

BRIEF REPORT OF THE JOINT SOVIET-AUSTRALIAN EXPEDITION OF THE USSR FRV
PROFESSOR MESYATSEV TO THE AUSTRALIAN FISHING ZONE AROUND THE TERRITORY OF
HEARD AND McDONALD ISLANDS, MAY-AUGUST, 1987

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Abstract

The results of the first joint Soviet-Australian expedition to the AFZ around Heard and McDonald Islands are briefly reported. Environmental conditions of the shelf area of Heard were favourable for the formation of commercial aggregations of Champscephalus gunnari during the austral winter. Stability of the aggregation is discussed in relation to the environmental conditions. The unique character of Heard's population of C. gunnari was determined according to a number of biological and morphological parameters. A preliminary stock assessment of the detected aggregation of C. gunnari is given.

Résumé

Le compte rendu des résultats de la première expédition conjointe URSS-Australie dans la zone de pêche australienne aux alentours du territoire des îles Heard et McDonald est brièvement présenté. Les conditions du milieu sur le plateau continental de Heard étaient favorables à la formation de concentrations commerciales de Champscephalus gunnari durant l'hiver austral. La stabilité de la concentration est examinée par rapport aux conditions du milieu. Le caractère unique de la population de C. gunnari à Heard a été déterminé d'après un certain nombre de paramètres biologiques et morphologiques. Une évaluation préliminaire du stock de la concentration détectée de C. gunnari est donnée.

Resumen

Se informa brevemente sobre los resultados de la primera expedición conjunta soviético-australiana a la Zona Pesquera Australiana alrededor de las islas Heard y MacDonald. Las condiciones del medio ambiente del área de la plataforma de Heard fueron favorables para la formación de concentraciones comerciales de Champscephalus gunnari durante el invierno austral. Se trata la estabilidad de la concentración en relación a las condiciones del medio ambiente. El carácter único de la población de C. gunnari de Heard fue determinado de acuerdo a un número de parámetros biológicos y morfológicos. Se presenta una evaluación de reserva preliminar de la concentración de C. gunnari que fuera detectada.

Резюме

Кратко излагаются результаты первой совместной советско-австралийской экспедиции в рыболовную зону Австралии вокруг островов Хёрд и Макдональд. Условия среды на шельфе острова Хёрд были благоприятны для образования промысловых скоплений щуковидной белокровки (ледяной Гуннара) зимой Южного полушария. Обсуждается стабильность скопления щуковидной белокровки в связи с условиями среды. Показано своеобразие популяции щуковидной белокровки о.Хёрд по ряду биологических и морфологических параметров. Дана предварительная оценка величины биомассы обнаруженного скопления щуковидной белокровки.

BRIEF REPORT OF THE JOINT SOVIET-AUSTRALIAN
EXPEDITION OF THE USSR FRV PROFESSOR MESYATSEV
TO THE AUSTRALIAN FISHING ZONE AROUND THE TERRITORY
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Annotation

This is a brief report on the outcome of the investigations in the Australian Fishing Zone around Heard and McDonald Islands; its purpose is to present concisely the results and a preliminary analysis of these results in order to facilitate planning and coordination of the research to be conducted during the next phase of the program.

As agreed in the conditions of the joint research, a full report on the research will be forwarded as soon as possible to the Australian contact through diplomatic channels. The Australian observer onboard the Professor Mesyatsev has obtained, as was agreed, copies of all the raw data resulting from the research.

INTRODUCTION

The Australian Commonwealth and the USSR have shown mutual interest in studying the fish stocks of the Australian Fishing Zone around the territory of Heard and McDonald Islands by sending to this area the USSR SRV Professor Mesyatsev during the austral winter of 1987. Research within the Australian waters was carried out during two periods : the first from 10 May until 27 June and the second from 24 July until 2 August. The Soviet Union was represented by 12 scientists, and Australia, by one observer.

The research program to be conducted in Australian waters was designed and proposed by Soviet scientists and totally agreed to by the Australian side provided a number of operational procedures were adhered to.

Soviet scientists believe that before rational management decisions about fish stocks can be made an assessment not only of the abundance of the objects of fishing but also the oceanological conditions which the fish inhabit must be studied in detail. The research program was therefore designed to investigate and assess the fish stocks of the Australian Fishing Zone and to simultaneously conduct a comprehensive study of the oceanological condition of the area. Where accumulations of fish were encountered an intensive study of the oceanological conditions was to be made. The research included hydrographic, geologic, oceanographic, hydrobiological (plankton) and ichthyological investigations. Ichthyological investigations included acoustic and trawling surveys, followed by a detailed biological analysis of the catches.

General Outline of Research Conducted during the Expedition:

1. Acoustic survey of the sea-bed and an investigation of the acoustic dispersing layers in the water column.
2. Complex oceanological studies were conducted at 83 stations. At these stations, samples were taken from the water column to determine salinity, dissolved oxygen, phosphates and silicic acid. Water temperature was also measured. Additional water samples were taken so that phytoplankton and suspended sediments could be studied. At a further 37 stations hydrological studies were carried out.

The methods used in the above determination were described in detail in the research proposal submitted to the Australian side by the USSR, and will only be briefly mentioned in this report.

Water samples were taken using Nansen water bottles (BM-48), salinity was determined using a Yeokal salinometer 601 Mark III. Phosphates and silicic acid were determined using a photoelectric calorimeter with microprocessor KPhK-2MP.

Zooplankton samples were taken from various strata in the water column using closing conically reverse JOM and Juday nets. Macroplankton was collected from selected horizons in the water column using a towed BMS-3 net (closing model). Ichthyoplankton collections were made with a drifting PNS-1 net.

3. The bottom was sampled at some shallower stations using a grab (Ocean 50) and a core sampling tube.
4. Midwater and Bottom trawls were carried out to study the fish of the shelf and sea mount areas.

Trawls used were : Bottom Trawl 39.6/41.7 and midwater trawl 70/370. (Detailed plans of the nets and cod ends used were made available to and copied by the Australian observer).

A detailed analysis of a sample from each catch was carried out. Analysis included:

- a) measurement of standard length/total length
- b) determination of weight
- c) collection of otoliths and scales for age determination
- d) determination of sex and sexual maturity
- e) description of stomach contents and degree of fullness of stomach
- f) state of digestion of food items
- g) state of fatness.

A total of 805 fish representing seven species were tagged and released.

5. Observations of the distribution and abundance of sea birds and marine mammals were conducted.

RESULTS

The main results of the expedition are briefly reported below, taking into account the suggestions made by the Australian observer (Mr P. Ensor) that in this brief report, emphasis should be placed on the outcome of the ichthyological studies.

NOTE : the method of calculating the estimate of fish stocks is given in detail. Charts and figures are not attached to this report but were copied by the Australian observer and will be available to the Australian side. A detailed chart resulting from the hydrographic surveys will be forwarded as part of the full report on the cruise.

I. Hydrographic and Geological Investigations

The upper surface of the Kerguelen Ridge to the north of Heard Island, within the AFZ, presents itself as a plateau incorporating the shelf of Heard Island and a number of submarine mountains in the form of truncated cones or greatly dissected sea mountains evidently of volcanic origin.

The above mentioned sea mountains are situated to the north and west of Heard Island and are orientated for the most part E-W and N-S. The sea mountains (Banks) have the following names:

1. Youznays (Southern)
2. Shrednaya (Middle)
3. Zapadnaya (Western)
4. Shootchaya (Pike)
5. Vostochnaya (Eastern)
and further to the east
6. Novaya (New)

According to our hydrographic survey Bank 3 is almost entirely in the French Fishing Zone, with the exception of the Southern slope and it is located further to the west than the previously charted position.

Bank 4 also appeared to be shifted to the NW and the border between the AFZ and the French FZ divides it in half. The other Banks are situated within the AFZ and their precise positions were charted during the cruise.

The fishing ground to the east of Heard Island is an extrusion of the morphologic, tectonic block forming the shelf of Heard Island. The west side of the fishing ground is bordered by a submarine valley and the slope into the valley is steep and dissected. On the eastern side of the border of the fishing ground is a broad basis with gentle slopes.

The relief of the tops of the Banks 1-5 and that of the fishing ground are considered suitable for bottom trawling. The relief of Bank 6 is not very suitable for bottom trawling and the echo sounder must be constantly monitored during trawls.

II. Oceanographic Investigations

Results obtained during the course of these investigations must be analysed more thoroughly because some conclusions are ambiguous, but it is possible to make some preliminary conclusions.

1. The thermohaline and hydrochemical structure of the waters of the investigated area are determined to a considerable degree by the location of the Antarctic convergence and the main stream of the circumpolar Antarctic current.
2. According to the complex survey data during May and June the investigated area was in the zone of mixing of Antarctic and sub-Antarctic waters. According to the survey, the northern and north-eastern streams, when approaching Heard Island and its shallow plateau-life shelf, divided into two streams which rounded the shelf on the eastern and western sides. The eastern stream was more intensive. The main frontal area of the Antarctic convergence was most likely in the southern part of the French Fishing Zone.

The vergencies of the streams and their meanderings which were influenced by the bottom relief produced in the investigated area a number of whirls of different scales, cyclonic and anticyclonic in nature, the most part of which have a complex thermohaline structure.

3. In May-June, the area was characterised by summer modification of the Antarctic water structure. Everywhere around the plateau, a cold, sub-surface layer was detected and correspondingly the season thermocline was detected.

Over the plateau the cold sub-surface layer was absent. It was modified by the presence of the formation of warm whirls over the plateau. In surface layers the whirl was characterised by increased salinity and increased concentration of biogenic salts, but in deep layers (more than 150m) the salinity and concentration of biogenic salts decreased. This whirl was most probably formed by Antarctic and sub-Antarctic surface waters and deep water Antarctic water in the ratio of approximately 2:2:1.

4. During the second cruise the structure of the waters of the area was of a winter character. Cold sub-surface layers and the seasonal thermocline correspondingly were absent as a result of intensive cooling of the surface waters during autumn-winter convection.

The surface water temperature decreased from 2.3-2.6°C (during the first cruise) to 1.3-1.8°C (during the second cruise).

5. According to the mesoscale and microscale oceanographic investigations in the area of aggregation of Champocephalus gunnari a cyclonic whirl was detected. The whirl was 25-30 miles in diameter and incorporated 2-3 smaller (7-10 miles diameter) ellipsoidal cyclonic whirls separated by

anticyclonic streams of the current. Their formation is related to meandering of the stream of the current passing in the south-eastern part of the area. The location of the aggregation of C. gunnari was related to the position of the south most of this cyclonic whirl during the first and second cruises. The water of the whirl was warmer and more saline and contained a higher concentration of biogenic salts. The whirl was most distinct in the layer deeper than 120m.

Low catches at the end of July are related to the destruction or movement of this whirl from the area when the velocity of the winds sharply increased.

6. It is considered worthwhile to recommend the discovered area of aggregations of C. gunnari for commercial exploration bearing in mind the abiotic conditions favourable for the formation of fish aggregations were quasi-stationary (they remain stable at the same position or location).

III. Hydrobiological Investigations (Plankton)

According to the results of the complex survey conducted from May to June there was an uneven distribution of meso and macroplankton over the surveyed area. The biomass of the mesoplankton was within the range 8-176 mg/m³ (mean 63.7 mg/m³) and macroplankton ranged from 1-166 mg per 10 minutes of trawling with the BMS-3 net (mean 33.7g/10 min of trawl). The least productive areas were to the north east from Heard Island and over Bank Youznaya (southern), (Biomass of mesoplankton was less than 50 mg/m³, macroplankton less than 20g/10 min of trawling). The most productive areas were the area of aggregation of C. gunnari; Banks Shrednaya (middle), Vostochnaya (eastern) and Schootchya (Pike) (Mesoplankton was greater than 100 mg/m³ and macroplankton 50-100g/10 min of trawling).

In May-June the catches of mesoplankton in the conically reverse nets consisted mainly of Copepoda and Ostracoda.

In samples of macroplankton Euphausia vallentini was dominant and only occasionally were found E. triacantha and Parathemista gaudichaudi.

In July, sub-adult Euphausiids predominated in the macroplankton forming the acoustic dispersing layer. E. vallentini and P. gaudichaudi were caught only occasionally. E. triacantha was absent from the catches.

In July the vertical development of the sound dispersing layer was considerably less than in May and June.

IV. Ichthyological Studies and Estimation of Stocks of Fish

In this part of the program 62 successful trawls were made (16 midwater and 46 bottom trawls). Location of the trawls is shown on the chart. Eleven bottom trawls were made on the Bank Novaya (New Bank), one bottom trawl was made on the Bank Vostochnaya (East Bank), and 26 bottom trawls were made in an area on the Heard Island shelf where an accumulation of Champscephalus gunnari (Lomberg : Channichthyidae) was located; three bottom trawls were made on the slopes at the shelf edge surrounding the area of aggregation. A number of trawls were made in the area between Heard Island and the area of accumulation of C. gunnari.

I. Bank Novaya :

Accumulations of fish were not detected on the Bank Novaya during research in this area on 26-27 July. Acoustic surveys revealed no trace of fish and catches in the 11 trawls were low. Catches ranged from several kg to 300 kg. At depths from 250 to 480m Notothenia squamifrons (Gunther, Notothenidae) prevailed. Only one catch from the north-western part of the bank consisted entirely of C. gunnari.

Analysis of hydrological data showed the absence of conditions necessary for the accumulation of fish.

The fish resources of Bank Novaya should not, however, be regarded as not promising since accumulations of C. gunnari and N. squamifrons were found here in autumn and spring 1975 and in spring 1976 by Soviet fishing operations. Further studies should be conducted in this area in the future.

The most common species in the catches were Dissostichus eleginoides (Smitt) (90.9% of catches), Notothenia squamifrons (90.9%) and Channichthys rhinoceratus (81.8%) and C. gunnari (81.8%).

By weight of fish in the catches, N. squamifrons dominated (63.3%) followed by C. gunnari (23.9%).

A. Notothenia squamifrons :

Notothenia squamifrons was caught over the whole range of trawled depths. Specimens varied in length from 5 to 50cm (mean TL = 24.4cm) and in weight from 4.7 to 1224g (mean weight = 237.6g). Some increase in size with depth was detected. Immature, never spawned fish prevailed (females 80%, males 90%).

$$\text{GSI females} = \frac{0.3-1.0}{0.5} \%, \quad \text{GSI males} = \frac{0.2-0.5}{0.4} \%$$

(GSI = Gonadosomatic Index)

A very small proportion of fish had gonads with signs of long past spawning (not less than half a year ago) (females 1.3%, males 7.8%).

$$\text{GSI females} = \frac{3.1-10.2}{7.3} \%, \quad \text{GSI males} = \frac{1.3}{1} \%$$

Out of the analysed fish 82% had food present in their stomachs. The average degree of stomach fullness (on a subjective scale from 0-4) was 1.6 and the mean weight ratio was 101.5‰.

Sex of individuals of the smallest size group could not be visually determined. Gonads of fish of the second group were of the stage II classification, characterised by protoplasmic growth. Gonads of the third group were in the resting stage, a considerable time after spawning (spawning had apparently occurred not less than two months previously). The maturity of these fish was assigned to stage VI-III for females and stage VI-II for males. GSI for these after spawning stages of development is 1.4% for females and 0.3% for males.

Of the analysed fish, 80% had food present in their stomach. The mean degree of stomach fullness was 1.9, (80.3°/ooo by weight ratio). [Ratio of sum of all stomach contents to sum of weight of all analysed fish, including ones with empty stomachs (total weight with intestines)].

The diet of C. gunnari was less diverse than that of N. squamifrons. Only five groups of food items were found : E. triacantha, E. vallentini, P. gaudichaudi and fry of C. gunnari and K. anderssoni. The dominant food items were E. vallentini, E. triacantha and P. gaudichaudi represented in respectively 47.8%, 41.3% and 4.3% of stomachs with food. These prey species represented, respectively. 40.1%, 36.6% and 14.2% of the weight of food.

Fry of C. gunnari were recorded in 4.3% of all stomachs with food and they represented 8.7% of the total weight of food.

C. Other species

Species other than N. squamifrons and C. gunnari were only occasionally recorded in the catches from Bank Novaya. The small number individuals of other species available for analysis was insufficient for a detailed discussion of their biology to be made.

Assessment of the stocks of fish in the area were not made because fish aggregation on the Bank Novaya were not detected and only trawling surveys were made.

II. Bank Vostochnaya :

On the Bank Vostochnaya no aggregations of fish were detected. The catch from the one bottom trawl in the area (238-250m depth) amounted to only 36.6kg. Traces of sound dispersing layers were identified as aggregation of planktonic organisms (P. gaudichaudi and E. vallentini). The results of previous cruises, by soviet vessels into this area (before the establishment of the AFZ), show the possibility of conditions favourable for fish aggregations to occur.

III. Heard Island Shelf :

Major trawls were made in May-June and July-August in the eastern shelf of Heard Island. Depth of trawls varied from 144m to 500m. C. gunnari dominated in the bottom and midwater catches. In catches in May-June, three size groups of C. gunnari may be discerned.

1. TL	$\frac{5-10}{6.8}$ cm	mean weight 1.14g
2. TL	$\frac{15-24}{18.9}$ cm	mean weight 28.3g
3. TL	$\frac{28-42}{34.9}$ cm	mean weight 233.2g

The first group is made up of fish of the present year (age group 0+). This group was detected in the water adjacent to the territorial waters east of Heard Island. Fish of the second group were distributed over a vast area to the east and north-east from Heard Island.

The eastern boundary of pelagic aggregations consisting mainly of fish of this size group coincides approximately with the 74°30' meridian. During the whole period of the investigations, dense vertically stretched aggregations of food organisms and of fish of this size were detected by echosounder EK-120S and CVS-881B.

In bottom trawls, on the shelf east of Heard Island during May-June when this aggregation of fish was first detected, fish of the third size group were present (depths from 218-265m). The aggregation was within the area bounded by 52°27'S, 74°48'E; 52°22'S, 75°09'E; 52°39'S, 75°38'E; 52°38'S, 75°12'E. In midwater trawls fish of the second and third size groups were present. It was also noted that the number of fry in the catches decreased with depth while the number of mature fish increased.

In July-August only bottom trawls were performed in this area where aggregations were discovered during the present cruise. It appeared that in the larger part of this area (to the west for the line running North-South between approximately 75°02' to 75°12') only large fish were present in the catches

(TL = $\frac{26-40}{34.8}$ cm; mean weight = 246g)

To the east of the above mentioned line, as well as fish of the large size group, smaller fish

(TL = $\frac{17-24}{19.9}$ cm; mean weight = 35.1g)

amounted to 5-36% of the catch by weight. Thus the available data allow us to make the general conclusion that the adult, mature part of the population occupies areas other than those occupied by immature fish. Substantial numbers of immature fish inhabit the western waters of the Heard Island Shelf on the eastern side of the island and adjacent to the boundary of the territorial waters of Heard Island. Immature fish also inhabit the waters to the east of the aggregation of mature fish and are also present in pelagic waters within the aggregation.

Sex of the smallest size group of fish caught on the shelf could not be visually determined. Gonads of the second size group were at stage II (stage of protoplasmic growth) during the whole period of the investigation. For fish of the third size group, significant changes were detected while comparing the stage of maturity of the gonads during the following three periods (25 May-9 June, 13 June-26 June, 26 July-1 August). For the purposes of this discussion, research during May-June was divided into two periods, since between 9 June and 13 June no trawls were made. Eight percent of females caught between 25 May and 9 June had gonads with signs of the previous spawning (not less than six months previously). Eighty-six percent of females were characterised by a low intensity trophoplasmatic growth of ova. The mean GSI of females during this period was

$$\frac{0.5-10.9\%}{1.8}$$

During the period between 25 May and 9 June, active spermatogenesis, as determined visually, had begun in only 42.9% of males. The mean GSI of males was

$$\frac{0.3-1.3\%}{0.8}$$

During the second period, 13 June-26 June, the processes of ripening of ova and sperm accelerated considerably. Mean GSI increased markedly and were

$$\frac{1.6-13.3\%}{3.4} \text{ for females and } \frac{0.3-3.75\%}{1.7} \text{ for males}$$

The differences in the degree of ripeness of sexual products are especially conspicuous when comparing the first and second periods with the third period. By 26 July-1 August, evidently, all fish capable of participating in the next spawning (possibly during the austral spring) are characterised by active processes of trophoplasmatic growth. Perhaps, it is possible to say that only 3.9% of females and 8.3% of males of the total population will not participate in the next spawning, i.e. : they are immature. All other fish were characterised by active processes of ova - and spermatogenesis. During this period the mean GSI for mature females varied from 7.2% to 31.1%. GSI for all females was

$$\frac{0.4-31.1\%}{7.50}$$

The mean GSI for mature males varied from 2.9% to 3.2%. GSI for all males was

$$\frac{0.1-5.2\%}{2.9}$$

According to these data the gonads of males and females have increased considerably in weight in comparison with the first and second periods.

Marked differences in the degree of fullness of stomachs of fish, and in the range of food items present, were also evident between the three periods.

During the first period (25 May-9 June) only bottom trawls were carried out. All fish in the catches were of the third size group. The degree of stomach fullness was very low (mean stomach fullness 0.5 or 11.1°/ooo). Only 36% of all analysed fish had food in their stomachs. The most frequent prey item was E. vallentini (present in 90.5% of stomachs containing food). P. gaudichaudi, fish fry and calanoida were present, in respectively, 6.3%, 7.9% and 1.6% of stomachs with food. By weight of stomach contents E. vallentini comprised 58.7%, P. gaudichaudi 29.3% and fish fry 11.8%.

During the second period (13 June-26 June), trawls were performed with the midwater trawl. Fish of the third size group were caught near the bottom. Out of all analysed fish, 55.3% had food in their stomachs. The degree of stomach fullness was higher (1.1 or 30.2°/ooo). The frequency of occurrence of E. vallentini was lower (76.4% of stomachs with food), but that of P. gaudichaudi and calanoida had increased (22.5% and 12.4% respectively). During this time the proportion of P. gaudichaudi in the stomach contents increased and represented 52.0% by weight and that of E. vallentini had decreased to 45.7%.

During the third period the degree of stomach fullness increased to 71.1% (mean 1.42) and 80.9 of analysed fish had food in their stomachs.

The range of food items was more similar to that found in the first period. The third period was characterised by the appearance of E. triacantha as a prey item. E. vallentini was found in 94.2% of stomachs with food, E. triacantha (14.0%) calanoida (11.1%), P. gaudichaudi (5.5%), Myctophidae (K. anderssonii) (6.1%). By weight of food E. vallentini, E. triacantha, P. gaudichaudi, K. anderssonii and calanoida represented respectively 77.7%, 5.6%, 5.1%, 10.7% and 0.7%. The percentage by weight of P. gaudichaudi had decreased by an order of magnitude.

An extremely interesting observation was that during May-June a diurnal migration of C. gunnari was observed. During night time this species migrated into the water column. At the end of June bottom aggregations were practically not seen. The composition of food in stomachs was similar to the composition of macroplankton sampled by the BMS-3 net.

In July-August, furcilia of Euphausids, which predominated in the acoustic dispersing layers, from the surface to 130m, were not present in the fish stomachs. The concentration of aggregations of fish decreased slightly but the aggregation remained near the bottom. It follows that during this period, the Euphausids E. vallentini and E. triacantha were present not far above the bottom. The behaviour of C. gunnari was primarily controlled by the distribution of food organisms.

The distribution of food organisms was, in turn, determined by considerable alterations in the structure of the water masses resulting from the range of summer structure to winter (the seasonal pycnocline practically disappeared).

The feeding of fish of the first and second size groups was considered peculiar. Fish of the first size groups were caught only in June, in midwater trawls and the degree of fullness of their stomachs was extraordinarily high 925.5°/ooo. Stomach contents were composed entirely of sub-adult euphausids (furcilia). During the second period fish of the second size group were caught with the midwater trawl but during the third period with the bottom trawl.

During the second period the degree of fullness of their stomachs was, on the contrary, very low. Mean degree of stomach fullness was 0.6 (12.5°/ooo). Among the food items were found P. gaudichaudi (in 77.5% of stomachs with food and representing 81.8% of food by weight). E. vallentini and Calanoida were present in respectively 70.5% and 5% of stomachs with food and represented 15.9% and 2.3% of the weight of food.

Late in July and at the beginning of August the composition of food of fish of the third size group changed even more markedly than that of fish of the second size group. P. gaudichaudi was not found among the food items which consisted of E. vallentini, E. triacantha and Calanoida and which were found in 85.3%, 23.5% and 32.4% of stomachs with food respectively and by weight of food these species represented respectively 82.5%, 7.0% and 10.5%.

Biological data, in particular the time of possible spawning, the size of fish at sexual maturity (females minimum length 29-30cm TL and males 27-28cm TL) and also results of the morphometric analysis demonstrate that the population of C. gunnari from the Heard Island Shelf is possibly discrete from the population of the same species of the shelf of the Kerguelen archipelago.

Thus, it is possible to determine the assessment of stocks and the sustainable yield for each of these areas separately.

It should be pointed out that, in general, the population dynamics of C. gunnari of the Heard Island Shelf area must be different from that of C. gunnari from the shelf of the Kerguelen archipelago. Prior to exploitations of the fish stocks of the Kerguelen Shelf, Notothenia rossii played the major role in regulating the population level of C. gunnari (Chechoon 1984, Kokos, pers comm). The results of the present and previous expeditions show that the population of N. rossii, on the Heard Island Shelf, is not large.

Large aggregations of D. eleginoides, the second largest carnivore of the sub-antarctic shelf waters, have not yet been detected in the Heard Island Shelf area. The population level of C. gunnari may be possibly influenced by predation by fur seals which were observed on the area of accumulation of C. gunnari and on Bank Novaya. But, all the same, it is clear that the principles regulating the Heard Island Shelf population of C. gunnari are unique and different from those regulating the Kerguelen Shelf population. A more precise answer will be obtained when some results of the tagging of 614 specimens of C. gunnari are obtained.

Evaluation of stocks :

Aggregation of C. gunnari were detected on the shelf area of Heard Island using a Simrad EK120S echosounder (working frequency 120 kHz and impulse duration 1 ms). Aggregations were also detected with a Koden 881B Fish-finder with a colour video display (working frequency 200 kHz). The attempt to use the Simrad integrater was not successful because of unfavourble conditions and the resulting weak signal strength of echo was lower than the threshold of the echo integrator QM-MkII. In the future an attempt will be made to evaluate the biomass with the help of the Soviet integrator SIORS with higher technical capabilities. The swept area method was therefore applied to determine the stock of C. gunnari in the area of the aggregation on the Heard Island Shelf. Traces recorded by the echosounder EK12) were also considered when determining the boundary of the aggregation.

Not many trawls were made on the area of aggregation during May and June (seven bottom trawls and eight midwater trawls) because hydrographic and oceanological investigations were conducted during the same period and because of worsening weather conditions after 10 June.

In general, traces of C. gunnari were recorded over the territory of about 123nm^2 . The central part of the aggregation, with catches up to 24+ per trawl, occupied an area of about 40nm^2 . The stock of the core of the aggregation was evaluated to be 25.7 ± 17.6 thousand tonnes and in the

area, in general, 47.8 ± 46.0 thousand tonnes. Such a large error in stock assessment (46.0 thousand tonnes) was a result of few trawls.

From 26 July to 1 August 19 bottom trawls were made and this enabled the boundaries of the aggregation to be more accurately defined and to speak with more assurance about the assessment of fish stocks and the level of sustainable yield.

The swept area method for assessing stocks assumes that the fish are distributed evenly over the area of trawling. The amount of fish in the aggregation (irrespective of the catchability of the trawl) may be represented by

$$Q = \frac{F}{f} (\bar{x} \pm \epsilon)$$

where F = the determined area of the aggregation
 f = the swept area of one trawl
 x = average catch per trawl
 ϵ = error in determination (Udovich 1974)

It is assumed that trawls have equal duration and that the density of aggregation (CPE) is constant during the time of the survey, if, within the determined area, there is a high variance in catches. Stocks should be separately calculated for areas with different catches, and then the results summed.

During the survey it was not always possible to follow all of the above mentioned conditions. Because trawls were not always of exactly the same duration, the catches were recalculated into catch per hour of trawl. Due to the considerable differences in the weight of catches the whole survey area (130.55 nm^2) was divided into areas where catches were high (50.64 nm^2) and areas where catches were low [$(\leq 1 \text{ tonne}), 79.99 \text{ nm}^2$].

The swept area for one hour of trawling is equal to $S = a$.
where a = horizontal opening of the net (bottom trawl $a = 29.5 \text{ m}$)
= distance swept in one hour of trawl.

For areas with density aggregations - 6.90km and in areas of lower density = 6.74km and the swept areas were 0.21km² and 0.20km² respectively.

Average catch per trawling ($x \pm \sigma$) in the area of dense aggregation was 8.01 ± 6.11 tonnes and in the area of lower density was 0.603 ± 0.688 tonnes.

The error in determination $\epsilon = t\beta \sqrt{\frac{\sigma}{n}}$

where $t\beta$ = students coefficient

For the area with dense aggregations

$$\epsilon = 1.812 \frac{6.11}{\sqrt{11}} = \pm 3.34 \quad (P \geq 0.90)$$

For the area with lower density

$$\epsilon = 1.812 \frac{0.688}{\sqrt{8}} = \pm 0.452 \quad (P \geq 0.90)$$

therefore : the values of mean catch for the areas are :

high density area $x = (8.01 \pm 3.34)$ tonnes

lower density area $x = (0.603 \pm 0.452)$ tonnes

the area of the dense aggregation occupied an area of 173.7km²

the value of the ratio of $\frac{F}{f} = 827.143$

the area of the low density region was 274.1km²

$$\frac{F}{f} = 1370.5$$

Q high density area = (6625 ± 2763) tonnes

Q low density area = (826.4 ± 619.5) tonnes.

But as mentioned above, the catchability of the trawl was not considered.

For the trawl of the given type and the given fishing object (C. gunnari) the practically determined catchability was previously determined as approximately 0.3. This value was obtained through studying the dynamics of catch in relation to the speed of trawling, which allows determination of the rate of evasion of fish from the trawl.

Therefore :

Q high density area = (22085 ± 9209) tonnes

Q low density area = (2755 ± 2065) tonnes

and the total stock of fish for the area equals 24840 ± 11274 tonnes.

Since the parameters of the equation of growth of the Heard Shelf population of C. gunnari are unknown as yet, and it is impossible to build a model of rational exploitation we have to use the value of the sustainable yield calculated in Azcherniro according to the Baranoff, Beverton and Holt model for the Kerguelen Archipelago Shelf population of C. gunnari which equals 30% from the commercial stock.

Considering that in the Heard Island Shelf population of C. gunnari the entire aggregation was composed of mature fish, the total population may be regarded as commercial stock. Taking into account the above statements, the sustainable yield of the investigated aggregation is (7452 ± 3382) tonnes (or approximately 7.5 ± 3.4 thousand tonnes). Bearing in mind that the dynamics of abundance of the Heard population of C. gunnari are not studied, we consider it possible to yield annually 6000 tonnes at the beginning of commercial exploration.

Because of the short research period and the resultant low number of trawls, catches from night trawls were also included in the calculations (although daytime catches exceeded night catches by two to three times), and we think the stocks of fish are considerably under estimated.

It should also be considered that while the vessel was moving out of the AFZ a prolonged bottom trace was recorded on the Simrad EK120S to the North-West of the aggregation of C. gunnari which was investigated. This additional trace had the characteristics of mature C. gunnari.

Thus it is recommended in the first stage of commercial fishing in the AFZ around Heard Island to yield annually 6000 tonnes of C. gunnari without damage to the population. In the future, as our knowledge of the fishing resource grows, this value will most probably increase.

V. Seabirds and Marine Mammals

Visual observations of seabirds and marine mammals were conducted from the Professor Mesyatsev in the Australian Fishing Zone.

Systematic 10 minute counts of seabirds were conducted in accordance with the methods recommended by the Scientific Committee on Antarctic Research.

Between 10 May and 27 June, 164 counts were conducted and 24 species were recorded; during the shorter second period of research (24 July-2 August) 13 species were recorded during 23 counts.

A high abundance of seabirds was observed over the Shelf waters of Heard Island on several occasions during the first period of research. The area of high abundance of seabirds which covered more than 20 square n miles was dominated by the following species : Daption capense, Fulmarus glacialisoides, Pachyptila sp and Halobaena caerulea. Large numbers of the birds in this area were in small flocks on the water surface and they were observed actively feeding.

The area of high abundance of birds coincided, each time that it was observed, with the area of highest catches of C. gunnari. In this area, and especially where the birds were feeding, there were well defined sound dispersing layers, characteristic of planktonic organisms, in the upper and middle strata of the water column.

Fur seals are rarely seen at sea away from their breeding areas and so it was very interesting to record 215 fur seals during the time in the Australian waters.

During the May and June period of research 158 seals were seen. The sightings were most frequent within the localised area of the Heard Island Shelf where catches of C. gunnari were highest and where large feeding aggregations of seabirds were observed.

Observations included three sightings of about 30 seals, near the same location, on separate days over a one week period (possibly resightings of the same group). On three occasions in this area individual fur seals were observed. These seals were at the surface of the water holding relatively large fish in their mouths.

A total of 57 seals were seen during the second period of research (24 July-2 August). Almost all of these were again recorded over the shelf area of Heard Island where they were frequently observed during May and June, but several were recorded on Bank Novaya.

CONCLUSION

As a result of the complex investigation during the cruise of the USSR SRV Professor Mesyatsev, it was found that during the Austral winter, an aggregation of C. gunnari is present on the shelf of Heard Island.

These data differ with the previously described distribution of fish resources in the Australian Fishing Zone. During the winter season the aggregation of C. gunnari occupied a stable position during a prolonged period of investigation of the area under study.

On the basis of a number of morphological and biological data a conclusion was made on the unique character of the population of C. gunnari of the shelf of Heard Island. It was also concluded that this population

was distinct from the population occupying the shelf area of the Kerguelen Archipelago. It was found that the hydrological conditions, favourable for the formation of food plankton and fish aggregation, are quasi-stationary.

The general picture of the circulation of water masses and peculiarities in the distribution of planktonic organisms in the investigated area were determined precisely enough.

It was shown that fish aggregations may form on some sub-marine mountains in the Kerguelen ridge under certain conditions.

Seabirds and fur seals were detected in the areas of the increased concentration of plankton and fish.

The location of the submarine mountains and the character of the relief of the submarine Kerguelen Ridge, within the AFZ were more precisely determined.

All the above mentioned results give basis to speak about relatively high biological productivity (including fish productivity) of the investigated area and allow us to regard this area as having potential for commercial fishing.

Table 1. Species composition by frequency and by weight + 0.01% by weight

	Shelf of Heard Island				New Bank			
	Ulenscp O. Xepg		Midwater		Bareka Hobar		Bottom trawls	
	%	%	%	%	%	%	%	%
	freq	occ	by weight	by weight	freq	occ	by weight	by weight
	2	3	4	5	6	7		
<u>Lamnidae</u>								
Lamna nasus (Bonnaterre, 1788)	2.9	0.1	11.8	0.5	-	-		
<u>Rajidae</u>								
Bathyraja eatonii (Gunther, 1876)	32.4	0.2	-	-	36.4	3.4		
B. murrayi (Gunther, 1880)	23.5	+	-	-	18.2	+		
B. irrasa Hureau a. OzoufCostaz, 1980	2.9	+	-	-	9.1	0.8		
Bathyraja sp.1	14.7	+	-	-	9.1	0.1		
Bathyraja sp.2	2.9	+	-	-	-	-		
<u>Myctophidae</u>								
Electrona antarctica (Gunther, 1878)	5.9	+	23.5	+	9.1	+		
Gymnoscopelus braueri (Lohnberg, 1905)	-	-	-	-	9.1	+		
G nicholsi (Gilber, 1911)	8.8	+	5.9	+	18.2	+		
G. opisthopterus Fraser-Bruhner, 1949	2.9	+	-	-	-	-		
Krefflichthys anderssonii (Lohnberg, 1905)	2.9	+	-	-	18.2	+		
Protomyctophum tenisoni (Norman, 1930)	2.9	+	-	-	-	-		
<u>Muraenolepididae</u>								
Muraenolepis marmoratus (Gunther, 1880)	11.8	+	-	-	45.5	0.1		
<u>Macrouridae</u>								
Macrourus carinatus (Gunther, 1878)	2.9	+	-	-	-	-		
Macrourus sp. c.f. whitsoni	2.9	+	-	-	-	-		

	Shelf of Heard Island								New Bank			
	Ulenscp O. Xepg				Bareka Hobar							
	Bottom trawls		Midwater trawls		Bottom trawls							
	% freq	% occ	% by	% weight	% freq	% occ	% by	% weight	% freq	% occ	% by	% weight
2	3	4	5	6	7							
<u>Congiopodidae</u>												
Zanclorhynchus spinifer (Gunther, 1880)	-	-	-	-	45.5	0.1						
<u>Nototheniidae</u>												
Notothenia rossii rossii (Richardson, 1844)	8.8	+	-	-	-	-						
N. squamifrons (Gunther, 1880)	26.5	+	-	-	90.9	63.3						
N. acuta (Gunther, 1880)	32.4	+	-	-	-	-						
N. mizops (Gunther, 1880)	8.8	+	-	-	63.6	0.1						
Dissostichus eleginoides (Smitt, 1889)	61.8	0.8	-	-	90.9	6.7						
<u>Harpagiferidae</u>												
Harpagifer sp. cf. spinosus	-	-	5.9	+	-	-						
<u>Channichthyidae</u>												
Chamsocephalus gunnari (Lomberg, 1905)	91.2	96.5	82.4	99.5	81.8	23.9						
Channichthys rhinoceratus (Richardson, 1844)	85.3	2.4	47.1	+	81.8	1.5						
<u>Tempylidae</u>												
Paradiplospinus antarcticus Andriashev	5.9	+	5.9	+	9.10	+						
<u>Bothidae</u>												
Mancopsetta maculata antarctica (Kothylar, 1978)	-	-	-	-	54.5	+						

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Légende du tableau

Tableau 1 Composition des espèces par fréquence et par poids + 0,01%
par poids.

Encabezamiento de la Tabla

Tabla 1 Composición de las especies por frecuencia y por peso
+ 0.01% por peso.

Заголовок к таблице

Таблица 1 Видовой состав по частоте встречаемости и по весу
+ 0,01%.