Regional diversity and biogeography of coastal fishes on the West Coast South Island of New Zealand

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Cover: Sampling rockpool fishes at low tide (station H20), point opposite Cape Foulwind, Buller, 13 February 2000. *Photo: MNZTPT*

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ABSTRACT

A fish survey was carried out along 500 km of the West Coast South Island (WCSI) between Milford Sound (Fiordland) and Gentle Annie Point (Buller) during 1998–2000. Sampling at depths of 0–25 m, using mainly rotenone ichthyocide and spear, was conducted by teams of 4–6 divers who spent c. 150 hours under water collecting specimens and recorded habitat data. Intertidal rockpools and estuarine/freshwater habitats were sampled for c. 70 hours. A total of 101 marine, estuarine, and freshwater fish species in 72 genera representing 45 families were recorded, with station inventory lists supported by c. 3000 voucher specimens. Greatest fish species diversity was on subtidal rocky reefs. Species composition differed with major changes in habitat: sheltered deep reefs in the fiord; semi-exposed deep reefs at Jackson Head; exposed shallow reefs along Westland and Buller coasts. The WCSI reef fish fauna is a typical assemblage of New Zealand widespread species, but contains some distinctive elements uncommon elsewhere. Three species new to science and four rare species were collected: (1) Milford Sound (Fiordland): orange rockfish *Acanthoclinus* ?n.sp., pygmy sleeper *Thalasseleotris* n.sp. (also at Jackson Head), fiord brotula *Fiordichthys slartibartfasti* Paulin and eyespot clingfish *Modicus tangaroa* Hardy; (2) Jackson Head and Murphy's Beach (South Westland): obscure triplefin *Gilloblennius abditus* Hardy; (3) Mokonui and Fourteen Mile (Westland): clingfish *Gastroscyphus* n.sp.; and (4) Seal Island, Punakaiki (Buller): marbled brotula *Bidenichthys consobrinus* (Hector). On the basis of physical and biological characteristics (including fishes, invertebrates and algae), three marine regions are recognised: Fiord; Fiordland open coast-South Westland; Westland-Buller. Results support the concept of a biogeographic transition zone between the Fiordland open coast and the Westland-Buller regions.

Keywords: coastal fishes, rotenone sampling, specimen collections, species diversity, rare species, new species, biogeography, West Coast South Island, Milford Sound, Buller, New Zealand

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1. Introduction

The marine fauna of the West Coast of the South Island (WCSI) is poorly known and the WCSI has always been a difficult area to study. Prior to the present study, there has been only restricted and isolated collecting of coastal fishes, mostly from intertidal areas. This was evidenced, for example, by the repeated blank sections along the West Coast in rockpool fish distributions plotted by Paulin & Roberts (1992), and the distribution maps of common rockpool and inshore fishes in Paulin & Roberts (1993), which were based on the holdings in the National Fish Collection (NFC) at the Museum of New Zealand Te Papa Tongarewa (Te Papa).

As part of an ongoing programme to survey the coastal fish fauna of New Zealand, a series of field surveys were organised with the Department of Conservation (DOC) to survey and collect along the WCSI. Comprehensive fieldwork, involving teams of scuba divers, began in the early 1990s as part of a programme to survey, collect and inventory New Zealand's coastal marine reef fishes. A total of three coastal surveys were carried out in 1998, 1999, and 2000 by the Te Papa Fish Team in association with DOC. These were the first serious attempts to systematically collect representative samples of inshore fishes along the WCSI.

1.1 WEST COAST MARINE ENVIRONMENT

The main difficulties associated with collecting along the West Coast (Fig. 1) have been ones of access, the absence of sheltered coast, high exposure of most of the inshore environment, a prevailing west to southwest air stream that creates very rough coastal sea conditions, and associated suspended sediments from large rivers and coastal erosion.

The following descriptive summary is based on Neale & Nelson (1998). The WCSI is a windward shore that transects a westerly temperate ocean current system, hence the shelf surface current is fed mostly by the warmer water derived from the Tasman Current. Its direction along the coast is determined primarily by local winds (prevailing from the southwest). As a result the west coast is swept by northward-moving current (the Westland Current) on some occasions and a southward-moving current on others. The mean current movement is weakly northward towards Cook Strait.

The coastline has a history of glaciation, tectonic uplift, erosion, and high sediment loading of the northern coastal waters. An excess of 2.4 m of rain falls annually, feeding several major rivers that drain onto the West Coast continental shelf. In addition, glacier-fed rivers in the South Westland area contribute substantial volumes of fresh water into the coastal region. The sediment loading of the northern inshore zone (north of Jackson Bay) is high compared to southern oceanic waters, due to the suspended loads of rivers and bottom disturbances by waves as they approach shallow water. It has been estimated that 127 million tonnes of sediment is carried down to the sea every

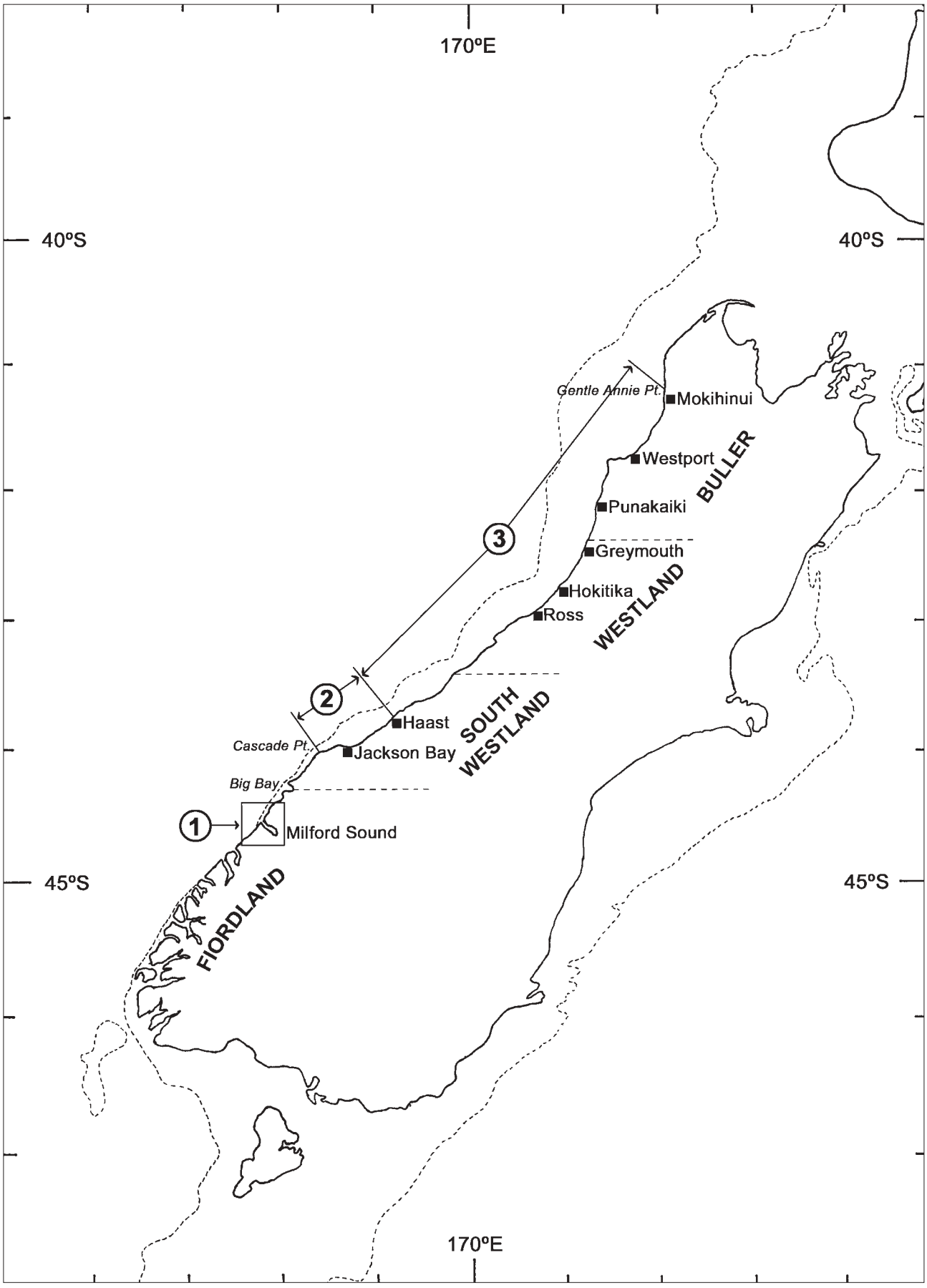

Figure 1. Map of South Island, New Zealand, showing locations of the three West Coast survey areas: (1) Milford Sound, (2) Cascade–Haast, (3) Haast–Buller.

year, giving this region one of the greatest terrestrial erosion rates in the world (Griffiths & Glasby 1985). Most of the sediment covers the continental shelf with a deep bed of fine sands and mud, and forms gravely beaches. The frequent storms and abundant sandy gravel cause the WCSI rocky shores to be heavily battered by sand scour. Only a few semi-sheltered areas with deep water close by are less affected. Exposed rocky shores and shallow reefs are formed where geological structures of mountain systems of the Southern Alps reach the sea. Except for a few small rocky sites nestled behind small islands (e.g. Seal Island, Open Bay Islands) or headlands (e.g. Jackson Head), the West Coast's sheltered shores are restricted to estuaries enclosed by barrier beaches (e.g. Haast River, Okarito lagoon).

1.2 HISTORICAL SUMMARY

Early work on the marine fishes of WCSI (e.g. Clarke 1879) suggested the presence of several new species, new species records for New Zealand, and rare species that continued to be only sporadically represented elsewhere in New Zealand. However, the total composition of the WCSI fish fauna remained poorly known. One of the earliest reviews of the biogeographic distributions of the New Zealand coastal fish fauna (Moreland 1959) was limited in its scope by incomplete geographical coverage. Moreland (1959) did, however, recognise that the shore fishes within New Zealand were not distributed evenly, and identified four types of distributions: widespread (throughout New Zealand), and three overlapping distributions: Subtropical (far north, south to Bay of Plenty); Northern (from North Cape to Kaikoura–Banks Peninsula) and Southern (from Stewart Island to Banks Peninsula and Kaikoura). None of these analyses of distributions included fishes from the west coasts of the North Island or South Island.

Knox (1963) summarised three decades of ecological research and divided New Zealand and Australian coastal waters into biogeographical provinces based on physical and biotic features of the littoral (intertidal) and shallow sublittoral. Biological characters were based on presence and abundance of selected marine algae and invertebrates and fishes did not form part of the analyses. The South Island coastline comprised two provinces: a southern Forsterian Province and a Cookian Province (that extended onto the North Island). The boundary between these two provinces was poorly defined: on the east coast the boundary 'lies to the north of Dunedin'; 'while on the west coast the boundary remains to be determined but probably lies to the north of the Sounds [= fiords] region.' The west coast boundary was mapped (Knox 1963: fig. 5) at about Jackson Head. Earlier, Dell (1962) criticised the subdivision of New Zealand into biogeographical provinces and concluded from molluscan distribution data that 'no clear boundaries can be defined for any of the mainland littoral provinces' and that 'the concept of provinces has largely outlived its usefulness.'

King et al. (1985) divided New Zealand into Neritic Territories and Coastal Ecological regions based on physical (topography, hydrology) and biological information. The West Coast (excluding the Fiords and their open coast) was classified as part of the Central Neritic Territory; this ran from Cape Taranaki

and southern East Cape in the north, to Cascade Point and Otago Peninsula in the south. Along the WCSI, there were two coastal ecological regions recognised: Buller (= north-west Nelson to Punakaiki) and Western South Island (= Hokitika to Cascade). However, the identification of distinctive boundaries proved difficult, especially in areas where little physical and biological information was available, such as the WCSI. Nevertheless, the boundary between the Central Neritic Territory and Southern Neritic Territory was at Stripe Point just north of Milford Sound. Their Southern Neritic Territory approximated the Forsterian Province of Knox (1963) and others.

Walls (1995) reported division of New Zealand into eight biogeographic regions, based on consultation with marine taxonomic specialists during a workshop held in Dunedin in 1992. The WCSI formed part of the Central Biogeographic Region, which ran from North Cape south to Jackson Head on the west coast and East Cape to Otago on the east coast. This large area was determined by a range of fish and invertebrate species, which showed wide distributions down both the west and east sides of the North and South Islands. At that time it was generally agreed there was a biogeographic boundary at Jackson Head separating the Central from the Southern Biogeographic regions. However, one of the key points arising from the workshop was that there were numerous 'information gaps', including the transition zone on the WCSI, and research should target these regions (Walls 1995).

The most recent, comprehensive, large-scale plotting of biogeographic distributions of New Zealand marine reef fishes was by Francis (1996). In this study, the West Coast from Jackson Bay to Cape Farewell was classified as a single geographical region (Area 10, NWSI), abutting a southern sector (Area 12 Fiordland). There was a paucity of hard sample information on the fish faunas of these two regions, with totals of 52 and 79 species respectively (Francis 1996: tables 1, 2). Following principal components analyses and ordination, eight distinct regional groups were recognised. Areas 10 and 12 aggregated into Group 5, which also included reef fishes at Chatham Islands, NE South Island, SE South Island and Stewart Island. Within Group 5, Area 10 aggregated most closely with Area 12 (Francis 1996: fig. 4D). The regional boundaries between geographic areas (i.e. Jackson Head separating Areas 10 and 12) were based on geographic and oceanographic features considered likely to influence fish distributions. Therefore, the Jackson Head boundary was of necessity subjective, hypothetical and applied a priori, but failed to gain clear support from the statistical analyses of the reef fish faunas known.

Neale & Nelson (1998) found the West Coast marine environment shared many biological characteristics with other South Island coasts, particularly with respect to fishes and algae, but separated it from other New Zealand coasts by combinations of latitudinal location, high degree of exposure to waves, effects of sedimentation and sand scour, and shelf and river hydrology. They distinguished the West Coast from the Fiordland coast by the absence of sheltered inlets, dominance of sediments on beaches, and the broad continental shelf; and from Stewart Island by the dominance of mobile sediments. Because such differences were also reflected in the species assemblages found on the WCSI, the West Coast was considered a distinct ecological region, with unique features. The boundaries of this region, although not sharp, were thought most likely around Cape Farewell in the north and Martins Bay in the south. The West

Coast marine region was itself divided into three similar biogeographic/ ecological districts: South Westland; Westland; and Buller (Neale & Nelson 1998: table 1).

In summary, the WCSI has a coastal marine environment that has been classified as distinct by a number of studies using physical and biological characters. Although the marine biota has been incompletely sampled, some major differences with other South Island and southern North Island coasts have been indicated. Two boundary areas have been proposed, one in the north around Cape Farewell, separating the Cook Strait area from the WCSI, and one in the south, separating the Fiordland coastal region from the WCSI. The southern boundary, although accepted generally as indistinct, has been proposed to lie at Jackson Head (Knox 1963; Francis 1996), Martins Bay (Neale & Nelson 1998), Stripe Point just north of Milford Sound (King et al. 1985), or to form a transition zone along the coast between Jackson Bay and Milford Sound (Walls 1995).

2. Objectives

The main aim of the present study was to survey and comprehensively sample the coastal reef fish fauna on the WCSI between Milford Sound and Buller (see Fig. 1), to provide baseline knowledge of fish diversity in the form of station inventories, and to seek evidence of the West Coast biogeographic boundary or transition area. Our research proposal (DOC Science investigation no. 2360) identified the following objectives:

- Observe, collect, and identify coastal reef fish species on the WCSI
- Preserve and deposit voucher specimens in the National Fish Collection to support the species listed for sample stations
- Carry out biogeographic analyses of the species present
- Assess the scientific importance of the species diversity and distributions
- Assess the evidence for a southern WCSI biogeographic transitional zone

3. Methods

3.1 SUMMARY OF SURVEY METHODS

The Te Papa fish team has been carrying out a long-term programme to survey and sample fishes in all New Zealand coastal waters. The sampling methods used here have been documented in several publications and reports (Paulin & Roberts 1990; Roberts et al. 1991; Roberts & Stewart 1992; Paulin & Roberts 1994a, b; Willis & Roberts 1996). Fieldwork comprised comprehensive collecting of coastal fishes with rotenone and spear (see Section 3.2), supplemented by fishing with baited lines, during three 2-week summer periods in 1998–2000. Similar rotenone-based sampling methods have been used widely and successfully overseas (e.g. Smith 1973; Lardner et al. 1993).

3.1.1 Rotenone ichthyocide

Rotenone is a natural plant toxin, considered to be environmentally benign because it is chemically unstable and breaks down rapidly in water, degrading faster with heat and light, as well as becoming inactive with dilution and dispersal through the effects of wave action and currents. Fishes are acutely sensitive to rotenone at concentrations <1 ppm; invertebrates are generally less sensitive while humans and other non-fish vertebrates are insensitive. This provides a large safety margin between concentrations that kill fishes and those that may be harmful to non-target organisms (Ling 2003). Experiments in coastal waters have shown that local populations of fishes and invertebrates sampled by rotenone quickly recover through rapid recruitment from adjacent areas (e.g. Willis & Roberts 1996; Polivka & Chotkowski 1998). Rotenone is used for ichthyological surveys requiring comprehensive inventories, as in biodiversity, biosecurity, taxonomic and ecological studies, because it effectively samples small cryptic fish species. These are abundant and highly speciose in our coastal waters yet rarely seen, so are missed or greatly under-recorded (by 50 to over 500%) by underwater visual census (Ackerman & Bellwood 2000; Willis 2001). Use of rotenone during Te Papa fieldwork is carried out under special permits from the Ministry of Fisheries and DOC (in marine reserves) in accordance with the objectives of the Museum of New Zealand Te Papa Tongarewa Act (1992).

3.2 FIELD METHODS

3.2.1 Survey areas, dates and vessels

Milford Sound—This fiord was surveyed during 30 March–5 April 1998 from DOC's vessel *Renown*. The 1998 survey was confined to Milford Sound because of very strong winds and rough seas outside the fiord. For this reason, coastal reefs near the mouth of Milford Sound, indeed most of the Fiordland open coast, remain largely unsampled. The most seaward sites sampled during the present survey were stations F54 and F55 at St Anne Bay near the mouth of Milford

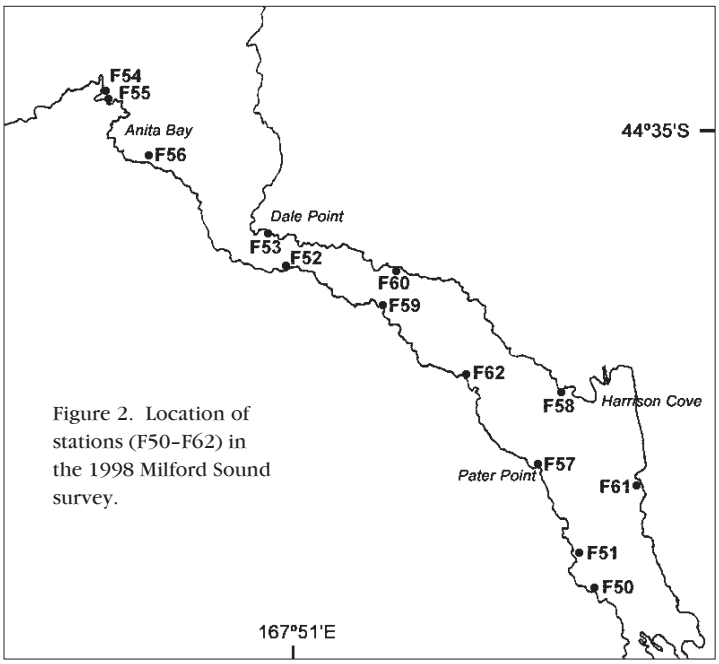

Figure 2. Location of stations (F50–F62) in the 1998 Milford Sound survey.

Sound. Stations F53, F58, F60, F61 were located within the Piopiotahi Marine Reserve that extends along the northern side of the fiord. A total of 34 hours were spent collecting and observing underwater by 6 scuba divers. Table 1 shows the dates and locations of the 13 sites surveyed (F50–F62) in the Milford Sound region; station locations are plotted in Fig. 2.

Cascade–Haast—Reefs between Teer Creek on the Cascade coast and the offshore Open Bay Islands were surveyed during 7–15 February 1999 using the 4.4-metre Te Papa dive boat *Beryx* in tandem with the local 6.0-metre vessel *Scorpion*. The 1999 survey, based out of Jackson Bay, experienced exceptionally favourable sea and wind

TABLE 1. LOCALITY DATA, COLLECTING METHODS AND SPECIES DIVERSITY AT STATIONS SAMPLED DURING THE MUSEUM OF NEW ZEALAND 1998 FISH SURVEY OF MILFORD SOUND.

STATION	LOCATION	POSITION	METHOD/ DEPTH	DATE	SPECIES		
					COLL.	SNC	TOTAL
F50	Sinbad Point	44° 39.76′S 167° 54.20′E	RO 17–20 m	30 Mar	5	10	15
F51	Point W of Sinbad Pt	44° 39.38′S 167° 53.92′E	RO 12–18 m	30 Mar	7	6	13
F52	Cabbage Tree Point	44° 36.38′S 167° 49.98′E	RO 11–20 m	31 Mar	7	12	19
F53 [m]	2nd point E of Dale Point	44° 35.98′S 167° 49.18′E	RO 11–17.5 m	31 Mar	2	20	22
F54	St Anne Bay	44° 34.53′S 167° 46.93′E	RO 10–14 m	2 Apr	9	12	21
F55 R	St Anne Bay	c.44° 34.53′S c.167° 46.93′E	RO (rockpool)	2 Apr	7	3	10
F56	Greenstone Point (W face)	44° 35.35′S 167° 47.98′E	RO 12–23 m	2 Apr	12	12	24
F57	Pater Point	44° 38.17′S 167° 52.62′E	RO 10–15 m	3 Apr	5	7	12
F58 [m]	Opposite Pater Point	44° 37.44′S 167° 53.35′E	RO 8–16 m	3 Apr	10	5	15
F59	Kettle Point	44° 37.34′S 167° 51.59′E	RO 10–18 m	4 Apr	10	7	17
F60 [m]	Punga Cove	44° 36.28′S 167° 51.26′E	RO 7–14 m	4 Apr	10	6	16
F61 [m]	Bridget Point	44° 38.61′S 167° 54.86′E	RO 6–14 m	5 Apr	14	5	19
F62	Point directly S of Stirling Falls	44° 37.45′S 167° 52.35′E	RO 4–17 m	5 Apr	12	9	21

R = rockpool; RO = rotenone; [m] = marine reserve station; Coll. = number of species collected; SNC = number of species seen, but not collected; Total = number of species present at station (sum of Coll. and SNC).

conditions (during a La Niña summer), which greatly aided the number of stations worked and underwater collecting conditions. Nevertheless, because of the very exposed nature of the region and distances involved for relatively small trailer boats, we were unable to extend the work south of Teer Creek. Hence, the more remote coast south to Milford Sound remains unsampled. A total of 76 hours were spent at marine stations collecting and observing underwater by 6 scuba divers. Table 2 shows the dates and locations of the 19 sites surveyed (H01–H19) in the Jackson Bay region; station locations are plotted in Fig. 3.

TABLE 2. LOCALITY DATA, COLLECTING METHODS AND SPECIES DIVERSITY AT STATIONS WORKED DURING THE MUSEUM OF NEW ZEALAND 1999 FISH SURVEY OF THE CASCADE–HAAST REGION.

STATION	LOCATION	POSITION	METHOD/ DEPTH	DATE	SPECIES		
					COLL.	SNC	TOTAL
H01	Flower Pot Rock, Jackson Bay	43° 58.04′S 168° 37.30′E	RO 5–9.5 m	7 Feb	16	13	29
H02	Reef 100 m N of Jackson Bay wharf	43° 58.94′S 168° 37.26′E	RO 1.5–2.5 m	7 Feb	16	4	20
H03	Smoothwater Bay, N side	43° 57.99′S 168° 35.46′E	RO 4.5–6 m	8 Feb	18	5	23
H04	Smoothwater Bay, N side	43° 57.99′S 168° 35.46′E	RO 1.5–2.5 m	8 Feb	17	8	25
H05	Jackson Bay Head 100 m on NE side	43° 57.63′S 168° 37.47′E	RO, HS 8–12 m	9 Feb	11	6	17
H06	Jackson Bay, 100 m from Flower Pot Rock	43° 57.87′S 168° 37.35′E	RO 0–3 m	9 Feb	16	1	17
H07	Smoothwater Bay, S side	43° 58.23′S 168° 35.02′E	RO, RL 2–4 m	10 Feb	9	6	15
H08	Cave Cove	43° 57.92′S 168° 35.76′E	RO 2.5–7 m	10 Feb	13	4	17
H09	Outer Frog Rock	43° 58.52′S 168° 33.49′E	RO, HS, RL 14–20 m	11 Feb	16	11	27
H10	Homminy Cove	43° 58.47′S 168° 34.23′E	RO, HS 0–3 m	11 Feb	21	4	25
H11	Outer Stafford Rock	43° 59.42′S 168° 31.79′E	RO, HS 11–15 m	12 Feb	18	10	28
H12 R	Inner Frog Rock, rockpools	43° 58.42′S 168° 33.95′E	RO 0–1 m	12 Feb	17	0	17
H13	Point S of Teer Creek Mouth	c. 44° 00′S c. 168° 28′E	RO, HS 15–18 m	13 Feb	15	12	27
H14	Seal Rock	43° 59.56′S 168° 31.45′E	RO 14–17 m	13 Feb	15	8	23
H15	Open Bay Islands S end of Popotai Island	43° 51.81′S 168° 52.48′E	RO 14–19 m	14 Feb	19	7	26
H16	Open Bay Islands S end of Taumaka Island	43° 51.75′S 168° 52.26′E	RO 0–3 m	14 Feb	13	4	17
H17	Jackson Bay, Mock-Maker Reef	43° 58.88′S 168° 37.26′E	RO 0–3 m	14 Feb	11	4	15
H18 F	Hapuka Estuary, Okuru	c. 42° 55′S c. 168° 54′E	RO, RL 0.5–2 m	15 Feb	4	2	6
H19 F	Frolic Brook, Arawhata River	44° 02.85′S 168° 43.50′E	RO 0–1 m	15 Feb	6	0	6

R = rockpool; RO = rotenone; F = estuary/freshwater station; HS = hand spear; RL = rod and line; Coll. = number of species collected; SNC = species seen but not collected; Total = total number of species present at each station (sum of Coll. and SNC).

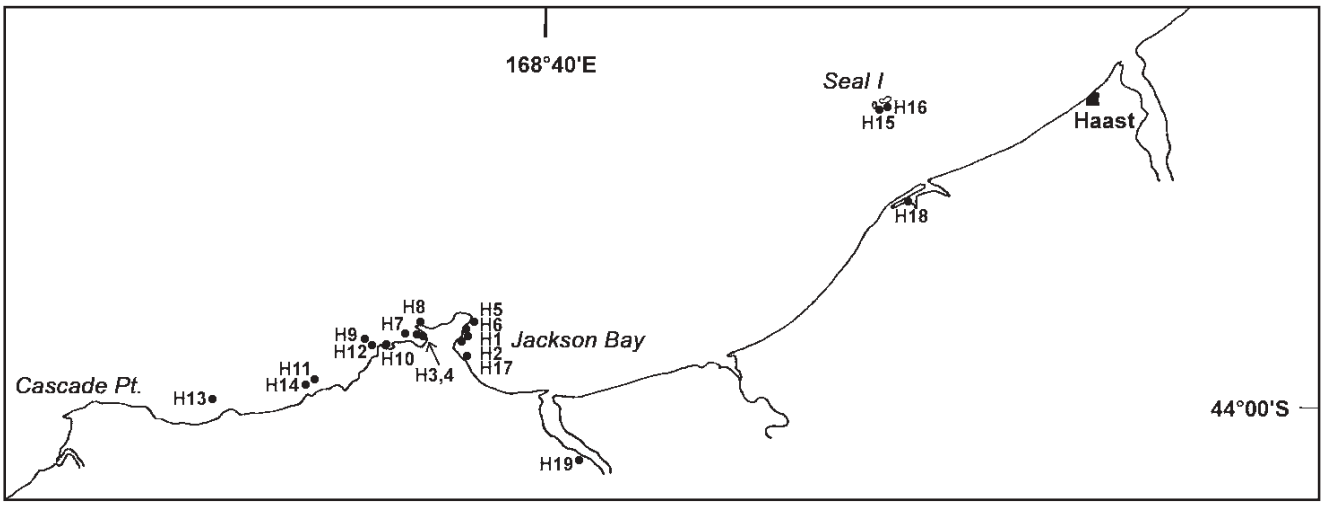

Figure 3. Location of stations (H01–H19) in the 1999 Cascade–Haast survey.

Haast–Buller—Reefs between Haast and Gentle Annie Point in Buller, including the near-shore Abbey Rocks, Hanata Island and Steeples Islands, were surveyed during 13–24 February 2000 using the local 6.3-metre vessel *Taku Hoa* or 4-wheel drive vehicles. In 2000, strong and persistent westerlies (an El Niño summer) made boat and underwater work difficult. A total of 25.5 hours were spent at marine stations collecting and observing underwater by up to 4 scuba divers. Dates and locations of the 17 sites (H21–H36) surveyed in the Haast–Buller region are shown in Table 3. Station locations are plotted in Fig. 4A and B.

3.2.2 Diving and sample stations

Stations surveyed by scuba or snorkel, were within coastal or near-shore intertidal reefs or shallow to middle-depth subtidal reefs (0–25 m deep). These habitats were targeted during the study, because they typically contain the greatest diversity of fishes and are near the maximum depth limit in temperate waters for safe collection by divers. Intertidal rockpools and reefs at the sublittoral fringe (0–3 m) were surveyed and sampled by wading and snorkel using nets and hand collecting; deeper reefs (3–25 m) were surveyed by scuba using nets and hand collecting. Collecting usually took place over a period of one to two hours at each station. Sandy seabed habitats were sampled only where they abutted or encroached into areas of reef at a station.

For each station, the information recorded was: station code and number, location, position (latitude and longitude with hand held or vessel GPS), site depth profile, habitat description, dominant fauna and flora as seen underwater, fish species seen underwater but not collected, and provisional identifications of specimens collected. Diving data (time of entry, duration underwater, maximum depth, depth profile) were recorded and monitored, following standard scientific diving practice (e.g. Flemming & Max 1996).

Each survey site was selected based on access (from either boat or shore), shelter from prevailing waves and currents, bottom topography and depth range, and predicted number and size of benthic habitats. Site selection was assisted by study of marine charts of the area, maritime radio weather forecasts, echo sounder readings and local knowledge. Station selection was determined underwater by the first pair of divers who marked the centre of the station with

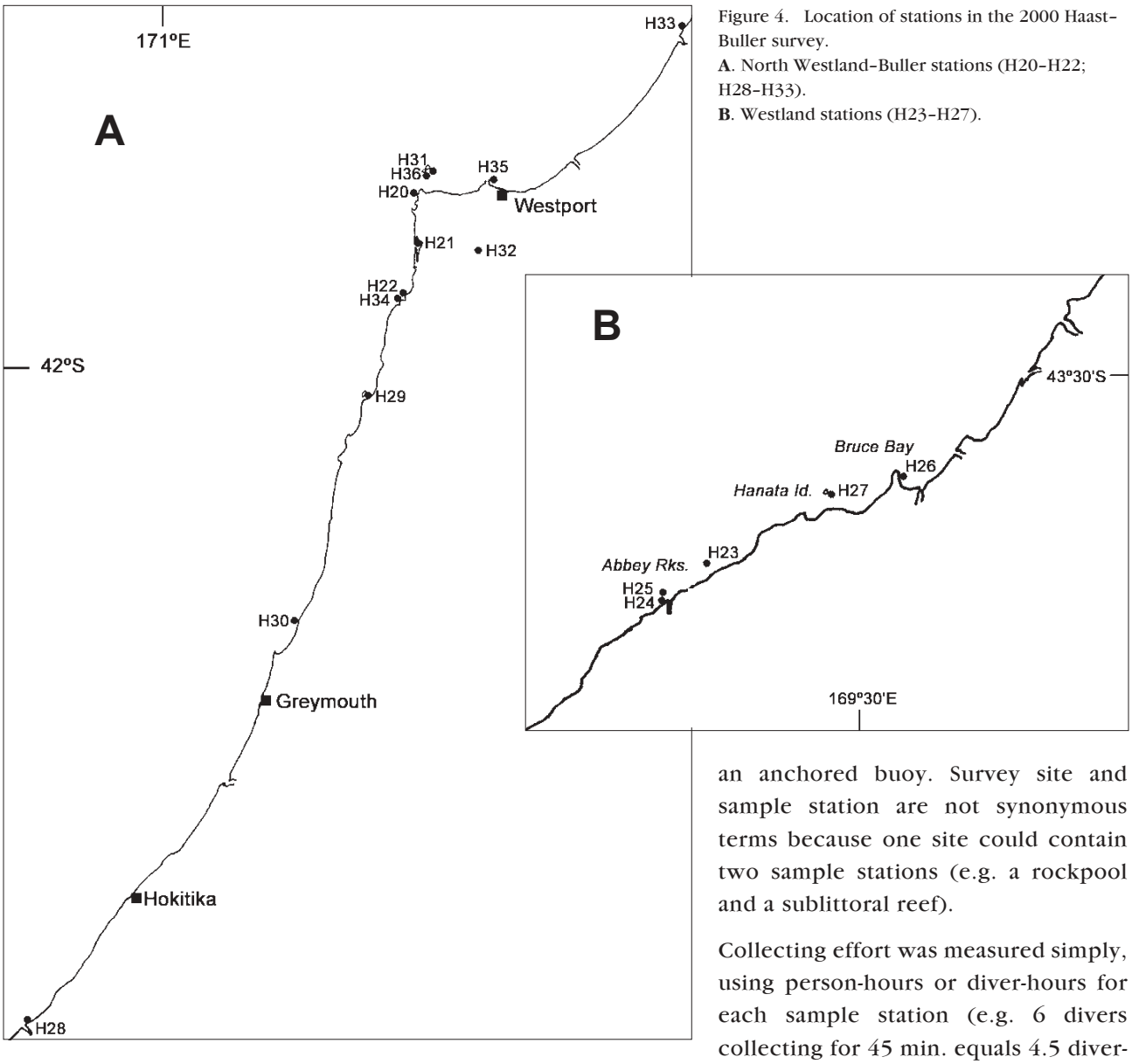

Figure 4. Location of stations in the 2000 Haast–Buller survey.
A. North Westland–Buller stations (H20–H22; H28–H33).
B. Westland stations (H23–H27).

an anchored buoy. Survey site and sample station are not synonymous terms because one site could contain two sample stations (e.g. a rockpool and a sublittoral reef).

Collecting effort was measured simply, using person-hours or diver-hours for each sample station (e.g. 6 divers collecting for 45 min. equals 4.5 diver-hours). Recording effort is similar, but includes fishes observed and identified, but not collected. The method of sampling rockpools and subtidal reefs aims to collect all species and all specimens present, and often the total time collecting is dictated by rate of capture. Usually collecting at a station will be finished c. 30 min. after the last fish has been collected, but the total time varies widely. For example, 10 rockpool species were collected from 3 different rockpools by 3, 8, and 10 person-hours of collecting, and from pools of 25, 40, and 90 square metres in approximate area (see Table 4).

During the three surveys, scuba divers spent a total of c. 150 diver-hours underwater at sublittoral marine stations in teams of 4–6, collecting rotenoned fishes, identifying large mobile fishes, and recording habitat observations. Intertidal stations were sampled for 38 person-hours, and freshwater or estuarine stations for 28 person-hours.

Intertidal rockpools—Rockpools were sampled opportunistically whenever medium-large sized pools (usually at least 10 m² in area and 0.5 m deep) were present in the lower intertidal reef area of a chosen site and tide, time and

weather conditions allowed. Rockpools on a windward coast can only be sampled effectively with rotenone when isolated from the sea at low tide because during higher stages of the tide waves will quickly flush rotenoned specimens out of the pool and dilute the rotenone concentration below its minimum strength to act as an ichthyocide. Also, rockpools can be hazardous places to work on exposed coasts during a rising tide.

Rockpools, 10–100 m² in approximate area and 0–1.5 m deep, sampled over the three surveys varied structurally and fell into the following types: deep depressions in hard granite reef containing rounded granite boulders and stones with very little cover underneath, and some fine sand on the bottom (e.g. F55 and H34); channels part-filled with boulders in hard rock, wave-cut platform

TABLE 3. LOCALITY DATA, COLLECTING METHODS AND SPECIES DIVERSITY AT STATIONS SAMPLED DURING THE MUSEUM OF NEW ZEALAND 2000 FISH SURVEY OF HAAST–BULLER.

STATION	LOCATION	POSITION	METHOD/ DEPTH	DATE	SPECIES		
					COLL.	SNC	TOTAL
H20 R	Rockpool on point opp. Cape Foulwind	41° 46.41′S 171° 22.15′E	RO 0–1.5 m	13 Feb	9	0	9
H21 F	Okari River lagoon S of Westport	41° 48.81′S 171° 27.89′E	RO, RL 0–1.5 m	13 Feb	5	0	5
H22 R	Rockpools, mid Little Beach N of Charleston	41° 53.54′S 171° 26.89′E	RO 0–0.5 m	14 Feb	3	0	3
H23	Abbey Rocks	43° 41.15′S 169° 20.02′E	RO 7–11 m	17 Feb	12	10	22
H24	N end Murphys Beach	43° 47.4′S 169° 14.1′E	RO 0–0.5 m	17 Feb	16	4	20
H25	Wehakapohai Rocks N end Murphys Beach	43° 42.27′S 169° 14.33′E	RO 12– 14 m	18 Feb	17	9	26
H26	Heretaniwha Point Bruce Bay	43° 35.2′S 169° 33.5′E	RO 0–2 m	18 Feb	7	2	9
H27	Hinata Island	43° 37.07′S 169° 27.47′E	RO 5–10 m	19 Feb	16	7	23
H28	Mussel Flats, Mikonui Reef, S of Ross	42° 54.2′S 170° 45.0′E	RO 0–0.5 m	19 Feb	6	0	6
H29	Seal Island, Punakaiki	42° 01.09′S 171° 22.02′E	RO 1–7 m	20 Feb	13	3	16
H30 R	Rockpools on reef flats, S of Fourteen Mile Creek	42° 19.20′S 171° 16.00′E	RO 0–1.5 m	20 Feb	12	0	12
H31	The Steeples, off Westport	41° 43.58′S 171° 43.58′E	RO 4–8 m	21 Feb	8	5	13
H32 F	Side creek up from bridge, Big Totara River	41° 43.81′S 171° 35.48′E	RO 0–1.5 m	22 Feb	5	0	5
H33 R	Gentle Annie Pt Tide pools	41° 30.20′S 171° 56.90′E	RO 0–0.5 m	22 Feb	12	0	12
H34 R	Rockpools, Parsons Hill Charleston	41° 53.33′S 171° 26.90′E	RO 0–1.5 m	23 Feb	10	0	10
H35	Outside N breakwater, Buller River	41° 43.59′S 171° 26.90′E	RO 0–2 m	23 Feb	2	2	4
H36	Black Reef, The Steeples, off Westport	41° 43.48′S 171° 28.19′E	RO 0–3 m	24 Feb	9	6	15

R = rockpool; RO = rotenone; RL = rod and line; F = estuary/freshwater station; Coll. = no. species collected; SNC = species seen but not collected; Total = no. species present at station (sum of Coll. and SNC).

(H30); and shallow pools around boulders on flat wave-cut platform of limestone and mudstone (H33).

Estuaries and freshwater—Although the marine fish fauna was the focus of the surveys, opportunities were taken to also sample the regions estuarine (lagoon) and freshwater habitats, which are poorly represented in scientific and museum collections. Slack water areas and the edges to a lagoon or river were chosen to avoid current, particularly were logs or rocks broke the water flow and provided more diverse habitat. Four estuarine (lagoon) and freshwater stations were sampled, for a total of 28 person-hours. The four stations comprising one estuary (H18), one lagoon (H21, an estuary with sand bar at mouth), and two river stations (H19 and H32). Each station was sampled for 4–8 person-hours with dip nets to depths of 0.5–1.5 m and briefly by angling with rod and line.

3.2.3 Biological samples

The primary method of fish collection was by rotenone ichthyocide applied as two 500 g bags of dry powder mixed with a surfactant (wetting agent) and water. Wet rotenone in the form of heavier-than-water sludge was dispersed around a small area (usually from 5 × 5 m to 10 × 5 m) of reef habitat to a maximum depth of 25 m. This was usually done with hand and fin movement by scuba divers to ensure penetration into rock crevices and algal stands. Initially two divers dispersed the rotenone at the sample station, followed by 2–4 divers operating in pairs every 30 min. to search out and collect immobilised specimens (in plastic bags) and record the identity of free swimming fishes. Rotenone affects different species at different rates; some such as triplefins usually succumb after 5–15 min., others such as the more resistant rockfishes and eels take 45–60 min. All stations continued to be searched for at least 20 min. after the last fishes were collected. Large fishes (>30 cm TL) were often unaffected by rotenone and swam in and out of the sample area. The identity of these fishes was recorded and a voucher specimen of each species routinely collected using a hand spear, supplemented by fishing at the edge of the station with rod and line and/or a set line with baited hooks.

Fish specimens and other biological samples were chilled immediately after collection and kept in ice-seawater slurry on site. On return to the local base, small fishes were labelled and fixed using 10% formalin and large fishes labelled, bagged and frozen. All fish samples were later registered into the NFC at the Te Papa laboratories in Wellington. These voucher fish specimens support the species listed and analysed (see Section 3.3) from the three WCSI surveys and are available for verification of all identifications made. Checklists of fishes from all sample sites were documented and compared. A relatively small number of fishes previously collected from the WCSI area and held in the NFC (including small collections made previously along the West Coast) were accessed through the computerised database and included in checklists. A few records unsupported by a specimen were included based on catches by local fishers and anglers (D. Neale, DOC Hokitika, unpubl. records) where their identity was considered reliable.

3.3 FISH IDENTIFICATION

Identifications were aided by comparison with specimens already held in the NFC; reference to identification guide books to New Zealand and Australian fishes (e.g. Last et al. 1983; Paulin et al. 1989; Paulin & Roberts 1992; Gomon et al. 1994; Francis 1993); reference to specialist taxonomic papers in scientific journals (held in the reprint section of the Te Papa Fish Library and the main Te Papa Hector Library); and through unpublished taxonomic keys prepared by specialists.

Because of the present incomplete knowledge of New Zealand fish taxonomy, some of our coastal reef fishes were not identifiable to species, or only provisionally assigned species names (operational taxonomic units) that may change with new knowledge. Voucher specimens support the species inventories compiled during the present survey and are, therefore, important for future reference, to enable current identifications to be validated or changed. Thus, the species inventories are scientific because they can be tested. It has been argued (e.g. Cotterill & Dangerfield 1997) that species lists without voucher support are pseudo-scientific because the inventory identifications cannot be tested. Also, voucher collections, particularly from remote or poorly sampled areas such as WCSI, provide an important source of comparative material on which future taxonomic studies and revisions can be based. Some coastal fish families and species groups require substantial biosystematic research before they can be identified with confidence, and these collections underpin ongoing taxonomic projects on these difficult groups. Fish species are listed following the popular and scientific nomenclature of Roberts et al. (in press b) and higher classification of Nelson (1994).

4. Results

4.1 STATIONS SURVEYED AND FISHES COLLECTED

A total of 45 marine sample stations (7 rockpool to 2 m; 38 sublittoral to 23 m) and 4 estuarine–freshwater sample stations (0–1.5 m) were carried out on the WCSI between Milford Sound (44° 39.76′S) in the south and Gentle Annie Point (41° 30.20′S) in the north, during 1998–2000 (Appendix 1). The survey area covered a distance of approximately 500 km and a range of over 3 degrees of latitude (see Fig. 1). It was attempted to spread the survey stations evenly throughout the study region, but this was not always possible because of weather and sea conditions, site accessibility, time constraints, and the extent of suitable reef habitat.

A total of 101 fish species in 72 genera were recorded in 45 families, and are supported by about 3000 preserved specimens held in the NFC. Marine fishes recorded comprise 93 species in 67 genera and 41 families. Full inventories of species recorded during the surveys, supplemented by other records, are given by family in Appendices 2–4. Greatest fish species diversity was found at

subtidal stations, which, apart from three poor stations (4–9 spp.), normally had totals of 12–29 spp. (mean 20.0) per station. Lowest fish species diversity was found in freshwater and estuaries (5–6 spp.); while intertidal rockpools were intermediate with 3–17 spp. (mean 10.4) per station.

Three fish species collected are probably new to science (and are undergoing taxonomic research):

- A clingfish *Gastrophycis* n.sp., at two Haast–Westport stations (Mokinui Reef at Ross, H28; and rockpool at Fourteen Mile Creek, H30)
- Orange rockfish *Acanthoclinus* ?n.sp., at Milford Sound (10–18 m, F59)
- Pygmy sleeper *Thalasseleotris* n.sp., at Milford Sound (4–23 m, 10 stations) and Jackson Head (4.5–15 m, 3 stations)

Four fish species are particularly rare (see station data in Appendices 2–4):

- Fiord brotula *Fiordichthys slartibartfasti* Paulin, taken at Milford Sound (11–20 m, 3 stations)
- Marbled brotula *Bidenichthys consobrinus* (Hector), at Seal Island, Punakaiki (1–7 m, H29)
- Obscure triplefin *Gilloblennius abditus* Hardy, several specimens at Frog Rock (rockpool, H12) and Murphy's beach (0–0.5 m, H24)
- Eyespot clingfish *Modicus tangaroa* Hardy, at Milford Sound (10–15 m, 1994 station)

During the 1998–2000 WCSI surveys, the presence of shore fishes belonging to 16 families were of note because their presence or absence was biogeographically informative, taxonomically valuable, or their frequency of occurrence and/or abundance within stations was ecologically important. These are listed and discussed in Appendix 5. A number of marine coastal areas and sites surveyed had special species and biological features recognised (see text and Appendix 5), as follows:

- South side of Milford Sound (rare and new fish species discovered)
- Murphys Beach (high biological and fish diversity, and a rare fish species)
- Frog Rocks (high biological and fish diversity, and a rare fish species)
- Flowerpot Rock, Jackson Bay (high fish species diversity)
- North Westland/Buller (rare giant triplefin abundant, and a new clingfish species)
- South Westland (co-occurrence of both northern and southern species)
- Seal Island (a rare fish species collected)

No fishes could be classified with confidence as being unique to the WCSI or any sub-area surveyed during the present study. On the contrary, most fishes were classified as widespread in New Zealand coastal waters, with a few being either northern or southern (Paulin & Roberts 1993; Francis 1996). Northern fish species (n = 3) that have been recorded during the present surveys include: spotted black groper (*Epinephelus daemelii*), caught off Westport, being the southern-most record for the species in New Zealand waters (Paulin & Roberts 1992; Francis 1996); sweep (*Scorpis lineolata*) seen at the mouth of Milford Sound (F56), Seal Island (H29) and Wehakapohai Rocks (H25); and red moki (*Cheilodactylus spectabilis*) seen at Abbey Rocks and Hanata Island south of Bruce Bay (H23 and H27).

Southern fish species (n = 5) recorded were: rockling (*Gaidropsarus novaezelandiae*) at Milford Sound (4–17 m, F54 and F62), throughout the Jackson Bay–Haast area, and north to Hanata Island, Bruce Bay (5–14 m, 3 stations); fiord brotula (*Fiordichthys slartibartfasti*) at Milford Sound (F51, F52, F62); Maori chief (*Notothenia angustata*) seen at the mouth of Milford Sound (F54), collected at Jackson Bay (H02, H04), and seen at Seal Island (H16); and thornfish (*Bovichtus variegatus*) at the mouth of Milford Sound (F55), seen or collected at Jackson Bay–Haast (at 10 stations) and seen or collected at Greymouth–Westport (6 stations) (see Appendices 2–4).

4.1.1 Intertidal fish fauna

Seven rockpool stations were sampled (Table 4; Appendix 1). Five of these rockpools were in the northern Hokitika–Westport area, reflecting the high degree of exposure of the coast, general lack of diveable sublittoral reefs, and poor weather experienced during this part of the 2000 survey. There were usually 9–12 fish species recorded at each rockpool station, with a minimum of 3 species at Charleston (H22, rotenone too quickly diluted and washed out by waves) and a maximum of 15 at Frog Rock (H12) (Table 4).

The densities and composition of fish species collected from the 7 rockpools varied substantially between areas (Table 4). The rockpool sampled at the mouth of Milford Sound (F55) was dominated by the mottled twister (n = 34) and the common triplefin (n = 18); clingfishes were absent. At Frog Rock (near Jackson Head) the rockpool (H12) was much richer in fish numbers and was dominated by the mottled twister (n = 258) and twister (n = 238) with good

TABLE 4. COMPARISON OF COMMON ROCKPOOLS FISHES SAMPLED IN SEVEN INTERTIDAL STATIONS ON THE WCSI, AT MILFORD SOUND ENTRANCE (F stn), JACKSON HEAD (H12) AND BETWEEN HAAST AND BULLER (H stns). (Stations listed in order S–N.)

STATION	F55	H12	H30	H22	H34	H20	H33
SURVEY YEAR	1998	1999	2000	2000	2000	2000	2000
TOTAL NO. SPECIES	10	15	10	3	10	9	12
APPROX. POOL AREA (m^2)	25	50	90	12	40	40	100
PERSON HOURS COLLECTING	3	8	10	3	3	8	4
Plesiopidae: rockfishes							
Acanthoclinus fuscus	4	–	22	10	19	28	11
Tripterygiidae: triplefins							
Blennodon dorsale	–	–	214	2	13	6	282
Belapiscis lesleyae	34	258	–	–	7	18	36
Belapiscis medius	6	238	–	12	21	10	3
Forsterygion lapillum	18	57	–	–	3	2	3
Forsterygion varium	–	10	–	–	–	–	–
Grahamina capito	–	60	–	–	–	2	–
Grahamina gymnota	–	–	165	–	–	–	103
Gobiesocidae: clingfishes							
Dellichthys morelandi	–	19	13	–	–	–	–
Diplocrepis puniceus	–	–	30	–	1	1	5
Gastroscyathus n.sp.	–	–	13	–	–	–	–
Trachelchismus pinnulatus	–	2	45	–	–	–	–
Modicus minimus	–	4	–	–	–	–	–

numbers of common triplefin (n = 57) and robust triplefin (n = 60); three species of clingfish were present. Rockpools between Bruce Bay and Gentle Annie Point (Buller) had markedly different composition and fish densities. In particular, all had reasonably high numbers of large olive rockfish (n = 10–28) contributing substantially to the biomass; the giant triplefin was present in all five samples and dominated in very high numbers at two stations (H30 and H33); mimic robust triplefin was the second most abundant fish at two stations (H30 and H33), but absent at the other three; and clingfishes were an important component of rockpool H30 (4 spp., n = 13–45), but mostly absent (except for 1–5 specimens of the orange clingfish) from the four northern-most stations.

4.1.2 Estuarine and freshwater fish fauna

In total, 11 species in 9 genera representing 9 families were collected. Diversity was relatively low at 5–6 species per station, but varied between stations. Shortfin eel (*Anguilla australis*), longfin eel (*A. dieffenbachii*), inanga (*Galaxias maculatus*) and common bully (*Gobiomorphus cotidianus*) occurred at three out of the four stations, including one estuarine station. Five species occurred in estuarine/lagoon stations: the olive rockfish (*Acanthoclinus fuscus*), kahawai (*Arripis trutta*), yelloweyed mullet (*Aldrichetta forsteri*) estuarine triplefin (*Grahamina nigripinne*) and black flounder (*Rhombosolea retiaria*); and two species were confined to freshwater river stations: brown trout (*Salmo trutta*) and redfin bully (*Gobiomorphus huttoni*). Three estuarine/lagoon species were also recorded at fully marine stations: olive rockfish, kahawai and yelloweyed mullet.

4.2 SURVEY AREA ACCOUNTS

4.2.1 Milford Sound 1998

Table 1 shows the dates and locations of the 13 sites (F50–F62) surveyed in Milford Sound during 30 March–05 April 1998; station locations are plotted in Fig. 2. A total of 52 marine fish species in 39 genera and 26 families were recorded from Milford Sound (Appendix 2), and the number of fish species collected and observed was 10–24 per station.

Milford Sound marine environment

Hard rock shores: sheltered—The fiord walls are made up of near vertical granite with fractures, crevasses and holes. Boulders collect on the occasional ledge with sandy sediment and shell rubble. Walls are usually encrusted with sessile invertebrates and low algal cover. This habitat was the primary collection focus of the survey.

Hard rock shores: exposed—Granite boulder piles, and reefs at the mouth of Milford Sound, exposed to westerly winds and seas.

Soft shores: sheltered—This habitat is found in Harrison Cove on the inner northern side, but was not sampled in this survey.

Habitat patterns on hard rocky shores

Sampling underwater in Milford Sound was generally done on steeply inclined rock faces, fractured with cracks and gullies, and alternating with narrow flat ledges with boulders and sediment. General patterns were observed in the physical and biological make-up of the fiord wall habitats in common with other WCSI coasts.

Shellfish and barnacle zone (intertidal and 0–5+ m depth)—Bare rock with scattered barnacles and low growths of *Codium*. Towards bottom of zone, bands of blue mussels on rock faces, with a lower band of starfishes predating the lowest mussels at or near the limit of the low salinity layer (LSL). The LSL is usually 5–10 m deep (but can reach 15 m), which runs seawards continually. Water temperature in the LSL is lower (by several degrees) than the sea temperature. Silt, humic substances and the mixing effect of the fresh and salt water substantially reduced visibility, particularly during the frequent heavy rain. Supports only a depauperate fish fauna with few benthics (common triplefin) and only a few low salinity-tolerant demersals (spotties) and pelagics (yelloweyed mullet). The zone was not intentionally sampled, but may have been part of the top of the shallowest rotenone stations.

Sponge and sea squirt zone (10–25+ m depth)—Defined by a rich invertebrate fauna, comprising red snake brittlestars, kina, *Stichopus*, *Acanthogaster*, bryozoans, cerianthid anemones, sponges, tubeworms, terebelid worms, tunicates, black coral, brachiopods, *Atrina*, and scattered algae: *Lithothamnion* 'paint', *Ecklonia*, *Plocamium angusta*, *Codium*, *Caulerpa brownii*. Within the inner fiord, terrestrial cliffs were hung with beech trees (*Nothofagus* sp.) extending down to extreme high water level, and introducing high loads of leaf litter into the zone. Ten sample sites were located in this zone (F50, F51, F52, F53, F56, F57, F58, F59, F60, F62).

Intertidal rockpools (0–0.5 m depth)—Depressions and fractures in horizontal intertidal reef platform usually with variable sized granite boulders providing sheltered habitat. Inhabited by colonies of barnacles and mussels with clumps of *Hormosira*. Encountered only at the mouth of the fiord at Anita Bay. One site sampled (F55).

4.2.2 Cascade–Haast 1999

Table 2 shows the dates and locations of the 19 sites (H01–H19) surveyed at Cascade–Haast during 7–15 February 1999; station locations are plotted in Fig. 3. A total of 80 marine and estuarine species in 60 genera and 36 families were recorded from Cascade–Haast (Appendix 3), and the number of fish species collected and observed was 15–29 per station.

South Westland marine environment

Hard rock shores: exposed—Primarily inshore coastal rocky reefs and offshore stacks. These range from semi-exposed (e.g. Jackson Head–Cascade Point) to very exposed (e.g. Cascade Point–Big Bay, Open Bay Islands, and Ship Creek–Heritaniwha Point). There is also a wide range of habitat types within this group, some of which are described in the next section of this report. In most places, the rocks abut a bed of coarse sand at depths probably in the range

of 5–30 m. The current fish survey focused on a small portion of South Westland's hard shores.

Hard rock shores: sheltered—A few inshore coastal rocky reefs and the lee side of offshore stacks. Scarce, with only areas along the semi-sheltered Jackson Bay coast.

Soft shores: exposed—Comprising sandy shores, pocket beaches, and inshore seabed. These are physically spread throughout South Westland, but the main area of soft shore is along the Haast coast between Neil's Beach and Arnott Point. The offshore boundary between the shore and the continental shelf is not at all clear, but key physical factors such as wave action, sediment exchange and light penetration drop significantly in depths greater than about 20 m.

Soft shores: sheltered—Confined to estuaries and river mouths. These are small areas at the mouths of the main rivers, mostly of coarse river sediments, with some backwater areas of finer silt and mud. The maximum depth in these areas is around 3 m. Okuru Estuary is one of the most extensive of these ecosystems in South Westland.

Habitat patterns of hard rock shores

Diving at a number of stations over a short period of time allowed a good impression to be formed about the habitat patterns and zonation that characterise the sample area. Six main zones are briefly described below that appear to encompass the greater proportion of hard rock marine habitats observed. Further work could be usefully directed towards mapping the overall extent of each habitat within the study area, and to use them as a basis for describing the whole of the South Westland marine district.

Shellfish and barnacle zone (intertidal area, including rockpools to 1.5 m deep)—Usually large areas of bare rock face that are heavily scoured by beach sands and gravels. Dominated by barnacles, limpets, littorinid snails and *Xenostrobus* mussels. Beds and turfs of intertidal seaweed that are found elsewhere on WCSI (e.g. turfs of *Gigartina, Sarcothalia,* and *Champia*, common north of Okarito) are very uncommon in South Westland. Rockpools have a short turf of corallines, *Pterocladiella*, and other seaweeds, with numerous kina and a fish fauna comprising large numbers of twisters, mottled twisters, and common triplefins. Only one intertidal rockpool sampled (H12).

Shallow sublittoral zone (0–5 m)—The low tide surge zone is often significantly scoured by sand-laden waves, but also occupied in places by low seaweed turfs. Bull kelp (*Durvillaea antarctica*) and large mussels (*Perna* and *Mytilus*) are generally uncommon and patchily distributed in South Westland. The fish fauna of scarce bull kelp beds was not surveyed, because of the high wave surge. Dominant fish species in the zone include common triplefins and banded wrasse. Six sites were sampled (H02, H04, H06, H10, H16, H17).

Seaweed zone (3–10 m depth)—Seaweeds tend to dominate upper levels of the subtidal reef faces. This zone comprises a dense cover of very low turf and encrusting algae, including encrusting corallines: *Microzonia*, *Ballia callitricha*, *Halopteris* spp. and numerous delicate red seaweeds. 'Emergent' seaweeds (e.g. *Glossophora*, *Asparagopsis*, *Anotrichium*) are present but seldom reach lengths greater than about 20 cm, the exception being sparse

fields of the brown seaweeds *Ecklonia radiata*, *Landsburgia quercifolia,* and *Cystophora scalaris* (especially prevalent at Open Bay Islands), and some low-tide areas of bull kelp (*Durvillaea*) described above. The dominant fish species include banded wrasse, marblefish, triplefins (blue-eyed, variable, mottled) and rock cod. Four sites sampled (H01, H03, H05, H08).

Grazed boulder flats zone (5–20 m)—Predominantly composed of large boulders (c. 1 m diameter), interspersed with coarse sand and large rocks. Kina (*Evechinus chloroticus*), cats eyes (*Turbo smaragda*), and other grazing invertebrates dominate considerable areas of the rock flats, with a greater diversity of sessile (attached) biota on the steeper rocks. Few fish species seemed to live here, though the dominant fish species included banded wrasse and variable triplefin (e.g. station H07).

Sponges and sea squirts zone (10–20+ m depth)—Sessile (attached) invertebrate animals dominate the lower levels of the bedrock reefs. It was difficult finding deep rocky reef stations in this zone. The extent of these reefs needs to be further investigated by field survey and by discussion with local fishers and divers. Common fish species in this zone include yellow-black triplefins, blue-eyed triplefins, bluedot triplefins, banded wrasse, scarlet wrasse and cave dwelling fish (rock cod, conger eels, common roughy). This habitat tends to have the most diverse fish fauna. Five sites sampled (H09, H11, H13, H14, H15).

Sandy reef margins (10–20+ m depth)—Away from the main reef areas, the seabed becomes increasingly dominated by mobile sediments, ranging from fine silt in sheltered areas (e.g. Jackson Bay), to coarse sand and gravel in the more exposed places. These areas of sand adjoining the reefs appear superficially to be devoid of life, but a diverse fauna lives within the sediment. These include worms and bivalve shellfish that are important food sources for a number of fish species. Small rock outcrops may rise out of the sandy bed beyond the edges of the larger reefs. Fish that live in this zone close to the reef edge include sand divers (Creediidae) and bluecod (*Parapercis colias*). Sandy margins were sampled during some stations in the Sponge and sea squirt zone (above), but open areas of sandy seabed well away from the main reefs were not surveyed.

4.2.3 Haast–Buller 2000

Table 3 (see above) shows the dates and locations of the 17 sites (H20–H36) surveyed at Cascade–Haast during 13–24 February 2000; station locations are plotted in Fig. 4A, and 4B. The 2000 survey had difficulty finding coastal rocky reefs over 10 m depth. Further, at suitable reefs, diving operations were hampered by low visibility, which caused several sample sites to be aborted. Nevertheless, a total of 59 marine and estuarine species in 43 genera and 28 families were recorded from the coast between Haast and Gentle Annie Point (Buller) (Appendix 4), and the number of marine fish species collected and observed was 3–26 per station.

Haast–Buller marine environment

Hard rock shores: sheltered—Very limited in area and mostly inaccessible microhabitat in the lee of a few coastal reefs, offshore islets and rock stacks.

Semi-sheltered reef rockpools were sampled, but no sublittoral biota in this habitat were surveyed or collected.

Hard rock shores: exposed—Granitic and sedimentary boulder piles and rocky reef platforms along the coast. This habitat occurred quite commonly in the area but appeared to rarely extended much below c. 10 m depth. Very little algal cover, the large macroalgae stands (except for *Durvillaea*) were very scarce.

Soft shores: exposed—Broad tidal flats with small rocks and occasional terrestrial debris; high exposure to strong westerly wind and swell. Habitat very reduced and fishes often small in size.

Soft shores: sheltered—This habitat was only found in association with shallow river estuaries and lagoons. Comprising soft muddy sediment with shell debris and buried logs, and strong river flow.

Habitat patterns on hard rocky shores

Sampling along this part of the WCSI was only possible in areas sufficiently sheltered for rotenone to act before being dispersed by current or wave action, and water visibility was sufficient to allow specimens to be seen and collected.

Shellfish and barnacle zone (intertidal area, including rockpools to 0.5 m deep)—Bands of mussels, barnacles, *Gigartina*, *Champia,* and other algal tufts. Rockpools richer than dry intertidal, with invertebrates such as gastropods and camouflaged anemones, and algae such as encrusting corallines, and *Gymnogongrus furcatus*. This zone is subjected to high wave action, even at low water, because of persistent strong onshore winds. Rock fractures, gullies, and granite boulders provide some semi-sheltered habitat. Four rockpool sites sampled during survey, at low tide (H20, H22, H30, H33).

Mussel zone (0–5+ m depth)—Bands of greenlip and blue mussels and a range of invertebrates such as barnacles, gastropods and reef stars. The bull-kelp *Durvillaea* spp. occurred at exposed sites where adequate rocky reefs exist; other algae were present, but were generally small and turfing. Similar sea conditions in the Shellfish and barnacle zone. One site sampled (H24).

Grazed boulder flats zone (5–20 m depth)—Some blue mussels and barnacles, but generally very sparse marine life. One site sampled (H26).

Sponge and sea squirt zone (10–20+ m depth)—Possibly because of the lack of macroalgae, this zone extended into the lower Mussel zone. Invertebrates included *Patiriella regularis*, anemones, and gastropods. Algae were usually sparse, but with some crustose corallines, *Halopteris* and *Landsburgia*. Five sites surveyed (H23, H25, H27, H29, H31).

Sand at reef margins (5–25+ m)—This habitat was only sampled if adjacent to a patch of reef. Rotenone was often only partly effectual in this habitat due to dispersal. Sampled at three sites (H23, H25, H27).

4.3 FISH DIVERSITY

4.3.1 Cumulative species graphs

The cumulative numbers of fish species recorded for each of the three surveys are graphed in Fig. 5 and plotted in station order. When the cumulative species data were plotted by decreasing species abundance per station (not shown), the shapes of the three curves were similar to those in Fig. 5.

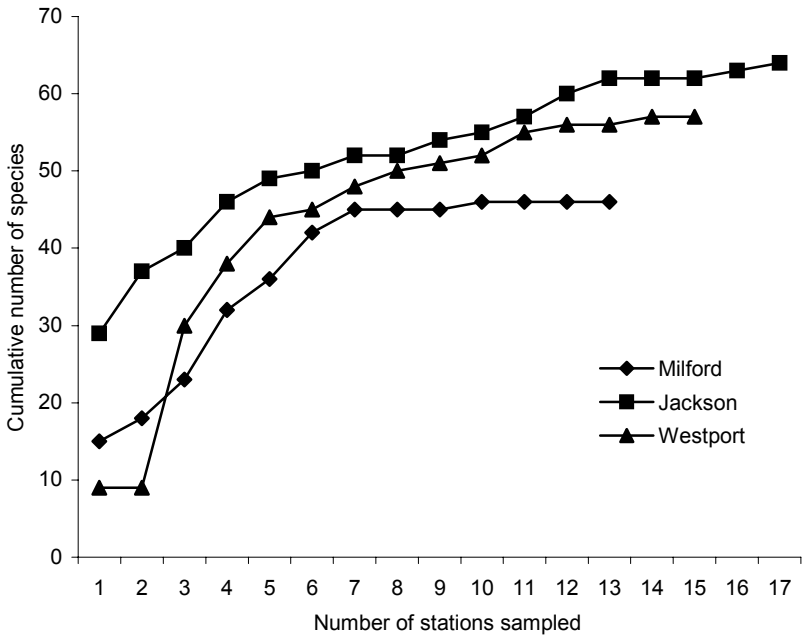

Figure 5. Graphs of cumulative marine fish species numbers by survey area.

Milford Sound—The number of species recorded increased rapidly during the first seven sample stations, and then more-or-less flattened for the remaining six stations (to a maximum of 46 spp.). This curve indicates that sampling intensity (13 stations) was adequate to reflect the species diversity present in the fiord. Nevertheless, an additional six species were recorded outside the 1998 survey period and two of these were benthic species (*Modicus tangaroa* and *Lissocampus filum*) that were collected within the fiord (Appendix 2). So, despite the asyntopic shape of the cumulative species curve, further sampling will probably discover additional species at Milford Sound.

Cascade–Haast—The cumulative number of species recorded started high (29 spp.) at the first station and increased at a relatively fast rate to the fifth station (49 spp.), then continued at a slightly slower rate progressively to a final high of 64 spp at the last (17th) station. The curve shows little sign of an asymptote, suggesting sampling intensity was not quite adequate to capture the full diversity likely to be present in the area. Sampling additional sites would therefore probably produce more fish species for the Cascade–Haast area. In support of this, an additional 13 species were recorded outside the 1999 survey period and three of these were benthic species (*Hippocampus abdominalis, Scorpaena* sp. and *Acanthoclinus fuscus*) observed at Jackson Bay and the Open Bay Islands (Appendix 3).

Haast–Buller—The cumulative number of species recorded started at nine in two rockpool stations, increased rapidly for the next three stations, continued at a slower rate to station 13, then levelled out for the remaining two stations at 57 spp. (Fig. 5). An asymptote appears to be beginning, but needed another two stations to be clear. The shape of the species cumulation curve for the Haast to Buller coast is approximately in between that of Milford and Cascade–Haast, suggesting that sampling 15 stations was almost adequate to capture the diversity of species present.

4.3.2 Species diversity with effort, depth, and area

Reef habitats were sampled in three survey areas and three depth zones: (1) intertidal rockpools, (2) sublittoral reefs at 0–5 m, and (3) sublittoral reefs at 6–25 m depth (Table 5). Because of the wide variation in field conditions between surveys, and availability of reef stations between sites, sampling was not evenly distributed between habitats. Nevertheless, some generalisations can be made.

Intuitively, the greater the amount of time spent collecting (effort, measured as collector or diver hours per station) then the total number of fish species collected would be expected to be greater. The present data for rockpools (Fig. 6A, $R^2 = 0.31$) and sublittoral reefs (Fig. 6B, $R^2 = 0.13$) show this general trend when graphed, but the correlations are low due to high variability in the numbers of species collected for any particular level of effort at both rockpool and sublittoral stations. It is probable that the variability in number of species collected at a station is a reflection of the true diversity present, rather than the amount of collecting effort. This is because the collecting methodology aims for total collection of samples, which is generally achieved.

At all three survey areas mean numbers of species sampled per station appear to increase with depth (Table 5). Rockpools hold the lowest mean numbers of species (8.8–15.0 per station), whereas the deepest reef stations hold the

TABLE 5. COMPARISON OF MARINE FISH SPECIES SAMPLED ON THE WCSI AT MILFORD SOUND (1998), CASCADE–HAAST (1999) AND HAAST–BULLER (2000). (Areas ordered N–S.)

AREA	DEPTH	(m)	N	%	Spp.	MEAN/STN
Haast–Buller (59 spp.)						
	rockpools	0–2	5	33.3	3–12	8.8
	sublittoral	0–5	**8**	53.3	3–20	10.0
	sublittoral	6–20	2	13.3	13–26	**20.0**
Cascade–Haast (64 spp.)						
	rockpools	0–2	1	5.9	15	15.0
	sublittoral	0–5	**10**	58.8	15–25	19.0
	sublittoral	6–20	6	35.3	15–29	**23.0**
Milford Sound (52 spp.)						
	rockpools	0–2	1	7.7	10	10.0
	sublittoral	0–5	0	0	–	–
	sublittoral	6–25	**12**	92.3	13–24	**17.8**

N = number of stations sampled; **Bold** type = highest values (N, mean)
Spp. = range of species sampled per station.

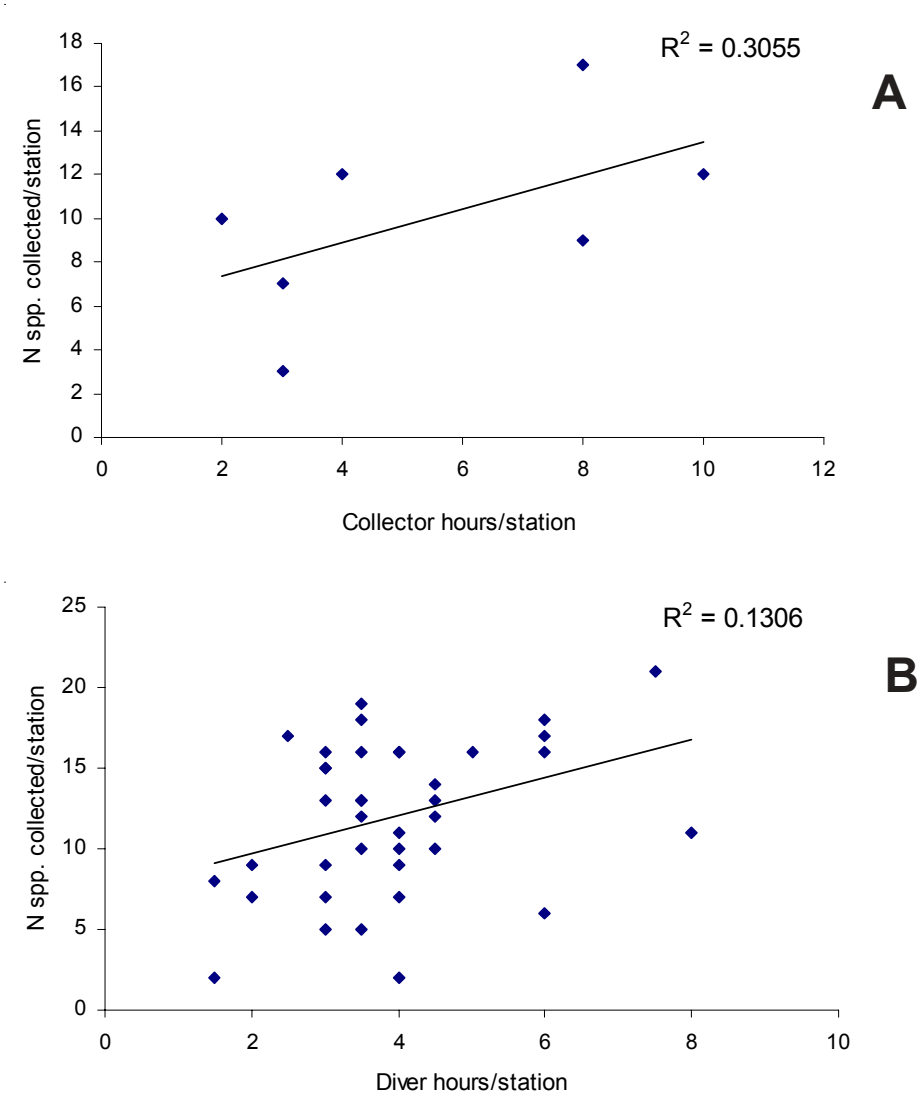

Figure 6. Scatter graphs showing relationship between sampling effort and number of fish species collected. **A**. Rockpool stations. **B**. Sublittoral stations.

highest mean numbers of species (17.8–23.0 per station) (Table 5). However, plots of the number of species recorded per station and mid depths (Fig. 7A and 7B) do not provide much support for this relationship. For the total number of species recorded (collected and observed) at sample stations (Fig. 7A) there is a trend line of increasing species numbers with increasing depth, but this trend has a poor correlation (R^2 = 0.26) with the data. For the number of species collected (Fig. 7B) there is a nearly horizontal trend line and no correlation (R^2 = 0.00) with the data. These low correlations are due to the wide scatter of values plotted. This is not surprising because in a field situation there are many factors affecting the number of species sampled, in addition to varying natural numbers of fish species. In general, the greater the diversity of habitat within the restricted sample area then the greater the diversity of fish species that will be collected. However, the number of species collected by scuba divers, can be affected by a range of factors, such as, sea conditions, water clarity, water temperature, sample depth, and differences in performance between divers. During survey operations, collection planning and underwater methodology aim to minimise or delete such limiting factors, so that the collections are representative. However, some conditions such as poor visibility (encountered along the Westland–Buller coast) cannot be mediated. Hence, the variation in

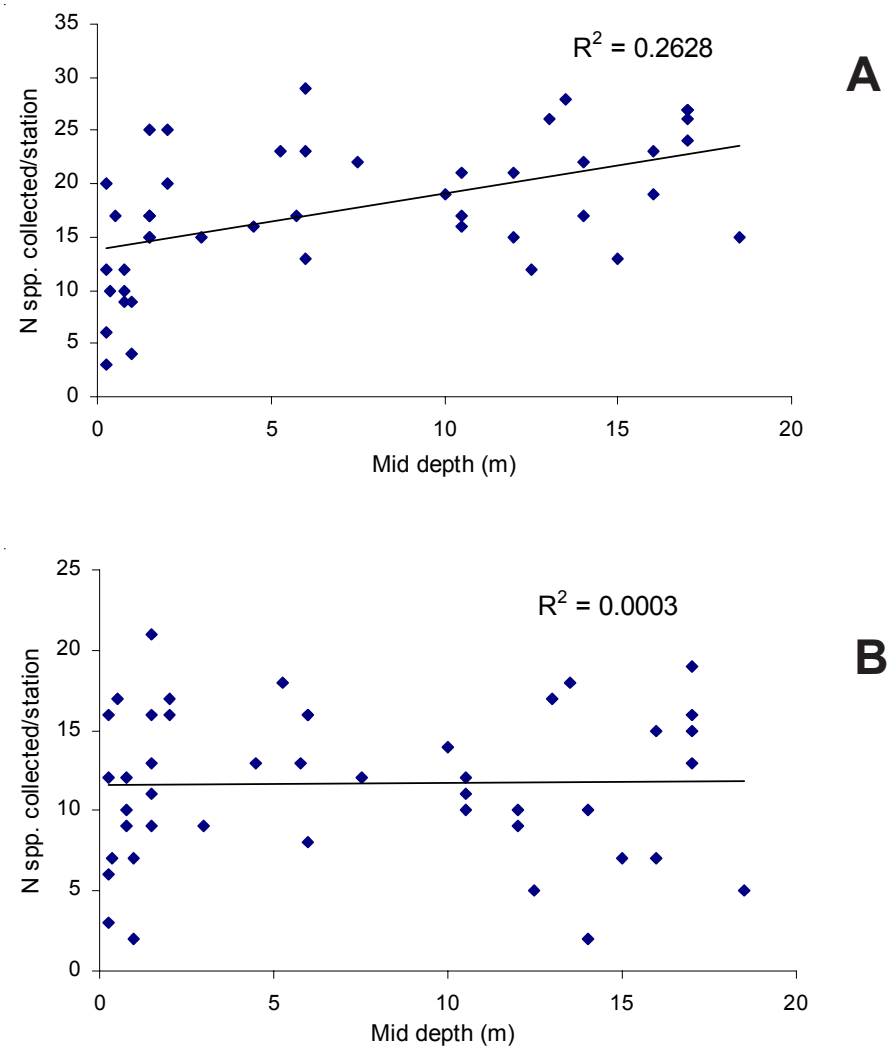

Figure 7. Scatter graphs showing relationship between depth (station mid depth) and number of marine fish species. **A**. Species recorded. **B**. Species collected.

species sampled with depth is a result of both collector variability and true variation in fish diversity.

Milford Sound—Fish species in the fiord were collected at a rate of 2–14 per station and observed at 3–19 per station (see Table 1). Most sample stations (12, 92%) were restricted to sheltered deep rocky walls and reefs at 6–25 m depth, with 13–24 species (mean 17.8) recorded per station (Table 5). It is probable that the relatively low variety of habitats (no shallow sublittoral reefs, few exposed sites) in Milford Sound influenced the overall diversity of the fish fauna compared to other areas surveyed.

Cascade–Haast—In this area fish species were collected at a rate of 9–21 per station and observed at 1–13 per station (see Table 2). Most sample stations were sublittoral on rocky reefs at 0–5 m (10 stations) with 15–25 (mean 19.0) species; and at 6–25 m depth (6 stations) with 15–29 (mean 23.0) species recorded per station (Table 5). Compared with Milford Sound there was a greater range of habitats sampled in the Cascade–Haast area, including shallow and deep reefs, ranging from semi-sheltered to very exposed. The wider range of habitats surveyed was almost certainly reflected in the increased diversity of fish species sampled. However, underwater sampling was more efficient than expected because of the unusually calm weather and reasonable underwater

visibility during the 1999 survey period. This may have influenced the rate of collection of fish species (15–21 at 12 stations) and aided the sighting of others (10–13 species observed at 4 stations) (Table 2), with an overall mean for the area of 23 recorded per station (Table 5).

Haast–Buller—For this area, 2–17 (mean 10.1) fish species were collected per station and observed at 0–10 (mean 3.2) per station (Table 3). Most collecting effort (86.6%) went into rockpools and shallow sublittoral reefs, which had relatively low species diversities of 8.8 and 10.0 mean species per station respectively. In contrast, deep sublittoral reefs held much richer fish life with a mean of 20.0 species per station (Table 5), although only two stations were worked at that depth due to lack of available habitat. There were few stations worked on reefs deeper than 8 m and none over 14 m (Table 3). Hence the number of habitats and the number of fishes sampled for the Haast–Buller area was lower than the Cascade–Haast area. Furthermore, collecting efficiency was affected by poor weather and low underwater visibility. The low number of fish species observed (mean 3.2 per station) is probably in part because of the poor visibility.

4.3.3 Species diversity with latitude

The area surveyed during the 1998–2000 period covers c. 500 km and over 3 degrees of latitude of the WCSI, extending from Gentle Annie Point (station H33R at 41°30.20′ S) north of Westport (Buller), to Sinbad Point (station F50 at 44°39.76′ S) in Milford Sound (Fiordland). Given the big differences in reef habitat evident along this section of the West Coast (e.g. exposed shallow coast to deep sheltered fiord; sedimentary coast with patchy scattered reefs to extensive reefs and rocky headlands), it is to be expected that changes in species diversity occur with habitat. Furthermore these changes might be consistent along the coast and evident at a large scale as well as locally. A plot of the number of marine fish species recorded against latitude (Fig. 8A) shows a general trend towards increased species diversity per station with increase in latitude. Greatest diversity is found at the southern stations (Milford Sound and Cascade–Haast area). However, with such large data scatter the correlation is poor ($R^2 = 0.25$). Access to limited sample sites generally on the WCSI is seen in the clumping of stations by latitude. The strongest trend and best correlation between diversity and latitude is shown by the number of species recorded per station during the Cascade–Haast and Haast–Buller surveys in Fig. 8B ($R^2 = 0.52$). This is because stations in the Cascade–Haast area have consistently high species diversity (range 15–29, means 15–23 per station), while those between Haast and Buller have predominantly lower and more variable species diversity (3–26, means 8.8–20 per station) (Table 5). It can be concluded that fish species diversity is highly variable within a given area, but general trends are for greater reef fish diversity at southern latitudes within the WCSI area surveyed.

4.3.4 Stations with high species diversity

Milford Sound—Four fiord stations had totals of 21–24 fish species recorded per station (Table 1; Appendix 1 and 2). Three of these were at the mouth of the fiord (F53, F54 and F56), but were semi-sheltered from the open ocean by St Anne Point (Fig. 2). Wave action near the fiord mouth helped break up the low

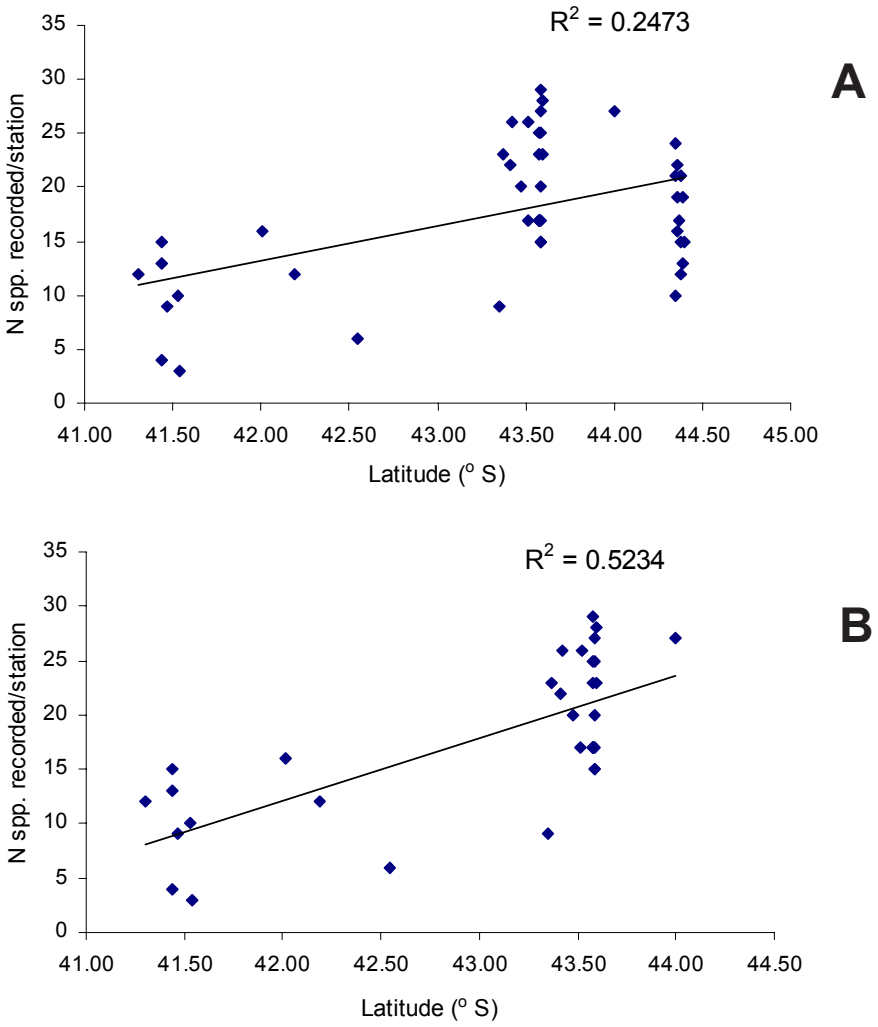

Figure 8. Scatter graphs showing relationship between species recorded per station and latitude South. **A**. Marine species recorded. **B**. Marine species recorded in the Cascade–Haast and Haast–Buller areas.

salinity layer (LSL), observed at station F56 flowing out to sea past Greenstone Point, although water movement at the station itself was negligible. In addition, light levels underwater (c. 10 m visibility at the bottom) were increased because of the inflow of clean water from the open sea. In consequence, there was a marked increase in abundance of algae (e.g. *Ecklonia, Caulerpa, Carpophyllum, Plocamium, Codium*) compared to inner fiord stations. At each of these three high diversity stations, high numbers of large open coast fishes (e.g. blue moki, trumpeter, tarakihi, telescope fish, sweep, Maori chief) as well as small benthic species were observed (n = 12–20) in addition to those collected by rotenone. The fourth species-rich station (F62, with 21 spp.) was in the middle reaches of the fiord located at a rocky point south of Stirling Falls (Fig. 2). That station comprised a rocky cliff face broken by a gutter and deep slots that dropped away to a flat ledge with extensive boulder rubble and sand. The close adjacency of this range of complex microhabitats supported a rich fish fauna (including the rare fiord brotula—Fig. 9) that was sampled by rotenone and visually recorded.

Cascade–Haast—Nine out of 17 marine stations sampled in this area had species diversities of 23–29 per station (Table 2; Appendix 1 and 3). The station with the highest number of fish species was in Jackson Bay (H01, Flower Pot

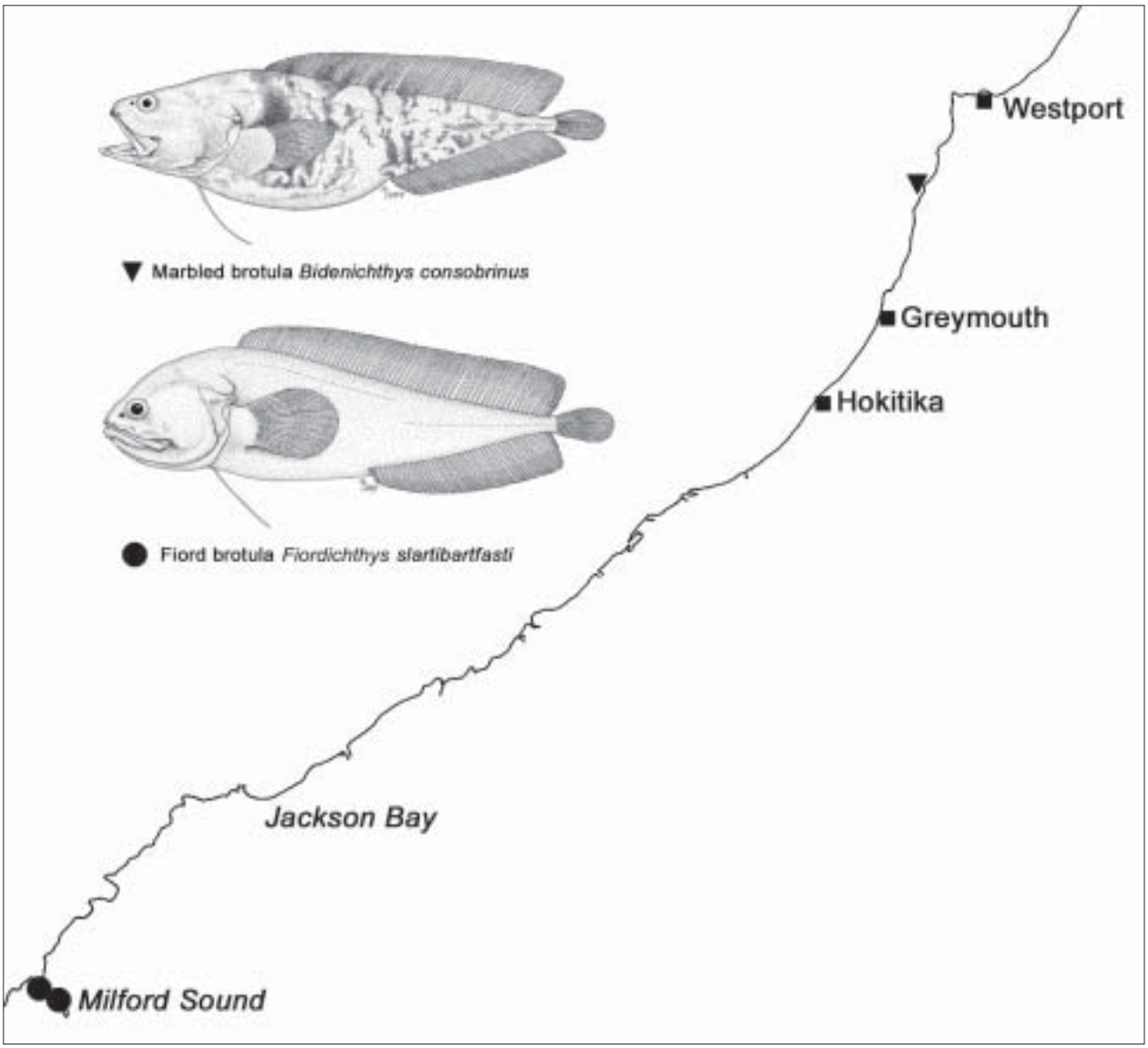

Figure 9. Distribution of two rare brotulas within west coast survey area. Fish illustrations from Paulin (1995a).

Rock with 29 spp.), but all the others were located past Jackson Head towards Cascade Point or at the Open Bay Islands, away from the turbid outflow of the Arawhata River into Jackson Bay (Fig. 3). These stations varied in depth from 0–20 m; those shallower than c. 10 m were rich in algae (e.g. *Cystophora*, *Pterocladia*, *Zonaria*, and *Corallina* turf), and those deeper were rich in sessile invertebrates (e.g. sponges, tunicates, tube worms, barnacles, brachiopods). Water clarity was generally good (underwater visibility >10 m at the bottom) and there was a reasonable number of large open coast fishes observed (e.g. schools of blue and copper moki) (n = 4–13 spp./station), but also a rich benthic fish fauna sampled by rotenone (n = 15–21 spp./station).

Haast–Buller—Overall fish diversity for this area was very low; only four marine stations (H23, H24, H25 and H27) out of 15 had 20–26 species recorded (Fig. 4B; Table 3; Appendices 1 and 4). With the exception of Murphy's Beach, the other three richest stations were located at offshore islands and rock stacks. These were part-sheltered off lee shores, had reduced sediment scour, and were

greater than 5 m depth. The greatest fish species diversity was at Whakapohai Rocks (H25 with 26 spp.) just north of Murphy's Beach, and was the deepest station (12–14 m) sampled during the 2000 survey.

Murphy's Beach (H24) (Fig. 4B) deserves mention as a site of biological significance for the Haast–Buller area. This site was unique compared with the rest of the coastal stations surveyed in 2000. The seawater did not have a heavy sediment loading and the algal cover, while sparse, had a relatively high diversity of species. It was the richest intertidal–shallow subtidal (0–5 m) site sampled on the survey, with a total of 20 fish species recorded (Table 3; Appendix 1). This station had the highest density of three triplefin species, reflected by the numbers of specimens collected: cryptic triplefin (*Crypticbthys jojettae*, n = 93), mottled twister (*Bellapiscis lesleyae*, n = 66), and Yaldwyn's triplefin (*Notoclinops yaldwyni*, n = 36). Also of note was the presence of the rare obscure triplefin (*Gilloblennius abditus*, n = 1).

4.3.5 Taxonomic diversity

Fishes recorded from the WCSI (Appendices 2–4) fell unevenly into three phyletic groups: hagfishes and lampreys (Class Agnatha, 1 species), cartilaginous fishes (Class Chondrichthys, 9 species) and bony fishes (Division Teleostei, 91 spp.). The most diverse group, the bony fishes, comprised 90% of the fish fauna and were represented by ten orders, most with 1–4 species. The exception was the Perciformes, which is by far the most diverse order (72 spp.) representing over 72% of the total WCSI fish fauna recorded. Although bony fishes dominate (c. 90%) the whole New Zealand fish fauna, the portion of perciform fishes recorded here for the WCSI is very high (72% cf. 30% of the whole fauna) (Roberts et al. in press a). This was because sampling during the present study targeted intertidal and shallow reef habitats, which are dominated by this order.

The most speciose family of fishes recorded from the present samples was the triplefins (Tripterygiidae, 22 species), followed by clingfishes (Gobiesocidae, 8 spp.), rockfishes (Plesiopidae, 6 spp.), wrasses (Labridae, 4 spp.), trumpeters (Latrididae, 4 spp.), morid cods (Moridae, 3 spp.), scorpionfishes (Scorpaenidae, 3 spp.), perches (Serranidae, 3 spp.), sand divers (Creediidae, 3 spp.) and sleepers (Eleotrididae 3 spp.); 8 families had two species; 26 families just one (Appendices 2–4). The dominance of triplefins, clingfishes and rockfishes on the WCSI is characteristic of the New Zealand coastal reef fish fauna (Paulin & Roberts 1992, 1993; Willis & Roberts 1996), which is a globally unique fish assemblage because of the abundance of New Zealand endemic species (Roberts et al. in press a, b).

Comparisons of taxonomic diversity of families, genera and species (FGS) between the three survey areas are given in Table 6. The relationship between numbers of FGS between areas is remarkably consistent. Milford Sound had the lowest numbers (26 : 39 : 52 respectively); whereas Cascade–Haast had the highest (35 : 60 : 77) and Haast–Buller had a count in the middle (29 : 43 : 59). Because the numbers of families and genera follow the numbers of species so closely, it is concluded that taxonomic diversity closely follows species diversity in the three survey areas.

TABLE 6. TAXONOMIC DIVERSITY OF MARINE FISH SPECIES SAMPLED ON THE WCSI AT MILFORD SOUND (1998), CASCADE–HAAST (1999), AND HAAST–BULLER (2000). (Areas ordered N–S.)

AREA	MARINE STNS	FAMILIES	GENERA	SPECIES	SPP. *EX* SURVEY	MEAN SPP./STN	SURVEY TOTAL SPP.
Haast–Buller	15	29	43	59	2	3.8	57
Cascade–Haast	17	35	60	77	13	3.8	64
Milford Sound	13	26	39	52	6	3.5	46

4.4 ICHTHYOFAUNAL COMPOSITION

4.4.1 Species numbers and composition

Major differences were apparent in ichthyofaunal composition between the three areas of the WCSI surveyed. The numbers of fish species and species faunal composition were different between areas (Appendices 2–4). For example, differences in species numbers[1] between areas can be seen in the five most species-rich families:

- Triplefins (Tripterygiidae: M, 13 spp.; C, 21 spp.; H, 19 spp.)[1]
- Clingfishes (Gobiesocidae: M, 2 spp.; C, 6 spp.; H, 6 spp.)
- Rockfishes (Plesiopidae: M, 6 spp.; C, 4 spp.; H, 3 spp.)
- Trumpeters (Latrididae: M, 3 spp.; C, 4 spp.; H, 2 spp.)
- Wrasses (Labridae: M, 4 spp.; C, 4 spp.; H, 3 spp.)

Hence, Milford Sound has relatively low species diversity in triplefins and clingfishes, but relatively high diversity in rockfishes. The Haast–Buller area has the reverse: relatively high diversity in triplefins and clingfishes, but relatively low diversity in rockfishes, trumpeters and wrasses. Cascade–Haast has the highest diversity in triplefins, and high diversity of clingfishes and trumpeters, but no groups that are relatively low in diversity compared to the other two areas.

In addition to species diversity, species composition can be substantially different between areas, markedly changing the faunal character. This change in composition was seen, for example, in the 3 most speciose fish families, and this difference was greatest between the two most distant areas surveyed. Triplefins in the Haast–Buller area (total 18 spp.) included the following 7 species not found at Milford Sound (total 13 spp.) (Appendices 2 and 4): giant triplefin, obscure triplefin, thripenny, robust triplefin, mimic robust triplefin, Yaldwyn's triplefin, and longfinned triplefin. Six of these are species that are usually found in shallow, exposed reef habitats, abundant in the Buller area but absent from Milford Sound. The seventh, Yaldwyn's triplefin, is a deepwater (6–25 m) reef species, also usually associated with exposed open coasts. A total of eight species of clingfishes were found in the WCSI survey area. Six species were found in the Haast–Buller area and two different species found in Milford Sound, hence the clingfish fauna is exclusively different in these two survey

[1] Using abbreviations for these areas: M = Milford Sound, C = Cascade–Haast, and H = Haast–Buller.

areas (Appendices 2 and 4). The two clingfishes in Milford Sound (pink clingfish and eyespot clingfish) are deepwater species preferring broken reefs with abundant holes, largely absent off the Haast–Buller area.

Comparison of the fish faunas at the three areas surveyed showed a surprising level of dissimilarity considering that the coastline is contiguous and the majority of the fish species are widely distributed in New Zealand coastal waters. Pairwise comparison of marine species between the three areas (Table 7) show that the numbers of fish species shared are similar for adjacent areas (54.5–58.0%), but low (43.0%) for the disjunct area pair (Milford Sound and Haast–Buller). Reciprocal values show comparable levels of dissimilarity for adjacent areas (42.0–45.5%) and greatest dissimilarity between Milford Sound and Haast–Buller (57.0%) (Table 7). Dissimilarity levels of 42–57% are high, indicating that approximately half the fish species in a survey area are restricted to that one area. The relative closeness of the similarity and dissimilarity values between the pairwise comparisons of the two adjacent areas suggest faunal differences in composition are occurring along most of the WCSI surveyed. This trend is supported by the observation that least similarity (43%) and maximum dissimilarity (57%) are found at the two ends of the WCSI survey areas (Table 7). If major differences were evident between adjacent pairs of areas, that would indicate a restricted area of faunal change, such as would be expected at a biogeographic boundary. However, the present data provide strong support for transitional change in composition of the marine reef fish fauna along most of the West Coast surveyed, in particular South Westland.

TABLE 7. PAIRWISE COMPARISON OF MARINE SPECIES BETWEEN THE THREE SURVEY AREAS ON THE WCSI. (Areas ordered N–S.)

AREA PAIR (spp./area)	TOTAL spp.	SIMILARITY spp. shared (%)	DISSIMILARITY spp. not shared (%)
Haast–Buller (57) & Milford Sound (52)	79	34 (43.0)	45 (57.0)
Haast–Buller (57) & Cascade–Haast (77)	88	48 (54.5)	40 (45.5)
Cascade–Haast (77) & Milford Sound (52)	81	47 (58.0)	34 (42.0)

4.4.2 Dominant and abundant species

In addition to changes in diversity of fish species with area, substantial changes in the suite of dominant and frequently occurring species were found between survey areas. The 10 most frequently recorded species in each survey area are shown in Table 8. No species ranked in frequency between 1–10 occur within that rank in all three areas. Only 3 of the 10 ranked species occurred in more than one area, and each area had a different set of species that occurred in two areas. Seven out of 10 ranked species were recorded (at this frequency) in only one area. Therefore, on the basis of frequency of occurrence and abundance (individuals collected), the suite of species listed in Table 8 help characterised the fish fauna in each area.

TABLE 8. MOST FREQUENTLY SAMPLED MARINE FISH SPECIES ON THE WCSI AT MILFORD SOUND (1998), CASCADE–HAAST (1999) AND HAAST–BULLER (2000) AREAS. (Areas ordered N–S.)

AREA/ RANK		COMMON AND SPECIES NAME	N STATIONS PRESENT	SPECIMENS COLLECTED
Milford Sound (13 stns)				
1.		Butterfly perch *Caesioperca lepidoptera*	12	2
2.		Yellowblack triplefin *Forsterygion flavonigrum* +	12	471
3.	■	Scarlet wrasse *Pseudolabrus miles*	11	28
4.	●	Mottled triplefin *Forsterygion malcolmi*	11	49
5.		Oblique swimming triplefin *Obliquichthys maryannae* +	11	158
6.		Jock Stewart *Helicolenus percoides*	10	7
7.		Spotty *Notolabrus celidotus*	10	18
8.		Pygmy sleeper *Thalasseleotris* n.sp. +	10	134
9.	◆	Rock cod *Lotella rhacina*	9	8
10.		Pink clingfish *Modicus minimus* +	8	15
Cascade–Haast (17 stns)				
1.		Marblefish *Aplodactylus arctidens*	17	0
2.	○	Red scorpionfish *Scorpaena papillosa*	16	71
3.	◇	Banded wrasse *Notolabrus fucicola*	15	43
4.	■	Scarlet wrasse *Pseudolabrus miles*	15	140
5.		Rockling *Gaidropsarus novaezelandiae* +	14	64
6.		Blue-eyed triplefin *Notoclinops segmentatus* +	13	141
7.	θ	Variable triplefin *Forsterygion varium*	12	328
8.	◆	Rock cod *Lotella rhacina*	12	43
9.	●	Mottled triplefin *Forsterygion malcolmi*	11	54
10.	Δ	Thornfish *Bovichtus variegatus*	10	15
Haast–Buller (15 stns)				
1.		Giant triplefin *Blennodon dorsale* +	12	728
2.	◇	Banded wrasse *Notolabrus fucicola*	9	34
3.		Longfinned triplefin *Ruanoho decemdigitatus*	9	107
4.		Olive rockfish *Acanthoclinus fuscus* +	8	69
5.		Mottled twister *Bellapiscis lesleyae*	8	144
6.		Orange clingfish *Diplocrepis puniceus* +	7	69
7.		Mimic robust triplefin *Grahamina gymnota* ++	7	460
8.	θ	Variable triplefin *Forsterygion varium*	7	121
9.	○	Red scorpionfish *Scorpaena papillosa*	6	27
10.	Δ	Thornfish *Bovichtus variegatus*	6	5

Closed symbols = species in common in first two areas; open symbols = species in common in last two areas; + = most widespread species that characterise fish fauna of each area; ++ = unique to one area during present survey.

Note within rank 1–10: no species occur in all three areas, and none are shared between first and third areas; all specimens were observed as well as collected.

Milford Sound—The 10 most frequently sampled fishes in the fiord occurred at 8–12 (61.5–92.3%) stations, three collected in abundances of over 100 specimens per station. Because of a combination of sample frequency, local abundance, and uniqueness to the area, four species in particular characterised the Milford Sound fish fauna: yellow-black triplefin (12 stations, 471 collected), oblique swimming triplefin (11 stations, 158 collected), pygmy sleeper (10 stations, 134 collected) and pink clingfish (8 stations, 15 collected). Three species were shared with frequently sampled fishes at Cascade–Haast reefs: scarlet wrasse, mottled triplefin and rock cod (Table 8).

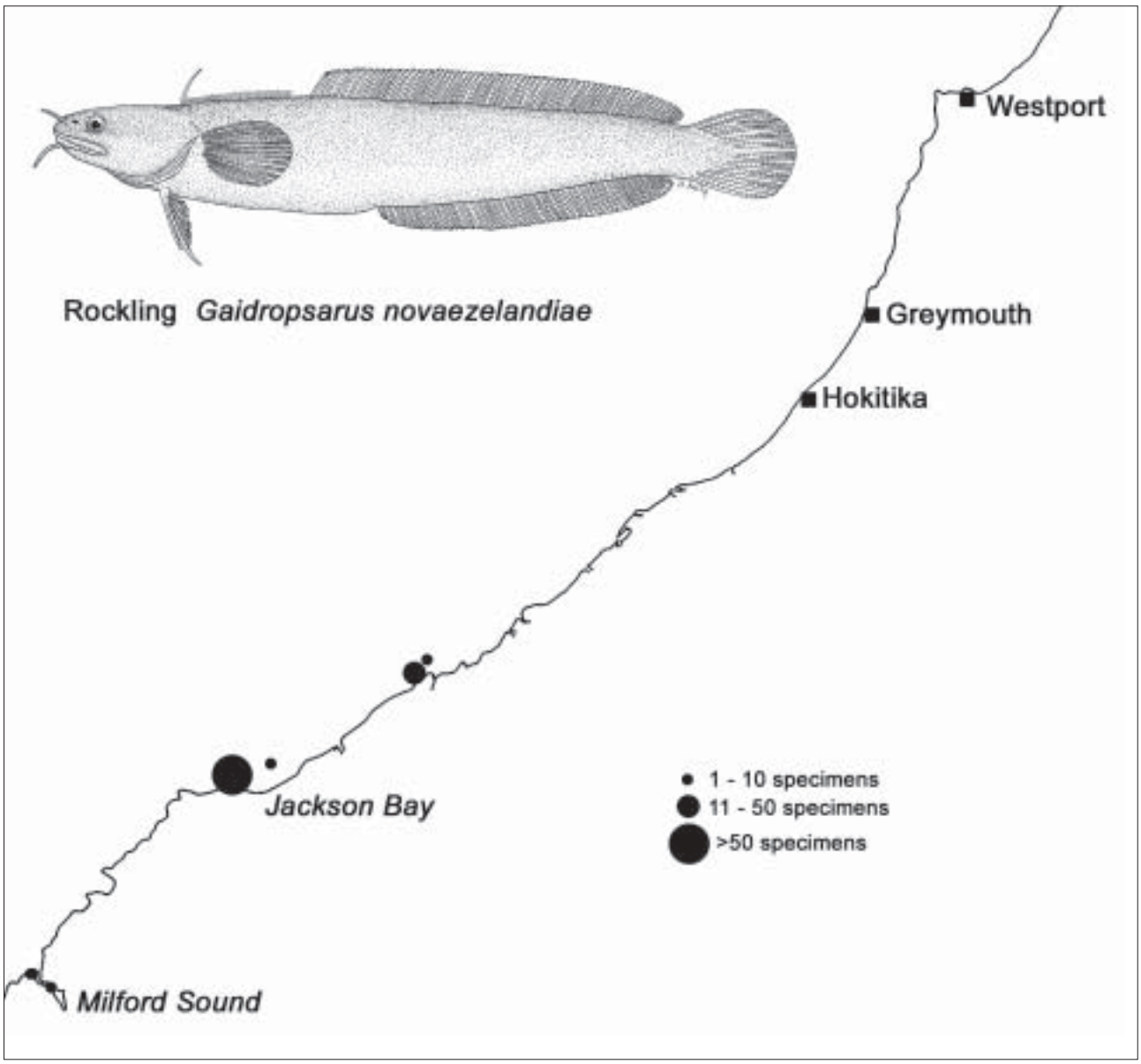

Figure 10. Distribution and abundance of rockling, a 'southern species' reaching its northern limit on the west coast at Hanata Island. Fish illustration from Paulin & Roberts (1992).

Cascade–Haast—The 10 most frequently sampled fishes in this area occurred at 10–17 (58.8–100.0%) stations, 3 collected in abundances of over 100 specimens per station. Two species in particular characterised the Cascade–Haast reef fish fauna: rockling (14 stations, 64 collected; see Fig. 10) and blue-eyed triplefin (13 stations, 141 collected). Two others were abundant, but also found at high frequencies in one other survey area: scarlet wrasse and variable triplefin. In total, 7 species were found at high frequencies in one other survey area: 3 of these were shared with Milford Sound and 4 with Haast–Buller reefs (Table 8). The thornfish was most frequently recorded in the Cascade–Haast area (10 stations), but was also recorded in the Haast–Buller area (6 stations) and once (in an exposed rockpool) at the mouth of Milford Sound (Fig. 11).

Haast–Buller—In this area, the 10 most frequently sampled fishes occurred at 6–12 (40.0–80.0%) stations, 5 collected in abundances of over 100 specimens

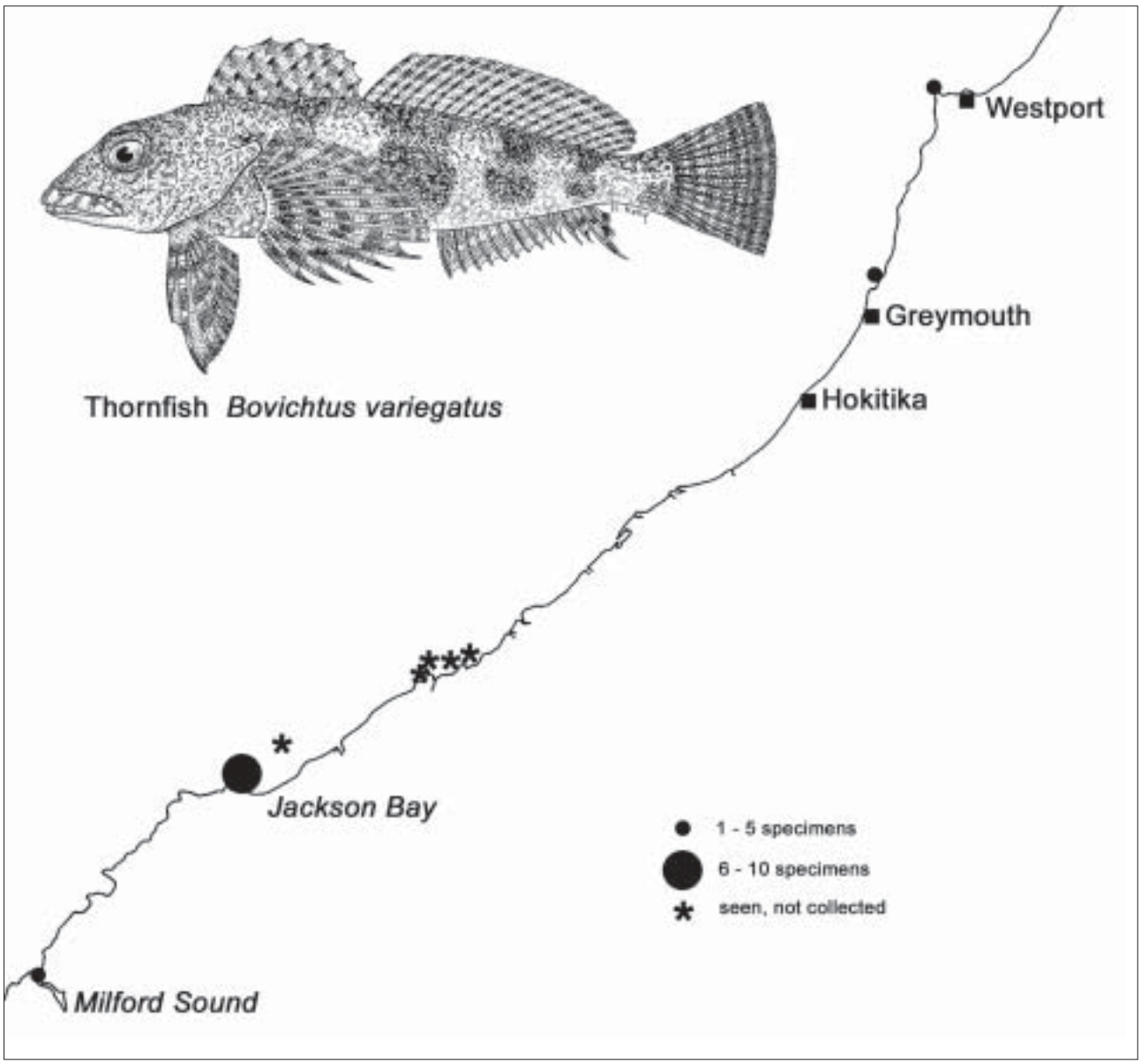

Figure 11. Distribution and abundance of thornfish, a 'southern' species common on exposed reefs along west coast. Fish illustration from Paulin & Roberts (1992).

per station. Four species in particular characterised the Haast–Buller reef fish fauna: giant triplefin (12 stations, 728 collected; see Fig. 12), olive rockfish (8 stations, 69 collected), orange clingfish (7 stations, 69 collected) and mimic robust triplefin (7 stations, 460 collected, and not taken elsewhere on WCSI). Three others were abundant, but also commonly found in another survey area: longfin triplefin, mottled twister and variable triplefin (Table 8).

These changes in ichthyfaunal composition, species numbers, frequency of occurrence and abundance/dominance between the three survey areas appear to be directly associated with major changes in rocky reef habitat between the areas. Reefs at Milford Sound are generally deep and sheltered with variable complexity of structure; between Cascade and Haast reefs range from deep and exposed to shallow and semi-exposed and are structurally complex; and between Haast and Buller the reefs are shallow and exposed with little cover or complexity. In addition, other environmental variables change greatly between

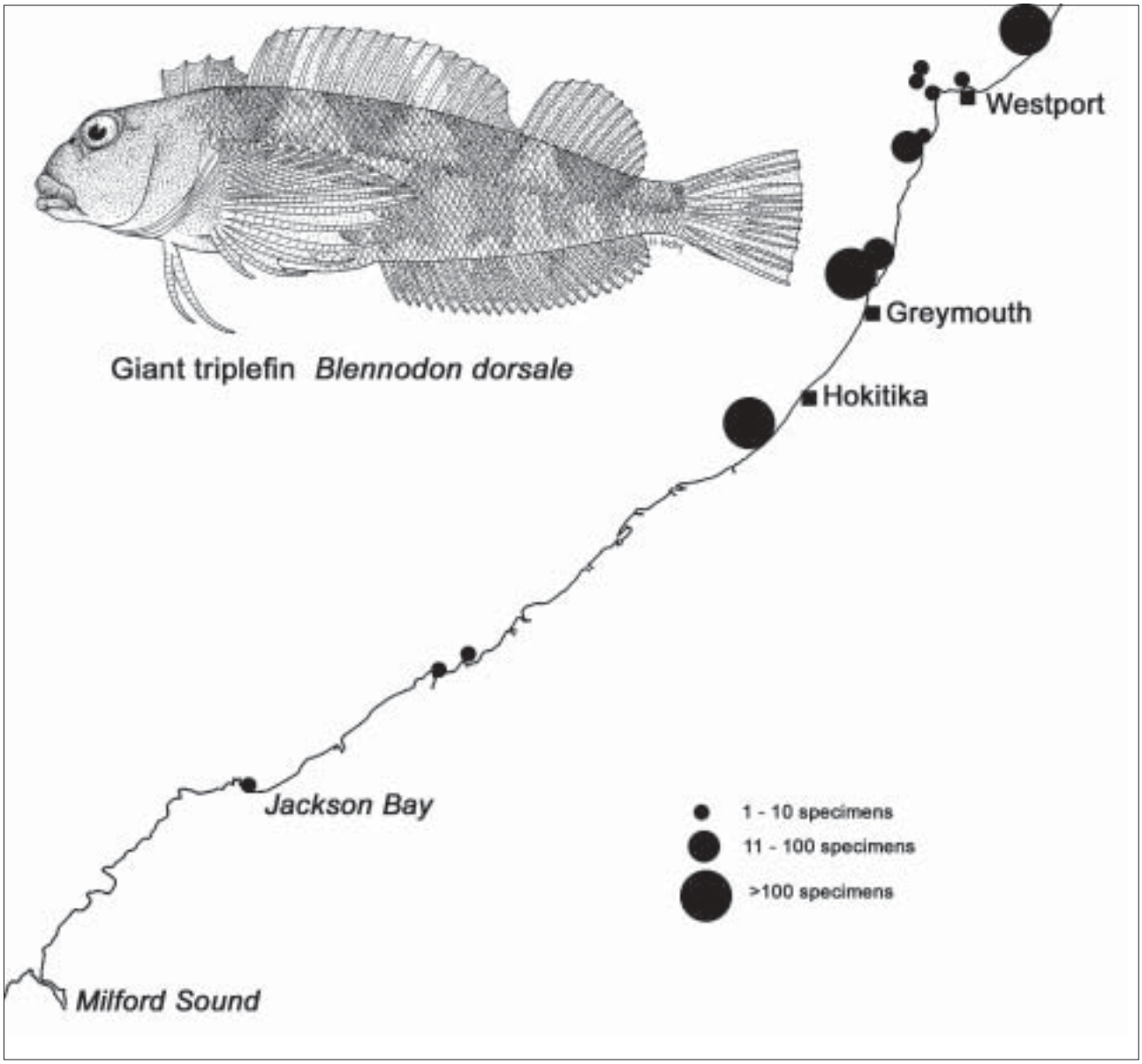

Figure 12. Distribution and abundance of giant triplefin, a prominent shallow reef species in the Westland–Buller region. Fish illustration from Paulin & Roberts (1992).

the areas and can be expected to strongly influence the character and composition of the fish fauna present. For example, high loads of suspended silt (carried in coastal plumes originating from both glacial and non-glacial rivers), sediment re-suspended by heavy wave action, abrasion of reef areas especially in shallow water, low light levels, an increase in sedimentary habitats with a corresponding decrease in reef habitats northwards; and an associated decrease in macroalgal abundance and cover northwards.

4.4.3 Marine regions

On the basis of physical and biological characteristics (including fishes, invertebrates and algae) found during the present study, three marine biogeographic regions are recognised: (1) Fiord, (2) Fiordland open coast–South Westland, and (3) Westland–Buller. The last two regions extend along most of the west coast of the South Island, with a broad zone of transition

between them at South Westland (Fig. 13). The three biogeographic regions are characterised and distinguished according to their faunal diversity and composition, especially the dominance and presence or absence of particular fish species, as follows.

Fiord Region

New Zealand fiord marine environment (Milford Sound sampled during present survey).

Physical characters—Reefs along more than 90% of coastline; steeply inclined rock walls forming sheltered deep reefs and benches (0–25+ m); cold turbid low salinity layer usually 5–10 m deep; clear seawater beneath.

Biological characters—Algae: (reduced diversity and area cover) scattered *Ecklonia* and patches of small reds (outer fiord), *Codium* and '*Lithothamnion*' paint (inner fiord). Invertebrates: encrusting sponge *Mycale*, grey cup sponge *Axinella*; bryozoans; brachiopods *Magasella*, *Notosaria*, *Calloria*; red coral *Errina*; black coral *Antipathes*. Fishes: (small benthics) fiord brotula (Fig. 9), yellow-black triplefin, oblique swimming triplefin, mottled triplefin, pink clingfish, pygmy sleeper, splendid rockfish; (large benthics/demersals) butterfly perch, spotty, girdled wrasse.

Fiordland open coast–South Westland Region

Puysegur Point–Bruce Bay, including Open Bay Islands (area south of Cascade coast unsampled during present survey, except mouth of Milford Sound).

Physical characters—Reefs along more than 60% of coastline; rockpools and exposed shallow reefs (0–5 m); exposed to semi-exposed deep reefs (6–25+ m); reefs covered in large boulders; high exposure to wave action and regular onshore storms; clear oceanic water. Shelf area mostly very narrow, increasing to c. 20 km offshore northwards.

Biological characters—Algae: bull kelp *Durvillaea* patchy; rich stands of brown macrophytes *Cystophora*, *Landsburgia*, *Carpophyllum*, *Ecklonia*; understorey of *Glossophora*, *Zonaria*, *Microzonaria*; patches of *Caulerpa*; turfing reds, intertidally the southern *Apophlaea* prominent (*Gigartina* and *Champia* virtually absent). Invertebrates: erect sponges grey *Ancorina*, green sponge; kina *Evichinus*, gastropod *Turbo*, *Cookia*, paua *Haliotis*; starfish *Pterialla*, *Coscinasterias*, sea cucumbers *Stichipus*; brachiopods; ascidians. Fishes: (small benthics) rockling, brown topknot, blue-eyed triplefin, bluedot triplefin, variable triplefin, mottled triplefin, Yaldwyn's triplefin, red scorpionfish; (large benthic/demersals) marblefish, blue moki, copper moki, tarakihi, banded wrasse, butterfish, thornfish (see Fig. 11).

Westland–Buller Region

Bruce Bay–Gentle Annie Point (the exposed coast between Bruce Bay and Hokitika, and between Westport and Cape Farewell remain poorly sampled).

Physical characters—Reefs along less than 40% of coastline; exposed rockpools and shallow reefs (0–10 m); beaches and seabed predominantly graded sands and gravels; high sediment scour and turbidity; shelf area increasing northwards to over 80 km offshore.

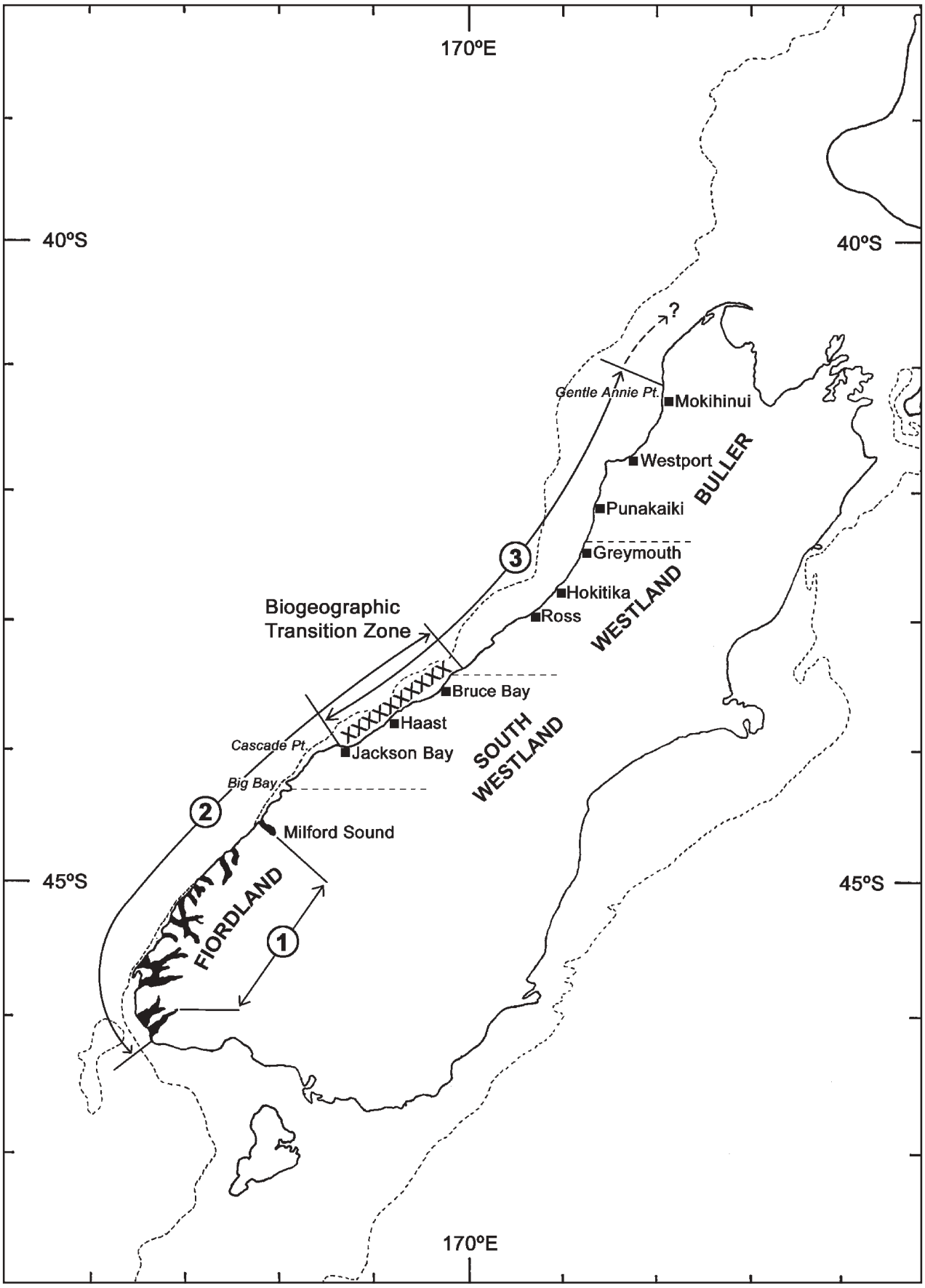

Figure 13. Map of South Island, New Zealand, showing locations of three marine biogeographic regions on the west coast: (1) Fiord, (2) Fiordland open coast–South Westland, and (3) Westland–Buller. Most of South Westland coast (marked XXXX) is a broad transition zone between regions 2 and 3.

Biological characters—Algae: Bull kelp common to dominant; patchy dense turfs of *Gigartina*, *Glossophora* and *Champia* (north of Okarito); large areas of bare rocks. Invertebrates: blue and green mussels (often forming beds), limpets, littorinid gastropods; barnacles, *Plagusia* crabs. Fishes: (small benthics) marbled brotula (Fig. 9), new clingfish, orange clingfish, olive rockfish, giant triplefin, mimic robust triplefin; (large benthics/demersals) spotty, banded wrasse, sand stargazer, spotted stargazer. The following fishes absent: pink clingfish, common roughy, stout rockfish, girdled wrasse, Maori chief, topknot, pygmy sleeper.

The biogeographic transition zone between the Fiord open coast–South Westland region and the Westland–Buller region, extends approximately from Jackson Bay to Bruce Bay (Fig. 13). This zone includes physical and biological characteristics of both regions, with a wide variety of habitat types occurring within relatively small distances. For example, at Jackson Head exposed and semi-sheltered, shallow and deep reefs occur, while nearby at Jackson Bay, shallow exposed reefs are subjected to high sedimentation from the outflow of the Arawata River. Slightly to the north, the Open Bay Islands support a rich offshore marine environment with exposed and sheltered deep reefs, while nearby at Okuru the coast is shallow and exposed with few reefs and mostly sedimentary beaches and seabed covered with turbid water from the Haast River. Elements of the Fiord open coast–South Westland region extend northwards to about Bruce Bay, and include most near-shore stacks and islands. Whereas, elements of the Westland–Buller region extend southwards along the exposed sedimentary coastline to about Jackson Bay. The presence of such a wide variety of habitats in this transitional area support an equally high diversity of marine life, especially fishes. In consequence, the South Westland biogeographic transition zone has the highest diversity of fishes found along the WCSI during this study.

5. Discussion

The main aim of the present study was to survey and sample the coastal reef fish fauna on the WCSI between Milford Sound and Buller, to provide baseline knowledge of fish diversity in the form of station inventories and to seek evidence of the West Coast biogeographic boundary or transition area. The fish surveys carried out in 1998–2000 were the most comprehensive to date along the WCSI, and as such provide a valuable base-line of taxonomic, biodiversity and ecological information on coastal marine fishes inhabiting the region. This study has approximately doubled the known coastal marine fish fauna from the non-fiord WCSI and increased the known Fiordland fish fauna. Excluding records for Milford Sound (part of the fiords fish fauna), the present study recorded 96 species (cf. 52 NWSI species in Francis 1996) in 70 genera and 44 families of marine fishes from the Cascade coast to Gentle Annie Point, many for the first time. More comprehensive collecting along the West Coast and taxonomic work on those collections is helping to classify and expand the known distributions of fish species, including some that were first described from the WCSI.

5.1 FISH DIVERSITY AND DISTRIBUTIONS

Early reviews of the distributions of the New Zealand fish fauna were constrained by incomplete coverage of the coastline (e.g. Moreland 1959; Paulin & Roberts 1992, 1993) and this has remained problematic on the WCSI until the present study. For example, distribution maps for 83 rockpool and surge zone fishes (including 75 widespread in New Zealand coastal waters) given by Paulin & Roberts (1992) were lacking records from the WCSI, with only 17 species included for the area (orange clingfish, longsnout pipefish, giant triplefin, brown topnot, estuarine triplefin, robust triplefin, butterfish, John dory, tarakihi, southern pigfish, red cod, common roughy, Jock Stewart, redbanded perch, spotted black groper, thornfish and scarlet wrasse). Even the most common and widespread coastal reef species were not recorded (e.g. red scorpionfish, spotty, blue cod, common triplefin and variable triplefin), despite being mapped as occurring to the north and south. Similarly, Paulin & Roberts (1993) only recorded 18 species from 'Westland' out of a total of 94 species (56 widespread) for New Zealand.

Prior to the present study, the most complete account of WCSI fishes was by Francis (1996) who analysed distributions of marine reef fishes in the New Zealand region. The WCSI area, named the North-West South Island region (NWSI: Cape Farewell–Jackson Head), had a total of 52 fish species recorded. The NWSI region was bounded by the South-West North Island region (109 species) to the north and by the Fiordland region (79 species) to the south. Francis found that reef fish species diversity decreased linearly with increasing latitude. However, he noted that because there had been less collecting and observational effort in the south, four of the regions plotted (including his NWSI) were outliers having species diversities only 50–60% of those expected on the basis of their latitude. The low species diversity of these regions was explained in part by their low habitat diversity (high exposure, low shelter), also that species diversity was underestimated because of frequently inclement environmental conditions hampering fish collection and observation. Francis predicted that further sampling might produce species compositions more similar to those from adjacent regions. The results of the present study show that his prediction was correct.

Francis (1996) defined reef fishes broadly as shallow water species living mainly less than 100 m deep that inhabit or are associated with rocky reefs. He used a wider range of sources for his database fish records than the present study; including published and unpublished reports, unpublished scuba observations, trawl records, and photographs and sightings. Nevertheless, his records add only another 15 species, indicating that our sampling was comprehensive. Amalgamating the two species lists for the WCSI (excluding our Milford Sound records and four deepwater/pelagic species) gives a total of 107 reef fish species. Following Paulin & Roberts (1992, 1993) and Roberts et al. (1991), 95 (88.8%) are classified as widespread in New Zealand waters, 1 (0.9%) is unknown, 8 (7.5%) are northern, and 6 (5.6%) are southern species.

Northern WCSI species are (* = after Francis 1996): *Epinephelus daemelii*, *Callanthias australis**, *Pseudocaranx dentex**, *Seriola lalandi**, *Pagrus auratus**, *Scorpis lineolata, Scorpis* sp., and *Cheilodactylus spectabilis.* Southern species

are: *Gaidropsarus novaezelandiae*, *Congiopodus leucopaecilus**, *Callanthias allporti**, *Notolabrus cinctus*, *Bovictus variagatus* and *Notothenia angustata*. This analysis confirms the strong widespread affinities of the WCSI fish fauna, with relatively small northern and southern elements.

5.2 FIORD REGION

5.2.1 Milford Sound

Most of the 52 species discovered in Milford Sound during the present study were the first verified records for fishes in that single fiord, and included 28 species from within the Piopiotahi Marine Reserve. Five species were not recorded on the coast further north: *Fiordichthys slartibartfasti*, *Acanthoclinus matti*, *Acanthoclinus* ?n.sp., *Modicus minimus*, and *M. tangaroa*. The two clingfishes (*M. minimus* and *M. tangaroa*) are known from elsewhere around New Zealand, but at much deeper depths (90–150 m). Four sample stations were permitted in the Marine Reserve (F53, F58, F60, F61), while six were located outside the reserve along the opposite (southern) wall. No major differences in habitat were noted between the reserve and the non-reserve stations. Surprisingly, however, all the new and rare species collected within Milford Sound were found outside the Piopiotahi Marine Reserve area.

That result was contrary to expectations and is hard to explain. Possibly it is simply due to the greater sampling effort along the southern side of the fiord (6 cf. 4 sample stations), and more hours spent underwater collecting and observing (16.5 hours cf. 12.8 hours). The relationship between sampling effort and sublittoral species collected is complex and highly variable (Fig. 6B), so all sample locations of the new and rare species being located outside the reserve may be due to chance. However, our observations in Milford Sound give support for a recent theory (Willis & Anderson 2003) that sites within a marine reserve contain, on average, lower densities of cryptic fishes than sites outside, due to increased effects of predators that are protected from extractive fishing. Our underwater observations made at stations within the marine reserve recorded the presence of numerous large benthic and demersal predatory species, such as conger eels, trumpeter, blue cod, rock cod, and wrasses, with a note (station F53) that seaperch were more numerous and larger inside the reserve than those seen along the south side of the fiord. If these large and common predatory fishes in the Piopiotahi Marine Reserve are preying on the smaller benthic and cryptic fish species to such an extent they are reducing their numbers and diversity, then occurrence of this phenomenon in Milford Sound gives support to the generalisation of this theory, originally proposed by Willis & Anderson (2003) for Leigh Marine Reserve in Northland. This hypothesis warrants further testing, since our observations are highly subjective.

The majority (84.6%) of the 52 fish species recorded at Milford Sound can be classified as widespread throughout coastal waters of New Zealand (Paulin & Roberts 1992, 1993; Francis 1996). One species (1.9%), the orange rockfish, has an unknown distribution. Six species (11.5%) represent southern New Zealand cool temperate fauna: rockling (*Gaidropsarus novaezelandiae*), fiord brotula (*Fiordichthys slartibartfasti*), splendid rockfish (*Acanthoclinus matti*), girdled

wrasse (*Notolabrus cinctus*), Maori chief (*Notothenia* sp., observed) and thornfish (*Bovichtus variegatus*). One species (1.9%), sweep (*Scorpis lineolata*), represents a northern warm temperate species, which occasionally reaches the Fiordland and West Coast region. The predominantly widespread New Zealand affinity of the fish fauna of Milford Sound is in close agreement with the analysis of Francis (1996) who found 87.3% of a total of 79 reef fishes to be widespread throughout the whole Fiordland region. His warm temperate (= northern) species were represented by more species than we found in Milford Sound; and conversely his cool temperate/subantarctic (= southern) species were represented by fewer species, probably reflecting differences in sources of records between the two studies.

5.2.2 Other fiords

Milford Sound is the northern-most fiord of 15 in the Fiordland area. Early European and New Zealand marine scientists have been carrying out research in the fiords for over 230 years, but only in the last 30 years has research been sufficiently focussed and intensive to begin to understand the unique, but highly complex nature of the fiord marine environment. We are discovering that the marine life in the fiords is quite different to that elsewhere: the relative composition of the biota is different, the characterisation of the communities is different, the ecological processes are different, the habitats are different, and clearly the physical and chemical processes are different. Indeed there are even important biological and environmental differences between fiords (Roberts 2001). How the marine ecosystem in Milford Sound compares with the ecosystems of other fiords is unclear. Initial results from surveys of habitats and fish faunas of several fiords (Te Papa unpubl. data), show that diversity and richness of sublittoral habitats and their associated reef fishes change and possibly increase southward, although this pattern is complicated by reductions in diversity between outer and inner fiord areas. Similar patterns of diversity as shown by fishes appear to be shown by algae and invertebrates in the fiords (Grange et al. 1981; Nelson et al. 2001).

5.3 FIORDLAND OPEN COAST

As with much of the WCSI to the north, the open coast between the fiords is very exposed, with continual high levels of onshore wave action and regular battering by storms. Access is difficult and biological collecting has been limited or non-existent. In consequence, the intertidal and subtidal reef communities are poorly described. Nevertheless, the open Fiordland coast supports a rich flora of macroalgae and a diverse and abundant fish fauna (Nelson et al. 2001; Te Papa unpubl. data). Several sample stations at the mouths of fiords during Te Papa fish surveys have recorded up to 33 fish species per station, with an abundance of large demersals (e.g. blue cod, butterfish, banded wrasse, marblefish, telescopefish, trumpeter, blue moki, copper moki) and small benthics (e.g. rockfish, bluedot triplefin, variable triplefin, mottled triplefin, topknot, brown topknot) (Te Papa unpubl. data). The reef fish fauna appears to be remarkably similar to that sampled and observed along the Cascade coast north of Milford Sound, but better sampling is needed.

5.4 WESTLAND–BULLER REGION

During the 2000 Haast–Buller survey, suitable and accessible rocky reefs were scarce. Much of the coast is steep, graded coarse sand and gravel beaches. Offshore reefs are relatively shallow and exposed to storms, currents, waves and extreme sand scour. Underwater the reefs were observed to be smooth with very few holes or crevices for habitat. Diving was not possible below 14 m; and most stations were at less than 10 m. Bad weather and poor sea conditions limited sampling to c. 50% of the expected hours spent underwater and dives at four sample stations (33% of stations) were aborted.

Most rocky shores on the WCSI are a jumble of bedrock and boulders, providing a range of habitats for plants and animals. Intertidally the rocky shore biota can vary greatly, depending mainly on the physical nature of the shore. Most are dominated by animals such as mussels, limpets, reef stars, anemones and rockpool fishes, and plants such as short algal turfs. Shores comprising granite boulders usually appear quite barren, but can harbour a number of animal species concealed in spaces beneath the rocks. Limestone shores are often barren intertidally, perhaps because of substrate instability, but are richer in the subtidal zone. The high frequency of storms and severe sand scour action makes it very difficult for many plants and animals to survive. Hence, many West Coast rocky shores are generally lower in species diversity than other New Zealand shores, although this appears to have a lesser effect on mobile and non-benthic species such as fishes (Neale & Nelson 1998).

Shores and reefs along the Haast–Buller coast often comprise granite or sedimentary boulders and bedrock, which offer relativity little habitat cover. This kind of rock forms barren reefs even in very sheltered coasts (e.g. Golden Bay, Nelson, A. Stewart pers. obs.). The dominant large brown alga along the Haast–Buller coast is the bull-kelp, *Durvillaea* spp., which is relatively common in exposed sites where adequate rocky reefs exist. Other algae that are present are generally small and turfing, and most commonly confined to intertidal sites (see list and analysis in Neale & Nelson 1998). Algal cover is also probably severely diminished by a combination of suspended sediment clouding the water, severely reducing available light for photosynthetic activity, and the scour effects on exposed coasts of rough seas with high sediment loads. In addition, the absence of large stands of laminarian algae, results in a corresponding absence of fish species dependent on it for habitat and food (e.g. giant clingfish *Haplocylix littoreus*, butterfish *Odax pullus*, topknots *Notoclinus* spp.).

5.5 MARINE BIOGEOGRAPHIC TRANSITION

One of the main objectives of the present study was to seek evidence among the fish fauna of a boundary or transition between southern and northern parts of the WCSI. Two regional biogeographic boundary areas have been proposed, one in the north around Cape Farewell, separating the Cook Strait area from the WCSI, and one in the south, separating the Fiordland coastal region from the WCSI. The northern boundary was not investigated during the present study. The southern boundary, although generally accepted as indistinct, had been variously proposed to lie at Jackson Head (Knox 1963; Francis 1996), Martins

Bay (Neale & Nelson 1998), Stripe Point just north of Milford Sound (King et al. 1985), or to form a transition zone along the coast between Jackson Bay and Milford Sound (Walls 1995).

Neale & Nelson (1998) investigated biogeographic patterns along the WCSI, based on algal communities and their physical habitats. The number of algal species that reached their latitudinal limits within the region was notable, but regional boundaries located around Cape Farewell and Martins Bay were not sharp. In addition, three sub-regional biogeographic districts were proposed with approximate boundaries at Martins Bay, Bruce Bay, Greymouth, and Cape Farewell. Their survey failed to identify a 'discontinuity' at Jackson Bay, but instead found a 'transitional zone', extending between Martins Bay and Bruce Bay, that supported features common to both the West Coast to the north and Fiordland to the south. In particular, Neale & Nelson (1998) found that the southern part of the South Westland marine district had biological features similar to the outer coasts of Fiordland. Hence, algal distributions and abundance on the West Coast in general complement the present results for fishes, particularly identifying South Westland as a transitional area.

The present study has described three biogeographic marine regions (Fiord, Fiordland open coast–South Westland, and north Westland/Buller), defined according to their physical and biological characteristics, including fish diversity and faunal composition. It was concluded that variation in composition of the marine biota along the West Coast could be best explained by substantive differences in physical and biological characteristics of coastal reef habitats between Milford Sound and Buller. Changes in ichthyofaunal composition, species diversity, algal associations and other biotic characteristics between the regions appear to be directly associated with major changes in physical environmental conditions, especially the degree of exposure to onshore wind and wave action, sedimentation levels, depth of coastal waters, and extent of rocky reef habitat.

The fourth area described here, the South Westland biogeographic transition zone (Fig. 13), has the greatest variety of habitat types and the highest diversity of fishes for the WCSI area surveyed. Fish species numbers at all depths (from rockpool to 25 m) and total numbers recorded per station were consistently highest within the Cascade–Haast area. The biological characteristics of this heterogeneous coastal marine area of South Westland agree well with those shown by transition zones globally. These are typically areas with steep physical gradients or 'ecotones', characterised by high species richness (fishes, invertebrates, and algae) that are located between two distinct biogeographic regions (Odum 1971; Dawson 2001).

Our survey of West Coast fishes showed that differences in faunal composition are occurring along the WCSI; with least similarity and maximum dissimilarity found at the two ends of the WCSI survey area (Table 7). Major differences evident between adjacent pairs of areas, would indicate a restricted area of faunal change, as expected at a biogeographic boundary. However, the biological data, obtained from detailed regional surveys of coastal fishes (this study) and algae (Neale & Nelson 1998), provide strong support for transitional change (extending over 0.5 of a degree of latitude South) in the marine reef biota of the South Westland coast.

6. Summary and conclusions

1. Accurate and testable inventories of the fish fauna have been compiled for the first time at 45 marine sites and four estuarine/freshwater sites on the WCSI. A total of 101 fish species in 72 genera representing 45 families were recorded, with inventory lists supported by c. 3000 voucher specimens.
2. A large number (>50) of new distributional records of fishes have been made for the area, including 4 rare species and up to 3 species new to science.
3. The accuracy of most fish species identifications made during this study can be assessed by examination of the voucher specimens held in archival storage at the National Fish Collection at Te Papa.
4. The fish fauna of the WCSI is predominantly comprised of widespread New Zealand species. The small numbers of northern and southern fish species reflect the position of the WCSI relative to the rest of New Zealand and are comparable to other marine regions of the South Island.
5. The diversity of marine fishes does not vary greatly in numbers of species between the three areas surveyed.
6. In contrast, the composition of the fish fauna differs markedly between the three areas surveyed, particularly in the most frequently sampled species and the dominant species. Thus, the WCSI fish fauna is distinctive and different to other areas of coastal New Zealand.
7. Variation in composition of the fish fauna can be best explained by substantive differences in physical and biological characteristics of coastal reef habitats, between Milford Sound and Buller.
8. Diversity and composition of the fish fauna of the Milford Sound (and probably all New Zealand fiords) are different to all other WCSI areas.
9. Diversity and composition of the fish fauna of the Fiordland open coast are different to that of the Buller area, and the South Westland fish fauna shares features intermediate between both regions.
10. The South Westland coastal area is a broad region of biogeographic transition, rather than sharp discontinuity or boundary.
11. The southern extent of this biogeographic transition zone should be determined by sampling the reef fishes (and other marine biota) along the exposed outer coasts of southern South Westland and Fiordland.
12. Three biogeographic regions (Fiord, Fiordland open coast–South Westland, and north Westland/Buller) can be characterised and distinguished according to their fish diversity and faunal composition, especially the dominance and presence or absence of particular fish species.

6.1 FURTHER WORK

Probably the most serious omission from this study was detailed information about the composition and character of the coastal reef biota, including fishes, along exposed coasts of Fiordland. This work is difficult because of poor access

(boat or helicopter only) and extreme exposure making diving more hazardous, and safe biological collection impossible for much of the time. Nevertheless, experienced divers with local knowledge can probably successfully carry out well-planned survey work in La Niña years (giving easterly, offshore winds) and sample the abundant rock pools at low tide and shallow subtidal stations, especially those protected from ocean swells and waves by near-shore reef formations. Providing the sea conditions allow safe diver operation, clear water and good underwater visibility along this coast will enable the efficient collection of samples and visual assessment of the marine biota and their habitats.

Similarly, the exposed coast between Bruce Bay and Hokitika, and between Westport and Cape Farewell remain relatively poorly sampled, and require biological survey. The same comments apply to these stretches of coast as those for the Fiordland coast (above), although underwater visibility may not be as good. In addition, the Whanganui Inlet, just south of Cape Farewell, is the largest sheltered shore on the WCSI (King et al. 1985), and the fish fauna has never been systematically surveyed. Rocky reefs present at the mouth and within the inlet would be a valuable source of intertidal and subtidal samples that could be analysed for diversity and biogeographic affinities with the WCSI and the Nelson–Cook Strait region, as well as the biological effects of the exposure–shelter gradient.

Okarito Lagoon, although lying within the 2000 Haast–Buller survey area, was not sampled because of time constraints. This sheltered inlet has a diverse and highly productive benthic biota (King et al. 1985), but the fishes are not well surveyed. Sampling in Okarito Lagoon, particularly rotenone stations in saltwater habitats would provide useful data for comparison with the exposed adjacent coast and the sheltered Whanganui Inlet to the north.

Whereas offshore trawl surveys have produced some excellent analyses of the fish fauna of the continental shelf of the West Coast north of Haast, the fish fauna of shallow (<25 m) soft sediment areas and deep reefs (>25 m) off the West Coast have not been systematically surveyed.

Finally, relatively little biological sampling and biogeographic analyses have been carried out along the WCSI apart from marine algae (Neale & Nelson 1998) and fishes (the present study). Future coastal surveys of marine invertebrates will be valuable and informative in their own right and for comparison with existing studies. For example, sediment samples collecting from Westland in 2000 during the present study have revealed 181 mollusc species, with all but three being new records for the area (B.A. Marshall, Te Papa, unpubl. data).

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Appendix 1

SAMPLE STATIONS DURING THE 1998, 1999, AND 2000 WCSI SURVEYS

(Ordered by latitude, N–S)

STATION	LOCALITY	LATITUDE	DEPTH (m)	SPECIES		
				COLLECTED	SEEN NC	TOTAL
Westport (2000)						
H33 R	Gentle Annie Pt	41° 30.20′S	0–0.5	12	0	12
H36	The Steeples, Westport	41° 43.48′S	0–3	9	6	15
H31	The Steeples, Westport	41° 43.58′S	4–8	8	5	13
H35	Buller River breakwater	41° 43.59′S	0–2	2	2	4
H32 F	Big Totara R. side creek	41° 43.82′S	0–0.5	5	0	5
H20 R	Cape Foulwind	41° 46.41′S	0–1.5	9	0	9
H21 F	Okari River lagoon	41° 48.81′S	0–1.5	5	0	5
H34 R	Charleston	41° 53.33′S	0–1.5	10	0	10
H22 R	Charleston	41° 53.54′S	0–0.5	3	0	3
Punakaiki (2000)						
H29	Seal Island, Punakaiki	42° 01.09′S	1–7	13	3	16
H30 R	14 mile Creek	42° 19.20′S	0–1.5	12	0	12
H28	Mikonui reef, Ross	42° 54.20′S	0–0.5	6	0	6
Bruce Bay	(2000)					
H26	Heretaniwha Point	43° 35.20′S	0–2	7	2	9
H27	Hinata Island	43° 37.07′S	5–10	16	7	23
H23	Abbey Rocks	43° 41.15′S	7–11	12	10	22
H25	Wehakapohai Rocks	43° 42.27′S	12–14	17	9	26
H24	Murphy's Beach	43° 47.40′S	0–0.5	16	4	20
Cascade coast (1999)						
H16	Open Bay Islands	43° 51.75′S	0–3	13	4	17
H15	Open Bay Islands	43° 51.81′S	14–19	19	7	26
H18 F	Hapuku R. estuary, Okuru	43° 54.45′S	0–1.5	4	2	6
H05	Jackson Bay Head	43° 57.63′S	8–12	11	6	17
H06	Jackson Bay	43° 57.87′S	0–3	16	1	17
H08	Cave Cove	43° 57.92′S	2.5–7	13	4	17
H03	Smoothwater Bay	43° 57.99′S	4.5–6	18	5	23
H04	Smoothwater Bay	43° 57.99′S	1.5–2.5	17	8	25
H01	Flower Pot Rock	43° 58.04′S	5–9.5	16	13	29
H07	Smoothwater Bay	43° 58.23′S	2–4	9	6	15
H12 R	Inner Frog Rock	43° 58.42′S	0–1	17	0	17
H10	Homminy Cove	43° 58.47′S	0–3	21	4	25
H09	Outer Frog Rock	43° 58.52′S	14–20	16	11	27
H17	Jackson Bay	43° 58.88′S	0–3	11	4	15
H02	Jackson Bay	43° 58.94′S	1.5–2.5	16	4	20
H11	Outer Stafford Rock	43° 59.42′S	11–15	18	10	28
H14	Seal Rock	43° 59.56′S	14–17	15	8	23

R = rockpool station; F = estuarine/freshwater station; Collected = number of species with at least one voucher specimen; NC = not collected.

STATION	LOCALITY	LATITUDE	DEPTH	SPECIES		
			(m)	COLLECTED	SEEN NC	TOTAL
H13	Off Teer Creek	44° 00.00′S	15–18	15	12	27
H19 F	Frolic Brook, Arawhata R.	44° 02.85′S	0–0.75	7	0	7
Milford Sound (1998)						
F54	St Anne Bay	44° 34.53′S	10–14	9	12	21
F55 R	St Anne Bay	44° 34.53′S	0–0.75	7	3	10
F56	Greenstone Point	44° 35.35′S	12–23	12	12	24
F53	2nd point E of Dale Point	44° 35.98′S	11–17.5	2	20	22
F60	Punga Cove	44° 36.28′S	7–14	10	6	16
F52	Cabbage Tree Point	44° 36.38′S	11–20	7	12	19
F59	Kettle Point	44° 37.34′S	10–18	10	7	17
F58	Opposite Pater Point	44° 37.44′S	8–16	10	5	15
F62	S of Stirling Falls	44° 37.45′S	4–17	12	9	21
F57	Pater Point	44° 38.17′S	10–15	5	7	12
F61	Bridget Point	44° 38.61′S	6–14	14	5	19
F51	Point W of Sinbad Point	44° 39.38′S	12–18	7	6	13
F50	Sinbad Point	44° 39.76′S	17–20	5	10	15

R = rockpool station; F = estuarine/freshwater station; Collected = number of species with at least one voucher specimen; NC = not collected.

Appendix 2

FISH SPECIES IDENTIFIED FROM MILFORD SOUND

(See Table 1 and Appendix 1 for locality data.)

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES (see next page)
Myxinidae			
Eptatretus cirrhatus (Forster)	hagfish	–	(2)
Squalidae			
Squalus acanthias L.	spiny dogfish	F56°, F57°, **F61**°, F62°	
Congridae			
Conger verreauxi Kaup	conger eel	**F53**°, **F58**°, F59°, **F61**°	
Bythitidae			
[e]*Fiordichthys slartibartfasti* Paulin	Fiord brotula	F51, F52°, F62	
Moridae			
Lotella rhacina (Forster)	rock cod	F50, F52, **F53**°, F54°, F56, F59, **F60**, **F61**, F62	(2°)
Pseudophycis barbata Günther	southern bastard red cod	F52°, F61, F62°	
Phycidae			
Gaidropsarus novaezelandiae (Hector)	rockling	F54, F62	
Mugilidae			
Aldrichetta forsteri (Valenciennes)	yelloweyed mullet	F52°	
Trachichthyidae			
[e]*Paratrachichthys trailli* (Hutton)	common roughy	**F53**°, **F58**	(2°)
Syngnathidae			
[e]*Lissocampus filum* (Günther)	shortsnout pipefish	–	(1a)
Scorpaenidae			
Helicolenus percoides (Richardson)	jock stewart	F50, F51°, F52°, **F53**° , F56°, F57°, **F58**, F59, **F60**°, **F61**, F62°	(2)
Scorpaena papillosa (Schneider & Forster)	red scorpionfish	F51, F52°, **F53**°, F54, F56, F59°, **F61**	(1b)
Serranidae			
Caesioperca lepidoptera (Forster)	butterfly perch	F50°, F51°, F52, **F53**°, F54°, F56°, F57°, **F58**°, F59°, **F60**°, **F61**°, F62	(2)
[e]*Hypoplectrodes huntii* (Hector)	redbanded seaperch	**F53**°, F56, **F60**, F62	(2°)
Polyprionidae			
Polyprion oxygeneios (Schneider & Forster)	hapuku	–	(3)
Plesiopidae			
[e]*Acanthoclinus fuscus* Jenyns	olive rockfish	F55	
[e]*Acanthoclinus littoreus* (Forster)	black rockfish	F55	
[e]*Acanthoclinus marilynae* (Hardy)	stout rockfish	F50°, F51°, F52, F54, F56, **F61**	
[e]*Acanthoclinus matti* (Hardy)	splendid rockfish	F50°, **F58**, F59, F60, **F61**, F62	
[e]*Acanthoclinus rua* (Hardy)	little rockfish	F56	
[e]*Acanthoclinus* ?n. sp.	orange rockfish	F59	
Kyphosidae			
Scorpis lineolata Kner	sweep	F56°	(1c°)
Aplodactylidae			
Aplodactylus arctidens Richardson	marblefish	F52°, **F53**°, F54°, F56°, F59°, **F61**, F62°	

[e] = NZ endemic species; F50–F62 = station records; ° = seen, but not collected. **Bold** stations: **F53, F58, F60, F61** = specimens collected or seen in Piopiotahi Marine Reserve.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES
Cheilodactylidae			
Nemadactylus macropterus (Forster)	tarakihi	F50°, F51°, **F53°**, F54°, F56, F57°, **F58°**, F62°	(2°)
Latrididae			
[e]*Latridopsis ciliaris* (Forster)	blue moki	**F53°**	
Latris lineata (Forster)	trumpeter	**F53°**, F54°	
Mendosoma lineatum Guichenot	telescope fish	**F53°**, F54°, F56°	(1c°, 2°)
Labridae			
[e]*Notolabrus celidotus* (Bloch & Schneider)	spotty	F50°, F51°, F52°, F54°, F56°, F57°, **F58°**, **F60°**, **F61°**, F62°	(2°)
[e]*Notolabrus cinctus* (Hutton)	girdled wrasse	F50°, F54°, F56°, F57°, F60°	
Notolabrus fucicola (Richardson)	banded wrasse	F51°, F52°, F53°, F54°, F55, F56°, **F60°**	
[e]*Pseudolabrus miles* (Forster & Schneider)	scarlet wrasse	F50, F52°, **F53°**, F54, F56, F57°, **F58**, F59°, **F60°**, **F61**, F62°	(1b)
Bovichthyidae			
[e]*Bovichtus variegatus* Richardson	thornfish	F55	
Nototheniidae			
Notothenia sp (?)	Maori chief	F54°	
Pinguipedidae			
[e]*Parapercis colias* (Forster)	blue cod	F52°, **F53°**, **F58°**, **F61°**, F62°	(2)
Tripterygiidae			
[e]*Bellapiscis lesleyae* Hardy	mottled twister	F55	
[e]*Bellapiscis medius* (Günther)	twister	F55	
[e]*Cryptichthys jojettae* Hardy	cryptic triplefin	–	(1c°)
[e]*Forsterygion flavonigrum* Fricke & Roberts	yellowblack triplefin	F50, F51, F52, **F53**, F54, F56, F57, **F58**, F59, **F60**, **F61**, F62	(1a, 1b, 2°)
Forsterygion lapillum Hardy	common triplefin	F50°, F55, **F58**, F59°, **F60°**, **F61**, F62°	
[e]*Forsterygion malcolmi* Hardy	mottled triplefin	F50°, F51, F52°, **F53°**, F54°, F57, **F58**, F59, **F60**, **F61**, F62	(1a, 1b, 2°)
Forsterygion varium (Forster)	variable triplefin	F59°	
[e]*Karalepis stewarti* Hardy	scalyheaded triplefin	–	(1c°)
[e]*Notoclinops caerulepunctus* Hardy	bluedot triplefin	F52°, F54°,	
[e]*Notoclinops segmentatus* (McCul. & Phillipps)	blue eyed triplefin	**F53°**, F56°	
[e]*Notoclinus fenestratus* (Forster)	topknot	F56	
[e]*Obliquichthys maryannae* Hardy	oblique swimming triplefin	F50°, F51, F52, **F53°**, F54, F56, F57, F58, F59, **F60**, F62	(1b, 2°)
[e]*Ruanoho whero* Hardy	spectacled triplefin	**F53°**, F56°	
Gobiesocidae			
[e]*Modicus minimus* Hardy	pink clingfish	F50, F51, F52, F57, F59, **F60**, **F61**, F62	(1a, 1b)
[e]*Modicus tangaroa* Hardy	eyespot clingfsh	–	(1b)
Gobiidae			
[e]*Gobiopsis atrata* (Griffin)	black goby	**F53°**, **F58**, **F60**, **F61**, F62	
Eleotridae			
[e]*Thalasseleotris* n. sp.	pygmy sleeper	F50°, F51, F52, F56, F57, **F58**, F59, **F60**, **F61**, F62	(1a, 1b)
Gempylidae			
Thyrsites atun (Euphrasen)	barracouta	F56	(2)

[e] = NZ endemic species; F50–F62 = station records; ° = seen, but not collected. **Bold** stations: **F53, F58, F60, F61** = specimens collected or seen in Piopiotahi Marine Reserve.

Notes:

(1a) Rotenone sample, Andrew Stewart / Euan Harvy site 12, 15–20 m depth, 14 Nov 1994.

(1b) Rotenone sample, Andrew Stewart / Euan Harvy site 8, opposite Stirling Falls, 10–15 m depth, 19 Nov 1994.

(1c) Observation dives at entrance to Milford Sound, Euan Harvy / Andrew Stewart, 2–20 m depth, 16 Nov 1994.

(2) Angling with rod and line, and observations, The Boulders, Mitre Peak, 20–40 m depth, 20 Mar 1995.

(3) Angling with rod and line, mid-Milford Sound, 20–40 m depth, 1998.

Appendix 3

FISH SPECIES IDENTIFIED FROM THE CASCADE–HAAST REGION

See Table 2 and Appendix 1 for locality data.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES (see p. 60)
Myxinidae			
Eptatretus cirrhatus (Forster)	hagfish	–	(1)
Carcharhinidae			
Prionace glauca (L.)	blue shark	–	(6)
Hexanchidae			
Notorynchus cepedianus (Peron)	seven gill shark	–	(2)
Lamnidae			
Carcharodon carcharias (L.)	great white shark	–	(4)
Lamna nasus (Bonnaterre)	porbeagle	–	(5)
Dalatiidae			
Dalatias licha (Bonnaterre)	seal shark	–	(3)
Squalidae			
Squalus acanthias L.	spiny dogfish	H09, H11°	
Dasyatidae			
Dasyatis sp.	stingray	–	(7)
Myliobatidae			
Myliobatis tenuicaudatus Hector	eagle ray	H04°	
Anguillidae			
Anguilla australis Richardson	shortfin eel (Fw)	H19	
[e]*Anguilla dieffenbachii* Gray	longfin eel (Fw)	H19	
Congridae			
Conger verreauxi Kaup	southern conger	H01, H02, H03, H04, H06, H08°, H09°, H10, H13°, H15	
Galaxiidae			
Galaxias maculatus (Jenyns)	inanga (Es, Fw)	H18, H19	
Salmonidae			
Salmo trutta L.	brown trout (Fw)	H19	
Moridae			
Lotella rhacina (Forster)	rock cod	H01, H02, H03, H05, H06, H08, H09, H10, H11, H13, H14, H15	
Pseudophycis bachus (Forster)	red cod	H05°, H09	
Pseudophycis barbata Günther	southern bastard red cod	H13, H15	
Phycidae			
Gaidropsarus novaezelandiae (Hector)	rockling	H01, H02, H03, H04, H05, H06, H09, H10, H11, H13, H14, H15, H16, H17	
Mugilidae			
Aldrichetta forsteri (Valenciennes)	yelloweyed mullet	H01°, H02°, H10°, H17°, H18°	
Trachichthyidae			
[e]*Paratrachichthys trailli* (Hutton)	common roughy	H01°, H08, H09, H13°, H14, H15, H17	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H01–H19 = station records; ° = seen, but not collected.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES (see p. 60)
Syngnathidae			
Hippocampus abdominalis Lesson	seahorse	–	(13)
[e]*Lissocampus filum* (Günther)	shortsnout pipefish	H01, H10, H17	
Scorpaenidae			
Helicolenus percoides (Richardson)	Jock Stewart	H04°, H11, H13, H14°, H15	
Scorpaena papillosa (Schneider & Forster)	red scorpionfish	H01, H02, H03, H04, H05, H06, H08, H09, H10, H11, H12, H13, H14, H15, H16, H17	
Scorpanea sp.	yellow scorpionfish	–	(8)
Serranidae			
Caesioperca lepidoptera (Forster)	butterfly perch	H01°, H09°, H11°, H13°, H14°, H15	
[e]*Hypoplectrodes huntii* (Hector)	redbanded seaperch	H01, H03, H05, H06, H09, H13, H15	
Plesiopidae			
[e]*Acanthoclinus fuscus* Jenyns	olive rockfish	–	(9)
[e]*Acanthoclinus littoreus* (Forster)	black rockfish	H02, H03, H04, H08	
[e]*Acanthoclinus marilynae* (Hardy)	stout rockfish	H01, H03, H04, H09, H10, H11, H13, H14, H15	
[e]*Acanthoclinus rua* (Hardy)	little rockfish	H01, H03, H09	
Carangidae			
Trachurus ?symmetricus (Ayres)	slender mackerel	–	(12)
Kyphosidae			
Scorpis lineolata Kner	sweep	H11, H13°	
Arripidae			
Arripis trutta (Forster)	kahawai	H13°, H18	
Aplodactylidae			
Aplodactylus arctidens Richardson	marblefish	H01°, H02°, H03°, H04°, H05°, H06°, H07°, H08°, H09°, H10°, H11°, H12, H13°, H14°, H15°, H16°, H17°	
Cheilodactylidae			
Nemadactylus macropterus (Forster)	tarakihi	H03°, H05, H07°, H09°, H11°, H14°, H15°	
Latridae			
[e]*Latridopsis ciliaris* (Forster)	blue moki	H01°, H04, H05°, H09°, H11, H13°, H14°, H15°	
Latridopsis forsteri (Castelnau)	copper moki	H01°, H09°, H11°, H13, H15°	
Latris lineata (Forster)	trumpeter	H09°, H13°	
Mendosoma lineatum Guichenot	telescope fish	–	(10)
Labridae			
[e]*Notolabrus celidotus* (Bloch & Schneider)	spotty	H01°, H02°, H03°, H04, H05°, H07, H8°	
[e]*Notolabrus cinctus* (Hutton)	girdled wrasse	H03°, H11	
Notolabrus fucicola (Richardson)	banded wrasse	H01°, H02, H03, H05°, H06, H07, H08, H09°, H11°, H12, H13°, H14°, H15°, H16, H17°	
[e]*Pseudolabrus miles* (Forster & Schneider)	scarlet wrasse	H01, H02, H03, H04, H05, H06, H07, H08, H10, H11, H12, H13, H14, H15, H16	
Odacidae			
[e]*Odax pullus* (Forster)	greenboned butterfish	H04°, H08, H10°, H11°	
Bovichthyidae			
[e]*Bovichtus variegatus* Richardson	thornfish	H01°, H03, H06, H07°, H08, H09, H11°, H12, H16°, H17°	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H01–H19 = station records; ° = seen, but not collected.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES (see p. 60)
Nototheniidae			
Notothenia angustata Hutton	Maori chief	H02, H04, H16[o]	
Pinguipedidae			
[e]*Parapercis colias* (Forster)	blue cod	H01[o], H09, H11[o], H13[o], H14[o] H15[o], H16[o]	
Creediidae			
[e]*Limnichthys polyactis* Nelson	tommyfish	H05, H06, H07, H10, H11, H13, H14, H15	
[e]*Tewara cranwellae* Griffin	sand diver	H07	
Unidentified		H04[o]	
Tripterygiidae			
[e]*Bellapiscis lesleyae* Hardy	mottled twister	H02, H04[o], H10, H12, H16, H17	
[e]*Bellapiscis medius* (Günther)	twister	H10	
[e]*Blennodon dorsale* (Clarke)	giant triplefin	H17	
[e]*Cryptichthys jojettae* Hardy	cryptic triplefin	H04, H10, H12, H16	
[e]*Forsterygion flavonigrum* Fricke & Roberts	yellowblack triplefin	H01, H05, H11, H13, H14, H15	
Forsterygion lapillum Hardy	common triplefin	H02, H04, H06, H10[o], H12, H16, H17	
[e]*Forsterygion malcolmi* Hardy	mottled triplefin	H01, H03, H05, H06, H07[o], H08, H10, H11, H13[o], H14, H15	
Forsterygion varium (Forster)	variable triplefin	H01, H02, H03, H04, H05, H06, H07, H08, H09[o], H10, H14, H16	
[e]*Gilloblennius abditus* Hardy	obscure triplefin	H12	
[e]*Gilloblennius tripennis* (Forster)	thripenny	H06, H10, H17	
[e]*Grahamina capito* (Jenyns)	robust triplefin	H01, H04, H12, H17	
[e]*Grahamina nigripenne* (Valenciennes)	estuarine triplefin (Es)	H18	
[e]*Karalepis stewarti* Hardy	scalyheaded triplefin	H01, H11, H14, H15	
[e]*Notoclinops caerulepunctus* Hardy	bluedot triplefin	H01, H03, H05, H11, H13, H14, H15	
[e]*Notoclinops segmentatus* (McCull & Phil)	blue eyed triplefin	H03, H04, H06, H07, H08, H09[o], H10, H11, H13, H14, H15, H16, H17	
[e]*Notoclinops yaldwyni* Hardy	Yaldwyn's triplefin	H16	
[e]*Notoclinus compressus* (Hutton)	brown topknot	H04	
[e]*Notoclinus fenestratus* (Forster)	topknot	H10	
[e]*Obliquichthys maryannae* Hardy	oblique swimming triplefin	H09[o], H11, H14[o], H15[o]	
[e]*Ruanoho decemdigitatus* (Clarke)	longfinned triplefin	H02, H04, H06, H07, H08, H10, H12, H16, H17	
[e]*Ruanoho whero* Hardy	spectacled triplefin	H01, H03, H06, H07, H10, H11, H13, H14, H15	
Gobiesocidae			
[e]*Dellichthys morelandi* Briggs	urchin clingfish	H03[o], H04[o], H07[o], H08, H10, H16	
[e]*Diplocrepis puniceus* (Richardson)	orange clingfish	H07[o]	
[e]*Gastroscyphus hectoris* (Günther)	Hector's clingfish	H04	
[e]*Modicus minimus* Hardy	pink clingfish	H12	
[e]*Trachelochismus pinnulatus* (Forster)	lumpfish	H03, H12	
[e]*Trachelochismus* sp.		H02[o]	
Eleotrididae			
[e]*Gobiomorphus cotidianus* McDowall	common bully (Es, Fw)	H18, H19	
[e]*Gobiomorphus huttoni* (Ogilby)	redfin bully (Fw)	H19	
[e]*Thalasseleotris* n.sp.	pygmy sleeper	H01[o], H03, H11	
Gobiidae			
[e]*Gobiopsis atrata* (Griffin)	black goby	H08[o], H11[o], H14, H15, H16	

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES
Gempylidae			
Thyrsites atun (Euphrasen)	barracouta	H05°	
Scombridae			
Thunnus alalunga (Bonaterre)	albacore	–	(11)
Pleuronectidae			
[e]*Rhombosolea retiaria* Hutton	black flounder (Es)	H18°	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H01–H19 = station records; ° = seen, but not collected.

Notes:

(1) Found dead on beach, C. Paulin, 1995.
(2) Open Bay Islands, D. Neale.
(3) Found dead on beach, C. Paulin, 1995.
(4) Off Haast, D. Neale, photograph.
(5) Okuru, D. Neale, 1990.
(6) Jackson Bay wharf, 1999.
(7) Open Bay Islands, D. Neale and P. Ryan, 1996.
(8) Open Bay islands, D. Neale and P. Ryan, 1996; photographs.
(9) Jackson Bay area, Ocean Beach and Smoothwater Bay, D. Neale, 1994.
(10) Open Bay Islands, D. Neale and P. Ryan, 1996.
(11) Commercial catch off Jackson Bay in summer (landed 1999).
(12) Jackson Bay wharf, 1999.
(13) Jackson Bay, D. Neale.

Appendix 4

FISH SPECIES IDENTIFIED FROM THE HAAST–BULLER REGION

See Table 3 and Appendix 1 for locality data.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES (see p. 63)
Carcharhinidae			
Prionace glauca (L.)	blue shark	H31°	
Triakidae			
Galeorhinus galeus (L.)	tope	–	(1, 4)
Squalidae			
Squalus acanthias L.	spiny dogfish	H36°	(1, 2, 3)
Anguillidae			
Anguilla australis Richardson	shortfin eel (Es, Fw)	H21, H32	
[e]*Anguilla dieffenbachii* Gray	longfin eel (Es, Fw)	H21, H32	
Congridae			
Conger verreauxi Kaup	southern conger	H27°, H29, H30, H33	
Galaxiidae			
Galaxias maculatus (Jenyns)	inanga (Fw)	H32	
Bythitidae			
[e]*Bidenichthys consobrinus* (Hutton)	marbled brotula	H29	
Moridae			
Lotella rhacina (Forster)	rock cod	H23, H25, H27, H29, H36	
Pseudophycis barbata Günther	southern bastard red cod	H25, H36°	
Phycidae			
Gaidropsarus novaezelandiae (Hector)	rockling	H23, H25, H27	
Mugilidae			
Aldrichetta forsteri (Valenciennes)	yelloweyed mullet	H21, H24°, H25°, H26°, H29°, H33, H35°, H36	
Syngnathidae			
[e]*Lissocampus filum* (Günther)	shortsnout pipefish	H24°, H25	
Scorpaenidae			
Scorpaena papillosa (Schneider & Forster)	red scorpionfish	H23, H25, H27, H29, H31, H36	
Triglidae			
Chelidonichthys kumu (Lesson & Cuvier)	red gurnard	–	(3)
Serranidae			
Caesioperca lepidoptera (Forster)	butterfly perch	H23°	
Epinephelus daemelii (Günther)	spotted black groper	–	(5)
[e]*Hypoplectrodes huntii* (Hector)	redbanded perch	H23, H25, H27	
Plesiopidae			
[e]*Acanthoclinus fuscus* Jenyns	olive rockfish	H20, H21, H22, H26, H29, H30, H33, H34	
[e]*Acanthoclinus littoreus* (Forster)	black rockfish	H25, H36	
[e]*Acanthoclinus rua* (Hardy)	little rockfish	H23, H27	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H20–H36 = station records;
° = seen, but not collected.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES
Carangidae			
Trachurus sp.	mackerel	H23°	
Kyphosidae			
Scorpis sp.		H25°, H29°	
Arripidae			
Arripis trutta (Forster)	kahawai	H35	(1°)
Aplodactylidae			
Aplodactylus arctidens Richardson	marblefish	H23°, H24°, H25°, H26, H36°	
Cheilodactylidae			
Cheilodactylus spectabilis Hutton	red moki	H23°, H27°	
Nemadactylus macropterus (Forster)	tarakihi	H23°, H25°, H27°, H31°, H36°	
Latrididae			
[e]*Latridopsis ciliaris* (Forster)	blue moki	H25°, H27°	
Latridopsis forsteri (Castelnau)	copper moki	H25°	
Labridae			
[e]*Notolabrus celidotus* (Bloch & Schneider)	spotty	H30, H31°, H33, H34, H36	
Notolabrus fucicola (Richardson)	banded wrasse	H23°, H24, H25°, H26°, H27°, H29°, H30, H31°, H36°	
[e]*Pseudolabrus miles* (Forster & Schneider)	scarlet wrasse	H23, H25, H27	
Labridae unidentified species	wrasse	–	(6)
Bovichthyidae			
[e]*Bovichtus variegatus* Richardson	thornfish	H20, H23°, H24°, H25°, H27°, H30	
Pinguipedidae			
[e]*Parapercis colias* (Forster)	blue cod	H23°, H25°, H27	
Creediidae			
[e]*Limnichthys polyactis* Nelson	tommyfish	H23, H25, H27	
Leptoscopidae			
[e]*Crapatalus novaezelandiae* Günther	sand stargazer	H33	
Uranoscopidae			
[e]*Genyagnus monopterygius* (Schneider)	spotted stargazer	H28, H30, H34	
Tripterygiidae			
[e]*Bellapiscis lesleyae* Hardy	mottled twister	H20, H24, H26, H28, H31, H33, H34, H35°	
[e]*Bellapiscis medius* (Günther)	twister	H20, H22, H26, H33, H34	
[e]*Blennodon dorsale* (Clarke)	giant triplefin	H20, H22, H24, H26, H28, H29, H30, H31, H33, H34, H35, H36°	
[e]*Cryptichthys jojettae* Hardy	cryptic triplefin	H24	
[e]*Forsterygion flavonigrum* Fricke & Roberts	yellowblack triplefin	H23°, H25	
Forsterygion lapillum Hardy	common triplefin	H20, H24, H33, H34, H36	
[e]*Forsterygion malcolmi* Hardy	mottled triplefin	H23, H25, H27, H29, H31	
Forsterygion varium (Forster)	variable triplefin	H23, H24, H25, H27, H29, H31, H36	
[e]*Gilloblennius abditus* Hardy	obscure triplefin	H24	
[e]*Gilloblennius tripennis* (Forster)	thripenny	H24	
[e]*Grahamina capito* (Jenyns)	robust triplefin	H20, H24, H34	
Grahamina gymnota (Scott)	mimic robust triplefin	H26, H28, H29, H30, H31, H33, H36	
[e]*Grahamina nigripenne* (Valenciennes)	estuarine triplefin (Es)	H21	
[e]*Karalepis stewarti* Hardy	scalyheaded triplefin	H25	
[e]*Notoclinops caerulepunctus* Hardy	bluedot triplefin	H23°, H25	
[e]*Notoclinops segmentatus* (McCull. & Phil.)	blue eyed triplefin	H23, H24, H25, H27	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H20–H36 = station records;
° = seen, but not collected.

FAMILY, SPECIES, AND AUTHORITY	COMMON NAME	STATIONS	NOTES
[e]*Notoclinops yaldwyni* Hardy	Yaldwyn's triplefin	H23, H27°, H31	
[e]*Ruanoho decemdigitatus* (Clarke)	longfinned triplefin	H20, H24, H25, H27, H29, H30, H31, H34, H36	
[e]*Ruanoho whero* Hardy	spectacled triplefin	H23, H25, H27, H29	
Tripterygiidae larvae, unidentified		H24, H27	
Gobiesocidae			
[e]*Dellichthys morelandi* Briggs	urchin clingfish	H27, H36°	
[e]*Diplocrepis puniceus* (Richardson)	orange clingfish	H20, H24, H28, H29, H30, H33, H34	
[e]*Gastroscyphus hectoris* (Günther)	Hector's clingfish	H24	
[e]*Gastroscyphus* n. sp.	mottled clingfish	H28, H30	
[e]*Trachelochismus pinnulatus* (Forster)	lumpfish	H24, H26, H28, H30, H33	
[e]*Trachelochismus* sp.	juvenile	H27	
Eleotrididae			
[e]*Gobiomorphus cotidianus* McDowall	common bully (Fw)	H32	
[e]*Gobiomorphus huttoni* (Ogilby)	redfin bully (Fw)	H32	
Gobiidae			
[e]*Gobiopsis atrata* (Griffin)	black goby	H31	

[e] = endemic species; (Es) = recorded in estuary; (Fw) = recorded in freshwater (river); H20–H36 = station records;
° = seen, but not collected.

Notes:

(1) Collected by set line, 22 m, seaward of Stn H25 (43° 42.08′S, 169° 14.17′E), 18 February 2000.
(2) Collected by set line, 18 m, off Stn H29 (42° 01.27′S, 171° 21.17′E), 20 February 2000.
(3) Collected by set line, 20 m, adjacent to Stn H31 (41° 43.30′S, 171° 28.12′E), 21 February 2000.
(4) Collected by set line, 19 m, adjacent to Stn H36 (41° 43.26′S, 171° 28.12′E), 24 February 2000.
(5) Collected by trawler off Westport (41° 40′S, 171° 35′E), 23 July 1984.
(6) Illustrated by F.E. Clarke in the 1870s, from a specimen off Hokitika; possibly a hybrid.

Appendix 5

FISH FAMILY ACCOUNTS

During the 1998–2000 WCSI surveys, the occurrence of several groups of shore fishes were of note because their presence or absence was biogeographically informative, or because their frequency of occurrence and/or abundance within stations was ecologically important. These WCSI fishes are discussed by family below.

Brotulas (family Bythitidae)

Brotulas (Fig. 9) are a warm-water family usually collected north of Cook Strait. These fishes are livebearers, have limited dispersal ability and a high degree of endemism. See Fig. 9 for their distribution in the 1998–2000 surveys

Milford Sound—Three specimens of the rare endemic fiord brotula (*Fiordichthys slartibartfasti*) were collected in Milford Sound: one at station F51 and two at station F62, with a possible sighting at station F52.

This is possibly an emergent species (= deepwater species living at shallow depths in the fiords, including Milford Sound) living in much deeper water outside the fiords. Only three other specimens have been collected: two from Preservation Inlet and one from Bradshaw Sound in Fiordland. It has been taken in areas of broken rubble and relatively deep water (10–18 m). Little is known of the biology of this species, which has one of the most restricted distributions of any fishes found around the coasts of mainland New Zealand.

Cascade–Haast and Haast–Buller—A single specimen of another very rare species, the marbled brotula (*Bidenichthys consobrinus*) was collected at Seal Island, Punakaiki, in 1–7 m depth. This is only the fourth specimen of this species known and the first juvenile ever collected (see Paulin 1995a).

The site sampled at Seal Island (H29) was somewhat unusual for the WCSI, being relatively sheltered from wind, waves, and swell by both a rocky headland and an artificial concrete platform. Underwater, tumbledown boulder rubble also afforded cover and habitat that was usually scoured out at other more exposed localities. Tufting and erect red algae (of unidentified species) were common at this site.

Rockling (family Gadidae)

Rockling (Fig. 10) are small cryptic reef fishes, with about 10 species mostly restricted to cool temperate waters of all oceans, but particularly the North Atlantic (Andrew et al. 1995).

The rockling (*Gaidropsarus novaezelandiae*) has a southern New Zealand distribution, being relatively commonly found in samples south of Cook Strait in coastal waters, but nowhere in large numbers (Paulin & Roberts 1992; Te Papa unpublished records). Globally, it has a Southern Ocean distribution, also being recorded from Tasmania, the south Indian Ocean (St Paul and Amsterdam Islands), the south Atlantic (Tristan da Cunha, Gough Islands) and the southeastern Pacific Ocean (Nazca Ridge and Bromley Plateau) (Andrew et al. 1995). This species has an active and prolonged larval stage, potentially allowing extensive dispersal and adult distribution. Robertson & Mito (1979) record larval and pre-juvenile (up to 24.6 mm total length) rockling on the Chatham Rise occurring in densities of 11–100 per 10 min. tow, and in some areas rising to 101–1000 per 10 min. tow. They considered rockling to be the most abundant young fish in surface waters on the Chatham Rise. Given the high numbers (64 specimens) taken on the Cascade–Haast survey, it is possibly recruiting from populations offshore affected by the Tasman Current. Figure 10 shows the distribution in the 1998–2000 surveys.

Milford Sound—The rockling is caught infrequently inside other fiords, but is relatively common at some stations near fiord entrances (Te Papa unpublished records). Three specimens were taken from two stations at the mouth of Milford Sound during the 1998 survey. Its distribution along the outer coast of Fiordland is unknown.

Cascade–Haast—Rockling were taken on most marine stations in 1999 (n = 14; 82% of total), and in relatively large numbers (up to 12 per station) compared to collections made elsewhere around New Zealand (Te Papa unpublished records). The total number caught from the Jackson Bay area was large compared to stations elsewhere on the West Coast and the rest of New Zealand (n = 64, mean 4.6 per station where present, size range 33–221 mm standard length).

Haast–Buller—Very few specimens were taken during the 2000 survey (n = 13, mean 4.3 per station, size range 111–170 mm standard length) with an occurrence at only one in five of marine stations sampled.

Clingfishes (family Gobiesocidae)

Clingfishes are small- to medium-sized fishes that live closely associated with the substratum (rock or algae) and are able to withstand substantial exposure to waves and currents by holding fast with their pectoral fins which are modified into a sucking cup. The clingfish family has a high degree of endemism at the species and generic levels in New Zealand waters, and often form an important part of coastal and intertidal samples.

Milford Sound—The pink clingfish (*Modicus minimus*) was taken in high numbers throughout Milford Sound; being collected at 8 stations (67% of total). This abundance is much higher than in the other fiords (Te Papa unpublished records). A single specimen of eyespot clingfish (*Modicus tangaroa*) was taken at station (1b) along with several pink clingfish (*M. minimus*). Both *Modicus* species were taken well inside the mouth of Milford Sound, and were the only species of clingfish to be collected in Milford Sound.

Cascade–Haast—In spite of the presence of suitable habitat, very few clingfishes were collected. Only four small specimens of pink clingfish (*M. minimus*) were taken in the large rockpools at Inner Frog Rock, Jackson Bay (H12). Orange clingfish (*Diplocrepis puniceus*) was observed once, at Jackson Head (H7).

Haast–Buller—In 2000, two collections (n = 55) were made of an undescribed species of clingfish (*Gastroscyphus* n.sp.), from two sites (H28 and H30). Similar to Hector's clingfish (*Gastroscyphus hectoris*), it differs in colour pattern, proportional differences in ventral sucker lengths and habits. It was also observed underwater, and recorded as 'common' at Cape Foulwind (C. Duffy pers. comm.).

Hector's clingfish (*Gastroscyphus hectoris*), a weed-dwelling species, was taken at one site (H24). The orange clingfish (*Diplocrepis puniceus*) was most abundant (n = 10) and largest (reaching 85 mm SL) at Station H24, the north end of Murphy's Beach.

The urchin clingfish (*Dellichthys morelandi*) was sporadically seen underwater or collected by rotenone from Cascade to Buller. The juveniles in particular are closely associated with the common urchin (*Evechinus chloroticus*), under which one or two clingfish can usually be found.

Orange clingfish (*Diplocrepis puniceus*) was collected at seven stations in 2000. The largest specimens and biggest collection were from Murphy's Beach (n = 10, maximum size 91 mm SL), but it was most commonly encountered in the northern area of WCSI.

In the genus *Trachelochismus*, only the lumpfish (*T. pinnulatus*) was collected. Specimens identified as *Trachelochismus* sp. (H02, H27) listed in Appendices 2 and 3 are juveniles, and are difficult to identify to species.

Two distinct and often common clingfish species, the slender clingfish *(Gastroscyathus gracilis*) and giant clingfish (*Haplocylix littoreus*) were absent throughout the WCSI surveys, probably because of the absence of stands of brown macro-algae, their preferred habitat.

Perches (family Serranidae)

Two very common New Zealand seaperch species in the fiord and Jackson Bay area were the butterfly perch (*Caesioperca lepidoptera*) and redbanded perch (*Hypoplectrodes huntii*).

Observation and capture of the butterfly perch diminished northward. This is a demersal species usually found at 15 m and deeper. The species was seen at Abbey Rocks (H23) at 7–11 m, but not at Whakapohai Rocks (H25) at 12–14 m. Its recorded

absence between Haast and Buller could be due to the lack of deep reef stations dived in that area.

Redbanded perch is an endemic benthic species, which favours broken rocky reef habitats. Although recorded at all three survey areas, this species was only taken in the southern section (H23, H25, H27) of the 2000 survey.

Rockfishes (family Plesiopidae)

The family is represented in New Zealand waters by the endemic genus *Acanthoclinus*, with at least five species inhabiting rocky coastal waters, ranging from the intertidal zone to deep sublittoral.

Milford Sound—All five endemic species of New Zealand *Acanthoclinus* were collected from Milford Sound.

The splendid rockfish (*Acanthoclinus matti*) has a southern distribution around the New Zealand coast. Although usually taken in samples as isolated individuals, it is relatively common throughout the fiords where it is one of the two dominant rockfish species. At station F59, two unidentified specimens of *Acanthoclinus* were caught with very different fresh colour patterns to other rockfish species. The meristics and morphometrics of these specimens overlap with *A. matti*, so possibly they are conspecific and represent a previously unknown colour form, such as male breeding colours. Conversely they may represent a new species, closely related to but distinct from the splendid rockfish. To answer this question, more specimens are required to support taxonomic research. No specimens of splendid rockfish (*A. matti*) were taken from Jackson Bay to Buller, possibly due to lack of suitable deep rocky reef habitat.

Cascade–Haast and Haast–Buller—The olive rockfish (*Acanthoclinus fuscus*) was recorded from previous work at Jackson Bay in 1994 (Te Papa unpublished records), but not collected during the 1999 survey. It was dominant in the 0–5 m depths on the 2000 survey (n = 102). The specimens taken were on average much larger than those generally seen elsewhere around the country (maximum size exceeding 200 mm SL in specimens from 4 stations). These fish are adapted to survival in extreme conditions, tolerating desiccation and exposure to fresh water for extended periods. Their body shape also allows them to take advantage of the minimal cover available often living under boulders in very exposed sites, for example at Gentle Annie Point and St Anne Bay, at the entrance to Milford Sound.

The other intertidal species, the black rockfish (*A. littoreus*), was only taken intermittently in all three surveys: at the entrance to Milford Sound (F55), at Jackson Head and Whakapohai, and the Steeples Rocks (H25 and H36).

The stout rockfish (*A. marilynae*) is most often found in deeper water, and was collected in 1999 around Jackson Bay, but not north of Haast in 2000. The little rockfish (*A. rua*) is another deeper living species, and a few specimens (n = 5) were collected at the two deeper stations (H23 & H27) sampled at the southern end of the 2000 survey.

Marblefishes (family Aplodactylidae)

Milford Sound—Marblefish (*Aplodactylus arctidens*) were readily identified and observed underwater at seven sites in Milford Sound. No specimens were collected because they are too large to be affected by rotenone and would have had to be speared. Adequate collections of vouchers from the area have been made already (Te Papa unpublished data).

Cascade–Haast—On the 1999 survey, adult marblefish were observed at every marine station, even the small rockpools at H12 on Frog Rocks.

Haast–Buller—The marblefish was abundant in numbers observed from Haast to Westport (recorded at 5 of the subtidal marine stations). This species was absent from all rockpools sampled in the area.

Trumpeters and moki (family Latrididae)

Milford Sound and Cascade–Haast—Trumpeter (*Latris lineata*) and telescopefish (*Mendosoma lineatus*) were observed at a few sites in Milford Sound and around

Jackson Bay. None were seen or sampled north of Haast, but as these are mobile and migratory species, their presence off the northern West Coast cannot be discounted.

Some of the highest densities of the copper moki (*Latrodopsis forsteri*) for New Zealand were observed at the Teer Creek Station, H13. A mixed school of blue moki (*L. ciliaris*) and copper moki was observed containing approximately equal numbers (c. 30) of each species. Copper moki were observed at four other stations.

Haast–Buller—Copper moki were only recorded once between Haast and Buller at H25 (off Murphy's Beach).

Wrasses (family Labridae)

Wrasses are colourful and numerous inhabitants of temperate coastal reefs. Juveniles, females, and males all have different colour patterns, which can make identification difficult. New Zealand temperate reefs, including those on the WCSI, usually support a suite of four widespread species, as discussed below.

Two labrid species, the banded wrasse (*Notolabrus fucicola*) and endemic scarlet wrasse (*Pseudolabrus miles*), were found throughout the three areas surveyed, living among clumps of rocks and reefs at 0–23 m depth. Banded wrasse was one of the most frequently collected fishes, being taken at 7/13, 15/17, and 9/15 marine stations during the 1998, 1999, and 2000 surveys respectively. Similarly, scarlet wrasse was taken at 11/13, 15/17, and 3/15 stations.

The endemic girdled wrasse (*Notolabrus cinctus*) was a common deepwater species in Milford Sound (5 stations, 7–23 m); but it was collected from only at one station (H11, 11–13 m depth) at Jackson Bay; and was absent between Haast and Buller. This is likely to be due to a combination of reduced subtidal reef habitat (especially below 10 m) and increased wave and wind exposure northwards along the WCSI.

The endemic spotty (*N. celidotus*) was common in Milford Sound (10 stations, 4–23 m) and the Jackson Bay–Jackson Head area (7 stations, 1.5–12 m), but was lower in numbers and frequency of occurrence northwards between Haast and Buller (5 stations, 0–8 m). As with the girdled wrasse (above), the distribution of the spotty along the WCSI appears to be affected by high exposure and limited habitat. Juveniles inhabit intertidal rockpools where there is some shelter among boulders (e.g. Gentle Annie Point). This pattern of distribution is also reflected in other areas of New Zealand, where the species is more common in sheltered reefs and bays than exposed reefs (Paulin & Roberts 1992).

Butterfish (family Odacidae)

The endemic butterfish or greenbone (*Odax pullus*) was not recorded at any site from Milford Sound, probably due to the low incidence of laminarian algae, which this species favours for habitat and as a food source. It was observed at four stations around Jackson Bay (H04, H08, H10, H11, 0–15 m); but was not recorded in the Haast–Buller area. There are anecdotal accounts of specimens occasionally being caught on the coast between Greymouth and Westport (D. Neale pers. comm., 2004). Because the butterfish is a distinctive and generally well-known fish, these accounts may be correct, but there are no voucher specimens to confirm the identifications.

Thornfish (family Bovichthyidae)

The thornfish (*Bovichtus variegatus*) (Fig. 11), an endemic species (Hardy 1988), is especially abundant in the reef fauna at the Snares, Auckland, and Campbell Islands, and has a southern distribution around New Zealand (Paulin & Roberts 1992, 1993). Its distribution from samples collected during the present study is plotted in Fig. 11. During the WCSI surveys (and other Te Papa surveys), this fish demonstrated considerable resistance to the effects of rotenone, so it is probably under-represented in the samples, making assessment of its abundance difficult. It can be hard to see underwater, often living upside down on the roof of caves and under rock bridges. Judging from the location of samples, it is tolerant of exposure to severe wave action.

Milford Sound—Two specimens of thornfish (*B. variagatus*) were taken from the St Anne Bay rockpool station at the entrance to Milford Sound (F55).

Cascade–Haast—The thornfish was common around Jackson Head and Jackson Bay occurring at 10 stations, being observed at 5 and collected at 5 (H03, H06, H08, H09, H12; n = 10 specimens, 0–20 m).

Haast–Buller—In the 2000 survey, the thornfish was recorded at 6 stations: observed at 4 (all south from Bruce Bay, 0–14 m), but only collected at 2 (H20, Cape Foulwind, and H30, 14 Mile Creek; n = 5, 0–1.5 m).

Ice cods (family Nototheniidae)

Milford Sound—A single observation of an undetermined species of *Notothenia* (but probably Maori chief) was made of this Southern Ocean–Antarctic family at the entrance to Milford Sound (F54).

Cascade–Haast—Two captures of the Maori chief (*Notothenia angustata*) were made at Jackson Bay (H02, H04) with an observation at Open Bay Island (H16).

Haast–Buller—No ice cods were taken or observed north of Haast.

Sand divers (family Creediidae)

Fishes in this family are small, thin, habitat specialists living in clean sand, and were only taken when deep sediment was abutting the reef being sampled by rotenone. Given the abundance of this habitat along the WCSI, more sampling will almost certainly reveal much wider and more accurate distributions for sand divers in this area. From samples collected during the present study creediids were most abundant in the Jackson Bay to Haast area.

Milford Sound—No creediids were taken in Milford Sound or its entrance; suitable sedimentary habitat was absent at all stations sampled.

Cascade–Haast—Specimens of the two widespread endemic species, the sand diver (*Tewara cranwellae*) and tommyfish (*Limnichthys polyactis*) were taken during the 1999 survey. The tommyfish was collected at 8 stations from Cascade to Haast (0–19 m). The sand diver was less common, and was taken only at Smoothwater Bay (H07, 2–4 m). Another single unidentified creediid was observed, but not collected at Smoothwater Bay (H04, 1.5–2.5 m).

Haast–Buller—Specimens of the tommyfish were caught off Hanata Island (H27, 5–7 m). More creediids were expected along this coast, but despite the abundance of sedimentary habitat, few stations were carried out on clear sand adjacent to sublittoral rocky reefs.

Stargazers (families Uranoscopidae and Leptoscopidae)

Stargazers usually prefer soft, muddy-sand habitat, and were only collected as post-settlement juveniles between Haast and Westport. Adult specimens are resistant to rotenone and uranoscopids in general are more common offshore. Their presence is almost certainly under-represented in this study.

Haast–Buller—Juveniles of the endemic spotted stargazer (*Genyagnus monopterygius*) were collected at three shallow stations (H28, H30, H34, 0–1.5 m) after being trapped among low flat reefs at low water. The endemic sand stargazer (*Crapatulus novaezelandiae*) was taken at Gentle Annie Point (H33, 0–0.5 m) at low water.

Triplefins (family Tripterygiidae)

All known New Zealand intertidal triplefin species (n = 21, all endemic) were taken over the three surveys, but with some notable regional absences and abundances.

Giant triplefin—The giant triplefin (*Blennodon dorsale*) (Fig. 12), named for its large size (attaining 150 mm SL), is a New Zealand endemic that has been found in relatively few shallow, exposed coastal sites. It appears to be resistant to the affects of rotenone when sampled at subtidal stations (Andrew Stewart unpub. obs.). During the present study, the giant triplefin was not collected at Milford Sound, although it may be present along the open coast. From Cascade to Haast, it was represented by just three juveniles

collected from one station within Jackson Bay (H17, 0–3 m). In contrast, between Haast and Buller this species was the most common and abundant triplefin taken (n = 728 specimens) with captures at most (67%) marine stations sampled. Numbers of specimens collected per station increased northwards (see Figure 12). The giant triplefin was most abundant and most frequently collected at intertidal and shallow subtidal depths to about 2 m. Notable catches were: 165 specimens from among mussel clumps at Mikonui Reef (H28, 0–0.5 m); 214 from rockpools and channels on a large intertidal reef south of 14 Mile Creek (H30, 0–1.5 m); and 282 in low tide pools among low reef flat and large boulders at Gentle Annie Point (H33, 0–0.5 m). The giant triplefin was originally described, as *Tripterygium dorsalis*, by Clarke (1879) from a single specimen taken at Hokitika. Over 100 years later, on erecting a new genus (*Blennodon*) for this species, Hardy (1987) stated that the original specimen was the only record from the South Island west coast. This emphasises the lack of collecting effort from the WCSI up until now, because *Blennodon dorsale* is locally so abundant that it characterises the coastal reef fauna in the Haast to Buller area. Large numbers have also been recorded from the west coast of the North Island (Fricke 1994), which has abundant areas of similar exposed shallow reefs.

Robust triplefin—A robust-type of triplefin was described by Clarke (1879), as *Forsterygion robustum*, based on specimens collected from Jackson Bay. However, Clarke's type specimens have subsequently been lost, and there has been considerable confusion as to which name to assign to the species (see Paulin 1995b; Clements et al. 2000), in consequence it currently has the status of *nomen dubium*. In spite of sampling at stations along the shore at Jackson Bay (H02, H06, H17) and several nearby sublittoral locations, only 6 juvenile fishes of the related, but probably distinct, robust triplefin (*Grahamina capito*) were collected. It is possible that Clarke's robust triplefin inhabits the stony intertidal at Jackson Bay, but this habitat was not sampled because of high wave action at the time of collecting.

Milford Sound—The oblique swimming triplefin (*Obliquichthys maryannae*) was widespread throughout the fiords and sometimes recorded around Jackson Bay, but was not recorded from any station between Haast and Buller.

Cascade–Haast—The obscure triplefin (*Gilloblennius abditus*) is another rare endemic species that has been collected at a few sites on exposed coasts around New Zealand. The largest collections of this species have been made at the Snares Islands and rockpools on Breaksea Island, Fiordland (Te Papa unpublished records; Fricke 1994). During the present survey, several juveniles were taken from rockpools on Frog Rock (H12, 0–1 m), and one from Murphy's Beach (H24, 0–0.5 m).

Haast–Buller—The two endemic weed-dwelling species, the topknot (*Notoclinus fenestratus*) and brown topknot (*N. compressus*), were absent from the area sampled north of Haast. This was probably due to the absence of stands of laminarian seaweeds (*Carpophyllium* spp. and *Cystophora* spp.) on which these fishes almost exclusively rely for habitat (Paulin & Roberts 1992).

Gobies (family Gobiidae)

The black goby (*Gobiopsis atrata*), a New Zealand endemic, is widespread in coastal waters. Its preferred habitat is areas of broken rock with silty holes and caves (Paulin & Roberts 1992). Collections were made at four sites in Milford Sound (n = 5); three sites around Jackson Bay (n = 3) and one site at The Steeples off Westport (n = 2). Black gobies were also observed but not collected at stations in the Milford and Cascade–Haast surveys.

Sleepers (family Eleotridae)

The endemic pygmy sleeper (*Thalasseleotris* n.sp.) was found almost exclusively associated with deep reefs containing crevices and holes lined with fine sediment. It was frequently taken in Milford Sound (11 stations, n = 113); and at two sites at Jackson Bay (n = 3), but nowhere between Haast and Buller. Its absence from northern areas surveyed is probably due to its preferred habitat (deep reefs) being almost entirely absent from this part of the coast.