International Council for
the Exploration of the Sea

C.M. 1980/H:10
Pelagic Fish Committee
Ref. Demersal Fish Cttee

PRELIMINARY RESULTS OF A STUDY ON THE FOOD AND FEEDING RELATIONSHIPS OF FISH SPECIES FROM THE CAMPBELL PLATEAU, NEW ZEALAND.

by

Malcolm R. Clark*
Victoria University of Wellington
Wellington, New Zealand

Abstract

Preliminary results from analyses of stomach contents of nine fish species from the Campbell Plateau are presented. These include composition of the diet, and principal prey groups as assessed by an Index of Relative Importance. Feeding overlap and possible competition for food is discussed. Competition could occur between hoki (Macruronus novaezelandiae), southern blue whiting (Micromesistius australis) and javelin fish (Lepidorhynchus denticulatus) in some areas of the Campbell Plateau. In general however, partitioning of the food resource is apparent.

Introduction

New Zealand's 200 mile Exclusive Economic Zone is comparatively large and contains potentially rich fishing areas. New Zealand fishing effort has in the past been concentrated in shallow inshore areas, but with growing realisation of the potential of the southern areas of the zone, more attention is now being paid to the deepwater trawl fishery on the Campbell Plateau (Fig.1). Russian, Japanese and Korean vessels have been fishing in the area since the early 1970's, with New Zealand participation in recent years through joint ventures with foreign companies.

The predominant species available to the deepwater trawl fishery are southern blue whiting (Micromesistius australis), hoki (Macruronus novaezelandiae), hake (Merluccius australis), ling (Genypterus blacodes), silverside (Argentina elongata), and javelin fish (Lepidorhynchus denticulatus) (Cawthorn 1978).

*Present address; Institut für Seefischerei,
Bundesforschungsanstalt für Fischerei,
Hamburg, Federal Republic of Germany.

Ghost sharks (Hydrolagus spp), a number of species of rattail (Coelorinchus spp), and in southern areas of the Campbell Plateau, Notothenids (primarily small scaled notothenid, Notothenia microlepidota), are also relatively abundant. Illustrations and descriptions of these species are given in Appendix 1. Of these species, southern blue whiting and hoki are the most important, comprising 382000t and 191000t respectively of the estimated potential production of the Campbell Plateau region of 666000t/yr (Francis and Fisher 1979).

There have been few intensive studies on the food and feeding relationships of New Zealand fish. Graham (1939) discussed feeding relationships of fish from the Otago harbour area. Godfriaux (1970) investigated snapper (Chrysophrys auratus) and other fish trawled from the Hauraki Gulf, and Godfriaux (1974) examined the food of snapper and tarakihi (Cheilodactylus macropterus) in relation to the bottom fauna in the Bay of Plenty, and discussed some aspects of competition between the two fish species.

The purpose of the present study, of which this is a preliminary account, is to establish the food and feeding habits of the fish involved, and to determine the extent of partitioning of the food resource. This study also involves a comparative investigation of relevant aspects and conditions of North Sea and North Atlantic fisheries with those of the Campbell Plateau (work which is presently being conducted at the Institut für Seefischerei, Hamburg).

Stomach samples analysed for this report were collected from fish caught in bottom trawls during April and May 1979 from the factory trawler FMS 'Wesermünde', during participation in a joint New Zealand-Federal Republic of Germany research programme in New Zealand waters. Further samples were obtained in September and October 1979, but have at present been only briefly examined.

Stomach examination methods

The majority of stomachs collected were removed from the fish soon after capture, labelled and fixed in 10% buffered formalin, later to be transferred to 40% isopropanol. Large stomachs were frozen, as were some samples of whole fish, to enable later examination of the entire digestive tract. Relative numbers of empty, everted and full stomachs were recorded during selected consecutive trawls to investigate diurnal feeding variation.

Indices of stomach fullness and digestion state have been used(the former modified from Hunt and Jones 1972). For each prey type, or species where identifiable, the number of individuals, volume (displacement of water) and weight were recorded (the latter two measurements being adjusted to obtain approximate 'fresh' values).

Composition of Diet

The prey species of the major fish examined are shown in Table 1. A wide range of food types are consumed, especially by hoki and southern blue whiting, although this may to some extent reflect the larger numbers of stomachs examined of these two fish. The majority of prey species taken by hoki, southern blue whiting and javelin fish are characteristically pelagic; hyperiid amphipods (e.g. Parathemisto gaudichaudii, Vibilia stebbingi), natant decapods (e.g. Pasiphaea sp*, Sergestes arcticus), euphausiids (e.g. Euphausia vallentini, Thysanoessa gregaria) and myctophids (e.g. Lampanyctodes hectoris, Gymnoscopelus piabilis). This suggests that these species feed predominantly in midwater.

Hake appears also to be a midwater predator, small fish feeding on myctophids, with larger fish on a range of other fish, including hoki, southern blue whiting, silverside and javelin fish. Ling also consume these fish species, although probably when they are close to the bottom. Southern blue whiting has also been identified from stomachs of spotted dogfish (Mustelus lenticulatus) and 'black shark' (Etmopterus baxteri); hoki in stargazer (Kathetostoma gigantium), and pale ghost shark in skate (Raja nasuta) stomachs.

In contrast, the range of prey species of ghost sharks, ling, small scaled notothenid, silverside and rattail*[2] includes characteristically benthic organisms (brachyurans, thalassinid decapods, isopods, polychaetes) implying these fish generally feed close to or on the bottom. Indications are that ling and small scaled notothenid take their prey just off the bottom, while the regular occurrence of thalassinid and pagurid decapods in the stomachs of rattails and ghost sharks, and polychaetes in silverside, as well as sand and pebbles, imply feeding directly on the bottom.

Present knowledge of fish and plankton vertical movements on the Campbell Plateau permits only approximate determination of feeding position in the water column. It should also be kept in mind that the samples collected in this study are all from fish caught in bottom trawls during the day.

Principal Prey

Methods of analysing stomach content data are numerous (reviews by Hynes 1950, Pillay 1952, Windell 1968). In an attempt to overcome the biases inherent in single parameter analyses, measurements of numbers, volume and frequency of occurrence made in this study were combined to yield an Index of Relative

* -This species is as yet undescribed.

*[2]-The species of rattail referred to in this paper is Coelorinchus fasciatus

Importance, as formulated by Pinkas et al (1971):

$IRI = F (N + V)$

IRI = Index of Relative Importance
F = Frequency of occurence percentage
N = Numerical percentage
V = Volumetric percentage

Although individual prey species IRI values were calculated, species measurements were combined into higher taxonomic categories to enable a broad comparison of prey type between fish (Table 2)

For hoki, natant decapods (in particular Pasiphaea sp, Notopandalus magnoculus), amphipods (Parathemisto gaudichaudii) and myctophids (Lampanyctodes hectoris, Electrona subaspera, Gymnoscopelus piabilis) are overall the most important prey, with salps (Iasis zonaria) the only other prey group of significance. Amphipods (Vibilia stebbingi), natant decapods (Pasiphaea sp) and euphausiids (Euphausia vallentini) are the principal prey of southern blue whiting, the first two groups and cephalopods (Iridioteuthis maoria) also being the most important for javelin fish. Natant decapods (Campylonotus rathbunae) and macrourids (Coelorinchus fasciatus) are of equal importance to ling, while amphipods (P. gaudichaudii), percophidids (Hemerocoetes monopterygius) and salps (Iasis zonaria) are the principal prey of small scaled notothenid. Salps (Iasis zonaria), and isopds (Cirolana quadripustulata) are of great importance to silverside and rattails respectively, with natant decapods and thalassinids also important for the latter.

Calorific values have not been considered, although substantial differences between crustacea and fish may occur (e.g. Hertling 1938), and so the importance of fish as calculated here may be underestimated. However, the arrangement of the table clearly shows the differences in prey type, and a marked separation between the grouping of hoki, southern blue whiting and javelin fish; and the four other species considered,

Differences in prey importance with area

The Campbell Plateau is a large non-uniform area, and hence on the basis of geographical and hydrological variations, I have subdivided the Plateau into six areas (refer Fig.1). IRI prey analysis reveals differences in feeding between some of these areas.(Table 3)

Hoki feeding changes from predominantly myctophid prey in the south and west, to crustacea in other areas. This is possibly of significance considering the decrease in relative abundance of hoki with respect to southern blue whiting moving eastwards across the Plateau (Francis 1978). Macrourids, although not

important overall, are very predominant in the diet on the Bounty Platform. The feeding of southern blue whiting on crustacean groups is relatively constant, although euphausiids (primarily Thysanoessa gregaria) are particularly important in the Bounty region, where younger whiting predominate. Javelin fish prey composition also changes, amphipods being unimportant in southwest Campbell (although predominant elsewhere), and usually important natant decapods are not a significant prey group in the southwestern Pukaki area. Ling feeding also differs, macrourids being unimportant in southwest Pukaki, where isopods become significant. (It should be noted , The Bounty Platform is 'separated' from the bulk of the Campbell Plateau by the Pukaki Saddle, which could greatly affect biological and hydrological conditions, contributing to observed differences in the Bounty Islands area.)

However, the results presented in this paper must be interpreted with caution due to the small sample sizes (in particular with regional subdivision) of species other than hoki and southern blue whiting (due to problems of stomach regurgitation, and differences in fish abundance, distribution and density with respect to the sampling station distribution).

The table however clearly shows that prey importance changes in different areas of the Campbell Plateau, due to differing prey abundance or availability, or predator selection with differing environmental and biological factors.

Interspecific Competition

Feeding overlap between fish species was measured as the 'percentage similarity' between prey species assemblages in the diets (based on Odum 1950). This relationship is of the form;

$PS = 100 - 0.5 |a - b|$ (Whittaker 1967)

where a and b are the percentages of importance values of the prey in two samples (in this case IRI values have been used). A figure of greater than 50% is regarded as indicating a significant similarity between the samples (Odum, McEachran et al. 1976).

Table 4 shows that only three fish species of those analysed have similar diets; hoki, southern blue whiting and javelin fish. Ling, silverside, rattail and small scaled notothenid have statistically dissimilar diets from one another, and from hoki, southern blue whiting and javelin fish.

However, as shown in the previous section, regional differences are significant,

and hence these relationships were examined by subarea. This analysis yielded only one similar relationship, between southern blue whiting and hoki, in the Campbell East region (75.7%). Indices of relative importance were also calculated for the major prey species of hoki, southern blue whiting and javelin fish by area (Table 5). This table indicates a marked separation of the important prey species. However, the possibility of competition for food arises in the eastern Campbell area, where Vibilia stebbingi is important for both southern blue whiting and javelin fish, Pasiphaea sp for hoki and southern blue whiting, and Notopandalus magnoculus for hoki and javelin fish. An area of possibly more overlap however, is the Pukaki Rise, where all three fish could be competing for Pasiphaea sp. Discussion of these results is hindered at present by lack of knowledge concerning prey abundance, and hence whether food could be a limiting factor; and secondly whether active prey selection by the fish occurs.

Considerable overlap exists on the Campbell Plateau between hoki, southern blue whiting and javelin fish, both in areal distribution and depth regimes. Results from analyses of time of feeding, based on frequency and extent of stomach fullness and digestive state, are inconclusive for hoki. For southern blue whiting and javelin fish the respective periods mid-morning to mid-afternoon, and mid-morning to midday show an increase in feeding activity (It must be noted however, that no sampling was conducted 1800-0600hrs, and digestion rates are unknown). Hence; some degree of separation by time of feeding may occur.

Summary

1) Hoki, southern blue whiting and javelin fish feed in midwater. Ling and small scaled notothenid feed just off the bottom, while ghost sharks, rattails and, to a lesser extent silverside, feed on the bottom substrate.

2) Natant decapods, amphipods and myctophids are the most important prey groups for hoki. For southern blue whiting amphipods, natant decapods and euphausiids are the primary prey, the first two and cephalopods important also for javelin fish. Small scaled notothenid feeds predominantly on amphipods, salps and opal fish. Macrourid fish and natant decapods are the most important prey groups for ling. Rattails feed primarily on isopods, with natant and thalassinid decapods also significant, while silverside feeds almost exclusively on salps. Hake is a midwater predator on a range of fish, including macrourids, hoki, southern blue whiting and silverside.

3) Marked changes in prey composition in the diet occur in different areas of the Campbell Plateau.

4) There is a significant similarity between the diets of hoki, southern blue whiting and javelin fish (based on Whittakers percentage similarity index).

Competition for various prey species could occur between these fish in the eastern Campbell area, and on the Pukaki Rise for the natant decapod Pasiphaea sp.

5) Overall however, it would appear that food resource partitioning among the fish species on the Campbell Plateau occurs to a considerable extent.

References

Cawthorn,M.W.(1979).Resource prospects on the Campbell Plateau.In;Proceedings of the Demersal Fisheries Conference October 1978.Fisheries Research Division Occasional publications No.19;47-52.

Francis,R.C.(1978).MAF Scientist's calculations point to vast deepwater resource. Catch 5(6);22-24.

-----,K.A. Fisher.(1979).Assessment of the deepwater fish resource of the New Zealand area.Fisheries Research Division Occasional publication No.21;30pp.

Godfriaux,B.L.(1970).Food of predatory demersal fish in Hauraki Gulf.3;Feeding relationships.N.Z.Journal of Marine and Freshwater Research 4(4);325-36.

-----.(1974).Feeding relationships between tarakihi and snapper in Western Bay of Plenty,New Zealand.N.Z.Journal of Marine and Freshwater Research 8(4);589-609.

Graham,D.H.(1939).Food of fishes of Otago harbour and adjacent seas.Transactions & Proceedings of the Royal Society of N.Z. 68;421-36.

Hertling,H.(1938).Quantitative Nahrungsuntersuchung an Schellfisch,Wittlingen und Dorschen aus der Nordsee unter besonderer Berücksichtigung des Wärmewertes der Nahrung.Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung;N.F. 9;274-317.

Hunt,P.C,J.W.Jones.(1972).The food of Brown Trout in Llyn Alaw,Anglesey,North Wales.Journal of Fish Biology 4;333-52.

Hynes,H.B.N.(1950).The food of freshwater sticklebacks (Gasterosteus aculeatus & Pygosteus pungitius) with a review of methods used in studies of the food of fishes.Journal of Animal Ecology 19;36-58.

McEachran,J.D,D.F.Boesch,& J.A.Musick.(1976).Food division within two sympatric species-pairs of skates(Pisces:Rajidae).Marine Biology 35;301-317.

Odum,E.P.(1950).Bird populations of the Highlands (North Carolina) Plateau in relation to plant succesion and avian invasion.Ecology 31(4);587-605.

Pillay,T.V.R.(1952).A critique of the methods of study of food of fishes.Journal of the Zoological Society of India 4(2);185-200.

Pinkas,L,M.S.Oliphant,I.L.K.Iverson.(1971).Food habits of Albacore,Bluefin tuna & Bonito in Californian waters.California Fish & Game Dept. Fishery Bulletin 152;105pp.

Whittaker,R.H.(1967).Gradient analysis of vegetation.Biological Review 42;207-264.

Windell,J.T.(1968).Food analysis and rate of digestion.In;Methods for Assessment of Fish Production in Freshwaters.W.E.Ricker(ed).I.B.P.Handbook No.3,Oxford, Blackwell;197-203.

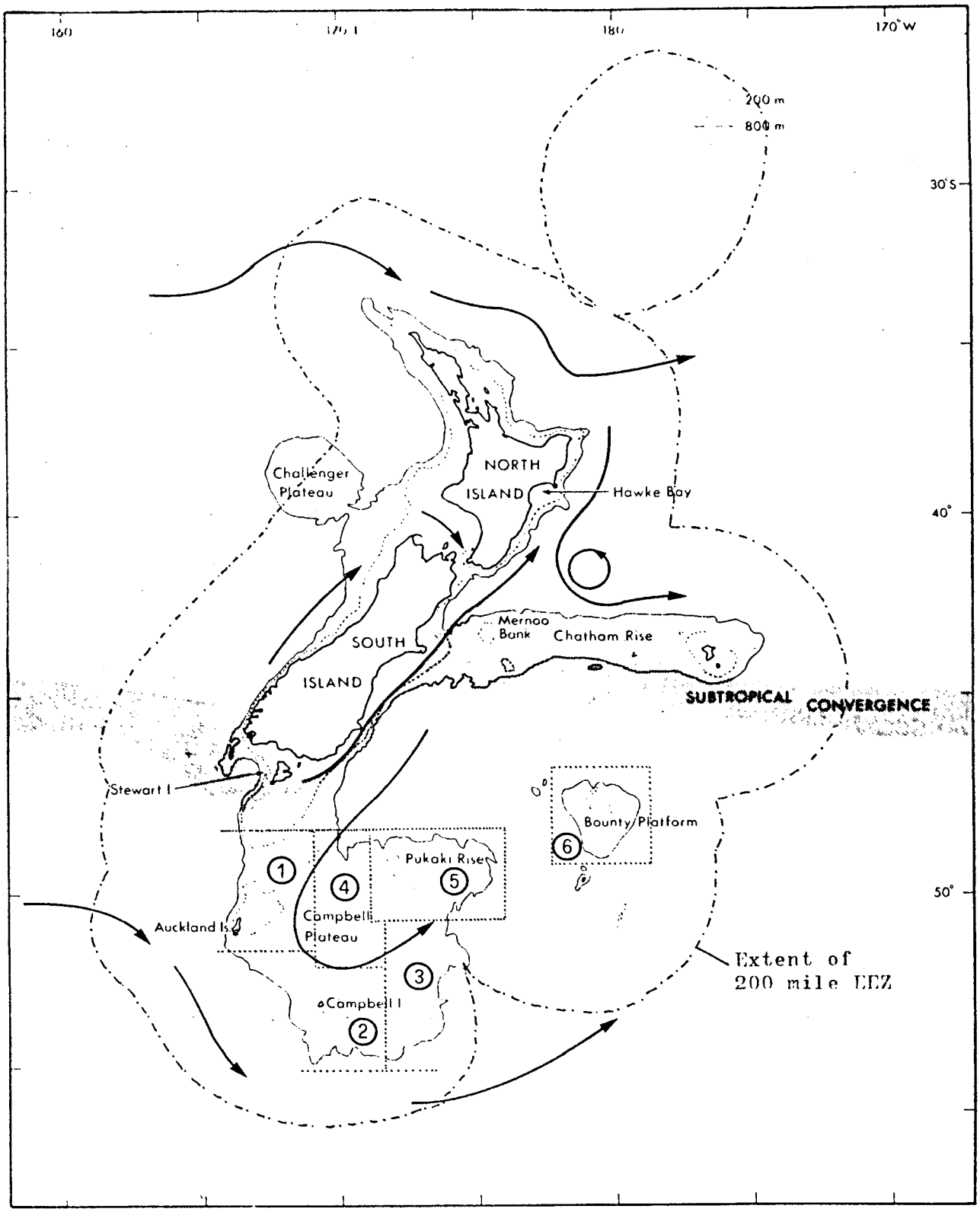
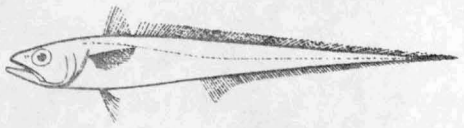
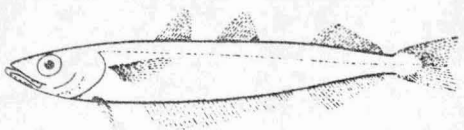


Fig. 1: Major bathymetric features, surface currents, place names, and topographic features of the New Zealand region.

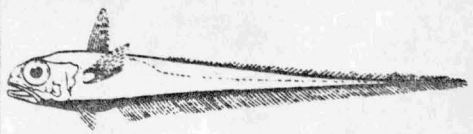
①–⑥: Subdivision of the Campbell Plateau (refer text).



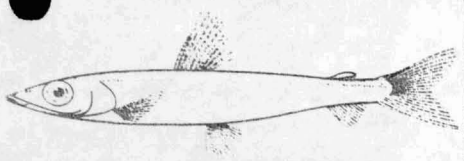
HOKI *Macruronus novaezelandiae* Whiptail, blue hake, blue grenadier. Family *Merlucciidae* (hakes), subfamily *Macruroninae* southern Australia, also N.Z. Blue-green above, silvery on sides and belly, with dark fins, skin smooth. Distinguished from the smaller javelin fish by the pointed snout, smaller eye, and silver belly. Average size 60-100 cm. Most abundant around the South Island, in 200-800 m. Trawling grounds on outer shelf, Chatham Rise, and Campbell Plateau. N.Z. catch 150 t, foreign catch 50 000 t.



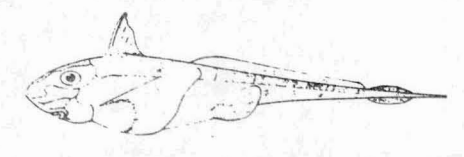
SOUTHERN BLUE WHITING *Micromesistius australis* Southern poutassou. Family *Gadidae* (cods). N.Z. and southern South America; a similar species occurs in the northern hemisphere. Grey, faintly bluish above, with many small black spots, silvery-white below; small, loose scales. Distinguished from small hake by three dorsal and two anal fins, but similar to some other deepwater cods. Average size 30-50 cm. Abundant on the Campbell Plateau, in 300-600 m. No N.Z. catch, foreign catch 50 000 t.



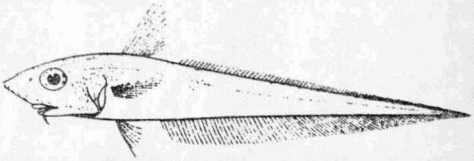
JAVELIN FISH *Lepidorhynchus denticulatus* Whiptail (incorrect). Family *Macrouridae* (grenadiers, rattails). N.Z. and southern Australia. Silvery above, black below, very small scales. Similar in general appearance to small hoki, but distinguished by larger eye, blunt snout, and black belly. Average size 20-30 cm. Common around N.Z. in offshore waters, 300-700 m. No N.Z. catch, probably a moderate by-catch on foreign trawlers.



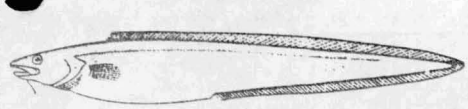
SILVERSIDE *Argentina elongata* Argentine, snodgall. Family *Argentinidae* (argentines). N.Z. and southern Australia, similar species elsewhere. Pale yellowish grey, with a bright silvery band along each side; large but thin and loose scales. The silver sides characterise this species. The rather similar cucumberfish *Chlorophthalmus nigripinnis* lacks this colouring and has larger, more vertically directed eyes. Average size 15-25 cm. Widespread in offshore waters, 100-600 m. No N.Z. catch, foreign catch unknown, possibly moderate, especially on Campbell Plateau.



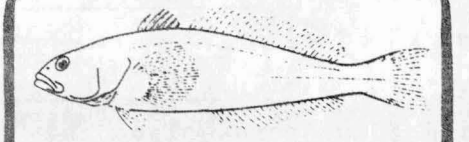
PALE GHOST SHARK *Hydrolagus sp.* Chimaera, ratfish. Family *Chimaeridae* (chimaeras). Relationship to other chimaeras unknown, it may be a new species. Very pale brown above, with only a few darker vertical bars above the lateral line; white below. Distinguished from the dark ghost shark by this more uniform colouring. Average size 60-70 cm, excluding tail filament. Fairly common on Campbell Plateau, 200-600 m, and occurs in similar depths off Banks Peninsula and Snares shelf; perhaps restricted to Subantarctic water. No N.Z. catch, probably a moderate foreign trawler by-catch.



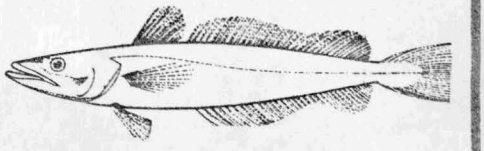
RATTAILS Family *Macrouridae* (grenadiers, rattails). Probably several genera and 10-15 species, two or three of which are common. Inadequately known and described scientifically, and not easily distinguished from each other. Most species can be distinguished from the related javelin fish by rounder bodies, visible scales, brownish rather than silver and black colouring, and pointed snouts; some species are greyish and flatter. Average size 15-30 cm; a few species are larger. No N.Z. catch, foreign catch unknown, but could be a significant by-catch component.



LING *Genypterus blacodes* Family *Ophidiidae* (Cusk-eels). N.Z. and southern coasts of Australia and South America, with a similar species (king-klip) off southern Africa. Unrelated to the European ling but superficially similar. Robust and eel-shaped, becoming relatively thicker with increasing size. Orange-pink and brown above, with irregular markings, paler to white below. Skin smooth. Average size 80-140 cm. Widespread and common in 200-700 m around the South Island, N.Z. catch about 500 t, foreign catch about 30 000 t.



SMALL-SCALED NOTOTHENID *Notothenia microlepidota* Family Nototheniidae. NZ and her Subantarctic Islands to Macquarie Island. D VI-VIII, 25-29 A 21-24 P 20-21. 78-99 lateral line scales, the two lines considerably overlap. Tail fin concave but not actually forked. Head smooth, rather flattened above. Brown or greenish above, with slight irregular mottling, pale, sometimes yellowish below. Small scales. Average size 25-35 cm. Not uncommon off southern NZ in nearshore rocky areas, but quite often taken by trawlers. No present commercial value. The name black cod has sometimes been applied to this species.



HAKE *Merluccius australis* English hake. Family *Merlucciidae* (hakes), subfamily *Merlucciinae*. N.Z. and southern Australia, similar species elsewhere. Silvery-grey above, white below, small scales. Distinguished from the cods by two dorsal and one anal fins (anal and 2nd dorsal indented). Average size 50-90 cm. Occurs around the South Island, in 200-800 m. Main trawling ground off Westland in winter. N.Z. catch 150 t, foreign catch 10 000 t.

Appendix 1.

Major deepwater fish species of the Campbell Plateau, and referred to in this study.

Table 1.

Occurrence of prey species in the diets of the major fish species examined.

Note: In this and subsequent tables the following abbreviations have been used:

HOK-Hoki (*Macruronus novaezelandiae*)
SBW-Southern blue whiting (*Micromesistius australis*)
JAV-Javelin fish (*Lepidorhynchus denticulatus*)
NOT-Small scaled notothenid (*Notothenia microlepidota*)
RAT-Rattail (*Coelorinchus fasciatus*)
LIN-Ling (*Genypterus blacodes*)
SSI-Silverside (*Argentina elongata*)
GSP-Pale ghost shark (*Hydrolagus sp*)
HAK-Hake (*Merluccius australis*)

	HOK	SBW	JAV	NOT	RAT	LIN	SSI	GSP	HAK
Amphipoda Hyperidea									
Parathemisto gaudichaudii	+	+	+	+					
Vibilia stebbingi	+	+	+	+					
Vibilia propinqua	+								
Cyllopus magellanicus	+	+	+						
Cyphocaris anonyx	+	+	+						
Bougisia ornata?							+		
Phronima sedentaria	+	+							
Primno macropa		+							
Amphipoda Gammaridea: unid.					+				
Decapoda Natantia									
Pasiphaea sp	+	+	+	+		+			
Pasiphaea barnardi	+								
Notopandalus magnoculus	+	+	+			+			
Campylonotus rathbunae		+	+		+	+			
Sergestes arcticus	+	+	+						
Pontophilus acutirostratus	+	+	+			+			
Nauticaris marionis				+					
Oplophorus sp	+	+							
Brachyura									
Nectocarcinus bennetti				+		+			
Leptomithrax richardsoni				+					
Thalassinidea: unid.					+	+		+	
Paguridae									
Eupagurus sp					+			+	
Galatheidae									
Munida sp					+				
Euphausiacea									
Thysanoessa gregaria	+	+	+	+	+				
Nematoscelis megalops	+	+		+					
Stylocheiron maximum	+	+							
Euphausia vallentini	+	+	+			+			
E. similis	+	+							
E. lucens	+	+	+						
E. longirostris	+	+							
Isopoda									
Cirolana quadripustulata			+		+	+		+	
Unid. Serolid			+			+			
Mysidacea: unid.		+	+		+				
Copepoda: unid.		+					+		
Salpidae									
Iasis zonaria	+	+		+			+	+	
Salpa thompsoni	+	+		+			+		
Cephalopoda									
Iridioteuthis maoria	+	+	+						
Kondakovia longimana		+							
Galoteuthis sp			+						
Teuthowenia antarctica	+		+						
Histioteuthis atlantica			+						
Nototodarus gloani	+		+						
Chiroteuthis picteti	+								
Likoteuthis diodema	+								
Onychoteuthis banksii	+								
Moroteuthis ingens	+								
Octopus maorum	+	+	+	+		+			
Macrouridae									
Lepidorhynchus denticulatus	+	+				+			+
Coelorinchus fasciatus						+			
Coelorinchus spp	+					+			
Percophididae									
Hemerocoetes monopterygius	+			+	+	+			
Myctophidae									
Lampanyctodes hectoris	+	+		+					+
Protomyctophum normani	+	+							
Protomyctophum sp	+								
Gymnoscopelus piabilis	+	+	+						
Electrona subaspera	+	+							
E. paucirastra		+							
E. carlsbergi	+	+							
Hintonia candens	+								
Other fish									
Austrophycis marginatus	+	+				+			
Macruronus novaezelandiae						+			+
Micromesistius australis						+			+
Argentina elongata	+								+
Nansenia sp	+								
Bassanago sp						+			
Mancopsetta milfordi						+			
Maurolicus muelleri	+								
Photichthys argenteus	+	+	+						+
Stomias boa gracilis		+							
Hydrolagus sp									
Polychaeta									
Rhamphobrachium sp							+		
Chaetognatha									
Sagitta sp	+	+	+						

	HOK (n=378)	SBW (n=239)	JAV (n=29)	LIN (n=28)	NOT (n=18)	RAT (n=10)	SSI (n=25)
Decapoda Natantia	+++	+++	+++	+++		+++	
Amphipoda	+++	+++	+++		+++		
Euphausiacea		+++					
Myctophidae	+++						
Cephalopoda			+++				
Macrouridae				+++			
Percophididae					+++		
Salpidae	++				+++		++++
Brachyura					++		
Thalassinidea						+++	
Isopoda						++++	

Table 2.

Principal prey groups, as assessed by the Index of Relative Importance.

Symbol used	IRI value	Comments
	< 100	Considered unimportant (accidental ingestion?)
+	100-499	Regarded as 'secondary prey'
++	500-999	
+++	1000-4999	Regarded as 'primary prey'
++++	>5000	

(max. 20000)

	Auckland Is.	Campbell SW	Campbell East	Pukaki SW	Pukaki Rise	Bounty Is.
HOK (378)	(73)	(29)	(81)	(87)	(98)	(10)
Decapoda Natantia	+	+	+++	+++	+++	++++
Amphipoda	+	++	+++	+++	++	++
Euphausiacea	+	+++	+	+	+	+
Salpidae	+		++	+++	++	+
Cephalopoda	+	+	+	+	+	
Myctophidae	+++	++++	++	+	+++	+
Macrouridae						+++
SBW (239)			(62)	(56)	(103)	(18)
Decapoda Natantia			+++	++	++++	
Amphipoda			+++	++++	+++	+
Euphausiacea			+	+	+++	++++
Salpidae			+	+		
Cephalopoda				+		
Myctophidae			+++		+	+
Other (id) fish						++
JAV (29)		(5)	(6)	(2)	(16)	
Decapoda Natantia		+++	+++		+++	
Amphipoda			++++		+++	
Euphausiacea		+			+	
Mysidacea		+++			+	
Isopoda			+++			
Cephalopoda		+++	+		+++	
Chaetognatha		+	+		++	
Myctophidae					+	
NOT (18)		(16)			(1)	(1)
Amphipoda		++++				
Brachyura		+				
Salpidae		+++				
Percophididae		+++				
LIN (28)	(1)	(2)	(9)	(4)	(10)	(2)
Decapoda Natantia			+++	++++	+++	
Isopoda				+++		
Brachyura					+	
Macrouridae			++++		+++	
Percophididae						
Other (id) fish			++		+	
RAT (10)				(8)		(2)
Decapoda Natantia				+++		
Isopoda				++++		
Thalassinidea				+++		
SSI (25)	(2)		(2)	(12)	(9)	
Salpidae				++++	++++	
Polychaeta					+++	

Table 3.

Relative importance of prey groups/predator/area.

(Symbol values as per Table 2 - numbers in brackets indicate number of samples)

	HOK	SBW	JAV	NOT	RAT	LIN	SSI
HOK							
SBW	59.3						
JAV	53.2	62.9					
NOT	29.3	44.1	36.3				
RAT	17.6	13.7	13.7	3.5			
LIN	38.0	37.3	29.5	0.9	15.9		
SSI	7.7	2.2	1.4	11.8	3.0	0	

Table 4.

Percentage similarity values between the fish species.

(based on the Index of relative importance)

	Auckland Is.	Campbell SW	Campbell East	Pukaki SW	Pukaki Rise	Bounty Is.
Parathemisto gaudichaudii		HOK++	HOK+++	HOK+++	SBW++	
Vibilia stebbingi			SBW++ JAV++++	SBW+++	JAV+++	
Cyllopus magellanicus				SBW+++		
Cyphocaris anonyx				SBW++		
Pasiphaea sp		JAV++	HOK++ SBW++	HOK+++	HOK+++ SBW++++ JAV++	HOK+++
Notopandalus magnoculus			HOK++ JAV+++	HOK++		
Campylonotus rathbunae			JAV+++			
Euphausia spp					SBW+++	
Thysanoessa gregaria						SBW++++
Iasis zonaria				HOK+++		
Electrona subaspera		HOK+++	SBW++			
Lampanyctodes hectoris	HOK+++					

Table 5.

Relative importance of individual prey species in the feeding of hoki, southern blue whiting and javelin fish, as broken down by area.