THE OFFSHORE FISHERIES RESOURCES OF THE FALKLAND ISLANDS

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Foreword by Dr N A Mackintosh to the report by Dr T J Hart[20] on the prospects for commercial trawling on the Patagonian shelf, 1946.

"It will be realised that this report deals mainly with the general biology and ecology of the demersal fish, and with the prospects of commercial trawling. The surveys were planned for this purpose and did not include an investigation of the pelagic fish such as the Falkland herring. Various references to these fish are included in the report, but there is still little information on the prospects of commercial fishing by other means than trawling. The principal conclusion of the report is that hake, and some other edible species, are obtainable in moderate numbers by trawling. Although the shelf has been found to be less rich in trawlable fish than might have been expected, it is possible that enough could be taken to support an industry if markets could be found, and problems of preservation and delivery could be overcome. The report may be regarded as a contribution to our knowledge of the fish faunas of the world, and it is hoped that it will be of assistance in any consideration of the future economic development of the Falkland Islands."

SUMMARY

a. British vessels collected much of the earliest information on the fisheries resources of the Patagonian shelf and even before the 1939-45 war there had been a survey aimed at assessing the prospects for a commercial trawl fishery, but the results were considered not very promising because of the marketing problems. Only the shelf area itself, water down to 100 fathoms, is of great interest commercially although the adjacent slope is of some interest. Open ocean waters, whether they are within a 200-mile exclusive fishing zone (EFZ) or not, are of little commercial consequence. The area of shelf that would be within a 200-mile Falkland Islands EFZ is in the order of 51,920 square nautical miles (178,320 square kilometres).

b. As well as the early British surveys there have now been several others, and commercial fishing by foreign vessels (USSR) began in 1967. Two species, southern blue whiting and hake, are now known to be of by far the greatest consequence on the southern Patagonian shelf. They, together with grenadier, red cod, whiptail and kingklip are likely to constitute 90% of the commercial catch off the Falkland Islands. Squid are unlikely to form more than about 1% of the trawl catch. Most fish species undertake substantial migrations and the best fishing areas, separately for summer and winter, are identified in text figures.

c. Argentina has taken, and continues to take, the largest catches from the Patagonia shelf. Commercial fishing by long range fleets began in 1967. The combined fishing effort has now reached about the level required to take the maximum sustainable yield of the common hake and the southern blue whiting but other species are only lightly exploited.

d. There have been many estimations of the biomass or the maximum sustainable yield (MSY) of different species inhabiting the Patagonian shelf from which seven estimations relating specifically to the Falkland Islands are developed. The Falkland Islands MSY is estimated to be 210,000 tonnes/year ± 20%

e. The value of the catch to the Falkland Islands depends on a legal claim to the fish. The value of the catch to the one who takes it depends entirely on the ability to market it. The southern blue whiting, the most abundant of the Falkland Islands species, currently has no value other than as fish meal because of a heavy parasite infestation in the flesh: trawlers having no fish meal manufacturing capability simply discard this species at sea. It is possible that heavy fishing will reduce the level of infection when the fish may be marketable for human consumption. Hake are familiar on international markets but other species are not well known. It is estimated that the market value, in Europe, of the total catch with the southern blue whiting acceptable for human consumption would be c. £60 million, but currently, with that species being of value only as meal, the market value is only c.£45 million. However, essential costs including transport and processing to get the fish to market make substantial inroads into those receipts so that the value of the catch at the surface of the sea off the Falkland Islands is estimated to be only c.£47 million with the southern blue whiting being edible, or c.£37 million currently. These figures give average values of £223/tonne and £174/tonne respectively.

f. The annual revenue to the Falkland Islands that would be generated through licence fees based on 5% of the value of the catches is estimated to be £1.85 million at the present time rising to about £2.5 million as the southern blue whiting becomes edible.

g. There is a big difference in the ability of trawlers of different classes to utilise the catches they take but the concentrations of fish in the best areas within the 200-mile EFZ are adequate to support even large trawlers catching and processing up to 2,000 tonnes/month (but the commercial viability of such operations has not been examined). Basing licence fees on 5% of the anticipated value of the catch requires judgment on the ability of each vessel to catch and process fish. Vessels utilising all the catch, processing the southern blue whiting to meal (ie probably all 3,000 GT* trawlers and larger vessels, and some 2,000 GT trawlers) should be assessed on a basis of 5% x £174 x anticipated catch: a 3,000 GT trawler catching 2,000 tonnes/month should be expected to pay £17,400 for a month's fishing licence. Vessels discarding the southern blue whiting should be assessed on 5% x £233 x anticipated catch: a 2,000 GT trawler catching 480 tonnes/month should be expected to pay £5,590 for a month's fishing licence.

h. 210,000 tonnes of fish (MSY) will support about 55 x 2,000 GT trawlers each fishing for 8 months in the year but it will support only 13 x 3,000 GT trawlers. The fleet finally licenced is likely to be of mixed classes and careful control will be necessary.

(*) Gross Tons

INTRODUCTION

1. This report has been assembled from all the known published literature on the fisheries resources of the southwest Atlantic Ocean, in particular the area of the Patagonian shelf. The literature search was carried out by the Directorate of Fisheries Research of the Ministry of Agriculture, Fisheries and Food, Lowestoft, where all the reading was undertaken. Specific references in the report are identified in the list of selected references by a number (eg Hart[20]).

2. The report was prepared as part of a consultancy requested by the Government of the Falkland Islands, and directed by the Overseas Development Administration of the Foreign and Commonwealth Office, London. The terms of reference relating to the preparation of this report state:

> "You will undertake a search of literature and published information to provide the best available estimate of fish stock abundance, catch rates, species composition, optimum sustainable yield, and value, of the fish stocks in the South Atlantic, and in particular in areas that would be covered by a 200 mile exclusive economic zone around the Falkland Islands."

3. Although all the information was obtained second hand, from published (and some unpublished) material, I was able to draw on my own brief experience of the Falkland Islands obtained during a visit in 1978 and the report prepared at that time by the team I led (Hall [19]).

THE GENERAL DISTRIBUTION OF THE FISHERIES RESOURCES

4. By far the most important of the world's fisheries occur over the continental shelf, the relatively shallow sea adjacent to most land masses before the sea-bed plunges, frequently very sharply, to the ocean depths. The reasons for this are twofold; firstly, the seawater is much more fertile, and therefore much more capable of supporting fish populations, close to land masses because of the nutrients running into the sea from the land and other natural processes including upwelling of deep, nutrient-rich water and turbulence generated by storms; secondly, because it is so much easier to catch fish in shallow water.

5. Basic organic productivity in the sea, just as on land, depends on sunlight, which provides the energy needed by the minute plants (phytoplankton) to synthesise their food materials (kelp is of little consequence in the general food chain). The top 400 feet or so (70 fathoms) of the sea surface are absolutely crucial to all life in the sea. However, there are virtually no marine herbivorous fish: almost all the marine herbivores are small invertebrates (zooplankton) which browse on the living algae (the plants of the sea) which are confined to the illuminated surface layers. Below that the ocean is totally dark and unproductive no matter how great the concentration of nutrients may be. Fish living at such depths are dependent for their food either on fish that have migrated to those depths for some reason or other (eg to spawn) or on the sedentary marine life which itself is dependent on the rain of organic matter from the surface waters, consisting largely of excreta and dead bodies.

6. The waters of open oceans tend to be unproductive. The surface water does not receive any replenishment of the nutrients that are used up by the plants drifting in the water, and the further the water drifts from

the land the more infertile it becomes. Fish populations in those oceans tend to be sparse because there is little on which to feed. Some indication of the feeding relationships in the sea is shown in Figure 1.

7. Fish are most easily caught when they are lying on or close to the sea-bed and when they can be collected by a net dragged along the sea-bed. The most important fishing technique of this kind is trawling and fish that can be caught in this way are described as "demersal". The contrast in fish types is "pelagic", fish that can live freely in the water column. The distinction between demersal and pelagic may seem to be trivial but it is fundamental. Fish living on or close to the sea-bed are fish that feed on benthic invertebrates or on slow moving fish: they themselves tend to be slow moving, flat bellied, light coloured ventrally and frequently sandy coloured dorsally, whereas pelagic fish are very active, fusiform, steel blue dorsally and silvery below, and mostly they are encountered in shoals.

8. Catching pelagic fish may be much more difficult than catching demersal fish because of the problem of positioning the gear both laterally and vertically in the water, but if the operation is successful the catches can be dramatic. For similar reasons, and because pelagic fish are generally much more active than demersal fish, estimating the size of pelagic stocks tends to be a more difficult exercise than estimating demersal stocks where one standard technique is to assume that a trawl has taken most of the fish in its path; hence the numbers per unit area of sea-bed can be determined. The use of echo-sounders and echo-integrators, once considered to have solved the problem of estimating pelagic fish stocks, is now recognised as contributing just one more item of information to the total data bank, which information has to be evaluated along with the rest.

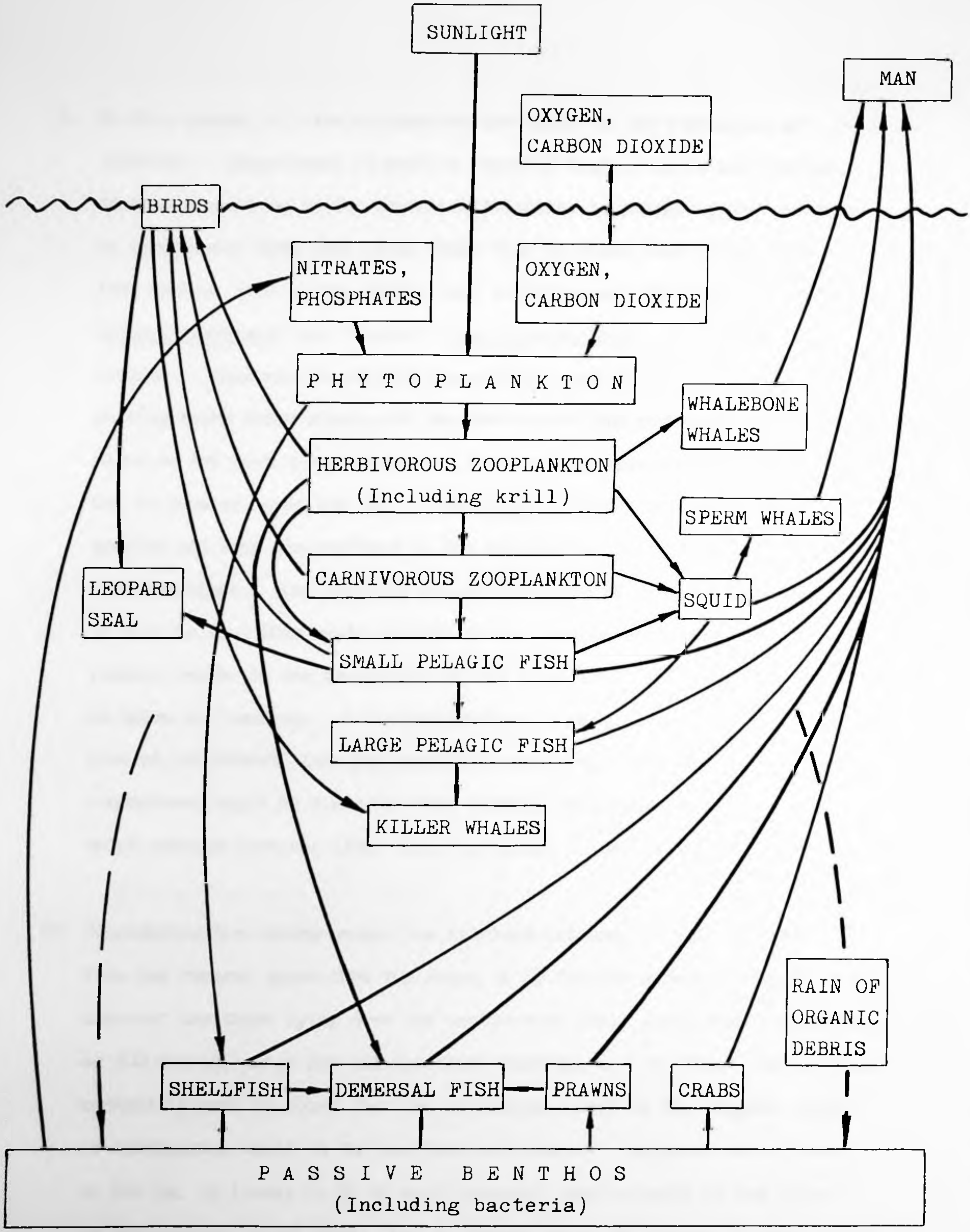


Figure 1. Some feeding relationships in the sea.

9. In this report, all the estimations are based on the evaluation of trawling. Regrettably it must be reported that, despite substantial fishing operations in the southwest Atlantic, no pelagic fish resources of consequence have been found other than in close association with land masses, such as the anchovy off Argentina and the Falkland herring (Clupea fuegensis) and "mullet" (Eleginops maclovinus) off the Falkland Islands. However, at certain times of the year the southern blue whiting forms dense shoals off the sea-bed so that mid-water trawling might be the most effective way of catching the species at that time; but in general terms the only proven fish resources are of demersal species and they are confined to the continental shelf and the immediately adjacent slope. One non-fish pelagic resource of consequence is squid. It will be seen that squid feature in the various estimations, but those figures relate to the proportion of the total squid resource that might be taken by trawling. A further catch of squid, essentially of unknown size at the present time but possibly much larger than the demersal proportion, might be taken by other fishing techniques (squid "jigging" which employs vertical lines carrying hooks, is one of these).

10. Considering the waters around the Falkland Islands, it will be seen from the remarks above that the areas of by far the greatest commercial interest are those lying over the continental shelf (less than 100 fathoms or 200 metres, which for all practical purposes are the same), and in this context it must be noted that the Patagonian shelf is the biggest extent of continental shelf in the southern hemisphere. Adjacent water, down to 500 fm, is likely to be of some interest, particularly if the slope of the sea-bed is not great, but in deeper water the chance of there being fish resources of consequence is very slight indeed. These different

areas are identified in Figure 2, which shows also the approximate limit of a 200 mile exclusive fishing zone (EFZ) around the Falkland Islands [Areas down to 100 fm are shown in black; areas from 100-500 fm are stippled]. Based on the most up-to-date Admiralty charts I estimate these areas to be as listed in Table 1.

11. One final point must be made in this general consideration of the distribution of fish, namely the patchiness of the distribution. The sea-bed is not a uniform plateau; it has a range of character greater than that on land with a wide variety of muds, sands, shells gravels and rocks lying exposed, together with hills, valleys, cliffs, and greater mountain ranges than on land. These different characteristics provide a wide range of different habitats for sedentary life and for the demersal species living on or close to the sea-bed, some of which are more favourable and support much higher numbers of animals than other habitats. Nor is the water column itself homogenous no matter how uniform it may appear at the surface. The sea consists of a large number of different water masses each with its own composition, salinity, temperature and density, all of which may be more or less favourable to basic productivity and to particular species. Added to all these inequalities is the shoaling tendency, particularly for spawning and for self protection. All these characteristics contribute to the uneven distribution of all forms of marine life.

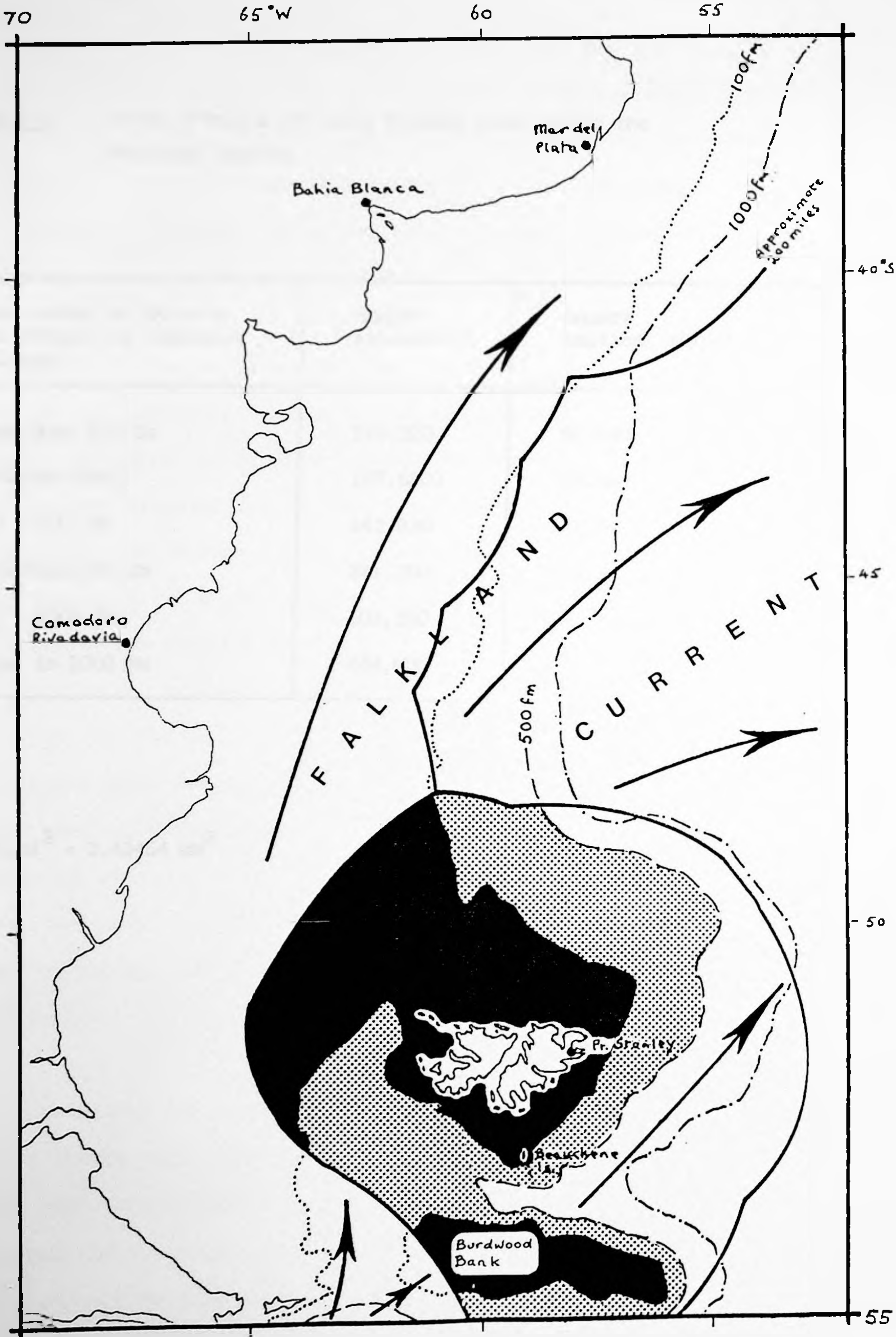


Figure 2. The continental shelf (0-100 fm) and the adjacent slope within a 200-mile Falkland Island EFZ.

Table 1. Areas within a 200 mile fishing zone around the Falkland Islands.

Area within a 200 mile EFZ around the Falkland Islands.	Square kilometres	Square nautical miles*
Less than 100 fm	178,320	51,920
(Burdwood Bank)	(27,680)	(8,060)
100 - 500 fm	162,930	47,440
Less than 500 fm	341,250	99,360
500 - 1000 fm	103,350	30,090
Total to 1000 fm	444,600	129,450

(*) $n.mi^2 = 3.43454\ km^2$

THE WEATHER AND THE SEASONS

12. The climate of the Falkland Islands is cool, damp and notably windy (Table 2). The general area of the southern Patagonian shelf is exposed to an almost unbroken series of depressions from the west. Except in sheltered locations, predominantly cold and stormy weather can be expected with much cloud and rain. Violent and unpredictable squalls are frequent.

13. The weather, particularly in winter, seems cold more as a result of the wet and stormy conditions than the low temperature. Average cloud cover over the Falkland Islands themselves is six-eighths, with skies cloudiest towards sunset and clearest towards midnight. There is no dry season and in winter much of the precipitation falls as snow (on average August has 11 days on which snow falls). Sea fog is not frequent but low cloud may extend to the surface. Visibility may be greatly reduced also because of rain, drizzle or snow, but bad visibility can be replaced in a few minutes by cloudless skies and exceptionally good visibility. The average wind speed is about three times that in UK. In summer the strongest winds are from the west and southwest with some from the northwest and even north: in winter the strongest winds are generally westerly (W, NW, SW) but some strong winds can come from both the north and the south.

14. The predominant sea current reflects the westerly-flowing Southern Ocean Current which flows around Cape Horn and then northeasterly, both summer and winter (Fig 2). The flow is more constant in strength and direction along the east coast of East Falklands than elsewhere but the rate of flow generally is not great, not usually

Table 2. Weather conditions in the Falkland Islands.

Month	Temperature		Rain fall		Wind		Fog
	Mean highest (°C)	Mean lowest (°C)	Days with 1mm or more	Total (mm)	Mean wind (knots)	Days with gales	Days with fog
Jan	19	1	15	69	16	5	2
Feb	18	1	14	58	16	4	2
Mar	17	0	13	59	16	5	2
Apr	14	-2	12	57	15	4	4
May	11	-3	14	64	15	5	5
Jun	8	-6	12	54	15	4	5
Jul	8	-6	11	53	16	5	5
Aug	9	-5	12	51	17	5	5
Sep	12	-3	11	37	17	4	4
Oct	14	-2	10	38	16	5	3
Nov	17	-1	12	50	17	5	2
Dec	18	0	14	71	16	4	3

Information from the Admiralty Pilot, South America, Volume II exceeding 1 knot. Close to the Falkland Islands, in waters less than 100 fm, a considerable part of the water movements are tidal in character. The flood stream can run at 6 knots off the Jason Islands, for example, causing heavy and dangerous races. The flood stream enters Falkland Sound from both north and south, meeting at about Swan Island and causing a double high tide.

15. The mean sea surface temperature in summer (February) is 9-10°C and in winter (August) 4-5°C off the Falkland Islands. Broken pack ice may approach to within about 500 miles of East Falkland while icebergs are liable to be encountered over a considerable part of the southern Patagonian shelf: ice islands, 20 miles in length, have been reported to the east of the Falkland Islands.

16. The seasons are essentially reversed from those in UK:

Spring	(September), October, November
Summer	December, January, February, (March)
Autumn	(March), April, May
Winter	June, July, August, (September)

IMPORTANT COMMERCIAL FISH SPECIES AND THE BEST FISHING AREAS

17. The general nature of the fish fauna of the Patagonian shelf has been known for many years. The first description of fish species was based on a small collection made by Captain Cook during his second expedition with ADVENTURE and RESOLUTION, 1772-1775. Norman[26], in his report on the fish collected during the "Discovery" expeditions of 1927-32, took the opportunity of listing all the 89 species that were known from the shelf at that time (1937). The "Discovery" expeditions were undertaken with the intention of considering the prospects of commercial trawling over the shelf but the war interrupted the preparation of the final report, which was finally undertaken by Hart[20] in 1946. The conclusions were not promising. Fish were found to be scarce within 20 miles of the Falkland Islands, which Hart concluded was "unquestionably due to seals". Within this distance from the islands, however, invertebrates were found to be "extra-ordinarily abundant" but mostly they were species of no commercial consequence although some crabs were noted (para 23-1).

18. On the shelf to the north of the Falkland Islands the sea-bed was found to be fairly clean and good for trawling, with a dark, greenish-brown sand predominating. The same was found to the southeast, south and west of the islands and on parts of the Burdwood Bank, with a high proportion of shell fragments, but other parts of the Burdwood Bank had foul ground and gales were prevalent with steep, breaking seas.

19. Hart made the first report of the substantial seasonal migrations undertaken by the fish of the Patagonian shelf and noted that, in

order to be successful, "a commercial fishery would have to follow the spawning fish throughout the year". He also noted the crucial problem of marketing the fish and concluded, "It must be plainly stated that the results are not encouraging; but this is due to economic and geographical factors, rather than to lack of suitable fish". These same problems are vitally important today.

20. There have been several, more recent, expeditions since the "Discovery" expeditions, some of them aimed much more directly at assessing commercial fisheries prospects and equipped with much heavier trawling gear and much larger and more comprehensive vessels than RRS WILLIAM SCORESBY during the "Discovery" period of 1927-32, such as those reported by Anon[1], Cotrina[9] and Cousseau[11]. There are reports also from commercial activities over the Patagonian shelf although none from the USSR which was the first country to begin fishing heavily, as early as 1967. These records, dating back to 1970, cover commercial fishing by vessels from Bulgaria, GDR, GFR, Poland and Japan as well as by Argentinian, Brazilian and Uruguayan vessels and some foreign vessels fishing on behalf of those fleets. From all these sources a reliable species list can be constructed. This is given in Table 3. Although the proportion of the catch will differ with the seasons and location the seven species listed in the first part of the table are likely to constitute 90% of the catch within a 200 mile exclusive fishing zone around the Falkland Islands (see Table 8 in which these species total 91%).

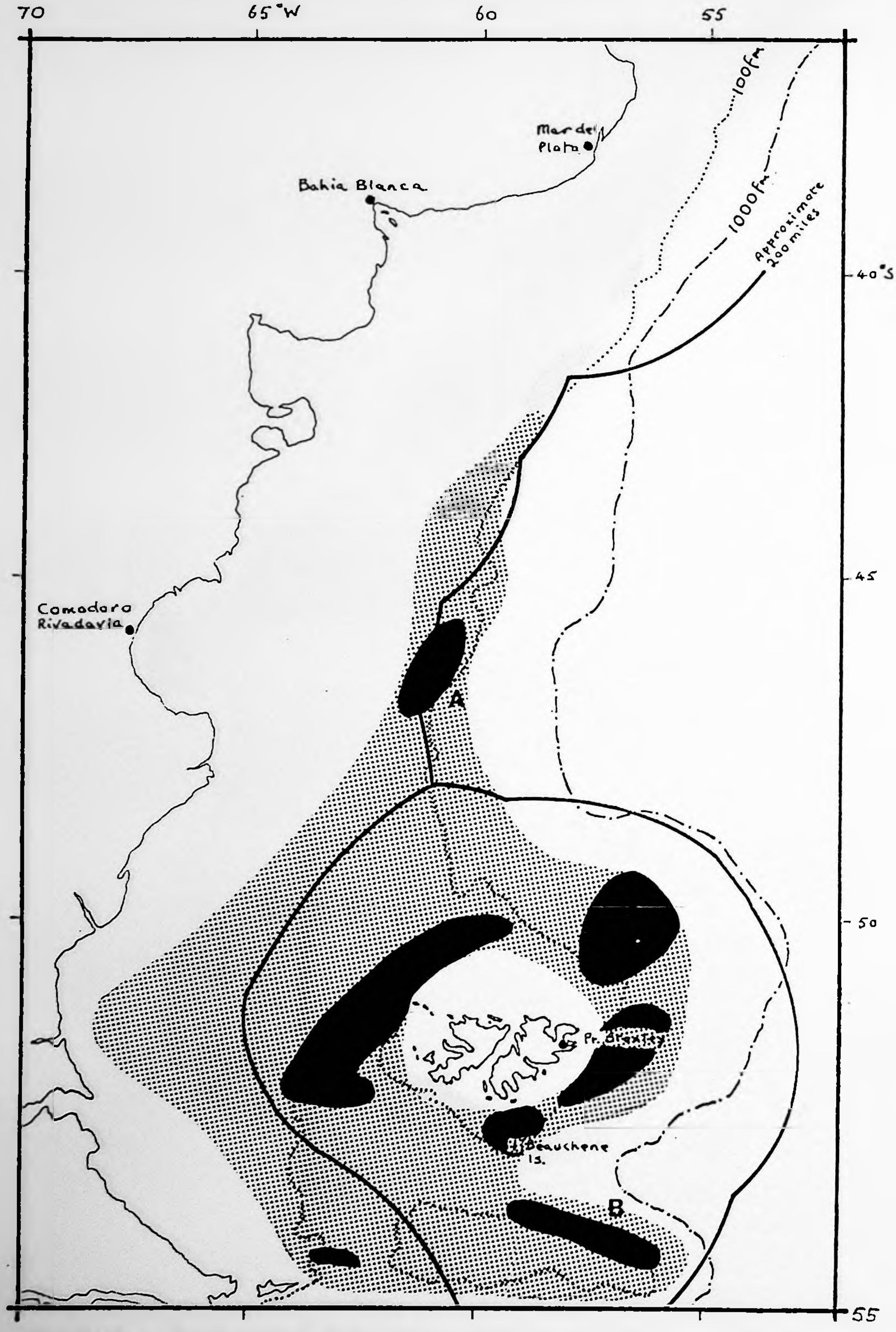
Table 3. The off-shore fish of the Falkland Islands.

A. FISH SPECIES OF GREATEST IMPORTANCE	
Micromesistius australis Norman	Southern blue whiting, polaca
Merluccius polylepis Ginsburg = M. australis (Hutton)?	Patagonian hake, austral hake, English hake, merluza austral
Macrourus whitsoni (Regan)	Grenadier, granadero
Salilota australis (Günther)	Red cod, austral cod, bacalao austral/criollo
Macruronus magellanicus Lönnberg	Patagonian whiphake, long tailed hake, whiptail, merluza de cola
Merluccius hubbsi Marini	Common hake, Argentine hake, merluza común
Genypterus blacodes (Schneider)	Kingklip, pink cusk eel,abadejo
B. OTHER NOTABLE SPECIES	
Dissostichus eleginoides Smitt	Patagonia toothfish,Falkland haddock, merluza negra
Coelorhynchus fasciatus (Günther)	Grenadier
Stromateus brasiliensis Fowler	Pomfret, palometa
Pagrus pagrus Linnaeus	Gilt-head, porgy
Callorhynchus callorhynchus	Elephant fish, pez elefante
Acanthistius brasiliensis (Valenciennes)	Wreckfish, mero
Notothenia ramsayi Regan	Antarctic cod
Notothenia guntheri Norman	Antarctic cod
Mugiloides (Pinguipes) sommambula	Salmon de mer
Helicolenus dactylopterus lahillei Norman	Rubio
Polyprion americanum (Schneider)	Wreckfish, bass, mero
Sebastodes oculatus (Cuvier & Valenciennes)	Red fish
Percophis brasiliensis Quoy & Gaimard	
Thyrsites atun (Euphrasen)	Snoek, barracouta
Seriolella puntata (Schneider)	
Cheilodactylus bergi Norman	Morwong
Schedophilus grisseolineatus (Norman)	Medusa fish

21. The most recent analysis of the data on the fish stocks of the Patagonian shelf was undertaken by FAO in 1983 in preparation for the technical session of the World Fisheries Conference, October 1983, (FAO[16]), which in turn relied heavily on the work of Dr H O Otero. I have added additional material to that analysis where insufficient weight seemed to have been given to other published, and some unpublished, data to produce Figures 3-14. The best fishing areas are marked in black while the general distribution of substantial numbers of a species is stippled: odd individuals may be caught outside the marked areas.

22. Two "species" are of outstanding importance over the Patagonian shelf, hake and the southern blue whiting. From north to south the proportion of hake decreases in the catches and the proportion of southern blue whiting increases. There is also a change in the species of hake since it is now recognised that two distinct species exist, the common hake (Merluccius hubbsi) to the north and the Patagonian or austral hake (Merluccius polylepis) to the south. They can be separated absolutely only by counting the vertebrae (Gosztonyi[17] quotes 49-50 for hubbsi and 54-56 for polylepis). A number of other differences have been identified as a result of analysing large numbers of fish but none is conclusive in a single example (Cousseau[12]). These differences include:

a. The snout of hubbsi is shorter than that of polylepis
b. The eye of hubbsi has a bigger diameter
c. The inter-orbital space of hubbsi is smaller
d. The pectoral fins of hubbsi are shorter
e. The scales of hubbsi are larger



<u>Figure 3</u>. Best areas for southern blue whiting - summer. Areas "A" and "B" best of all.

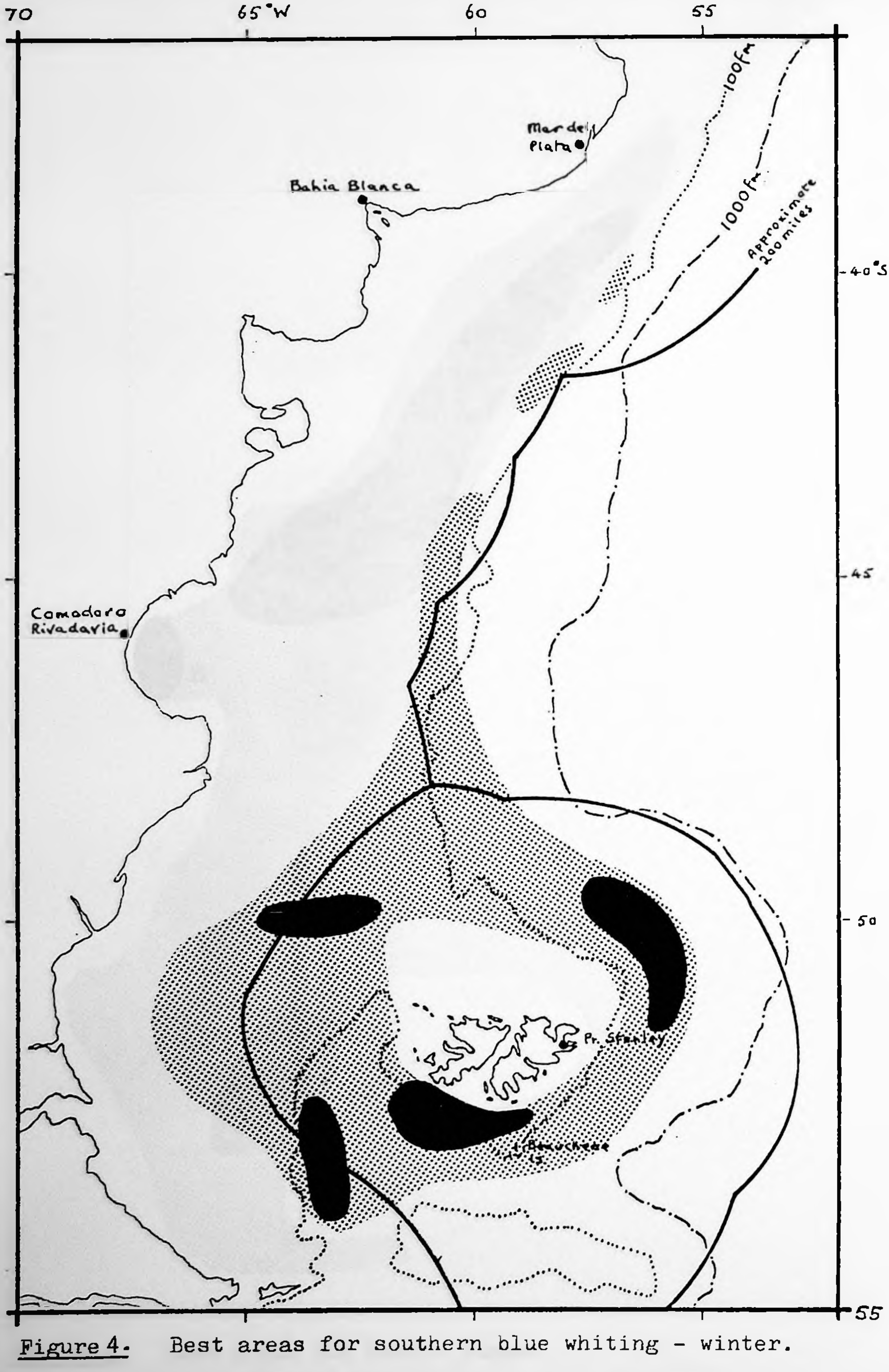


Figure 4. Best areas for southern blue whiting - winter.

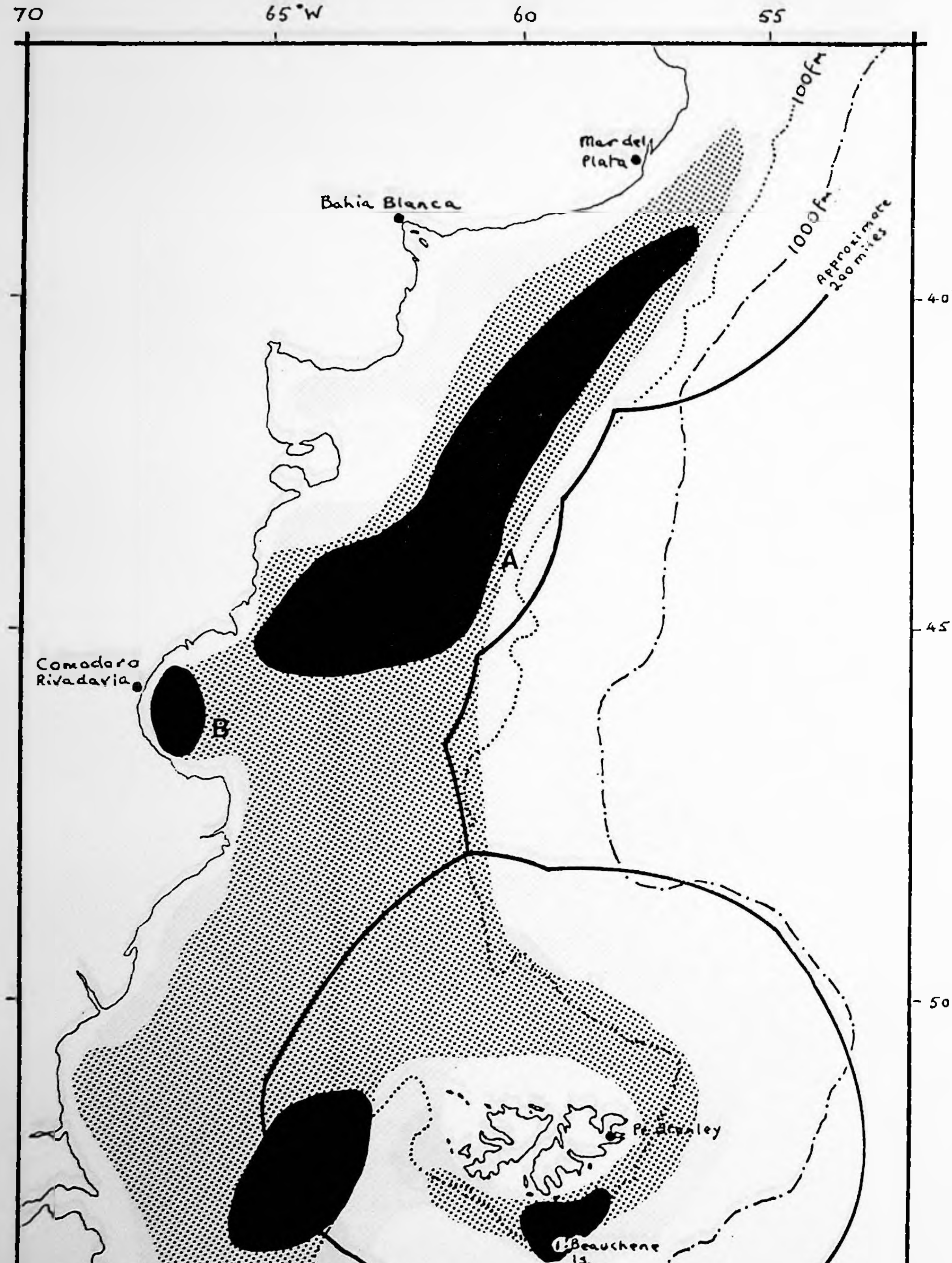


Figure 5. Best areas for hake - summer.
Areas "A" and "B" are the common hake.

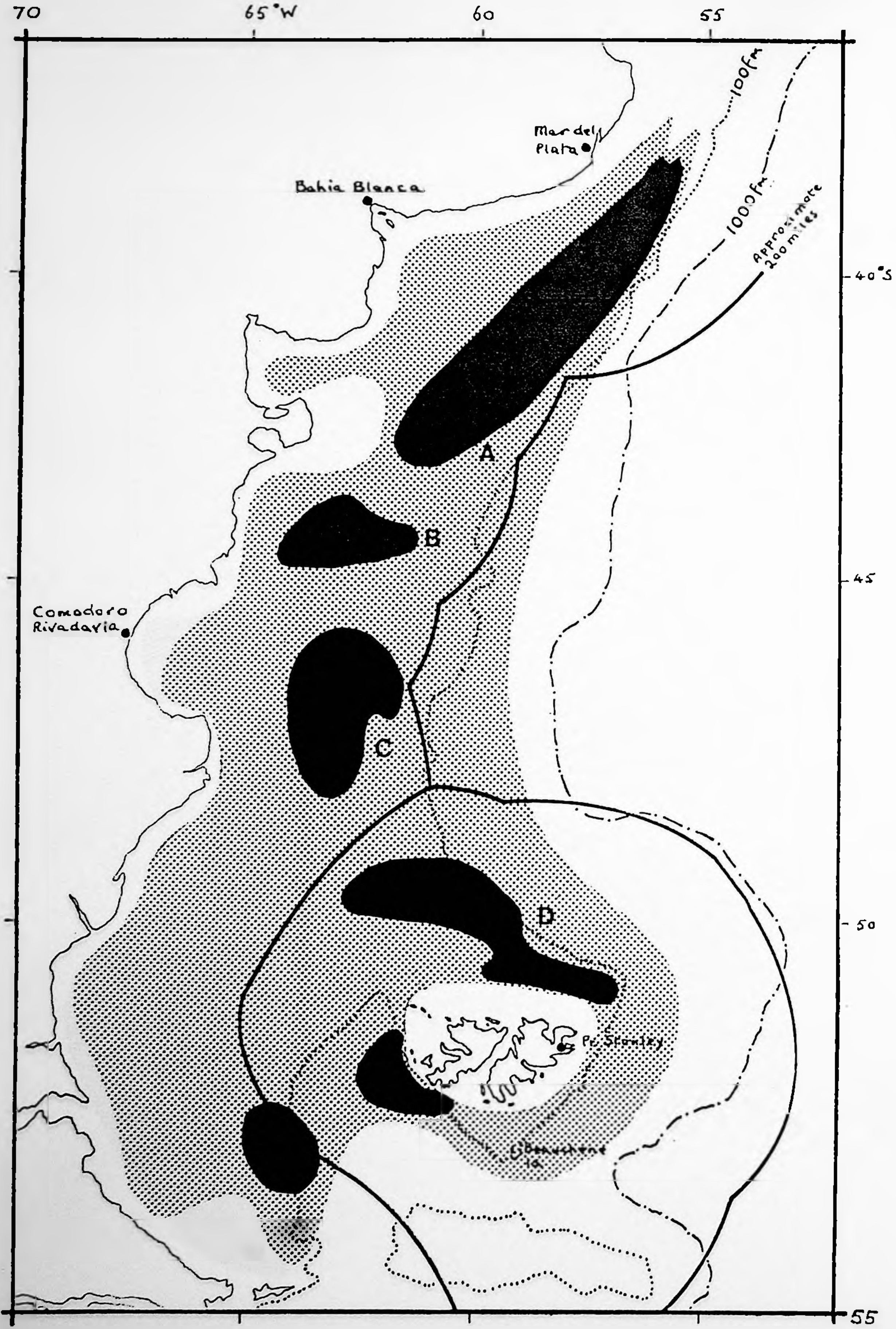


Figure 6. Best areas for hake - winter.
Areas "A", "B", "C" and "D" are the common hake.

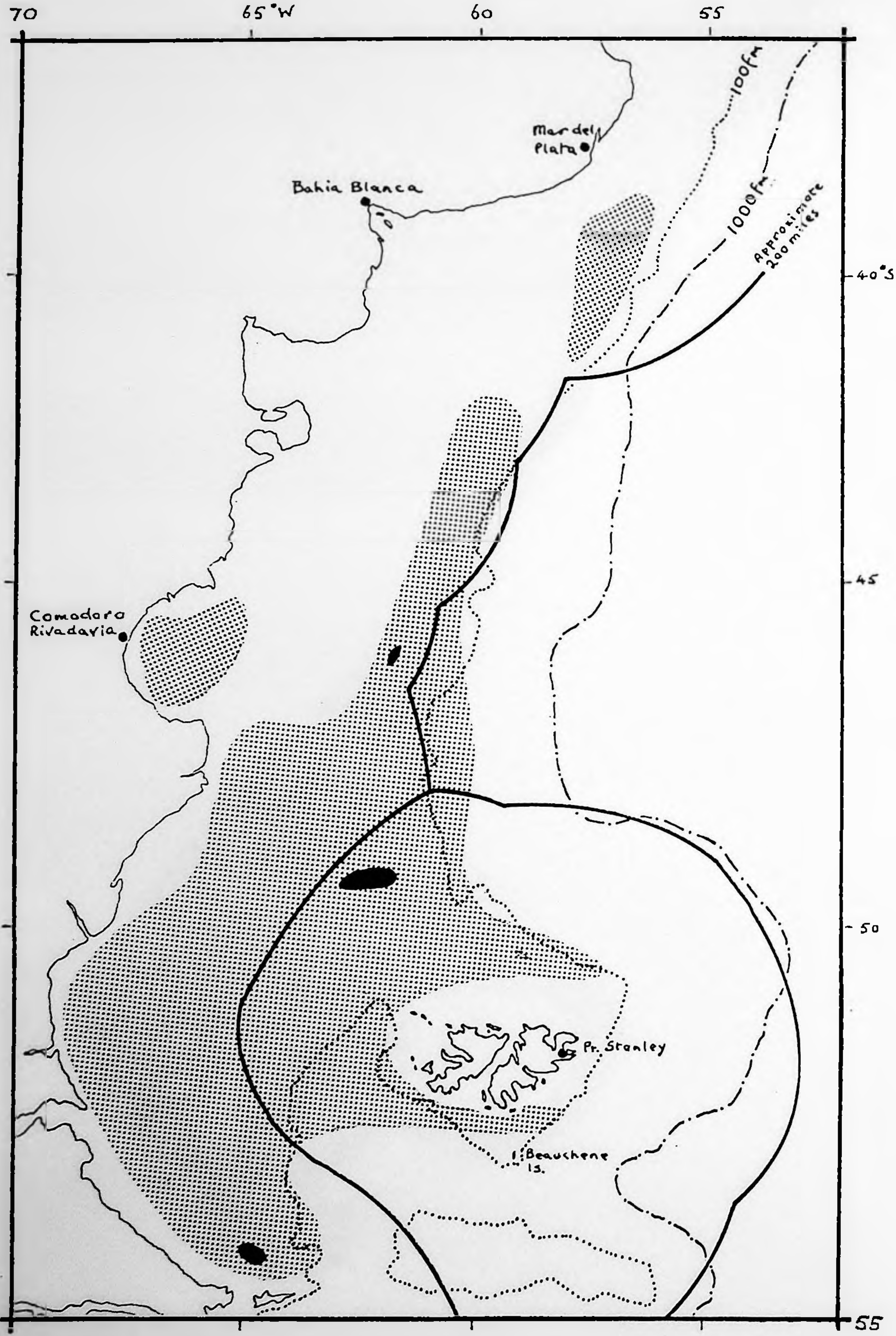


Figure 7. Best areas for red cod - summer.

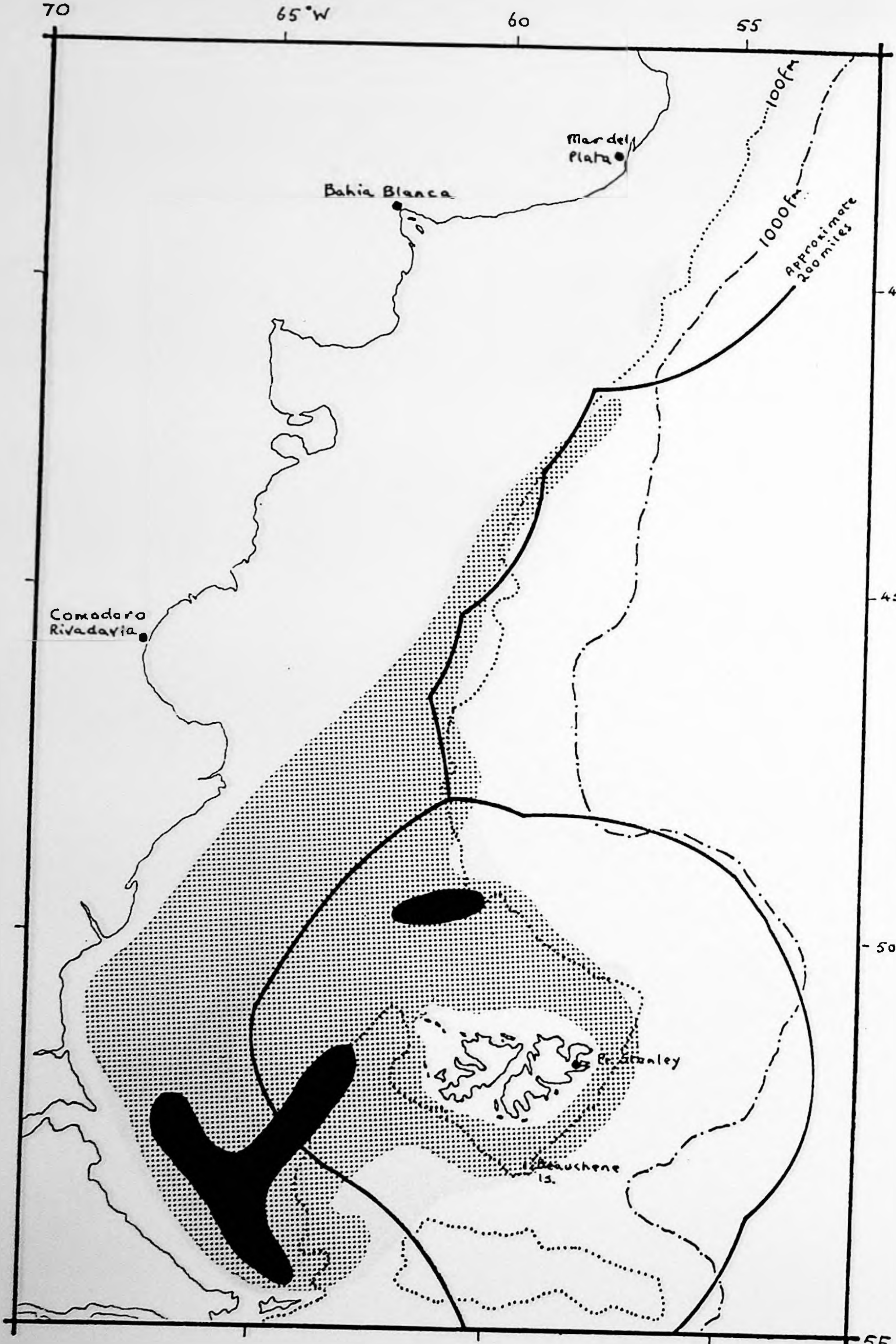


Figure 8. Best areas for red cod - winter.

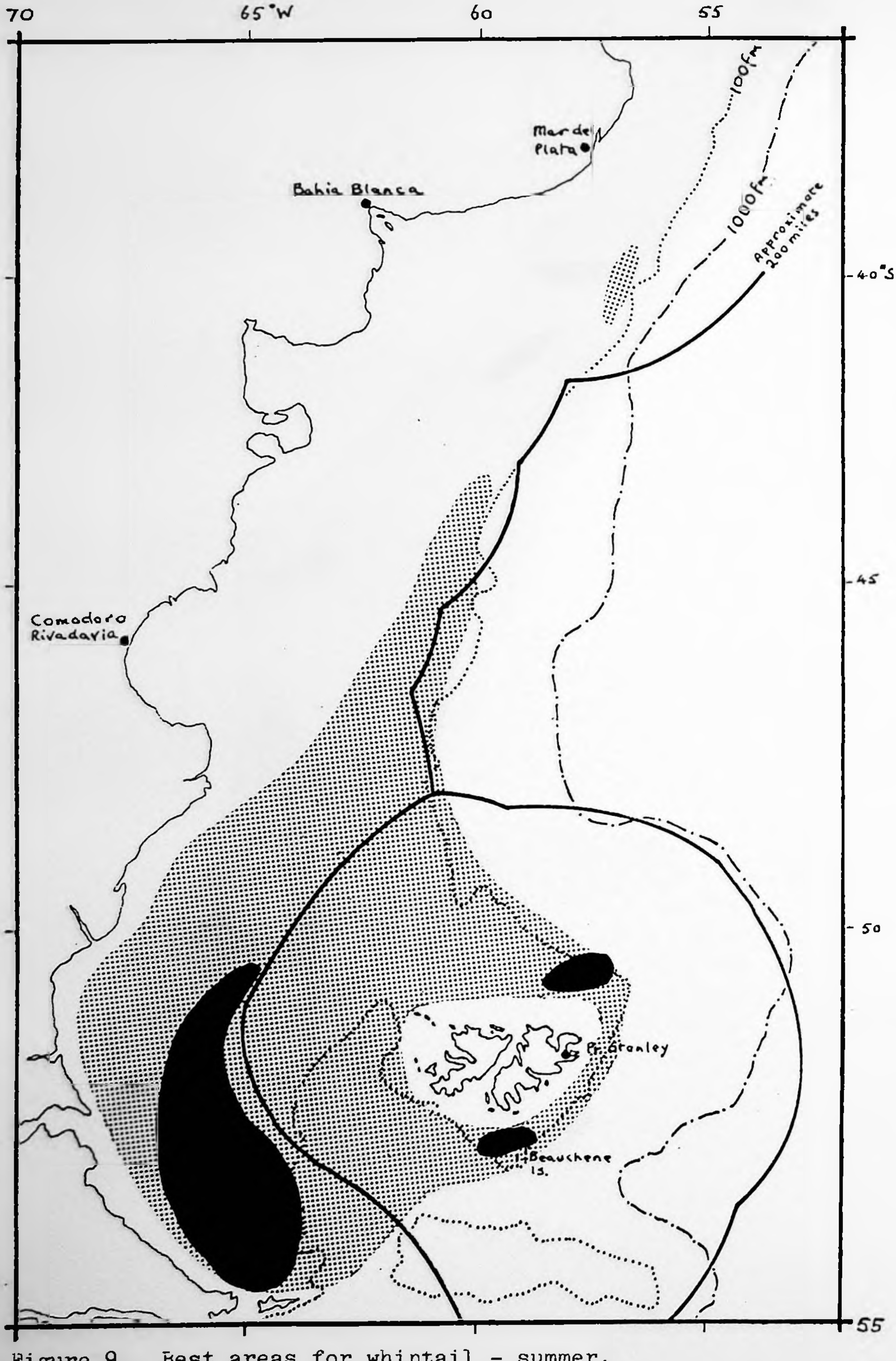


Figure 9. Best areas for whiptail - summer.

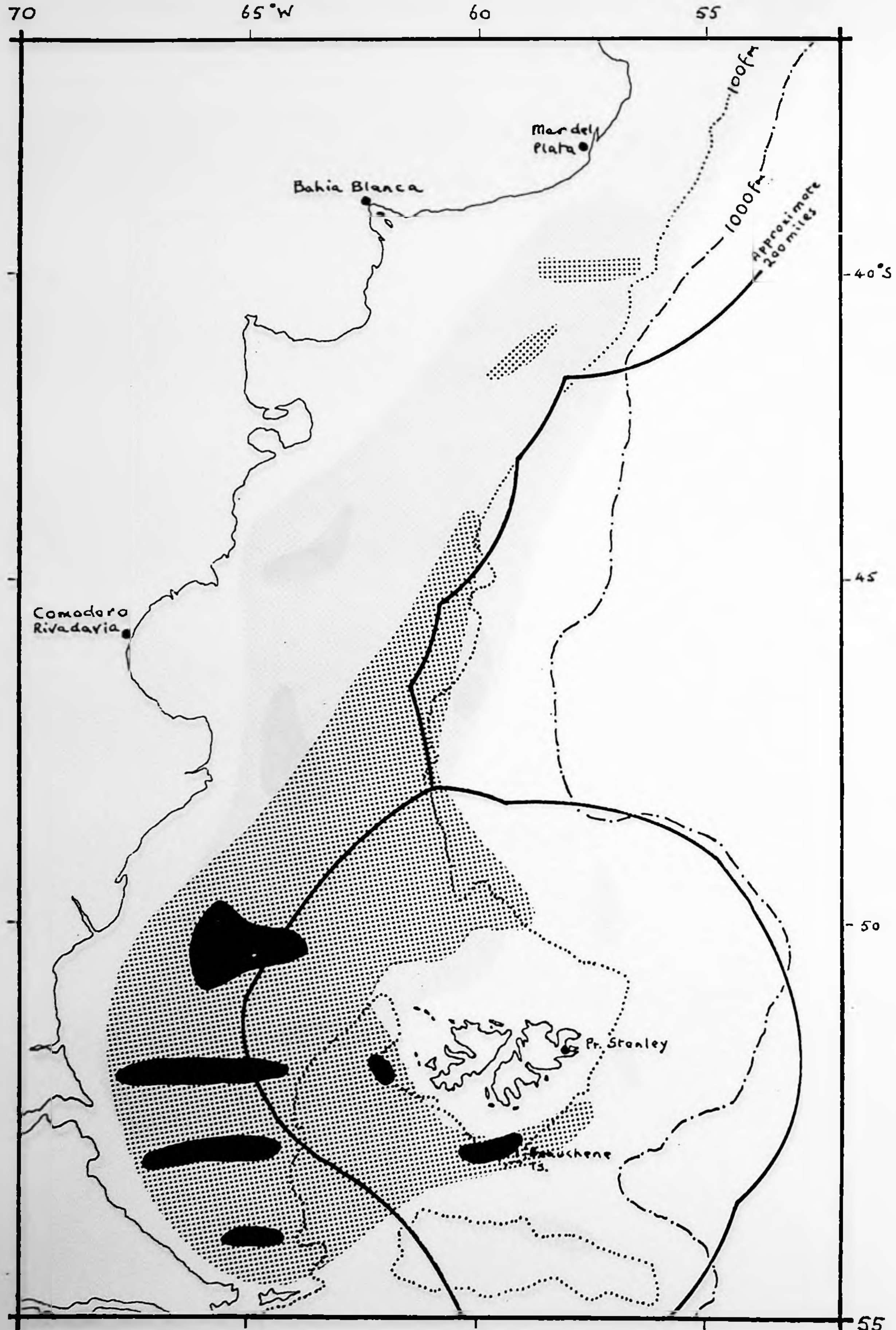


Figure 10. Best areas for whiptail - winter.

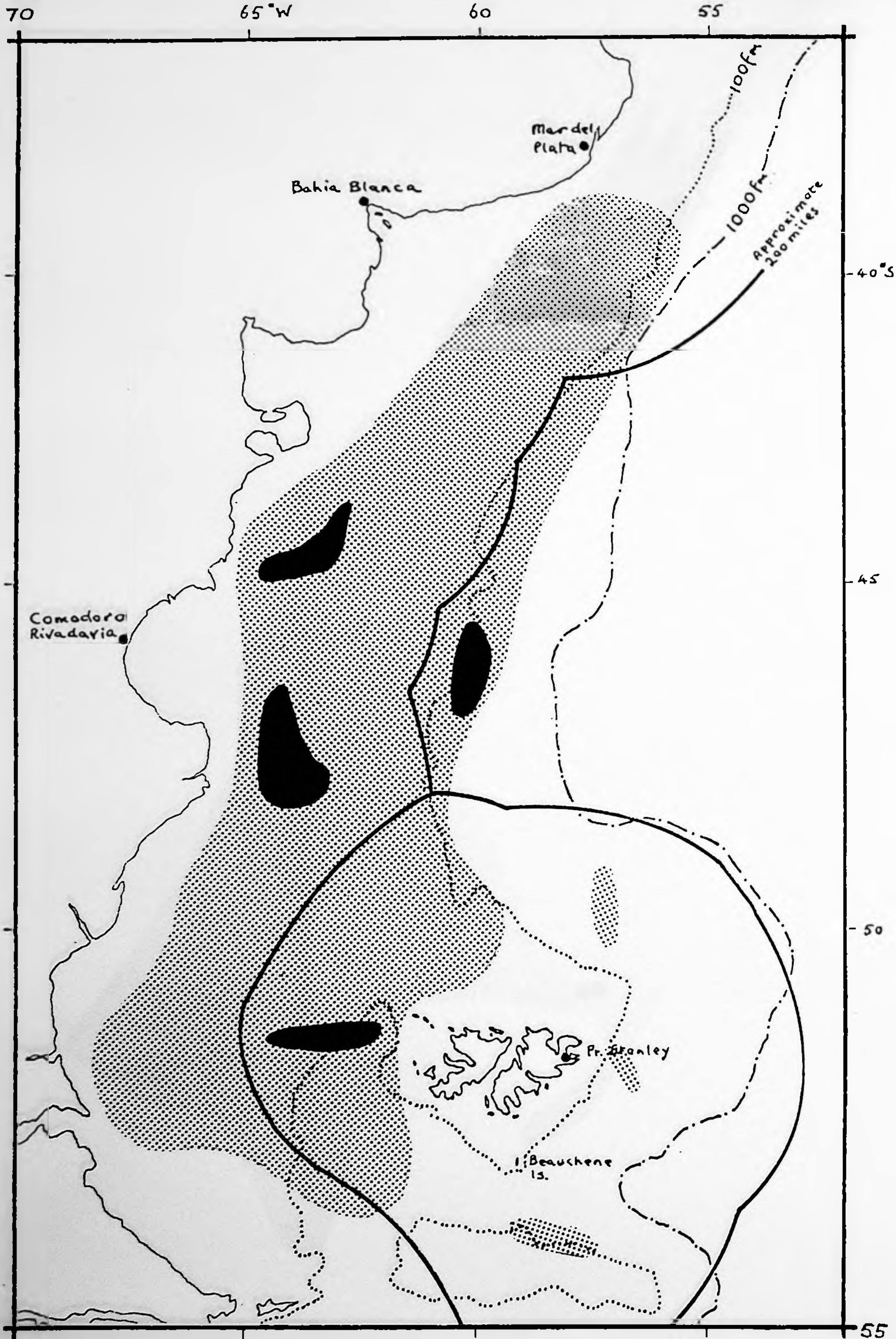


Figure 11. Best areas for short-finned squid - summer.

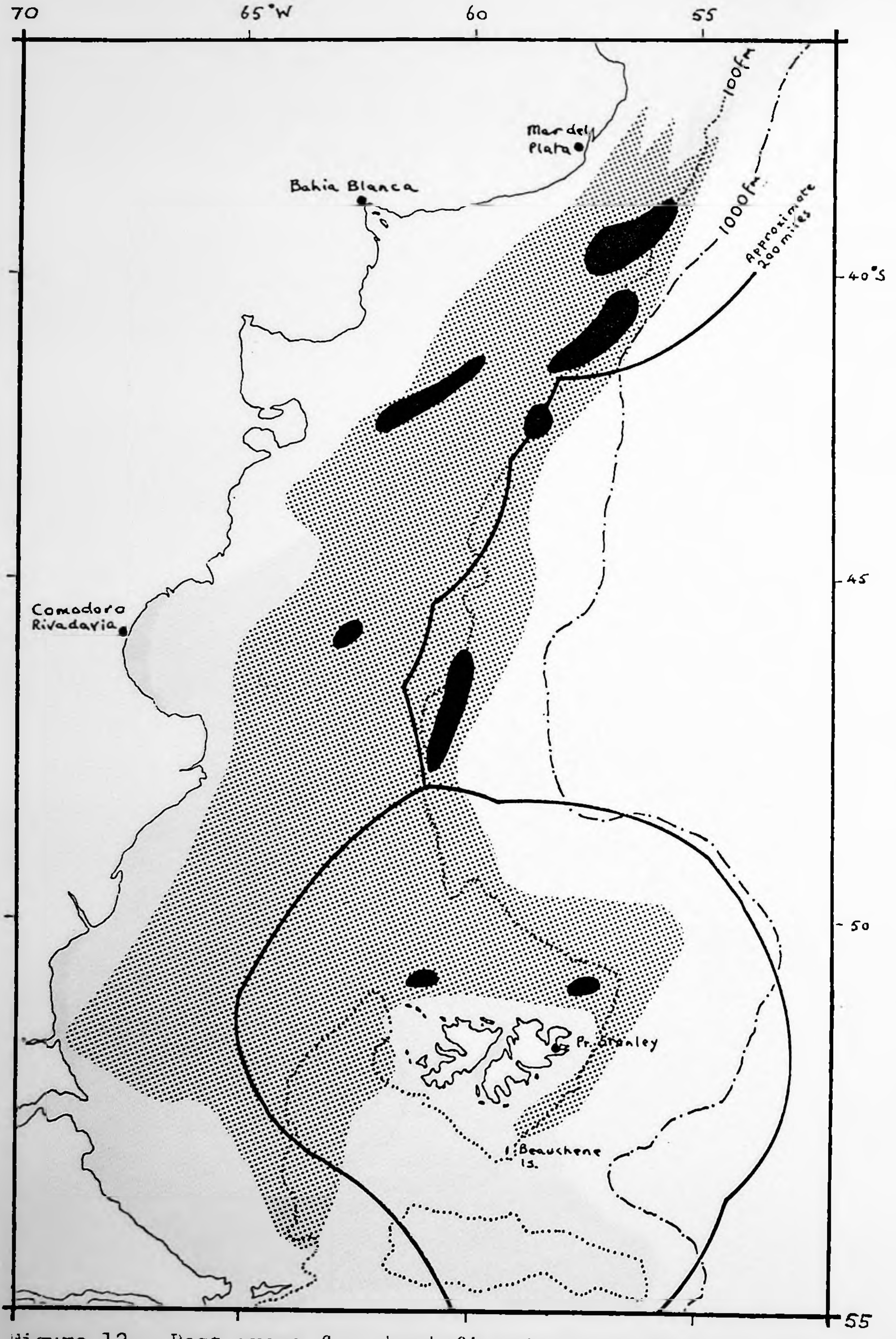


Figure 12. Best areas for short-finned squid - winter.

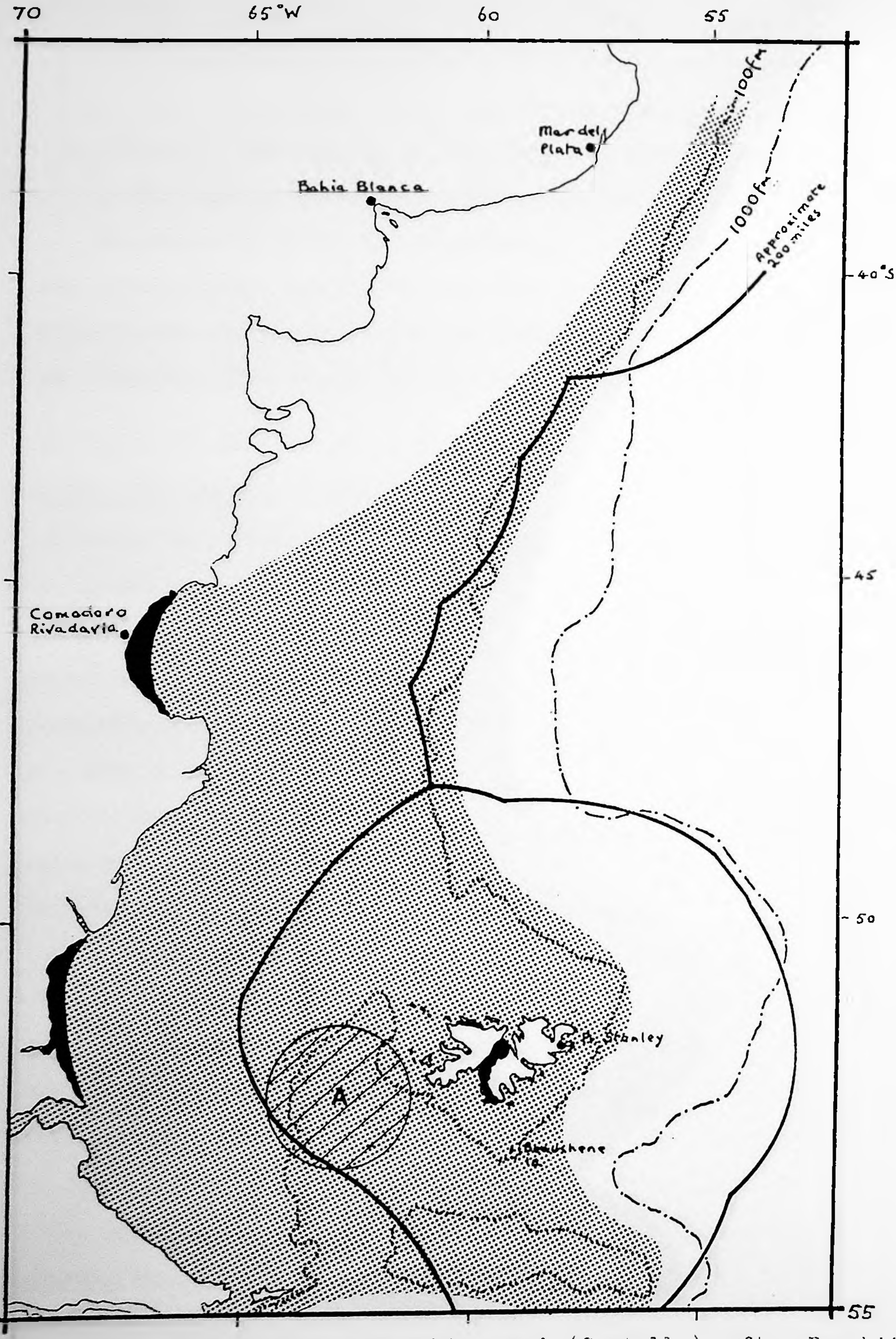


Figure 13. Best areas for red king crab (Centolla), after Boschii. Area "A" - see text (para 23-1).

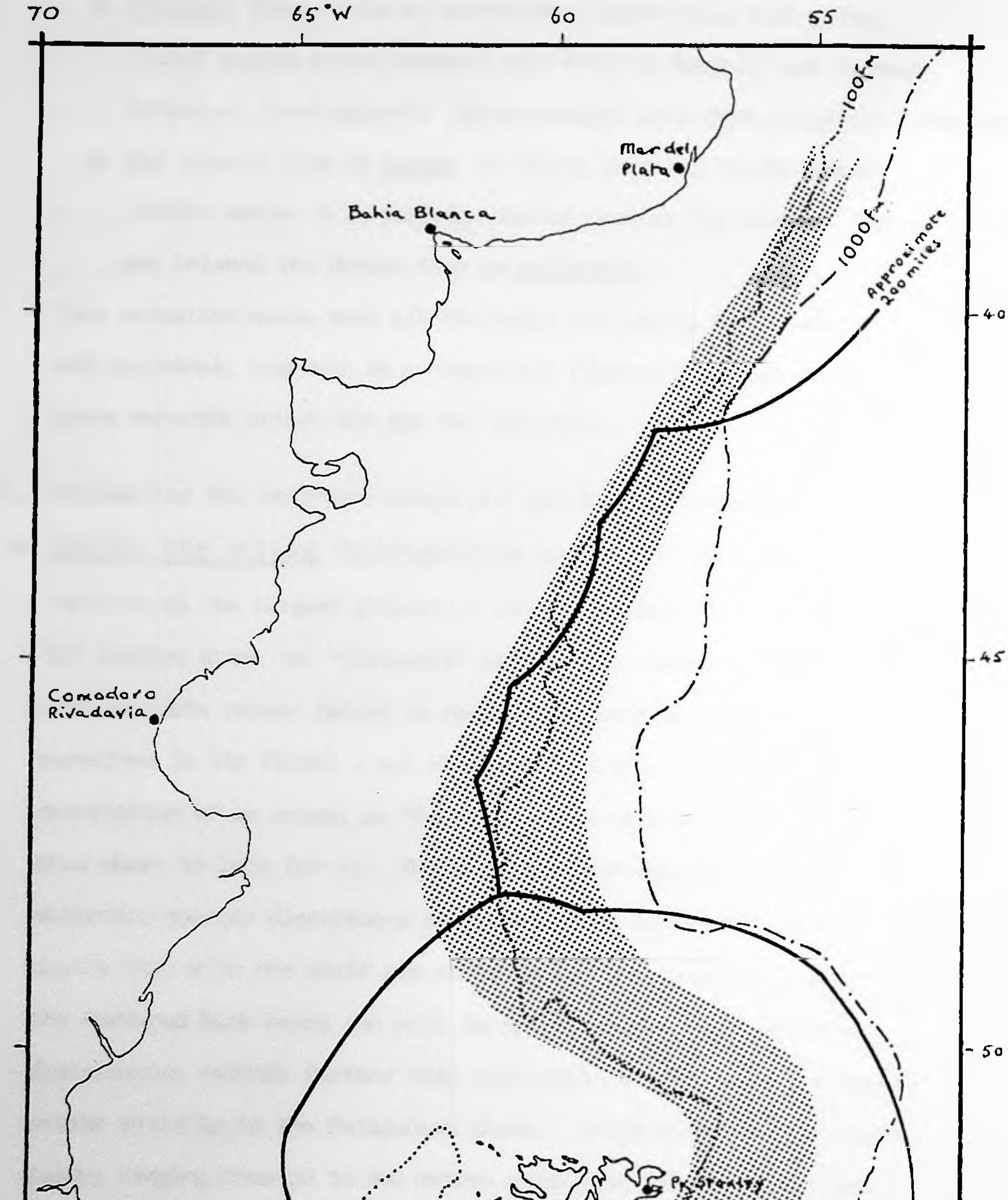


Figure 14. Distribution of deep-water prawns and lobsters, after Boschii.

f. Polyepis grows to be an appreciably larger fish than hubbsi (total length 124cm compared with 93cm in females) and is much larger at first maturity (85cm compared with 40cm in hubbsi - females)

g. The lateral line of hubbsi is almost parallel to the dorsal profile while it is markedly curved down at the level of the gap between the dorsal fins in polylepis.

This situation means that all the hakes are likely to be counted, and processed, together in a commercial fishery (although Taiyo quote separate prices for the two species).

23. Considering the important groups and species individually:

a. Southern blue whiting (Micromesistius australis): This species has constituted the largest proportion of the catches of, I think, all the surveys since the "Discovery" expeditions, which for some unaccountable reason failed to record its great abundance (or the parasites in its flesh) - but it might be noted that a scientist's description of an animal as "rare" may mean simply that he does not know where to look for it. The southern blue whiting is a sub-antarctic species distributed southwards from about 38°S into the Scotia Sea, with the shelf and slope around the Falkland Islands and the Burdwood Bank being the most important areas. This southward distribution extends further than that shown in Figures 3 & 4 which relate entirely to the Patagonian shelf. It has been recorded from depths ranging from 50 to 900 metres with greatest concentrations usually within 100-500m. Very large concentrations of fish occur during winter and early spring when spawning occurs in waters to the south and east of the Falkland Islands. Length (fork) at first maturity is 45cm in both sexes. The dominant food of the southern blue whiting is krill (Euphausia spp.).

b. Very high levels of a protozoan (amoeboid) parasite infestation* in the flesh making the fish useless for anything but reduction to meal have been recorded (Stott[36] quoted 100%) but Davidovich[13] noted that where filleting was possible a high fillet yield (>35%) could be obtained. It has been argued (Shackleton[33]) that a high fishing pressure on the population resulting in the destruction of a high proportion of the older and more heavily infected fish could be beneficial in reducing the level of infestation but Stott[36] has questioned the practicability of fishing sufficiently selectively to achieve this result. The life history of the parasite is not known but I strongly suspect that Stott is wrong; that active selective fishing will not be needed; and that the normal fishing pressure of commercial trawling, which automatically brings greater fishing pressure to bear on older (larger) fish, will result in a reduction of the level of infestation. Some confirmation that parasite levels in 1983 were substantially lower in at least one location off the Falkland Islands was received very recently (ANAMER≠ - personal communication).

c. Hake (Merluccius polylepis, M. hubbsi): Ichthyologists studying the hakes have still not yet decided whether the Patagonian hake is the same as that taken off Australia and New Zealand. If it is then the name "polylepis" would be superseded by the specific name "australis", which is much the older (1872 compared with 1954). The Patagonian hake (polylepis) is found south of 40°S, mainly 45°- 55°S in depths from 50 to 1000 m. High concentrations have been recorded on the edge of the shelf and the slope off the Falkland Islands, 51°- 55°S 200-400 m during winter but migration patterns are not known. The common hake (hubbsi) has a southern distribution overlapping that of the Patagonian hake, being recorded from 30 to 55°S and in waters from 20 to 800 m but excluding the Burdwood Bank. Seasonal migrations are between inshore

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(*) A myxosporidian, possibly Kudoa thyrsites Gilchrist

(≠) Asociation Nacional de Armadores de Buques Congeladores de Pesca de Merluza (Enrique Lopez), Vigo.

spawning areas in the spring, in particular the Gulf of San Jorge (Comodoro Rivadavia), and deeper offshore waters for feeding in the autumn. The dominant food is other fish. Davidovich[13] found the Patagonian hake gave medium yields during manual filleting (25-35%) while Lupin[24] noted an appreciable difference in the storage time of iced hake between summer (not more than 9-10 days) and other times of the year when periods up to 14-15 days were achieved. Calabrese[7] found that blocks of frozen hake maintained at $-22^{\circ}C$ remained acceptable for 13 months.

d. Grenadier (*Macrourus whitsoni*): This species has a distribution from 37° to $55^{\circ}S$ and generally deeper than 200 m but it is found mostly $49^{\circ}-54^{\circ}S$, 400-800 m, with greatest concentrations occurring in winter, $52^{\circ}-54^{\circ}S$, 500-800 m. A migration from shallower water into deeper water may take place in the spring.

e. Red cod (*Salilota australis*): The red cod is found mostly south of $48^{\circ}S$ in depths from 80 to 800 m but mostly on the shelf, 100-200 m. In spring it forms big spawning concentrations between the Falkland Islands and the mainland; at other times of the year it is more widely scattered. Length (TL) at first maturity is 45cm in females. Fish and a wide range of crustaceans constitute the diet. Davidovich[13] found the red cod gave medium yields in manual filleting (25-35%).

f. Whiptail (*Macruronus magellanicus*): The whiptail ranges from 48° to $55^{\circ}S$ and from 20 to 600 m with highest concentrations occurring at 100-200 m on the shelf and around the Falkland Islands from spring to autumn. It moves into deeper water in winter when it is thought to spawn. Length (TL) at first maturity is 24cm (Otero[29]). Davodovich[13] found the whiptail gave high yields (>35%) in manual filleting although Anon[3] reported a low yield.

g. Kingklip (Genypterus blacodes): This eel is widely distributed on the shelf and the slope from 37° to 55°S except the Burdwood Bank. Major concentrations are found 43–48°S and 50–200 m in the summer, 42–47°S in autumn, 45–48°S in winter and 48–51°S 100–200 m in the spring. It is thought to migrate to the north in autumn and to the south in spring. Length (TL) at first maturity is 90cm in females.

h. Patagonian toothfish (Dissostichus eleginoides): In Anon[3] it is reported that Mr Roberts, one of the British observers with the Taiyo survey of 1974–75 and himself an experienced fishing skipper, referred to this species as "the best eating of all Falkland fish, but hard to find". It is found towards the edge of the shelf and on the slope from 40° to 55°S with higher concentrations all year round in waters deeper than 500 m. The southeast slope of the Burdwood Bank has been noted as a particular area. A migration into shallower water in spring and deeper water in autumn may take place. Davidovich[13] reported that this species gives high yields in manual filleting (>35%).

i. Antarctic cod (Notothenia ramsayi, N. guntheri): The former is the more important of the two and is widely distributed from the Burdwood Bank to north of 37°S. Major concentrations have been found on the slope of the Burdwood Bank and on the slope south of Rio de la Plata in spring. N. ramsayi was the commonest fish of the "Discovery" catches. Hart[20] noted that it was so abundant that it might be used for a fish meal operation in association with some other, more lucrative, fishery, but in general terms the group was considered to be unimportant, other than as forage for hake, because of their small size. Davidovich[13] reported a low yield (<25%) in manual filleting.

j. Sharks and rays: There are several species that occur from shallow water to 200 m but no high concentrations occur south of 45°S. Hart[20] reported that elasmobranchs, generally, were unimportant in the catches and consisted mostly of skates and rays with very few dogfish.

k. Squids: The most important of several species is the short-finned squid, *Illex argentinus*, but it does not constitute a high proportion of trawl catches being generally rather widely distributed southward along the Patagonian shelf to 53°S, 50-1000 m. The lowest concentrations occur in late winter/early spring when it is assumed they migrate into oceanic water for spawning. The highest concentrations recorded are 42°-47°S 100-400 m in summer and 200-800 m in autumn: in winter the highest concentrations occur north of 40°S 200-800 m. The best areas of relatively high abundance are beyond 200 miles of the Falkland Islands. Two other species might be noted, *Loligo gahi* and *L. braziliensis*: both are widely distributed down to 800 m with no obvious seasonal density changes.

l. Crustaceans: Prawns, shrimps, lobsters and crabs have never formed other than a small proportion of the catches of the commercial and survey trawlers operating off-shore over the Patagonian shelf but the "Discovery" Reports noted that the red king crab (*Lithodes antarcticus*) had some potential as it was caught in more than half the trawl hauls off the Falkland Islands. Currently the only important commercial fisheries for any crustacean species are in the two mainland locations marked in Figure 13, Golfo San Jorge and Bahia Grande. Taiyo undertook a three-month coastal survey in the Falkland Islands, October-December 1976 (Anon[1]). A local Falkland Islands Company (FIC) boat, PENELOPE, was chartered for this survey but she proved to be too small to cope effectively with the sea conditions, which also destroyed some of the static fishing gear.

Nevertheless the survey was able to form an opinion that the red king crab (Centolla - Lithodes antarcticus) might have some commercial consequence and that the areas to the north of West Falkland (Middle Island to Byron Sound) and from south of East Falkland to Port Howard might provide the best fishing. Further, they suggested that a migration of centolla into deeper water during the winter might take place and that the area marked "A" in Figure 13 should be explored with this in mind.

m. One small crustacean group, the lobster -krill (notably Munida gregaria not to be confused with the much better known euphausiid krill Euphausia superba) has been recorded very widely in the south western Atlantic Ocean where enormous shoals of the juvenile, so-called Grimothea stage, may colour the sea bright red over large areas. The adult of Munida gregaria may also be found in swarms at the surface of the sea although more usually the adults of lobster-krill are demersal. RRS DISCOVERY trawled Munida from the sea-bed off Eddystone rock in East Falkland in 50-60 fm when Matthews[25] recorded that they were "much appreciated in the ward room and on the mess deck". Large numbers, easily fished, could provide the basis for a new commercial industry.

n. In deeper water, a number of potentially commercially significant crustaceans have been caught but never in great numbers. The distributions of three such animals are shown in Figure 14, the two prawns Pandalopsis ampla and Campylonotus semistriatus and the deep water lobster Thymops birsteini. If they could be found during a spawning association they could provide the basis for a commercial operation.

o. Molluscs: Hall[19] reviewed all the information then available on molluscan resources. Other than squid, to which reference has been made, no resources that would excite commercial interest other than as an addition to some other substantial inshore fishery had been found. The possibilities included scallops, shells of which have been found on beaches in West Falkland, mussels which are abundant around the Falkland Islands and which are reputed to grow quickly, and octopus which have been recorded from Stanley harbour. More recently Lasta[23] has reported on trawling by the research vessels WALTER ERWIG and SHINKAI MARU. Several locations within 200 miles of the Falkland Islands revealed scallops (Chlamys patagonica) but at only one location, about 110 miles NNW of the Jason islands, was a substantial catch taken (75 kg). The prospects do not seem promising.

p. Other possibilities: The only other possible basis for a small commercial fishery identified during the fisheries mission of 1978 was sea urchins, which had been recorded from New Island (Hall[19]).

24. Conclusions on species and areas: Otero[30] drew together the information from all sources and the two charts, Figures 15 and 16, are based largely on his conclusions. Otero noted the importance of the parallel 48°S, which approximately separates a northern fishery in which the common hake is dominant, and a southern fishery dominated by the southern blue whiting. He also identified the four species most likely to be important in the two main seasons, summer and winter, for the southern fishery:

Order	Summer	Winter
1	Southern blue whiting	Southern blue whiting
2	Whiptail	Patagonian hake
3	Patagonian hake	Grenadier
4	Red cod	Red cod

25. During the summer he estimated that daily catches might exceed 35 tons and that in winter this figure could rise to 79 tonnes with over 85% of the catch consisting of southern blue whiting. More specific estimates were prepared for the areas identified in the two charts, which are listed

in Table 4 (A - Summer B - Winter). However, Otero's summary excludes some locations known to be capable of sustaining high catch rates, and referred to already in Figures 3-14. I have, therefore, re-drawn Figures 15 and 16 to include all the information provided in those Figures. The result is Figures 17 & 18, which must be considered to be as definitive a picture as it is possible to draw at the present time . Ten different areas are identifiable in both summer and winter:

Summer (Figure 17)

Area	Important species
1	Common hake
2	Common hake, kingklip, red cod
3	Common hake
4	Southern blue whiting
5	Red cod
6	Southern blue whiting, whiptail, grenadier, Patagonian hake
7	Southern blue whiting, Patagonian hake, whiptail, red cod
8	Grenadier, southern blue whiting, Patagonian hake, whiptail
9	Southern blue whiting
10	Southern blue whiting

Winter (Figure 18)

Area	Important species
1	Common hake
2	Common hake, kingklip
3	Common hake, kingklip, red cod
4	Common hake
5	Southern blue whiting
6	Common hake, whiptail, red cod, southern blue whiting
7	Whiptail
8	Red cod, whiptail
9	Southern blue whiting, Patagonian hake, grenadier, red cod
10	Southern blue whiting, Patagonian hake, grenadier, whiptail

Table 4. Catches to be taken in the best fishing areas, after Otero 1981. Table 4A - Summer (Fig 15).

Area	Catch species	Concentration (tonnes/n.mi^2)	Catch rate (t/day)
1	Southern blue whiting 100%	80	33
2	Whiptail 83% Patagonian hake 14% Red cod 3%	56	23
3	Southern blue whiting 64% Whiptail 21% Patagonian hake 14% Red cod 1%	68	28
4	Grenadier 62% Southern blue whiting 26% Patagonian hake 12%	38	16
5	Southern blue whiting 39% Whiptail 35% Grenadier 24% Patagonian hake 2%	89	35
6	Kingklip 55% Red cod 31% Common hake 14%	54	21
7	Common hake 99% Kingklip 1%	69	23

Table 4. Catches to be taken in the best fishing areas, after Otero 1981. Table 4B - Winter (Fig 16).

Area	Catch species	Concentration (tonnes/n.mi^2)	Catch rate (t/day)
1	Southern blue whiting 86% Patagonian hake 7% Grenadier 7%	192	79
2	Southern blue whiting 80% Patagonian hake 10% Grenadier 8% Red cod 2%	144	57
3	Common hake 20% Whiptail 10% Red cod 15% Southern blue whiting 55%	94	38
4	Common hake 51% Kingklip 23% Red cod 26%	42	13
5	Common hake 100%	40	11
6	Common hake 77% Kingklip 23%	64	23
7	Common hake 100%	48	18

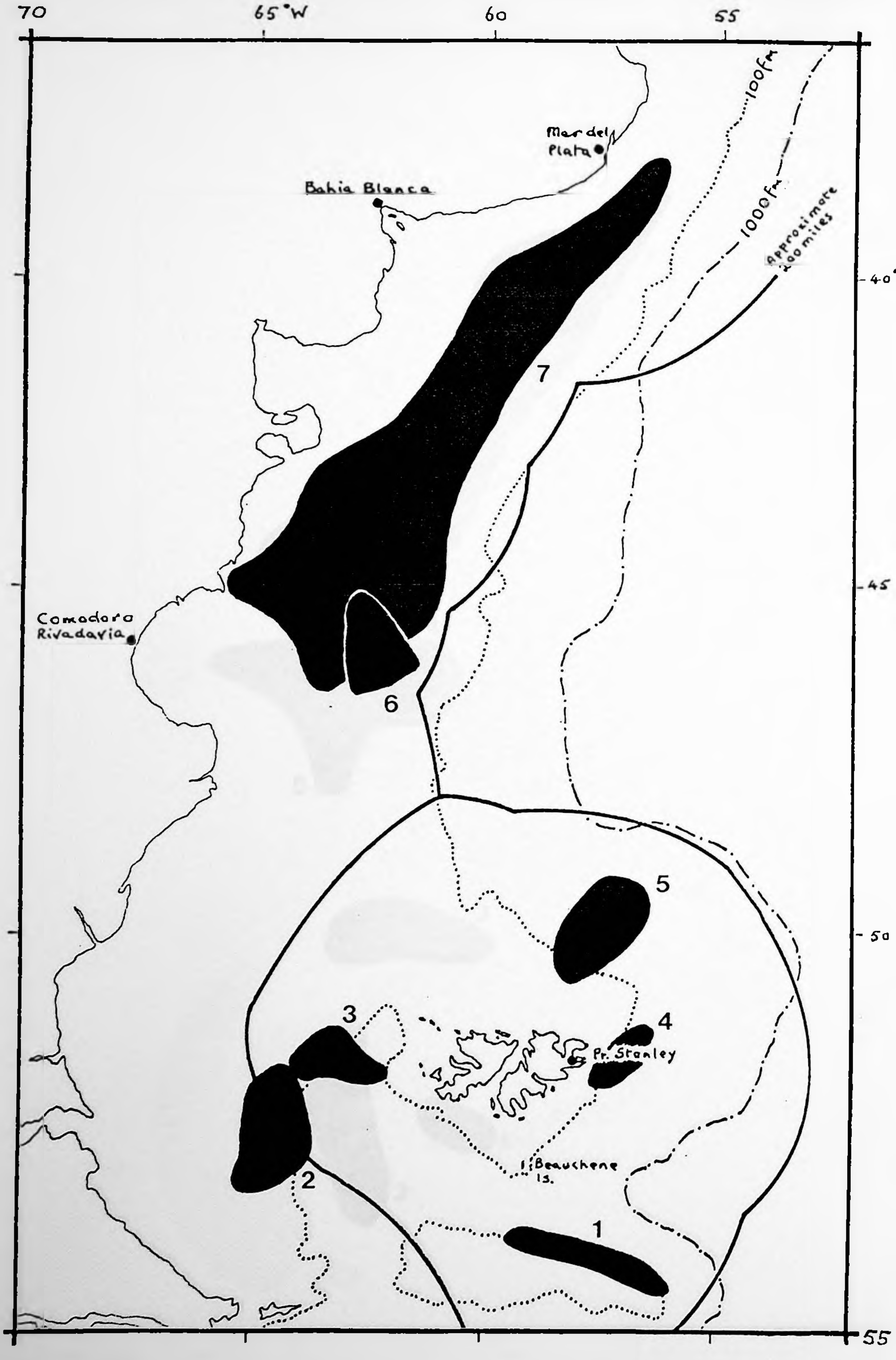

Figure 15. Best areas, all species - summer.
(Based on Otero 1981)

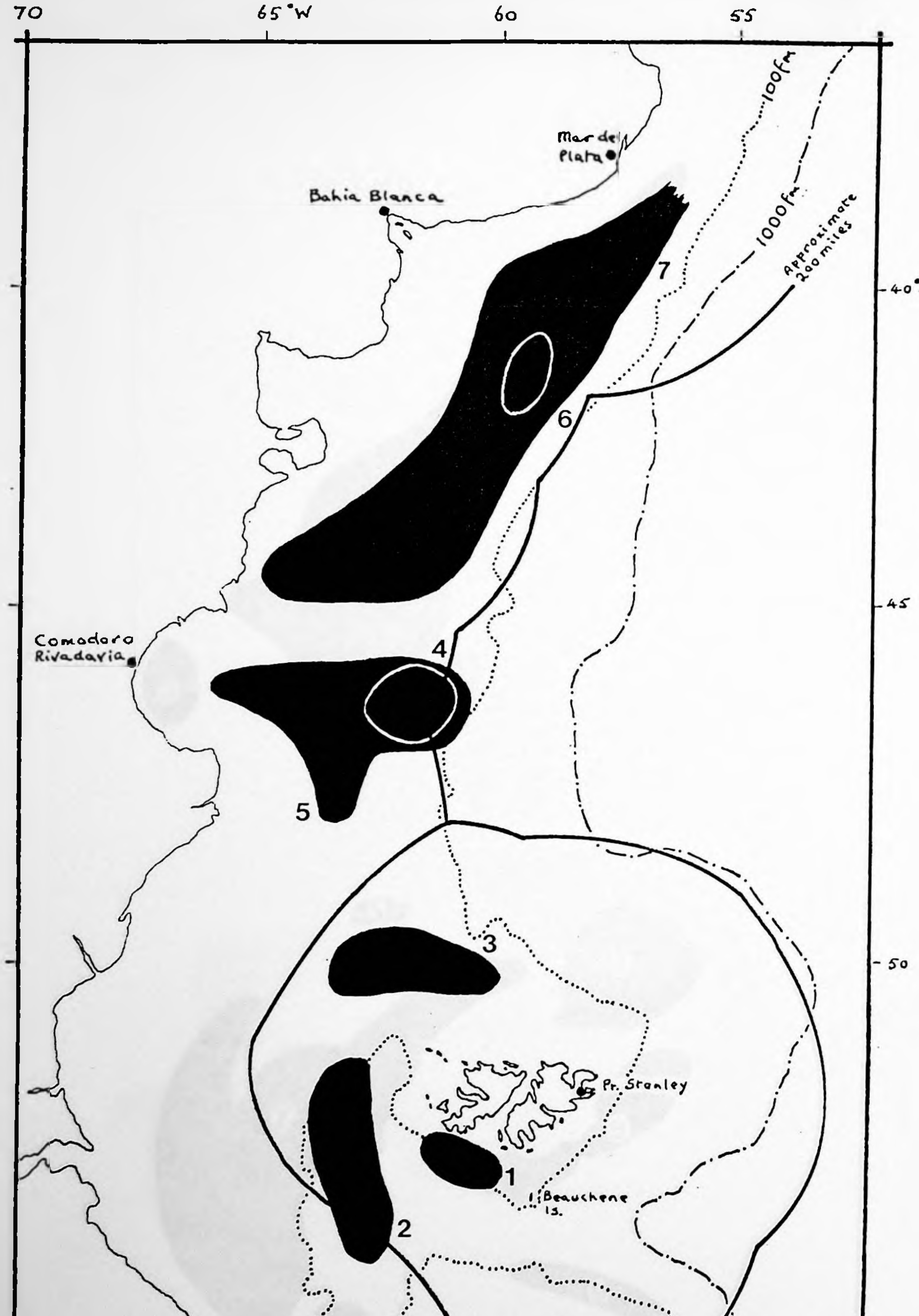

Figure 16. Best areas, all species - winter.
(Based on Otero 1981)

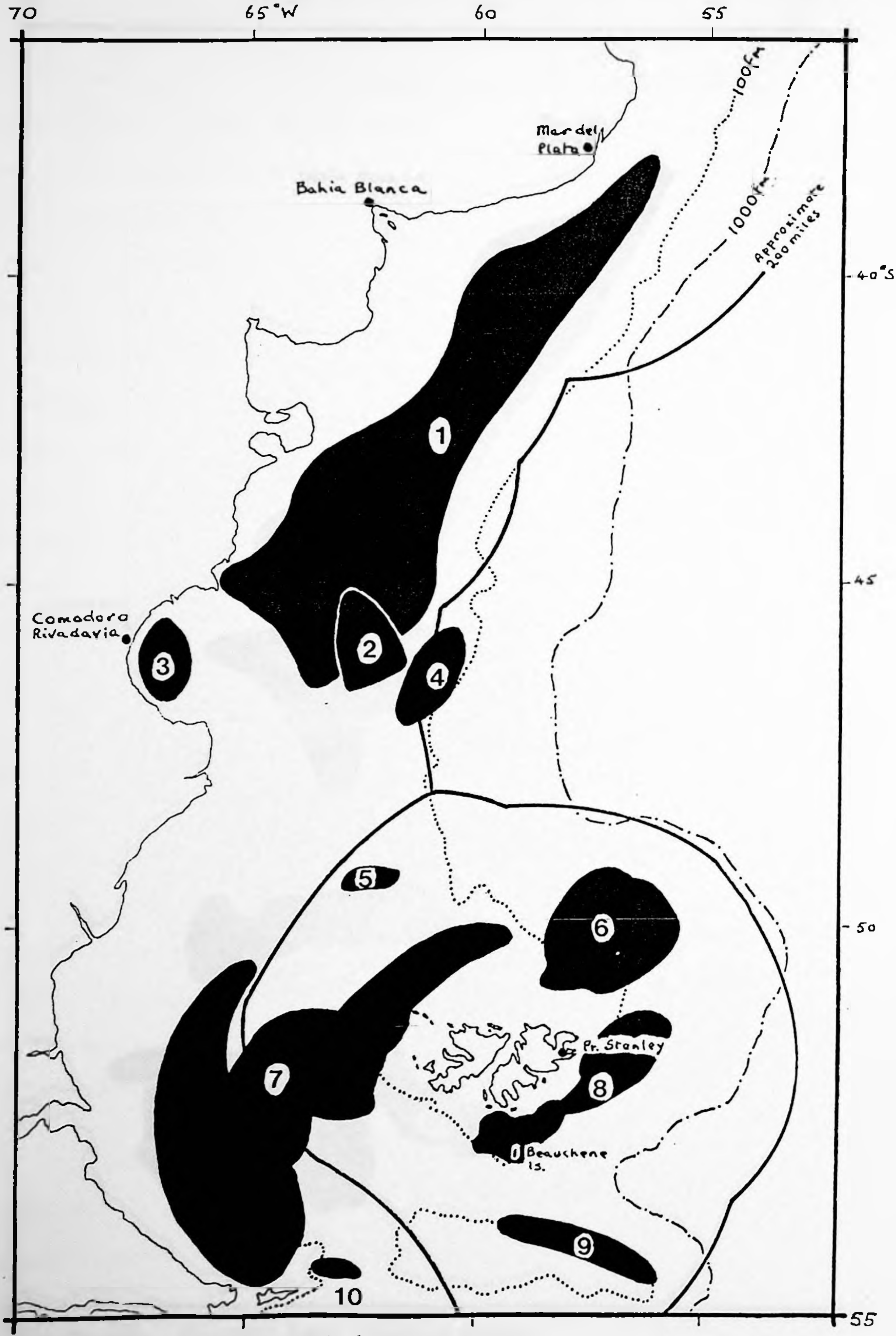

Figure 17. Summer: best fishing areas.
(Key to numerals in text, para 25).

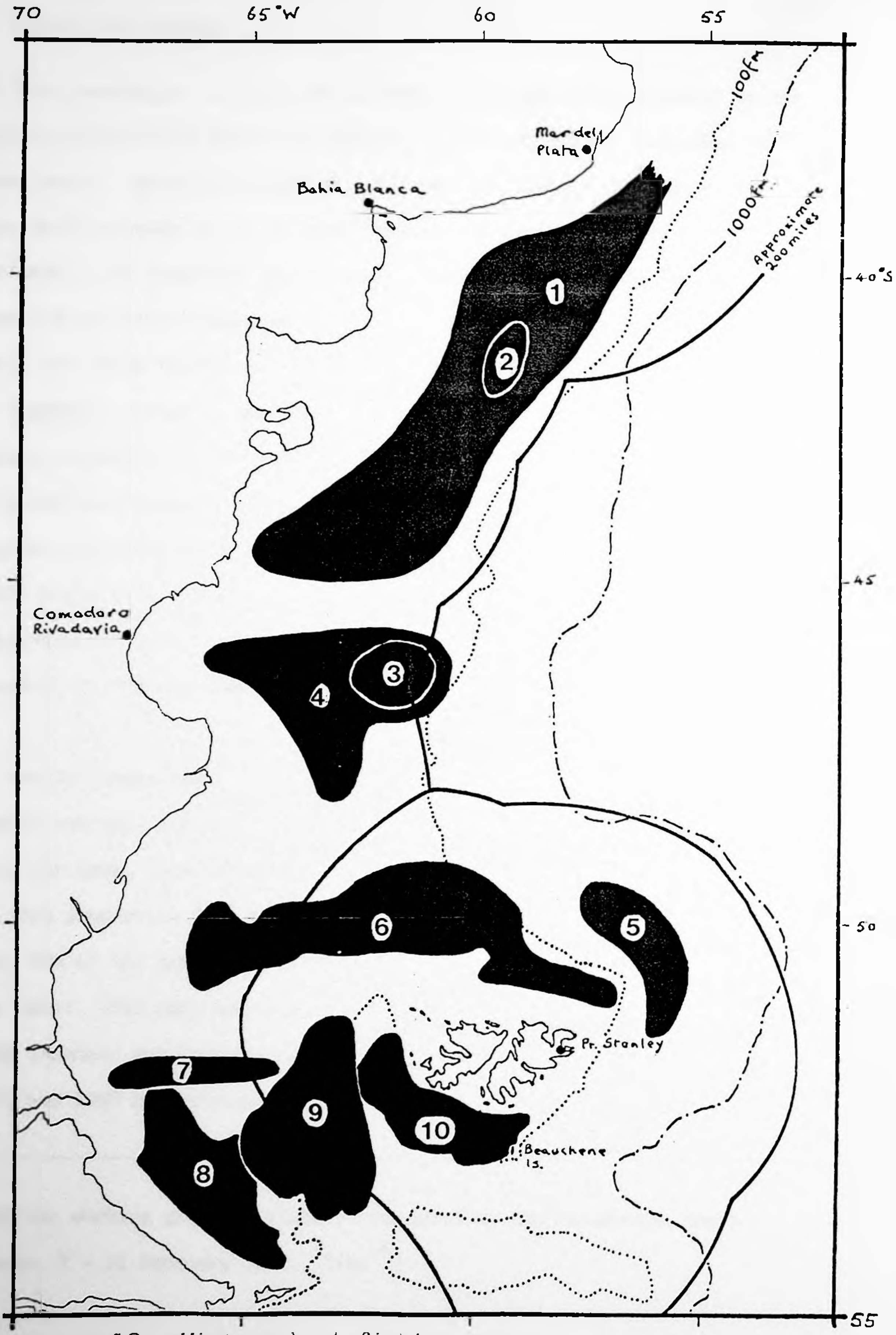

Figure 18. Winter: best fishing areas.
(Key to numerals in text, para 25).

SIZE OF THE FISHERIES RESOURCES

Historical catches

26. From time immemorial, it is to be presumed, the population adjacent to the Patagonian shelf must have been dominant in exploiting the fisheries resources of the shelf. Certainly Argentina has taken the largest catches for many years, and continues to do so, with Uruguay and Brazil next in order of importance. The Argentine fleet operates mainly from Mar del Plata and fishes the northern Patagonian shelf where the most productive fishing grounds are to be found, the most important of the catches being the common hake (hubbsi): kingklip and the short finned squid (Illex) are highly valued constituents of the catches (FAO[16]). Long range fleets have been a very recent development, starting with the USSR in 1967. Of the other countries operating major long range fleets, Japan began commercial fishing in 1975 followed by Poland in 1977. Efforts by other nations referred to in the footnote to Table 5 had not been sustained up to the time of the FAO conference of February 1983* (Table 5, Fig 19).

27. Hake, mostly common hake, have constituted by far the most important part of the shelf catches, and Argentina has been much the most important of the nations fishing for hake, usually taking more than three-quarters of the catch. In 1981, this proportion fell to 69% but Uruguay and Brazil between them took a further 30% of the hakes. Long range fleets have never taken a large proportion of the hake: USSR made one significant catch in 1977, of 22,000 tonnes (6%) but the Japanese and Polish catches, individually, have not exceeded 2% (highest in 1978 and 1980 respectively).

(*) Ad hoc working group on fishery resources of the Patagonian shelf. Rome, 7 - 11 February 1983. (FAO[16]).

Table 5. Declared catches by the most important nations* fishing the Patagonian shelf ('000 tonnes: FAO[16]).

Year	Hake	Southern b.w.	Whiptail	Red cod	Grenadier	Kingklip	Patagonian tf.	Antarctic cod	Short-finned squid	Loligo	Sharks/rays	Total
1970	108	-	-	-	1.5	1.1	-	-	1	0.7	11	123
1971	116	-	-	-	0.6	1.1	-	-	2	0.5	12	133
1972	139	-	-	-	-	2.5	-	-	2	0.5	12	156
1973	184	-	-	-	-	1.5	-	-	4	0.7	14	204
1974	173	-	-	-	0.4	2.3	-	-	5	0.4	16	197
1975	126	-	-	-	1.0	1.5	-	3.5	5	0.5	16	153
1976	226	-	-	-	0.2	3.4	-	8.3	8	1.0	13	260
1977	351	2	-	-	1.6	2.6	0.7	2.8	2	0.9	12	376
1978	426	16	2.3	-	0.6	5.8	<.1	0.1	73	1.5	15	541
1979	465	39	5.7	-	4.9	7.7	<.1	3.0	122	1.8	11	660
1980	375	78	6.7	-	0.8	7.0	0.4	7.5	29	1.9	12	518
1981	333	70	2.3	0.1	0.5	4.7	0.4	1.3	52	1.5	8	474

(*) Argentina
Brazil
Bulgaria
Germany D.R.
Germany F.R.
Japan
Korea
Poland
Uruguay
USSR

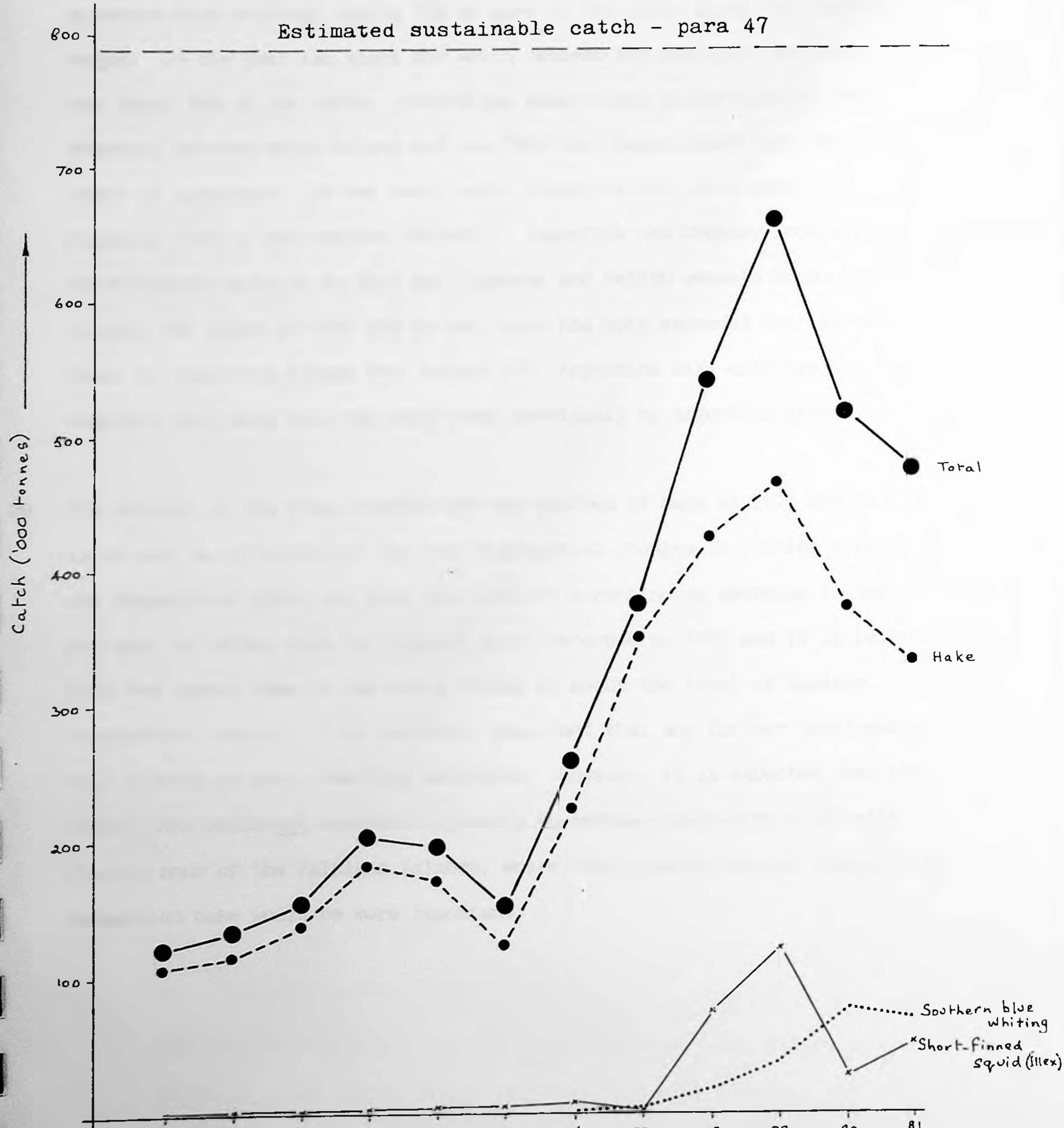

Figure 19. Recent catches from the Patagonian shelf.

28. Poland has dominated the recently developed commercial fishery for the southern blue whiting, taking 70% or more of the catch since the fishery began: in the last two years for which records are available the USSR has taken 25% of the catch. Poland has taken large proportions of the whiptail catches while Poland and the USSR have taken almost all the small catch of grenadier. On the other hand, Argentina has taken almost all the kingklip (93% of the catches 1977-81). Argentina and Uruguay took all the short-finned squid up to 1977 but Japanese and Polish vessels began to exploit the squid in 1978 and by 1981 they had both exceeded the catches taken by Argentina (Japan 38%, Poland 37%, Argentina 21%) although all three together were less than had been taken previously by Argentina alone.

29. The decline in the total catches and the catches of hake in 1975 and in 1980-81 is in part a reflection of the very substantial changes in fishing effort by the Argentinian fleet but they also reflect a continuing decrease in the catch per unit of effort from the highest level recorded in 1972 and it is believed that the common hake is now being fished at about the level of maximum sustainable yields. It is certainly important that any further development of this fishery be very carefully monitored. However, it is expected that the common hake would <u>not</u> contribute greatly to catches taken with a 200 mile fishing zone of the Falkland Islands, where the southern blue whiting and the Patagonian hake would be more important.

Falkland Islands resource estimations

30. The Falkland Current, which bathes the southern Patagonian shelf (Fig.2) has been described as amongst the most productive areas of the world oceans (Gulland[18]). Primary production (the growth of algae, on which everything else depends) in the area is high but it decreases from north to south. The abundance of zooplankton and benthic organisms, which support all fish life, is also high and has been likened to the same order as in the North Sea except that the water temperature remains higher in the Falkland Current and the stock of plankton does not fall to the same extent in winter. In general terms, the area should be capable of supporting rather larger populations of fish than the North Sea but estimations relating to the Falkland Islands should take into account the fact that almost all the data on fish stock abundance has originated over the northern, more productive, part of the Patagonian shelf.

31. A standard method of estimating very crudely the likely catch that can be taken on a sustainable basis is to derive some measure of basic productivity, such as that above, and multiply by the area under consideration. Given the tendency for inshore waters to be more productive than offshore waters, fish production can be considered, crudely, to be twice as great over the near-shore one-quarter of the continental shelf as over the offshore three-quarters,and for the Falkland Islands the figures I have used below are 30 kg/ha and 15 kg/ha (cf North Sea 17 kg/ha):

Continental shelf area: 178,320 km^2

a. Near-shore one-quarter $\frac{30 \times 100 \times 178,320}{4 \times 1000} = 133,740$ tonnes

b. Offshore three-quarters $\frac{15 \times 100 \times 178,320 \times 3}{4 \times 1000} = 200,610$ tonnes

Total estimated annual production = 334,000 tonnes ——————— A

32. Gulland[18] considered that an overall production rate for demersal fish of 2.6 tonnes/km^2 might be applied in the region. For the Falkland Islands continental shelf within a 200-mile EFZ (178,320 km^2) this gives a sustainable yield of 464,000 tonnes. ———————————— B

33. Young fish increase in weight in geometric proportion to their age. The optimum catching rate is a nice balance between allowing fish to survive and grow rapidly while they are young and catching them sensibly before they die from predation or some other natural cause. More accurate estimates of the sustainable yield than the crude figures given above can be obtained only from more accurate information on the composition of the stocks. The concept of a fixed annual maximum sustainable yield (MSY) is useful but it is not found in practice because the stocks and the maximum catch that can be allowed from each species will vary from year to year depending on a wide range of influences including the fishing pressure on the different sizes of fish, larval survival and recruitment to the fishable stock (food, water temperature, current direction), fish density, growth rate, disease, predation, availability of food and so on.

34. The application of fishing pressure results in fishing mortality, which is the way fisheries scientists refer to the fish catch, but the relationship between effort and catch is exponential, not linear. The numbers of fish surviving from a year of fishing are proportional to e^{-F} where F is a measure of the fishing pressure. Similarly, the numbers of fish surviving natural causes of death are proportional to e^{-M} where M is a measure of natural mortality. Hence, the survivors (numbers of individual fish) of both fishing and natural mortality are proportional to $e^{-(F+M)}$ and the deaths will be proportional to $[1 - e^{-(F+M)}]$.

35. In the beginning the values of F and M that equate to the state of maximum catches cannot be known. Refining the data and producing increasingly accurate estimations of the stock size and the allowable catch for each species contributing to the fishery is a matter for sustained research over many years. There are no short cuts.

36. Because the amount of fishing that will take the maximum sustainable catch from an as yet unexploited stock, represented by F, cannot be known before fishing has begun, some reasonable assumption has to be made, and it has been found from experience that maximum catches are likely to be taken when the fishing pressure equals the natural mortality, that is F = M. However, determining M may not be easy: even after decades of research on North Sea stocks M is still not known with any great degree of accuracy for some important species. The same problems have been found on the Patagonian shelf but Hempel[21], using Russian data, determined that annual survivors of the southern blue whiting stock were about 70% and he suggested therefore that M be considered as 0.4.

37. Once M has been determined it can then be used in another equation to give a first estimation of the maximum sustainable yield (MSY), in terms of weight, from an unexploited stock:

$$MSY = 0.5 \times M \times Bo$$

where Bo is the biomass (tonnes) of the virgin stock on the assumption that a natural population conforms to a Verhulst-Pearl logistic (Schaefer[32]). This approach has been followed by a number of workers and their results are quoted below, but before leaving this section the non-linear effect of varying the fishing pressure might be noted.

38. Deaths, by numbers, from fishing and natural mortality are proportional to the two pressures, F and M, that is :

$$\text{Catch} \propto \frac{F}{F + M}\left[1 - e^{-(F+M)}\right] \quad \text{and}$$

$$\text{Natural deaths} \propto \frac{M}{F + M}\left[1 - e^{-(F+M)}\right]$$

If F = M = 0.4

$$\text{Catch} \propto \frac{0.4}{0.8}\left[1 - e^{-0.8}\right] = 0.275$$

That is, the catch is 27.5% of the numbers of fish and, below, the effect of halving, doubling, trebling and quadrupling the fishing pressure is given:

Value of F	Catch taken (% by numbers)
0.2	15.1
0.4	27.5
0.8	46.8
1.2	59.8
1.6	69.2

(Note : This, and other characteristics of an exploited fish population, are well explained by Pope[31])

39. Returning now to the fish stocks of the Patagonian Shelf, in the absence of other data the natural mortality estimated for the southern blue whiting (0.4) has been applied to all the fish species. Although it is very unlikely that such a situation would obtain, in the absence of accurate information it is an acceptable beginning.

It should be noted, however, that if survivors are 70%, as determined by Hempel (para 36), that is $e^{-M} = 0.7$, M is more nearly 0.36 and it is this latter value, not 0.4, that has been used by some recent workers (eg Otero [28, 29]) and applied also to the common hake; but there is little point at this time to alter the FAO estimations that are quoted below. The reasons for adopting this attitude include:

a. The expression MSY = 0.5 x M x Bo does not give a hard and fast value for the sustainable catch. It is just a crude first order estimation of the likely complex biological reaction of a living population to an additional, relatively large, cause of deaths. For example, if the fishing activity takes fish early in their lives, say as one year olds, the MSY determined in this way will be much too high (Beddington[4]) and as the fishery develops other methods independent of M have to be introduced to determine the sustainable yield (Sullivan[37]).

b. Values of M for most other species of fish of the Patagonian shelf have not been determined and there is no reason to think they will be nearer 0.36 than 0.4.

c. The difficulty of determining the size of the virgin biomass (Bo) once commercial fishing has begun. The population of younger, active, rapidly growing fish that constitutes the equilibrium population supporting the maximum sustainable yield may be as little as one-quarter of the virgin biomass.

d. The Gadidae (cods), which includes the southern blue whiting, tend to be resilient to fishing pressure.

40. Based on cruises of RV WALTHER HERWIG in 1966 Gulland[18] estimated the total biomass over the whole coastal area southwards from 35°S, from which the Falklands Islands component can be estimated:

	45°-55°S	Falkland Is
Shelf area (km^2)	595,000	178,320
Biomass (tonnes)	5,500,000	1,648,000
Yield (tonnes/year)	1,110,000	333,000
Slope (200-1000 m) area (km^2)	97,000	162,930
Biomass (tonnes)	830,000	553,000*
Yield (tonnes/year)	165,000	110,000*

(*) I estimate the slope area of the Falkland Islands to be substantially greater than that estimated in Gulland[18] for the whole coastline from 45° to 55°S. I have used a factor for the Falkland Islands proportions of two-thirds the Gulland figures, which factor I estimated by inspection of relevant charts.

The two yield figures determined above, for the shelf and the slope, give a total estimated sustainable yield of 443,000 tonnes/year. —————— C

41. The White Fish Authority (Anon[3]) undertook an assessment of the potential yield of the Falkland Islands in 1979 and based only on hake and southern blue whiting reached a figure of 150,000 tonnes/year (hake 100,000 southern blue whiting 50,000). —————————————— D

42. Otero[28, 29] estimated the standing stock and potential yield of several of the important fish species of the Patagonian shelf from which it is possible to estimate the proportions attributable to the Falkland Islands based on a judgement of the contributions of each species to catches taken within 200 miles of the Falkland Islands (EFZ).

	Biomass	Yield	Falkland * proportion	Falkland yield(t/yr)
Hake+	3,920,000	594,000	10%	59,000
Southern blue whiting	522,973	86,285	90%	78,000
Whiptail	421,702	75,906	20%	15,000
Red cod	200,300	36,054	40%	14,000
Squid	635,968	127,000"	5%	6,000
			Total	172,000 —— E

Notes + Common hake only
* Author's judgement based on reported distribution
" Estimated from biomass on the same basis as fish

43. A number of other authors also have made estimates of the biomass of different species of fish of the Patagonian shelf, which were brought together by the FAO analysis of 1983 (FAO[16]). These estimates, which frequently differ widely, are summarised in Table 6, and assuming a contribution of 5% by all other species, a sustainable yield of 330,000 tonnes/year is reached. ———— F

44. FAO[16] reviewed all the estimates made by previous authors and considered the impact of current fishing on the stocks and concluded that "Given the present exploitation levels and the general situation of the resources, it seems unlikely that current fisheries beyond the 200 n mi (off Argentina) are

Table 6. Possible Falklands Islands sustainable yield based on estimates to 1982.

Species	Number of estimates	Range of estimates ('000 t)	Mean biomass * ('000 t)	Falkland proportion (%)+	Falkland biomass ('000 t)	Falkland yield " (tonnes/year)
Hake	6	1,154-5,000	2,500	20	500	100,000
Southern b.w.	6	406-1,624	740	90	666	133,000
Whiptail	5	242-2,069	520	20	104	21,000
Red cod	5	91- 491	190	40	76	15,000
Grenadier	4	71- 540	180	70	126	25,000
Kingklip	6	93- 570	220	20	44	9,000
Patagonian tf.	4	30- 118	50	50	25	5,000
Antarctic cod	-		50=	30	15	3,000
Squids	5	61-1,380	310	5	15	3,000
						314,000
Assume all other species contribute a further 5%						16,000
Total						330,000

Notes

* Mean of all estimates excluding the highest and lowest

\+ Author's judgement based on reported distribution

" Derived by the method described in paras 33-39

= Assumed about the same as Patagonian toothfish significantly affecting current fisheries within the coastal exclusive economic zone and vice versa." The meeting also agreed a "best estimate" of the standing stocks of the species listed in Table 6 (except antarctic cod) from which an estimate of the sustainable yield of the Falkland Islands stock can be derived - Table 7 - based on the same assumptions as Table 6. The sustainable yield figure produced by this estimation is 204,000 tonnes/year. ——— G

45. Seven estimations are given above of the possible sustainable catch to to taken by off-shore trawling within a 200 mile Falkland Islands EFZ, lettered A-G. For convenience they are Listed below:

A	334,000	Hall, from first principles
B	464,000	Gulland 1971, from first principles*
C	443,000	Gulland 1971 (based on 1966 data)*
D	150,000	WFA 1979, two species only
E	172,000	Otero 1981, five species only*
F	330,000	Based on mean of 41 separate estimates*
G	204,000	FAO 1983, based on the most up-to-date data (1981)*

(*) Origin of original premise relating to the Patagonian shelf from which the Falkland Islands estimate is derived.

46. The first impression given by these figures, bearing in mind the range of methods used, is their similarity: they are all of the same order. Recalling the comment by Mackintosh in the foreword to Hart[20] that the shelf had been found to be less rich in trawlable fish than might have been expected, might suggest that estimations based on first principles would present an optimistic picture of the situation, and this appears to be the case. Three estimates are particularly close, namely D, E and G. If D and E be adjusted from the two and five species basis respectively to cover the full

Table 7. Falkland Islands sustainable catch derived from the FAO best estimate of the Patagonian shelf biomass for the year 1981.

Species	Patagonian Shelf Biomass ('000 t)	Falkland proportion* (%)	Falkland biomass ('000 t)	Falkland Yield + (t/yr)
Hake	1,758	20	350	70,000
Southern b.w.	406	90	365	73,000
Shiptail	350	20	70	14,000
Red cod	119	40	48	10,000
Grenadier	71	70	50	10,000
Kingklip	222	20	44	9,000
Patagonian tf.	39	50	20	4,000
Antarctic cod	39 =	30	12	2,000
Squids	230	5	12	2,000
				194,000
Assume all other species contribute a further 5%				10,000
Total estimated Falkland Islands catch				204,000

Notes

* Author's judgement based on reported distribution

\+ Derived by the method described in paras 33-39

= Assumed about the same as Patagonian toothfish range of species they become 214,000 and 208,000 tonnes respectively. A figure of 210,000 ± 5% would cover all three close estimates but that would suggest an air of confidence which the data do not justify. I therefore recommend that the sustainable trawl catch be regarded as 210,000 tonnes/year ± 20% until more accurate data prove otherwise. On this basis the virgin biomass would have been some 840,000 - 1,260,000 tonnes.

47. Referring back to the section on historical catches, the estimated combined maximum sustainable yield of the most important species was marked on Figure 19 at 789,000 tonnes (FAO[16]). These species were the common hake (hubbsi), southern blue whiting, whiptail, red cod, grenadier, kingklip, patagonian toothfish and squid (Illex), and there would seem to be room for more than 100,000 tonnes of extra catch from the shelf beyond the highest catches so far recorded, in 1979. However, the situation is not entirely straightforward because some species are relatively heavily exploited while others are only lightly exploited. The two species believed to be heavily exploited are the common hake (MSY assessed by FAO[16] at 437,000 tonnes was exceeded in 1979 - Table 5) and southern blue whiting (FAO[16] MSY 74,000 tonnes* was exceeded in 1980): the other species are lightly exploited while there is insufficient evidence with regard to the Patagonian hake to form a judgement.

48. The implications from this are quite clear, namely that in the further development of the fishery in the Falkland Islands it will be important to emphasis the exploitation of the lightly exploited species through a careful selection of the mesh size, other regulations such as closed seasons or areas as information becomes available, and the continuous monitoring of the situation by a professional fisheries team. Unregulated fishing on the southern blue whiting, in particular, should not be permitted.

(*) The suggested MSY of 1,000,000 tonnes by Shackleton[33] has not been substantiated.

VALUE OF THE FALKLAND ISLANDS OFFSHORE FISHERIES RESOURCE

49. The Falkland Islands fisheries resource is of no value to anyone if it stays at the bottom of the sea, nor is it of any significant value to the Falkland Islands in the absence of any legal claim to it through the establishment of an exclusive fishing zone. Because there is no absolute value to any fisheries resource a price can be estimated only by making some assumptions in response to the queries "In what form?", "Where?".

50. One standard form in which fish are traded is "Headed and gutted" and thereafter frozen. In Table 8 it is assumed that 210,000 tonnes of Falkland Islands fish catch are marketed in this form (North America, Europe and the Far East are most likely) and that the waste from this processing is itself converted to fish meal (allowing a 10% waste in this last process). It is assumed the 210,000 tonnes consist of the species and proportions listed in Table 7: they produce 147,600 tonnes of dressed fish and 11,230 tonnes of meal. The market prices quoted are the best estimates for the same or similar species on European Community markets, or, in the absence of such a figure, half the average of all prices. The total value of the fish and fish meal is £60.1 million.

51. This figure, £60.1 million, is closely similar to that derived by the White Fish Authority, in 1979, who valued the estimated potential catch of 150,000 tonnes/year of hake and southern blue whiting at £65 million (Anon[3]). This was based on a price of £500/tonne for hake (whole) and £300/tonne for southern blue whiting (whole) delivered to British markets by the vessels

Table 8. Market value of the Falkland Islands catch.

Species 1	Catch prop.^{n} (%) 2	Catch weight ('000t) 3	Dressed weight ('000t) 4	Market price (£/t) 5	Fish value (£m) 6	Meal prod.^{n} (t) 7	Meal value (£m) 8
Hake	34	72	50.4	430	21.67	3,890	1.17
Southern b.w.	36	76	53.2	330	17.56	4,100	1.23
Whiptail	7	15	10.5	560	5.88	810	0.24
Red cod	5	10	7.0	330	2.31	540	0.16
Grenadier	5	10	7.0	330	2.31	540	0.16
Kingklip	4	9	6.3	330	2.08	480	0.15
Patagonian tf.	2	4	2.8	330	0.92	220	0.07
Antarctic cod	1	2	1.4	330	0.46	110	0.03
Squid	1	2	2.0	600	1.20	–	–
Others	5	10	7.0	330	2.31	540	0.16
Total	100	210	147.6		56.70	11,230	3.37

Notes
- Col 2 – Proportion derived from Table 7
- Col 3 – Break down of the recommended sustainable catch
- Col 4 – 70% of the raw weight except squid which is assumed to be marketed whole
- Col 5 – Based on FAO/INFOFISH Trade News and TDRI. Where no price is quoted half the average of all prices is used
- Col 7 – $\frac{\text{Col 3} - \text{Col 4} \times 90\%}{5}$
- Col 8 – Assumed £300/tonne (FAO/INFOFISH Trade News)

doing the catching. Although WFA assumed selling prices of Falkland Islands species and products to be "about 50% of the prices for North Atlantic species" it is not possible to substantiate such high prices on today's markets. Hake (hubbsi), for example, is quoted regularly in international price lists at about £360-£480/tonne headed and gutted (ie part processed and therefore with added value). Also, in order to estimate the value of the catch at the surface of the sea in the Falkland Islands, the cost of processing, transport and handling have to be deducted from the figure of £60.1 m.

52. Transport: The Falkland Island Company prices for shipping dry and frozen products between the Falkland Islands and the United Kingdom are £180 and £140/tonne respectively. It is expected that a container service will start in May, 1984: the price for a 20ft container will be £2,000 (dry or refrigerated) but there will be a weight limit of 8 tonnes (contents), giving a price of £250/tonne. Bigger containers and a much larger weight allowance will be possible when a new jetty is built in the Falkland Islands and a price of possibly half the May price is foreseeable (say £130/tonne). Transhipments to chartered reefers, or using the catching vessel to effect the transportation, avoid the shore-side limitations but transhipments within a harbour attract harbour dues on top of the charter fee while, even if the catching vessel has to leave the fishing area for refuelling or maintenance, carrying a load of fish increases the fuel consumption of the main engine because of the need to move a bigger bulk through the water, and of the auxiliaries to provide power for refrigeration.
Considering this latter form of transportation, main engine fuel

consumption is proportional to $(\text{Displacement})^{2/3}$: a vessel with a light displacement of 5,000 t will burn 13% more fuel in the main engine at constant speed when carrying 1,000 t of cargo. Assuming this vessel has a main engine of 3,000 bhp which gives it a cruising speed of 12 knots running light, it will burn 150 gallons/hour equal of 91,250 gallons (367 tons) over the journey from Port Stanley to (say) Hull. 13% of this is 48 tons, which, at £235/ton, equals £11,280 additional cost in transporting 1,000 t of cargo, say £11/tonne.

53. Such a vessel might be expected to have also some 1,500 bhp of auxiliary machinery. If 500 bhp of this is needed simply to maintain refrigerated cargo it will consume 25 gallons/hour, or 15,210 gallons (61 tons) between Port Stanley and Hull. At £235/ton this will cost £14,335 or £14/tonne if all the 1,000 t in the original assumption were frozen cargo. This would be a cost additional to £11/tonne required to move the cargo through the water. Thus, based only on fuel costs and excluding any element for wear and tear or manpower supervision that might be needed, two costs can be derived, £11/tonne for dry cargo and £25/tonne for refrigerated goods. Double these figures might be regarded as realistic "minimum cost" estimates, say £22 and £50/tonne for dry and refrigerated cargo respectively, which figures have been used in later calculations.

54. Processing: Heading and gutting is a form of processing that can be undertaken by one man feeding a suitable machine. A processing rate of 1½ tonnes/hour can be expected, say 12 tonnes/ 8-hour day. At this rate,capital costs per tonne of production on a machine costing £3,000 and the cost of power to operate it are both small (both together amount to c.50p/tonne) while manpower might amount to some £2-3/tonne, giving total handling and gutting costs of about £3/tonne.

55. In shore-based plants it takes about 4.8 tonnes of raw product to produce 1 tonne of fish meal. Ship-board plants tend not to be as efficient and a ratio of 5:1 has been used in Table 8. Because of the great difficulty in attributing shipboard capital costs to any one isolated aspect such as meal production, a figure of £30/tonne of meal has been included in the following calculations, of which an estimated £25 is accounted for largely in energy costs.

56. Freezing on board ship is another item that is difficult to cost accurately. Energy costs are about £10/tonne while in a shore-based plant capital, labour and overheads cost a further £70/tonne giving £80/tonne altogether. One-quarter of this figure has been used in the following calculations.

57. Handling: A handling charge of £10/tonne has been assumed at the port of delivery.

58. All the charges to be set against the market value of the catch are summarised in Table 9a, which shows also the derived value for the catch at the surface of the sea, £46.94 million. However, there are still other factors to be taken into account, factors that are essentially imponderable.

59. In Table 8 it has been assumed that all the southern blue whiting could be sold for human consumption. This is certainly not the case at the present time (because of the parasite infestation) and its only value is for reduction to fish meal. Whereas in the form of a frozen, headed and gutted product with the waste being made into fish meal the southern blue whiting was shown to have a market value of £18.79 million, converted <u>entirely</u> to fish meal (15,200 tonnes with no allowance whatsoever for waste, it would have a market value of only £4.56 million. Making due allowances for processing, transport and handling, this factor alone reduces the "current" value of the total catch to £36.50 million (average £174/tonne, Table 9b). At some future date the southern blue whiting might have the enhanced value of a commodity for human consumption but at the present time its value must be set at the lower figure obtained for fish meal.

60. In Table 8 it was assumed that all the 30% of heads and guts could be processed into fish meal (allowing a 10% total wastage factor), but this is not necessarily the case. Some large trawlers do not have the ability to process the waste; they discard the heads and guts and so far as they are concerned the value of the catch lies simply in the frozen, dressed fish. Other trawlers are able to make much better use of the catch than just heading and gutting the fish. These trawlers are able to produce fish fillets, and they turn the much larger amounts of waste into meal. Most trawlers that aim to produce a headed and gutted main

Table 9. Annual value of the Falkland Islands offshore fisheries resources.

	Table 9a*			Table 9b+	
	£million	£million		£million	£million
Market value (Table 8) (£56.70 m frozen, £3.37 m meal)		60.07	(£39.14 m frozen, £6.70 m meal)		45.84
Less					
a. Transport, frozen 147,600 @ £50/t	7.38		94,400 t	4.72	
b. Transport, meal 11,230 @ £22/t	0.25		22,330 t	0.49	
c. Heading and gutting, 208,000 @ £3/t	0.62		[illegible] t	0.40	
d. Freezing, 147,600 @ £20/t	2.95		94,400 t	1.89	
e. Meal manufacture, 11,230 @ £30/t	0.34		22,330 t	0.67	
f. Handling charges, dry and frozen, 158,830 @ £10/t	1.59		116,730 t	1.17	
Total transport, processing and handling costs		13.13			9.34
Annual value of the catch at the surface of the sea (£m)		£46.94m			£36.50m
Average value at the surface of the sea (£)		£223/t			£174/t

* Southern blue whiting headed and gutted and the waste converted to fish meal

\+ All southern blue whiting converted to fish meal product do not convert the waste into fish meal: most vessels that aim to produce fillets are capable of making fish meal. Calculations based on the former assumption would reduce the opinion of the total value of the resource from that quoted in Table 8 by the value of the fish meal: calculations based on producing all fillets (plus meal) would enhance the opinion but by a very speculative factor based on little evidence of the likely fillet yields and the even less certain value of such products on the market. In this situation I recommend the only reasonable view of the ultimate value of the fishery be based on the approach summarised in Tables 8 & 9 modified for the time being by the "southern blue whiting factor" and costed in line with Table 9b. In other words, I recommend that the offshore resource be valued, currently, at about £37 million but that the catch of southern blue whiting in particular be kept under review to assess the likely ability to process it for human consumption, when a total value of about £50 million might be more appropriate.

61. The value of the catch to the Falkland Islands Government depends entirely on a legal claim to the resource. Assuming the declaration of a 200-mile EFZ and the collection of revenue through licences, a reasonable rate to charge would be 5% of the value of the catch. If all 210,000 tonnes were caught it would yield an annual revenue of £1.85 million (5% of £37 million) at the present time, with the possibility that this might rise to about £2.5 million as the southern blue whiting became suitable for human consumption.

62. There are other, indirect, benefits to the Falkland Islands from the fisheries resources, some of which are being received now without any declaration of an EFZ and which will be better known to the Falkland Islands Government than to a consultant. I refer to the use of Stanley harbour as a refuge within which transhipments of fish

to reefers can take place safely, for a small fee. These fish may have been taken anywhere outside the current coastal limit of the Falkland Islands and very possibly from outside the area that might be included within a 200-mile EFZ. In 1979, the White Fish Authority (Anon[3]) listed two other indirect benefits that might accrue to the Falkland Islands from the fishery, namely revenue from a levy on fuel that might be supplied to fishing and other vessels operating in the area and from the hire of cold storage. Neither of these is dependent on the creation of an EFZ but on the commercial attractiveness of the offer.

CATCH RATES, LICENCE FEES AND NUMBERS OF TRAWLERS

63. The White Fish Authority assessed the possibility of operating British trawlers profitably off the Falkland Islands in 1979 (Anon[3]). They considered two types of trawler, one which freezes fish that have been headed and gutted (or simply gutted) and which discards the waste, and one which freezes fillets, converting the waste into fish meal. General data on these vessels are included in Table 10, which shows comparative data on some other trawlers (taken from Hjul[22]) together with data on the two Taiyo vessels currently engaged in the survey off the Falkland Islands.

64. Two comments of particular note on the operation of the British trawlers included in the WFA report were that it was assumed the production rates would be limited by the processing capacity rather than the ability to catch fish, and that, no matter how well planned a particular operation may be it was very difficult to maintain the full production capability of the processing plant. Although both types of trawler were capable of catching and processing 45 tonnes of fish each day the anticipated overall production rate was based on one-quarter of that rate, about 11.7 tonnes/day. This was a reflection of the known problems of working at sea; it was a realistic assessment by a highly professional organisation. However, in another section of the same report the assumed catch rate was more nearly one-third of the nominal processing capacity and it is this latter figure that I have used later in this section of the report to derive reasonable estimates for licence fees.

65. Considering the two Taiyo vessels, the information provided on the length and main engine power of the second vessel suggests that it is a sister ship of ZUIYO MARU No 2, but clearly she is operating with a much reduced crew, only about one-third of the normal complement.

66. Japanese vessels of the "2,000 GT" class, such as SHIRANE MARU and MIKAMI MARU, although slightly longer than the British trawlers considered by WFA, nevertheless seem to have a catching/processing capability not greatly different from the British vessels, about 45-50 tonnes/day. Assuming a realistic sustained capability of one-third of this rate they should be able to catch and process about 16 tonnes/day, equal to about 480 tonnes/month. At an average of £174/tonne (Table 9b) the value of this catch would be about £83,520 and based on 5% of the value the monthly licence for this class of vessel might be set at £4,170.

67. Vessels of the "3,000 GT" class are fillet freezers, like the second of the British vessels included in Table 10, only much bigger. Davidovich[13] has undertaken manual filleting trials on a number of fish species from the Patagonian shelf. He found that the southern blue whiting, the whiptail and the Patagonian toothfish all gave high yields, above 35%. However, the hake and the red cod gave yields of only 25-35% while antarctic cod and some other unimportant species gave low yields, less than 25%. On this basis the average fillet yield of the Falkland Islands catch may be set at a little above 31% by manual filleting; but machine filleting, which would be the standard method on large fishing vessels, produces a lower yield. A figure of 30% has been used to estimate the likely catching capability of the 3,000 GT trawlers, based on the fillet yields.

Table 10. Some characteristics of large trawlers.

Name (Year built)	Gross tonnage	Length (m)	Main engine (hp)	Crew	Freeze capability (t/day)	Freeze hold (m^3)	Meal capability (t/day)	Meal hold (m^3)
SHIRANE MARU (1967)	2,529	84	2,750	65	45^+	2,327	–	–
MIKAMI MARU (1964)	2,538	84.9	2,800	75	49.1^+	2,353	–	–
KOYO MARU No 2 (1968)	3,456	88	3,900	?	48*	2,723	50^+	?
ZUIYO MARU No 2 (1968)	3,339	99.5	4,000	129	60*	3,069	50^+	342
NIITAKA MARU (1968)	3,914	96.7	4,400	99	60*	3,210	?	250
Taiyo 1 ≠	2,000	80.5	3,150	42	?	?	–	–
Taiyo 2≠	3,000	99.5	4,000	42	60*?	3,069?	50^+?	342?
British whole ø freezer	?	70	?	24	45^+	1,430"	–	–
British fillet ø freezer	?	70	?	35	15*	570""	30^+	240±

Notes

* Output of fillets

\+ Raw material input

" 700 tonne hold at 0.49 tonnes/m^3 (Waterman[38])) Including allowance for supports and access

"" 400 tonne hold at 0.71 tonnes/m^3 (fillets))

± 120 tonne hold at 0.50 tonnes/m^3 (bagged meal))

≠ Taiyo vessels engaged in current survey

ø General type of vessel considered by WFA (Anon[3])

(m^3 = 35.32 ft^3)

68. Vessels such as KOYO MARU might be expected to be able to catch 160 tonnes/day. A realistic catch of one-third of this gives 53 tonnes/day or 1600 tonnes/month, valued at £278,400. A licence fee for one month based on 5% of the catch value might be set at £13,900. The other two vessels noted in Table 10 in the 3,000 GT class might both be expected to catch 200 tonnes/day. One-third of this gives a realistic catch of 67 tonnes/day, or 2,000 tonnes/month valued at £348,000. Based on 5% of the value, a monthly licence for such vessels might be set at £17,400.

69. These estimated catches and licence fees are all based on an opinion of the capability of the vessels to catch and process fish, but what of the fishing areas? Are the fish present in numbers to provide such catches? It is known, for example, that many millions of tonnes of fish living in some parts of the western Atlantic Ocean and the Caribbean Sea will never be caught commercially simply because they are too widely dispersed: it costs more to catch them than they are worth at the market. While this situation obtains over some parts of the Patagonian shelf, others might provide adequate catches.

70. The Taiyo Fishing Company undertook a survey off the Falkland Islands in 1973/75 (Figure 20, Table 11). Three separate voyages constituted the survey and for the first two voyages a trawler of 2,400 GT was used. Although this vessel was slightly smaller than either of the 2,000 GT class trawlers noted in Table 10 it was, nevertheless, slightly more powerful with a main engine of 3,150 hp, and it also had a capability for manufacturing fish meal. Between 4 December 1973 and 4 March 1974 (summer) during which there were 90 operational days, 45 days were spent fishing, which produced 713 tonnes of frozen fish and 190 tonnes of meal. Assuming the frozen fish were headed and gutted (70% yield) they came from 1,020 tonnes of catch.

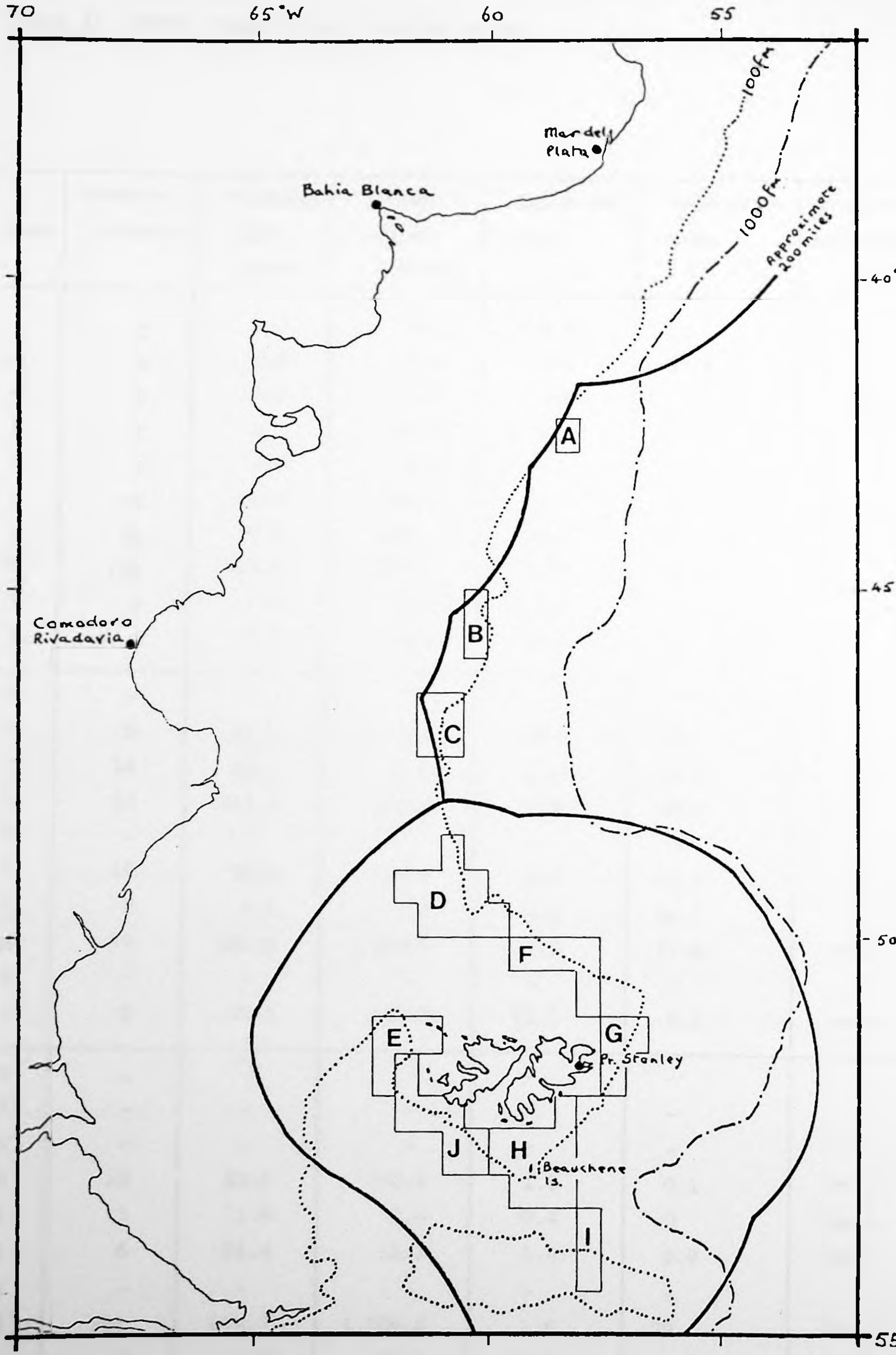

Figure 20. Areas surveyed by Taiyo, 1973/75.

Table 11. Catch rates in Taiyo survey areas.

	Area	Number of hauls	Fishing time (hours)	Total catch (tonnes)	Catch per hour (tonnes)	Proportion hake (%)	Proportion southern b.w. (%)
Voyage 1 (1973–1974)	A	2	1.7	0.3	0.2	2.9	37.1
	B	2	4.3	1.8	0.4	37.8	0
	C	3	6.8	53.0	7.8	1.4	98.6
	D	6	9.7	22.2	2.3	0.9	87.0
	E	6	7.9	0.5	0.1	9.1	3.6
	F	26	50.4	188.0	3.7	4.0	78.9
	G	23	30.2	386.7	12.8	4.2	95.2
	H	159	337.5	1,777.7	5.3	31.8	24.6
	I	2	1.6	7.0	4.4	0	98.6
	J	5	4.7	69.3	14.7	2.3	97.6
Voyage 2 (1974)	A	–	–	–	–	–	–
	B	5	11.8	9.5	0.8	92.7	0
	C	14	38.4	99.0	2.6	83.3	0
	D	54	211.0	622.2	2.9	94.8	0
	E	–	–	–	–	–	–
	F	10	28.0	14.8	0.5	49.6	4.7
	G	2	5.5	3.0	0.5	66.7	0
	H	79	221.6	1,390.5	6.3	11.8	74.1
	I	–	–	–	–	–	–
	J	6	10.3	125.0	12.1	2.2	94.8
Voyage 3 (1974–1975)	A	–	–	–	–	–	–
	B	–	–	–	–	–	–
	C	–	–	–	–	–	–
	D	32	82.6	146.2	1.8	0.1	77.3
	E	1	1.0	0.4	0.4	0	94.8
	F	6	11.4	16.1	1.4	2.9	83.3
	G	–	–	–	–	–	–
	H	261	674.7	1,106.2	1.6	22.1	58.3
	I	5	4.3	67.5	15.7	0.7	99.2
	J	12	30.4	36.4	1.2	11.6	80.0

Assuming also that the 30% of waste from this process contributed to the meal (61 tonnes) the balance of the meal, 129 tonnes, came from 645 tonnes of catch, making a total for the voyage of some 1,665 tonnes, or 1,110 tonnes/month. This is a much higher catch rate than the previously estimated "realistic catch" of the 2,000 GT trawlers having no fish meal manufacturing capability (para 66) and it seems to prove that the limiting factor in such operations is the capacity to process the catch.

71. During the second survey voyage, by the same vessel, 11 July - 23 September 1974 (winter), 564 tonnes of frozen fish and 154 tonnes of meal were produced in 35 fishing days, Using the same assumptions, this production came of 1,335 tonnes of fish which were caught at a rate of 1,145 tonnes/month, closely similar to the figure above.

72. These catch rates, it must be emphasised, were taken during a survey, but it has to be noted that the survey was very commercially orientated. Ten different areas were examined during the first voyage but 92% of the effort based on actual trawling time was put into just three areas and 74% into only one (area H). Although it was a survey only in name, nevertheless, without the trials in relatively unproductive areas an even higher overall catch rate could have been achieved. During the second voyage the same pattern was repeated. Seven areas were examined but 82% of the effort was devoted to the best two ares (H and D).

73. The third voyage, 20 November 1974 - 12 February 1975 (summer), was undertaken with a slightly smaller vessel, 1,859 GT, but one having the same size of engine, 3,150 hp. This vessel had no fish meal capability. During 52 fishing days 445 tonnes of frozen fish were produced, equivalent to 635 tonnes of fresh fish and a catch rate of 366 tonnes/month. This might seem to be surprisingly low but the explanation becomes clear when a breakdown of the catch and areas is examined. With no fish meal manufacturing capability the effort was concentrated on an area proven already, through the work during the preceding summer, to yield a relatively high proportion of hake (area H, the eastern end of Area 10 in Figure 18, around Beauchene Island: cf Figures 3, 5) even though the catch rate was not very high. 84% of the time was devoted to this one area, which produced 22% of hake (58% southern blue whiting) at an overall catch rate of 1.6 tonnes/hour compared with, for example, the northern face of the Burdwood Bank (area I) which produced only 0.7% hake (99.2% southern blue whiting) at an overall rate of 15.7 tonnes/hour. It is apparent that the 58% of southern blue whiting from most of the catches was simply discarded at sea, along with the even higher proportion from some other catches.

74. Based on the declared catches during the 1973/75 Taiyo survey a monthly licence fee based on 5% of £174/tonne would have yielded £9,660 for the first voyage and £9,960 for the second. However, because no meal whatsoever was produced during the third voyage, £174/tonne is not an appropriate basis for calculations. Assuming all the southern blue whiting was discarded the selected part of the catch would have been more valuable than previously: the appropriate figure, derived from Tables 8 and 9, is £233/tonne, and the monthly licence fee £4,260 (based on a catch of 366 tonnes).

75. These Taiyo survey voyages may be taken as a guide also to the amount of fishing completed in a day:

Voyage	Number of fishing days	Trawling hours	Hours/day
1	45	454.8	10.1
2	35	526.6	15.0
3	52	804.4	15.5
Total/average	132	1,785.8	13.5

It is to be expected that a commercial trawler would at least equal the fishing rate of a survey vessel: some 16 hours/day can be expected. To produce the realistic daily catches estimated from the processing capability of the three different vessels (16, 53 and 67 tonnes/day - paras 66, 68) the fishing areas must be capable of yielding 1, 3.3, and 4.2 tonnes/fishing hour respectively. How do such rates compare with experience?

76. The areas surveyed by the Taiyo vessels in 1973/75 are marked in Figure 20 and the catch rates obtained during the three voyages are shown in Table 11. During summer (voyages 1, 3) only area E within the EFZ would appear to have been not capable of supporting the operations of the 2,000 GT trawlers (ie needing at least 1 tonne/hour) but whereas in 1974 all five of the other areas yielded substantial catch rates, in 1975 only area I, the northern edge of the Burdwood Bank, appeared capable of supporting the operations of the 3,000 GT class. In the winter voyage two areas, H and J, had this capability.

77. As a result of other, more recent, surveys Otero[30] summarised likely catch rates in the best fishing areas (Table 4, Figs 15,16). He concluded that all five very good fishing areas in summer and all three in winter, within a 200-mile EFZ, were capable of supporting the operation of trawlers of the 2,000 GT size and capability and that in winter areas 1 and 2, to the south and west of the Falkland Islands, might support trawlers of the 3,000 GT size.

78. Bearing in mind the cautionary remarks by Hart[20] about the need to follow the spawning fish (para 19) and my earlier remarks on the patchiness of marine life (para 11) nevertheless there would appear to be a substantial area of sea-bed within a Falkland Islands 200-mile EFZ probably capable of providing the quantity of fish expected to be caught, by trawling, by large vessels of up to the 3,000 GT class. However, as noted, this conclusion relates entirely to the quantity of fish, not to the economic viability of fishing, which has not been tested.

79. The numbers of trawlers that might be permitted to exploit the offshore fisheries resources depends entirely on the size of the vessels (and the finally agreed size of the resources). 210,000 tonnes catch per year would support about 440 fishing months by 2,000 GT trawlers. Such vessels would be able to fill their holds within about 2½ months and would then have to return to port or liaise with a reefer, to transfer the catch, before being able to resume fishing. Taking maintenance also into account it is doubtful whether any single vessel would exceed eight fishing months in a year. 55 vessels of this 2,000 GT class might be expected,therefore, to be in operation during the course of a year. On the other hand, 210,000 tonnes would provide only 105 fishing months for the two largest (3000 GT) vessels listed in Table 10, ZUIYO MARU and NIITAKA MARU, equivalent to only 13 vessels each operating for eight months in a year.

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