

6. References

- Anonymous (2000). *The New Zealand Biodiversity Strategy - Our chance to turn the tide*. Department of Conservation and Ministry for the Environment, Wellington, 146 pp.
- Belbin, L. (1995). *PATN analysis package*. Division of Sustainable Ecosystems, CSIRO, Canberra. 237 p.
- Boyer, T.; Levitus, S.; Garcia, H.; Locamini, R.; Stephens, C.; Antonov, J (2005). Objective analyses of annual, seasonal, and monthly temperature and salinity for the world ocean on a 1/4degree grid. *International Journal of Climatology* 25: 931-945.
- Duan, N. (1983). Smearing estimate: a non-parametric retransformation method. *Journal of the American Statistical Association* 78: 605-610.
- Fielding, A.H.; Bell, J.F. (1997). A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation* 24: 38-49.
- Fletcher, D.; MacKenzie, D.; Villouta, E (2005). Modelling skewed data with many zeros: A simple approach combining ordinary and logistic regression. *Environmental and Ecological Statistics* 12: 45-54.
- Francis, M.P.; Hurst, R.J.; McArdle, B.H.; Bagley, N.W.; Anderson, O.F (2002). New Zealand demersal fish assemblages. *Environmental Biology of Fishes* 65: 215-234.
- Friedman, J.H. (2001) Greedy function approximation: the gradient boosting machine. *The Annals of Statistics* 29: 1189-1232.
- Guisan, A.; Zimmerman, N.E. (2000). Predictive habitat distribution models in ecology. *Ecological Modelling* 135:147-186.
- Hastie, T.; Tibshirani, R.J. (1990). *Generalized Additive Models*. Chapman and Hall, London.

- Hastie, T.; Tibshirani, R.; Friedman, J.H. (2001), *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*. Springer-Verlag, New York.
- Leathwick, J.R.; Dey, K.; Julian, K. (2006a). Development of a marine environmental classification optimised for demersal fish. *NIWA Client Report: HAM2006-063*. 19 PP.
- Leathwick, J.R.; Julian, K.; Francis, M. (2006b). Exploration of the use of reserve planning software to identify potential Marine Protected Areas in New Zealand's Exclusive Economic Zone. *NIWA Client Report: HAM2006-064*. 36 p.
- Leathwick, J.; Image, K.; Snelder, T.; Weatherhead, M.; Wild, M. (2004). Definition and test of Marine Environment Classifications of New Zealand's Exclusive Economic Zone and the Hauraki Gulf. *NIWA Client Report CHC2004-085*. 64 pp.
- Leathwick, J.R.; Elith, J.; Francis, M.P.; Hastie, T.; Taylor, P (in press). Variation in demersal fish species richness in the oceans surrounding New Zealand: an analysis using boosted regression trees. *Marine Ecology Progress Series*.
- Margules, C.R.; Pressey, R.L. (2000). Systematic conservation planning. *Nature* 405: 243-253.
- Pinkerton, M.H.; Richardson, K.R. (2005). Case 2 Climatology of New Zealand: Final report. *NIWA Client Report WLG2005-49*. 16 pp.
- Pinkerton, M.; Hadfield, M.; Hunter, K.; MaCaskill, B. (2005). Three additional layers for Marine Environment Classification: (1) Sea bed temperature; (2) Calcium compensation depth; (3) Sea-bed light levels. *NIWA Client Report WLG2005-50*. 40 pp.
- Roberts, C.M.; Andelman, S.; Branch, G.; Bustamante, R.H.; Castilla, J.C.; Dugan, J.; Halpern, B.S.; Lafferty, K.D.; Leslie, H.; Lubchenco, J.; McArdle, D.; Possingham, H.; Ruckelshaus, M.; Warner, R.R. (2003). Ecological criteria for evaluating candidate sites for marine reserves. *Ecological Applications* 13: S199-S214.
- Snelder, T.; Leathwick, J.R. and others (in press). Development of an ecologic marine classification system in the New Zealand region. *Environmental Management*.
- Venables, W.N.; Dichmont, C.M. (2004). GLMs, GAMS, and GLMMs: an overview of theory for applications in fisheries research. *Fisheries Research* 70: 319-337.

7. Appendix I - Species codes and their equivalent common and scientific names.

Code	Common name	Scientific name
ANC	Anchovy	<i>Engraulis australis</i>
BAR	Barracouta	<i>Thyrsites atun</i>
BBE	Banded bellowsfish	<i>Centriscopus humerosus</i>
BCO	Blue cod	<i>Parapercis colias</i>
BEE	Basketwork eel	<i>Diastobranchus capensis</i>
BJA	Black javelinfish	<i>Mesobius antipodum</i>
BNS	Bluenose	<i>Hyperoglyphe antarctica</i>
BOE	Black oreo	<i>Alloctytus niger</i>
BRA	Short-tailed stingray	<i>Dasyatis brevicaudata</i>
BSH	Seal shark	<i>Dalatias licha</i>
BSL	Black slickhead	<i>Xenodermichthys spp.</i>
BYX	Alfonsino & long-finned Beryx	<i>Beryx splendens & B. decadactylus</i>
CAR	Carpet shark	<i>Cephaloscyllium isabellum</i>
CAS	Oblique banded rattail	<i>Caelorinchus aspercephalus</i>
CBA	Humpback rattail (slender rattail)	<i>Coryphaenoides dossenus</i>
CBE	Crested bellowsfish	<i>Notopogon lilliei</i>
CBO	Bollons rattail	<i>Caelorinchus bollonsi</i>
CDO	Capro dory	<i>Capromimus abbreviatus</i>
CFA	Banded rattail	<i>Caelorinchus fasciatus</i>
CHA	Viper fish	<i>Chauliodus sloani</i>
CHP	Brown chimaera	<i>Chimaera sp. C</i>
CIN	Notable rattail	<i>Caelorinchus innotabilis</i>
CKA	Kaiyomaru rattail	<i>Caelorinchus kaiyomaru</i>
CMA	Mahia rattail	<i>Caelorinchus matamua</i>
COL	Olivers rattail	<i>Caelorinchus oliverianus</i>
CSE	Serrulate rattail	<i>Coryphaenoides serrulatus</i>
CSQ	Leafscale gulper shark	<i>Centrophorus squamosus</i>
CSU	Four-rayed rattail	<i>Coryphaenoides subserrulatus</i>
CUC	Cucumber fish	<i>Chlorophthalmus nigripinnis</i>
CYO	Owstons dogfish	<i>Centroscymnus owstoni</i>
CYP	Longnose velvet dogfish	<i>Centroselachus crepidater</i>
EGR	Eagle ray	<i>Myliobatis tenuicaudatus</i>
ELE	Elephant fish	<i>Callorhynchus milii</i>
EMA	Blue mackerel	<i>Scomber australasicus</i>
EPT	Deepsea cardinalfish	<i>Epigonus telescopus</i>
ESO	N. Z. sole	<i>Peltorhamphus novaezeelandiae</i>
ETB	Baxters dogfish	<i>Etmopterus baxteri</i>

ETL	Lucifer dogfish	<i>Etmopterus lucifer</i>
FHD	Deepsea flathead	<i>Hoplichthys haswelli</i>
FRO	Frostfish	<i>Lepidopus caudatus</i>
GAO	Filamentous rattail	<i>Gadomus aoteanus</i>
GSP	Pale ghost shark	<i>Hydrolagus bemisi</i>
GUR	Red gurnard	<i>Chelidonichthys kumu</i>
HAK	Hake	<i>Merluccius australis</i>
HAP	Hapuku	<i>Polypriion oxygeneios</i>
HCO	Hairy conger	<i>Bassanago hirsutus</i>
HJO	Johnsons cod	<i>Halargyreus johnsonii</i>
HOK	Hoki	<i>Macruronus novaezelandiae</i>
HPE	Common halosaur	<i>Halosaurus pectoralis</i>
HYB	Black ghost shark	<i>Hydrolagus sp. A</i>
JAV	Javelin fish	<i>Lepidorhynchus denticulatus</i>
JDO	John dory	<i>Zeus faber</i>
JGU	Spotted gurnard	<i>Pterygotrigla picta</i>
JMD	Horse mackerel;	<i>Trachurus declivis</i>
JMM	Murphys mackerel	<i>Trachurus murphyi</i>
JMN	Golden mackerel	<i>Trachurus novaezelandiae</i>
KAH	Kahawai	<i>Arripis trutta</i>
KIN	Kingfish	<i>Seriola lalandi</i>
LCH	Longnose spookfish	<i>Harriotta raleighana</i>
LDO	Lookdown dory	<i>Cyttus traversi</i>
LEA	Leatherjacket	<i>Parika scaber</i>
LIN	Ling	<i>Genypterus blacodes</i>
LSO	Lemon Sole	<i>Pelotretis flavilatus</i>
MCA	Ridge scaled rattail	<i>Macrourus carinatus</i>
MDO	Mirror dory	<i>Zenopsis nebulosus</i>
NNA	Squashed face rattail	<i>Nezumia namatahi</i>
NSD	Northern spiny dogfish	<i>Squalus sp cf mitsukurii</i>
OPE	Orange perch	<i>Lepidoperca aurantia</i>
ORH	Orange roughy	<i>Hoplostethus atlanticus</i>
PCO	Ahuru	<i>Auchenoceros punctatus</i>
PDG	Prickly dogfish	<i>Oxynotus bruniensis</i>
PHO	Lighthouse fish	<i>Photichthys argenteus</i>
PIL	Pilchard	<i>Sardinops neopilchardus</i>
PLS	Plunkets shark	<i>Proscymnodon plunketi</i>
POP	Porcupine fish	<i>Allomycterus jaculiferus</i>
PSK	Longnose deepsea skate	<i>Bathyraja shuntovi</i>
PSY	Blob fish	<i>Psychrolutes microporos</i>
RBM	Rays bream	<i>Brama brama</i>

RBT	Redbait	<i>Emmelichthys nitidus</i>
RCH	Pacific spookfish	<i>Rhinochimaera pacifica</i>
RCO	Red cod	<i>Pseudophycis bachus</i>
RIB	Ribaldo	<i>Mora moro</i>
RMU	Red mullet	<i>Upeneichthys lineatus</i>
RUD	Rudderfish	<i>Centrolophus niger</i>
SBI	Bigscaled brown slickhead	<i>Alepocephalus sp.</i>
SBK	Spineback	<i>Notacanthus sexspinis</i>
SBW	Southern blue whiting	<i>Micromesistius australis</i>
SCG	Scaly gurnard	<i>Lepidotrigla brachyoptera</i>
SCH	School shark	<i>Galeorhinus galeus</i>
SCO	Swollenhead conger	<i>Bassanago bulbiceps</i>
SDO	Silver dory	<i>Cyttus novaezealandiae</i>
SFL	Sand flounder	<i>Rhombosolea plebeia</i>
SKI	Gemfish	<i>Rexea solandri</i>
SMC	Small-headed cod	<i>Lepidion microcephalus</i>
SNA	Snapper	<i>Pagrus auratus</i>
SND	Shovelnose spiny dogfish	<i>Deania calcea</i>
SOR	Spiky oreo	<i>Neocyttus rhomboidalis</i>
SPD	Spiny dogfish	<i>Squalus acanthias</i>
SPE	Sea perch	<i>Helicolenus spp.</i>
SPO	Rig	<i>Mustelus lenticulatus</i>
SPZ	Spotted stargazer	<i>Genyagnus monopterygius</i>
SRH	Silver roughy	<i>Hoplostethus mediterraneus</i>
SSH	Slender smooth-hound	<i>Gollum attenuatus</i>
SSI	Silverside	<i>Argentina elongata</i>
SSM	Smallscaled brown slickhead	<i>Alepocephalus australis</i>
SSO	Smooth oreo	<i>Pseudocyttus maculatus</i>
STY	Spotty	<i>Notolabrus celidotus</i>
SWA	Silver warehou	<i>Seriolella punctata</i>
TAR	Tarakihi	<i>Nemadactylus macropterus</i>
TOP	Pale toadfish	<i>Amblophthalmos angustus</i>
THE	Trevally	<i>Pseudocaranx dentex</i>
TRS	Cape scorpionfish	<i>Trachyscorpia capensis</i>
TUB	Tubbia tasmanica	<i>Tubbia tasmanica</i>
VCO	Violet cod	<i>Antimora rostrata</i>
VNI	Blackspot rattail	<i>Ventrifossa nigromaculata</i>
WAR	Common warehou	<i>Seriolella brama</i>
WHX	White rattail	<i>Trachyrincus aphyodes</i>
WIT	Witch	<i>Amoglossus scapha</i>
WOE	Warty oreo	<i>Allocyttus verrucosus</i>

WRA	Longtail stingray	<i>Dasyatis thetidis</i>
WWA	White warehou	<i>Seriolella caerulea</i>
YBF	Yellow-belly flounder	<i>Rhombosolea leporina</i>

8. Appendix II - Species composition table

This table describes the species composition of 16 demersal fish assemblages identified by multivariate classification. Table entries indicate the average occurrence and average catch (in brackets) for the most important species, i.e., the n most frequently occurring, where n is the average number of species caught in a standardised trawl. The presence of minor species in a group is indicated by a "+" .

Groups: Species	Inshore		Shelf			Shallow Upper Slope					Mid-water Upper Slope			Mid Slope		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
WRA	+		+			+										
BRA	+	+	+			+										
YBF	+	+														
EGR	+	+		+												
PIL	+	+														
STY	+	+		+												
SPZ	+	+		+												
PCO	+	+		+												
ESO	+	+		+	+											
SFL	+	+		+	+											
ANC	+	+		+												
ELE	+	47.8 (12.6)		+	+											
TRE	+	+	+	+												
KAH	+	+	+	+	+											
SNA	78.5 (43.2)	+	+	+												
RMU	+	+			+											
LEA	+	37.2 (1.7)	+	+	+											

WAR	+	54.0 (3.2)	+	+	+	+	+				
GUR		83.0 (14.6)	68.1 (7.7)	+	43.8 (3.2)	+	+				
JDO		76.3 (3.7)	+	+	+	+					
JMN		66.3 (11.0)	+	+	+	+	+	+			
KIN		+	+				+				
SPO	+	46.5 (4.9)	+	24.8 (2.5)	+	+	+	+	+		
BCO	+	+	+	21.4 (0.9)	+		+				
EMA	+	+	+	+	+						
CAR	+	36.98 (2.3)	65.6 (4.6)	63.70 (6.0)	34.99 (2.8)	+	+	+	+	+	+
POP	+	+	+	+	+						
BAR		75.4 (18.3)	81.6 (60.1)	80.0 (34.5)	90.3 (93.9)	43.61 (17.59)	+	67.0 (27.4)	+	+	+
CBE			+	+	25.6 (1.1)		+	+	+		
SCH	+	57.6 (8.3)	60.5 (15.0)	65.2 (15.0)	+	+	+	+	+	+	+
LSO	+	36.4 (0.5)	+	+	+	+	+	22.1 (0.4)	+		+
SCG	+	+	44.3 (0.3)	56.7 (0.8)	+	+	+	+	+		
JMD	+	+	47.5 (3.1)	44.0 (3.5)	+	+	+	+	+		
WIT	+	39.1 (0.3)	+	47.3 (0.3)	30.3 (0.2)	+	63.6 (0.7)	41.8 (0.3)	21.2 (0.2)	+	+
TAR	+	36.3 (3.4)	85.0 (31.4)	67.5 (15.5)	+	30.3 (7.8)	+	+	+		

HAP	+	+	+	51.1 (5.8)	34.5 (4.3)	+	40.1 (4.0)	+	+	+							
JMM	+	+	+	26.1 (9.4)	+	+	+	+	+	+	+						
RCO	+	50.7 (18.0)	+	40.6 (12.1)	29.5 (2.4)	25.3 (1.8)	67.9 (15.7)	50.8 (6.3)	40.3 (3.8)	+	+						
FRO	+	+	55.3 (7.0)	+	+	33.4 (1.7)	+	+	+								
SPD	+	94.0 (117.5)	55.4 (33.9)	95.9 (244.5)	76.7 (116.2)	27.0 (10.7)	94.1 (118.6)	94.5 (87.5)	63.3 (18.7)	76.1 (9.7)	+	+	+	+	+	+	+
CUC	+		42.3 (0.5)	+		+	+	+									
RBT	+	+	+	+	38.4 (1.5)	+	+	+	+	+	+						
JGU	+		+			+	+	+									
MDO	+		+	+	+	+	+	+	+								
SDO	+	+	52.7 (6.3)	39.0 (1.9)	30.7 (1.7)	37.2 (7.0)	65.3 (16.8)	35.6 (3.4)	17.9 (2.3)	+	+						
NSD	+		+	+	+	48.5 (4.6)	+	+	+								
SWA	+	+	+	49.7 (3.5)	33.5 (8.3)	32.7 (11.8)	73.1 (31.6)	67.5 (31.6)	14.5 (5.7)	+	+	+	+				
SKI	+	+	+	+	+	46.9 (5.5)	+	+	+	+	+						
CDO	+		+	+	+	65.1 (0.6)	+	+	+	+	+	+					
OPE			+	+	+	+	+	+	+								
SPE	+	+	52.4 (1.0)	39.2 (3.1)	+	71.9 (3.3)	58.6 (8.2)	88.1 (28.7)	+	+	78.7 (8.3)	+	+				
RBM			+	+	+	+	+	+	+	+	+	+	+				
WWA			+		+	+	+	74.9 (15.9)	26.5 (1.8)	19.1 (1.0)	+	+	+				

SSI	+	+	+	20.2 (0.1)	32.8 (0.7)	35.2 (1.1)	55.7 (0.5)	81.5 (1.2)	77.7 (8.1)	92.2 (12.6)	+	+	+	+	+	+
CAS			+		+	+	+	+	+	+	+		+			
BYX			+			+	+	37.8 (10.5)	+		+	+	+	+		
SSH			+		+	42.2 (2.9)			+		+					
FHD						+	+	41.9 (0.9)	+	+	+	+	+	+		
BNS						+	+	+	+	+	+	+	+	+	+	+
PDG						+	+	+	+	+	+	+	+	+		
BBE		+	+	+	+	+	+	41.5 (3.4)	+	+	+	+	+	+	+	+
LIN	+	+	+	30.3 (2.2)	26.7 (3.0)	68.4 (33.1)	53.6 (6.8)	92.1 (45.4)	54.2 (13.2)	95.1 (63.0)	93.9 (54.0)	+	69.9 (23.8)	+	+	+
TOP			+		+	+	+	+	+	38.4 (0.8)	+	+	+	+	+	+
LDO		+	+	+	+	40.1 (3.3)	+	83.1 (33.4)	+	57.9 (2.2)	79.4 (17.7)	+	+	+	+	+
SBW		+			+	+		+	55.8 (11.8)	82.0 (43.1)	+		+	+	+	+
RUD						+	+	+	+	+	+	+	+	+	+	+
CBO			+			+	+	+	+	+	43.3 (8.1)	+	+	+		
ETL			+			+	+	+	+	+	51.1 (0.6)	+	+	+	+	+
SRH			+			26.5 (0.6)	+	+	+	+	+	+	+	+	+	+
JAV				+	+	78.0 (5.0)	38.7 (1.5)	92.6 (29.1)	48.2 (1.7)	96.6 (30.7)	97.6 (44.2)	78.2 (21.7)	95.3 (44.8)	+	+	+
COL						+	+	+	+	+	+	+	+	+	+	+

HOK	+	+	+	+	+	56.7 (26.5)	55.4 (31.9)	95.9 (151.1)	42.4 (10.3)	93.3 (30.8)	95.7 (85.1)	80.0 (17.9)	89.9 (33.0)	+	+	+
HAK	+	+	+	+	+	+	+	22.6 (1.8)	+	15.2 (1.8)	57.0 (11.2)	54.5 (9.3)	+	+	+	+
GSP					+	+	+	26.7 (6.0)	17.5 (5.6)	91.9 (36.1)	72.7 (24.6)	65.4 (6.6)	89.7 (21.4)	+	+	+
SCO						+	+	+	+	+	+	+	+	+	+	+
HCO						+	+	+	+	14.7 (0.4)	+	+	+	+	+	+
BSH			+			+	+	+	+	+	+	+	+	+	+	+
VNI						+		+	+	+	+	+	+	+	+	+
CFA			+			+	+	+	+	61.3 (1.1)	+	+	78.3 (4.3)	+	+	+
LCH						+	+	+	+	53.8 (2.8)	+	+	+	+	+	+
EPT						+		+		+		+	+	+	+	+
RIB						+		+	+	+	60.7 (7.3)	80.6 (14.2)	71.8 (9.6)	+	+	+
SBK						+	+	+	+	+	+	71.8 (6.9)	67.9 (8.6)	+	+	21.3 (0.3)
CSQ						+		+		+	+	+	+	+	+	+
PLS						+				+	+	+	+	+	+	+
SOR								+		+	+	55.0 (5.2)	+	+	+	+
HPE											+	+	+	+		
CMA											+	+	+	+	+	+
BSL											+	+	+	+	+	+

SND	+	+	+	+	+	+	71.7 (51.1)	+	+	+	+
TUB							+	+	+	+	+
TRS						+	+	+	+	+	+
BOE					+	+	+	+	+	53.7 (67.2)	+
CYP					+	+	54.8 (6.6)	+	+	+	+
PHO	+				+	+	+	+	+	+	36.5 (0.0)
CBA						+	+	+	+	+	+
SMC						+	+	+	+	+	+
CYO						+	+	+	+	+	+
CIN						+	+	+	+	+	+
ETB	+		+		+	+	+	+	+	75.6 (18.5)	20.5 (0.9)
CHA	+						+	+	+	+	+
WHX						+	+	+	+	+	+
ORH						+	63.2 (126.2)	+	65.6 (65.4)	45.9 (16.0)	+
CSU						+	+	+	+	55.4 (3.0)	+
CSE						+	61.9 (3.4)	+	52.6 (2.5)	+	+
SSO						+	+	+	+	76.3 (357.9)	18.6 (32.0)
PSY							+	+	+	+	+

CKA					+	79.9	+
						(0.3)	
BJA					+	+	+
HJO			+	+	+	69.3	44.1
						(5.2)	(5.1)
MCA		+	+	+	+	+	44.2
							(8.5)
RCH			+	+	+	+	+
GAO				+		+	+
BEE			+	+	+	88.4	78.2
						(13.0)	(9.6)
PSK			+	+	+	+	14.3
							(0.6)
SSM			+	+	+	53.4	49.2
						(28.8)	(19.8)
NNA	+		+	+	+	+	+
VCO				+	+	+	82.1
							(1.2)
SBI				+	+	61.5	42.3
						(12.4)	(11.4)
WOE			+	+		+	+
CHP				+		+	+
HYB						+	+