of which recur across the different forms of MWT (Fig. 1; Appendix 2).

Elements such as long term monitoring, stricter regulations and increased ecological awareness of both operators and visitors can be applied to different contexts, independently from the location or the target species/habitat. The development and application of such strategies and best practices requires however considerable knowledge of the organisms and ecosystems involved. Based on the literature available it is evident that more physiological studies and monitoring assessments are required to cover the knowledge gap related to MWT. Given that studies of this type are often difficult to carry out (particularly for marine species) and require time, it would be best in the meantime to adopt a precautionary approach in the management of the interaction between tourist and animals (e.g. Gallagher et al., 2015; Richards et al., 2015), a prime example being the minke whale tourism (see Section 3.3.2). This issue is not unique of marine tourism, but common also to other recreational activities, like sportfishing (Kieffer, 2000; Meka and McCormick, 2005; Suski et al., 2004). Nevertheless, the rapidly increasing number of studies and literature available on the subject, coupled with the growing interest from the public, are a promising sign of the effort aimed at addressing this knowledge gap.

A further step that can be taken to improve MWT is the application of the core elements of successful cases to other forms of marine tourism to improve their long term sustainability (Table 2; Appendix 3). As the sea turtle nesting industry has demonstrated, common regulations can be developed and implemented leading to positive outcomes, despite the geographical, cultural and socio economical differences existing between locations (e.g. Costa Rica vs. Mon Repos). The application of such elements should not be limited to the same form of marine tourism: principles and management guidelines from turtle tourism could be adapted and applied to other forms of wildlife tourism. For example: identifying a limit distance for approach, establishing restricted areas for tourism presence, keeping the visitors in small controlled groups, and prohibition of direct approach or any behaviour that could disturb the animals are all policies employed in turtle tourism that can be readily applied to any other form of MWT.

Based on the evaluation of the existing literature, the recorded cases of successful and sustainable marine wildlife tourism all share the implementation of an adaptive management framework (Fig. 2), which is characterised by five major points:

1) A well organised management plan of the activity, where the socio economic and ecologic aims of the MWT practice as well as the roles of the different stakeholders are clearly delineated.

2) The development of clear policies/guidelines based on current scientific knowledge and direct on field observations.

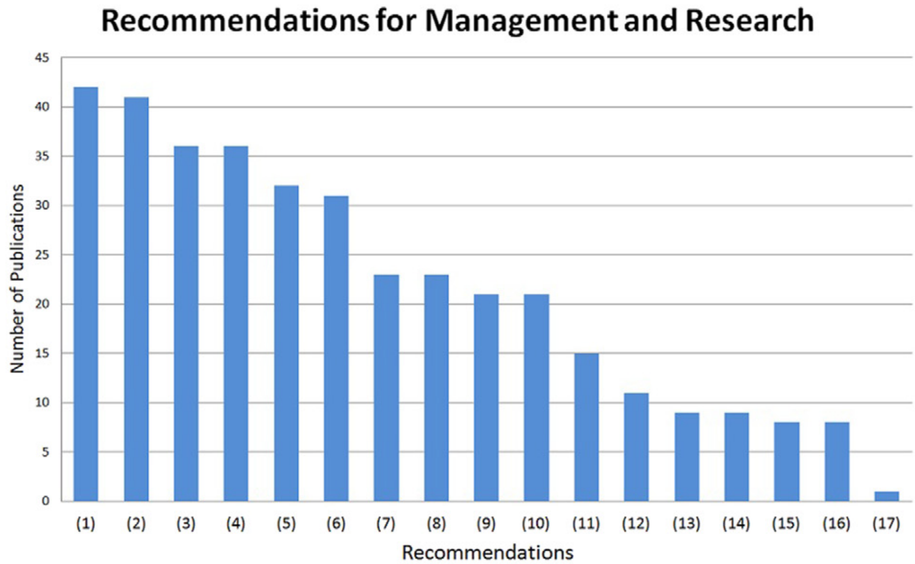
3) The structured and strict enforcement of said rules on behalf of the operators and, where possible, official local/governmental authorities, coupled with the active education of tourists.

4) Long term monitoring of the effects of the MWT practice on the environment and target species to provide researchers and stakeholders with information required to adequately upgrade the policies and management frames implemented (feedback mechanism).

5) An active effort at increasing the ecological awareness, education and involvement of both tourists and operators in the conservation of the species/habitat involved in the MWT practice (thus reducing the risk of accidental negative impacts on the environment).

These steps should be taken into consideration when planning the development of a MWT practice, or integrated in the management of existing marine tourism activities. Several models, approaches, and frames for management have in fact been proposed in the past to address the issue of tourism impact on the environment while at the same time allowing for economic and social growth (Barker and Roberts, 2004; Higham et al., 2008; Rouphael and Hanafy, 2007). Their implementation however, often results non viable for reasons that range from costs and time limitation to socio economic issues (Dobson, 2006; Harriott et al., 1997; Parsons, 2012; Pirotta and Lusseau, 2015).

Generalised regulations and strategies however are not always sufficient for the proper development of a marine touristic activity. The diversity between different forms of MWT, and even within the



Recommendations
(1) Long-term monitoring of effects and ecosystem health
(2) Control of access: careful and strict regulation of number of visitors and duration/frequency/closeness of encounters
(3) Structured and official enforcement of regulations
(4) Increase ecological awareness and education of visitors and operators
(5) Clear management frameworks
(6) Monitoring and regulation of visitors' behaviour
(7) Creation of specific guidelines, protocols and codes of conduct based on scientific knowledge and case-specific observations
(8) Increase of scientific research on the ecology and physiology of species/habitats involved in MWT
(9) Adaptive Management: feedback mechanisms to improve management frameworks with information collected through monitoring
(10) Promotion of stakeholders involvement and collaboration
(11) Clear understanding of the ecological strength and weaknesses of each touristic site/species to create appropriate management frames
(12) Detailed information on the ecological, social, economic, and touristic demands as well as requirements involved in each site/case
(13) Creation of seasonal or permanent no-go areas
(14) Entrance fees to provide funds for research, management and enforcement
(15) Creation of infrastructures that reduce risk of habitat damage
(16) Precautionary approach in absence of clear data
(17) Development of prediction models and simulation platforms to account for all the different components in the management of MWT (ecologic, economic, social, etc.)

Fig. 1. Occurrence of the most popular recommendations for management and research in the MWT literature (for more details see Appendix 2).

same type of activity, requires the guidelines to be adjusted to the situation (Constantine and Bejder, 2008; Higham et al., 2008; Pirotta and Lusseau, 2015). Characteristics such as location, species involved, environmental factors, tourist demand and pressure, local socio economic factors, and so forth, must be taken into account when developing and analysing a marine touristic activity. Different strategies and tailored management that actively involve all the interested stakeholders are therefore an essential component of MWT development.

Another factor to be addressed when generating a long term management framework is the different scales at which this type of tourism takes place (Fig. 3). Given the complexity and wide distribution of marine tourism around the world, each different form of this activity should be analysed at different levels: Global, National and Local (Fig. 3). This would allow various issues to be addressed at their appropriate scale and develop suitable solutions.

4. Conclusions

There is still quite a way to go before marine tourism around the world can be considered an effective, long term sustainable activity from both an economic and ecological point of view. We are not saying that marine tourism is failing in its attempt to be ecologically sustainable as well as profitable. On the contrary, as a world wide industry facing a diversity challenges due to its inherent characteristics and variability, the work dedicated at all levels (operators, managers, scientists, tourists, etc.) to reduce negative impacts has been and still is quite extensive, and has proven in several occasions to lead to positive outcomes (Bramwell and Lane, 2000; Davis and Gartside, 2001; Dolnicar et al., 2008; Miller et al., 2010; Swarbrooke, 1999).

In many cases, the problems associated with marine tourism are not the result of direct malpractice or absence of regulations, but rather the consequence of 1) lack of proper structure and

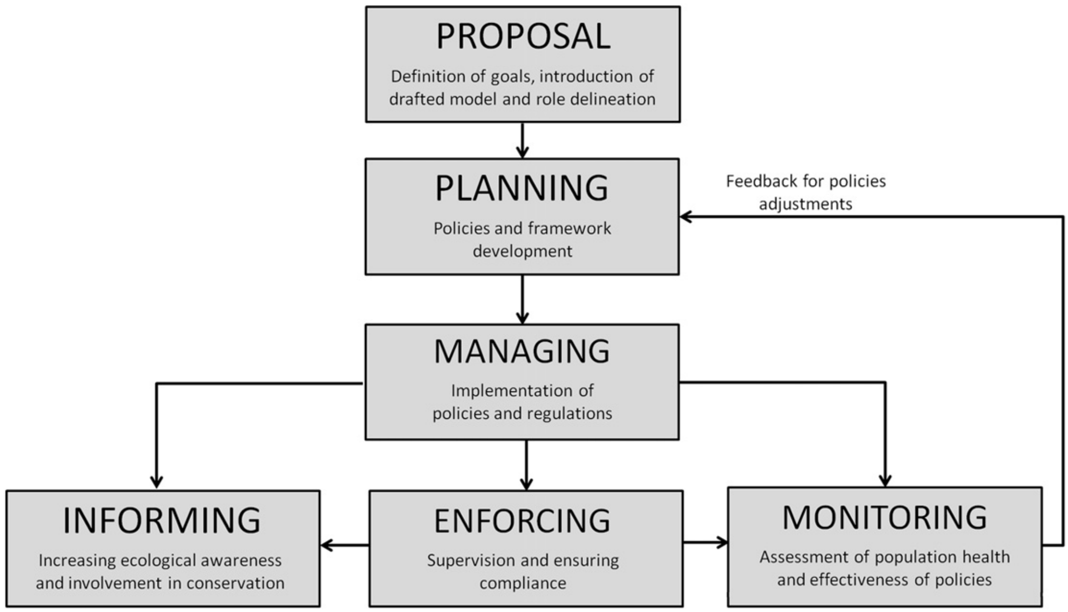


Fig. 2. Characteristics of MWT policies and management strategies at three different scales: global, national and local.

coordination, 2) conflicting/ineffective policies (due to being developed without proper scientific knowledge on the species and habitat involved), or 3) lack of enforcement of set regulations. These factors need to be taken into account and properly addressed when developing or managing MWT, particularly when considering that the ecological sustainability of any marine tourism activity varies on a case to case basis based on the combination of such factors and how well they are addressed.

There are still issues concerning negative effects of MWT that need to be addressed, but as demonstrated by the examples of successful cases it is possible to find an adequate solution for such issues, or at least mitigate the related downsides and therefore increase the likelihood of MWT providing tangible conservation benefits. To ensure the development of suitable policies, frameworks and management strategies for MWT activities that would ensure the achievement of both economic and conservation objectives, collaboration among stakeholders should focus on:

Increase research effort on the biology, ecology and behaviour of the species/habitat involved, with particular focus on establishing suitable indicators of health and enable early detection of negative impacts linked to MWT. Often data collection can be integrated in the MWT activity and carried out by operators and researchers.

Integration of the knowledge obtained through research in the planning phase of MWT practices as well as in the update/improvement process of existing policies (adaptive management framework).

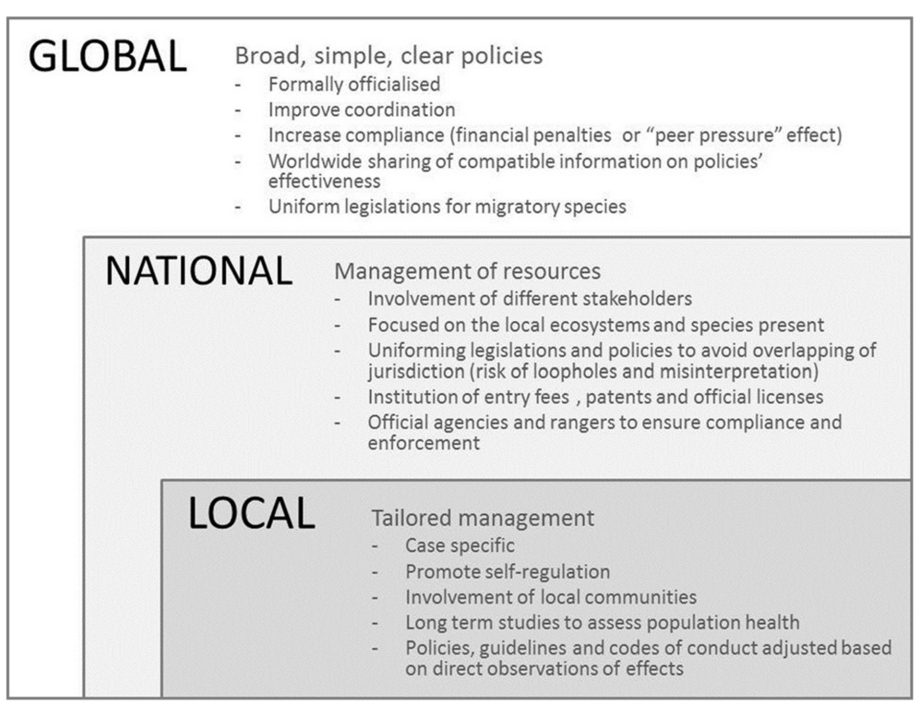


Fig. 3. Adaptive management framework for marine tourist activities.

Focus on reducing the observed negative impacts of MWT practices through prevention as well as improving existing frameworks: a) Increase education and ecological awareness of operators and visitors regarding the local species/habitat, b) Involve local communities in preserving their natural assets through non consumptive activities and adequate management of MWT, and c) ensure the enforcement of policies by MWT operators and local authorities.

Apply the five core elements of adaptive management framework (as described in Section 3.5) from the planning phase of MWT, if possible.

Evaluate the possibility to implement conceptual elements, existing policies and frameworks from reported 'successful' cases, in the structure of other MWT cases/activities by adapting them to the specific circumstances of each case.

Increase the consideration of scale (Fig. 3) as well as MWT type, geographical , and species specific characteristics during the planning phase of each MWT activity and the development/improvement process of policies to ensure their applicability and maximize success on a case specific level.

Management of marine touristic activities is not a static process. It is only with the active participation of all the different parties involved (i.e. governments, management agencies, researchers and scientists, operators, and local communities) in the main stages of any marine touristic industry planning, managing and monitoring (Fig. 2) that it is possible to work toward the betterment of MWT and ensure its long term ecological sustainability. Information sharing, planning and cooperation at all levels of development and management are essential for the success of this endeavour.

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Department of Conservation
Te Papa Atawhai

Media release

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Kaikoura whale watching review decisions

A Department of Conservation review of Kaikoura sperm whale tourism has decided not to allow any new whale watching tours at this time but additional aircraft viewing may be permitted in the future.

A 10-year suspension of new permits for commercial sperm whale watching off Kaikoura has been declared. Additional permits for commercial aircraft viewing could be considered within that period if a change was made to the 1992 Marine Mammals Protection Regulations. That change would be to exclude aircraft from the rule allowing no more than three vessels at a time, aircraft or boats, to view a whale or pod of whales.

The review decisions were made in the interests of the sperm whales. They took into account scientific research into the impacts of commercial tour activity on the sperm whales, comments and information in 12 public submissions, and the requirements of the Marine Mammals Protection Act 1978 and its regulations.

A preliminary DOC report had proposed allowing a small precautionary increase in commercial whale watching but DOC South Marlborough Area Manager David Hayes said as a result of further information the department concluded more caution was needed for the welfare of the whales.

‘Additional information including in public submissions and from other research along with further discussions with the research scientists have led us to reconsider allowing additional commercial boat whale watching activity out of concern it might have a significant adverse impact on the whales. It has also led to us taking a more precautionary approach towards allowing additional aircraft permits.

‘Ten submissions opposed the preliminary report’s proposal to allow three further boat trips a day, one supported it and one did not comment on it. Eight submissions commented on the proposed two additional aircraft permits with one supporting it, one partially supporting it and six opposing it.

‘A factor in the decision not to allow further boat permits was that the number of boat trips made daily could increase significantly under the current two boat permits. The number of whale watching boat trips taking place is not at the full capacity allowed in those permits. It was also likely to be much reduced during the period the research was carried out with fewer tourists due to the economic downturn.

‘Consideration of additional aircraft permits has been made conditional on the rule on no more than three craft viewing a group of whales being changed to allow more aircraft to be present. Otherwise the additional aircraft could result in whales being watched for longer or more whales being focused on.

‘The review concluded aircraft could be excluded from the three-vessel rule and additional aircraft permits could be considered if this occurred given the research found aircraft on their own had little or no apparent effects on the whales. The research team observed changes in whale behaviour when boats, and boats and aircraft were present, no matter how many there were, but changes in whales’ surface behaviour were not apparent when only aircraft were there.’

The Department is currently considering reviewing the Marine Mammals Protection Regulations 1992 separate to this Kaikoura sperm whale tourism review.

The proposed increases in whale watch activity in the Department’s preliminary report were based on findings from the scientific research for DOC from 2009 to 2011 by an international team of marine mammal experts that observed changes in whale behaviour from tour activity but concluded these effects were small and minor.

The review of Kaikoura sperm whale tourism took place ahead of the expiry of a previous 10-year suspension of new permits for commercial whale watching put in place in 2002. It is intended further scientific research on the impacts of commercial whale watching on Kaikoura sperm whales would take place before the expiry in 2022 of this year’s 10-year suspension of new permits.

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Contacts
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Additional information

- Currently, there are four permits for aircraft-based marine mammal watching off Kaikoura which each allow one aircraft at a time to view marine mammals. The aircraft permits are operated by Kaikoura Helicopters (two permits), Wings over Whales and the Kaikoura Aeroclub. Whale Watch Kaikoura Ltd is the only company with permits for boat-based whale watching. It has two permits which in total allow a maximum 16 trips per day.

- The scientific research team observed three changes in whale behaviour. When boats were present the whales breathed slower, there was more variance in their changes of direction and the whales began to echo-locate slightly later once underwater.

- Decisions on the management of permitting of commercial whale watching are made in line with the Marine Mammals Protection Act 1978 and the Marine Mammals Protection Regulations 1992 which focus on the conservation, management and protection of marine mammals. Under the legislation, socio-economic factors such as commercial competition and effects on people are not relevant and cannot be taken into account.