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SELECTED SCIENTIFIC PAPERS
PART II

COMMUNICATIONS SCIENTIFIQUES SELECTIONNEES
PARTIE II

ИЗБРАННЫЕ НАУЧНЫЕ РАБОТЫ
ЧАСТЬ II

DOCUMENTOS CIENTIFICOS SELECCIONADOS
PARTE II

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Abstract

This volume contains a selection of the scientific papers presented at meetings of the Scientific Committee and Working Groups of the Scientific Committee in 1988. The volume is published in two parts. Part I contains papers related to Antarctic krill. Part II contains papers on other Antarctic Marine Living Resources. The text of the papers is reproduced in the original language of submission; abstracts of the papers and captions of tables and figures are translated into the official languages of the Commission (English, French, Russian and Spanish).

Résumé

Le présent tome contient une sélection de communications scientifiques présentées aux réunions du Comité Scientifique et aux Groupes de travail du Comité Scientifique en 1988. Ce tome est publié en deux parties. La première partie contient les communications qui se rapportent au krill antarctique. La deuxième partie contient les communications sur les autres ressources marines de l'Antarctique. Le texte de ces communications est reproduit dans la langue originale dans laquelle celles-ci ont été présentées; les résumés des communications ainsi que les titres des tableaux et des figures ont été traduits dans les langues officielles de la Commission (anglais, français, russe et espagnol).

Резюме

Настоящий том содержит подборку научных работ, представленных на совещаниях Научного комитета и Рабочих групп Научного комитета в 1988 г., и состоит из двух частей. Первая часть содержит документы, имеющиеся отношение к антарктическому крилю. Вторая часть содержит документы касающиеся других морских живых ресурсов Антарктики. Они представляются на языке оригинала; резюме докладов, название таблиц и подписи к рисункам переведены на официальные языки Комиссии (английский, французский, русский и испанский).

Resumen

Este volumen contiene una selección de los documentos científicos presentados en las reuniones del Comité Científico y de los Grupos de Trabajo del Comité Científico en 1988. Se publica en dos partes. La Parte I comprende los trabajos relacionados con el krill. La Parte II comprende los trabajos sobre los otros recursos vivos marinos antárticos. El texto de estos documentos está reproducido en el idioma original; los resúmenes de éstos y los títulos de los cuadros y figuras están traducidos a los idiomas oficiales de la Comisión (inglés, francés, ruso y español).

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CHAMPSOCEPHALUS GUNNARI STOCK STATUS IN THE SOUTH GEORGIA AREA

R. Borodin, P. Kochkin

Abstract

Data of age composition and fishing effort for 1976/77-1987/88 were used to analyse stock status and TAC for *C. gunnari*. Stock estimates were obtained using VPA with the following variations: mean F, *Gamma* methods, Pope and Shepherd method, using F regression on fishing effort and method of average weighted F.

For 1986/87 the values obtained by different methods differed considerably from each other, from 120 thousand tonnes (regression method) to 213 thousand tonnes (Pope-Shepherd method). For TAC prediction the stock size value was obtained by VPA with variations using F regression methods. The recruitment was taken at the lowest possible level for all these years (400 million specimens). Catch-per-unit-effort was also taken at the lowest level.

TAC was calculated for three possible situations:

(a) Fishing intensity (F) in a predicted period was equal to the average value of fishing mortality:

(b) For the predicted period fishing intensity was at the level of that in 1987/88;

(c) For the predicted period fishing intensity was $F_{0.1}$.

In the first two cases TAC=25-30 thousand tonnes and stock size does not change. For the third case TAC=14-18 thousand tonnes and stock size increases. The analysis of the information shows that at the currently used value of stock size and even at the lowest possible recruitment levels and catch-per-unit-effort the present fishing regime does not lead to a decline in *C. gunnari* stock size.

Résumé

Des données sur la composition en âges et l'effort de pêche de 1976/77-1987/88 ont été utilisées pour analyser l'état du stock et les TAC de *C. gunnari*. Des estimations du stock ont été obtenues en utilisant VPA avec les variations suivantes: F moyen, méthodes *Gamma*, la méthode de Pope et Shepherd, utilisant la régression de F sur l'effort de pêche et la méthode de F moyen pondéré.

Pour 1986/87, les valeurs obtenues par les différentes méthodes variaient considérablement l'une de l'autre, de 120 mille tonnes (méthode de régression) à 213 mille tonnes (méthode Pope-Shepherd). Pour la prédiction des TAC, la valeur de la taille du stock a été obtenue au moyen de VPA avec des variations utilisant des méthodes de régression de F. Le recrutement a été pris au niveau le plus bas possible pour toutes ces années (400 million de spécimens). La capture par unité d'effort a aussi été prise d'être au niveau le plus bas.

La TAC a été calculée pour trois situations possibles :

(a) L'intensité de la pêche (F) lors d'une période prédéterminée a été égale à la valeur moyenne de la mortalité par pêche;

(b) Pendant la période prédéterminée, l'intensité de la pêche était au même niveau qu'en 1987/88;

(c) Pendant la période prédéterminée, l'intensité de la pêche était de $F_{0.1}$.

Dans les deux premiers cas, la TAC=25-30 mille tonnes et la taille du stock ne change pas. Dans le troisième cas, la TAC=14-18 mille tonnes et la taille du stock augmente. L'analyse de l'information démontre qu'à la valeur de la taille du stock utilisée actuellement, et même aux niveaux de recrutement et de prise par unité d'effort les plus bas, le régime de pêche actuel ne mène pas à une diminution de la taille du stock de *C. gunnari*.

Резюме

Данные о возрастном составе и промысловом усилии за 1976/77-1987/88 гг. были использованы при анализе состояния запаса и ОДУ для *C. gunnari*. Оценки запаса были достигнуты при использовании метода VPA со следующими настройками : средняя величина F, *Gamma* методы, метод Поупа и Шепарда, метод регрессии F на промысловое усилие и метод F средневзвешенный.

Величины, полученные различными методами в сезон 1986/87 г., значительно отличаются - от 120 тысяч тонн (метод регрессии) до 213 тыс. т. (метод Поупа и Шепарда). Для прогноза ОДУ оценка величины запаса была достигнута при помощи метода VPA с изменениями при использовании методов регрессии F. Численность пополнения была взята на самом низком уровне в течение всех этих лет (400 млн. экз.). "Улов на единицу усилия" также находился на самом низком уровне.

ОДУ был рассчитан для трех возможных ситуаций :

(a) Интенсивность промысла (F) в прогнозируемый период равна средней величине промысловой смертности :

(b) В прогнозируемый период интенсивность промысла (F) сохраняется на уровне сезона 1987/1988 г.

(c) В прогнозируемый период интенсивность промысла была $F_{0,1}$.

В первых двух случаях ОДУ=25-30 тыс. т., и величина запаса не изменяется. В третьем случае ОДУ=14-18 тыс. т. и величина запаса увеличивается. Анализ данных показывает, что при использованной в последнее время величине запаса и даже при наинизших уровнях пополнения и невысоком улове на единицу усилия настоящий промысловый режим не ведет к уменьшению величины запаса *C. gunnari*.

Resumen

Se utilizaron los datos de composición por edades y de esfuerzo pesquero para 1976/77-1987/88 para analizar el estado de la población y la TAC para *C. gunnari*. Las estimaciones de la población se obtuvieron usando un VPA con las siguientes variaciones: promedio de F, métodos *Gamma*, método Pope y Shepherd, la regresión F en el esfuerzo pesquero y el método de la media ponderante de F.

En 1986/87, los valores obtenidos mediante los distintos métodos discreparon considerablemente entre ellos, de 120 mil toneladas (método de regresión) a 213 mil toneladas (método Pope-Shepherd). Para el pronóstico de la TAC se obtuvo el valor del tamaño de la población mediante un VPA con variaciones utilizando los métodos de regresión F. El reclutamiento se tomó al nivel más bajo posible para todos esos años (400 millones de ejemplares). La captura-por-unidad-de-esfuerzo se tomó también al nivel más bajo.

Se calculó la TAC para tres situaciones posibles:

(a) La intensidad de pesca (F) en un período previsto fue igual al valor medio de la mortalidad por pesca;

(b) Para el período previsto la intensidad de pesca estuvo al mismo nivel que en 1987/88;

(c) Para el período previsto la intensidad de pesca fue $F_{0.1}$.

En los dos primeros casos, la TAC=25-30 mil toneladas y el tamaño de la población no cambia. Para el tercer caso la TAC=14-18 mil toneladas y el tamaño de la población aumenta. El análisis de la información muestra que para el valor actualmente utilizado del tamaño de la población e incluso para el nivel más bajo posible de reclutamiento y captura-por-unidad-de-esfuerzo el presente régimen de pesca no conduce a un descenso en el tamaño de la población de *C. gunnari*.

1. РАСПРОСТРАНЕНИЕ

К настоящему времени щуковидная белокровка известна из антарктических вод Атланического и Индоокеанского секторов Южного океана - районы островов Южная Георгия, Южные Оркнейские, Южные Шетландские, Южные Сандвичевы, Буве, Кергелен, Херд и близлежащие подводные возвышенности в этих двух районах (банки Скиф, Средняя, Щучья, Новая), Макдональд и у Антарктического полуострова - районы архипелага Пальмера и о-ва Жуэнвиль. С таким распространением щуковидную белокровку относят к рыбам с типом ареала - Западная Антарктика - Кергелен.

2. ОБОСНОВАНИЕ ВОЗРАСТНОГО И ВЕСОВОГО СОСТАВА

Разработанные нами способы подготовки срезов отолитов и костей рыб и обработки позвонков антарктических рыб (Кочкин, 1980 а,б) позволили получить тонкие окрашенные шлифы отолитов и препараты из позвонков щуковидной белокровки. Сходство результатов, полученных при изучении отметок роста на указанных структурах (отолиты, позвонки) позволило получить бо́льшую уверенность в точности определения возраста данного вида. По вычисленным обратным расчислением значениям длины тела рыб были получены параметры линейного роста щуковидной белокровки на период закладки на ее отолитах годовых отметок роста (близкому к началу билогического года рассматриваемого вида) (уравнение I) и на период ее вылова в ареале-мае (уравнение II).

Уравнения имеют вид:

$$L_t = 71,994 \, (I - e^{-0,1296 \, (t \, + \, 0,6722)}) \qquad (I)$$
$$L_t = 71,187 \, (I - e^{-0,131 \, (t \, + \, 1,4766)}) \qquad (II)$$

где L_t - длина рыбы (см) в возрасте t лет.

Полученные по этим уравнениям данные были приведены к разным временным отметкам и показали близкое сходство результатов при временной отметке 1 августа, что позволило принять эту дату (1 августа) за среднюю дату закладки годовых отметок роста близкую ко времени рождения рассматриваемого вида. Достоверность полученных средних данных о росте рыбы подтверждается сходством максимальных значений длины тела рыбы - теоретической (71,9 см) и наблюденной (69,5 см), поскольку по Паули (Pauly, 1980) у рыб средних размеров максимальная наблюденная длина обычно близка к 95 % вычисленной асимптотической. Кроме того, определение интенсивности роста щуковидной белокровки показало, что замедление ее роста наблюдается при достижении средней длины тела 27 см, что согласуется с литературными данными о длине тела рыб во время массового созревания (26-32 см), когда рост рыбы должен замедляться (Лисовенко, 1982; Kock, 1981; Sosinski,1981 ; "Antartida 8611", 1987).

На основе определенной нами для апреля-мая размерно-весовой зависимости:

$$W = 0,00162 \cdot L^{3,389}$$

где W - общая масса рыбы (г),
L - общая длина тела (см)

и средней длины тела рыб разного возраста был определен также весовой рост щуковидной белокровки. На период начала биологического года весовой рост рыбы описывается уравнением:

$$W_t = 3343{,}75\ (l - e^{-0{,}1167\ (t\ +\ 0{,}4827)})^3$$

где W_t - масса рыбы (г) в возрасте t лет.

Достовереность полученных размерно-весовых данных подтверждается сходством максимальных значений веса рыбы - теоретического (3343,7 г) и наблюденного (3200 г). Вычисленная масса тела рыбы длиной 30 см составила 171,8 г, что близко к наблюденным нами в апреле-мае 1981 г. средним данным - 178,3 г, а также данным ряда зарубежных авторов (Kompowski, 1980; Kock, 1981; Sosinski, 1981, 1985).

Сопоставление расчетных данных о среднемесячной длине тела рыб разного возраста со средними модальными размерами рыб в уловах (с преобладанием особей одного поколения) показывает относительное сходство расчетных и наблюденных данных для одновозрастных особей. Относительно стабильный рост щуковидной белокровки в районе о-ва Южная Георгия, видимо, можно объяснить довольно постоянными термическими условиями в районе ее обитания и наличием хорошей кормовой базы в летне-осенний период практически ежегодно. Такая особенность роста щуковидной белокровки также косвенно подтверждается практически постоянной зависимостью радиуса отолита от длины тела рыб, пойманных в разные годы. Учитывая значительные трудности при определении возраста щуковидной белокровки и относительно постоянный темп ее роста использование средних расчетных данных о линейном и весовом росте рыбы поможет получить сравнительно близкую к действительности картину о динамике запаса этого вида.

3. ОЦЕНКА СОСТОЯНИЯ ЗАПАСА И ОПТИМАЛЬНОГО ДОПУСТИМОГО УЛОВА (ОДУ)

На основе статистической информации, взятой из опубликованных сборников АНТКОМа, был использован метод VPA. Для оценки терминального коэффициента мгновенной промысловой смертности F_T были применены следующие настройки: среднее многолетнее, метод Гамма, метод Поупа и Шепарда, метод регрессии F на промысловое усилие f и метод F средневзвешенный.

Затем были получены оценки запаса ледяной по сезонам при M=0,3, начиная с сезона 1976/77 г.

Все методы показывают примерно одинаковую динамику запаса щуковидной белокровки. В сезон 1976/77 г. запас оценивается в 106 тыс. т. Затем резкое снижение до 25 тыс. т и быстрый рост до около 220 тыс. т в сезон 1982/83 г. Затем опять резкое снижение до 63 тыс. т в сезон 1984/85 г. и последующий рост запаса до сезона 1986/87 г. Однако оценки на сезон 1986/87 г., полученные разными методами значительно отличаются - от 120 тыс. т до 213,9 тыс. т (метод Поупа-Шепарда). При этом следует отметить, что численность пополнения младших возрастных групп не корректировалась.

Для дальнейшего анализа использовался метод регрессии F на промысловое усилие (табл. 1 - 5).

Численность пополнения 1 возрастной группы была взята на самом низком уровне за последние десять лет (400 млн. экз.). В этом случае запас щуковидной белокровки в сезон 1986/87 г. оценивается в 129,3 тыс. т, а в сезон 1987/88 г. в 67,2 тыс. т. Затем был сделан прогноз возможного состояния запаса и ОДУ ледяной на сезоны 1988/89 и 1989/90 г.г. (табл. 6-8). При этом были рассмотрены следующие варианты:

(а) Интенсивность промысла (F) в прогнозируемый период равна средней величине промысловой смертности F для основных промысловых возрастных групп (2-4 года). При принятых условиях (наименьшая численность пополнения - 400 млн. экз.) и ОДУ=29,2 тыс. т в сезон 1988/89 г. и ОДУ=26,1 тыс. т в сезон 1989/90г. величина запаса будет снижаться до 60 тыс. т.

(б) В прогнозируемый период интенсивность промысла (F) сохраняется на уровне сезона 1987/88 г. Тогда в сезон 1988/89 г. ОДУ=22,9 тыс. т, а в сезон 1989/90 г. ОДУ=26,5 тыс. т. Величина запаса увеличится к сезону 1989/90 г. до 72,1 тыс. т.

(в) В прогнозируемый период интенсивность промысла (F) будет равна $F_{0,1}$= 0,439. Тогда в сезон 1988/89 г. ОДУ=13,6 тыс. т, а в сезон 1989/90 г. ОДУ=18,5 тыс. т. Величина запаса возрастет до 81,9 тыс. т в сезон 1989/90 г.

4. ЗАКЛЮЧЕНИЕ

Анализ состояния запаса и промысла щуковидной белокровки показывает, что величина улова зависит от пульсирующего пополнения. Первоначальный запас составлял немного больше 100 тыс. т, затем увеличился более чем в два раза и оценивался примерно в 220 тыс. т, а к настоящему времени опять снизился примерно до 70 тыс. т.

Прогноз возможного состояния запаса и уловов на последующие два сезона показывает, что даже при возможной наименьшей численности пополнения и существующей интенсивности промысла $F_{0,1}$=0,439 (ОДУ=15-20 тыс. т) запас щуковидной белокровки должен увеличиваться.

При этом необходимо отметить, что прогноз проводился для самой низкой величины пополнения за все годы и самом низком улове на усилие в последний сезон.

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Таблица 1: Средняя масса (г) разновозрастных рыб по сезонам

Возраст-ная группа	Коэффициент естественной смертности	СЕЗОНЫ							
		1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1	0,35	24,7	26,3	27,8	38,3	32,8	20,5	31,1	36,5
2	0,35	76,1	79,0	81,9	100,4	91,9	68,0	87,8	97,2
3	0,35	159,1	163,3	167,4	193,4	180,2	147,1	175,8	189,0
4	0,35	270,7	276,0	281,2	313,4	297,2	255,4	291,8	308,0
5	0,35	405,8	411,9	418,0	455,1	436,4	387,9	430,2	448,9
6	0,35	558,5	565,2	571,8	612,3	592,0	538,7	585,2	605,5

Возраст-ная группа	Коэффициент естественной смертности	СЕЗОНЫ			
		1984/85	1985/86	1986/87	1987/88
1	0,35	26,3	31,1	27,8	21,8
2	0,35	79,0	87,8	81,9	70,6
3	0,35	163,3	175,8	167,4	151,0
4	0,35	276,0	291,8	281,2	260,5
5	0,35	411,9	430,2	418,0	393,8
6	0,35	565,2	585,2	571,8	545,3

Таблица 2: Возрастной состав уловов (млн. экз)

Возрастная группа	Коэффициент естественной смертности	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
					СЕЗОНЫ				
1	0,35	0,00	2,67	0,07	29,57	17,02	5,87	25,97	98,63
2	0,35	0,13	13,96	2,49	25,76	71,49	159,37	162,20	167,08
3	0,35	19,61	18,46	1,45	1,73	108,23	158,39	428,08	120,92
4	0,35	112,20	4,33	0,41	4,96	2,86	30,19	68,13	76,11
5	0,35	97,55	2,77	0,10	2,88	2,07	5,91	24,97	21,54
6	0,35	24,44	1,12	0,03	0,73	0,88	1,89	8,55	4,31
Итого		253,90	43,30	4,50	65,60	202,50	361,60	717,90	488,60
Средний возраст		4,50	2,90	2,60	1,90	2,50	2,70	2,90	2,50

Возрастная группа	Коэффициент естественной смертности	1984/85	1985/86	1986/87	1987/88
			СЕЗОНЫ		
1	0,35	5,28	21,64	6,92	3,03
2	0,35	18,20	39,62	207,12	8,33
3	0,35	47,05	34,01	276,94	52,41
4	0,35	12,71	1,89	19,31	41,65
5	0,35	1,80	0,67	4,21	19,21
6	0,35	0,54	0,13	0,70	4,35
Итого		85,60	98,00	515,20	129,00
Средний возраст		2,90	2,20	2,60	3,60

Таблица 3: Коэффициенты промысловой смертности

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ 1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1	0,35	0,0000	0,0258	0,0002	0,0421	0,0134	0,0115	0,0668	0,3466
2	0,35	0,0022	0,2991	0,0352	0,0853	0,1589	0,1958	0,5914	0,9541
3	0,35	0,8451	0,5838	0,0531	0,0359	0,7108	0,7602	1,5795	1,7559
4	0,35	2,8701	0,7442	0,0257	0,3052	0,0896	0,5310	1,1629	2,8841
5	0,35	6,3710	0,9440	0,0244	0,2980	0,2380	0,3191	1,6042	2,9387
6	0,35	4,6215	0,7432	0,0250	0,3015	0,1638	0,4250	1,3834	2,9105
2-4	F взвешенный	1,7082	0,4344	0,0382	0,0880	0,3142	0,3461	1,1742	1,4897

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ 1984/85	1985/86	1986/87	1987/88
1	0,35	0,0072	0,0485	0,0249	0,0090
2	0,35	0,1156	0,0796	1,0668	0,0440
3	0,35	1,0131	0,3894	1,5550	1,1487
4	0,35	1,2833	0,1082	0,4822	1,5918
5	0,35	0,9015	0,2244	0,4430	1,8547
6	0,35	1,0917	0,1662	0,4626	1,1731
2-4	F взвешенный	0,4462	0,1309	1,2619	0,5463

Таблица 4: Численность запаса (млн. экз)

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ							
		1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1	0,35	90,04	124,15	540,81	849,41	1518,67	607,67	475,51	395,07
2	0,35	69,19	63,45	85,26	381,04	573,90	1055,98	423,32	313,44
3	0,35	39,77	48,65	33,15	58,01	247,05	344,99	611,79	165,12
4	0,35	131,12	12,04	19,12	22,15	39,43	85,53	113,67	88,85
5	0,35	103,03	5,24	4,92	13,15	11,51	25,41	35,44	25,04
6	0,35	26,47	2,48	1,44	3,39	6,87	6,39	13,01	5,02
Итого		459,60	256,00	684,70	1327,10	2397,40	2126,00	1672,70	992,50

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ			
		1984/85	1985/86	1986/87	1987/88
1	0,35	875,40	540,91	333,24	400,71
2	0,35	196,85	612,47	363,12	229,06
3	0,35	85,07	123,57	398,59	88,05
4	0,35	20,10	21,77	58,99	59,32
5	0,35	3,50	3,93	13,76	25,67
6	0,35	0,93	1,00	2,21	6,23
Итого		1181,90	1303,60	1169,90	809,00

Таблица 5: Биомасса запаса (тыс. т)

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ 1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1	0,35	2,22	3,27	15,03	32,53	49,81	12,46	14,79	14,42
2	0,35	5,27	5,01	6,98	38,26	52,74	71,81	37,17	30,47
3	0,35	6,33	7,94	5,55	11,22	44,52	50,75	107,55	31,21
4	0,35	35,49	3,32	5,38	6,94	11,72	21,84	33,17	27,36
5	0,35	41,81	2,16	2,06	5,98	5,02	9,85	15,25	11,24
6	0,35	14,79	1,40	0,82	2,07	4,07	3,44	7,61	3,04
Итого		105,90	23,10	35,80	97,00	167,90	170,20	215,50	117,70

Возрастная группа	Коэффициент естественной смертности	СЕЗОНЫ 1984/85	1985/86	1986/87	1987/88
1	0,35	23,02	16,82	9,26	8,74
2	0,35	15,55	53,78	29,74	16,17
3	0,35	13,89	21,72	66,72	13,30
4	0,35	5,55	6,35	16,59	15,45
5	0,35	1,44	1,69	5,75	10,11
6	0,35	0,53	0,59	1,26	3,40
Итого		60,00	100,90	129,30	67,20

Таблица 6: Прогноз состояния запаса и ОДУ при заданной интенсивности промысла Интенсивность промысла в прогнозируемый период равна средней величине F для основных возрастных групп (2 - 4)

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1987/88				1988/89			
				F	C млн.экз	N млн.экз	B тыс.т	F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0090	3,03	400,00	9,880	0,0866	0,69	400,00	9,880
2	0,35	0,3829	0,076	0,0440	8,33	229,06	17,431	0,4744	6,87	279,35	21,258
3	0,35	1,0000	0,159	1,1487	52,41	88,05	14,009	1,2391	15,25	154,47	24,575
4	0,35	1,0000	0,271	1,5918	41,65	59,32	16,057	1,2391	3,30	19,67	5,325
5	0,35	1,0000	0,406	1,8547	19,21	25,67	10,415	1,2391	2,14	8,51	3,453
6	0,35	1,0000	0,558	1,5731	4,35	6,23	3,478	1,2391	0,98	2,83	1,581
Итого					129,00	808,30	71,300		29,20	864,80	66,100

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1989/90			
				F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0866	0,69	400,00	9,880
2	0,35	0,3829	0,076	0,4744	6,36	258,49	19,671
3	0,35	1,0000	0,159	1,2391	12,09	122,49	19,488
4	0,35	1,0000	0,271	1,2391	5,30	31,53	8,535
5	0,35	1,0000	0,406	1,2391	1,01	4,02	1,629
6	0,35	1,0000	0,558	1,2391	0,60	1,74	0,970
Итого					26,10	818,30	60,20

Примечание: Численность 1-ой возрастной группы в терминальный, первый и второй прогнозируемые годы задана исследователем

Таблица 7: Прогноз состояния запаса и ОДУ при заданной интенсивности промысла Интенсивность промысла в сезон 1987/88 г. сохраняется в прогнозируемом периоде.

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1987/88				1988/89			
				F	C млн.экз	N млн.экз	B тыс.т	F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0090	3,03	400,00	9,880	0,0090	0,07	400,00	9,880
2	0,35	0,3829	0,076	0,0440	8,33	229,06	17,431	0,0440	0,77	279,35	21,258
3	0,35	1,0000	0,159	1,1487	52,41	88,05	14,009	1,1487	14,63	154,47	24,575
4	0,35	1,0000	0,271	1,5918	41,65	59,32	16,057	1,5918	3,74	19,67	5,325
5	0,35	1,0000	0,406	1,8547	19,21	25,67	10,415	1,8547	2,58	8,51	3,453
6	0,35	1,0000	0,558	1,5731	4,35	6,23	3,478	1,5731	1,10	2,83	1,581
Итого					129,00	808,30	71,300		22,90	864,80	66,100

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1989/90			
				F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0090	0,07	400,00	9,880
2	0,35	0,3829	0,076	0,0440	0,77	279,35	21,258
3	0,35	1,0000	0,159	1,1487	17,84	188,38	29,971
4	0,35	1,0000	0,271	1,5918	6,56	34,51	9,342
5	0,35	1,0000	0,406	1,8547	0,86	2,82	1,145
6	0,35	1,0000	0,558	1,5731	0,37	0,94	0,524
Итого					26,50	906,00	72,10

Примечание: Численность 1-ой возрастной группы в терминальный, первый и второй прогнозируемые годы задана исследователем

Таблица 8: Прогноз состояния запаса и ОДУ при заданой интенсивности промысла: $F_{0,1} = 0{,}439$

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1987/88				1988/89			
				F	C млн.экз	N млн.экз	B тыс.т	F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0090	3,03	400,00	9,880	0,0307	0,25	400,00	9,880
2	0,35	0,3829	0,076	0,0440	8,33	229,06	17,431	0,1681	2,79	279,35	21,258
3	0,35	1,0000	0,159	1,1487	52,41	88,05	14,009	0,4390	7,46	154,47	24,575
4	0,35	1,0000	0,271	1,5918	41,65	59,32	16,057	0,4390	1,62	19,67	5,325
5	0,35	1,0000	0,406	1,8547	19,21	25,67	10,415	0,4390	1,05	8,51	3,453
6	0,35	1,0000	0,558	1,5731	4,35	6,23	3,478	0,4390	0,48	2,83	1,581
Итого					129,00	808,30	71,300		13,60	864,80	66,100

Возрастная группа	Коэффициент ест. смерт.	Коэффициент част. попол.	Средняя масса рыбы (кг)	1989/90			
				F	C тыс.т	N млн.экз	B тыс.т
1	0,35	0,0699	0,025	0,0307	0,25	400,00	9,880
2	0,35	0,3829	0,076	0,1681	2,73	273,36	20,802
3	0,35	1,0000	0,159	0,4390	8,04	166,40	26,474
4	0,35	1,0000	0,271	0,4390	5,77	70,17	18,996
5	0,35	1,0000	0,406	0,4390	1,10	8,94	3,627
6	0,35	1,0000	0,558	0,4390	0,66	3,87	2,159
Итого					18,50	922,70	81,90

Примечание: Численность 1-ой возрастной группы в терминальный, первый и второй прогнозируемые годы задана исследователем

Table Legends

Table 1	Age (years) and weight (gr) data.
Table 2	Age composition of catches.
Table 3	Fishing mortality coefficients.
Table 4	Stock abundance (million of individuals).
Table 5	Biomass (thousand tonnes).
Table 6	Stock status and TAC prediction if F is an average value for the main age groups.
Table 7	Stock status and TAC prediction if F = constant.
Table 8	Stock status and TAC prediction if $F_{0.1}$ = 0.439.

* All stock status and TAC predictions were made with the assumption that recruitment was minimal.

Légendes des tableaux

Tableau 1	Données sur l'âge (ans) et le poids (g).
Tableau 2	Composition en âges des prises.
Tableau 3	Coefficients de mortalité de pêche.
Tableau 4	Abondance du stock (millions d'individus).
Tableau 5	Biomasse (mille tonnes).
Tableau 6	Etat du stock et valeur théorique calculée de la TAC si F est une valeur moyenne pour les principaux groupes d'âge.
Tableau 7	Etat du stock et valeur théorique calculée de la TAC si F=constante.
Tableau 8	Etat du stock et valeur théorique calculée de la TAC si $F_{0.1}$=0.439.

* Toutes les valeurs théoriques des états des stocks et des TAC ont été calculées sur l'hypothèse que le recrutement était minimal.

Encabezamientos de las Tablas

Tabla 1	Datos de edad (años) y peso (gr).
Tabla 2	Composición por edades de las capturas.
Tabla 3	Coeficientes de mortalidad por pesca.
Tabla 4	Abundancia de la población (millones de individos).

Tabla 5 Biomasa (mil toneladas).

Tabla 6 Estado de la población y pronósticos de la TAC si F es un valor promedio para los grupos de edad principales.

Tabla 7 Estado de la población y pronóstico de la TAC si F=constante.

Tabla 8 Estado de la población y pronóstico de la TAC si $F_{0.1}$=0.439.

* Todos los estados de la poblacón y los pronósticos de la TAC se efectuaron suponiendo que el reclutamiento fue mínimo.

RESULTS OF FISH STOCK ASSESSMENT SURVEY, SOUTH GEORGIA, DECEMBER 1987 - JANUARY 1988

J. E. McKenna, Jr. and S. B. Saila

Abstract

Commercial fish stocks around South Georgia have been declining since the early 1970's. A survey to monitor these stocks was carried out from December 1987 to January 1988. It complements earlier surveys in the same area and showed that most of the stocks are continuing to decline. *Notothenia rossii* is showing no signs of recovery and *Champsocephalus gunnari* is likely to continue declining in abundance.

Résumé

Les stocks de poissons commerciaux autour de la Géorgie du Sud ont été en déclin depuis le début des années 70. Une campagne d'étude pour contrôler ces stocks a été effectuée de décembre 1987 à janvier 1988. Elle complète les études antérieures effectuées dans la même région, et a démontré que la plupart des stocks continuent à décliner. *Notothenia rossii* ne manifeste en aucune façon s'être rétabli, et l'abondance de *Champsocephalus gunnari* risque de continuer à décliner.

Резюме

Коммерческие запасы рыбы в районе Южной Георгии уменьшались с начала 70-х годов. Съемка по мониторингу этих запасов проводилась с декабря 1989 г. по январь 1988 г. Это дополнило результаты предыдущих съемок, проводившихся в этом районе, и показало, что большинство запасов продолжают уменьшаться. *Notothenia rossii* не имеет никаких признаков восстановления и численность *Champsocephalus gunnari*, возможно, будет продолжать уменьшаться.

Resumen

Las poblaciones de peces, comerciales alrededor de Georgia del Sur han estado declinando desde principios de los años 70. Se llevó a cabo una prospección para controlar estas poblaciones, desde diciembre de 1987 a enero de 1988. Esta complementa prospecciones anteriores en la misma área e indica que la mayoría de poblaciones continúan declinanado. *Notothenia rossii* no muestra cambios de recuperación, y es probable que *Champsocephalus gunnari* continúe declinando abundantemente.

1. INTRODUCTION

The fish stocks of the South Georgia region represent an important commercial resource to a number of nations. However, these stocks have been declining since the late 1970's (Kock 1985,1986; Gabriel 1987). In the early 1970's the fishery was supported mostly by the catch of *Notothenia rossii*, which yielded hundreds of thousands of tonnes in a season (Kock 1986). The decline in abundance of this species since that time has been striking. By 1985 the stock was estimated to be less than 10% of its pristine size (Kock 1985). The fishery is presently supported by catches of *Champsocephalus gunnari*, but its decline is also evident (Kock 1986). Other species have also shown rapid declines in the South Georgia region. Between 1975/76 and 1980/81 abundance estimates decreased by as much as two orders of magnitude (Kock et al. 1985).

The Commission for the Conservation of Antarctic Marine Living Resources has adopted a set of measures aimed at rebuilding the stocks of *N. rossii* and maintaining the other fish resources in the Antarctic. Commercial fishing has been prohibited within 12 miles of the island of South Georgia. A minimum mesh size of 120 mm is required of fisheries directed toward *N. rossii* and *Dissostichus eleginoides* and 80 mm of fisheries directed toward *N. gibberifrons*, *N. kempi*, *N. squamifrons*, and *C. gunnari*. The Commission has also recommended minimization of by-catch of *N. rossii* in other fisheries.

In an effort to monitor the status and response of these stocks, a number of surveys have been conducted around South Georgia by research vessels. This paper will examine the status of these fish stocks as of the 1987/88 survey cruise and discuss their changes over recent years. The analysis is based mostly on the comparison of estimates of stock biomass and size structure from the research vessel cruise surveys in 1984/85 (Kock 1985a), 1986/87 (Gabriel 1987), and 1987/88.

2. METHODS

The 1987/88 survey took place between 19 December 1987 and 10 January 1988. The sampling was based on a stratified random survey design. Stations were allocated to 100 m depth strata roughly in proportion to the area within each stratum and randomly assigned to specific locations within stratum (stratum 1: 50-150 m, stratum 2: 151-250 m, stratum 3: 251-500 m; Everson 1984) (Figure 1). This procedure follows that of Kock (1985) and Gabriel (1987). Most of the comparisons made here will be in reference to these two surveys.

Thirty minute tows (at 3.5 Knots) were made by the R.V. *Professor Siedlecki* using a P32/36 otter trawl equipped with 80 mm mesh and 43 - 52 mm mesh liner (Crawford 1988). The mouth opening was 17.5 m and the headrope height was 4 m (Christensen pers. comm.).

A total of 113 tows were conducted during the survey. One hundred and four occurred along the South Georgia coast and were considered standard (e.g. little or no gear damage) (Figure 1). Only four successful tows were conducted in the Shag Rocks area (division 89, Everson 1984). This maintains continuity of sampling for Shag Rocks, but can only give qualitative results. Sampling density was 1 standard tow/350 Km^2 around South Georgia and 1 standard tow/1326 Km^2 at Shag Rocks. Total biomass was estimated based on swept-area calculations (Mini-SURVAN program, Appendix A; McKenna 1988). All analyses in this report are in reference to data which has been corrected for any subsampling on deck or in the laboratory, and was standardized to 30 minute tows.

3. RESULTS

Four species (*C. gunnari, Pseudochaenichthys georgianus, N. gibberifrons,* and *Chaenochephalus aceratus*) accounted for over 86% of the catch (by weight) in the 1987/88 survey. The status of each of these species will be described in turn, as well as four other species that are of interest in the region. The biomass estimates for each species are summarized in Table 1 and are compared with earlier estimates in Table 2. A brief summary of the length information for the 1987/88 survey is given in Table 3. Too few tows were made at Shag Rocks to explicitly describe the population structure in that area. The length data from Shag Rocks was combined with those from South Georgia for the discussion here.

3.1 *Champsocephalus gunnari*

Since the decline of *N. rossii* the fishery in the South Georgia region has been supported mostly by *C. gunnari.* During the 1987/88 survey *C. gunnari* occurred in 98% of the tows around South Georgia and 100% of the Shag Rocks tows. It accounted for 33.5% of the catch by weight. The largest concentrations were located west and southwest of the island (Figure 2a). The largest tow was at station 86, yielding 428 kg. This represents 13% of the catch of this species. Most of the catch was from stratum 2 (15/31/1*)(Table 1).

The stratified mean catch per tow was 27.7 kg and the population was estimated to be 15086 mT at South Georgia. At Shag rocks the mean catch per tow was 18.2 kg and the population was estimated to be 1445 mT. This estimate is about 31% of the 1986/87 population (52672 mT, Gabriel 1987) and is very close to Kock's (1985) estimate for the 1984/85 stock (Table 2).

The average length was 26.7 cm with obvious modes at approximately 16, 23, and 32 cm (Figure 3a). The first and second modes were present in both 1986/87 and 1987/88, but no discernable mode was seen at 32 cm in 1986/87. The large mode found at 22 cm in 1986/87 (Gabriel 1987) progressed to form a smaller mode at about 32 cm in 1987/88. Fifty percent of the fish in the 22 - 25 cm size range are mature (L_{50}) (Kock et al. 1985). based on survey catches 44% of the population was at or below L_{50}.

3.2 *Pseudochaenichthys georgianus*

This species of ice fish was relatively more predominant than in earlier surveys and was the only major species which showed an increase in estimated biomass since the 1986/87 survey. During the 1987/88 survey *Ps. georgianus* occurred in 80% of the tows around South Georgia and did not occur in the Shag Rocks area. It accounted for 23.6% of the catch by weight. The largest concentrations were located northeast of the island (Figure 2b). The largest tow was at station 27, yielding 456 kg. This represents 20% of the catch of this species. Most of the catch was from stratum 2 (4/17/1*) (Table 1).

The stratified mean catch per tow was 20.9 kg and the population was estimated to be 11412 mT. This estimate is roughly double the estimate for 1986/87, but only 29% greater than the 1984/85 estimate (Table 2).

The average length was 42.9 cm with obvious modes at approximately 21, 35, and 44 cm (Figure 3b). This size structure is similar to the 1986/87 season, but the magnitudes of the two largest length modes (35 cm and 44 cm) were reversed in 1987/88.

3.3 *Notothenia gibberifrons*

This species was the most common Notothenid in the South Georgia region during the 1987/88 survey. It occurred in 93% of the tows around South Georgia and 75% of the Shag Rocks tows, and accounted for 15.6% of the catch by weight. The largest concentrations were located southeast of the island (Figure 2c). The largest tow was at station 45, yielding 122 kg. This represents 8% of the catch of this species. Most of the catch was from stratum 2 (6/9/1*) (Table 2).

The stratified mean catch per tow was 13.2 kg and the population was estimated to be 7189 mT at South Georgia. At Shag rocks the mean catch per tow was 7.7 kg and the population was estimated to be 609 mT. This value for the stock size is more than 40% lower than that estimated for the 1986/87 season (Table 2).

The average length was 42.9 cm with obvious modes at approximately 5, 17, and 37 cm (Figure 3c). This is nearly identical to that found in 1986/87. It is unclear whether a mode existed at about 22 cm.

3.4 *Chaenocephalus aceratus*

C. aceratus was the rarest of the three species of ice fish during the 1987/88 survey. However, it still accounted for 13.5% of the catch by weight. It occurred in 89% of the tows around South Georgia, but was not found in the Shag Rocks area. The largest concentrations were located east and northeast of the island (Figure 4a). The largest tow was at station 39, yielding 78 kg. This represents 6% of the catch of this species. Most of the catch was from stratum 2 (3/14/1*) (Table 1).

The stratified mean catch per tow was 12.2 kg and the population was estimated to be 6642 mT. This estimate is 58% of the 1984/85 stock (Kock 1985) and has decreased by about 40% since the last season (1986/87) (Table 2).

The average length was 38.6 cm, which is nearly 5 cm greater than the 1986/87 mean (33.9 cm, Gabriel 1987). The obvious modes occurred at approximately 15, 24, 32, and 46cm (Figure 5a). The size structure in 1986/87 was similar, but had a stronger mode at about 25 cm and a weak one at about 33 cm. There is also an indication of decreasing size with increasing depth for this species, whereas all other species showed either an increase in mean size with depth or no apparent change (Table 3).

There are four additional species of fish which are, or have been, of commercial interest. They are *N. rossii*, *N. squamifrons*, *Dissostichus eleginoides*, and *Patagonotothen brevicauda guntheri*.

3.5 *Notothenia rossii*

Although this species is rare now, it is the species that supported the commercial fishery in the South Georgia region in the early 1970's. Everson (1977) estimated the pristine stock at 500 000 tonnes. It declined rapidly from that time. By 1985 its population had dropped to less than 10% of this value (Kock 1985). It has continued to drop even at this low population level. The biomass was estimated to be between 2 000 and 4 000 mT in 1986/87 (Gabriel 1987). The estimated value from the 1987/88 survey was 1049 mT.

During the 1987/88 survey *N. rossii* occurred in only 32% of the tows around South Georgia and was not found in the Shag Rocks area. Eighty three percent of these contained less than five individuals and 43% contained a single individual. It accounted for 2.1% of the catch by weight. The largest concentrations were located north and southwest of the island (Figure 4b). The largest tow was at station 21, yielding 35 kg and consisting of 24 fish. This represents 16% of the catch of this species. Most of the catch was from stratum 2 (3/6/1*) (Table 1).

The stratified mean catch per tow was 1.9 kg and the population was estimated to be 1049 mT. This population estimate is 26% of the 1986/87 estimate (based on a normal distribution, Gabriel 1987) and 8.2% of the stock present in 1984/85 (Kock 1985) (Table 2).

The average length was 49.9 cm, which is the same as for the 1984/85 population (Kock 1985). It is close to the length of 50% maturity (Scherbich 1976, cited in Kock et al. 1985). The size structure was not clear enough to accurately identify any modes (Figure 5b). Only one individual less than 35 cm was caught.

3.6 *Notothenia squamifrons*

This Notothenid was more common in past surveys (Table 1). During the 1987/88 survey *N. squamifrons* occurred in 23% of the tows around South Georgia and 25% of the Shag Rocks tows. It accounted for 0.5% of the catch by weight. The largest concentrations were located northeast of the island (Figure 4c). The largest tow was at station 31, yielding 7 kg. This represents 15% of the catch of this species. It was unique in that most of the catch was from stratum 3 and it was completely absent from stratum 1 (shallowest) (0/1/13*) (Table 1).

The stratified mean catch per tow was 0.7 kg and the population was estimated to be 384 mT at South Georgia. At Shag rocks the mean catch per tow was 13.2 kg and the population was estimated to be 42 mT. At best this estimate shows a decline in biomass of an order of magnitude (based on the delta distribution, Gabriel 1987) and possibly two orders of magnitude (based on the normal distribution, Gabriel 1987) since the 1986/87 season (Table 2).

The average length was 18.7 cm. This is about half of the 1986/87 value. The size structure of this species was very different from that of the 1986/87 season. Although the modes at 17 and 28 cm correspond to the first two in the 1986/87 season, the third and largest peak (at 40-42 cm) was absent from the 1987/88 survey. The strongest peak in 1987/88 was at the smallest size (~ 18 cm)(Figure 5c). Only 20 individuals greater than 30 cm were collected.

3.7 *Dissostichus eleginoides*

This predatory species was generally uncommon in the 1987/88 survey, but accounted for the single largest catch (12 mT) at a non-random site (this observation could not be included as a representative station). It occurred in 32% of the tows around South Georgia and 75% of the Shag Rocks tows, and accounted for 1.3% of the catch by weight. The largest concentrations were located northwest of the island and at Shag Rocks (Figure 6a). The largest tow was at station 104, yielding 20 kg. This represents 15% of the catch of this species, which was evenly distributed between the three strata (1/1/1*) (Table 1).

The stratified mean catch per tow was 1.3 kg and the population was estimated to be 697 mT at South Georgia. At Shag rocks the mean catch per tow was 5.1 kg and the population was estimated to be 408 mT. This population is approximately half of the 1986/87 stock and 14% of the 1984/85 population (Kock 1985) (Table 2).

The individual lengths had the widest range of any species (6 - 125 cm). The average length was 33.3 cm; a decrease of over ten centimeters from 1986/87. Sampling was not extensive enough to clearly describe the size structure, but there appear to be modes at roughly 16, 27, and 46 cm (Figure 7a). Nine individuals over 55 cm were collected.

3.8 *Patagonotothen brevicauda guentheri*

Patagonotothen brevicauda guentheri is unique in that it is endemic to Shag Rocks. During the 1987/88 survey it occurred in 100% of the Shag Rocks tows, but was not found in the South Georgia area. It accounted for 0.5% of the catch by weight. The largest tow was at station 129, yielding 30 kg (Figure 6b). This represents 63% of the catch of this species. Most of the catch was from stratum 1 (7/4/1*) (Table 1).

The stratified mean catch per tow was 11.28 kg and the population was estimated to be 895 mT. This stock estimate is greater than that for 1986/87 (331 kg, Gabriel 1987), but is 14% of the 1984/85 estimate (Kock 1985) (Table 2).

The average length was 15.2 cm and the only obvious mode was at about 15 cm (Figure 7b), which is similar to that described for the 1986/87 population.

4. DISCUSSION

The stock of *C. gunnari* experienced a severe decrease since the 1986/87 survey (Table 2). The catch for that season was supported by the single, strong 84/85 year class (Gabriel 1987). The decreased biomass in 1987/88 would suggest that this cohort has been greatly reduced. Length frequency distributions suggest that this cohort (32 cm) is the strongest, but its magnitude relative to the 85/86 cohort (~23 cm) is much smaller than in the previous season (Figure 3a). The abundance of pre-recruit fish appears to be low (Figure 3a). Future catches of *C. gunnari* will depend on what remains of the 84/85 year class and the weak 85/86 cohort. Future declines in biomass are likely.

Fish in the 44-48 cm size class were responsible for the increased stock of *Ps. georgianus* in 1987/88 (Figure 3b, Table 3)). However, this increase may be temporary, because the following two year classes are small (Figure 3b). As members of this strong year class are removed by fishing the population will probably decline again.

The decrease in the *N. gibberifrons* population was substantially greater between 1986/87 and 1987/88 (5331 mT) than from 1984/85 to 1986/87 (2633 mT) (Table 2). However, the stock might be improved by the relatively large number of fish less than 25 cm that are about to recruit (Figure 3c).

The biomass of *Ch. aceratus* has declined steadily from 1984/85 to the present (Table 2), while the average size has increased. This can be explained by the progression of the large mode found at 25 cm, in 1986/87, to about 32 cm in 1987/88. The cohorts following the 32 cm class are small and will probably not substantially increase this stock (Figure 5a). Without strong recruitment the decrease in biomass can be expected to continue.

Despite the very low stock size of *N. rossii* it has continued to decline. Declining biomass and a relatively large mean length (49.9 cm), indicate the continued removal of sexually mature individuals without new recruitment to rebuild the population.

---

* The proportion of catch, by weight, in each stratum : stratum1/stratum2/stratum3

The biomass of *N. squamifrons* showed the most drastic decline of the species examined. The population dropped by one to two orders of magnitude and the mean length was halved since 1986/87. It appears that the fishery was almost completely supported by fish that were in the 40-42 cm size class during 1986/87. This size class was absent from the 1987/88 population and no fish over 40 cm were caught. The length frequency distribution shows that the strongest mode was at 18 cm (1987/88) (Figure 5c). This group of recruits might contribute to a recovery in the 1988/89 season, but the magnitude of that recovery is uncertain.

The estimated population of *D. eleginoides* is about half the size of the 1986/87 population and the mean length has dropped by over 10 cm. The decreasing mean size shows the removal of large, sexually mature individuals and the decreasing biomass indicates no substantial recruitment. It is not clear from the length frequency distribution (Figure 7a) if substantial recruitment can be expected in the near future.

The population estimate of *P.b. guentheri* increased relative to the 1986/87 season, but this is probably due to the difference in sampling gear used (80 mm mesh in 1986/87 at Shag Rocks). The population as of 1987/88 is about 14% of that estimated for the 1984/85 season (Table 2). The significance of this decrease is unknown, but appears to be substantial. Not enough information is available to accurately describe the biomass trends of this species.

In summary, it is clear that all of the stocks examined here, with the exception of *Ps. georgianus*, have declined since the 1986/87 survey, and most for much longer than that. It seems likely that this trend will continue. The increase of *Ps. georgianus* appears to be due to a strong year class, but this will probably be short-lived. Based on research catches, without a substantial increase in recruitment, *C. gunnari* is likely to decline rapidly in the future.

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APPENDIX A

SOURCE CODE OF THE SURVEY ANALYSIS PROGRAM; WRITTEN IN QUICK basic (MICROSOFT), VERSION 4.0.

```
PRINT "Mini-SURVAN,  filename:SMSURVAN.BAS"
PRINT
PRINT "  BY Jim McKenna"
PRINT "  7 June 1988"
PRINT
'
'  STATISTICAL FORMULAS USED TO ESTIMATE THE POPULATIONS OF FISH IN THE
'  SOUTH GEORGIA AND SHAG ROCKS AREAS DURING THE 1987-1988 AMLR CRUISE.
'
'
'  KEYWORD DEFINITION
'
'        µk - Sample mean for stratum k
'        µST - Stratified mean
'        xi - Observation (catch of tow i)
'        Nk - Number of stations in stratum k
'        N - Total number of stations (=tows)
'        S2k - Sample variance for stratum k
'        SEk - Standard error for stratum k
'        ßk - Expansion factor for stratum k
'        ßST - Expansion factor for the whole survey area
'          a.s.t - Area of standard tow (0.019452838 n.mi.2, Gabriel 1988
'                                    pers comm)
'        CONF - 95% confidence limits of the stratified mean population
'             estimate.
'        Vk - Variance of mean for stratum k
'        VST - Variance of stratified mean
'        SEST - Standard error of stratified mean
'         CVk - Coefficient of variation for stratum k
'        CVST - Coefficient of variation for stratified mean
'         Pk - Minimum population for total area, stratum k
'        S2Pk - Variance of the Minimum population for the total area,
'                                    stratum k
'        PST - Minimum population for total area based on stratified mean
'        S2PST - Variance of Minimum population for the total area, based
'              on the stratified mean.
'
'                         Nk
'                          Σ xi
'                         i=1
'    Sample Mean      µk=------------                 Manual
'                           Nk
'
'
'                             Nk
'                               Σ(xi-µk)
'                             i=1
'     Sample  Variance      S2k=----------------           Cochran
'                                   (Nk-1)
```

Coefficient of variation $CVk = \frac{Sk}{\mu k} \times 100$ Manual

Variance of the Mean $Vk = \frac{S2k}{Nk}$ Snedecor

Standard Error of the Mean $SEk = \beta Vk$ Manual

Minimum population for total area $Pk = \mu k \beta k$

Variance of the Minimum Population for Area $S2Pk = Vk\ \beta k$

STRATIFIED STATISTICS

Stratified Mean $\mu ST = \frac{\sum_{k=1}^{L} \beta k\ \mu k}{\beta ST}$ Cochran

Population Variance $S2ST = \frac{\sum_{i=1}^{N} (xi - \mu ST)}{(N - 1)}$

Variance of Stratified Mean $VST = \Sigma(Vk\ (\beta k / \beta ST))$ Cochran

Standard Error of Stratified Mean $SEST = \beta VST$ Manual

Coefficient of Variation $\frac{SEST}{\mu ST} \times 100$ Manual

Minimum Population for Total Area, $PST = \mu ST\ \beta ST$

```
'    Stratified
'
'
'   Variance of Minimum
'  Population for Area,     S2PST= VST ßST
'   Stratified
'
'                                ΣAk
'                        ,βST=-----
'                                a.s.t.
'
'   95% Confidence Limits:      µST æ (1.96 SEST)
'
'
' 1986: STRATUM  AREA(S.G.)  EXPANSION FACTOR  # OF TOWS
'                -------  -----------  -----------------  ----------
'            1      2249             115333.328       34
'            2      5271             270307.688       56
'            3      3089             158410.250       19
'
'
'
DEFDBL A
PRINT
PRINT "This program will accept either weight or number data"
PRINT "The purpose is to produce the same statistical breakdown and "
PRINT "population estimates as SURVAN"
PRINT "  Data are expected in the following form:"
PRINT "      station,stratum,species(full name in quotes),weight or count"
PRINT "  The data must be sorted by species!!"
PRINT "  All observations with an abundance value of 0. should be removed!"
PRINT "  This program expects the data to have been corrected to a standard"
PRINT "  tow of 30 min. at 3.5 knots, and for any subsampling that occurred."
PRINT "  A representative tow is defined as one in which the quality code"
PRINT "   values are as follows:"
PRINT "    STATION_TYPE_CODE = 1"
PRINT "     HAUL_COND        = 1 or 2"
PRINT "    GEAR_COND       <= 6"
PRINT
PRINT "during program operation the data are stored in arrays according"
PRINT "to stratum."
PRINT
'
INPUT "Please, enter a title for this run :"; TITL$
PRINT "INITIALIZATION AND DIMENSIONING ..."
AST = .019452838#: 'area of standard tow (n.mi. )
DIM BETA(3), AREA(3)
DIM AR(3, 300), NK(3): ' abundance arrays and # of obs. in each stratum
DIM MEAN(3), S2(3), S(3), CV(3), V(3), SE(3), P(3), S2P(3): ' SAMPLE statistics
'
GOSUB INIT:
FIRSTPASS = 1
COUNT = 1
TOTAREA = 0
FOR I = 1 TO 3
   PRINT "Please, enter the area expansion factor for stratum"; I; " (n.mi. ):"
```

```
   INPUT BETA(I)
   PRINT "Please, enter the area of stratum"; I; " (n.mi. ):"
   INPUT AREA(I)
   PRINT "Please, enter the # of REPRESENTATIVE stations (=tows) in stratum"; I; ":"
   INPUT NK(I)
  TOTAREA = TOTAREA + AREA(I)
NEXT I
BETAST = TOTAREA / AST
'
PRINT "Are the data for this run WEIGHT (W) or NUMBERS (N)?"
INPUT TYPFLAG$:  ' flag for weight or counts
IF TYPFLAG$ = "W" OR TYPFLAG$ = "w" OR TYPFLAG$ = "WEIGHT" OR TYPFLAG$ = "weight"
OR TYPFLAG$ = "wt" OR TYPFLAG$ = "WT" THEN TYPFLAG$ = "WEIGHT (Kg)" ELSE
TYPFLAG$ = "NUMBERS"
'
INPUT " Enter the name for the output file"; FIL2$
OPEN "O", 2, FIL2$
'
RETRY: INPUT "Are the data in a file"; ans1$
IF ans1$ <> "Y" AND ans1$ <> "y" AND ans1$ <> "n" AND ans1$ <> "N" THEN GOTO RETRY:
IF ans1$ = "N" OR ans1$ = "n" THEN GOTO LOOP1:
'
INPUT "ENTER THE NAME OF THE DATA FILE", FILN$
OPEN "I", 1, FILN$
'
LOOPX: IF ans1$ = "y" OR ans1$ = "Y" THEN GOSUB READDATA:
IF ans1$ = "y" OR ans1$ = "Y" THEN GOTO RRUN:
'
' ENTER DATA DIRECTLY
LOOP1:   PRINT "ENTER station,stratum,species,abundance FOR POINT"; PT; ":"
        PT = PT + 1
       INPUT ST, STRT, SPP$, ABUND
       IF FIRSTPASS = 1 THEN LASTSP$ = SPP$: FIRSTPASS = 0
        IF SPP$ <> LASTSP$ THEN PRINT "Please hold that datum. The program will now run
the stats on "; LASTSP$; " and return to this point for the next species": GOTO RDEND:
       LASTSP$ = SPP$
      ON STRT GOTO ARRAY1, ARRAY2, ARRAY3
ARRAY1: AR(1, ARCOUNT1) = ABUND
       ARCOUNT1 = ARCOUNT1 + 1
      GOTO LOOP1:
ARRAY2: AR(2, ARCOUNT2) = ABUND
       ARCOUNT2 = ARCOUNT2 + 1
      GOTO LOOP1:
ARRAY3: AR(3, ARCOUNT3) = ABUND
       ARCOUNT3 = ARCOUNT3 + 1
      GOTO LOOP1:
'
RDEND: LASTSP$ = SPP$
'
RRUN: PRINT "Calculating statistics..."
FOR K = 1 TO 3
   PRINT "STRATUM"; K; " ..."
   PRINT "MEAN"
   SUM1 = 0
   IF AR(K, 1) = 0 THEN
      MEAN(K) = 0!
```

```
      S2(K) = 0!
      CV(K) = 0!
      V(K) = 0!
      SE(K) = 0!
      P(K) = 0!
      S2P(K) = 0!
'
    GOTO 50
  END IF
  FOR I = 1 TO NK(K)
    SUM1 = SUM1 + AR(K, I)
  NEXT I
  MEAN(K) = SUM1 / NK(K): 'MEAN BY STRATUM
  PRINT "VARIANCE"
  SUMV = 0
  FOR I = 1 TO NK(K)
    SUMV = SUMV + (AR(K, I) - MEAN(K)) ^ 2
  NEXT I
  IF NK(K) = 1 THEN
      S2(K) = 0
   ELSE
      S2(K) = SUMV / (NK(K) - 1):  ' VARIANCE BY STRATUM
  END IF
  PRINT "COEFFICIENT OF VARIATION"
  CV(K) = SQR(S2(K)) / MEAN(K) * 100:  ' COFF. OF VAR.
  PRINT "VARIANCE OF THE MEAN"
  V(K) = S2(K) / NK(K): ' VAR. OF THE MEAN
  PRINT "STANDARD ERROR OF THE MEAN"
  SE(K) = SQR(V(K))
  PRINT "MINIMUM POPULATION ESTIMATE FOR TOTAL AREA"
  P(K) = MEAN(K) * BETA(K)
  PRINT "VARIANCE OF THE MINIMUM POPULATION ESTIMATE"
    S2P(K) = (V(K) * BETA(K) ^ 2):  ' VAR. OF MIN. POP. EST.
50 NEXT K
PRINT " ---- STRATIFIED  STATISTICS ---- "
  N = NK(1) + NK(2) + NK(3): ' TOTAL NUMBER OF SAMPLES TAKEN
  PRINT "STRATIFIED MEAN"
  SUM1 = 0
  FOR K = 1 TO 3
     SUM1 = SUM1 + (MEAN(K) * BETA(K))
  NEXT
  STMEAN = SUM1 / BETAST: 'STRATIFIED MEAN
  PRINT "POPULATION VARIANCE"
  PSUM = 0
  FOR K = 1 TO 3
    FOR I = 1 TO NK(K)
       PSUM = PSUM + (AR(K, I) - STMEAN) ^ 2
    NEXT I
  NEXT K
  IF N = 1 THEN
    S2ST = 0
   ELSE
    S2ST = PSUM / (N - 1): ' POPULATION VARIANCE
  END IF
  PRINT "VARIANCE OF STRATIFIED MEAN"
  VST = 0
```

```
FOR K = 1 TO 3
   VST = VST + (V(K) * (BETA(K) / BETAST) ^ 2): ' VAR. OF STRAT. MEAN
NEXT K
PRINT "STANDARD ERROR OF THE STRATIFIED MEAN"
SEST = SQR(VST)
PRINT "COEFFICIENT OF VARIATION"
IF STMEAN = 0! THEN
  CVST = 0
 ELSE
  CVST = SEST / STMEAN * 100
END IF
PRINT "MINIMUM POPULATION ESTIMATE, BASED ON STRATIFIED MEAN"
PST = STMEAN * BETAST
PRINT "VARIANCE OF MIN. POPULATION ESTIMATE, BASED ON STRATIFIED MEAN"
S2PST = VST * BETAST ^ 2: ' VAR. OF MIN. POP., STRAT. MEAN
  PRINT "95% confidence limits"
 CONFU = STMEAN + (1.96 * SEST)
 CONFL = STMEAN - (1.96 * SEST)
'go to output sub.
 GOSUB POUT:
 IF EOF(1) AND COUNT = 1 THEN COUNT = 2: GOSUB POUT ELSE IF EOF(1) AND COUNT = 2
THEN STOP
'
GOSUB INIT: ' REINITIALIZE VARIABLES
GOTO LOOPX: ' CONTINUE WITH THIS DATA SET
'
'
READDATA: PRINT "SUB. TO READ DATA FROM A FILE..."
IF FIRSTPASS = 1 THEN INPUT #1, ST, STRT, SPP$, ABUND
IF FIRSTPASS = 0 THEN ST = NEXTST: STRT = NEXTSTRT: SPP$ = NEXTSP$:
ABUND = NEXTAB
LASTSP$ = SPP$
WHILE SPP$ = LASTSP$ AND NOT EOF(1)
      ON STRT GOTO ARR1, ARR2, ARR3
ARR1: AR(1, ARCOUNT1) = ABUND
        PRINT "1"; ARCOUNT1; AR(1, ARCOUNT1)
       ARCOUNT1 = ARCOUNT1 + 1
      GOTO LOOP2:
ARR2: AR(2, ARCOUNT2) = ABUND
        PRINT "2"; ARCOUNT2; AR(2, ARCOUNT2)
       ARCOUNT2 = ARCOUNT2 + 1
      GOTO LOOP2:
ARR3: AR(3, ARCOUNT3) = ABUND
        PRINT "3"; ARCOUNT3; AR(3, ARCOUNT3)
       ARCOUNT3 = ARCOUNT3 + 1
      GOTO LOOP2:
LOOP2: IF EOF(1) THEN GOTO EX1:
INPUT #1, ST, STRT, SPP$, ABUND: PRINT ST, STRT, SPP$, ABUND
EX1: WEND
'
FIRSTPASS = 0
'Hold these as the first record of the next species input set.
NEXTST = ST
NEXTSTRT = STRT
NEXTSP$ = SPP$
NEXTAB = ABUND
```

```
'
RETURN
'
INIT: ARCOUNT1 = 1:  ' next empty element of array AR1
ARCOUNT2 = 1: ' next empty element of array AR2
ARCOUNT3 = 1: ' next empty element of array AR3
PT = 1:  ' count of points entered for this species-location
'
' Re-initialize abundance array.
FOR K = 1 TO 3
  FOR I = 1 TO 300
       AR(K, I) = 0!
  NEXT I
NEXT K
RETURN
'
POUT: 'SUB. TO SEND RESULTS TO OUTPUT FILE.
PRINT #2, "Mini-SURVAN", "CATCH/TOW"
PRINT #2, " "
PRINT #2, TAB(25); DATE$, TIME$
PRINT #2, " "
PRINT #2, TAB(12); LASTSP$, TYPFLAG$
PRINT #2, TITL$
PRINT #2, " "
PRINT #2, TAB(115); "VARIANCE"
PRINT #2, "STRATUM"; TAB(15); "SAMPLE"; TAB(30); "SAMPLE"; TAB(45);
"COEFFICIENT"; TAB(60); "VARIANCE"; TAB(72); "STANDARD ERROR"; TAB(90);
"MINIMUM POPULATION"; TAB(110); "MINIMUM POPULATION"
PRINT #2, TAB(11); "N"; TAB(15); "MEAN"; TAB(30); "VARIANCE"; TAB(45); "OF
VARIATION"; TAB(60); "THE MEAN"; TAB(72); " OF THE MEAN"; TAB(90); "FOR TOTAL
AREA"; TAB(110); "FOR TOTAL AREA"
PRINT #2, " "
FOR K = 1 TO 3
   PRINT #2, K; TAB(11); N; TAB(15); MEAN(K); TAB(30); S2(K); TAB(45); CV(K);
TAB(60); V(K); TAB(72); SE(K); TAB(90); P(K); TAB(110); S2P(K)
NEXT K
PRINT #2, " ": PRINT #2, " "
PRINT #2, TAB(115); "VARIANCE OF"
PRINT #2, TAB(10); "STRATIFIED"; TAB(25); "POPULATION"; TAB(38); "VARIANCE OF ";
TAB(53); "STANDARD ERROR OF"; TAB(71); " COEFFICIENT"; TAB(85); "MINIMUM
POPULATION"; TAB(110); "MINIMUM POPULATION"
PRINT #2, TAB(10); "  MEAN     "; TAB(25); "VARIANCE"; TAB(38); "STRATIFIED MEAN";
TAB(55); "STRATIFIED MEAN"; TAB(71); " OF VARIATION"; TAB(85); " FOR TOTAL AREA";
TAB(110); "FOR TOTAL AREA"
PRINT #2, " "
PRINT #2, TAB(10); STMEAN; TAB(25); S2ST; TAB(38); VST; TAB(55); SEST; TAB(71);
CVST; TAB(85); PST; TAB(110); S2PST
PRINT #2, " "
PRINT #2, "95% CONFIDENCE LIMITS"
PRINT #2, "ABOUT STRATIFIED MEAN", "LOW:", CONFL, "HIGH:", CONFU
PRINT #2, " ": PRINT #2, " "
'
RETURN
```

Table 1: Estimates of mean trawlable biomass and coefficients of variation by depth strata, December 1987 - January 1988.

	Stratum							
	50-150 m		151-250 m		251-500 m		Combined	
	Minimum biomass (mt)	Coef. var. (%)	Minimum biomass (mt)	Coef. var. (%)	Minimum biomass (mt)	Coef. var. (%)	Minimum biomass (mt)	Coef. var. (%)
C. gunnari								
South Georgia	3557	46.8	10878	24.0	651	36.9	15086	20.7
Shag Rocks	225	-	1188	94.8	34	-	1447	77.8
Ps. georgianus								
South Georgia	1426	22.7	9017	28.1	970	88.4	11412	23.6
N. gibberifrons								
South Georgia	1834	28.0	4404	17.5	950	29.9	7189	13.5
Shag Rocks	538	-	60	100.	10	-	609	9.9
Ch. aceratus								
South Georgia	703	16.1	5252	14.5	686	31.7	6642	12.0
N. rossii								
South Georgia	234	30.2	634	35.7	181	73.1	1049	25.9
N. squamifrons								
South Georgia	-	-	17	38.8	367	26.6	384	25.5
Shag Rocks								
D. eleginoides								
South Georgia	65	53.9	221	45.6	410	25.2	697	21.3
Shag Rocks	326	-	83	81.8	-	-	408	16.5
P.b. guntheri								
Shag Rocks	564	-	331	69.1	103	-	999	-
Number of hauls								
South Georgia	33		54		17		104	
Shag Rocks	1		2		1		4	

Table 2: Comparison of estimates of mean trawlable biomass, standard deviation and coefficient of variation based on the normal distribution, 1984/85 and 1986/87, relative to estimates for 1987/88.

	Shag Rocks			South Georgia			Combined		
	Minimum biomass (mt)	Std. dev.	Coef. var. (%)	Minimum biomass (mt)	Std. dev.	Coef. var.	Minimum biomass (mt)	Std. dev.	Coef. var. (%)
C. gunnari									
Kock (1985)	-	-	-	-	-	-	15821	16042	101.4
Gabriel(1987)	10023	5523	55.1	42649	8047	18.9	52672	9760	18.5
1987/88	1447		77.8	15086		20.6	16533	3301	20.0
Ps. georgianus									
Kock (1985)	-	-	-	-	-	-	8134	2684	33.0
Gabriel(1987)	-	-	-	4579	671	14.6	4579	671	14.6
1987/88	-	-	-	11412	2691	23.6	11412	2691	23.6
N. Gibberifrons									
Kock (1985)	-	-	-	-	-	-	15762	4476	28.4
Gabriel(1987)	363	164	45.2	12766	1975	15.5	13129	1982	15.1
1987/88	609	60	9.9	7189	969	13.5	7798	971	12.5
Ch. aceratus									
Gabriel(1987)	-	-	-	10816	1441	13.3	10816	1441	13.3
1987/88	-	-	-	6642	800	12.0	6642	800	12.0
N. rossii									
Kock (1985)	-	-	-	-	-	-	12781	12768	99.9
Gabriel(1987)	-	-	-	3966	2707	68.3	3966	2707	68.3
1987/88	-	-	-	1049	277	25.9	1049	277	25.9
N. squamifrons									
Gabriel(1987)	30	17	56.7	37166	29164	78.5	37196	29165	78.4
1987/88	42	-	-	384	98	25.5	284	98	25.5
D. eleginoides									
Kock (1985)	-	-	-	-	-	-	8159	6242	76.5
Gabriel(1987)	763	305	39.9	1541	519	33.7	2304	602	26.1
1987/88	408	67	16.5	697	149	21.3	1105	163	14.8
P.b. guntheri									
Kock (1985)	-	-	-	-	-	-	7256	3417	47.1
Gabriel(1987)	331	141	45.4	-	-	-	331	141	45.4
1987/88	999	229	25.6	-	-	-	999	229	22.9

Table 3 : Summary of length information for 1987/88 AMLR survey of South Georgia

Species	Size Range (cm)	Mean Overall Length (cm)	Mean Length by Stratum (cm) 1	2	3	L_{50}* (cm)	Obvious Modes (cm)
C. gunnari	2 - 57	26.7	21.4	29.2	34.9	22 - 25	16,23,32
Ps. georgianus	8 - 57	42.9	44.9	42.4	44.6	41 - 46	21,35,44
N. gibberifrons	3 - 51	21.4	17.7	24.0	27.5	32 - 34	5,17,37
N. rossii	7 - 69	49.9	52.3	48.4	53.4	41 - 51	- - -
Ch. aceratus	11 - 71	38.6	43.7	38.1	36.1	46 - 58	15,24,32,46
N. squamifrons	7 - 40	18.7	-	22.6	18.6	~ 30 [1]	18,28
D. eleginoides	6 - 125	33.3	24.2	40.3	47.7	~ 95 [2]	16,27,46
P.b. guntheri	9 - 22	15.2	14.9	16.2	14.6	-	15

* Length of 50% maturation, taken from Table 2, Kock et al. 1985

1 for Kerguelen

2 for Crozet

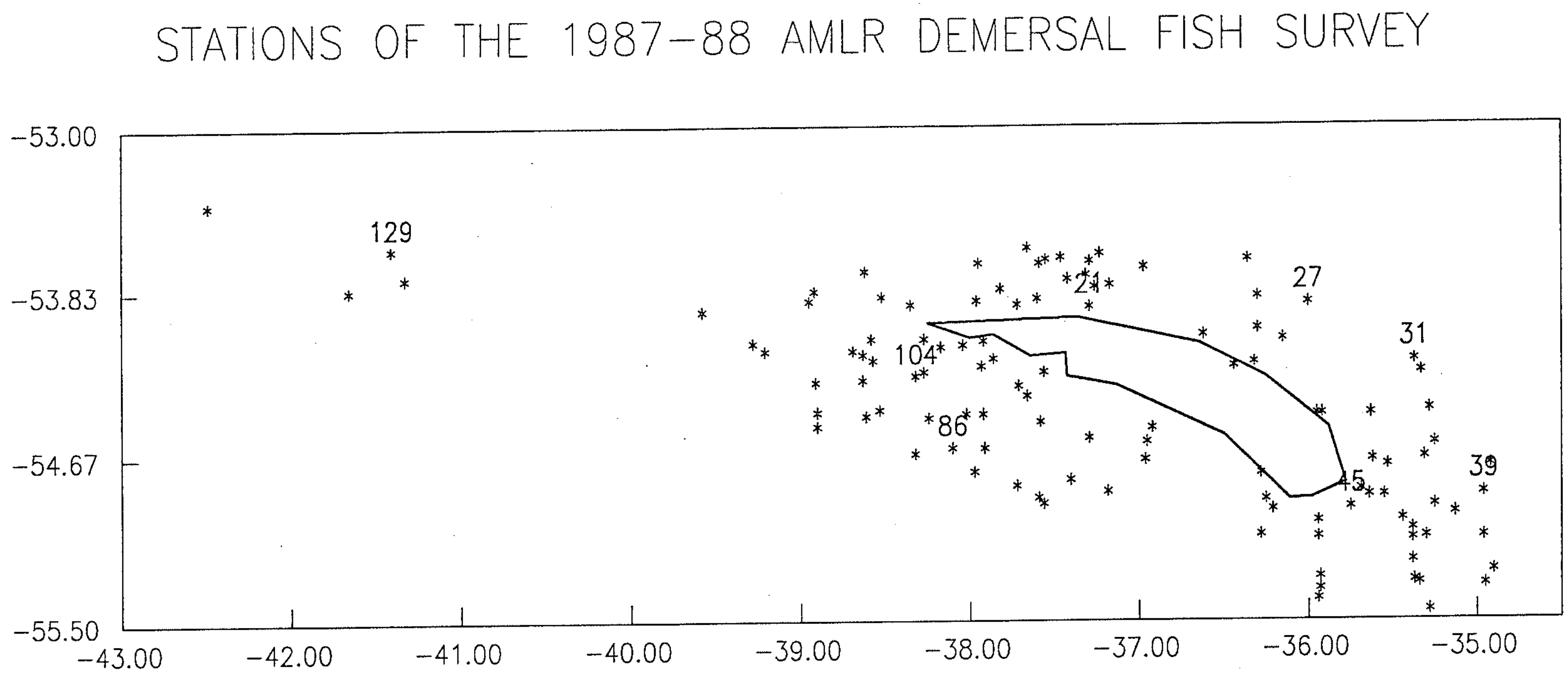


Figure 1: Map of station locations for the 1987-1988 AMLR survey cruise - South Georgia and Shag Rocks. The axes are in degrees west longitude and degrees south latitude, respectively. Only those stations which are explicitly referenced in the text have been labelled with a number.

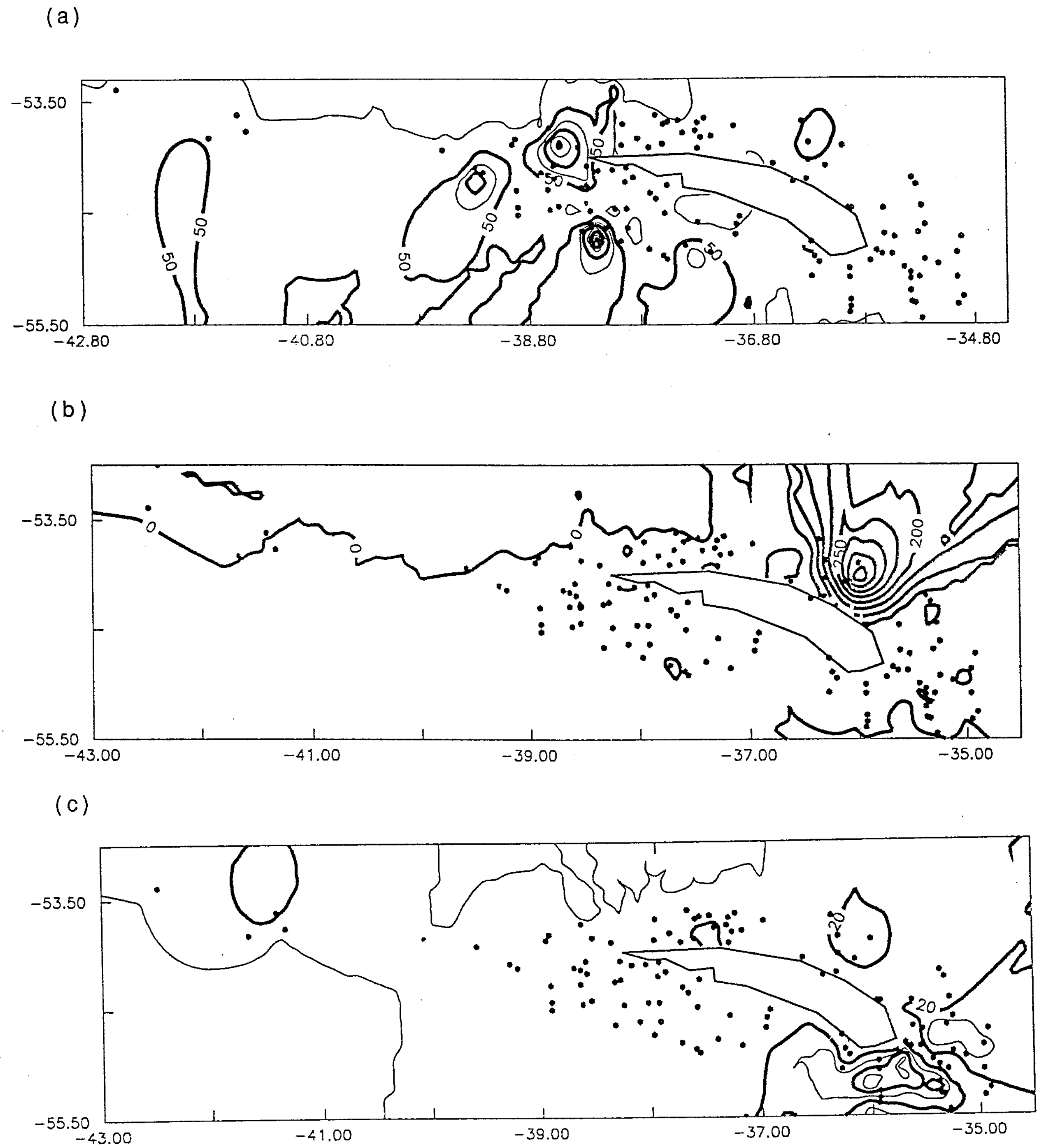
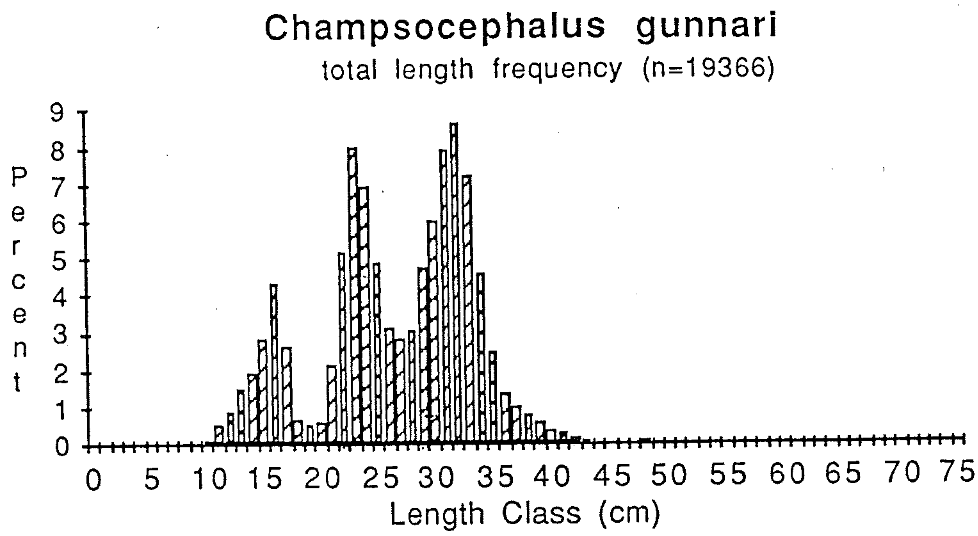


Figure 2: (a) Distribution of catch per tow, *Champsocephalus gunnari*. Contour interval is 50 kg (range 0-350).

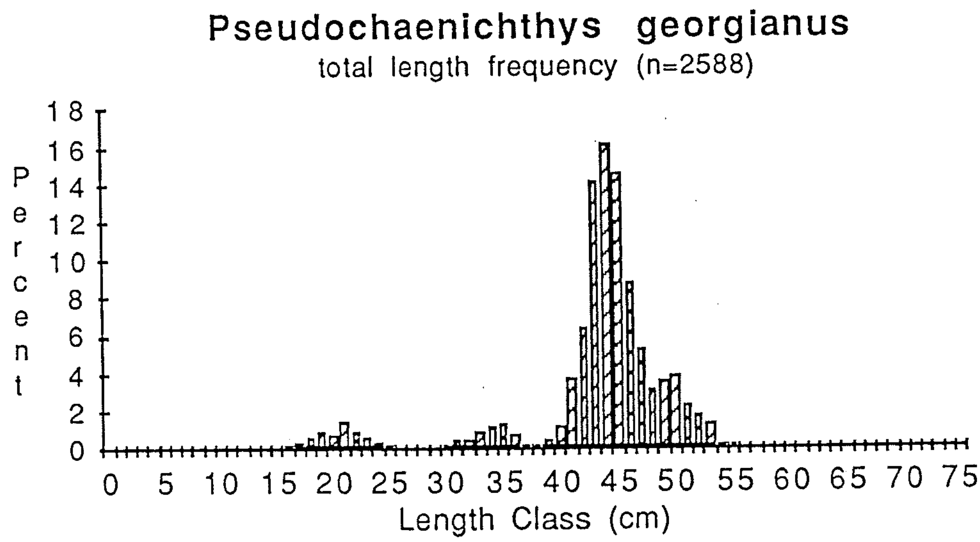
(b) Distribution of catch per tow, *Pseudochaenichthys georgianus*. Contour interval is 50 kg (range 0-400).

(c) Distribution of catch per tow, *Notothenia gibberifrons*. Contour interval is 20 kg (range 0-80).

(a)



(b)



(c)

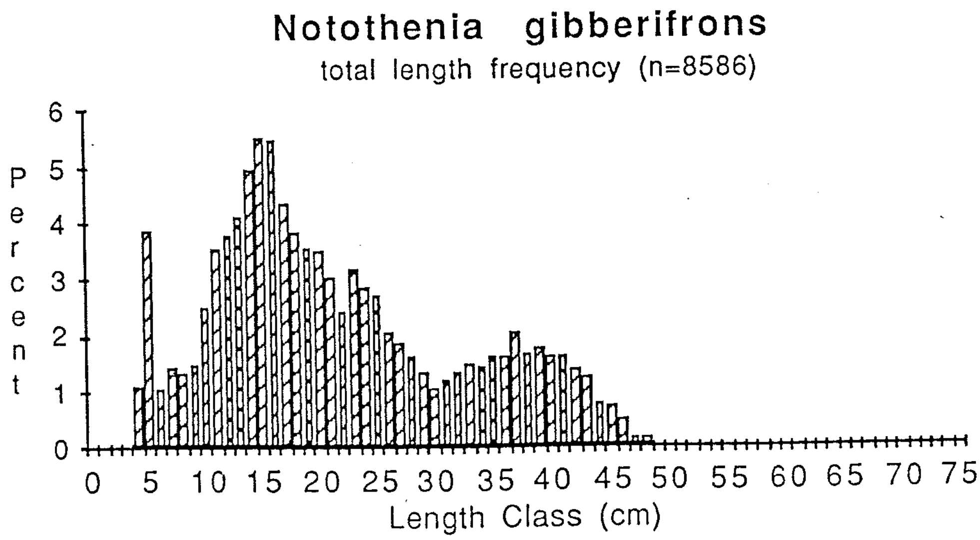


Figure 3: (a) Length frequency distribution, *Champsocephalus gunnari.*

(b) Length frequency distribution, *Pseudochaenichthys georgianus.*

(c) Length frequency distribution, *Notothenia gibberifrons.*

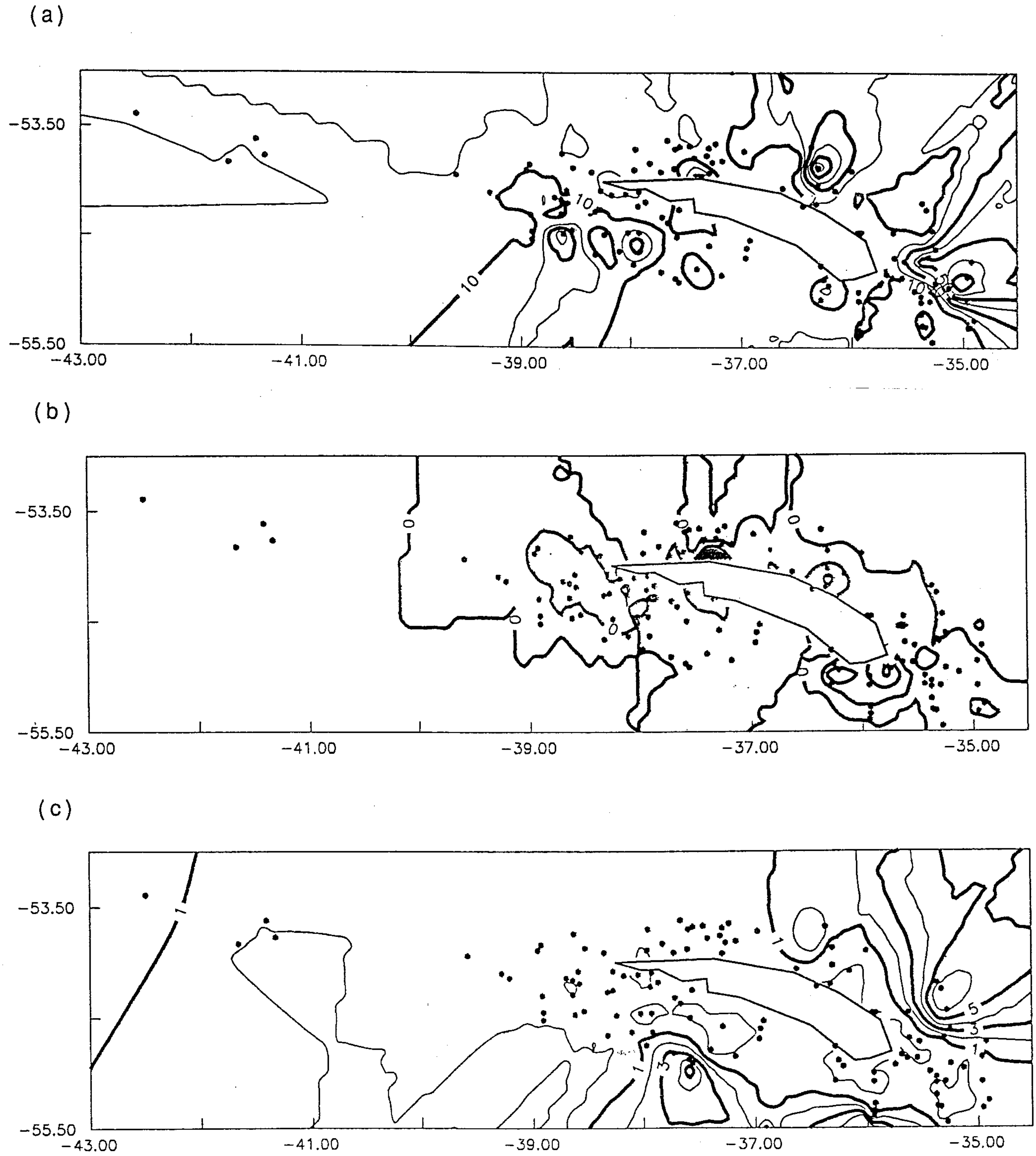
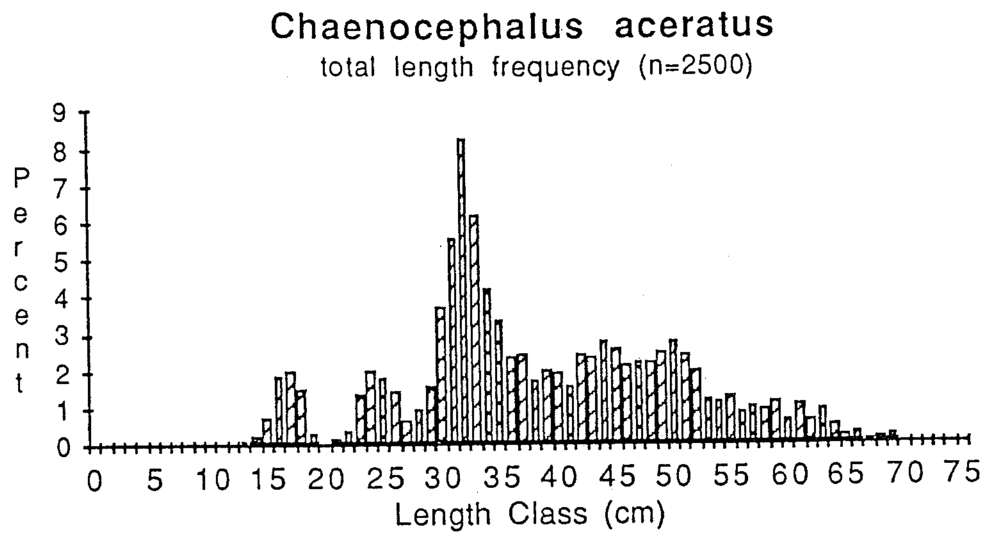


Figure 4: (a) Distribution of catch per tow, *Chaenocephalus aceratus*. Contour interval is 10 kg (range 0-70).

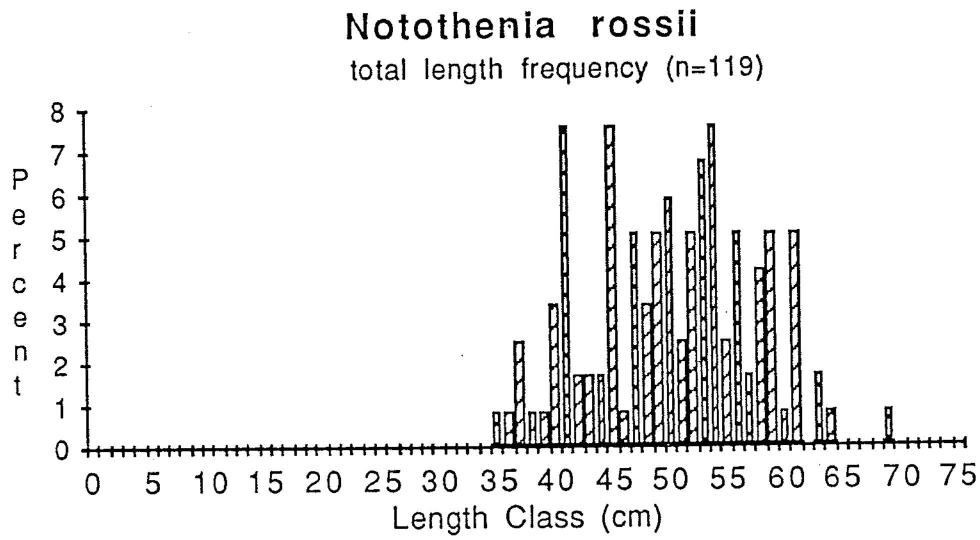
(b) Distribution of catch per tow, *Notothenia rossii*. Contour interval is 5 kg (range 0-25).

(c) Distribution of catch per tow, *Notothenia squamifrons*. Contour interval is 1 kg (range 0-6).

(a)



(b)



(c)

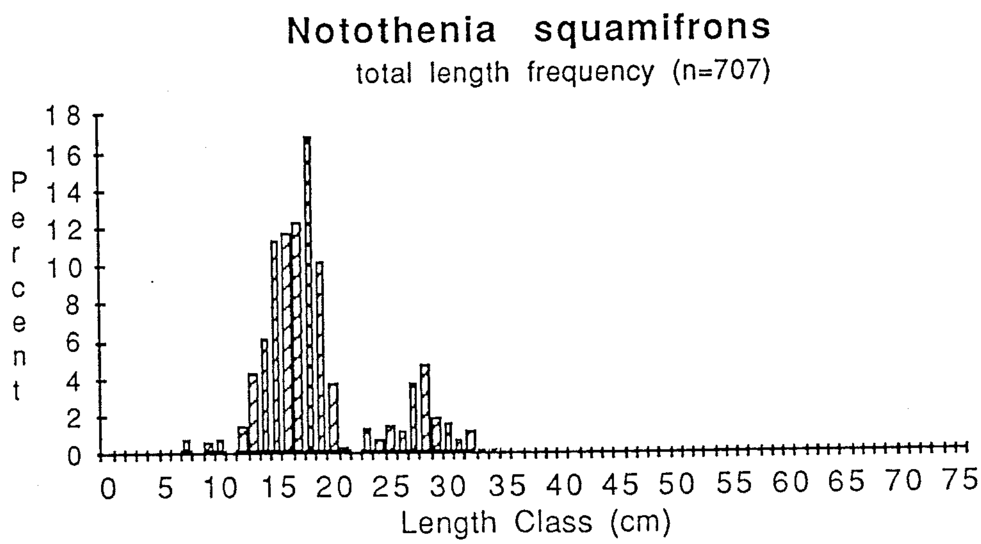
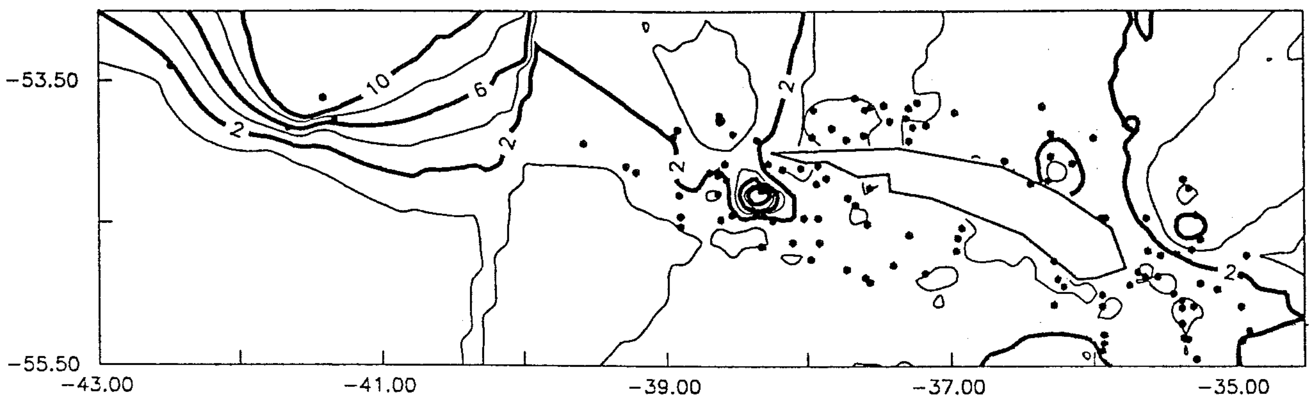


Figure 5: (a) Length frequency distribution, *Chaenocephalus aceratus.*

(b) Length frequency distribution, *Notothenia rossii.*

(c) Length frequency distribution, *Notothenia squamifrons.*

(a)



(b)

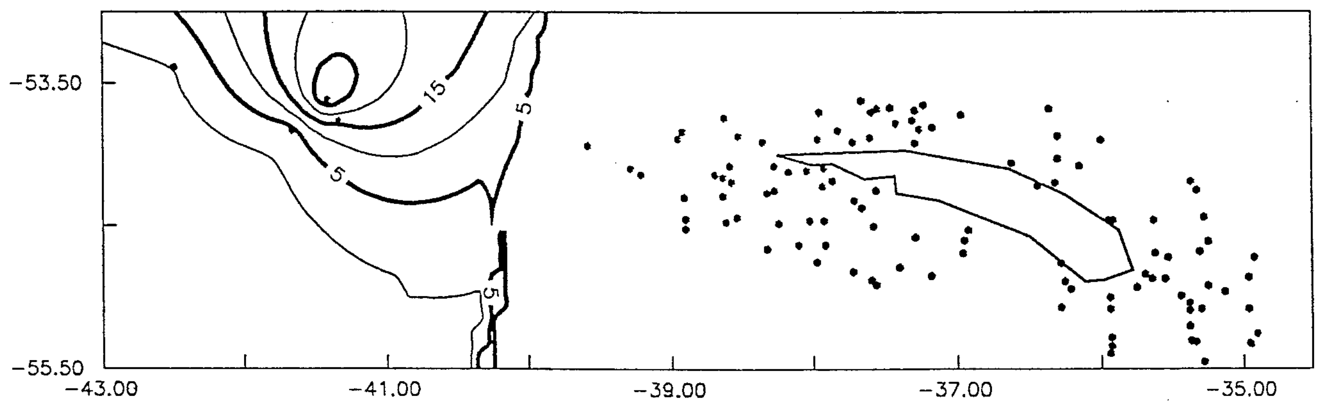
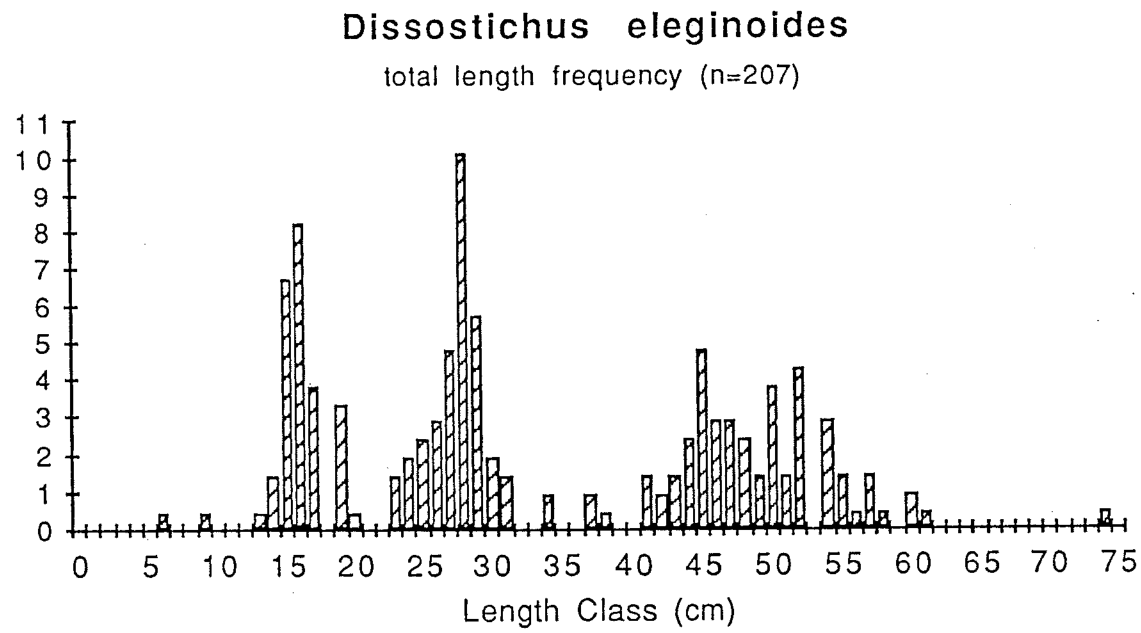


Figure 6: (a) Distribution of catch per tow, *Dissostichus eleginoides.* Contour interval is 2 kg (range 0-10).

(b) Distribution of catch per tow, *Patagonothen brevicauda guntheri.* Contour interval is 5 kg (range 0-25).

(a)



(b)

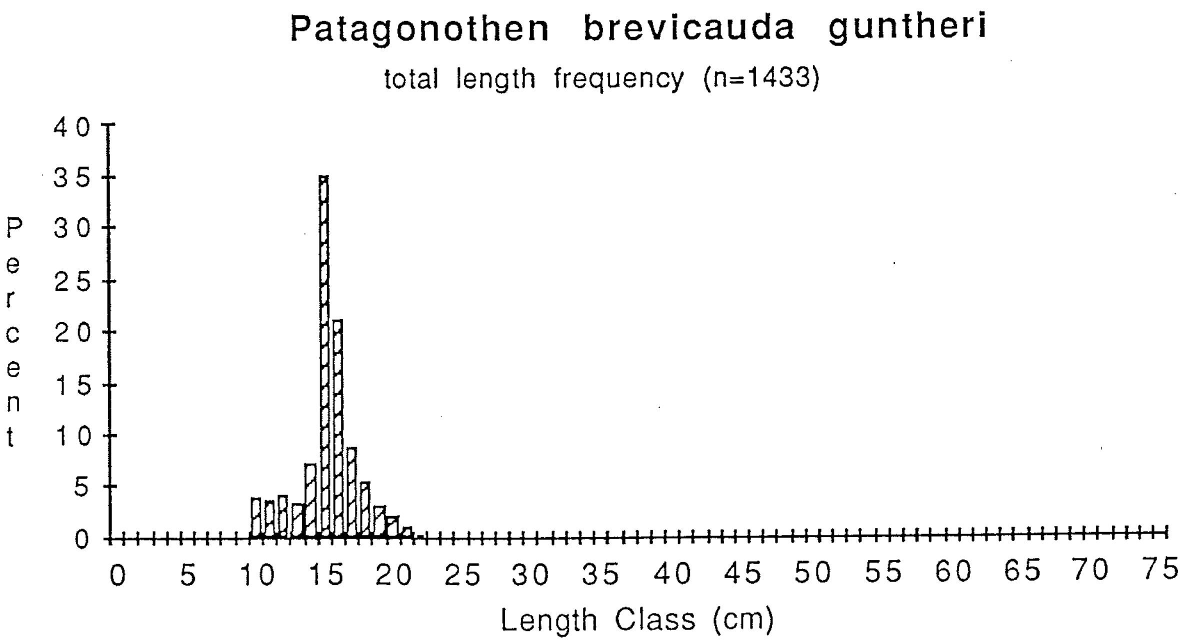


Figure 7: (a) Length frequency distribution, *Dissostichus eleginoides*

(b) Length frequency distribution, *Patagonothen brevicauda guntheri.*

Légendes des tableaux

Tableau 1 Estimations de la biomasse chalutable moyenne et des coefficients de variation par couches de profondeur, décembre 1987 - janvier 1988.

Tableau 2 Comparaison des estimations de la biomasse chalutable moyenne, de l'écart-type et du coefficient de variation basés sur la distribution normale, 1984/85 et 1986/87, par rapport aux estimations pour 1987/88.

Tableau 3 Résumé des informations sur les longueurs pour la campagne d'étude des AMLR au large de la Géorgie du Sud.

Légendes des figures

Figure 1 Carte des emplacements des stations pour la campagne d'étude des AMLR de 1987-88 - en Géorgie du Sud et dans les Shag Rocks. Les axes sont en degrés de longitude ouest et degrés de latitude sud, respectivement. Seules les stations dont il est fait mention explicite dans le texte ont été indiquées par un chiffre.

Figure 2 (a) Distribution de prise par trait de chalut, *Champsocephalus gunnari.* L'équidistance des courbes est de 50 kg (fourchette 0-350).

(b) Distribution de prise par trait de chalut, *Pseudochaenichthys georgianus.* L'équidistance des courbes est de 50 kg (fourchette 0-400)

(c) Distribution de prise par trait de chalut, *Notothenia gibberifrons.* L'équidistance des courbes est de 50 kg (fourchette 0-80)

Figure 3 (a) Distribution de fréquences de longueurs, *Champsocephalus gunnari.*

(b) Distribution de fréquences de longueurs, *Pseudochaenichthys georgianus.*

(c) Distribution de fréquences de longueurs, *Notothenia gibberifrons.*

Figure 4 (a) Distribution de prise par trait de chalut, *Chaenocephalus aceratus.* L'équidistance des courbes est de 10 kg (fourchette 0-70).

(b) Distribution de prise par trait de chalut, *Notothenia rossii.* L'équidistance des courbes est de 5 kg (fourchette 0-25).

(c) Distribution de prise par trait de chalut, *Notothenia squamifrons.* L'équidistance des courbes est de 1 kg (fourchette 0-6).

Figure 5 (a) Distribution de fréquences de longueurs, *Chaenocephalus aceratus.*

(b) Distribution de fréquences de longueurs, *Notothenia rossii.*

(c) Distribution de fréquences de longueurs, *Notothenia squamifrons.*

Figure 6 (a) Distribution de prise par trait de chalut, *Dissostichus eleginoides.* L'équidistance des courbes est de 2 kg (fourchette 0-10).

(b) Distribution de prise par trait de chalut, *Patagonothen brevicauda guntheri.* L'équidistance des courbes est de 5 kg (fourchette 0-25).

Figure 7 (a) Distribution de fréquences de longueurs, *Dissostichus eleginoides.*

(b) Distribution de fréquences de longueurs, *Patagonothen brevicauda guntheri.*

Заголовки к таблицам

Таблица 1 Оценки средней величины биомассы промысловой части запаса и коэффициенты вариативности по горизонтам, декабрь 1987 г. - январь 1988 г.

Таблица 2 Сравнение оценок средней величины биомассы промысловой части запаса, среднего квадратического отклонения и коэффициента вариативности, основанных на нормальном распределении, 1984-85 гг. и 1986-87 гг.

Таблица 3 Сводка данных по длине для съемки AMLR в районе Южной Георгии, 1987-88 гг.

Подписи к рисункам

Рисунок 1 Карта расположений станций для рейса 1987-88 гг. с целью съемки AMLR в районе Южной Георгии и скал Шаг. Оси координат соответственно выражены в градусах западной долготы и градусах южной широты. Цифрами обозначены только те станции, о которых подробно говорится в тексте.

Рисунок 2 (a) Распределение величин улова за одно траление, *Champsocephalus gunnari.* Расстояние между контурами равно 50 кг (диапазон 0-350).

(b) Распределение величин улова за одно траление, *Pseudochaenichthys georgianus.* Расстояние между контурами равно 50 кг (диапазон 0-400).

(c) Распределение величин улова за одно траление, *Notothenia gibberifrons.* Расстояние между контурами равно 20 кг (диапазон 0-80).

Рисунок 3 (a) Частотное распределение длин, *Champsocephalus gunnari.*

(b) Частотное распределение длин, *Pseudochaenichthys georgianus.*

(c) Частотное распределение длин, *Notothenia gibberifrons.*

Рисунок 4 (a) Распределение величин улова за одно траление, *Chaenocephalus aceratus.* Расстояние между контурами равно 10 кг (диапазон 0-70).

(b) Распределение величин улова за одно траление, *Notothenia rossii*. Расстояние между контурами равно 5 кг (диапазон 0-25).

(c) Распределение величин улова за одно траление, *Notothenia squamifrons*. Расстояние меду контурами равно 1 кг (диапазон 0-6).

Рисунок 5 (a) Частотное распределение длин, *Chaenocephalus aceratus*.

(b) Частотное распределение длин, *Notothenia rossii*.

(c) Частотное распределение длин, *Notothenia squamifrons*.

Рисунок 6 (a) Распределение величин улова за одно траление, *Dissostichus eleginoides*. Расстояние между контурами равно 2 кг (диапазон 0-10).

(b) Распределение величин улова за одно траление, *Patagonothen brevicauda guntheri*. Расстояние между контурами равно 5 кг (диапазон 0-25).

Рисунок 7 (a) Частотное распределение длин, *Dissostichus eleginoides*.

(b) Частотное распределение длин, *Patagonothen brevicauda guntheri*.

Encabezamientos de las Tablas

Tabla 1 Estimaciones de la biomasa media explotable y coeficientes de variación por estratos de profundidad, diciembre de 1987 - enero de 1988.

Tabla 2 Comparación de las estimaciones de la biomasa media explotable, desviación estándar y coeficiente de variación basado en la distribución normal, 1984/85 y 1986/87, relativo a las estimaciones para 1987/88.

Tabla 3 Resumen de la información de tallas para la prospección AMLR de 1987/88 en Georgia del Sur.

Leyendas de las Figuras

Figura 1 Mapa con la localización de las estaciones para el crucero de prospección AMLR de 1987/88 - Georgia del Sur y rocas Cormoran. Los ejes están indicados en grados longitud Oeste y grados latitud Sur respectivamente. Solamente aquellas estaciones mencionadas explícitamente en el texto están designados con un número.

Figura 2 (a) Distribución de captura por arrastre, *Champsocephalus gunnari*. El intervalo del contorno es 50 kg (rango 0-350).

(b) Distribución de captura por arrastre, *Pseudochaenichthys georgianus*. El intervalo del contorno es 50 kg (rango 0-400).

(c) Distribución de captura por arrastre, *Notothenia gibberifrons*. El intervalo del contorno es 20 kg (rango 0-80).

Figura 3 (a) Distribución de frecuencia por tallas, *Champsocephalus gunnari*.

(b) Distribución de frecuencia por tallas, *Pseudochaenichthys georgianus*.

(c) Distribución de frecuencia por tallas, *Notothenia gibberifrons*.

Figura 4 (a) Distribución de captura por arrastre, *Chaenocephalus aceratus*. El intervalo de contorno es 10 kg (rango 0-70).

(b) Distribución de captura por arrastre, *Notothenia rossii*. El intervalo de contorno es 5 kg (rango 0-25).

(c) Distribución de captura por arrastre, *Notothenia squamifrons*. El intervalo de contorno es 1 kg (rango 0-6).

Figura 5 (a) Distribución de la frecuencia por tallas, *Chaenocephalus aceratus*.

(b) Distribución de la frecuencia por tallas, *Notothenia rossii*.

(c) Distribución de la frecuencia por tallas, *Notothenia squamifrons*.

Figura 6 (a) Distribución de la captura por arrastre, *Disssostichus eleginoides*. El intervalo del contorno es 2 kg (rango 0-10).

(b) Distribución de la captura por arrastre, *Patagonothen brevicauda guntheri*. El intervalo del contorno es 5 kg (rango 0-25).

Figura 7 (a) Distribución de la frecuencia por tallas, *Disssostichus eleginoides*.

(b) Distribución de la frecuencia por tallas, *Patagonothen brevicauda guntheri*.

NOTOTHENIA (P.) GUNTHERI STOCK STATUS AND TAC ESTIMATION IN THE AREA OF SHAG ROCKS (SUBAREA 48.3)

K. Shust and R. Borodin

Abstract

Data on age composition of catches and fishing efforts for 1979/80-1987/88 were used to analyse *N. guntheri* stock status. On the basis of these data using VPA method with different adjustments stock estimates were obtained. Instantaneous natural mortality coefficient was M=0.7-0.9 (Atlantic Fisheries Research Institute data). To estimate terminal value of instantaneous fishing coefficient (F) different adjustments were used. Longterm mean of F, *Gamma* method, Pope and Shepherd method, using F regression on fishing effort and using average weighted F. Prior to the beginning of fishery *N. guntheri* abundance was estimated as 227 thousand tonnes (using all the abovementioned methods). For 1986/87 the figure was only 102 thousand tonnes when calculation was done using regression equation and 160 thousand tonnes when the *Gamma* method was used (actual values of first and second age groups abundance were not taken into consideration). Of all these methods adjustments of F using the regression equation at which the correlation coefficients were the highest is the most preferable. Taking into consideration the fact that in the 1986/87 season the recruitment in the first age group was not abundance of *N. guntheri* in 1987/88 was 152 thousand tonnes. Then the following TAC values were obtained:

(a) Fishing intensity (F) in the predicted period is equal to the mean value of fishing mortality for the main commercially taken age groups (2-4 years);

(b) Fishing intensity in the predicted period is at the level of 1987/88;

(c) Fishing intensity in the predicted period is $F_{0.1}$.

In the first two cases TAC is 12.3-12.7 thousand tonnes and in the third case - 32.3 thousand tonnes. The analysis of estimations demonstrates that at the current level of fishing (1987/88) the size of the stock of *N. guntheri* will remain unchanged.

Résumé

Des données sur la composition en âges des prises et sur l'effort de pêche pour 1979/80-1987/88 ont été utilisées pour analyser l'état des stocks de *N. guntheri*. Sur la base de ces données, utilisant des méthodes d'analyse VPA, des estimations des stocks ont été obtenues. Le coefficient de mortalité naturelle instantané était M=0.7-0.9 (données de l'Atlantic Fisheries Research Institute). Pour estimer la valeur terminale du coefficient de pêche instantanée (F), différents ajustements ont été utilisés. La moyenne à long terme de F, la méthode *Gamma*, la méthode de Pope et Shepherd, utilisant la

régression de F sur l'effort de pêche et utilisant F moyen pondéré. Avant que ne commencent les activités de pêche, l'abondance de *N. guntheri* a été estimée être de 227 mille tonnes (utilisant toutes les méthodes susmentionnées). Pour 1986/87, le chiffre n'était que de 102 mille tonnes quand le calcul a été fait utilisant l'équation de régression, et de 160 mille tonnes par la méthode *Gamma* (les valeurs réelles de l'abondance du premier et du second groupes d'âge n'ont pas été prise en compte). De toutes ces méthodes, la préférable est celle où les ajustements de F utilisant l'équation de regression à laquelle les coefficients de corrélation étaient les plus grands. Prenant en considération le fait que dans la saison 1986/87 le recrutement dans le premier groupe d'âge n'était pas moins de la moyenne à long terme (5 947 millions de spécimens), l'abondance de *N. guntheri* en 1987/88 était de 152 mille tonnes. Alors les valeurs de la TAC suivantes ont été obtenues :

(a) L'intensité de la pêche (F) dans la période définie d'avance égale la valeur moyenne de mortalité de pêche pour les principaux groupes d'âge pris commercialement (2-4 ans);

(b) L'intensité de la pêche dans la période définie d'avance est au niveau de 1987/88;

(c) L'intensité dans la période définie d'avance est $F_{0.1}$.

Dans les deux premiers cas, la TAC est de 12,3-12,7 mille tonnes, et, dans le troisième cas, de 32,3 mille tonnes. L'analyse des estimations démontre qu'au niveau courant de pêche (1987/88) la taille du stock de *N. guntheri* restera inchangée.

Резюме

Данные по возрастному составу уловов и по промысловому усилию за 1979/80-1987/88 были использованы для исследования состояние запаса *N.guntheri*. На основании этих данных, используя метод анализа виртуальных популяции с различными поправочными коэффициентами, была получена оценка запаса. Мгновенный коэффициент естественной смертности составлял M=0.7-0.9 (данные Атлантического научно-исследовательского института рыбного хозяйства).Для того, чтобы узнать конечную величину коэффициента промысловой смертности были использованы различные поправки: долгосрочная средняя величина F, *Gamma*-метод, метод Попа и Шеферда, использование регрессии F с промысловым усилием и использование средневзвешенной величины F. До начала промысла численность *N. guntheri* составляла 227 тысяч тонн, как показал *Gamma*-метод (фактические величины численности первых двух возрастных групп не принимались во внимание.) Из всех этих методов поправка к F с использованием уравнивания регрессии, при котором корреляция коэффициентов была наивысшей, является наиболее приемлемой. Принимая во внимание тот факт, что в 1986-1987 г. численность одногодовиков была не меньше чем средняя долгосрочная величина (5 947 миллионов

экземпляров), численность *N. guntheri* в 1987/88 г. составляла 152 тысячи тонн. В результате были получены следующие данные:

(а) Интенсивность лова (F) в предопределенные периоды эквивалентна средней величине промысловой смертности для наиболее важных для промысла возрастных групп (возраст от 2 до 4 лет);

(б) Интенсивность лова в предопределенные периоды находится на том же уровне, что и в период 1987/88 г;

(с) Интенсивность лова в предопределенные периоды равна $F_{0.1}$.

В первых двух случаях Общий Допустимый Улов составляет 12.3 - 12.7 тысяч тонн, в третьем случае - 32.3тысячи тонн. Анализ данных показывает, что настоящий уровень промысла (1987/88 г.) не повлияет на размеры запаса *N. guntheri*.

Resumen

Se utilizaron los datos de composición por edades y de esfuerzo pesquero de 1979/80-1987/88 para analizar el estado de la población de *N. guntheri*. Sobre la base de estos datos se obtuvieron estimaciones de la población utilizando el método VPA (Análisis de la Población Virtual) con algunos ajustes. El coeficiente de mortalidad natural instantánea fue M=0.7-0.9 (Datos del Atlantic Fisheries Research Institute). Para estimar el valor terminal del coeficiente de pesca instantánea (F) se emplearon distintos ajustes. El promedio a largo plazo de F, el método *Gamma* el método de Pope y Shepherd, se empleó la regresión F para el esfuerzo pesquero y se empleó la media pesada de F. Antes del inicio de la pesquería, la abundancia de *N. guntheri* se estimó en 227 mil toneladas (empleando los métodos citados anteriormente). Para 1986/87 la cifra fue sólo de 102 mil toneladas cuando en el cálculo se empleó la ecuación de regresión, y 160 mil toneladas al utilizar el método *Gamma*, (no se tomaron en consideración los valores reales de la abundancia del primer y segundo grupos de edades). De todos estos métodos es preferible realizar los ajustes de F mediante la ecuación de regresión, en la cual los coeficientes de correlación eran más altos. Teniendo en cuenta que en la temporada de 1986/1987, el reclutamiento del primer grupo de edad no fue menor que la media a largo plazo (5 947 millones de ejemplares), la abundancia de *N. guntheri* en 1987/88 fue de 152 mil toneladas. Se obtuvieron pues, los valores de la TAC (Captura Total Admisible) siguientes:

(a) La intensidad de pesca (F) en el período previsto es igual al valor medio de la mortalidad por pesca de los principales grupos de edades comerciales capturados (2-4 años);

(b) La intensidad de pesca en el período previsto está al nivel de 1987/88;

(c) La intensidad de pesca para el período previsto es de $F_{0.1}$.

En los dos primeros casos la TAC es de 12.3-2.7 miles de toneladas y en el tercer caso - 32.3 miles de toneladas. Los análisis de las estimaciones demuestran que en los niveles actuales de pesca (1987/88) el tamaño de la reserva de *N. guntheri* permenecerá igual.

Нототения Гюнтера или желтоперка (*Notothenia guntheri Norman*), типичный представитель шельфовых нотальных вод Фолклендско-Патагонского района, была определена Д. Р. Норманом в 1937 году (Norman , 1937) и описана как вид хорошо отличающийся от нототении бревикауда (*N. brevicauda*) и нототении Рамсея (*N. ramsai*). В конце семидесятых годов рыба очень близкая по морфологии и размерам к нототении Гюнтера была в значительном количестве выловлена в районе скал Шаг, расположенном недалеко от о. Южная Георгия. Проведенный советскими ихтиологами морфометрический анализ показал, что эта рыба является скорее всего подвидом нототении Гюнтера и присвоили ей латинское наименование - *Patagonotothen guentheri shagensis* (Балушкин, Пермитин, 1982). Аллопатричная популяция этого подвида существует, как выяснилось позднее, только в этом локальном районе (Шуст, 1987). В этой связи, ее определение как подвида *P. brevicauda guntheri* (Norman), обитающего в Патагонском районе, на банке Бердвуд и у скал Шаг, представленное в определителе рыб южного океана ФАО и АНТКОМ (FAO SPECIES IDENTIFICATION SHEETS...FAO, CCAMLR, 1985), считаем неправильным. По нашему мнению, за особями этой популяции района скал Шаг должен быть сохранен статус отдельного подвида *P. guentheri shagensis Balushkin, Permitin* который содержит определение района обитания.

По характеру распределения и поведения желтоперка района скал Шаг, также как и в Патагонском районе, должна быть отнесена к придонно-пелагическим видам, весь жизненный цикл которых проходит в шельфовых водах. В этой связи ареал изучаемой популяции ограничен небольшой шельфовой зоной скал (площадь шельфа составляет около 4000км^2). Даже на близлежащем шельфе о-ва Ю. Георгия особи этого вида за 20 лет регулярно проводимых здесь советских и иностранных экспедиционных исследований обнаружены не были. *

В то же время в небольшом районе скал Шаг желтоперка является доминирующим видом и ее численность здесь очень высока (табл 4.). В значительной мере это определяется, вероятно, как положением и высокой продуктивностью самого района ее обитания, так и адаптивными качествами вида (Шуст, 1987). По размерам тела желтоперка относится к самым мелким нототениям. Так длина встречающихся у скал Шаг особей колеблется от 7 до 24 см, а наиболее часто обнаруживается группа рыб, которые имеют длину 14-17 см. Вес особей модальной группы равен 30-40 г, при общих колебаниях от 5 до 115 г. Очень невелика и продолжительность жизни особей желтоперки, которая в среднем составляет 6 лет, хотя отдельные самки, по сообщению мурманского ихтиолога Б. Д. Живова, доживают до 9 лет и достигают длины более 30 см. По его же определениям, наиболее значительный прирост длины приходится на первый год жизни и составляет 7-8 см. На втором году он уменьшается до 3,0-3,5 см и в дальнейшем не превышает 1,5-2,0 см ежегодно. Наши определения темпа линейного роста желтоперки из района скал Шаг дали аналогичные результаты. Темп линейного роста самцов и самок не различается и параметры уравнения Берталанфи, определенные специалистами АтлантНИРО для обоих полов, имеют следующий вид:

$$L_t = 28{,}6 \ (1 - e^{-0{,}22 \ (- \ 0{,}37)})$$

Вес рыб увеличивается довольно медленно на 7-15 г в год (табл. 1)

* Этот феномен, такого отдаленного, но в то же время локального распределение генетически нотального вида в водах Антарктики, требует специального изучения и объснения.

Вместе с тем, в отличие от других видов нототений, половое созревание особей обоих полов происходит уже на 3 году жизни, а в возрасте 3 лет половозрелости достигают более 90% рыб. Именно эта черта биологии желтоперки является, по-видимому, ее основным преимуществом перед другими видами рыб в районе ее обитания, дающим возможность достигать высокой численности даже при очень невысокой плодовитости самок, равной 8-23 тыс. икринок (Шуст, 1987).

Кроме раннего полового созревания, достижение высокой численности желтоперки в районе скал Шаг происходит вследствие относительно невысокой смертности на первом году жизни, так как ее мальки ежегодно в массе встречаются в придонном слое мелководья (глубины 30-100 м) отдельно от взрослых или созревающих особей.

Немаловажное для ее жизни и численности приспособительное качество - это ее питание пелагическими организмами: эвфаузиидами, копеподами, амфиподами, оболочниками и другими планктонными организмами (Козлов, Шуст, 1984), численность и биомасса которых здесь очень велика в период наиболее активного нагула желтоперки, в летне-осенний для Антарктики период.

Все эти удачные биологические адаптивные качества желтоперки, в специфическом районе скал Шаг, способствовали развитию и поддержанию на высоком уровне численности и биомассы ее популяции. Начиная с семидесятых годов желтоперка встречалась в уловах в небольших количествах, но уже в 1979 г. и в последующие годы стала основным объектом лова в районе скал Шаг (Report of the Fifth Meeting of SC-CAMLR, 1986). В то же время, вылов по отдельным сезонам (разбитый год, например, 1982/83; 1983/84 и т.д) колебался довольно сильно от 4,5 тыс т. до 38,5 тыс. т., а улов на единицу промыслового усилия (CPUE) вплоть до последнего сезона изменялся мало и только в последнем сезоне снизился. Существенно не изменялся за весь исследуемый период и размерно-возрастной и весовой состав уловов желтоперки (табл. 1,2).

По данным сотрудника АтлантНИРО Шлибанова В. А., коэффициент мгновенной естественной смертности - M равен для желтоперки района скал Шаг - 0,9 и, с учетом уже накопленной к настоящему времени информации, для оценки запаса и общего допустимого улова (ОДУ) стало возможным применения метода анализа виртуальных популяций VPA. Для оценки терминального значения коэффициента мгновенной промысловой смертности использовались несколько различных настроек: среднее многолетнее, метод Гамма, метод Поупа и Шепарда, по уравнению регрессии на промысловое усилие F и метод средневзвешенной. Затем при помощи полученных терминальных значений F_i и M = 0,9 были получены оценки запаса по отдельным сезонам. В итоге, все методы оценки запаса в первый сезон эксплуатации 1979/80 г. при M = 0,9 дали примерно один и тот же результат - 227 тыс. т желтоперки. Для сезона 1986/87 гг., без учета истинных значений численности 1-й и 2-й возрастных групп, оценки различаются значительно сильнее, от 102 тыс. т по уравнению регрессии, до 160 тыс.т по методу Гамма. Из всех методов наибольшее предпочтение можно отдать настройке по уравнению регресии, которая дает наиболее высокие коэффициенты корреляции между F и f при наименьших стандартных ошибках.

Если принять, что в сезон 1986/87 гг. численность пополнения 1-й возрастной группы будет не ниже среднемноголетней (5947 млн. экз.), то оценка запаса желтоперки, при M = 0,9, в сезон 1987/88 гг. дает величину 152 тыс. т.

На основе оценки запаса по сезонам, методом VPA было расчитано также значение ОДУ желтоперки на последующие сезоны (табл. 6,7,8). Были рассмотрены следующие варианты:

(а) Интенсивность промысла (F) в прогнозируемый период равна средней величине промысловой смертности для основных промысловых возрастных групп (2-4 года), (табл. 6). При среднемноголетнем уровне пополнения, величина запаса будет изменяться со 143,8 тыс. т. в сезон 1987/88 гг., до 147,1 тыс. т в сезон 1989/90 гг., а ОДУ будет соответственно равен 12,3-12,7 тыс. т.

(б) Интенсивность промысла (F) в прогнозируемый период равна $F_{0,1}$=1,55. Тогда величина запаса будет несколько уменьшаться со 143,8 тыс. т. в сезон 1987/88 гг. до 130 тыс. т. в сезон 1989/90 гг., а ОДУ в сезон 1987/88 гг. - 32,8 тыс. т. в 1989/90 гг.

(в) Интенсивность промысла (F) в прогнозируемый период сохранится на уровне сезона 1987/88 гг. При такой эксплуатации величина запаса желтоперки останется неизменной (143,8 - 147,3 тыс. т.) и ОДУ может составить 12,3 - 12,7 тыс. т.

ЗАКЛЮЧЕНИЕ

Анализ состояния запасов и хода промысла желтоперки в районе скал Шаг и Блэк-Рок, проведенный при помощи VPA с различной настройкой показывает, что первоначальный запас в 1979/80 гг. при M = 0,9 оценивается в 227 тыс. т. Затем величина запаса уменьшилась, но в настоящее время стабилизировалась на уровне 145 - 155 тыс. т.

Выполненные расчеты и прогноз на сезоны 1988/89 гг. и 1989/90 гг. показывают, что существующий режим промысла желтоперки (около 15 тыс. т.) не приводит к снижению запаса. При интенсивности промысла в режиме $F_{0,1}$ равном 1,55 и ОДУ = 25 - 30 тыс. т. запас может немного снижаться.

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Таблица 1: Данные по средней массе особей желтоперки разного возраста, в разные годы.

ВОЗРАСТН. ГРУППА	ГОДЫ ПРОМЫСЛА 1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
1	5,30	5,50	5,30	5,50	6,00	5,70	5,70	4,50	5,30	5,30
2	13,50	13,50	14,00	11,50	14,50	13,30	13,30	14,50	20,70	23,30
3	25,20	25,20	27,30	21,60	28,50	25,80	25,80	22,50	31,60	37,90
4	39,00	39,00	37,00	42,50	39,00	39,60	39,60	36,30	60,30	59,50
5	51,70	51,70	46,30	58,50	51,50	52,10	52,10	49,50	95,10	90,00
6	72,70	72,70	66,30	90,00	68,50	77,30	77,30	57,00	137,20	130,00

Таблица 2: Возрастной состав уловов (млн. зкз.).

ВОЗРАСТ-НАЯ ГРУППА	КОЭФ. ЕСТЕСТВ. СМЕРТ.	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
1	0,900	33,00	11,80	80,90	34,50	19,10	55,10	84,60	20,80	2,68
2	0,900	274,90	21,30	467,50	320,30	46,20	36,20	173,70	454,80	57,88
3	0,900	160,50	91,70	306,70	382,00	43,00	58,90	102,60	77,40	177,31
4	0,900	97,90	84,70	336,10	232,10	47,30	125,00	83,20	70,10	70,59
5	0,900	9,90	8,20	60,00	59,70	10,40	36,00	18,90	29,40	15,72
6	0,900	6,30	0,90	6,10	4,70	1,30	3,20	2,50	5,60	10,37
И Т О Г О		562,50	218,60	1257,30	1033,30	167,30	314,40	465,50	658,10	334,50
СРЕДНИЙ ВОЗРАСТ		2,6	3,3	2,9	3,0	2,9	3,2	2,5	2,5	3,2

Таблица 3: Коэффициенты промысловой смертности.

ВОЗРАСТ-НАЯ ГРУППА	КОЭФ. ЕСТЕСТВ. СМЕРТ.	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
1	0,900	0,0037	0,6020	0,0181	0,0085	0,0077	0,0216	0,0167	0,0053	0,0006
2	0,900	0,0870	0,0091	0,2161	0,1950	0,0286	0,0367	0,1833	0,2479	0,0370
3	0,900	0,2333	0,0776	0,3797	0,6386	0,0735	0,0961	0,2957	0,2477	0,3126
4	0,900	0,8894	0,0105	1,1251	1,5749	0,3236	0,7347	0,4085	0,8147	0,9194
5	0,900	0,8718	0,5060	1,6752	1,9812	0,5987	1,1281	0,5266	0,5678	1,1369
6	0,900	0,8811	0,3884	1,4000	1,7779	0,4615	0,9319	0,4678	0,6917	1,0283
2-4	F ВЗВЕШ.	0,1633	0,0568	0,3678	0,4418	0,0601	0,1412	0,2426	0,2748	0,1543

Таблица 4: Численность желтоперки по годам (млн. экз.).

ВОЗРАСТ-НАЯ ГРУППА	КОЭФ. ЕСТЕСТВ. СМЕРТ.	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
1	0,900	8792,26	8851,27	6834,05	6197,38	3762,00	3900,75	7716,43	5959,23	6775,90
2	0,900	4970,69	3554,33	3591,38	2728,70	2498,41	1517,74	1552,01	3085,17	2410,02
3	0,900	1149,85	1852,43	1431,96	1176,43	914,69	987,55	594,81	525,33	978,97
4	0,900	236,47	370,21	696,92	398,26	253,36	345,52	365,36	179,93	166,72
5	0,900	24,24	39,50	99,84	91,98	33,52	74,53	67,38	98,75	32,39
6	0,900	15,51	4,12	11,14	7,60	5,16	7,49	9,81	16,18	22,75
ИТОГО		15188,60	14671,90	12665,30	10600,30	7467,10	6833,40	1035,80	9864,60	10386,70

Таблица 5: Биомасса желтоперки по годам (тыс. т.).

ВОЗРАСТНАЯ ГРУППА	СРЕДНЯЯ МАССА РЫБ	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	1986/87
1	10,000	87,92	88,51	68,34	61,97	37,62	39,01	77,16	59,59	67,76
2	18,400	91,66	65,40	66,08	50,21	45,97	27,93	28,56	56,77	44,34
3	30,200	34,73	55,96	43,25	35,53	27,62	29,82	17,96	15,86	29,56
4	42,000	9,93	15,55	29,27	16,73	10,64	14,51	15,35	7,56	7,00
5	58,800	1,43	2,32	5,87	5,41	1,97	4,38	3,96	5,81	1,90
6	66,300	1,02	0,27	0,74	0,50	0,34	0,30	0,65	1,07	1,51
ИТОГО		226,50	228,00	213,50	170,30	124,20	116,10	143,60	146,70	152,10

Таблица 6: Прогноз состояния запасов и ОДУ, если F есть средняя величина для основных возрастных групп.

ВОЗРАСТНАЯ ГРУППА	КОЭФ. ЕСТ. СМЕРТ.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ	1986/87 F	C	N	B	1987/88 F	C	N	B
			(в кг)		млн. экз	млн. экз	тыс. т		тыс. т	млн. экз	тыс. т
1	0,900	0,0167	0,010	0,0006	1,68	5947,00	59,470	0,0067	0,26	5947,00	59,470
2	0,900	0,1766	0,018	0,0570	57,88	2410,02	44,344	0,0707	2,01	2416,42	44,462
3	0,900	1,0000	0,030	0,5126	17,31	978,97	29,565	0,4005	6,39	944,25	28,516
4	0,900	1,0000	0,042	0,9194	70,59	166,72	7,002	0,4005	2,74	291,17	12,229
5	0,900	1,0000	0,059	1,1369	15,72	32,39	1,904	0,4005	0,36	27,03	1,589
6	0,900	1,0000	0,066	1,0283	10,37	22,75	1,509	0,4005	0,06	4,22	0,280
ИТОГО					334,50	9557,80	143,80		11,80	9630,10	146,50

ВОЗРАСТНАЯ ГРУППА	КОЭФ. ЕСТ. СМЕРТ.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ	1988/89 F	C	N	B		
					(в кг)		тыс. т	млн. экз	тыс. т
1	0,900	0,0167	0,010	0,0067	0,26	5947,00	59,470		
2	0,900	0,1766	0,018	0,0707	2,00	2401,75	44,692		
3	0,900	1,0000	0,030	0,4005	6,19	915,35	27,644		
4	0,900	1,0000	0,042	0,4005	2,42	257,21	10,803		
5	0,900	1,0000	0,059	0,4005	1,04	79,31	4,664		
6	0,900	1,0000	0,066	0,4005	0,11	7,36	0,488		
ИТОГО					12,00	9608,00	147,08		

Примечания:

1. Численность 1-ой возрастной группы в терминальный год задана исследователем
2. Численность 1-ой возрастной группы в первый прогнозируемый год задана исследователем
3. Численность 1-ой возрастной группы во второй прогнозируемый год задана исследователем

Таблица 7: Прогноз состояния запасов и ОДУ, если F-const.

ВОЗРАСТНАЯ ГРУППА	КОЭФ. ЕСТ. СМЕРТ.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ (в кг)	1986/87 F	C млн. экз	N млн. экз	B тыс. т	1987/88 F	C тыс. т	N млн. экз	B тыс. т
1	0,900	0,0167	0,010	0,0006	2,68	5947,00	39,470	0,0006	0,02	5947,00	59,470
2	0,900	0,1766	0,018	0,0370	57,88	2410,02	44,344	0,0570	1,07	2416,42	44,462
3	0,900	1,0000	0,030	0,3126	177,31	978,97	29,565	0,5126	0,16	944,25	28,516
4	0,900	1,0000	0,042	0,9196	70,59	166,72	7,002	0,9194	3,18	291,17	12,229
5	0,900	1,0000	0,059	1,1369	15,72	32,39	1,904	1,1369	0,77	27,03	1,589
6	0,900	1,0000	0,066	1,0283	10,37	22,75	1,509	1,0283	0,13	4,22	0,280
ИТОГО					334,50	9537,80	143,80		12,30	9630,10	146,50

ВОЗРАСТНАЯ ГРУППА т	КОЭФ. ЕСТ. СМЕРТ. млн.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ	1988/89 F (в кг)	C	N тыс. т	B млн. экз тыс. т
1	0,900	0,0167	0,010	0,0006	0,02	5947,00	51,470
2	0,900	0,1766	0,018	0,0370	1,07	2416,42	44,462
3	0,900	1,0000	0,030	0,3126	5,18	946,76	28,507
4	0,900	1,0000	0,042	0,9194	4,99	280,84	14,705
5	0,900	1,0000	0,059	1,1369	1,35	47,20	2,776
6	0,900	1,0000	0,066	1,0283	0,11	3,53	1,236
ИТОГО					12,70	9641,70	167,80

Примечания:

1. Численность 1-ой возрастной группы в терминальный год задана исследователем
2. Численность 1-ой возрастной группы в первый прогнозируемый год задана исследователем
3. Численность 1-ой возрастной группы во второй прогнозируемый год задана исследователем

Таблица 8: Прогноз состояния запасов и ОДУ при $F_{0,1}$

ВОЗРАСТНАЯ ГРУППА	КОЭФ. ЕСТ. СМЕРТ.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ (в кг)	1986/87 F	1986/87 C млн. экз	1986/87 N млн. экз	1986/87 B тыс. т	1987/88 F	1987/88 C тыс. т	1987/88 N млн. экз	1987/88 B тыс. т
1	0,900	0,0167	0,010	0,0006	2,68	5947,00	19,470	0,0259	1,00	5947,00	59,470
2	0,900	0,1766	0,018	0,0370	57,88	2410,02	44,344	0,2737	7,16	2416,42	44,462
3	0,900	1,0000	0,030	0,3126	177,31	978,97	29,565	1,5500	16,48	944,25	28,516
4	0,900	1,0000	0,042	0,9194	70,59	166,72	7,002	1,5500	7,07	291,17	12,229
5	0,900	1,0000	0,059	1,1369	15,72	32,39	1,904	1,5500	0,92	27,03	1,589
6	0,900	1,0000	0,066	1,0283	10,37	22,75	1,509	1,5500	0,16	4,22	0,280
ИТОГО					354,50	9557,80	143,80		32,80	9630,10	146,50

ВОЗРАСТНАЯ ГРУППА	КОЭФ. ЕСТ. СМЕРТ.	КОЭФ. ЧАСТ. ПОПОЛ.	СРЕДНЯЯ МАССА РЫБЫ (в кг)	1988/89 F	1988/89 C тыс. т	1988/89 N млн. экз	1988/89 B тыс. т
1	0,900	0,0167	0,010	0,0259	1,00	5947,00	59,400
2	0,900	0,1766	0,018	0,2737	6,98	2356,09	43,352
3	0,900	1,0000	0,030	1,5500	13,04	747,19	22,519
4	0,900	1,0000	0,042	1,5500	1,98	81,48	3,422
5	0,900	1,0000	0,059	1,5500	0,85	25,13	1,408
6	0,900	1,0000	0,066	1,5500	0,09	2,33	0,108
ИТОГО					24,00	9159,20	180,40

Примечания:

1. Численность 1-ой возрастной группы в терминальный год задана исследователем
2. Численность 1-ой возрастной группы в первый прогнозируемый год задана исследователем
3. Численность 1-ой возрастной группы во второй прогнозируемый год задана исследователем

Table Legends

Table 1	Data on average weight of *N. guntheri* individuals of different age, in different years.
Table 2	Age composition of catches (specimens).
Table 3	Fishing mortality coefficients.
Table 4	*N. guntheri* abundance in different years (millions of individuals).
Table 5	*N. guntheri* biomass by years (thousand tonnes).
Table 6	Stock status and TAC prediction, if F is an average value for the main age groups.
Table 7	Stock status and TAC prediction if F is constant.
Table 8	Stock status and TAC prediction at $F_{0.1}$.

Légendes des tableaux

Tableau 1	Données sur le poids moyen d'individus de *N. guntheri* d'âges différents, sur différentes années.
Tableau 2	Composition en âges des prises (millions).
Tableau 3	Coefficients de mortalité de pêche.
Tableau 4	Abondance de *N. guntheri* sur différentes années (millions d'individus).
Tableau 5	Biomasse de *N. guntheri* par années (mille tonnes).
Tableau 6	Etat du stock et valeur théorique calculée de la TAC, si F est une valeur moyenne pour les principaux groupes d'âge.
Tableau 7	Etat du stock et valeur théorique calculée de la TAC si F est constante.
Tableau 8	Etat du stock et valeur théorique calculée de la TAC à $F_{0.1}$.

Encabezamientos de las Tablas

Tabla 1	Datos de peso medio de individuos de *N. guntheri* de diferente edad, en años distintos.
Tabla 2	Composición por edades de las capturas (millones).
Tabla 3	Coeficientes de mortalidad por pesca.
Tabla 4	Abundancia de *N. guntheri* en años diferentes (millones de individuos).
Tabla 5	Biomasa de *N. guntheri* por años (miles de toneladas).

Tabla 6	Estado de la población y predicción de la TAC (Captura Total Admisible), si F es el valor medio para los grupos de edades principales.
Tabla 7	Estado de la población y predicción de la TAC, si F es constante.
Tabla 8	Estado del la población y predicción de la TAC cuando $F_{0.1}$.

RESULTS OF FISH LARVAE SAMPLING BY MEANS OF FINE-MESHED SAMPLERS ATTACHED TO A BOTTOM TRAWL

W. Ślósarczyk and I. Wójcik

Abstract

Fine-meshed samplers were attached to the top of a bottom trawl in order to provide information on the composition, distribution and abundance of Antarctic fish larvae in the near-bottom zone, which is usually not sampled using plankton nets. The efficiency of various sized meshes for sampling larvae in the bottom zone and the resistance of the samplers to damage during trawl operations were observed. Number of fish caught by samplers constructed using 0.505 mm net were similar to those taken by samplers made using 12 mm net with 0.505 mm insets. The 12 mm net was, however, more vulnerable to damage. The nets were more effective in sampling when attached to the top of the trawl belly, not to the codend. A total of 12 fish species were recorded. The most common fishes caught were postlarval *Nototheniidae*, and among them *Nototheniops larseni* (9.3-20.5 mm). The abundance of postlarval fish was highest in the shallow (108-166 m), nearshore waters of the northeastern shelf of South Georgia. Low values of the abundance index, including most of zero catches, were recorded on the western and southwestern part of the island shelf. Differences observed between the species composition of samples taken in this study and samples which have been collected in the midwater zone during the summer in the South Georgia area are discussed.

Résumé

Des échantillonneurs à mailles fines furent attachés en haut d'un chalut de fond afin d'obtenir des informations sur la composition, la répartition et l'abondance des larves de poissons antarctiques dans la zone proche du fond, où l'on ne procède pas d'ordinaire à des échantillonnages à l'aide de filets à plancton. L'efficacité de différentes tailles de mailles pour l'échantillonnage de larves dans la zone de fond ainsi que la résistance des échantillonneurs à l'endommagement au cours des opérations de chalutage ont été examinées. La quantité de poissons capturés par des échantillonneurs construits en utilisant un filet de 0,505 mm était semblable à celle capturé par des échantillonneurs construits en utilisant un filet de 12 mm avec des poches de 0,505 mm. Le filet de 12 mm était cependant plus susceptible à l'endommagement. Les filets étaient plus efficaces attachés au sommet du ventre du chalut, et non pas au cul de chalut. Un total de 12 espèces de poissons a été enregistré. Les plus communs dans la prise étaient des *Nototheniidae* à l'état post-larvaire, dont les *Nototheniops larseni* (9,3-20,5 mm). Les poissons à l'état post-larvaire étaient en plus grand nombre dans les eaux côtières peu profondes (108-166 m) du plateau nord-est de la Géorgie du Sud. Les valeurs faibles de l'indice d'abondance, y compris la plupart des prises nulles, ont été enregistrées sur la partie ouest et sud-ouest du plateau insulaire. L'on discute les différences observées entre la composition par espèces des échantillons pris dans cette étude et des échantillons qui ont été pris pendant l'été dans la zone mésopélagique de la zone de la Géorgie du Sud.

Резюме

Чтобы получить информацию о составе, распределении и количестве личинок антарктических рыб в придонном слое, пробы которого с помощью планктонных сетей обычно не берутся, использовались мелкоячеистые пробоотборники, прикрепленные к верхней части донного трала. Велись наблюдения по эффективности ячеи различных размеров при взятии проб личинок в придонном слое и прочности пробоотборников, в условиях проведения траления. Количество рыбы, пойманной пробоотборниками, сделанными из сетного полотна с ячеей в 0,505 мм, и пробоотборниками, сделанными из сетного полотна с ячеей в 12 мм и со вставками из ячеи в 0,505 мм было примерно одинаковым. Однако, сеть с ячеей в 12мм оказалась в большей степени подверженной повреждениям. При взятии проб эффективность пробоотборников была выше тогда, когда они были прикреплены к самому верху нижней части трала, а не к кутку. Всего было зарегистрировано 12 видов рыб. Чаще всего встречались *Nototheniidae* на постларвальной стадии, а среди них - *Nototheniops larseni* (9,3-20,5 мм) Численность рыбы в постларвальной стадии была наивысшей в мелководье (108-66 мм), в прибрежных водах северо-восточной части шельфа Южной Георгии. Низкие величины показателя численности, включая большинство нулевых уловов, были зарегистрированы в западной и юго-западной части островного шельфа. Обсуждаются наблюдающиеся различия в видовом составе проб, взятых при проведении этих исследовательских работ, и проб, собранных в течении лета в среднем слое воды в районе Южной Георгии.

Resumen

Se fijaron muestreadores de malla fina en la parte superior de un arrastre de fondo con el fin de obtener información sobre la composición, distribución y abundancia de larvas de peces antárticos en la zona cercana al fondo, la cual no se muestrea normalmente con redes de plancton. Se observó la eficiencia de mallas de diversos tamaños en el muestreo de larvas en la zona del fondo, y la resistencia al daño de los muestreadores durante las operaciones de arrastre. El número de peces capturados por los muestreadores fabricados con red de 0,505 mm fue parecido a los que se capturaron con muestreadores fabricados con red de 12 mm con insertos de 0,505 mm. La red de 12 mm resultó ser, sin embargo, más vulnerable a sufrir daños. Las redes fueron más efectivas en el muestreo cuando estaban fijadas a la parte superior del vientre del arrastre, y no en el copo. Se registró un total de 12 especies diferentes. Los peces capturados más comunes fueron *Nototheniidae* post larvales, y entre ellos

1. INTRODUCTION

This study was undertaken around South Georgia during the 1987/88 summer season as part of the US Antarctic Marine Living Resources (AMLR) Program. A bottom trawl survey was conducted aboard the R/V *Professor Siedlecki* in cooperation with US scientists*. The sampling methods and gear were developed at the Sea Fisheries Institute (MIR) in Gdynia following the AMLR principal coordinator's advice. The objective of the study was to provide information on the composition distribution and abundance of Antarctic fish larvae in the near bottom zone. The layer just above the seabed must be sampled in order to obtain information about early life history stages of some species (North, 1987). The bottom zone is, however, usually not sampled due to the danger of damage to or loss of nets.

2. METHODS

The survey was conducted between 18 December, 1987 and 10 January, 1988. The survey included 118 standard trawl stations in a random stratified design and an additional fifteen hauls conducted within commercially exploited fishing grounds. One or two pairs of fine-meshed samplers, designed to collect larvae, were attached to the trawl in 49 of the 118 hauls (Figures 1 and 2). Each pair consisted of one sampler with 12 mm mesh and one sampler with 0.505 mm mesh. The sampler made of 12 mm mesh could be fitted with an inset made of 0.505 mm mesh. The samplers were attached to the top of the trawl in the following positions: A - 4 m from the headrope on the first segment of the trawl belly; C - 12 m from the headrope on the second segment; B - 16 m from the headrope on the third segment; D - 28 m from the headrope on the codend and X - 8 m from the headrope on the second segment of the trawl belly (Figure 2).

The whole catch from a sampler or a sample taken from it was sorted, fish larvae were counted and their standard lengths were recorded. Samples were preserved in 4% formaldehyde or 70% methanol buffered with potassium hydroxide (for subsequent ageing of larvae). Unfortunately the buffer caused fading of pigment patterns and made further identification of some larvae, especially nototheniids, difficult.

3. RESULTS AND DISCUSSION

The first objective of the study was to test the efficiency of various sizes of meshes (0.505 mm, 12 mm and 12 mm with 0.505 mm inset) for sampling larvae in the near-bottom zone and to test the resistance of the samplers to damage during trawl operations. A summary of the sampling results for three different mesh sizes is given in Table 1. At the beginning of the bottom survey (stations 19-226) the 12 mm mesh sampler was used without a fine-meshed inset. Few fish larvae were caught using the 12 mm mesh, whereas the 0.505 mm net produced large samples. From station 30 onwards, therefore, the 0.505 mm mesh inset was fixed in the end of the 12 mm samplers of larvae. After this change, with a few exceptions, numbers of larvae were comparable in both nets (Table 1). The volume of small plankton and benthos in samples collected by the 12 mm net with the inset tended to be approximately half the volume taken by the 0.505 mm sampler (Table 1). Better filtering efficiency of the 12 mm mesh facilitated the subsequent sorting of fish larvae.

Stations 21, 28, 29, 2P, 3P and 4P were excluded from the analysis of sampling efficiency because counts were available from the 0.505 mm sampler only. The 12 mm

* Dr Valerie Loeb, Moss Landing Laboratory, USA, idenitified half of the samples of fish larvae, but did not have an opportunity to review the draft of this paper and incorporate results of her contribution. She will, however, be included as a co-author in the completed paper.

sampler was damaged during gear operations and then replaced before station 30. The 12 mm net was torn up again when placed on the codend in position D (Figure 2). It appears that this net was more vulnerable to damage than the 0.505 mm net.

Complete analysis of the sampling efficiency of nets in various positions on the trawl was not possible because only two positions (A-B and C-D) were tested simultaneously (Table 2). Moreover, damage to the 12 mm net in position D reduced the scope of analysis to the 0.505 mm sampler for positions C and D.

Catches by 12 mm and 0.505 mm samplers in positions A and B were similar. The 12 mm sampler with the fine mesh inset was in single hauls (especially 36 and 46) more effective in sampling than the 0.505 mm net. For example, the total number of larvae caught at station 36 reached 1 768 specimens per hour. As regards net positions C and D, the 0.505 sampler was much more efficient when attached to the second segment of the belly (position C), rather than to a codend (position D). In position D, the 12 mm sample on stations 67, 68 and 74 (before damage), also caught only single larvae . This was most probably caused by the fine-mesh inset as well as by the low filtering efficiency of that part of the trawl (Ziebo 1976).

The data set from the 12 mm net is not complete, therefore the 0.505 mm sampler in positions X, B and C (the second and third segments of the trawl belly) was selected for subsequent analysis of the distribution and abundance of fish larvae. That net sampled very efficiently fish larvae, as well as juveniles, throughout the entire shelf of South Georgia.

Species composition in selected samples is shown in Table 3. Out of 33 hauls, no fish were recorded in eight. A total of twelve fish species were identified in the remaining 25 samples. The most common fishes caught were postlarval *Nototheniidae* (Figure 3) and among them postlarval *Nototheniops larseni* (9.3-20.5 mm) (Table 3). Single juvenile and adult states of: *N. larseni* (64-175 mm), *N. nudifrons* (102 mm), *Champsocephalus gunnari* (112-370 mm) and *Artedidraco airus* (62 mm) were also captured.

The abundance of postlarval fish was highest in hauls 20, 22 and 36, which were carried out in the shallow (108-166 m) nearshore waters of the northeastern shelf of South Georgia (Table 3 and Figure 3). The exception was haul 15P which was towed over a wide range of depths (122-228 m). The upper depth limit of haul 15P was, however, in shallow water. Generally low values of abundance were recorded on the western and southwestern part of the island shelf. There were no differences observed in results of day and night sampling.

A preliminary analysis suggested that the species composition of samples obtained during this study differed substantially from that of most ichthyoplankton samples collected during the summer in the South Georgia area. Postlarval *Champsocephalus gunnari* and *Chaenocephalus aceratus* are quite abundant in midwater samples in this area (Kompowski, 1980 a, b), in contrast to postlarval *Pseudochaenichthys georgianus* which is usually scarce (Slosarczyk, 1983; North, 1987). These species were more or less equally abundant in the bottom samples collected during this study, however, North (1987) observed dominance of postlarval *Notothenia gibberifrons* and *Nototheniops nudifrons* in samples taken during the period 4 February-5 March 1986. In the bottom samples collected during this study, these nototheniids were very rare. Analysis of diurnal vertical distribution of fish larvae in the Cumberland East Bay of South Georgia during 4-14 January 1987 suggested that most fish larvae in summer are in the upper 100 m layer of the nearshore waters (North, 1987). Between 100-220 m only larger larvae of *Pagothenia hansoni* were present (North, 1987). *P. hansoni* was also one of the most abundant larvae observed in samples collected near the bottom in this study.

When analyzing the species composition of samples and the effectiveness of the nets used in this study to sample the near bottom layer, one must not forget that the samplers could not be closed when passing through midwater layers. Some of the larvae in samples were probably taken in the water column above the bottom. For example, postlarval *Nototheniops larseni* was probably captured during deployment or retrieval of the trawl. According to North (1987), in summer, the early life forms of this species concentrate mainly in the upper 20 m layer and only few specimens are found deeper than 100 m.

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Table 1: Abundance indices (numbers of larvae per hour fished) and total volume (ml) of samples (fish larvae, other zooplankton and benthos) collected using samplers with various mesh sizes (12 mm, 12/0.505 mm, 0.505 mm).

Station	Abundance Index			Total Volume of Samples		
	12 mm	12+0.505 mm	0.505 mm	12 mm	12+0.505 mm	0.505 mm
19	0		4	20		320
20	0		612	40		280
22	2		514	10		180
24	0		128	10		560
25	5		2	10		170
26	0		32	4		320
30		6	2		na	na
31		0	6		350	510
32		3	0		420	380
33		2	0		90	700
34		2	4		710	1390
35		312	106		590	na
36		2988	528		950	1800
37		12	4		na	670
38		8	10		430	150
45		50	138		90	720
46		298	120		960	1420
67		18	58		300	780
68		55	36		670	1490
74		8	18		440	800
89		12	8		90	600
94		10	10		340	760
95		4	6		110	490
97		10	10		na	490
109		4	2		250	470
116		2	0		100	230
14 P		0	2		100	900
15 P		304	364		110	330
122		10	12		340	790
123		0	16		190	290
124		4	2		50	640
127		4	6		50	760
130		4	8		20	60

na - data not available

Table 2: Abundance indices (numbers of larvae per hour fished) and total volume (ml) of samples (fish larvae, other zooplankton and benthos) for samples with various mesh sizes (12 mm, 12/0.505 mm, 0.505 mm) attached to the trawl in various positions (X, A, B, C, D).

Station	Abundance Index									
	12 mm	12+ 0.505 mm				0.505 mm				
	X	A	B	C	D	X	A	B	C	D
19	0					0				
20	0					612				
21	*					5				
22	2					514				
23	0					0				
24	0					128				
25	5					2				
26	0					32				
28	*					32				
29	*					76				
2P	*					7				
3P	*					2				
4P	*					10				
5P	0					0				
30		6	*				2	*		
31		0	0				2	6		
32		3	0				0	0		
33		0	2				0	0		
34		2	0				2	2		
35		50	66				60	38		
36		1768	1220				240	288		
37		12	0				4	0		
38		6	2				0	10		
45		38	20				74	58		
46		256	42				56	64		
67				16	2				58	0
68				55	0				31	5
74				6	2				16	2
89				12	*				6	2
94				10	*				10	0
95				4	*				4	2
97				10	*				8	2
109				4	*				2	0
116				2	*				0	0
14P				0	*				2	0
15P				304	*				364	0
122				10	*				12	0
123				0	*				10	6
124				4	*				2	0
127				4	*				6	0
130				4	*				10	*

* damaged sampler

Table 2 (continued)

Station	Total Volume of Samples									
	12 mm	12+ 0.505 mm				0.505 mm				
	X	A	B	C	D	X	A	B	C	D
19	20					320				
20	40					280				
21	*					190				
22	10					180				
23	20					20				
24	10					560				
25	10					170				
26	4					320				
28	*					400				
29	*					320				
2P	*					70				
3P	*					110				
4P	*					100				
5P	na					na				
30		na	*				na	*		
31		150	200				230	280		
32		250	170				170	210		
33		30	60				220	480		
34		130	580				420	970		
35		310	na				420	170		
36		470	480				600	1200		
37		420	na				170	500		
38		100	330				10	140		
45		20	70				420	300		
46		300	660				1000	420		
67				80	220				460	320
68				290	380				840	650
74				100	340				220	580
89				90	*				340	260
94				340	*				620	140
95				110	*				340	150
97				na	*				260	230
109				250	*				240	230
116				100	*				40	190
14P				100	*				640	260
15P				110	*				90	240
122				340	*				540	250
123				190	*				220	70
124				50	*				320	320
127				50	*				680	80
130				20	*				60	*

* damaged sampler

Table 3: Distribution and abundance of postlarval and juvenile fish on the continental shelf of South Georgia, 18 December 1987 to 10 January 1988 (R/V *Professor Siedlecki*, AMLR Cruise 8712, the bottom trawl 32/36, the fine-meshed sampler 0.505, sampler positions X,B,C).

Sta	Sampling time	Sampling depth range (m)	Volume sorted/ total (ml)	Abundance as numbers per hour fished						
				Nototheniidae	Nototheniops larseni	Nototheniops nudifrons	Notothenia gibberifrons	Pagothenia hansoni	Nototheniidae ind.	Channichthyidae
19	0620-0650	216-270	80/160							
20	0715-0745	136-166	70/140		440			156		
21	1035-1100	142-260	80		2					
22	1400-1430	139-153	5		370			128	16	
23	1620-1650	217-225	10/20							
24	2045-2115	118-149	140/280		98			26		
25	0245-0310	325-376	5							
26	0515-0545	219-227	80/160		24				8	
28	1240-1310	94-111	100/200		16	6	4			
29	1420-1450	124-174	80/160		28				8	
2P	2005-2055	168-205	30/60		7					
3P	2210-0030	266-300	130-260							
4P	0240-0340	129-164	50/100		10					
5P	0525-0825	124-244	na							
30	2245-2315	236-265	na		3					
34	1750-1820	187-216	485		1					
36	0545-0615	108-112	200/600		121			76		
38	1505-1535	230-290	70		2		5	2		
46	2025-2055	118-122	210		33		2	14		
68	1750-1815	137-150	350		15			2		
83	0045-0115	285-293	30							
87	0940-1000	157-160	na							
13P	1505-1540	302-319	75							
89	2235-2305	136-150	170		7					
95	1315-1345	217-220	170					1		
109	0135-0205	139-147	120		2					
110	0320-0340	169-198	120							
114	1820-1850	246-250	220							
115	2155-2225	201-227	245							
14P	2020-2150	244-267	320							
15P	0055-0230	122-228	25/140		353				4	
122	0905-0935	228-262	270						4	
124	1550-1620	262-265	160						2	

Table 3 (continued)

Abundance as numbers per hour fished														Total (number /hour)
Pseudochaenichthys georgianus	Chaenocephalus aceratus	Champsocephalus gunnari	Bathydraconidae	Psilodraco breviceps	Artedidraconidae	Artedidraco mirus	Myctophidae	Electrona antarctica	Paralepididae	Notolepis coatsi	Macrouridae	Macrourus whitsoni	Unidentified	
										4				4
										4			12	612
	2													4
														514
														0
								4						128
												2		2
														32
													8	34
4				28									8	76
														7
													2	2
														10
														0
		3												6
1													2	4
													91	288
													1	10
													15	64
	4			4		2							4	31
														0
														0
														0
1														8
2				1										4
		14												16
														0
														0
														0
	2													2
								7		4				368
2	4			2										12
														2

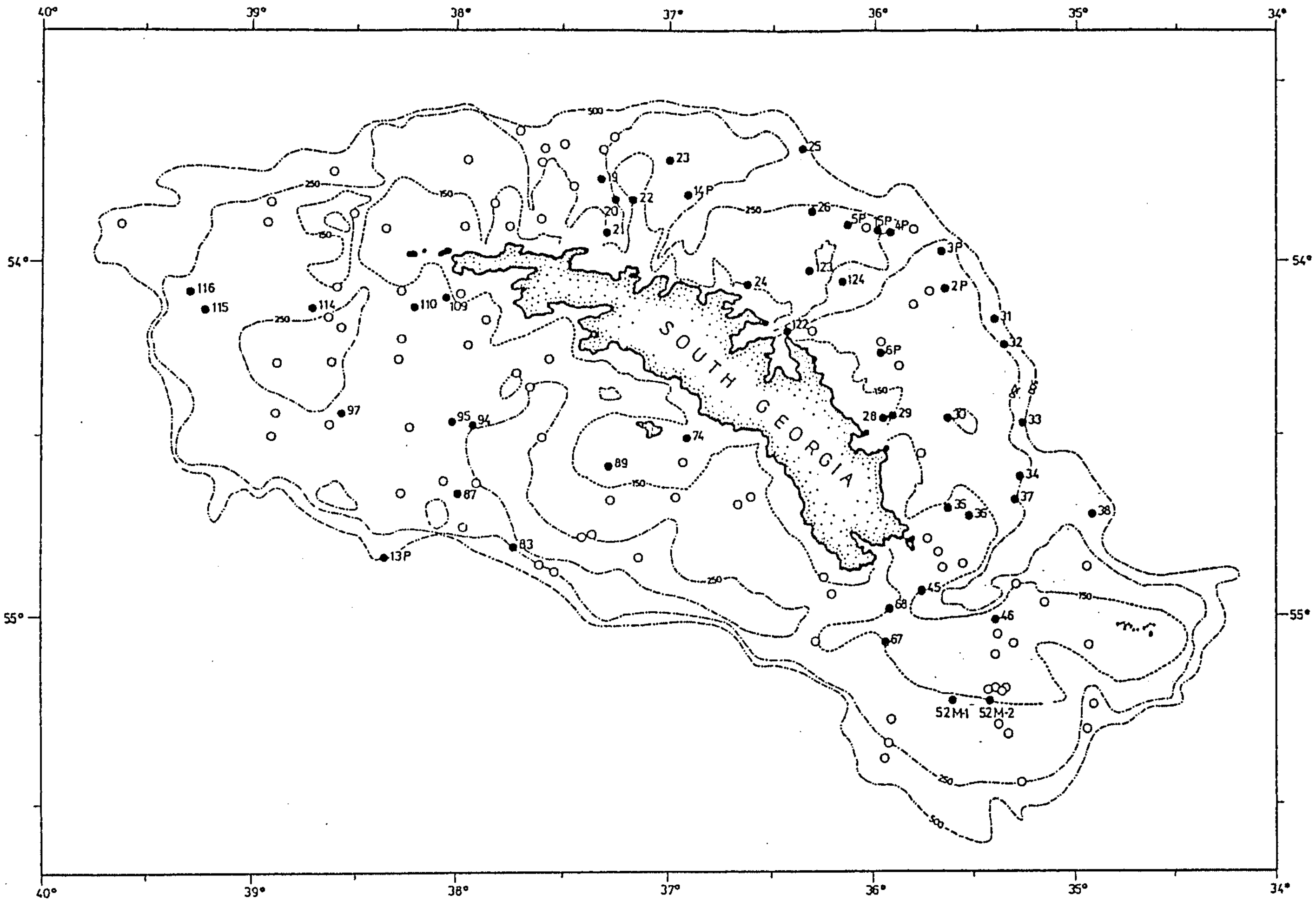

Figure 1: Trawling stations of RV *Professor Siedlecki* during US AMLR Program (18 December, 1987 to 10 January, 1988). Solid and numbered circles are hauls with fine-meshed samplers.

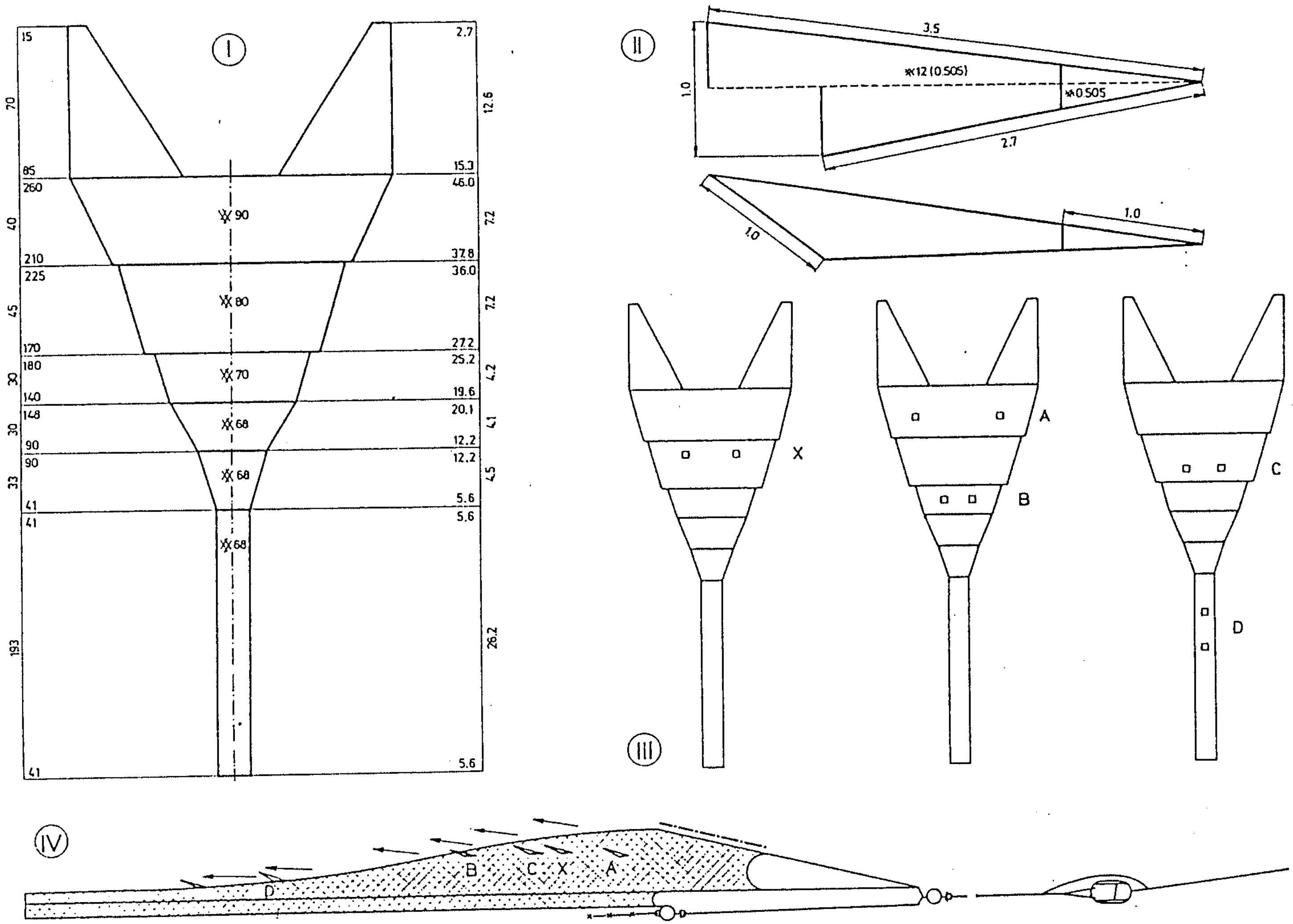

Figure 2: General layout of the bottom trawl 32/36 (I), the fine-meshed samplers (II) and their location on the topside of the trawl (III and IV).

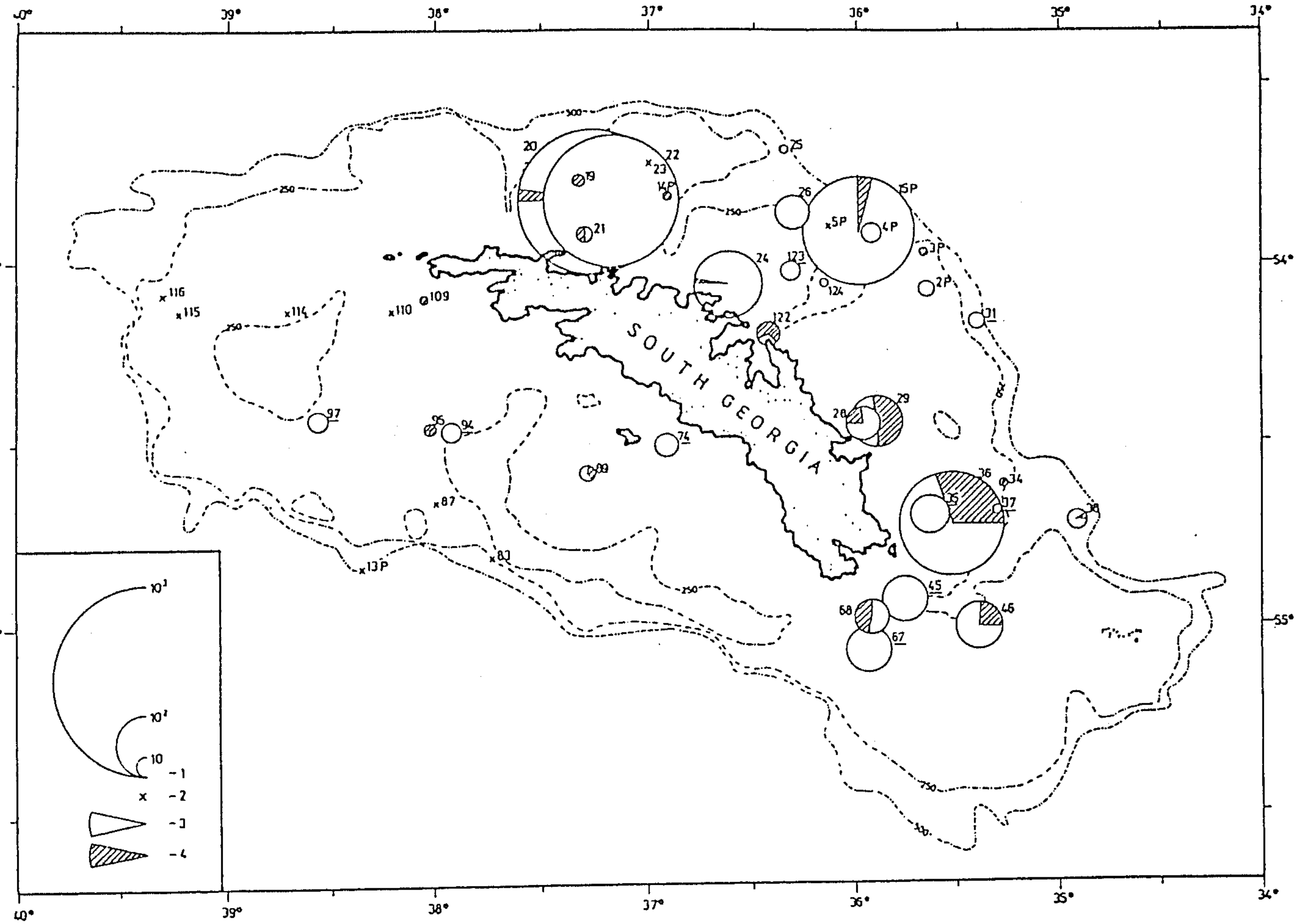

Figure 3: Distribution and abundance of postlarval Antarctic fish on the shelf of South Georgia (December-January 1987/88), 1 - number of fish captured per hour fished, 2 - hauls with no fish captured, 3 - *Nototheniidae*, 4 - other fish (see Table 3), station numbers underlined - samples sorted in USA

Légendes des tableaux

Tableau 1 — Indices d'abondance (nombres de larves par heure de pêche) et volume total (ml) des échantillons (larves de poissons, autre zooplancton et benthos) prélevés utilisant des échantillonneurs de divers maillages (12 mm, 12/0.505 mm, 0.505 mm).

Tableau 2 — Indices d'abondance (nombres de larves par heure de pêche) et volume total des échantillons (larves de poissons, autre zooplancton et benthos) pour des échantillonneurs de divers maillages (12 mm, 12/0.505 mm, 0.505 mm) attachés au chalut en divers positions (X, A, B, C, D).

Tableau 3 — Distribution et abondance de poissons à l'état post-larvaire et juvéniles sur le plateau continental de la Géorgie du Sud, du 18 décembre 1987 au 10 janvier 1988 (navire de recherche Professor Siedlecki, campagne d'étude AMLR 8712, chalut de fond 32/36, échantillonneur à maillage fin 0.505, positions d'échantillonneur X, B, C).

Légendes des figures

Figure 1 — Stations de chalutage du navire de recherche *Professor Siedlecki* au cours du Programme AMLR des Etats-Unis (du 18 décembre 1987 au 10 janvier 1988). Les cercles pleins et numérotés représentent les traits de chalut utilisant des échantillonneurs à maillage fin.

Figure 2 — Vue schématique générale du chalut de fond 32/36 (I), des échantillonneurs à maillage fin (II) et de leur emplacement au-dessus du chalut (III et IV).

Figure 3 — Distribution et abondance des poissons antarctiques à l'état post-larvaire sur le plateau de la Géorgie du Sud (décembre-janvier 1987/88). 1 - nombre de poissons capturés par heure de pêche, 2 - traits où aucun poisson n'a été capturé, 3 - *Nototheniidae*, 4 - autres poissons (voir le Tableau 3), numéros des stations soulignés - échantillons triés aux Etats-Unis.

Заголовки к таблицам

Таблица 1 — Индексы численности (количество личинок за час промысла) и общий объем (мл) проб (личинки рыбы, другой зоопланктон и бентос), собранных при использовании пробоотборников с разными размерами ячеи (12 мм, 12/0,505 мм, 0,505 мм).

Таблица 2 — Индексы численности (количество личинок за час промысла) и общий объем проб (личинки рыбы, другой зоопланктон и бентос), собранные при использовании пробоотборников с разными размерами ячеи (12 мм, 12/0,505 мм, 0,505 мм), прикрепленных к тралу в различных точках (X, A, B, C, D).

Таблица 3 — Распределение и численность рыбы на постличиночной стадии и молодей на материковом шельфе Южной Георгии, 18 декабря - 10 января 1988 г. (НИС "Профессор Седлецкий", рейс AMLR 8712, донный трал 32/36, мелкоячеистый пробоотборник с размером ячеи 0,505 мм, пробоотборники прикреплены в точках X, B, C).

Подписи к рисункам

Рисунок 1 — Станции сбора проб тралом НИС "Профессор Седлецкий" в течение работы программы США по морским живым ресурсам Антарктики (US. AMLR) (18 декабря 1987 г. - 10 января 1988 г.). Заштрихованные и пронумерованные точки обозначают траления с использованием мелкоячеистых пробоотборников.

Рисунок 2 — Общий чертеж донного трала 32/36 (I), мелкоячеистые пробоотборники (II) и их расположение в верхней части трала (III и V).

Рисунок 3 — Распределение и численность ледяной рыбы на постличиночной стадии по шельфу у Южной Георгии (декабрь-январь 1987/1988 гг.). 1 - количество рыбы, пойманной за один час промысла, 2 - траления, за которые не поймано рыбы, 3 - *Nototheniidae*, 4 - другие виды рыбы (см. Таблицу 3), номера станций подчеркнуты - пробы были классифицированы в США.

Encabezamientos de las Tablas

Tabla 1 — Indices de abundancia (número de larvas por hora de pesca) y volumen total (ml) de muestras (peces larvales, otros zooplancton y bentos) recolectados con muestreadores de distintos tamaños de malla (12 mm, 12/0.505 mm, 0.505 mm).

Tabla 2 — Indices de abundancia (número de larvas por hora de pesca) y volumen total de muestras (peces larvales, otros zooplancton y bentos) para muestras con distintos tamaños de mallas (12 mm, 12/0.505 mm, 0.505 mm), fijados al arrastre en distintas posiciones (X, A, B, C, D).

Tabla 3 — Distribución de peces postlarvales y juveniles en la plataforma continental de Georgia del Sur, 18 de diciembre de 1987 - 10 de enero de 1988 (B/I *Professor Siedlecki*. Crucero AMLR 8712, arrastre de fondo 32/36, muestreador de malla fina 0.505. posiciones del muestreador X, B, C).

Leyendas de las Figuras

Figura 1 — Estaciones de arrastre del B/I *Professor Siedlecki* durante el Programa AMLR de los Estados Unidos (18 diciembre 1987 - 10 enero 1988). Los circulos sólidos numerados corresponden a los lances con muestreadores de malla fina.

Figura 2 — Trazado completo del arrastre de fondo 32/36 (I), muestreadores de malla fina (II) y su posición en la parte superior del arrastre (III & IV).

Figura 3 — Distribución y abundancia de los peces postlarvales antárticos en la plataforma de Georgia del Sur (diciembre-enero 1987/88). 1 - número de peces capturados por hora de pesca, 2 - lances sin captura, 3 - *Nototheniidae*, 4 - otros peces (véase tabla 3), se subraya los números de las estaciones - muestras clasificadas en los EE.UU.

PARAMETROS DE SELECCION OBTENIDOS PARA *NOTOTHENIA GIBBERIFRONS* LÖNNBERG, 1905 Y *CHAMPSOCEPHALUS GUNNARI* LÖNNBERG, 1905, DURANTE LA CAMPAÑA "ANTARTIDA 8611"

E. Balguerías

Abstract

Mesh selectivity experiments for several finfish species were conducted during the Spanish antarctic cruise "ANTARTIDA 8611" using the covered codend technique. This paper presents the results obtained for *Notothenia gibberifrons* and *Champsocephalus gunnari*. Selection factors calculated following different methods with a codend mesh of 68 mm were 2.87 for *Notothenia gibberifrons* and 3.10 for *Champsocephalus gunnari*.

Résumé

Des expériences sur la sélectivité du maillage pour plusieurs espèces de poissons ont été effectuées au cours de la campagne d'étude espagnole "ANTARTIDA 8611", utilisant la technique du cul de chalut couvert. Cette communication présente les résultats obtenus pour *Notothenia gibberifrons* et *Champsocephalus gunnari*. Les facteurs de sélection calculés suivant différentes méthodes avec un maillage au raban de cul de 68 mm étaient de 2.87 pour *Notothenia gibberifrons* et de 3.10 pour *Champsocephalus gunnari*.

Резюме

В течение испанского антарктического рейса "ANTARDIDA 8611" были произведены эксперименты по селективности ячеи для некоторых видов плавниковых рыб, используя метод кутка с покрытием. В настоящем документе представлены результаты для *Notothenia Gibberifrons* и *Champsocephalus gunnari*. Используя куток с размером ячеи в 68 мм были вычислены различными методами следующие факторы селективности - 2.87 для *Notothenia Gibberifrons* и 3.10 для *Champsocephalus gunnari*.

Resumen

Durante la campaña "ANTARTIDA 8611", se realizaron experiencias de selectividad por el método del copo cubierto para varias especies de peces. En el presente trabajo se recogen los resultados obtenidos para *Notothenia gibberifrons* y *Champsocephalus gunnari*. Los factores de selección, calculados según diferentes métodos de ajuste, para un arte de 68 mm de luz de malla en el copo, fueron de 2.87 para *Notothenia gibberifrons* y 3.10 para *Champsocephalus gunnari*.

1. INTRODUCCION

Los estudios de selectividad, pretenden establecer cual es la forma de actuación de un arte, sobre los diferentes componentes de edad de una población. Su control es un importante medio de regulación. Reduciendo la mortalidad por pesca sobre ciertas clases de edad, se pueden conseguir apreciables beneficios a largo plazo, aún a costa de pérdidas inmediatas (Pope et al, 1983). Pero se necesita un buen conocimiento de la selectividad, para determinar que medidas se deben tomar para alcanzar el resultado deseado.

Las pesquerías del sector Atlántico del Océano Antártico, se empezaron a desarrollar en la década de los sesenta. En un principio las pescas estuvieron dirigidas a la captura de *Notothenia rossii marmorata* Richardson, 1844, pero la excesiva presión que se ejerció sobre ella, conjugada con su escaso poder de recuperación, provocaron una rápida caída de los rendimientos que la hicieron poco rentable desde el punto de vista comercial (Kock, 1986).

Desde ese momento, *Champsocephalus gunnari* pasó a ser la especie objetivo de las flotas pesqueras de distintos países que operaban en Georgia del Sur, iniciándose una explotación que rindió sus mejores resultados durante los años 1976/78 con una captura de 240 000 t (Kock, 1986).

Los signos aparentes de sobrexplotación a la que se encuentran sometidos distintos "stocks" de peces antárticos, motivaron a la Convención para la Conservación de los Recursos Vivos Marinos Antárticos (CCRVMA), a tomar una serie de medidas encaminadas a la protección de estas especies, en su área de jurisdicción.

Entre tales medidas figura una reglamentación de mallas que entró en vigor en el año 1987 y que no había sido aún refrendada científicamente (CCAMLR, 1986b).

Las únicas experiencias de selectividad realizadas en la zona datan de la temporada 1978/79 y fueron llevadas a cabo por científicos polacos (Zaucha, 1986). Los resultados obtenidos, a pesar de haber sido consistentes para *Champsocephalus gunnari* y *Notothenia gibberifrons*, fueron ampliamente discutidos en la quinta sesión del Comité Científico de la CCRVMA, e invalidados al haberse utilizado redes fabricadas con material actualmente en desuso para la pesca comercial (CCAMLR, 1986a).

Las sucesivas recomendaciones hechas por la CCRVMA para que se emprendieran estudios de este tipo, con artes de tipo comercial, llevaron a fijarlos como uno de los objetivos prioritarios de la campaña "ANTARTIDA 8611". Durante la misma, se establecieron los parámetros de selección de varias especies en los distintos archipiélagos que componen el Arco de Escocia.

El presente trabajo recoge los resultados obtenidos para las dos más importantes, por su abundancia y presencia constante en las capturas: *Notothenia gibberifrons* y *Champsocephalus gunnari*.

2. MATERIAL Y METODOS

Las experiencias de selectividad se llevaron a cabo en todos los archipiélagos del Arco de Escocia, a excepción de las islas Sandwich del Sur, donde la escasez de las capturas imposibilitó la obtención de suficiente cantidad de datos.

La campaña se realizó a bordo del B/F "PESCAPUERTA CUARTO". Se trata de un arrastrero congelador de 1627.5 T.R.B., dotado de un motor principal capaz de desarrollar una potencia de 2 000 C.V. a 300 r.p.m.

El arte utilizado durante toda la campaña fue del tipo semipelágico (figura 1), caracterizado por su gran abertura vertical (7.5 metros) en comparación con su moderada abertura horizontal (14 metros).

Estaba fabricado con hilo de polietileno en sus componentes anteriores, y de nylon en los posteriores. La relinga de flotadores y el burlón tenían una longitud de 35 y 42 metros respectivamente. El cuerpo medía 54.3 metros.

El armamento se mantuvo sin ningún tipo de alteración a lo largo de la prospección, con el fin de poder comparar los resultados obtenidos para cada especie en las distintas zonas. Con la misma finalidad, se procuró la normalización de las operaciones de pesca, en cuanto a duración (30 minutos), velocidad de arrastre (3 nudos), etc.

La luz media de la malla del copo, considerada ésta según la definición dada por la Organización Internacional de Normalización (ISO), fue calculada para cada archipiélago. Para ello, después de la mayoría de los lances se midieron 20 mallas contiguas de la parte dorsal, en dirección antero-posterior y paralelamente al eje mayor, con un calibrador ICES ajustado a 4 kg de presión.

Los trabajos se hicieron siguiendo el método del copo cubierto (Pope et al, 1983). Sobre el copo se adosó un sobrecopo de polietileno de 35 mm de abertura de malla, de tal forma que quedase un espacio de dos metros entre sus extremos terminales y una holgura lateral suficiente como para paliar al máximo el fenómeno del enmascaramiento. Los posibles embolsamientos del sobrecopo se evitaron con la colocación de dos ahorcaperros a su alrededor.

Los individuos retenidos por el copo y el sobrecopo fueron medidos separadamente sobre un ictiómetro, tomando en todos los casos la longitud total al centímetro inferior, de acuerdo con las recomendaciones de BIOMASS (1980).

A efectos de cálculo, fueron rechazadas todas las pescas en las que se produjeron capturas excesivamente grandes o pequeñas.

En la estimación de los parámetros de selección se ensayaron los siguientes sistemas de ajuste (Pope et al, 1983).

- Ajuste a una logística. Los datos observados se ajustaron a una logística de ecuación:

$$P = \frac{1}{1 + e^{-(a+bL)}}$$

siendo P la proporción de individuos de talla L retenidos por el copo.

- Método de Gulland (1983). La talla de primera captura se estima mediante la siguiente expresión:

$$Lc = Ln + 1 - \Sigma\ 1.pi$$

donde:

Lc = talla de primera captura.
Ln+1 = talla de retención del 100%.
pi = porcentaje de retención para cada intervalo de talla.
i = amplitud del intervalo de talla.

El factor de selección se obtuvo dividiendo las tallas de retención del 50% observadas, por la abertura de la malla, expresadas ambas en milímetros.

3. RESULTADOS

En las Tablas 1 y 2 se recogen las características de las tallas de la primera captura, el rango de selección y los valores de los factores de selección, calculados para las diferentes medidas de ajuste aplicadas, para las dos especies contempladas en el estudio, en las distintas zonas prospectadas.

3.1 *Nototheniа gibberifrons*

No se pudieron establecer los parámetros de selección de esta especie en Shag Rocks, por no haber sido capturada en ninguno de los lances efectuados.

En Georgia del Sur, presentó una gama de tallas seleccionada entre 15.9 y 23.1 cm. Las tallas de retención del 50% se situaron en 19.5 cm, para el ajuste a una logística, y en 21.1 cm para el método de Gulland. Los factores de selección fueron muy similares (2.87 y 3.10).

El rango de selección en Orcadas del Sur se mantuvo entre 17.9 y 23.6 cm. Las tallas de primera captura se localizaron en 20.8 cm y 20.5 cm para ajuste a la logística y método de Gulland respectivamente. En esta zona, los factores de selección se situaron alrededor de un valor medio de 3.00.

En Isla Elefante se produce una pequeña disminución en la talla de primera captura observada para los diferentes sistemas de ajuste utilizados (19.6 cm y 20.5 cm). El rango de tallas seleccionadas también se redujo considerablemente, estableciéndose entre 17.5 cm y 21.7 cm. Los factores de selección volvieron a tomar valores ligeramente inferiores, de magnitud semejante a los calculados en Georgia del Sur.

En Shetland del Sur registraron los valores más bajos en las tallas de retención del 50% (18.4 cm y 19.6 cm).

La gama de tallas seleccionada tuvo una amplitud de 6 cm, con límite inferior en 15.4 cm. Los factores de selección arrojaron los valores mínimos observados durante la campaña para la especie (2.70 y 2.88).

3.2 Champsocephalus gunnari

Se observó una gran variabilidad en los parámetros de selección calculados para esta especie.

Los ajustes hechos en Shag Rocks por los dos métodos empleados, dieron una gama de tallas seleccionadas bastante corta (de 21.9 cm a 25.1 cm). Los factores de selección oscilaron en torno a 3.50.

En Georgia del Sur se obtuvieron valores de las tallas de retención del 50%, sensiblemente inferiores (20.0 cm y 21.0 cm). El rango de selección se detectó entre 17.8 y 22.3 cm, y los factores de selección estuvieron muy próximos a un valor de 3.00.

Los ejemplares capturados en Orcadas del Sur no cubrieron toda la gama teórica de tallas seleccionadas (entre 15.6 y 27.1 cm).

La talla de primera captura calculada por el método de Gulland (22.3 cm), fue del orden de un centímetro superior a la obtenida por ajuste a la logística (21.3 cm). Los factores de selección se localizaron en 3.11 y 3.26.

Tampoco en Isla Elefante se capturó casi ningún individuo de talla menor al límite inferior teórico del rango de selección (19.7 cm). Las tallas de primera captura se situaron en niveles próximos a los observados en Orcadas del Sur, si bien el calculado por el método de Gulland fue bastante superior.

Los factores de selección tomaron valores de 3.11 y 4.19.

La gama de tallas seleccionada en Shetland del Sur alcanzó una amplitud de unos 9 cm, con valores extremos en 15.3 cm y 24.2 cm.

En este archipiélago se registró el valor mínimo de la talla de primera captura para la especie (19.7 cm).

Por el contrario, el factor de selección calculado por el método de Gulland arrojó uno de los valores máximos estimados a lo largo de toda al prospección (3.80).

4. DISCUSION

4.1 *Notothenia gibberifrons*

Se obtuvieron buenos ajustes a la logística en todas las zonas estudiadas, con coeficientes de correlación siempre por encima de 0.90 (figuras 2 y 3).

Las tallas de primera captura calculadas por el método de Gulland dieron siempre valores superiores, del orden de un centímetro (tabla 1). Este hecho puede ser debido a una cierta asimetría de las curvas, con lo que el punto de retención del 50% puede estar ligeramente por debajo de su valor real en las estimaciones por ajuste a la logística.

No se apreciaron grandes divergencias en los factores de selección obtenidos por los distintos tipos de ajuste.

Los rangos de selección observados fueron muy similares en Georgia del Sur y Orcadas del Sur y se hicieron más estrechos en Isla Elefante y Shetland del Sur. En este sentido, habría que destacar el menor número de individuos sobre los que se obtuvieron las curvas de las dos últimas zonas citadas, y la práctica ausencia en las mismas de representantes de tallas inferiores a la de retención del 25%.

En general, las estimaciones de los parámetros de selección hechas para *Notothenia gibberifrons*, no presentaron grandes diferencias ni en relación a la metodología seguida en el ajuste, ni entre las distintas zonas estudiadas, con lo que se puede concluir que para un arte de 68 mm de luz de malla en el copo y en condiciones experimentales, los valores medios calculados para la talla de primera captura (19.6 cm) y el factor de selección (2.87) son bastante consistentes.

4.2 *Champsocephalus gunnari*

Los resultados obtenidos para *Champsocephalus gunnari* presentaron una gran variabilidad entre zonas (figuras 4, 5 y 6).

En cada archipiélago, los valores calculados con el método de ajuste a la logística, están muy por debajo de los observados con el método de Gulland.

Los rangos de selección fueron cortos en Shag Rocks, Georgia del Sur e Isla Elefante, con amplitudes de 3.2 cm, 4.5 cm y 3.2 cm, respectivamente.

Los puntos de selección del 25% y del 75% estimado en Orcadas del Sur, deben tomarse como puramente teóricos, al haber sido calculados sin ninguna representación de porcentajes reales en longitudes extremas.

Las estimaciones hechas en Isla Elefante son muy poco fiables, al estar basadas en series de datos por encima de la talla de la primera captura.

En Shetland del Sur cabe resaltar la gran amplitud de la gama de tallas seleccionadas y el valor mínimo calculado para el punto de retención del 50%.

Las diferencias entre los parámetros calculados en las distintas zonas prospectadas, pueden estar motivadas por distintos factores. Diversos autores han hallado una relación entre el volúmen de captura y la selección, con una tendencia de la talla de primera captura a disminuir cuando aumentan las mismas (Pope et al, 1983). Tal fenómeno podría explicar el valor obtenido en Georgia del Sur.

El estado de engrasamiento visceral, el estado de madurez sexual y cualquier otro factor que afecte al volúmen corporal, influyen sobre la selectividad. En este sentido, el estudio conjunto de la selectividad y los factores implicados en su variación, ayudaría a desvelar las causas de estas diferencias.

Desestimados los resultados de Orcadas del Sur e Isla Elefante, se podría establecer la situación real de la talla de primera captura para esta especie, alrededor de 21.1 cm y la del factor de selección en 3.10.

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Tabla 1: Datos técnicos y resultados de las experiencias de selectividad realizadas para *Notothenia gibberifrons* durante la campaña "ANTARTIDA 8611".

ZONA	GEORGIA	ORCADAS	ELEFANTE	SHETLAND
MALLA (mm)	70	70	70	70
Número de lances	104	93	46	65
Duración media arrastre (minutos)	30	30	30	30
Velocidad media arrastre (nudos)	3	3	3	3
Profundidad media arrastre (metros)	226	273	249	220
Abertura malla del copo	68.04	68.38	68.56	68.08
Rango (mm)				
malla mínima	57	56	60	59
malla máxima	78	82	79	76
número de medidas	322	99	100	159
Rango de selección (cm)				
25%	15.9	17.9	17.5	15.4
75%	23.1	23.6	21.7	21.4
Número individuos en rango selección	993	10294	608	418
copo	347	6247	566	329
sobrecopo	646	4047	42	89
Peso medio por lance (kg)	5.12	14.42	17.36	6.94
copo	4.85	12.77	17.27	6.81
sobrecopo	0.27	1.65	0.09	0.13
Talla del 50% de retención				
Ajuste a logística	19.5	20.8	19.6	18.4
Gulland	21.1	20.5	20.5	19.6
Factor de selección				
Ajuste a logística	2.87	3.04	2.86	2.70
Gulland	3.10	3.00	2.99	2.88

Tabla 2: Datos técnicos y resultados de las experiencias de selectividad realizadas para *Champsocephalus gunnari* durante la campaña "ANTARTIDA 8611".

ZONA	SHAG ROCKS	GEORGIA	ORCADAS	ELEFANTE	SHETLAND
MALLA (mm)	70	70	70	70	70
Número de lances	29	104	93	46	65
Duración media arrastre (minutos)	30	30	30	30	30
Velocidad media arrastre (nudos)	3	3	3	3	3
Profundidad media arrastre (metros)	215	226	273	249	220
Abertura malla del copo	67.45	68.04	68.38	68.56	68.08
Rango (mm)					
malla mínima	61	57	56	60	59
malla máxima	75	78	82	79	76
número de medidas	198	322	99	100	159
Rango de selección (cm)					
25%	21.9	17.8	15.6	19.7	15.3
75%	25.1	22.3	27.1	22.9	24.2
Número individuos en rango selección	12606	112624	708	6145	5396
copo	8055	92770	379	4394	2666
sobrecopo	4551	19854	329	1751	2730
Peso medio por lance (kg)	243.42	224.17	1.85	23.53	4.46
copo	231.93	213.03	1.63	21.26	3.15
sobrecopo	11.49	11.14	0.22	2.27	1.31
Talla del 50% de retención					
Ajuste a logística	23.5	20.0	21.3	21.3	19.7
Gulland	24.1	21.0	22.3	28.7	25.9
Factor de selección					
Ajuste a logística	3.48	2.94	3.11	3.11	2.89
Gulland	3.57	3.09	3.26	4.19	3.80

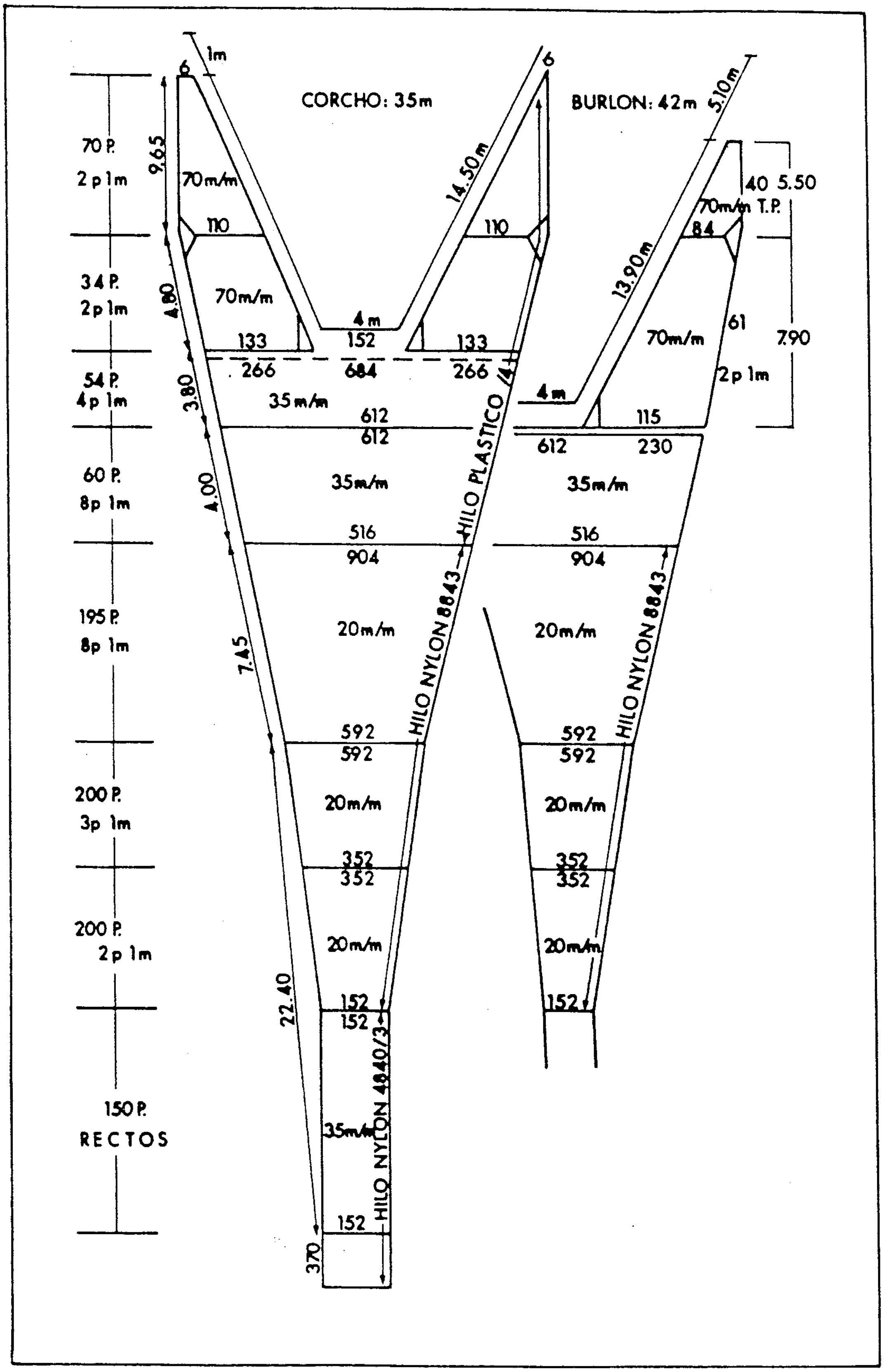
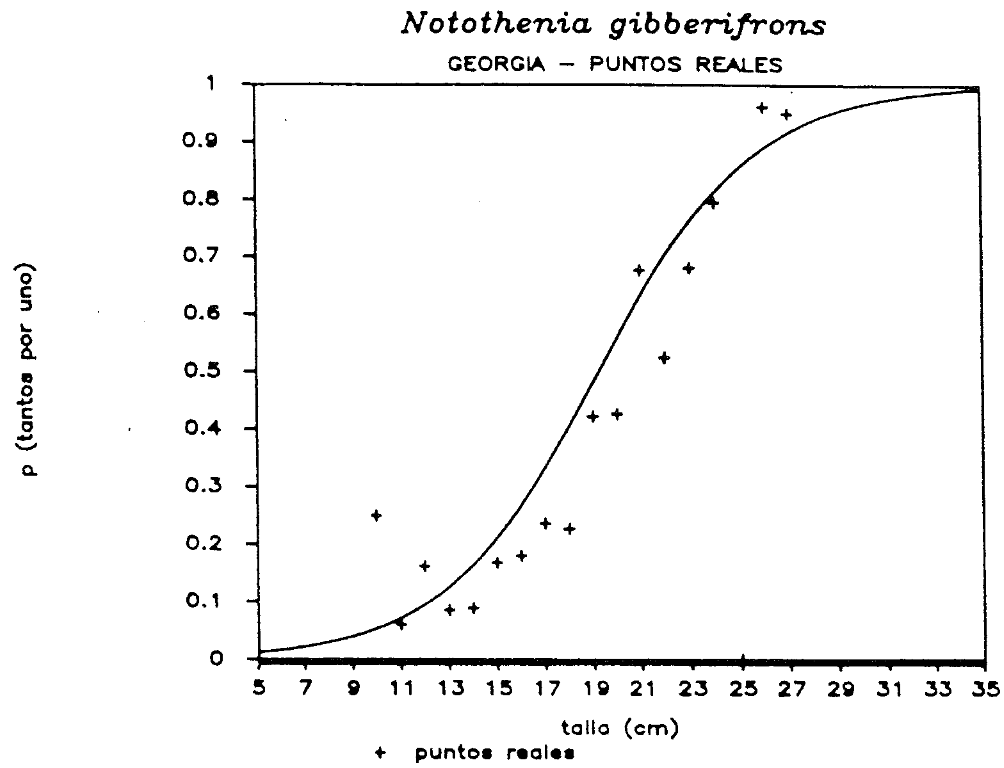


Figura 1: Esquema del arte utilizado durante la campaña "ANTARTIDA 8611".



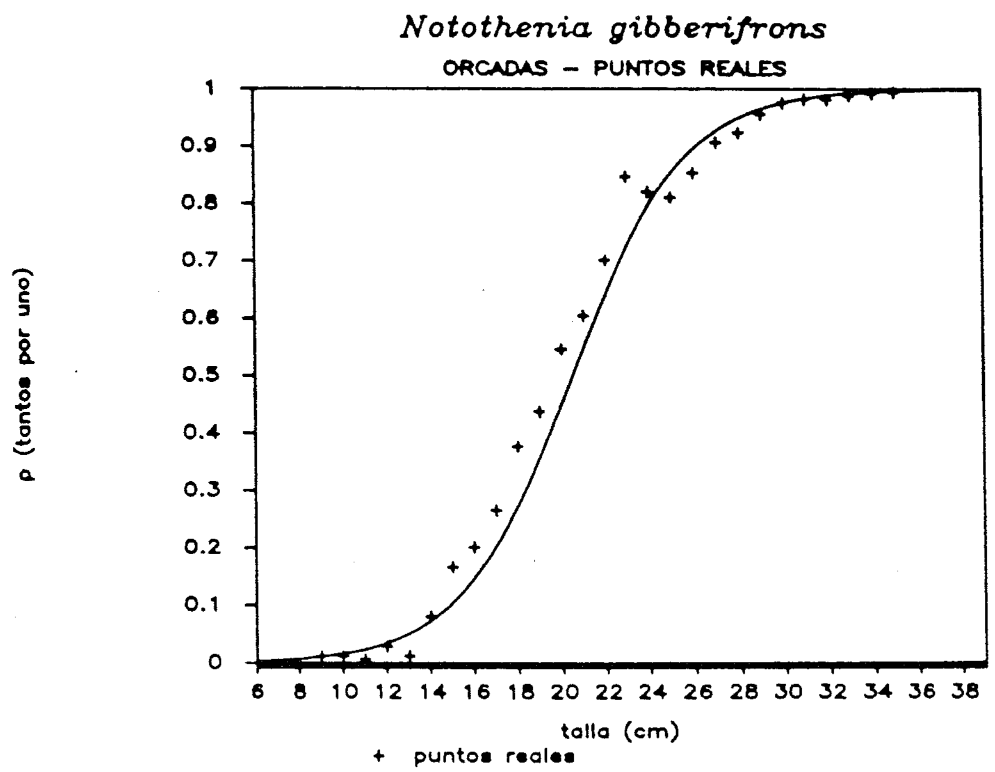


Figura 2: Curvas de selección obtenidas para *Notothenia gibberifrons* en Georgia del Sur y Orcadas del Sur, durante la campaña "ANTARTIDA 8611".

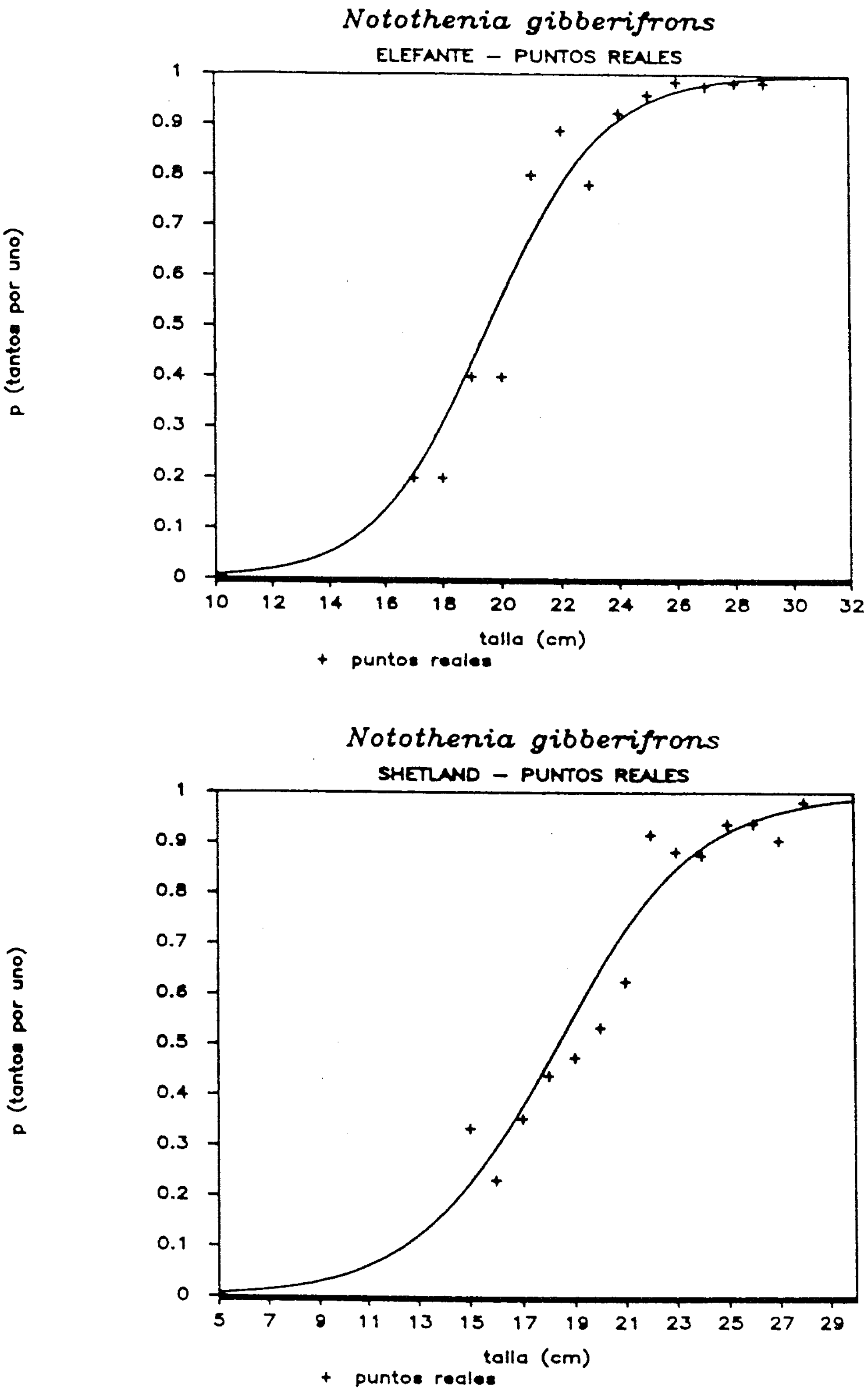
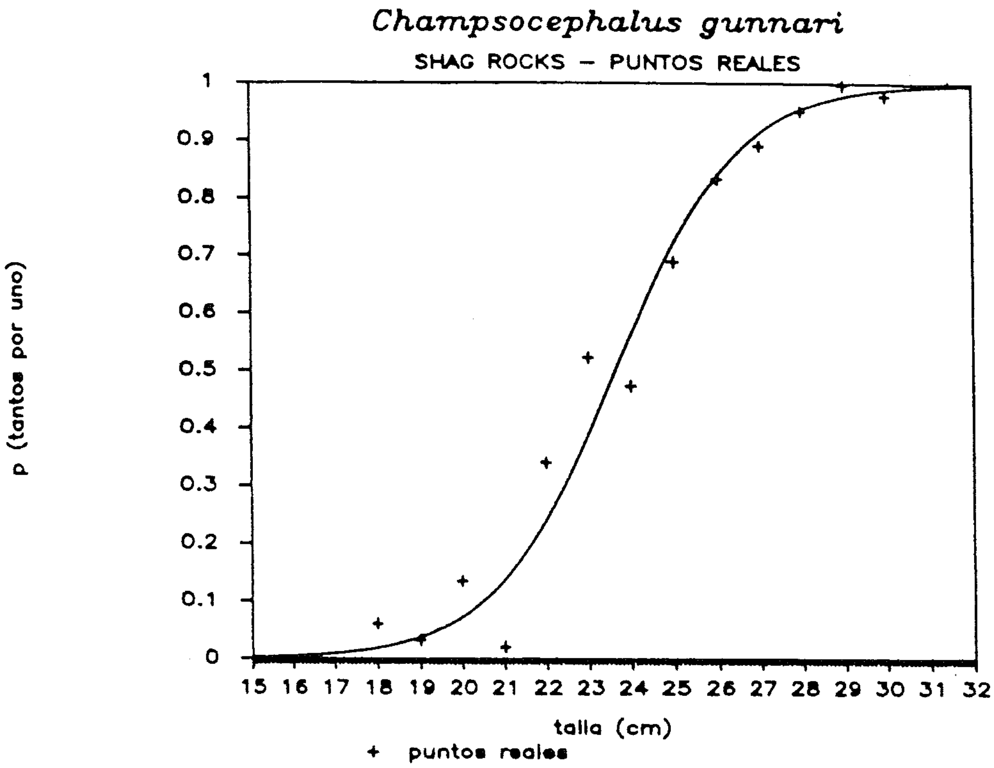


Figura 3: Curvas de selección obtenidas para *Notothenia gibberifrons* en Isla Elefante y Shetland del Sur, durante la campaña "ANTARTIDA 8611".



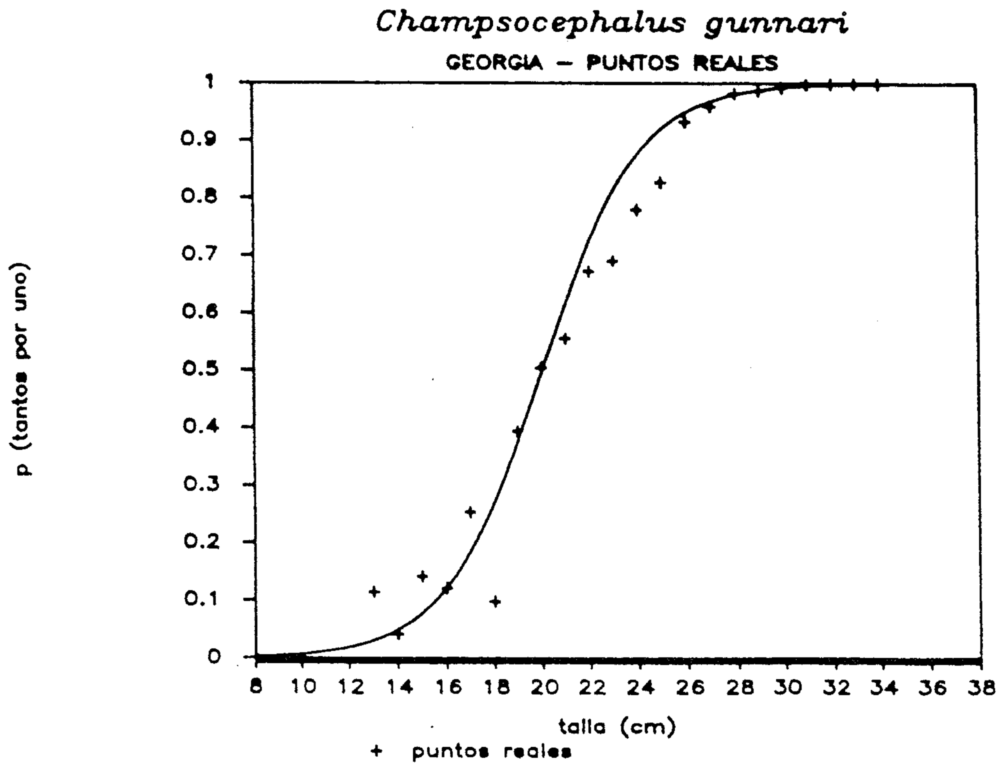
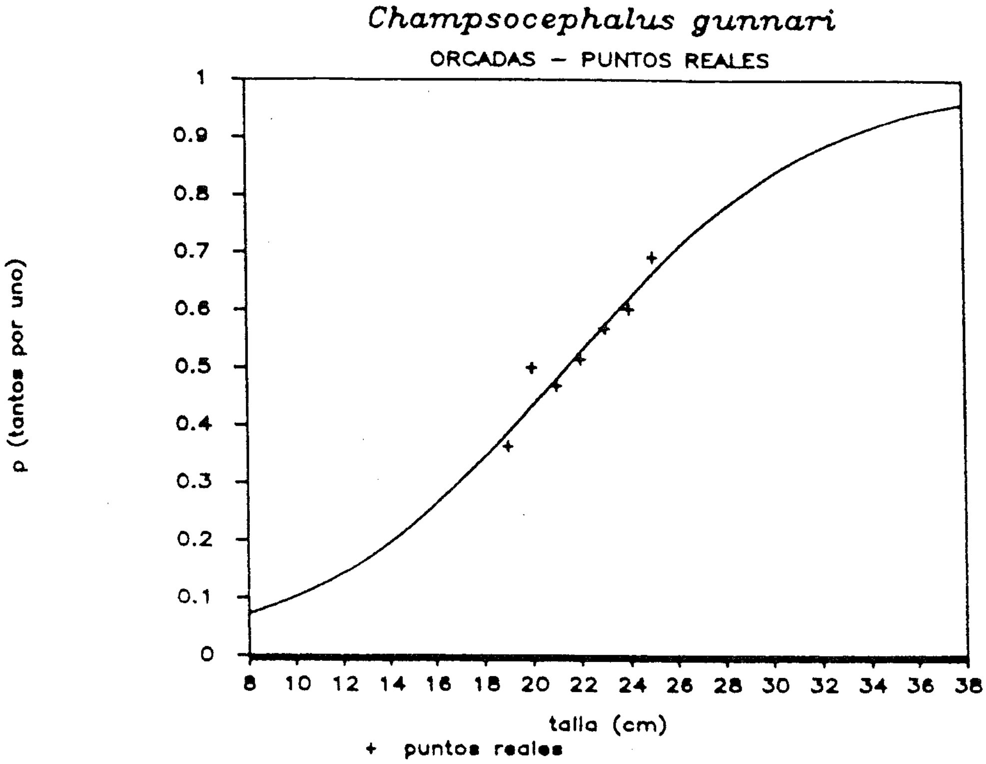


Figura 4: Curvas de selección obtendias para *Champsocephalus gunnari* en Shag Rocks y Georgia del Sur, durante la campaña "ANTARTIDA 8611".



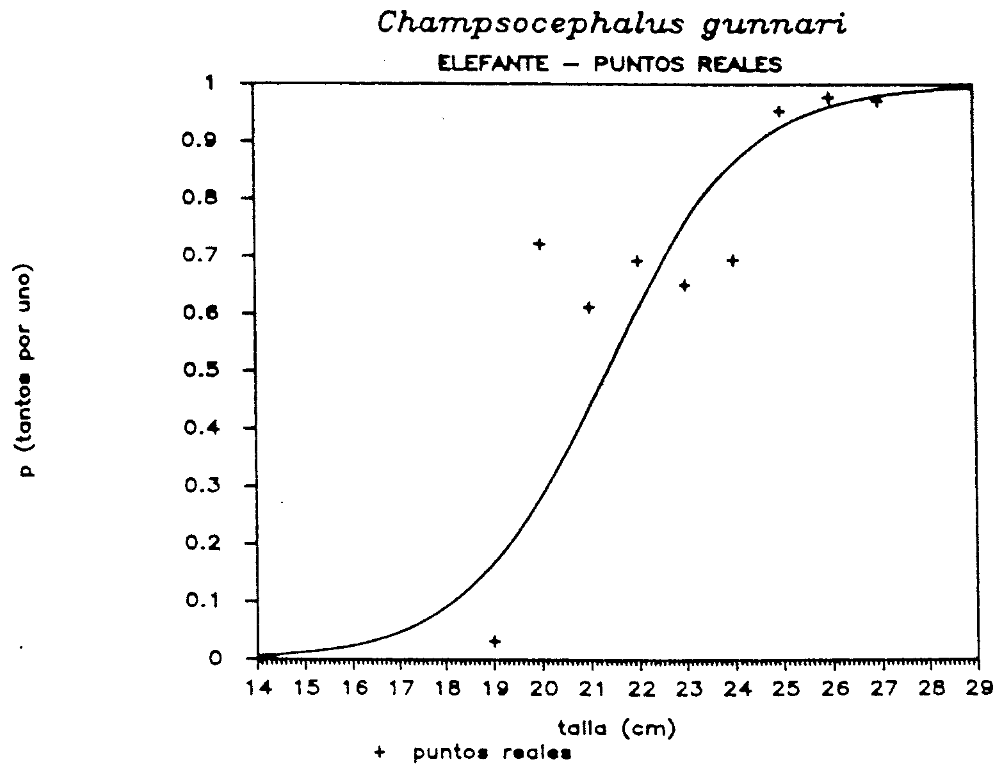


Figura 5: Curvas de selección obtenidas para *Champsocephalus gunnari* en Orcadas del Sur e Isla Elefante, durante la campaña "ANTARTIDA 8611".

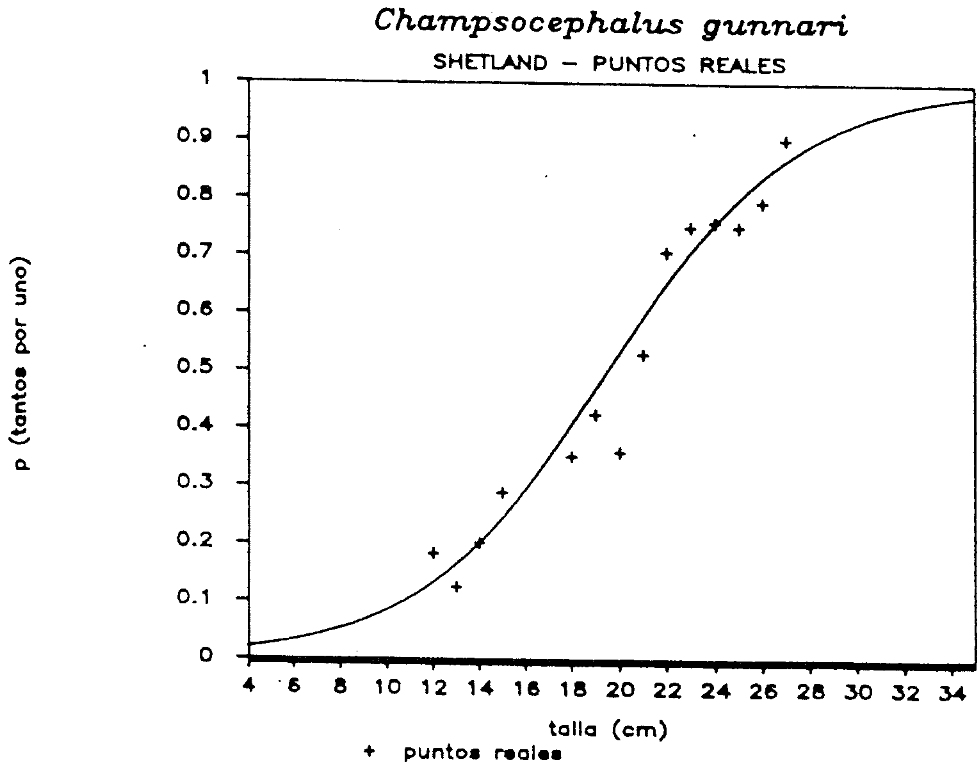


Figura 6: Curva de selección obtenida para *Champsocephalus gunnari* en Shetland del Sur, durante la campaña "ANTARTIDA 8611".

Table Legends

Table 1 — Technical data and results of selectivity tests for *Notothenia gibberifrons* during the "ANTARTIDA 8611" survey.

Table 2 — Technical data and results of selectivity tests for *Champsocephalus gunnari* during the "ANTARTIDA 8611" survey.

Figure Legends

Figure 1 — Schematic drawing of gear sued during the "ANTARTIDA 8611" survey.

Figure 2 — Selectivity ogives for *Notothenia gibberifrons* in the South Georgia Island and South Orkney Island areas during the "ANTARTIDA 8611" survey.

Figure 3 — Selecitivy ogives for *Notothenia gibberifrons* in the Elephant Island and South Shetland Island areas during the "ANTARTIDA 8611" survey.

Figure 4 — Selectivity ogives for *Champsocephalus gunnari* in the Shag Rockas and South Georgia Island areas during the "ANTARTIDA 8611" survey.

Figure 5 — Selectivity ogives for *Champsocephalus gunnari* in the South Orkney Islands and Elephant Island areas during the "ANTARTIDA 8611" survey.

Figure 6 — Selectivity ogive for *Champsocephalus gunnari* in the South Shetland Islands area during the "ANTARTIDA 8611" survey.

Légendes des tableaux

Tableau 1 — Données techniques et résultats des expériences de sélectivité réalisés sur le *Notothenia gibberifrons* lors de la campagne "ANTARTIDA 8611".

Tableau 2 — Données techniques et résultats des expériences de sélectivité réalisées sur le *Champsocephalus gunnari* lors de la campagne "ANTARTIDA 8611".

Légendes des figures

Figure 1 — Schéma de l'engin de pêche utilisé lors de la campagne "ANTARTIDA 8611".

Figure 2 — Courbes de sélection obtenues pour le *Notothenia gibberifrons* en Géorgie du Sud et dans les Orcades du Sud, lors de la campagne "ANTARTIDA 8611"

Figure 3 — Courbes de sélection obtenues pour le *Notothenia gibberifrons* dans l'île de l'Eléphant et les îles Shetland du Sud, lors de la campagne "ANTARTIDA 8611".

Figure 4 — Courbes de sélection obtenues pour le *Champsocephalus gunnari* dans les Shag Rocks et la Géorgie du Sud, lors de la campagne "ANTARTIDA 8611".

Figure 5 — Courbes de sélection obtenues pour le *Champsocephalus gunnari* dans les Orcades du Sud et l'île de l'Eléphant, lors de la campagne "ANTARTIDA 8611".

Figure 6 Courbes de sélection obtenues pour le *Champsocephalus gunnari* dans les îles Shetland du Sud, lors de la campagne "ANTARTIDA 8611".

Заголовки к таблицам

Таблица 1 Технические данные и результаты тестов по селективности для *Notothenia gibberifrons* во время съемки "ANTARTIDA 8611".

Таблица 2 Технические данные и результаты тестов по селективности для *Champsocephalus gunnari* во время съемки "ANTARTIDA 8611".

Подписи к рисункам

Рисунок 1 Схема орудия лова, использованного во время съемки "ANTARTIDA 8611".

Рисунок 2 Огивы селективности для *Notothenia gibberifrons* в районе Южной Георгии и Южных Оркнейских островов во время съемки "ANTARTIDA 8611".

Рисунок 3 Огивы селективности для *Notothenia gibberifrons* в районах о. Элефант и Южных Шетландских островов во время съемки "ANTARTIDA 8611".

Рисунок 4 Огивы селективности для *Champsocephalus gunnari* в районах скал Шаг и Южной Георгии во время съемки "ANTARTIDA 8611".

Рисунок 5 Огивы селективности для *Champsocephalus gunnari* в районах Южных Оркнейских островов и о. Элефант во время съемки "ANTARTIDA 8611"

Рисунок 6 Огивы селективности для *Champsocephalus gunnari* в районах Южных Шетландских островов во время съемки "ANTARTIDA 8611".

SELECTIVITY OF STANDARD POLISH COMMERCIAL TRAWL CODENDS ON ANTARCTIC FISHING GROUNDS

J. Zaucha

Abstract

Selectivity studies were carried out for two types of steelon codends used in commercial fishery, with a nominal mesh size A = 80 mm and A = 100 mm, made of double twines with a thickness of 4.2 mm. The studies covered 6 major fish species.

1. It appears from the study that Antarctic icefish and bumphead notothenia are subject to selection during trawling, although the effectiveness of this process - especially in the latter case - is not satisfactory.

2. Scotia Sea icefish, *Chaenodraco wilsoni*, and *Chionodraco rastrospinosus* exhibit a lower tendency to pass through meshes of the codend than Antarctic icefish and bumphead notothenia.

3. The solution to the problem of ensuring selectivity of codends at a sufficiently good level seems possible as a result of the application of webbing with permanently open meshes for codend construction.

4. The most difficult matter will be preparing a codend with proper selectivity properties for South Georgia icefish, because this species exhibits the smallest tendency to escape during the trawling among all the species studied.

Conclusions and observations were in some cases based on a relatively small amount of experimental material.

Further investigations of this problem are necessary since producing selective trawl gear for harvesting Antarctic fish seems crucial from the point of view of conservation of living fish resources on those fishing grounds.

Résumé

Des études sur la sélectivité ont été menées sur deux types de culs de chalut en steelon utilisés dans les pêcheries commerciales, avec un maillage nominal A = 80 mm et A = 100 mm, faits de cordes doubles d'une épaisseur de 4,2 mm. Les études portaient sur 6 majeures espèces de poissons.

1. L'étude montre que les poissons des glaces et les bocasses bossues sont sujets à sélection au cours du chalutage, bien que l'efficacité de ce procédé - particulièrement dans le dernier cas - laisse à désirer.

2. Les grandes-gueules antarctiques, les *Chaenodraco wilsoni* et *les Chionodraco rastrospinosus* ont moins tendance à passer à travers les mailles du raban de cul que les poissons des glaces et les bocasses bossues.

3. Il semble possible de résoudre le problème d'une sélectivité satisfaisante de rabans de cul grâce à l'utilisation d'une sangle à mailles ouvertes en permanence dans la fabrication des culs de chalut.

4. Le problème le plus difficile sera de préparer un cul de chalut ayant les propriétés de sélectivité nécessaires pour la pêche au poisson des glaces de la Géorgie du Sud qui, de toutes les espèces étudiées, est celle qui a le moins tendance à s'évader au cours du chalutage.

Les conclusions et les observations sont dans certains cas basées sur une quantité relativement faible de matériel expérimental.

Il est nécessaire de procéder à d'autres études sur ce problème, la production d'engins de chalutage sélectifs destinés à la pêche des poissons de l'Antarctique paraissant cruciale du point de vue de la conservation des ressources ichtyologiques vivantes dans ces lieux de pêche.

Резюме

Проводились иследования по селективности двух типов применяемых при коммерческом промысле стилоновых кутков с размером ячеи А = 80 мм и А = 00 мм, сделанных из двойного шпагата толщиной 4,2 мм. Исследования охватывали 6 основных видов рыб.

1. Исследования показали, что селекция ледяной рыбы и зеленой нототении происодит во время траления, хотя эффективность этого процесса, особенно в случае зеленой нототении, неудовлетворительна.

2. Крокодиловая белокровка, *Chaenodraco wilsoni* и *Chionodraco rastrospinosus* проявили меньшую тенденцию к прохождению сквозь ячеи кутка, чем ледяная рыба и зеленая нототения.

3. Представляется, что решение проблемы обеспечения достаточно хорошего уровня селективности кутка лежит в использовании при конструировании кутка тетивы с постоянно открытыми ячеими.

4. Самой трудной задачей будет изготовление для селекции темной белокровки кутка с нужными селектывными свойствами, так как из всех изучавшихся видов этот вид во время траления показал наименьшую тенденцию к выходу из сети.

В некоторых случаях выводы и наблюдения сделаны при относительно небольшом количестве экспериментального материала.

Необходимо проведение дальнейших исследований по этому вопросу, так как в плане сохранения живых рыбных ресурсов на этих промысловых участках наиважнейшим представляется конструирование селективных траловых сетей для проведения лова антарктической рыбы.

Resumen

Se realizaron estudios de selectividad con dos tipos de copos de "steelon" que se emplean en la pesca comercial, cuyo tamaño nominal de luz de malla era A = 80 mm y A = 100 mm, hechos con hilo doble de 4,2 mm de espesor. Estos estudios abarcaron seis especies principales de peces.

1. Según dicho estudio, parece que el draco rayado y la trama jorobada están sujetos a selección durante el arrastre, si bien la efectividad de este proceso - especialmente en el segundo caso - no es satisfactoria.

2. El draco antártico, *Chaenodraco wilsoni* y *Chionodraco rastrospinosus* presentan una menor tendencia a pasar por el copo que el draco rayado y la trama jorobada.

3. La solución al problema de asegurar la selectividad a un nivel aceptable parece ser posible aplicando un tejido con las mallas permanentemente abiertas en la fabricación del copo.

4. La cuestión más difícil será preparar un copo con las propiedades de selectividad adecuadas para el draco cocodrilo, ya que, de todas las especies estudiadas, ésta es la que presenta una menor tendencia a escaparse durante el arrastre.

Las conclusiones y observaciones se basaron, en algunos casos, en una cantidad de material experimental relativamente pequeña.

Es necesario investigar aún más este problema, ya que la fabricación de artes de arrastre selectivas para la recolección de peces antárticos parece vital desde el punto de vista de la conservación de los recursos de peces en estas zonas de pesca.

1. INTRODUCTION

Selectivity studies of trawls used by the Polish fishery were conducted in 1950-1980. Cieglewicz and Strzyzewski (1960) studies the mechanism of the passage of cod through various parts of the trawl made of different materials. They came to the conclusion that the main part through which juvenile fish escape is the upper part of the codend. In the 1960's and 1970's extensive investigations of selectivity, directed by Strzyzewski (1971) covered several fish species, taking into account a number of physical factors affecting the selection process, such as choice of material, technological structure of webbing, use of layered structure of material making up the codend, size relations of meshes in the cover and codend, etc. Evaluation of the effect of mesh size and shape on selection of cod in the Baltic was also carried out in the 1970's (Szymanski, 1980). For the first time in Poland, Szymanski used in those studies webbing with permanently open meshes, made of textile belts. It turned out that square, permanently open meshes had the best selectivity properties with respect to cod.

This conclusion was confirmed for other cod-like fish and lobsters by investigations of Robertson (Robertson, 1986a, 1986b). On the other hand, Gabriel, Kemp and Haberstroh (1987) expressed an opinion that the change of mesh shape from rhomboid to square has no special effect on the ratio of undersized fish to landing-sized fish in the codend, but results only in collecting fish less soiled with benthos. It should be emphasized that no attention has been paid in investigations carried out so far to the phenomenon of deferred or arrested reaction of escape of any fish species from the codend.

The first Polish selectivity studies of trawl gear in the Antarctic were carried out in the 1978/79 (Zaucha, 1979) season. It was established during those studies, with the use of, among others, tape codends, that Antarctic fish behave differently during trawling than fish studied before and that it was difficult to interpret the results obtained in an objective and convincing way.

2. OBJECTIVE OF THE STUDY

After the introduction of codend mesh-size regulations in the Antarctic, it was decided that selectivity studies begun in the 1978/79 season would be continued mostly on the basis of codends currently used in commercial fishing operations. The objective of investigations in the 1986/87 season was to determine whether technical and material conditions of codends with a mesh size of 80 mm ensures, from the point of view of the CCAMLR Convention, satisfactory selectivity or whether bottom codends require a certain modification. For comparison, a codend with a mesh size of 100 mm was tested.

3. MATERIALS AND METHOD

Steelon codends with a four-wall, oblique construction made of double steelon twines with a nominal thickness of 4.2 mm were used in the study. Their length was 22.5 m, the square-shaped opening had a side with a length of 6.9 m, while the codend's rectangular tip had sides with lengths of 6.9 x 4.0 m. The codend itself was covered on the outside from the top down to the middle of its height with a cover having relatively small meshes (mesh bar 20 mm). Three sets of floats, 5 in each, were attached to the rear part of the cover. The bottom part of the codend was covered from the inside up to half of the codend's height with a liner made of the same material as the cove. Thanks to such construction of the codend, undersized fish could escape from the codend only from the part equipped with the cover. They were later trapped in the end parts of the cover. Because of difficult conditions on the fishing grounds (stones, rocks, etc.), the codend was protected against mechanical damage by special protective materials placed at its bottom.

A schematic drawing of the codend's construction and construction of the codend proper made of steelon fabric with a nominal mesh size of 80 mm is presented in Figure 1. The codend with a 100 m mesh size had the same construction. In reality both codends had somewhat different mesh sizes than nominal ones, which will be discussed in detail when presenting changes in mesh size during codends use.

The codends used in the selectivity study were used on board the research vessel *Professor Siedlecki* which is a factory trawler with power of 1690 KW (2300 HP). Codends with similar constructions to those used in Polish commercial fishing vessels were included in a 32/31 bottom trawl set-up which was used in previous years on Antarctic fishing grounds and met with positive opinions. A schematic drawing of the construction and rigging of such a setup is presented in Figures 2 and 3.

The process of fish selection by a given codend is characterized by means of a selectivity ogive and a number of additional parameters:

- selectivity interval "Ps": difference in centimetres between the length class of fish retained in the codend in 75% (L_{75}) and the class retained in 25% (L_{25}),

$$Ps = L_{75} - L_{25}$$

- selectivity coefficient "Fs": ratio of the length of this class of fish which is retained and released in 50% (L_{50}) to the length of mesh size "A" in the codend, measured wet,

$$F_s = \frac{L_{50}}{A}$$

- selection quality "Ws": value of ratio of length class of fish released and retained in 50% (L_{50}) to the length class of fish fully retained by the codend (L_{100}),

$$W_s = \frac{L_{50}}{L_{100}}$$

- selection effectiveness "N": percentage value of ratio of the number of fish which passed onto cover "n_o" to the sum of the same number of fish and the number of fish "n_w" in the codend and having a length not greater than those in the cover, i.e. length L_{100},

$$N = \frac{n_o \bullet 100}{n_o + n_w}$$

- relative selective length "l_{ow}": value of the ratio of mean fish length inside the cover "l_o" to the mean length "l_w" of fish inside the codend in percent; the value of this index gives some idea as to the size of fish escaping from the codend when compared with mean length of fish retained by the codend,

$$l_{ow} = \frac{l_o}{l_w} \bullet 100$$

- relative selective weight "m_{ow}": value of the ratio of mean weight of fish in the cover "m_o" to mean weight of fish inside the codend "m_w" expressed in percent; the value of this index illustrates the weight of fish escaping from the codend in comparison with the mean weight of fish retained by the codend,

$$m_{ow} = \frac{m_o}{m_w} \bullet 100$$

Measurements of total length of fish in the cover and the codend was made to the nearest centimetre below. Measurements of mesh size in the codend were carried out in the upper part of the codend at a distance of not more than 2 m from the codend ending and 2 meshes from lace hood meshes touching with codend-strengthening rope (Figure 1). The measurements were carried out immediately after the trawl retrieval (wet) with an international ICES caliper, at a preliminary tension of the mesh with a force of 4 kg. The size of mesh size was calculated as an arithmetic mean from 30 random mesh measurements. The frequency of measurements was the following: before trawl use, dry and wet, after the first haul (3 hours of use) and after each subsequent 15 hours of trawling.

Hauls used for the selectivity study of fishing gear should technically resemble typical commercial hauls. This was expressed in the fact that the study was conducted on a vessel with similar technical characteristics to those of typical fishing vessels used in that area, the use of a codend of similar construction to those used in commercial fishery, the use of a similar fishing gear and parameters of trawling like those used by commercial trawlers.

The selectivity study should be based on hauls fulfilling certain requirements, especially the following:

- general catch rate of a haul should not be smaller than about 300 kg of fish and not greater than several tonnes,
- the fish species analyzed should be present in the haul in a quantity of at least 3% of total haul weight,
- the fish species analyzed must be present in both the codend and the cover, in at least several length classes.

An attempt was made during the study to attain the average catch rate since only for such hauls it could be assumed that fish in the codend will have the opportunity of direct contact with the codend material and, as a result, will be able to escape from the codend, if its dimensions will allow.

4. EXPERIMENTAL PART

4.1 Fishing Effort and CPUE

The selectivity study was conducted on various Antarctic fishing grounds between October 1986 and mid-February 1987.

Fishing effort characteristics from experiments and CPUE for studied fish species are presented in Tables 1 and 2.

Thirty hauls were selected for the study, each of them lasting from 2 to 3 hours and being similar to commercial hauls of 3 hour duration. A relatively high catch rate, similar to those attained by commercial trawlers, was achieved around South Georgia. Quite high CPUE was also attained on the Elephant I. fishing ground in the third leg of the experiment. Catch rates in the other experiments were much lower - the catches on the Joinville fishing ground was so small that further tests were abandoned for methodological reasons. Differences in catch rates attained in different phases of experiments were most likely connected with fluctuations in biological parameters of bottom fish concentrations on those fishing grounds and did not depend to any degree on technical factors used in the experiments such as type of gear used, its rigging, trawling parameters, etc.

The material collected (Table 2) is most representative for bumphead notothenia, Scotia Sea icefish, and Antarctic icefish, and less representative for *Chaenodraco wilsoni* and *Chionodraco rastrospinosus*, while for South Georgia icefish it is least representative.

4.2 Changes in Mesh Sizes in the Codends

The data presented in Table 3 demonstrated that before trawl was in use, the actual mesh size in the codend with a nominal mesh size of 80 mm was (both dry and wet) larger by about 10% than the nominal size. After a trawl was in use this value increased to about 14% in comparison with the nominal value, reaching 90 mm. Such value remained at a stable level during the first phase of the experiment and for that reason it was assumed as the actual mesh size for that phase. During the tests, experimental work with this codend was suspended for some time. After resuming work it was discovered that mesh size decreased considerably and exceeded the nominal value by only 8.5%. This value remained at a constant level during further tests, so it was assumed as actual size for that stage of the study.

Changes in mesh size in codends with a nominal mesh size of 100 mm resemble those in the 80 mm codend (Table 3). During the study, due to a failure, one codend had to be replaced by another. Therefore there were two series of codend tests with the same nominal mesh size. Generally speaking, mesh size in both codends remained at a level larger by 10-11% than the nominal value. That is why a value of 110.6 mm was assumed as actual for the 100 mm codend.

4.3 Selective Properties of Codends

4.3.1 Bumphead notothenia

Selection of bumphead notothenia was evaluated several times during 6 experiments on four Antarctic fishing grounds. Three experiments were made with 80 mm codend and three with 100 mm mesh codend. Proper calculations were made for each of them and a selectivity ogive was drawn. Those data are presented in Figures 4 and 5 and in Table 4.

Analysis of selectivity curves for the 80 mm codend obtained on the basis of data collected on various fishing grounds (Figure 4) revealed a number of common features despite quantitative differences. The most important feature was that all of these curves had a different shape in comparison with a standard selectivity ogive for net materials with a high selectivity coefficient. They were characterized by a very clear shift towards retention of small fish at a relatively high level. The ascent of the curves was very slow, which corresponded with high values of selection intervals "Ps". Selectivity coefficients F_s were decidedly low, as well as selection quality coefficients. Selectivity effectiveness was decidedly small - with this mesh size a much greater number of fish could escape through the meshes. Mean length of fish released and at the same time retained by the meshes was relatively small, decidedly smaller than could be theoretically predicted. That is why a general evaluation of the selection of bumphead notothenia by the 80 mm codend could not be positive.

Analysis of the selectivity curves for the 100 mm codend with respect to bumphead notothenia revealed their similar features with 80 mm codend's ogive. The greatest similarity was that these curves were very flattened and their shape did not clearly indicate the length range, for which fish selection would be more distinct. It covered several length classes which was reflected in exceptionally high values of selection intervals P_s. Values of selectivity coefficients were also relatively small. Indices of relative selective lengths and weights of fish escaped and retained by the codend were exceptionally high, indicating that there were no significant size differences between fish retained and escaped from the codend. The length of fish with 50% retention (L_{50}) was higher than for 80 mm codend, however, it was still relatively small. Distinctly higher length values were obtained in the case of fish retained by 100% in larger codend.

Since selectivity ogives for the two codends revealed basically similar qualitative tendencies, it was decided to group together all results collected on various fishing grounds for each codend and calculate their combined selectivity coefficients (8). Combined ogives are presented in Figure 6, while values of selection of bumphead notothenia by two different codends are presented in Table 5.

A comparison of the shape of both curves indicated clearly that selection of both net materials was qualitatively similar although there were distinct quantitative differences. The selection of bumphead notothenia occurred definitely during trawling although both ogives were shifted to the area of small fish. Selection intervals for both ogives were very wide, and the values of selectivity coefficients were relatively low, especially in the case of 80 mm codend. Selection effectiveness increased from 20% for 80 mm codend to almost 50% in the case of larger meshes. Both length L_{50} and L_{100} increased also. A general conclusion from the comparative analysis is that although both nets select bumphead notothenia during trawling, this property is not high enough. The use of larger meshes distinctly improved selection properties of bumphead notothenia but not to such a degree that they might be considered sufficient from a practical point of view. Therefore, none from those codends could be positively evaluated. Most likely that closed meshes in the codend constituted such an obstacle for fish that an increase in mesh size did not really solve the problem, although it improved selection. It may be expected that keeping meshes open may solve the problem of selection of bumphead notothenia because this species has a distinct tendency of escapement from the codend during trawling.

4.3.2 Antarctic icefish

Studies of selectivity properties of Antarctic icefish by 80 mm codend were carried out on two fishing grounds: South Georgia and Elephant I., while for 100 mm codend - only on the Elephant I. fishing ground. Three ogives were obtained as a result of these studies (Figure 7) for each experiment. The obtained coefficients are listed in Table 6. An assessment of the Antarctic icefish selection was based on a relatively large number of initial materials. The ogives resembled much more the standard selectivity ogive than in the case of bumphead notothenia, although they were characterized by the same negative feature, i.e., they were shifted towards the area of length classes of small fish. This was evident from relatively low values of L_{50}, especially on the South Georgia fishing ground as well as relatively low values of selection effectiveness (35-64%). This meant that between 35 and 65% of fish in the codend with a length smaller than L_{100} did not escape. Coefficients L_{ow} and m_{ow} characterized the selection of Antarctic icefish very clearly. Especially the former index showed that there was no great difference between mean length of fish escaped from the codend and fish retained. Thus, a large part of fish could pass through the meshes but did not grasp this opportunity.

In order to compare selectivity properties of both codends for Antarctic icefish, selectivity ogives of 80 mm and 100 mm codends were drawn together in Figure 8. Table 7 presents main selection indices for those curves.

The shape of both ogives was very similar (Zaucha, 1987), a significant difference was in much greater shift of 80 mm selectivity ogive towards the area of small fish than in the case of 100 mm ogive. Selection of Antarctic icefish by two codends was clearly evident but practical results of this process was insufficient. This may be seen from relatively long, extended selection intervals and not too high values of selectivity coefficients of about 2.8. It should be emphasized that the use of 100 mm mesh size resulted in an almost twofold increase in selection effectiveness as well as an increase of L_{50} by 21%. A general conclusion is that standard mesh-size does not ensure selection of Antarctic icefish to a sufficient degree. It seems that the partly closed meshes during trawling constituted too big an obstacle for Antarctic icefish to be able to escape from the codend. It may be expected that permanently open meshes may ensure a proper level of selection of Antarctic icefish.

4.3.3 Scotia Sea icefish

Selection of Scotia Sea icefish by 80 mm codend was studied on three fishing grounds: South Georgia, Elephant I., and King George I., for 100 mm codend - two experiments were carried out on the Elephant I. ground. Because of very modest materials collected off King George I. and in the second phase of the experiment off Elephant I., data from the King George I. fishing ground were not taken for further detailed analysis and all data from Elephant I. for 100 mm codend were combined.

As a result of these experiments, two selectivity ogives were drawn for 80 mm mesh and one for 100 mm codend (Figure 9). A set of selection coefficients was calculated for each ogive (Table 8). The main drawback of the material collected was that relatively few fish passed through the net during those tests. Under these circumstances the most important segment of the ogive, concerning those fish classes which escaped from the codend was based on relatively scarce materials. A general feature of all selectivity ogives was their exceptionally large shift towards the area of small fish. As a result, the values of L_{50} were low (Table 8). A second feature of these ogives were very low values of index P_s, which gave a negative indication of selection of Scotia Sea icefish by the codend. Both too large and too small values of selection intervals point to abnormalities in the process of fish selection by the codend. Selection quality indices were very unsatisfactory. Equally negative were selection effectiveness coefficients. Very low, much lower than for fish analyzed before, were the values of index m_{ow}, which meant that fish escaping through the meshes had exceptionally small weight compared with the fish retained. Generally speaking, both the shape of the selectivity ogive and the selection indices indicated that the ability to select Scotia Sea icefish by both kind of codends was unsatisfactory.

In order to determine characteristics of Scotia Sea icefish selection by the two codends in a more precise, comparative way, two ogives were presented in Figure 10, one for each type of codend. Table 9 presents main selection coefficients for each of these codends (Zaucha, 1987).

The most important feature of both curves was their overlapping. This meant that the selection processes of both codends were similar. This conclusion is emphasized by data from Table 9. It appears from them that values of selectivity coefficients were very low, even lower for the net with larger meshes than with smaller meshes. Selection effectiveness was at a very low level. As a result a great number of fish which could escape because of their size, remained in the codend. The values of both L_{50} and L_{100} for both types of nets were the same, within the limits of an experimental error.

A general conclusion from these tests may be brought down to the observation that a change in the mesh size in the codend did not bring about a qualitative change in selection of Scotia Sea icefish. This gave rise to a fear that even the use of permanently open meshes will not bring the desired results, i.e., such as is expected in the case of Antarctic icefish and bumphead notothenia.

4.3.4 Chaenodraco wilsoni and Chionodraco rastrospinosus

Selectivity studies of these two species were based only on tests with 100 mm codend on the Joinville fishing ground. Selectivity ogives for the two species are presented in Figure 11, their selection parameters in Table 10.

Both the shape of the curves and the values of the parameters give an almost identical evaluation of the selection process of these fish by the standard codend. The values of selectivity coefficients and selection quality were low. Selection effectiveness was of particularly low value: 15% for *Chaenodraco wilsoni* and 10% for *Chionodraco rastrospinosus*. This meant that from 85 to 90% of fish did not choose to escape although their size allowed them for that. Parameters L_{ow} and m_{ow} were at a high level. This meant that as regards length and weight, there were no great differences between escaped and retained fish .

It is not surprising that a general appraisal of selectivity of the standard codend with respect to both species is decidedly negative, as in the case of Scotia Sea icefish. In this case it is also difficult to foresee whether permanently open meshes will improve the quality of selection of these fish to such a degree that it may be possible to evaluate it positively.

4.4 Additional Remarks

During the tests carried out on South Georgia fishing grounds, South Georgia icefish was found in the codend but no fish of this species were noted in the cover. Examination of length composition of fish in the codend revealed that although there were no juvenile South Georgia icefish, quite numerous were specimens with a length of 34, 35, 36 and 37 cm and larger. Fish with a length between 34 and 37 cm could, due to their sizes, pass through the meshes of the codend but did not use this opportunity. Under these circumstances a conclusion may be drawn that South Georgia icefish must find it extremely difficult to pass through the meshes of the codend during trawling so that even open meshes might not be an effective means of improving selection of this species.

5. CONCLUSIONS

1. Antarctic icefish and bumphead notothenia are subject to net selectivity of the commercial codend during trawling, but the effectiveness of this process in the case of standard nets, i.e. made of double polyamide twine, is insufficient. For that reason the use of codends believed to be good on other fishing grounds, cannot be practically recommended for commercial fishery on Antarctic fishing grounds irrespective of the established mesh size.

2. An increase in the effectiveness of selection of these fish species may be expected as a result of changing the construction of the codends, i.e. the use of permanently open meshes.

3. A tendency to escape from the codend during trawling of such fish as South Georgia icefish, Scotia Sea icefish, *Chaenodraco wilsoni* and *Chionodraco rastrospinosus* seems to be smaller than in the case of Antarctic icefish and bumphead notothenia. It is expected that the use of permanently open meshes in the codend would greatly improve the existing situation.

4. Ensuring proper selection of major Antarctic fish species by introducing one mesh size does not seem possible. The mesh size recommended at present

(80 mm) seems well chosen for Antarctic icefish, while for others like Scotia Sea icefish, South Georgia icefish and *Chionodraco rastrospinosus* it seems too small.

5. Experiments at sea should be urgently undertaken in order to confirm the observed tendency of arrested ability of Antarctic fish to pass out of a standard codend despite the fact that both mesh size and fish size theoretically ensure such a possibility. A suggested technical solution is a change of codend design so that meshes will not close during trawling. It is believed that such solution will effectively reduce fishing mortality of valuable species of Antarctic fish.

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Table 1: Characteristics of fishing effort in each of the experiments

Study period		27-29 Oct 1986	13-15 Nov 1986	15-16 Nov 1986	18-20 Dec 1986	13-4 Feb 1987	18 Feb 1987
Fishing ground		Elephant I.	Joinville I.	Elephant I.	South Georgia I.	Elephant I.	King George I.
Number of hauls		8	6	4	5	5	2
Trawling time (h)	total	20^{35}	18^{00}	10^{00}	14^{50}	10^{30}	3^{50}
	per haul	2^{34}	3^{00}	2^{30}	2^{58}	2^{06}	1^{55}
Catch (t)	total	5.89	1.52	1.49	14.39	10.43	2.89
	per 1 haul	0.74	0.25	0.37	2.88	2.09	1.44
	per 1 hour fished	0.29	0.084	0.15	0.97	0.99	0.75

Table 2: Catch rates of fish species subjected to the study in each of the experiments (in t/h and percent)

Study Period	27-29 Oct 1986		13-15 Nov 1986		15-16 Nov 1986		18-20 Dec 1986		13-14 Feb 1987		18 Feb 1987	
Fishing Ground	Elephant I.		Joinville I.		Elephant I.		South Georgia I.		Elephant I.		King George I.	
Fish species	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%
Bumphead notothenia	4.12	69.9	0.39	25.8	1.18	79.2	3.47	24.1	8.02	76.9	2.15	74.3
Antarctic icefish	0.15	2.5	-	-	0.04	2.5	8.12	56.4	0.78	7.4	-	-
Scotia Sea icefish	0.79	13.4	-	-	0.26	17.6	1.71	11.9	1.51	14.5	0.44	15.2
Chaenodraco wilsoni	-	-	0.90	59.5	-	-	-	-	-	-	-	-
Chionodraco rastrospinosus	-	-	0.08	5.2	-	-	-	-	-	-	-	-
South Georgia icefish	-	-	-	-	-	-	1.00	7.0	-	-	-	-
Other species	0.83	14.2	0.15	9.5	0.01	0.7	0.09	0.6	0.12	1.2	0.30	10.5
Total	5.89	100	1.52	100	1.49	100	14.39	100	10.43	100	2.89	100

Table 3: Changes in mesh size in the codends tested

Parameter	Nominal mesh sizes	No. of codend	Mesh size				
			Before use		During use		
			Dry	Wet	Wet		
					After 3 h	After 15 h	After 30 h
Mean mesh size (mm)	80	I	87.2	88.2	91.2	90.0	86.8
	100	I	106.1	107.4	109.4	110.0	-
		II	108.3	110.2	111.8	111.2	-
Standard deviation (mm)	80	I	2.88	2.46	2.69	2.83	2.40
	100	I	2.36	3.06	2.37	1.87	-
		II	2.67	2.56	2.54	2.20	-
Coefficient of change (%)	80	I	3.3	2.8	3.0	3.1	2.8
	100	I	2.2	2.9	2.2	1.7	-
		II	2.5	2.3	2.3	2.0	-

Table 4: Main selection parameters of bumphead notothenia

Selection parameter	80 mm codend			100 mm codend		
	South Georgia I.	Elephant I.	King George I.	Elephant I. (i phase)	Elephant I. (ii phase)	Joinville I.
No. of fish measured in codend	6 814	20 701	3 217	7 053	3 090	835
No. of fish measured in codend	2 198	2 826	420	8 526	1 328	761
P_s	12.0	7.2	6.2	10.2	13.6	14.0
F_s	2.02	2.28	2.88	2.84	2.10	2.64
W_s	0.48	0.52	0.64	0.74	0.59	0.72
N	36.3	14.7	28.1	55.3	30.7	48.3
L_{ow}	60.8	85.4	70.8	86.9	92.8	85.9
M_{ow}	15.6	48.6	28.9	74.2	75.7	56.5
L_{50}	18.2	19.8	25.0	31.2	23.6	29.4
L_{100}	38.0	38.0	36.0	42.0	40.0	41.0
L_{25}	14.1	17.8	22.2	25.4	18.2	20.0
L_{75}	26.1	25.0	28.4	35.6	31.8	34.0

Table 5: Main selectivity indices of bumphead notothenia for two codends

Index	P_s	F_s	N	L_{50}	L_{100}
80 mm codend	13.1	2.29	20.0	20.6	38.0
100 mm codend	16.8	2.63	49.8	28.9	42.0

Table 6: Main selection parameters of Antarctic icefish

Selection parameter	80 mm codend		100 mm codend
	South Georgia I.	Elephant I.	Elephant I. (i and ii phase)
No. of fish measured in codend	56 342	2 330	604
No. of fish measured in codend	29 851	1 841	1 035
P_s	6.8	5.4	8.0
F_s	2.56	3.22	2.82
W_s	0.66	0.73	0.78
N	34.8	45.9	64.1
L_{ow}	93.1	76.2	84.1
M_{ow}	78.4	32.3	48.5
L_{50}	23.0	28.0	31.1
L_{100}	35.0	38.0	40.0
L_{25}	19.8	24.8	26.0
L_{75}	26.6	30.2	34.0

Table 7: Main selection indices of Antarctic icefish for two codends

Index	P_s	F_s	N	L_{50}	L_{100}
80 mm codend	9.6	2.84	35.2	25.6	38.0
100 mm codend	8.0	2.82	64.1	31.1	40.0

Table 8: Main selection parameters of Scotia Sea icefish

Selection parameter	80 mm codend		100 mm codend
	South Georgia I.	Elephant I.	Elephant I. (i and ii phase)
No. of fish measured in codend	2 954	1 801	1 691
No. of fish measured in codend	133	44	125
P_s	2.5	3.9	5.4
F_s	2.29	2.48	2.09
W_s	0.59	0.72	0.59
N	7.5	25.6	25.7
L_{ow}	63.0	44.0	59.0
M_{ow}	13.3	2.7	8.4
L_{50}	20.6	21.5	23.0
L_{100}	35.0	30.0	39.0
L_{25}	20.0	20.1	20.6
L_{75}	22.5	24.0	26.0

Table 9: Main selection indices of Scotia Sea icefish for two codends tested

Index	P_s	F_s	N	L_{50}	L_{100}
80 mm codend	6.2	2.48	10.2	22.3	39.0
100 mm codend	5.4	2.09	25.7	23.0	39.0

Table 10: Main selection parameters of *Chaenodraco wilsoni* and *Chionodraco rastrospinosus* for 100 mm codend on Joinville fishing ground

Selection parameter	*Chaenodraco wilsoni*	*Chionodraco rastrospinosus*
No. of fish measured in codend	3 484	164
No. of fish measured in codend	651	11
P_s	10.1	1.9
F_s	2.12	2.66
W_s	0.63	0.75
N	15.8	9.2
L_{ow}	93.4	90.6
M_{ow}	88.3	69.6
L_{50}	23.4	29.4
L_{100}	37.0	39.0
L_{25}	19.9	28.4
L_{75}	30.0	30.3

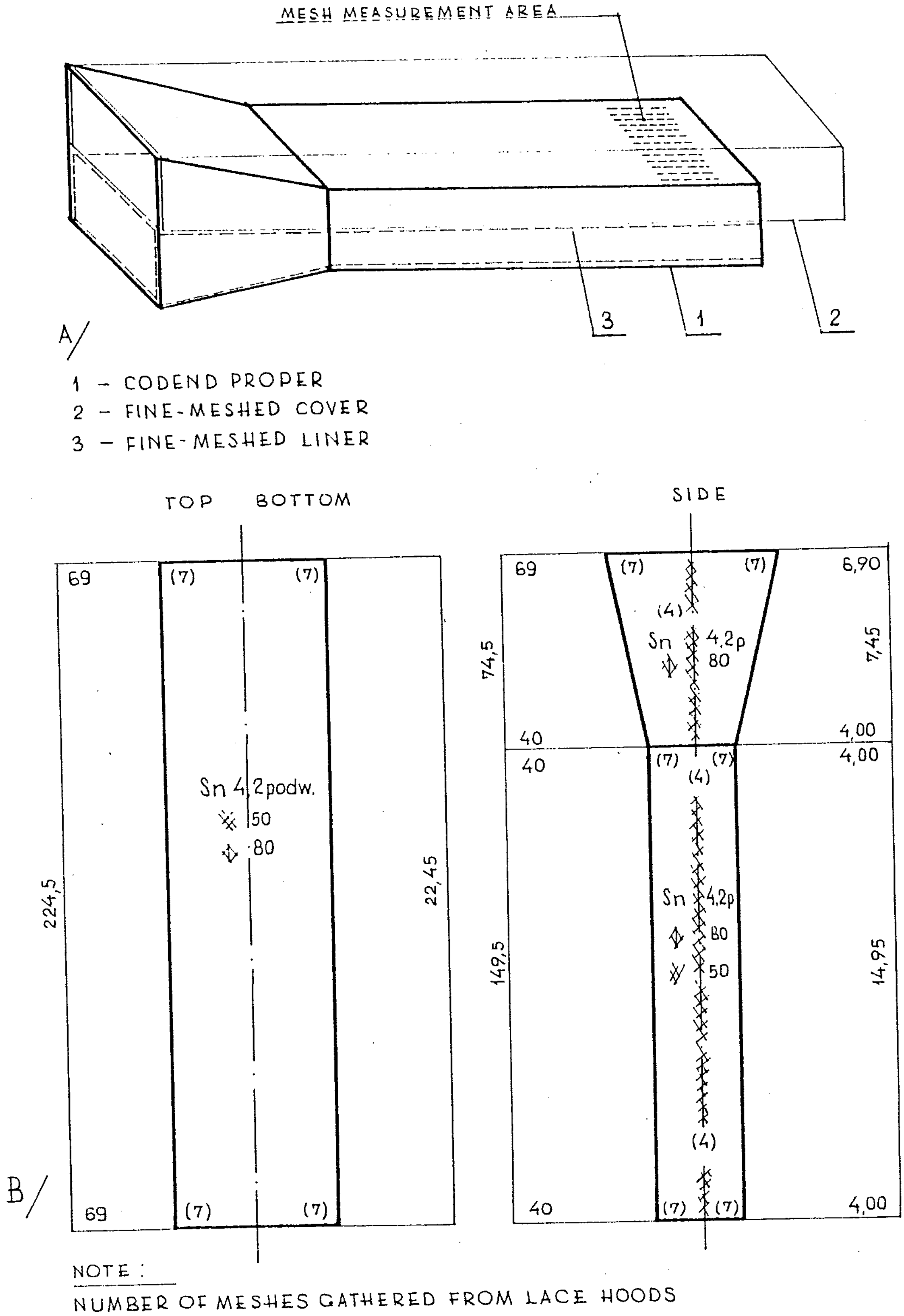

Figure 1: Schematic drawing of codend proper with cover and liner - for selectivity study (a) and construction of 80 mm codend proper (b).

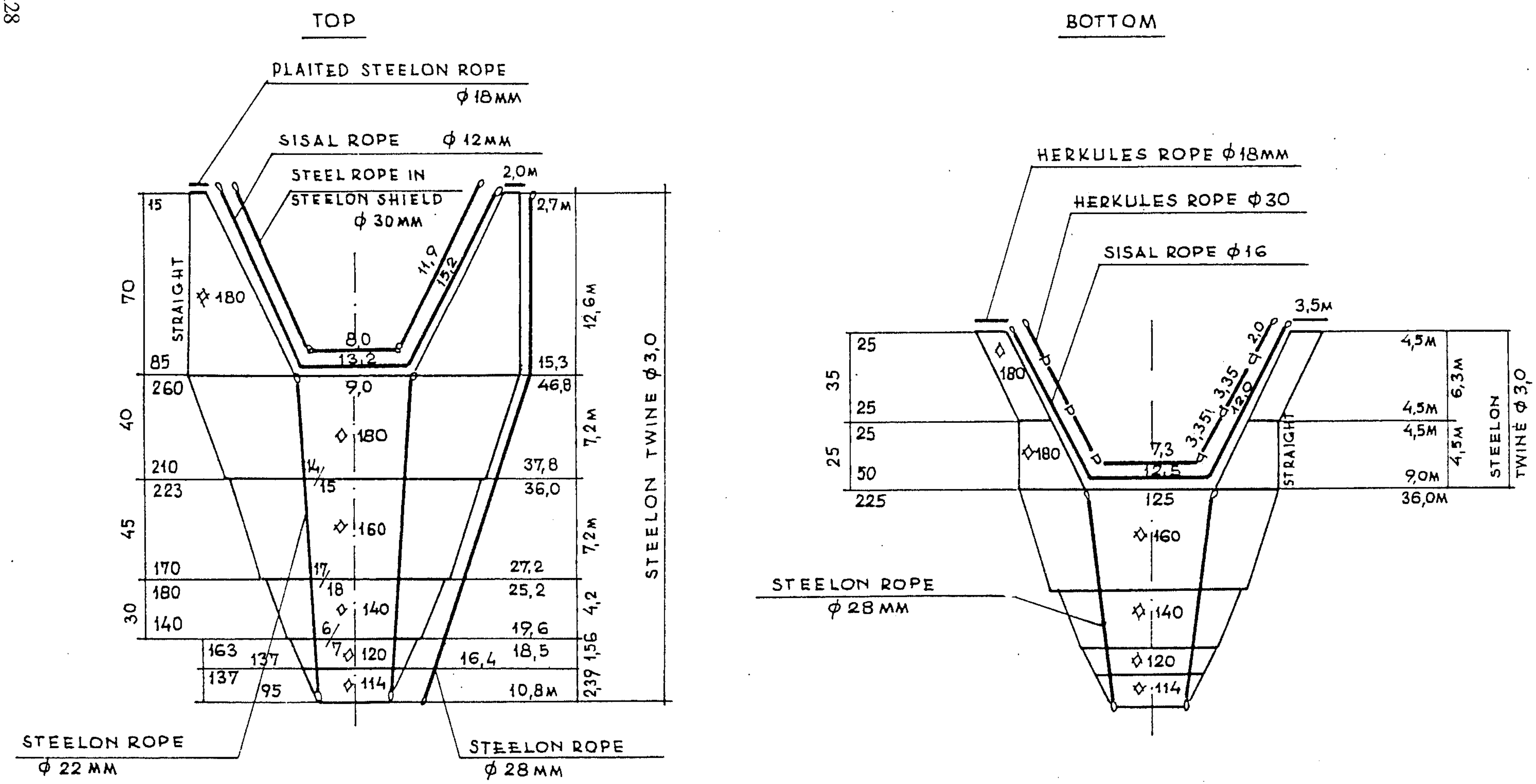

Figure 2: Schematic drawing of 32/31 bottom trawl construction

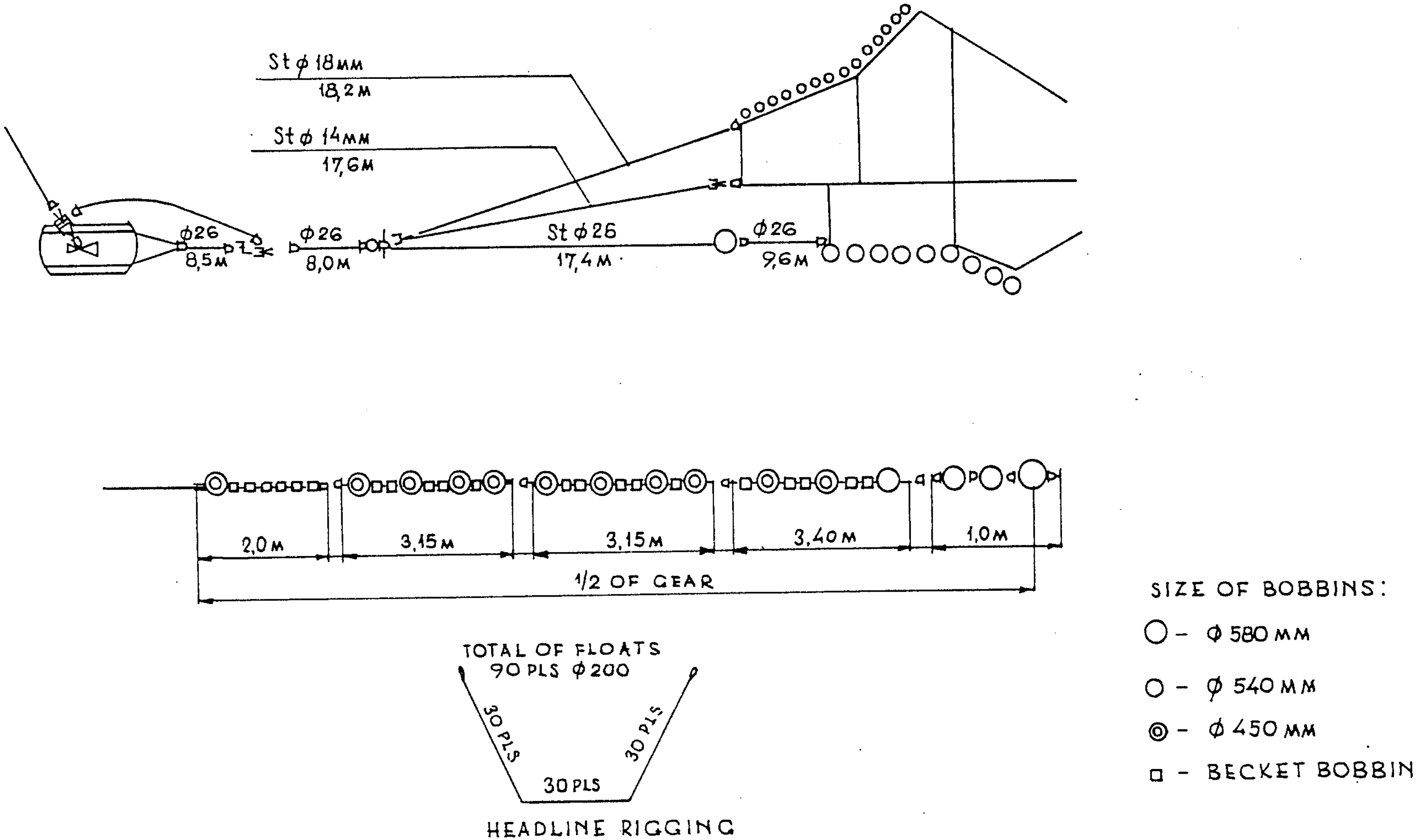

Figure 3: Schematic drawing of 32/31 bottom trawl rigging

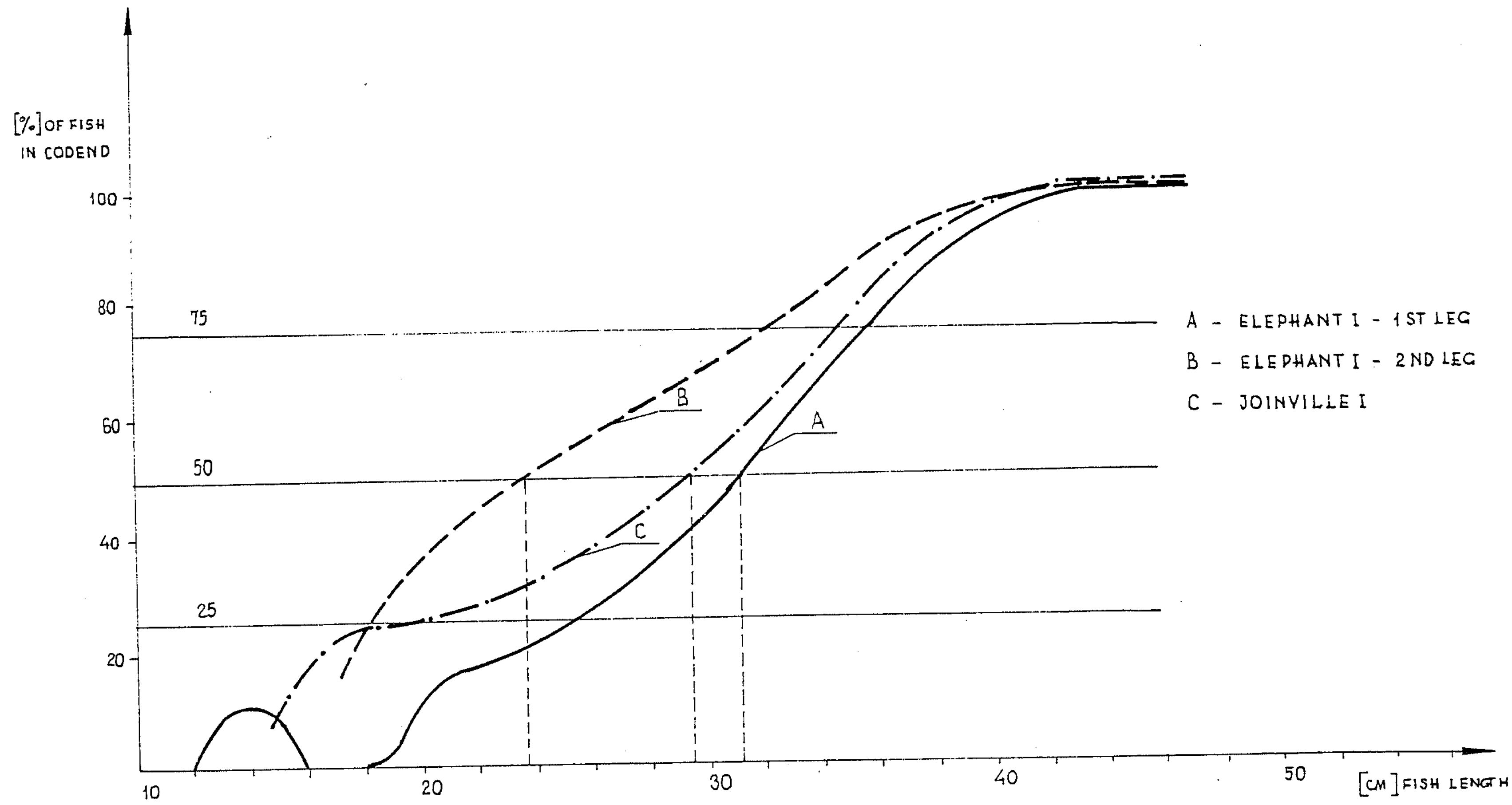

Figure 4: Selectivity ogive for bumphead notothenia by 80 mm codend

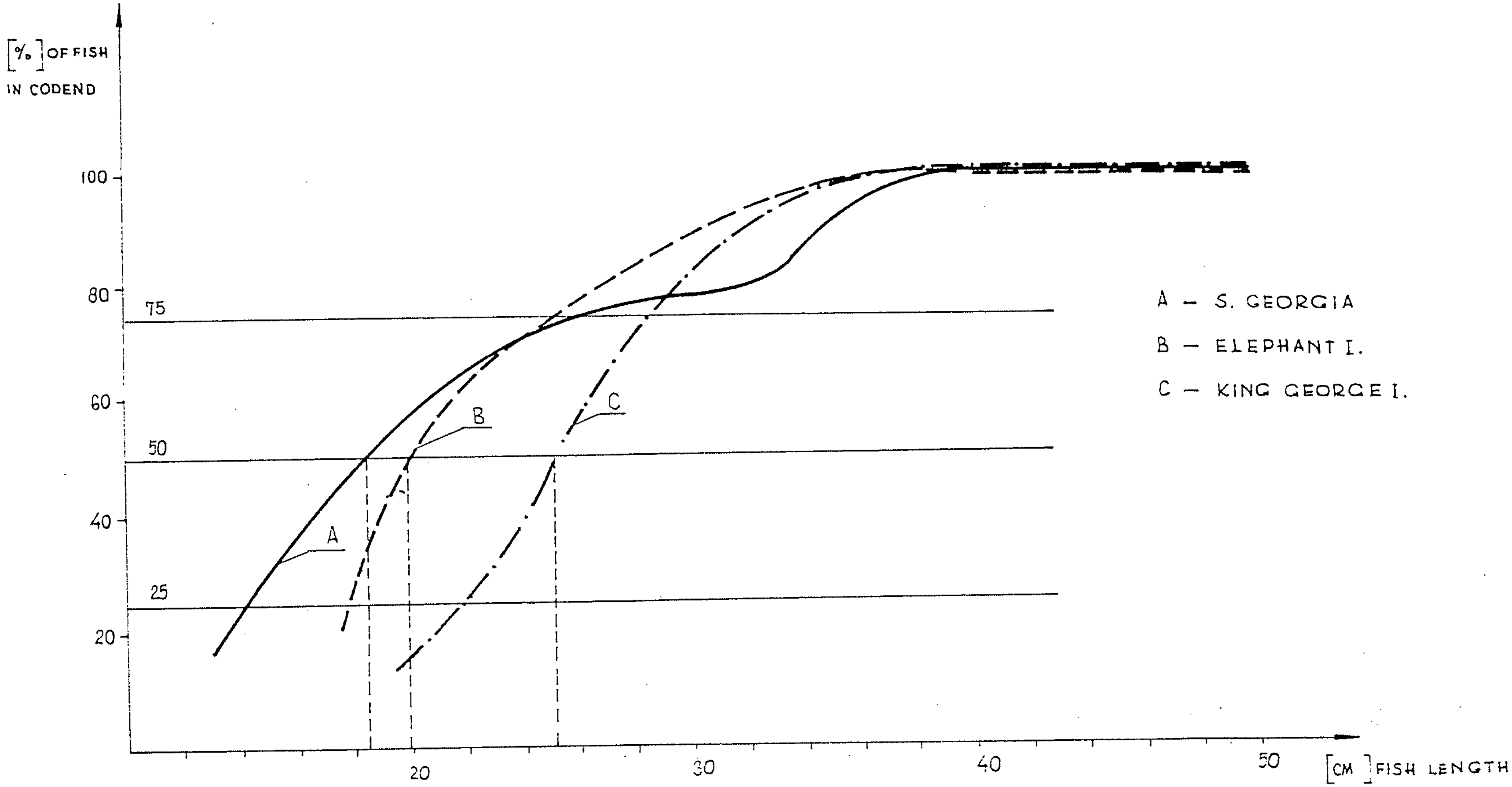

Figure 5: Selectivity ogive for bumphead notothenia for 100 mm codend

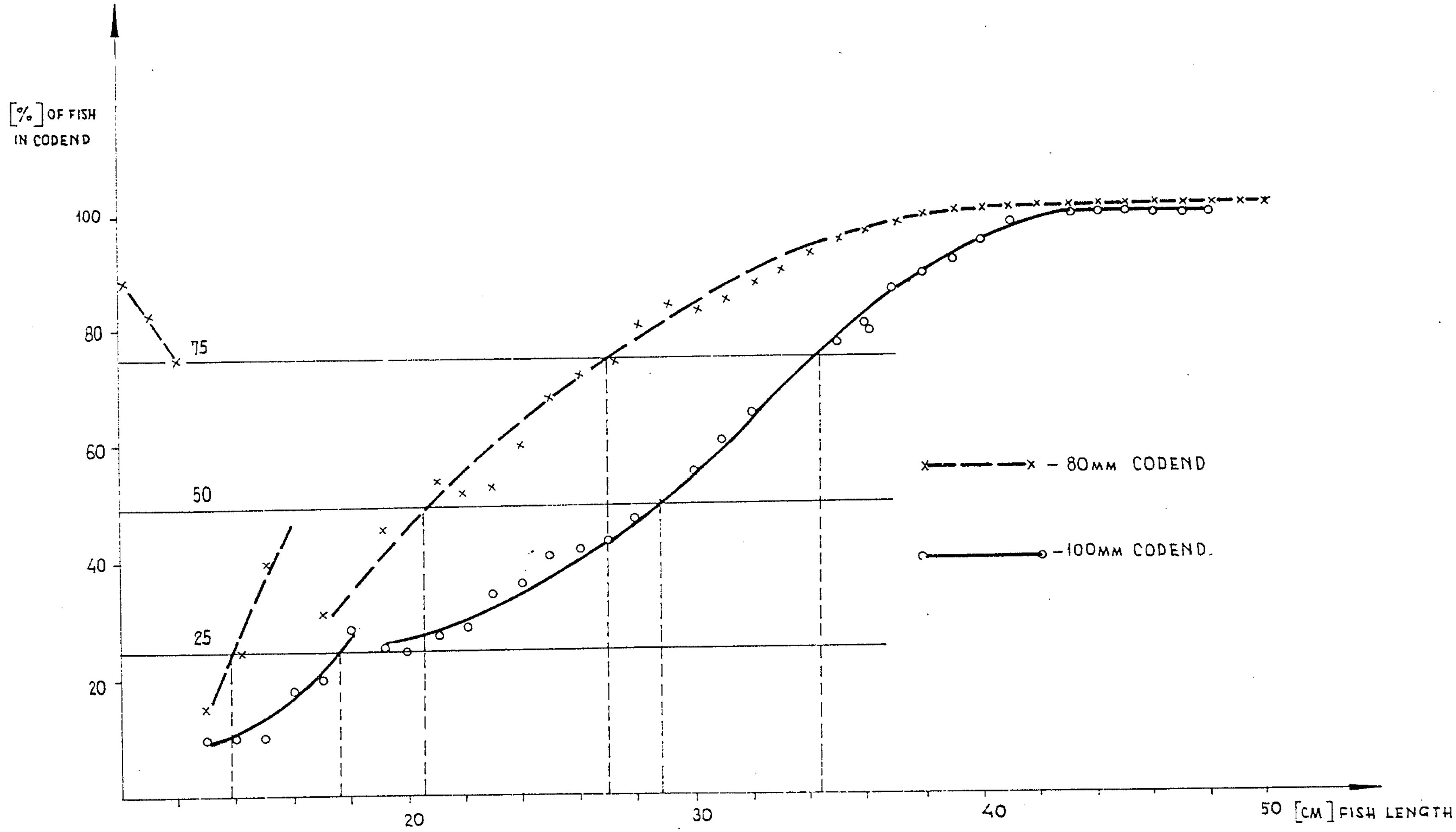

Figure 6: Selection of bumphead notothenia on Antarctic fishing grounds

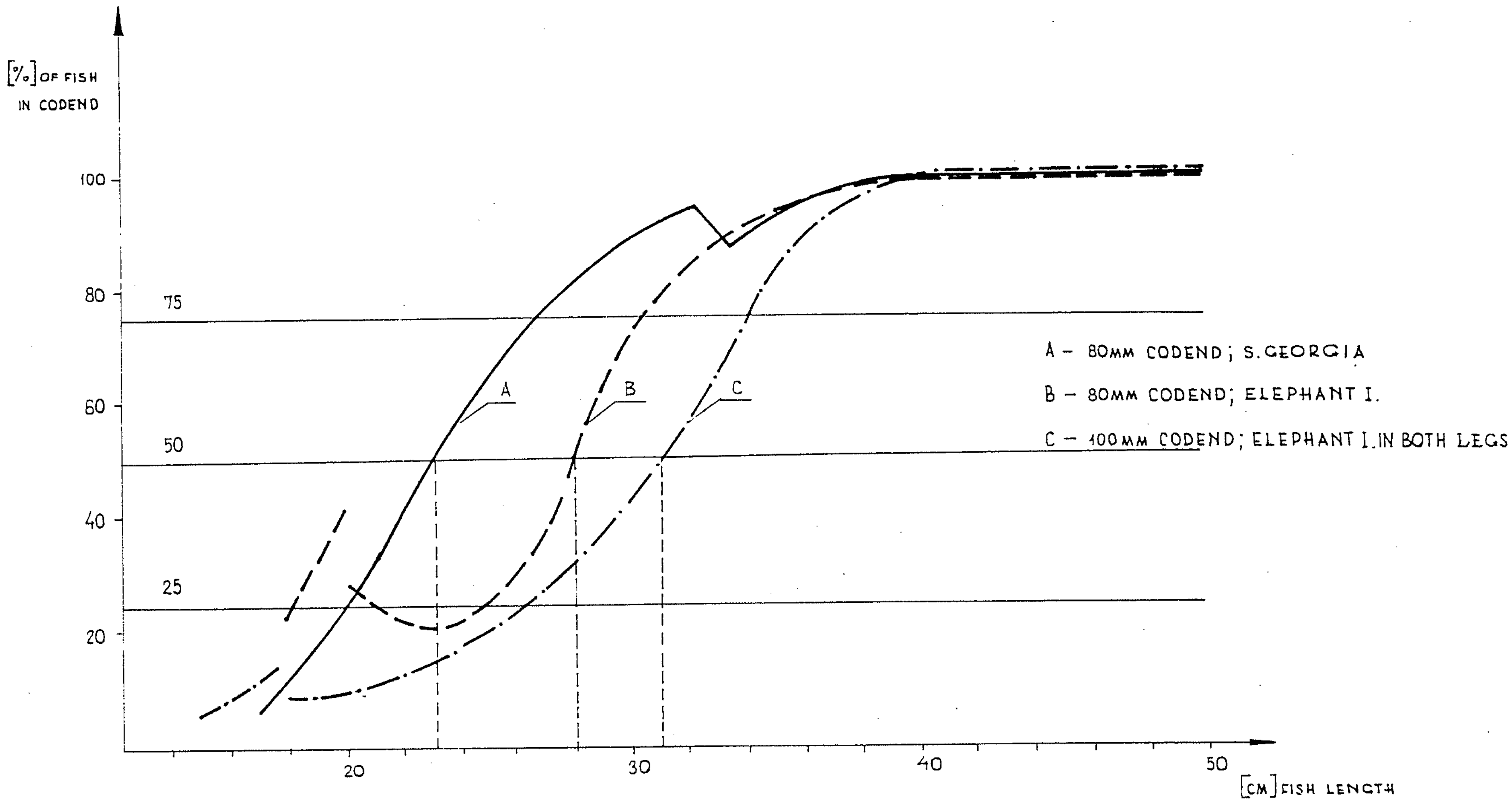

Figure 7: Selectivity ogive for Antarctic icefish by various codends on Antarctic fishing grounds

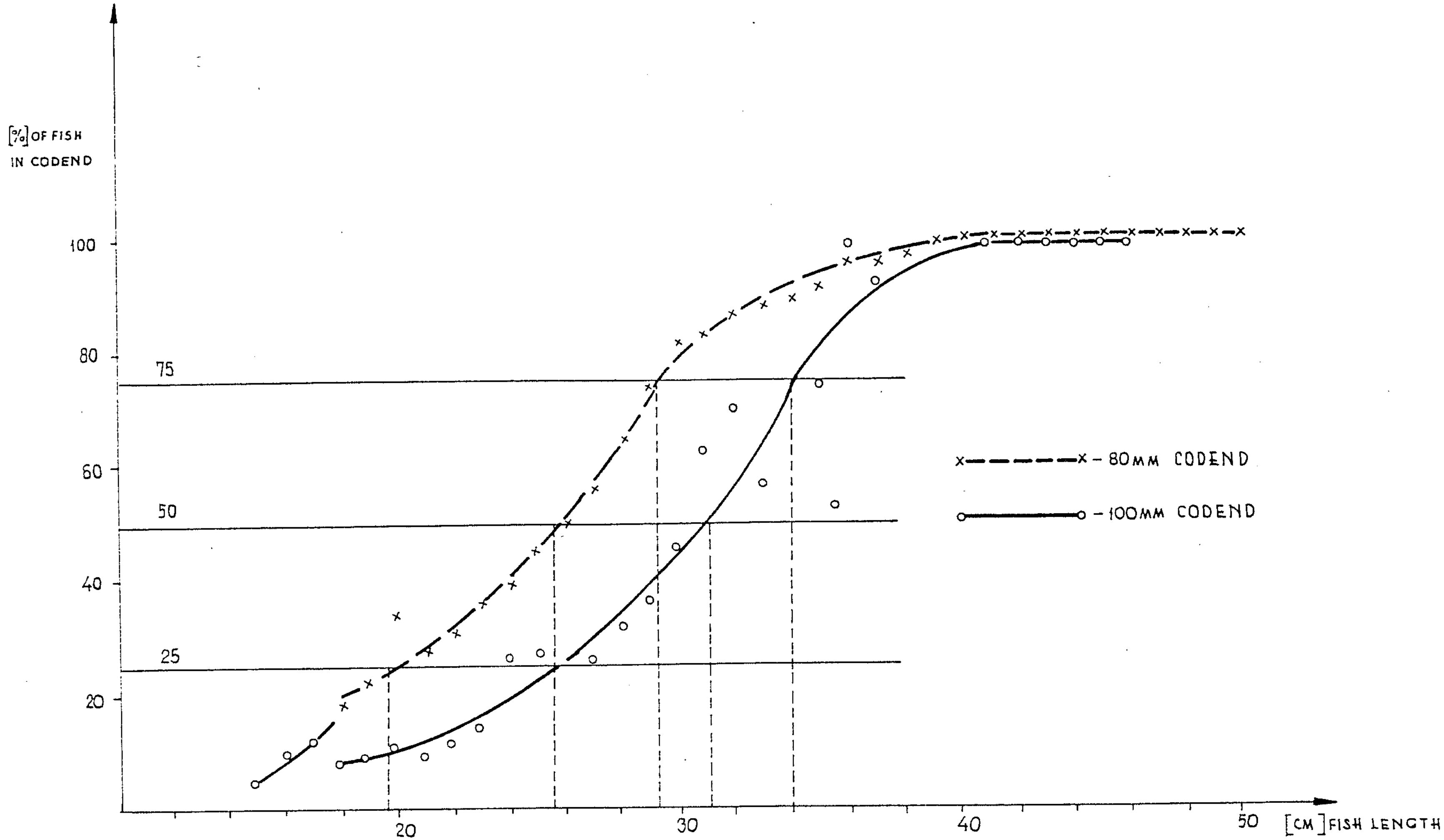

Figure 8: Selectivity ogives for Antarctic icefish on Antarctic fishing grounds

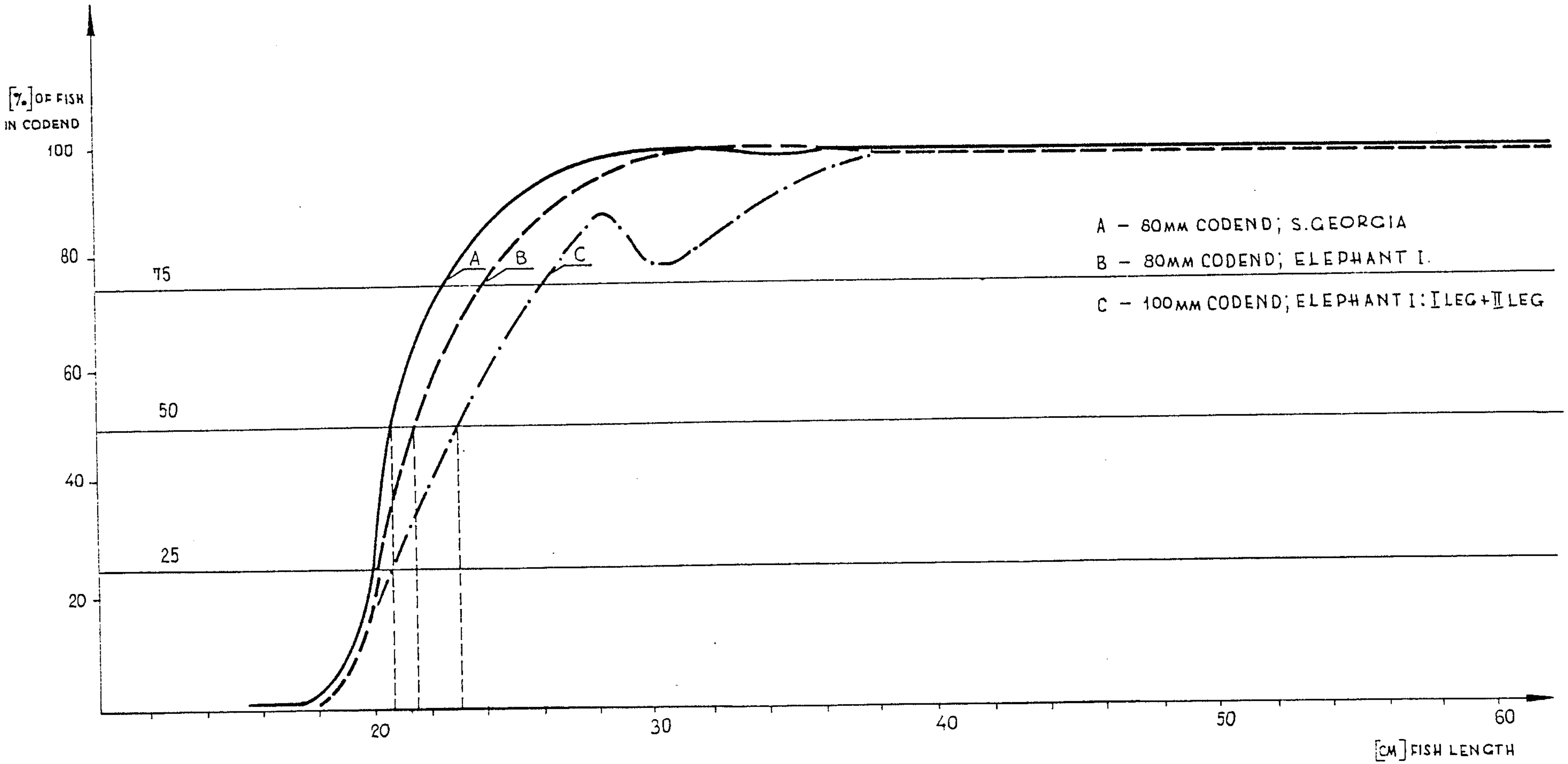

Figure 9: Selectivity ogive for Scotia Sea icefish on various fishing grounds by both types of codends

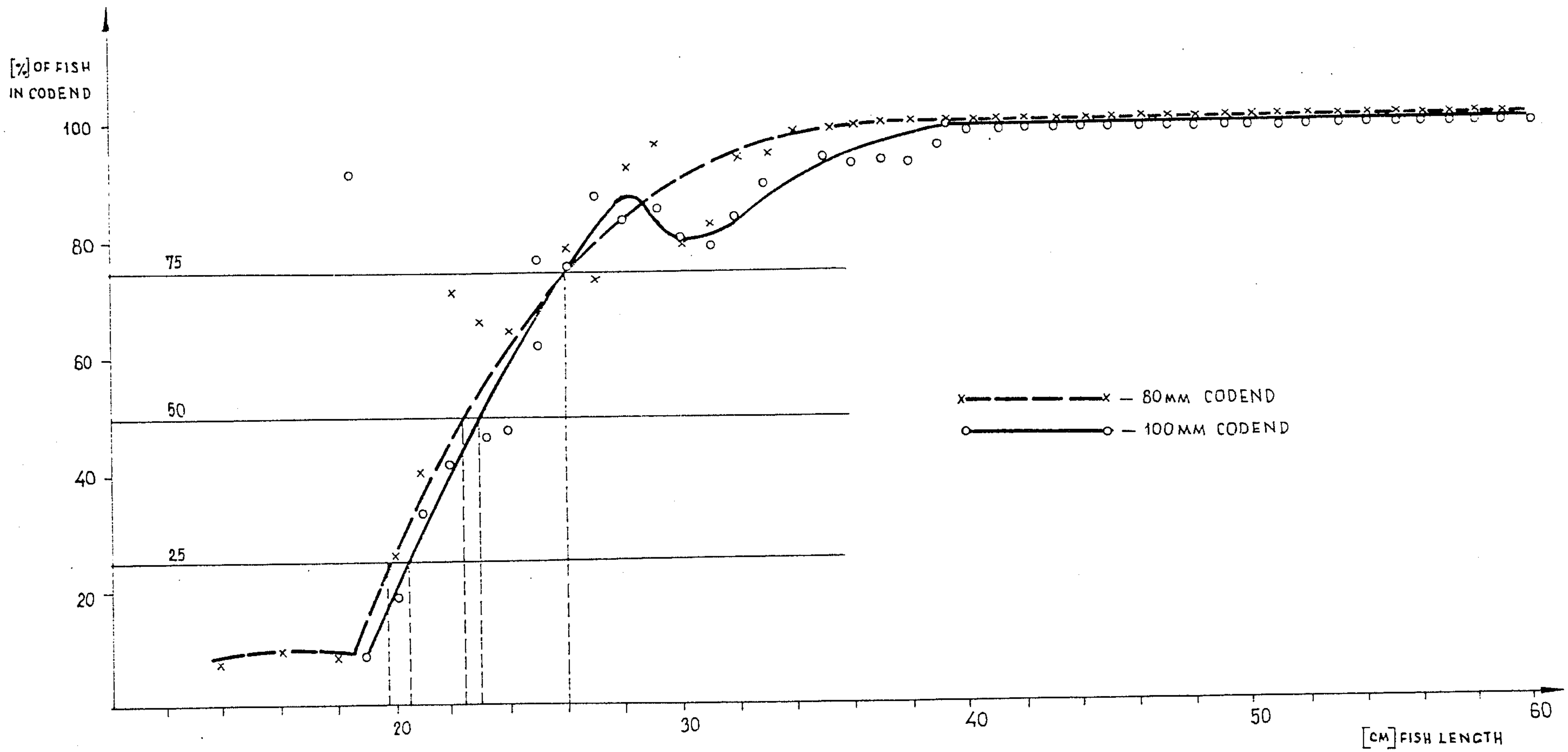

Figure 10: Selection of Scotia Sea icefish on Antarctic fishing grounds

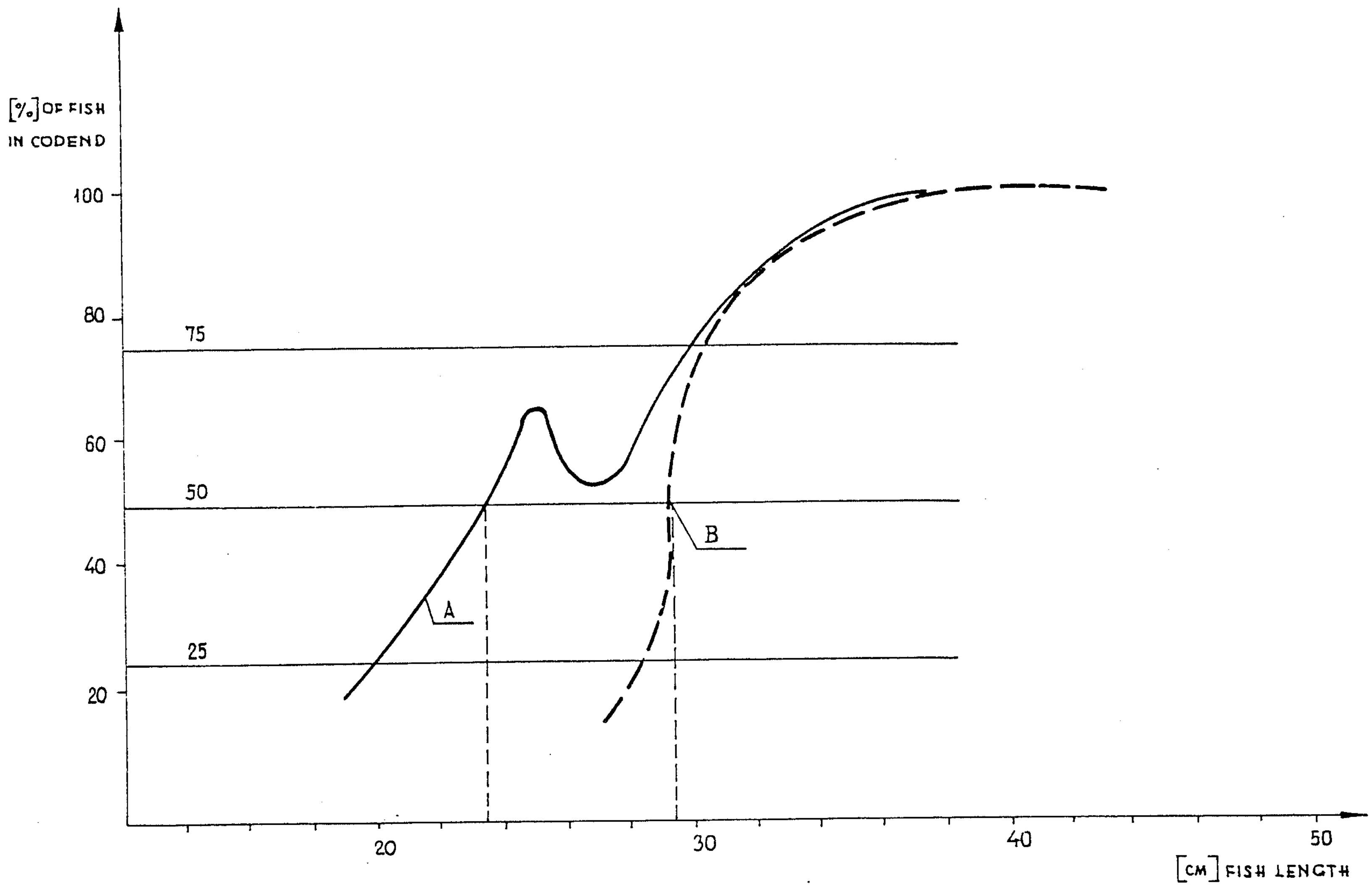

Figure 11: Selectivity ogives for *Chaenodraco wilsoni* (a) and *Chionodraco rastrospinosus* (b) on Joinville fishing grounds for 100 mm coded

Légendes des tableaux

Légendes des figures

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WG-FSA-88/15

AGE DETERMINATION OF *NOTOTHENIA GIBBERIFRONS* FROM THE SOUTH SHETLAND ISLANDS, ANTARCTIC PENINSULA SUBAREA (SUBAREA 48.1)

Esteban Barrera-Oro

Abstract

Age determination was carried out on *Notothenia gibberifrons* specimens collected at two localities near the South Shetland Islands (Low I. and Potter Cove, 25 De Mayo/King George I.). Samples consisted of small and medium sized fish (total length - 14.8-38 cm). Otolith and scale readings have been compared in 19 Potter Cove specimens. In some cases scale readings gave a result of one year more. This could arise from the difficulty in differentiating between false and annual checks in scales. Age determination by otolith cross sections proved to be the most reliable method. Mean length data at age presented here for Low I. specimens were compared with previous published values. This confirmed that fish from the Antarctic Peninsula Subarea are smaller than those in the same age group around South Georgia. Likewise, our values are lower than the ones reported previously for specimens of South Bay, Palmer Archipelago. Possible reasons for these differences are discussed. It is expected that the Otoliths/Scales/Bones Exchange System established by CCAMLR will help to eliminate discrepancies in age and growth studies of Antarctic fish.

Résumé

La détermination de l'âge a été effectuée sur des spécimens de *Notothenia gibberifrons* rassemblés à deux emplacements près des îles Shetland du Sud (Low Island et Potter Cove, île 25 De Mayo/du Roi George). Les échantillons consistaient en poissons de taille petite et moyenne (longueur totale - 14.8-38 cm). Les lectures d'otolithes et d'écailles ont été comparées pour 19 spécimens provenant de Potter Cove. Dans quelques cas, les lectures d'écailles ont donné un résultat d'un an de plus. Ceci pourrait résulter de la difficulté de différencier entre les quadrillages faux et annuels sur les écailles. La détermination de l'âge au moyen de section transversale s'est montrée la méthode la plus fiable. Les données sur la taille moyenne par âge présentées ici sur les spécimens provenant de Low I. ont été comparées avec des valeurs publiées antérieurement. Ceci a confirmé que les poissons de la sous-zone de la péninsule antarctique sont plus petits que ceux de la même groupe d'âge autour de la Géorgie du Sud. De même, nos valeurs sont plus basses que celles déclarées antérieurement pour des spécimens de South Bay, archipel Palmer. Les causes possibles de ces différences sont discutées. Il est attendu que le Système d'échange d'otolithes/écailles/os établi par la CCAMLR aidera à éliminera les écarts dans les études sur l'âge et la croissance des poissons antarctiques.

Резюме

Проводилось определение возраста *Notothenia qibberifrons* по образцам, собранным на двух участках района Южных Шетландских островов (о-в Лоу и бухта Поттер, о-в Кинг-Джордж). Образцы состояли из рыб маленького и среднего размера (абсолютная длина 14,8-38 см.). Было проведено сравнение отолитов и чешуи по 19 образцам из бухты Поттер. По некоторым из них данные по чешуе дали завышенный возраст - на один год больше. Это могло случиться в связи с тем, что в чешуе трудно отличить настоящую годовую отметку от обманной. Определение возраста по поперечному разрезу отолитов оказалось наиболее надежным методом. Было проведено сравнение представленных здесь величин средних длин по возрастам для образцов района о-ва Лоу с опубликованными раньше данными. Это подтвердило, что рыбы подрайона Антарктического полуострова меньше, чем рыбы той же возрастной группы, обитающие вокруг Южной Георгии. Подобно этому, полученные нами величины меньше известных ранее величин - для образцов из залива Саут-Бей, архипелаг Палмер Обсуждаются возможные причины этих расхождений. Ожидается, что учрежденная АНТКОМом Система обмена образцами отолитов/чешуи/костей поможет устранить расхождения в работах по возрасту и росту антарктических рыб.

Resumen

Se realizó la determinación de edad en ejemplares de *Notothenia gibberifrons* recolectados de dos localidades en las islas Shetland del Sur (Isla Baja y caleta Potter, isla Rey Jorge). Estas muestras comprendieron peces de tamaño pequeño y mediano (14.8-38 cm de talla total). Se compararon las lecturas otolitos y de escamas en 19 ejemplares Potter. En algunos de ellos las lecturas de escamas resultaron ser un sobrecálculo de la edad del pez por un año. Esto podría ser producto de la dificultad para distinguir entre controles falsos y anuales en las escamas. La determinación de la edad, por medio de cortes transversales de otolitos, demostró ser el método más fehaciente. Se compararon datos de talla promedio por edad aquí presentados para los ejemplares de la isla Baja, con aquellos valores publicados anteriormente. Esto confirmó que los peces de la Subárea de la Península Antártica son más pequeños que aquéllos del mismo grupo de edad en los alrededores de Georgia del Sur. Asimismo, nuestros valores son menores que los informados previamente para

los ejemplares de South Bay archipiélago de Palmer. Se tratan las posibles razones de estas diferencias. Se espera que el Sistema de Intercambio Otolitos/Escalas/Huesos, establecido por CCAMLR, contribuirá a la eliminación de discrepancias en los estudios sobre edad y crecimiento de los Peces Antárticos.

1. INTRODUCTION

Fish age determination is a subject of interest to the compass of CCAMLR. Since 1986 it has been discussed by the Fish Stock Assessment Working Group at the follow-up workshop held in Moscow in July 1986, and at the annual Scientific Committee meetings. As a result of the deliberations an exchange system has been established to examine otoliths, scales and bones of selected species of Antarctic Fish. *Notothenia gibberifrons* was included as one of the commercially most important species .

Up to now several papers have been published on the age and growth of *N. gibberifrons*. Kock et al. (1985) compiled data from different sources on mean total length and mean total weight for each age group of this species caught around South Georgia. Boronin and Frolkina (1976) (quoted in Kock et al. (1985); Shust and Pinskaya (1978) and Skora (quoted in Kock et al. 1985) worked with scales, while Hoffmann (1982) worked with first pelvic fin ray. Later on, Clasing et al. (1985), using otoliths, gave age-length information for a population sampled in South Bay (Palmer Archipelago, Antarctic Peninsula Subarea, Subarea 48.1). Discrepancies among the results of all these studies may arise from the following: different structures/methods used for age determination; different criteria for growth interpretation; growth differences due to geographical or populational variations of the samples. Thus, the aim of this paper is to contribute new data on age and length of *N. gibberifrons* from the South Shetland Islands by means of otolith analysis and emphasize the importance of the exchange system established by CCAMLR to standardize criteria for studying the age and growth of Antarctic fish.

2. METHODS

Samples* were obtained at two localities of South Shetland Is. (Figure 1) according to following detail:

Location	Low Island	Potter Cove (25 De Mayo/King George I.)
Date	January 1985	February-May 1986
Gear	Bottom-trawl (Scientific)	Trammel net
Depth	40-90 m	14-50 m

Fishes from Low I. were caught from the RV *Polar Duke* of the National Science Foundation, USA. For this study, immediately after capture, sagittal otoliths and scales of Potter Cove specimens were extracted, cleaned, dried and stored in paper envelopes until processing. Sex and total length of fishes were recorded.

As observed by Everson (1980), sagittal otoliths of *N. gibberifrons* are too thick for direct examination, therefore a sectioning technique was used. This technique and the equipment used in this work have been described by Tomo and Barrera-Oro (1985). The otoliths of 95 Low I. specimens and 37 Potter Cove specimens were cut in sections of 0.4 mm thickness; otolith cross sections of 82 specimens from the first area and 29 from the second were selected for age determination. Sections were cut in the transverse plane of the otolith, through the nucleus. The remaining parts were also examined. The second sagittal otolith of the pair was sometimes cut in halves, in order to compare the results of their readings with

* The material used in this study was not included in the CCAMLR Antarctic Fish Otolith/Scales/Bones Exchange System.

those obtained from the section of the first otolith. These procedures facilitated the age determination, which was made by direct examination of the growth rings. The counting method was similar to that used by Barrera-Oro and Tomo (1988). The terminology and reading method described by Williams and Bedford (1974) was adopted. The observations were done with a stereomicroscope Wild M 8 with transmitted-light Stand EB, using preferably reflected light against dark background, at magnifications from 8 to 25 x.

Before reading, scales were placed into a 5% alkaline solution for 36-48 hours. Then, selected scales of each specimen were cleaned mechanically, dried and mounted between microscope slides. Scales of 19 Potter Cove specimens were read. For age determination, the winter rings along the axis from the focus to the anterior margin were counted. The optical equipment used was the same as for the otoliths, but only with transmitted light at magnifications from 12 to 25 x.

After Scherbich (1975), July 1st was taken as the birth date from which the age of fish was calculated.

3. RESULTS

The examination of an otolith cross section under reflected and transmitted lights revealed that hyaline nucleus had an eccentric position. The growth rings could be observed in all the section; however the dorsal area was chosen as the best zone for counting the annuli (Figure 2). For further information about shape and size measurements of otoliths see North et al. (1984); Clasing et al. (1985) and Hecht (1987).

The length distribution (Figure 3) shows that specimens collected from both localities were of small and medium sizes (20.2-38 cm for Low I.; 14.8-35.5 cm for Potter Cove). In Low I. the sex ratio between males and females was 1:1.26 and females were of larger sizes. The amount of material from Potter Cove was insufficient to make a final comparison; however it was observed that fishes taken in the area were smaller (14.8-19.3 cm). This finding is in agreement with the known depth-distribution of the species. Our samples at Low I. were taken offshore, while Potter Cove is a fjord (shallow waters) area where the smallest juveniles of *N. gibberifrons* occur.

Comparative analysis of otolith cross sections and scales of chosen specimens from Potter Cove allowed a simultaneous age determination. Results are presented in Table 1. Both methods gave comparable results, however in some specimens reading of scales indicated one extra year. This finding is discussed below.

Table 2 shows the observed age-length for *N. gibberifrons* from both localities. Potter Cove and Low I. fishes ranged from 4 to 10 years and from 5 to 13 years, respectively. Comparison of mean length at certain age groups suggested similarity in growth; however data from Potter Cove were not enough for full analysis. Mean lengths of females from Low I. were higher than those of corresponding males; more data are needed to make a significant comparison. Few age groups were well represented (6-9 year groups predominated), however, no data were obtained for the first 1-4 year age groups. Therefore, growth curves were not fitted.

4. DISCUSSION

Fishes of larger sizes were absent in our samples (only one specimen from Low I. was of 38 cm while the rest were below 35.5 cm). Data compiled for the last 13 years on length distribution of *N. gibberifrons* for the Antarctic Peninsula (AP) area were considered. According to data of Kelle and Kock (unpublished) (quoted in Kock et al.. 1985) and

Hoffmann (1982) for the South Shetland Is. and of Clasing et al.. (1985) for South Bay, Palmer Archipelago, the largest specimens ranged from 45 to 52 cm. Fish of such length probably inhabit greater depths than our net could reach (40-90 m) and so this would explain their absence in the samples of Low I. In Potter Cove, fjord fishes from shallower waters were adequately represented by small and medium sizes.

In a qualitative analysis of otoliths, scales and bones (vertebrae-operculum) of *N. gibberifrons*, Kelle (1982) concluded that otoliths and preferably scales are useful for age determination studies of the species. Although Boronin and Frolkina (1976) (quoted in Kelle, 1982) had also indicated scales as the most appropriate structures, difficulties in their interpretation of the *N. gibberifrons* age have been reported. Everson (1980) found inconsistencies between age determined by otoliths and scales (scales indicated 1-2 years less). North et al. (1980) mentioned the difficulty in discriminating splits or false checks from the annual checks (winter checks) as well as in separating checks on the outer edge of old fish scales. In this study a comparison between age determination by means of scales and otolith cross sections of Potter Cove specimens showed general correlation. However, in some specimens scale readings resulted in one extra year (Table 1). This could arise from the difficulties with false checks as mentioned above, which caused age overestimation. Thus, in this work, age determination by otolith cross sections proved to be the most reliable method. Clasing et al. (1985) have already expressed the easiness of age determination of *N. gibberifrons* by otolith "crack and char method".

The observed hyaline nucleus in otoliths of *N. gibberifrons* from South Shetland Is. was also reported by Clasing et al.. (1985) for specimens from South Bay, South Georgia and South Orkneys Is. According to this publication, hatching of larvae occurs during the Antarctic winter; that is to say, a non favourable season of the year. The populations of *N. gibberifrons* from South Bay and South Georgia would reach sexual maturity at 6.7 years of age (Clasing et al., 1988).

Table 3 shows a comparison of mean total lengths data by age, between South Georgia (compiled by Kock et al. 1985) and AP specimens of *N. gibberifrons*. Mean lengths data have been calculated from the total length annuli number keys published in Clasing et al., (1985). The limited number of Potter Cove fishes has not been included in this comparison. For the South Georgia area, the reported data on age determination are well comparable in age groups up to 9 years except the data of Skora (quoted in Kock et al., 1985) due to discrepancies for fishes larger than 40 cm (Kock et al. 1985). Difficulties with checks, particularly in old fish might explain different results of authors working with scales. Length data at each age group clearly show a slower growth of fishes from the AP (Table 3). Colder waters at higher latitudes seem to be responsible for such a decrease in growth, as it was also observed by Clasing et al. (1985). Variations between the results obtained from South Georgia and AP specimens may also be in part explained by the different structures and methods used for age determination. Clasing et al. (1985) also used otoliths for the age readings and their samples (South Bay) were collected at nearly the same places as ours (Low I.). Nevertheless, they reported higher mean length values than those presented here (Table 3). Presumably, interpretation criteria used were different. Results of Skora (quoted in Kock et al. 1985) from scale analysis of South Georgia specimens, are similar to ours (Table 3). As it was mentioned, more than one reason might explain differences in the results of age and growth studies of a fish species.

The Otolith/Scales/Bones Exchange System established by CCAMLR seems to be the adequate way of eliminating discrepancies in this subject.

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Table 1: Comparison of age determined from otolith cross section (ot) and scales (s) in *Notothenia gibberifrons* specimens from Potter Cove, 25 De Mayo/King George Island. Age in years; total length in cm.

Specimen No.	MALES Total Length	MALES Age ot	MALES Age s	FEMALES Total Length	FEMALES Age ot	FEMALES Age s
1	20.6	5	5/6	18/6	4	4/5
2	23	6	6	20.3	5	6
3	29.3	9	10	22.9	5	6
4	29.4	8	9	24.2	6	5
5	31	10	10	24.7	6	6
6	31.6	10	11	25.1	6	6
7				25.6	7	7
8				29.9	9	9
9				30.1	9	10
10				31.2	9	9
11				31.7	10	9/10
12				32.3	10	10
13				33.2	10	11

Table 2: Age-length observed values for each age group in male and female *Notothenia gibberifrons* from Low Island and Potter Cove. Age in years; range and mean length in cm.

	LOW ISLAND						POTTER COVE					
	MALES			FEMALES			MALES			FEMALES		
Age group	N	Range	Mean length	N	Range	Mean length	N	Range	Mean length	N	Range	Mean length
4										3	18.6-19.3	19
5	1	-	20.2	4	22.3-23.2	22.75	3	19.4-21.5	20.5	2	20.3-22.9	21.6
6	3	22.8-24.8	24.07	5	24.6-26.4	25.14	1	-	23	3	24.2-25.1	24.67
7	8	24.9-27.8	26.51	12	24.9-30.9	27.05				1		25.6
8	9	25.9-29.8	27.91	21	26.3-32.3	28.79						
9	9	29.1-33.8	30.62	4	29.9-34.9	31.88	2	29.3-29.4	29.35	6	29-35.5	30.8
10	3	30.4-33.9	32.13				3	31-31.6	31.2	5	30.1-33.2	32
11	2	30.4-38	34.2									
12												
13	1		32.5									
	+ 36			+ 46			+ 9			+ 20		

Table 3: Mean length (cm) data according to age (years) of *Notothenia gibberifrons* for different authors in different zones. The type of structure used for age determination is specified. Sample numbers are indicated in parenthesis, when less than five.

	SOUTH GEORGIA							ANTARCTIC PENINSULA			
								South Bay		Low Island	
Age group	Boronin and Frolkina 1976 Scales ♂	♀	Shust and Pinskaya 1978 Scales ♂	♀	♂+♀	Hoffman 1982 Pelvic fin ray	Skora Scales	Clasing et al 1985 Otoliths ♂	♀	This paper Otoliths ♂	♀
1			8.4	8	8.2						
2			14.9	14.7	14.8						
3	21.5	22.9	20.5	20	20.2	21.7	21				
4	25.7	25.6	25.8	25.5	25.6	27.1	22.3				
5	29.5	29.1	29.5	29.6	29.5	30.6	23.2			20.2(1)	2.7 (4)
6	33.5	33.7	32.8	32.5	32.6	34.4	25.3			24 (3)	25.1
7	35.9	36.4	35.6	35.1	35.3	37.8	26.8	31 (1)	30 (2)	26.5	27
8	38.4	38.8	38.7	38.1	38.4	39.6	29.3	31.4	32.8	27.9	28.8
9	40.6	41.4	41.4	41.3	41.3	40.3	33.2	32.6	35.2	30.6	31.9(4)
10	41.7	42.6	43.5	43.7	43.6	43	35.2	33.6	37	32.1(3)	
11	43.1	43.6	45.7	46	45.7	43.8	36.3	35.5	35.8	34.2(2)	
12	43.3	44.6	47.1	47.5	47.3	44	37.6	37.5	38		
13	44.4	44.9	48	49.1	48.5		39	37.2	39.4	32.5(1)	
14	45.4	45.3	49.5	50.5	50		40	40 (1)	39.8		
15	46.1	46.3					41.3				
16	46.7	47.2					41				
17	47.5	48.4						41.5(1)	45 (1)		
18	49.1	48.5									
19								43 (1)			

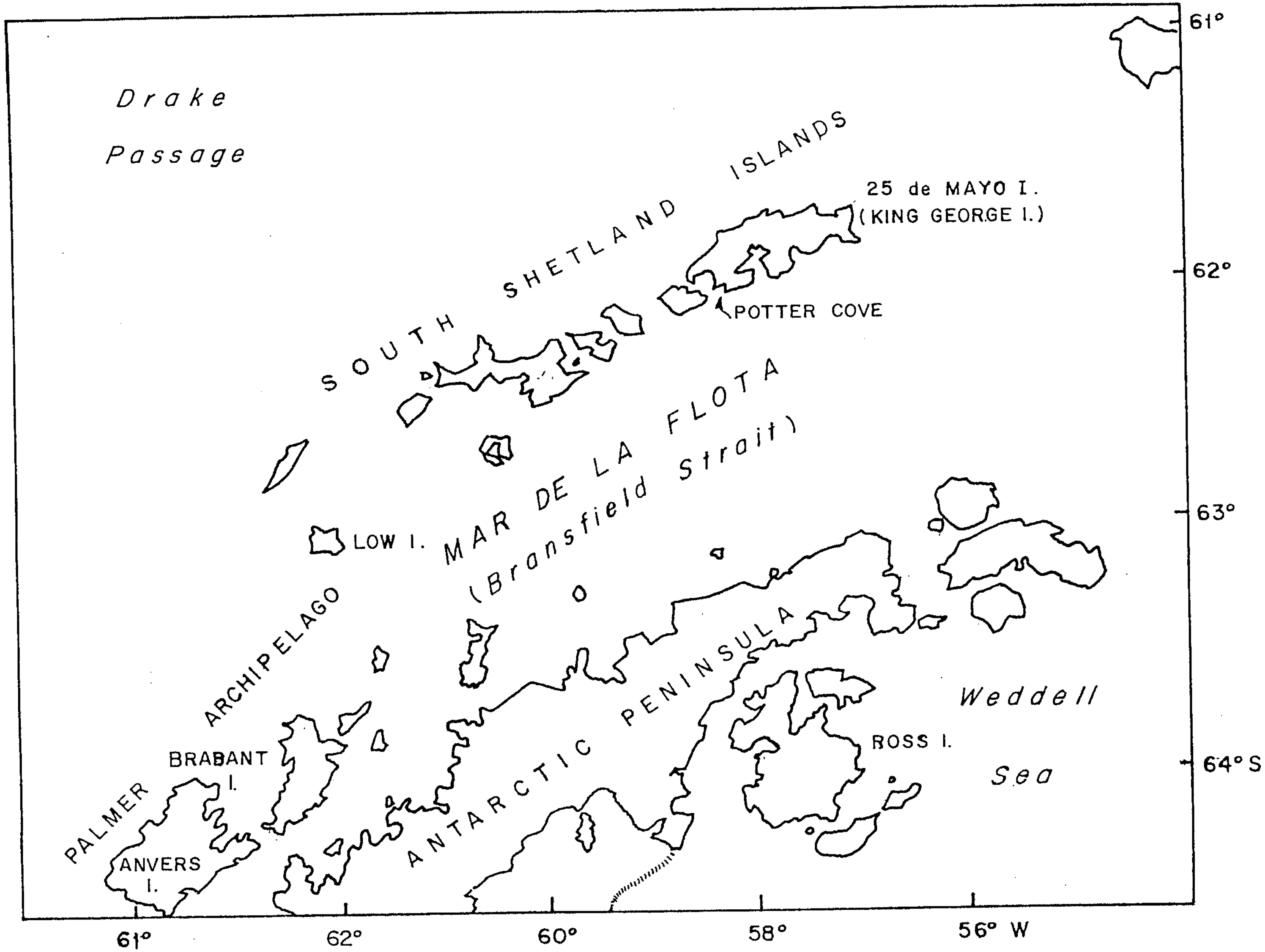

Figure 1: Catch sites of *Notothenia gibberifrons* sampled at two localities of the South Shetland Islands, Antarctic Peninsula Subarea.

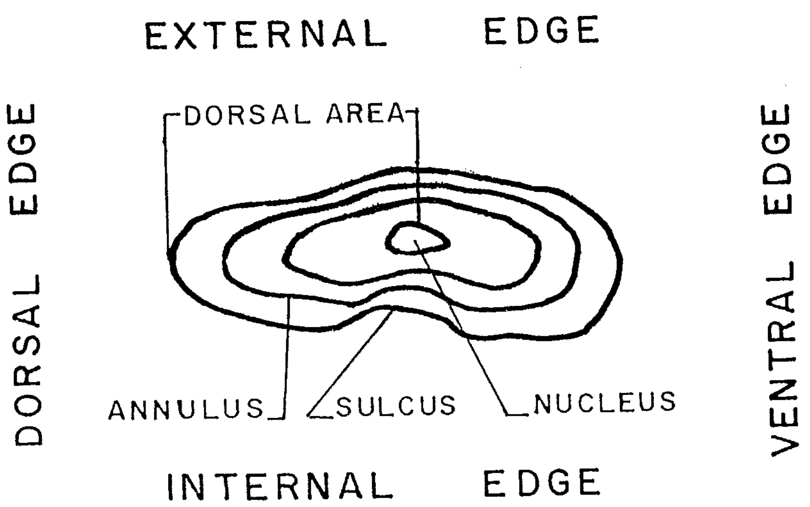

Figure 2: Drawing of an otolith cross section showing the counting area used for *Notothenia gibberifrons*.

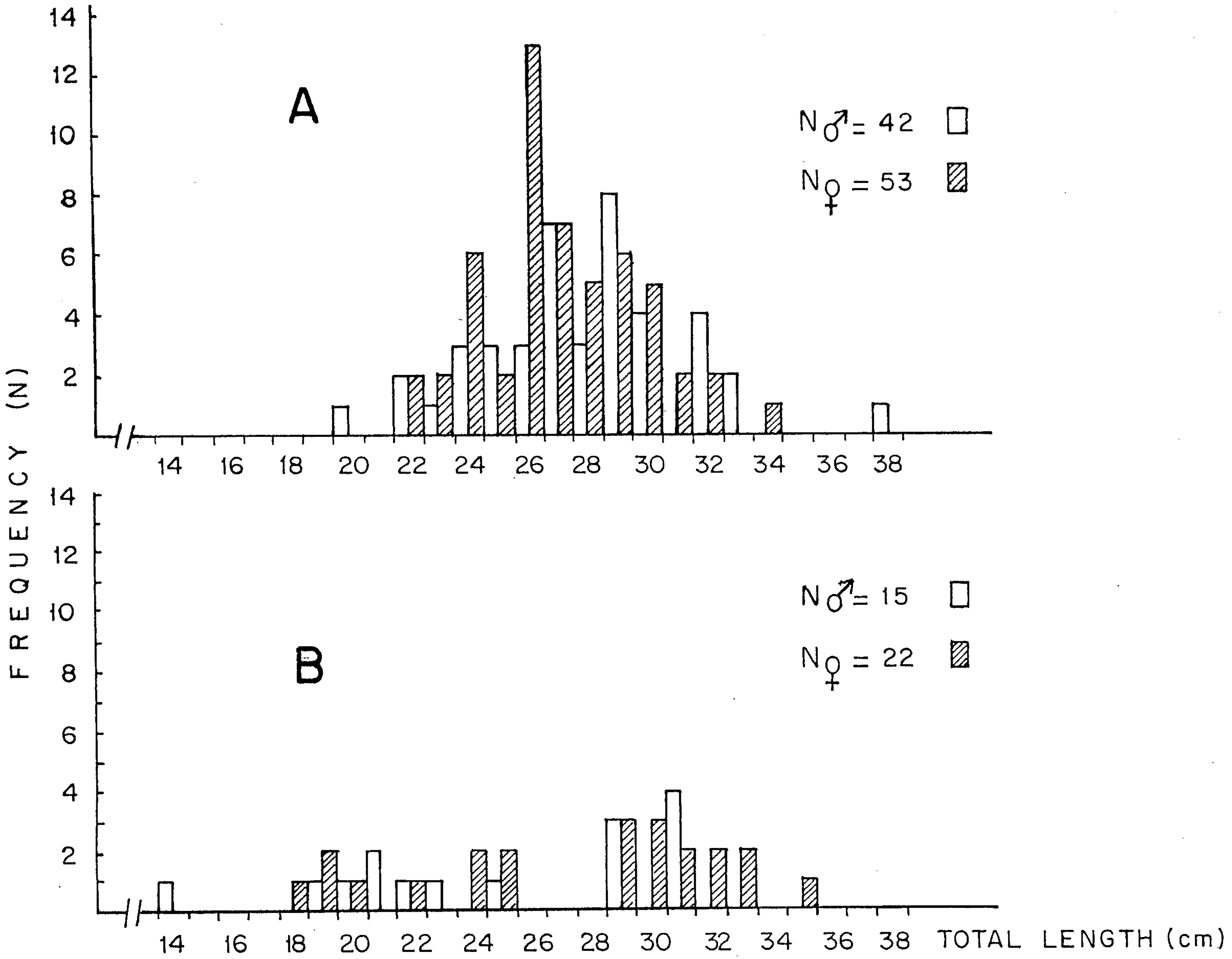

Figure 3: Distribution of length frequencies in *Notothenia gibberifrons*. (A) Specimens from Low Island; (B) Specimens from Potter Cover, 25 de Mayo/King George Island.

Légendes des tableaux

Tableau 1 — Comparaison des âges déterminés par examination d'une section transversale des otolithes (ot) et des écailles (s) des spécimens de *Notothenia gibberifrons* de Potter Cove, île 25 de Mayo/King George. Age en années; longueur totale en cm.

Tableau 2 — Valeurs âges-longueurs observées pour chaque groupe d'âges de *Notothenia gibberifrons* mâles et femelles de Low Island et Potter Cove. Age en années; limites et longueur moyenne en cm.

Tableau 3 — Données sur longueur moyenne (cm) par rang d'âge (années) des *Notothenia gibberifrons* pour différents auteurs dans différentes zones. Le type de structure utilisé pour la détermination de l'âge est spécifiée. Le nombre d'échantillons est indiqué entre parenthèses, s'il est inférieur à 5.

Légendes des figures

Figure 1 — Sites de capture de *Notothenia gibberifrons* échantillonné à deux emplacements des îles Shetland du Sud, dans la sous-zone de la péninsule Antarctique.

Figure 2 — Dessin d'une section transversale d'une otolithe montrant la zone de dénombrement utilisée pour le *Notothenia gibberifrons*.

Figure 3 — Distribution des fréquences de longueurs pour le *Notothenia gibberifrons*. (A) Spécimens de Low Island; (B) Spécimens de Potter Cove, île 25 de Mayo/King George.

Заголовки к таблицам

Таблица 1 — Сравнение возраста, определенного по спилу отолита (ot) и чешуй (s) экземпляров *Notothenia gibberifrons*, найденных в районе залива Поттер Коув, о. Кинг Джордж. Возраст в годах; общая длина в сантиметрах.

Таблица 2 — Полученные путем наблюдения величины соотношения возраст-длина для каждой возрастной группы мужских и женских особей *Notothenia gibberifrons*, с о. Лоу и из залива Поттер.Коув. Возраст в годах; пределы длины и средняя длина в сантиметрах.

Таблица 3 — Данные по средней длине (см) в соответствии с возрастом (годы) *Notothenia gibberifrons*, для разных авторов и в разных зонах. Уточнен тип использованной структуры для определения возраста. В скобках указано количество проб (в случае, если было меньше пяти проб).

Подписи к рисункам

Рисунок 1 — Места выловов *Notothenia gibberifrons*, пробы из которых были взяты в двух районах: у Южных Шетландских островов и у Антарктического полуострова.

Рисунок 2 Диаграмма спила отолита, в пределах которого производился подсчет годовых колец.

Рисунок 3 Распределение частот длины у *Notothenia gibberifrons*. (A) Экземпляры с о. Лоу; (B) Экземпляры из залива Поттер Коув, о. Кинг-Джордж.

Encabezamientos de las Tablas

Tabla 1 Comparación de edades determinadas por el corte transversal de otolitos (ot) y las escamas (s) en ejemplares de *Notothenia gibberifrons* procedentes de la caleta Potter, isla Rey Jorge. Edad en años; tamaño total en cm.

Tabla 2 Valores observados de edad-tamaño para cada grupo de edad en machos y hembras de *Notothenia gibberifrons* procedentes de la isla Baja y caleta Potter. Edad en años; rango y tamaño medio en cm.

Tabla 3 Datos de la talla promedio (cm) según la edad (años) de *Notothenia gibberifrons* por diferentes autores en distintas zonas. Se especifica el tipo de estructura utilizada para la determinación de la edad. Los números de la muestra están indicados entre paréntesis, cuando es menos de cinco.

Leyendas de las Figuras

Figura 1 Sitios de captura de *Notothenia gibberifrons* muestreados en dos localidades de las islas Shetland del Sur, Subárea de la Península Antártica.

Figura 2 Dibujo de una sección transversal de un otolito mostrando el área de recuento utilizada para *Notothenia gibberifrons* .

Figura 3 Distribución talla - frecuencia en *Notothenia gibberifrons*. (A) Ejemplares de la isla Baja; (B) Ejemplares de la caleta Potter, isla Rey Jorge.

PHYSICAL OCEANOGRAPHIC SETTING OF THE *SIEDLECKI* JANUARY 1987, SOUTH SHETLAND ISLAND DATA SET

Arnold L. Gordon

Abstract

In the vicinity of the northern tip of the Antarctic Peninsula, the Bransfield Straits and South Shetland Islands, cold polar waters from the Weddell Sea meet warmer circumpolar water from the Pacific Ocean. A series of fronts form which are collectively referred to as the Weddell-Scotia Confluence. Within the Confluence region the Weddell Gyre water is separated from the Pacific or Scotia Sea water by a zone of varied width (10 to 100 km) of water which can best be considered as continental margin water, advected into the region along the extreme western edge of the Weddell Gyre. It is relatively cold and low in salinity throughout the water column and prone to deep reach convective events, even as far north as the Bransfield Straits. Along the northern boundary of the Weddell-Scotia Confluence (the Scotia Front), where the Pacific water is encountered, there are indications of vigorous mixing processes of Bransfield Straits water (derived from the Weddell, with further local modification): an intrusive layer of Pacific derived relatively warm-salty water near 300 meters depth and deeper intrusions (500-1 500 meters; e.g. *Siedlecki* stations 217, 226, 231, 235, 236 and 250) of Pacific water, as the Scotia Front protrudes to the south, perhaps associated with mesoscale structures.

The Weddell-Scotia Confluence in the Bransfield Straits is associated with abundant krill populations. It is speculated that mixing of Weddell and Pacific waters near the tip of the Antarctic Peninsula is an important environmental feature related to this abundance.

Résumé

Aux alentours de l'extrémité nord de la Péninsule Antarctique, du détroit de Bransfield et des îles Shetland du Sud, les eaux froides polaires de la mer de Weddell rencontrent les eaux circumpolaires plus chaudes venant de l'océan Pacifique. Là se forme une série de fronts connus sous le nom collectif de Confluence de Weddell-Scotia. Au sein de la région de la Confluence, les eaux du courant tourbillonnaire de Weddell sont séparées des eaux du Pacifique ou de la mer de Scotia par une zone d''eau de largeur variée (10 à 100 km) que l'on peut considérer comme une eau continentale marginale dont l'advection dans la région a lieu de long de l'extrême bordure occidentale du courant tourbillonnaire de Weddell. Cette eau est relativement froide et sa teneur en sel est faible dans toute la colonne; elle est également sujette à des mouvements de convection allant en profondeur, et cela même au détroit de Bransfield au nord. Le long de la limite nord de la Confluence de Weddell-Scotia (le Front de Scotia), là où l'on rencontre les eaux du Pacifique, on remarque des indications d'importants processus de mélange de l'eau du détroit de Bransfield (provenant de la mer de Weddell, subissant par la suite

d'autres modifications locales) : une couche intrusive d'eau chaude et salée à près de 300 mètres de profondeur et des intrusions plus profondes (500-1 500 mètres; par exemple les stations de *Siedlecki* 217, 226, 231, 235, 236 et 250) des eaux du Pacifique au fur et à mesure que le Front de Scotia avance au sud - qui sont peut-être en rapport avec des structures à moyenne échelle.

La Confluence de Weddell-Scotia dans le détroit de Bransfield est associée à des populations abondantes de krill. Il est possible que le mélange des eaux de Weddell et du Pacifique près de l'extrémité de la péninsule Antarctique soit une caractéristique écologique importante liée à cette abondance.

Резюме

Невдалеке от северной оконечности Антарктического полуострова, пролива Брансфилда и Южных Шетландских островов холодные полярные заводы моря Уэдделла встречаются с более теплыми циркумполярными водами Тихого океана. Образуется ряд фронтов, которые все вместе называются конфлюэнцией Уэдделла-Скотия. В районе самой конфлюэнции воды циркуляции моря Уэдделла отделяются от вод Тихого океана и моря Скотия зоной различной ширины (от 10 до 100 км.), которую лучше всего рассматривать как континентальные прибрежные воды, перемещенные сюда вдоль самой крайней западной кромки циркуляции моря Уэдделла. Они относительно холодны и отличаются низкой соленостью по всему водяному столбу, и в глубине их часто происходят интенсивные конвекционные явления, даже так далеко к северу, как, например, в проливе Брансфилда. Вдоль северной границы конфлюэнции Уэдделла-Скотия (фронт Скотия), где встречаются воды Тихого океана, прослеживаются признаки интенсивного процесса перемешивания вод пролива Брансфилда (занесенных из моря Уэдделла, но с дальнейшими, возникшими уже здесь изменениями): слой вторгающейся из Тихого океана сравнительно теплой и более соленой воды на глубине около 300 м и, по мере того, как фронт Скотия выступает на юг, - более глубокий слой (500-1500 метров; напр., выполненные на "Седлецком" станции 217, 226, 231, 235, 236 и 250), что, по-видимому, связано с мезомасштабными структурами.

Конфлюэнция Уэдделла-Скотия в проливе Брансфильда ассоциируется с многочисленными популяциями криля. Делается предположение о том, что происходящее у оконечности Антарктического полуострова смешивание вод моря Уэдделла и Тихого океана является важным фактором окружающей среды, с которым связана вышеупомянутая многочисленность.

Resumen

En las proximidades del extremo norte de la Península Antártica, estrecho de Bransfield e islas Shetland del Sur, las frías aguas polares del mar de Weddell confluyen con aguas más cálidas circumpolares del océano Pacífico. Se forma una serie de frentes a los cuales se les llama colectivamente Confluencia de Weddell-Scotia. Dentro de la región de la Confluencia, las aguas de las vórtices de Weddell se separan de las del Pacífico o del mar de Scotia por una zona de agua una amplitud que varía entre 10 y 100 km que se puede considerar como agua del margen continental, llevada a la región, a lo largo del borde extremo occidental de las vortices de Weddell. Es relativamente frío y bajo en salinidad en toda la columna de agua y propenso a casos de convección de alcance profundo incluso extendiéndose hacia el norte hasta el estrecho de Bransfield. A lo largo del límite norte de la Confluencia de Weddell-Scotia (Frente de Scotia), donde converge con aguas del Pacífico, hay señales de vigorosos procesos de mezcla de las aguas del Estrecho de Bransfield (que llega del Weddell, con una mayor modificación local): una capa intrusa del Pacífico dió como resultado aguas relativamente cálidas y saladas cerca de los 300 metros de profundidad. Hubo también intrusiones aún más profundas (500 - 1 500 metros; por ej. estaciones *Siedlecki* 217, 226, 231, 235, 236 y 250) de aguas del Pacífico debido a que el Frente de Scotia sobresale con dirección al sur, esto tal vez esté relacionado con estructuras de media escala.

La Confluencia de Weddell-Scotia en el estrecho de Bransfield supone abundantes poblaciones de krill. Se especula que la mezcla de aguas del Weddell con las del Pacífico cercanas al extremo de la Península Antártica es una característica ambiental de importancia relacionada a dicha abundancia.

1. OCEANOGRAPHY AT THE TIP OF ANTARCTIC PENINSULA

As we obtain more observations of the physical environment of the Southern Ocean, the better we appreciate the extent of its variability, at a variety of scales (Gordon, 1988). The mean climatic condition exists for only brief periods as the ocean stratification and circulation continuously swings between extremes. Certainly the unique biological community of the Southern Ocean responds to these changes in the habitat. Our challenge is to understand the causes of environmental variability and the response of krill to these changes. This is a most difficult task. The ocean-atmosphere-ice coupled system is in itself exceedingly complex. Added to this is the life cycle of krill, which we are only very slowly getting to know.

The Bransfield Straits region marks the northwest corner of the Weddell Gyre. Here the cold Antarctic waters, which sweep north along the eastern margin of Antarctic Peninsula, meet the warmer waters carried in from the Pacific Ocean. It is a region of strong contrasts and deep reaching convection (Clowes, 1934, Gordon and Nowlin, 1978) and abundant krill population (Marr, 1962).

The Weddell Gyre is a large, wind-driven cyclonic gyre, with a transport of 70 to 90 Sv (Carmack and Foster, 1975; Gordon, Martinson and Taylor, 1981). The average speed of the surface current in the western boundary of the Gyre, of 8 cm/sec as measured by drifting ships and buoys, extended to the sea floor can easily account for the large transport. The western most rim of the Weddell western boundary current, pressed up against the continental slope, has been modified by convective processes and may be referred to as continental margin water, marking a transition from the deep water open ocean stratification to the colder shelf water masses. The continental margin water follows the continental slope, turning into the Bransfield Straits and becomes strongly coupled to the complex bottom topography of the South Scotia Ridge (including the South Shetland Islands), with some deep water passing into the Pacific Ocean (Nowlin and Zenk, 1988). Ocean dynamics suggests that the circulation would form an isobath contour following current, with shallower topography to the left of the velocity vector.

The merging of the Weddell water with circumpolar waters entering the Atlantic via the Drake Passage, creates a zone of low stability, referred to as the Weddell-Scotia Confluence (Figure 1 presents a schematic of the Confluence structure; Gordon, 1967; Gordon, Georgi and Taylor, 1977; Deacon and Moorey, 1975; Patterson and Sievers, 1980). It displays intense eddy activity, which increases downstream from the initial contact of the two circulation regimes (Foster and Middleton, 1984). The Weddell-Scotia Confluence varies in width from 10's to 100 kms scale, presumably a consequence of mesoscale activity. However, there does seem to be a quasi-stationary form which is related to the topography of the South Scotia Ridge. The fronts marking the northern and southern edge of the Confluence have been called the Scotia Front and the Weddell Front, respectively (Gordon, Georgi and Taylor, 1977). he sea ice edge along this front is investigated with the shuttle imaging radar-B (SIR-B) by Carsey et al (1986). Comiso and Sullivan (1986) compare passive microwave data from satellite with field observations along the ice edge of the region. The sea ice edge also displays irregular patterns responsive to the mesoscale activity.

In summary (see Figure 1): The Weddell-Scotia Confluence brings together waters with very different histories: cold polar Weddell water and warmer circumpolar Pacific water. In between these two large scale water mass or stratification regimes, is an order 100 km wide zone of very cold, generally fresher water. This zone is referred to as the Weddell-Scotia Confluence Zone, includes the water of the Bransfield Strait, and is essentially continental margin water which has migrated along the flanks of Antarctic Peninsula before being injected into the open ocean. This water has a low degree of stratification, with indications of vigorous vertical exchange processes and local water mass modification. The Weddell Scotia Confluence Zone extends northwest across the Scotia Sea and remnants can be identified as far east as the Greenwich Meridian.

2. *SIEDLECKI,* 1986/87

In 1986/87 the R/V *Professor Siedlecki* obtained oceanographic data within the waters surrounding South Georgia and along the South Shetland Islands from Livingston Island to Elephant Island (Figure 2a, b). The cluster of stations around South Georgia (*Siedlecki* leg 1)is not the focus of this paper. The South Georgia water mass structure varies little from station to station: it is essentially circumpolar water stratification (e.g. Gordon and Molinelli, 1982), with a temperature minimum of 0° to +1.0°C with an underlying pycnocline truncated near the 27.7 σ_0 density.

2.1 57°W Section

The water mass structure along the tip of Antarctic Peninsula does reveal strong spatial variability. A section of potential temperature and for salinity along approximately 57°W passes from the Pacific zone into the continental zone of the Bransfield Strait between Elephant and King George Island (Figure 3a, 3b). The relatively warm-saline deep water of the Pacific circumpolar water is clearly defined to a position just south of station 214. An abrupt change occurs between stations 214 and 217, over the continental slope, which is fairly characteristic of this region. This intense thermohaline front marks the initiation of the Scotia Front or continental water boundary (see Nowlin and Clifford, 1982). Above 100 meters the front separates low salinity colder water of the north from higher salinity warmer water to the south. The opposite is the case for the bulk of the water column, below 100 m. The haline front at the surface between stations 214 and 217 is quite strong, though the temperature expression of the front at the immediate surface is nearly absent.

South of the front a warm-saline layer is observed within the 200-300 meter range. The θ/S properties of this feature indicate that it represents poleward isopycnal spreading of much diluted Pacific deep water. Similar intrusions are often observed poleward of the shelf-slope front around Antarctica, re-enforcing the analogy that the South Shetland Island end of the Scotia Front is similar to a continental shelf-slope front of Antarctica. The *Discovery* data of the 1920's and '30's also shows the invasion of Pacific deep water into the Bransfield Strait through the passages of the South Shetland Islands (Clowes, 1934).

Further south along the section the Pacific intrusion attenuates, replaced by the very cold, but low salinity water filling the Bransfield Basin, fed by inflow from the Weddell Sea. Deep reaching convection is common within this region (Gordon and Nowlin, 1978) with surface winter (freezing point) water of salinity 34.62 responsible for the deep convection. This water is probably derived from the margin of the Antarctic Peninsula.

2.2 Potential Temperature/Salinity Relationship, θ/S

The regional θ/S distribution (from the Southern Ocean atlas data set of Gordon and Molinelli, 1982) for "climatic" January and February is given in figure 4. The θ/S position of the various component water masses are labelled on figure 4. The Pacific Ocean water stands out as an arc marking the warmest/saltiest water. The Weddell deep water θ/S cluster found in the eastern end of the Bransfield Straits falls in the region of 0° to -0.7°C; 34.65, marking the Weddell continental margin water advected into the area. The scatter of points at temperatures below -0.5°C marks the unique water mass filling the Bransfield Basins (see Gordon and Nowlin, 1978). The water within the Weddell-Scotia Confluence is similar to water of the upper 1 000 m within the Bransfield Strait; deeper than that the Bransfield water seems to be isolated from the open ocean, its only means of "communication" being vertical exchange processes (Gordon and Nowlin, 1978). The θ/S scatter at salinity less than 34.5 is composed of an array of points stretching from the summer surface water values to each of the three basic deep water units (Pacific, Weddell and Bransfield).

Comparison of this large scale water mass structure to that of the *Siedlecki* 1986/87 data provides a guide in identifying the origin of the stratification observed by the *Siedlecki* in the South Shetland Island region (the *Siedlecki* data set is separated into five groupings, shown in Figure 5).

2.3 Group #1 Bransfield Strait

The Bransfield Strait Group #1 (Figure 6) reveals the cold, low salinity water which fills the Bransfield Strait basins (to about 1 200 meters, the depth limits of the *Siedlecki* data). The relatively warm-saline feature observed between σ_0 range of 27.7 to 27.8 is the same water discussed above (Figure 3 a,b). Comparison with the large scale water mass distribution (Figure 4) supports the statement that it is of Pacific deep water origin, which spreads along isopycnal surfaces into the Bransfield Straits.

2.4 Group #2 South of Elephant Island

This area (Figure 7) is similar to Group #1, with two exceptions: A Pacific water column station (214) is included in the northwestern corner of the group and its neighboring station 217 displays a relatively salty bottom water mass, extending to 27.8 σ_0. In addition, the average depth of the stations is less than within group #1 and hence does not attain as low temperatures. The station 217 feature is similar to that observed within the cluster of stations centered at 60° 50'S and 55° 45'W, within group #3. The possible origin of this θ/S feature is included in the discussion section of this paper.

2.5 Group #3 North of Elephant Island

In the region just north of Elephant Island (area #3; Figure 8), there are various blends of Bransfield Strait and Pacific circumpolar water, associated with the sharp continental front (or western end of the Scotia front) over the continental slope. Labelled on figure 8 are two such features: "A" which is a less salty blend falling along the continental front and "B" which is found within the cluster of stations centered at 60° 50'S and 55° 45'W (as well as station 217 in group #2).

2.6 Group #4 and #5 Western South Shetland Islands

These shallow stations (Figure 9) show the typical Bransfield surface water. These stations are over the South Shetland Islands shelf zone and obviously south of the front with the Pacific water.

3. DISCUSSION

Besides Pacific water intrusions near 300 meters there appears to be Pacific influence within the deep water, below 500 meters.

The *Siedlecki* data within group #3 and at station 217 of group #2 reveal the presence of blends of Pacific deep water with Bransfield Straits water. These water columns have contact only along the front (the westward extension of the Scotia Front, shown in Figure 1) and hence are indicative of cross frontal mixing. Figure 8 shows the end-member water columns (Pacific, represented by station 244 and Bransfield, represented by station 223) and stations representing various stages on mixing, for the blends marked A and B in the group #3 θ/S. The stations with blend B all fall in the 1 000 to 1 500 m bottom depth interval, with the salinity steadily increasing to the bottom. It is possible that this mixture is induced by interaction of the front with the sea floor as the Scotia (or Continental) Front protrudes further south, perhaps associated with meso-scale variability. Stations with blend A (only three stations in the northeast corner of the group #3), are in deeper water, over 3 000 m, and the deepest segment of the θ/S curve follows the Pacific water column. Thus it is not the product of (at least) local interaction with the sea floor.

The abundance of krill swarms, which often are confined to the northern slope of the Shetland Islands, might be related to the presence of mixing of Pacific water with water derived from the Weddell undergoing further modification within the Bransfield Straits. Additionally, in this region the cold waters of the Weddell, with a substantial winter sea ice cover, encounter the much warmer Pacific water. This is particularly the case north of Elephant Island. Rapid melting along the ice edge might enable establishment of an environment conducive to krill development and/or swarming.

The Bransfield Straits, with its unique oceanographic regime and its krill population, make for an ideal area for study of the relationship of krill to its environment.

ACKNOWLEDGEMENTS

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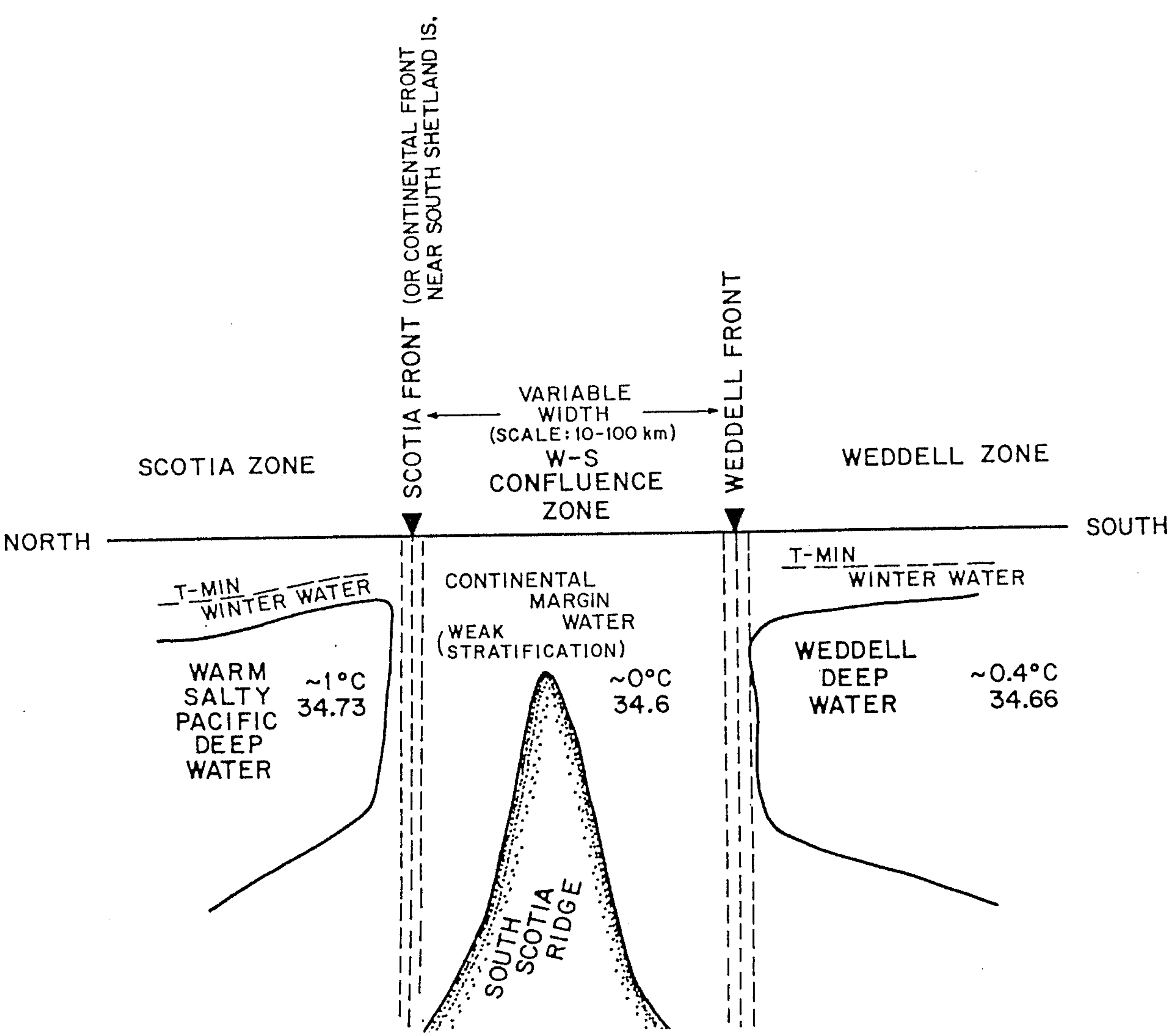

Figure 1: A schematic of water mass zones and fronts associated with the Weddell-Scotia Confluence. A sequence of stratification regimes and fronts encountered from south to north composing the Weddell-Scotia Confluence structure is as follows (Gordon, Georgi and Taylor, 1977) : Weddell Gyre zone; Weddell front; Weddell-Scotia Confluence zone; Scotia front (which along the northern edge of the South Shetlands may be called the continental front); Pacific zone.

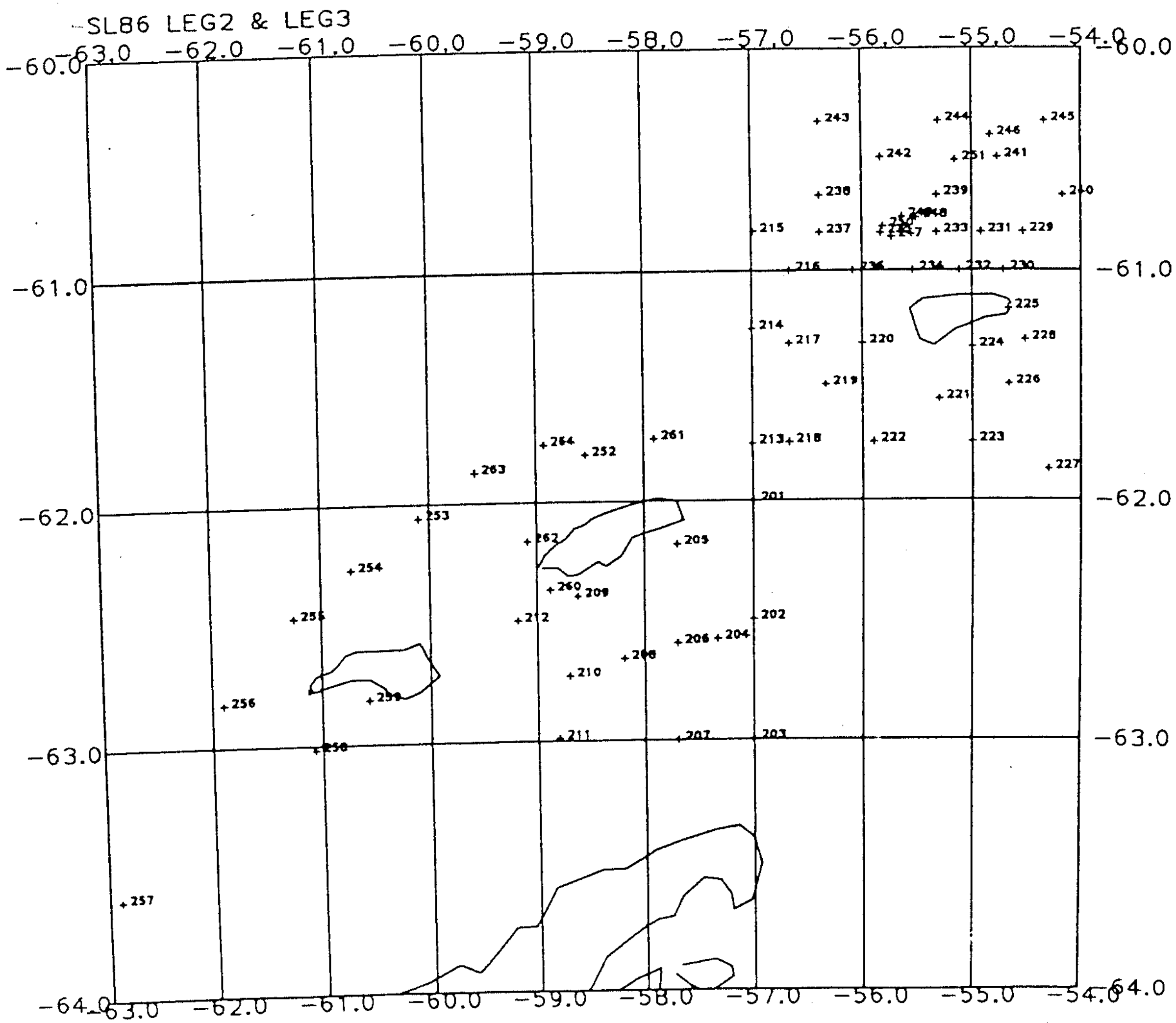

Figure 2a: Station map of *Siedlecki* hydrographic stations 1986/87

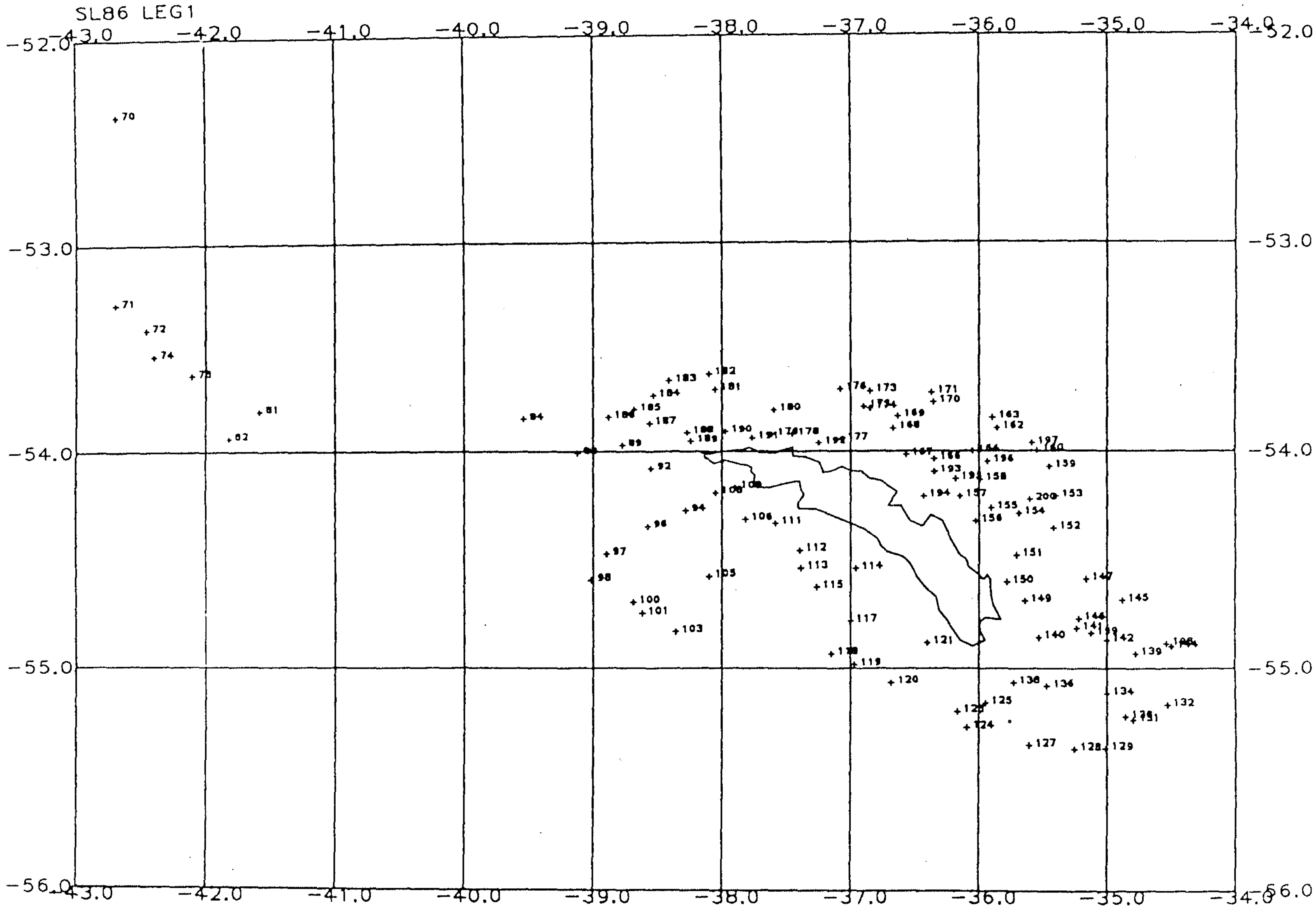

Figure 2b: Station map of *Siedlecki* hydrographic stations 1986/87

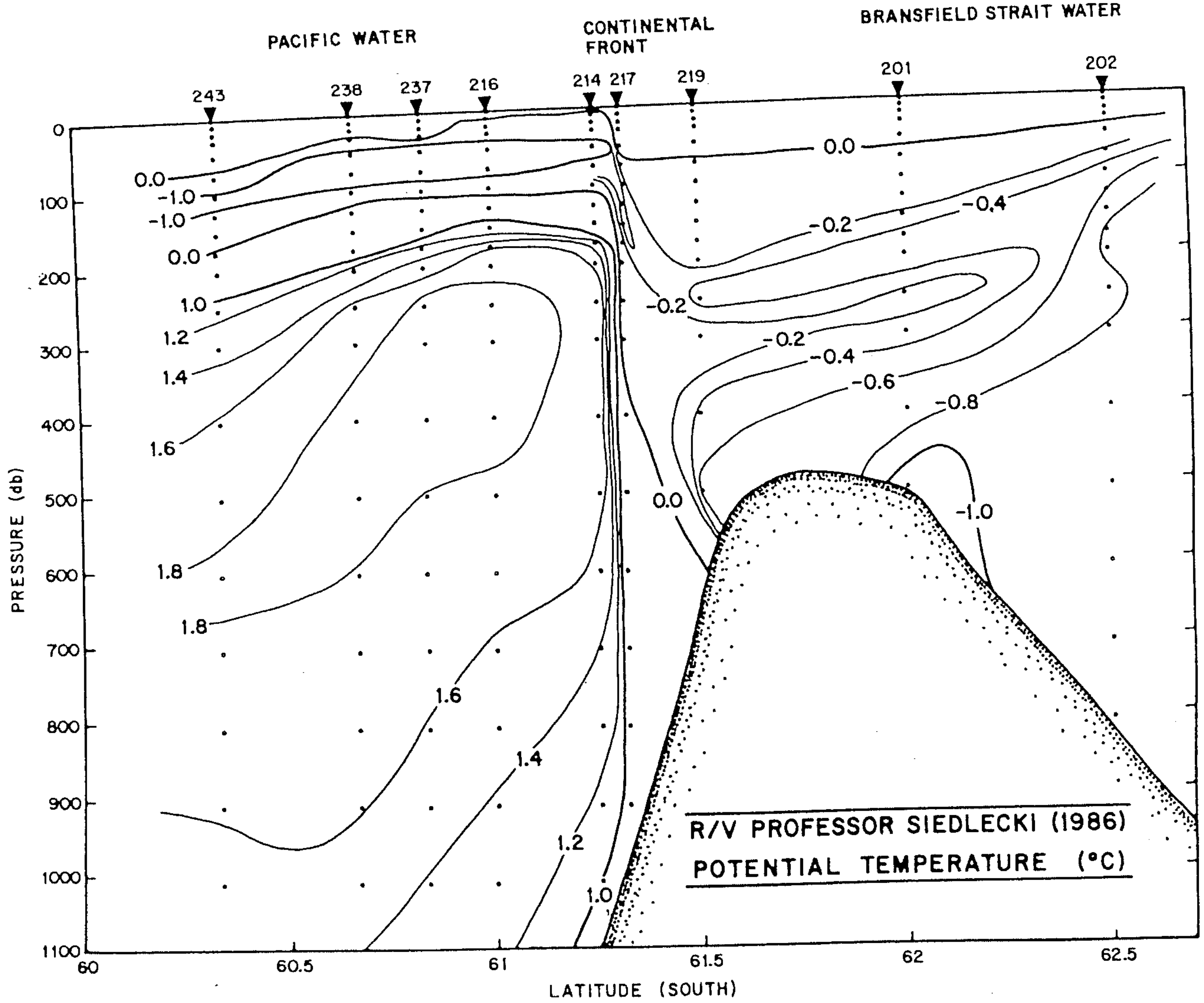

Figure 3a: Potential temperature section along 57°W

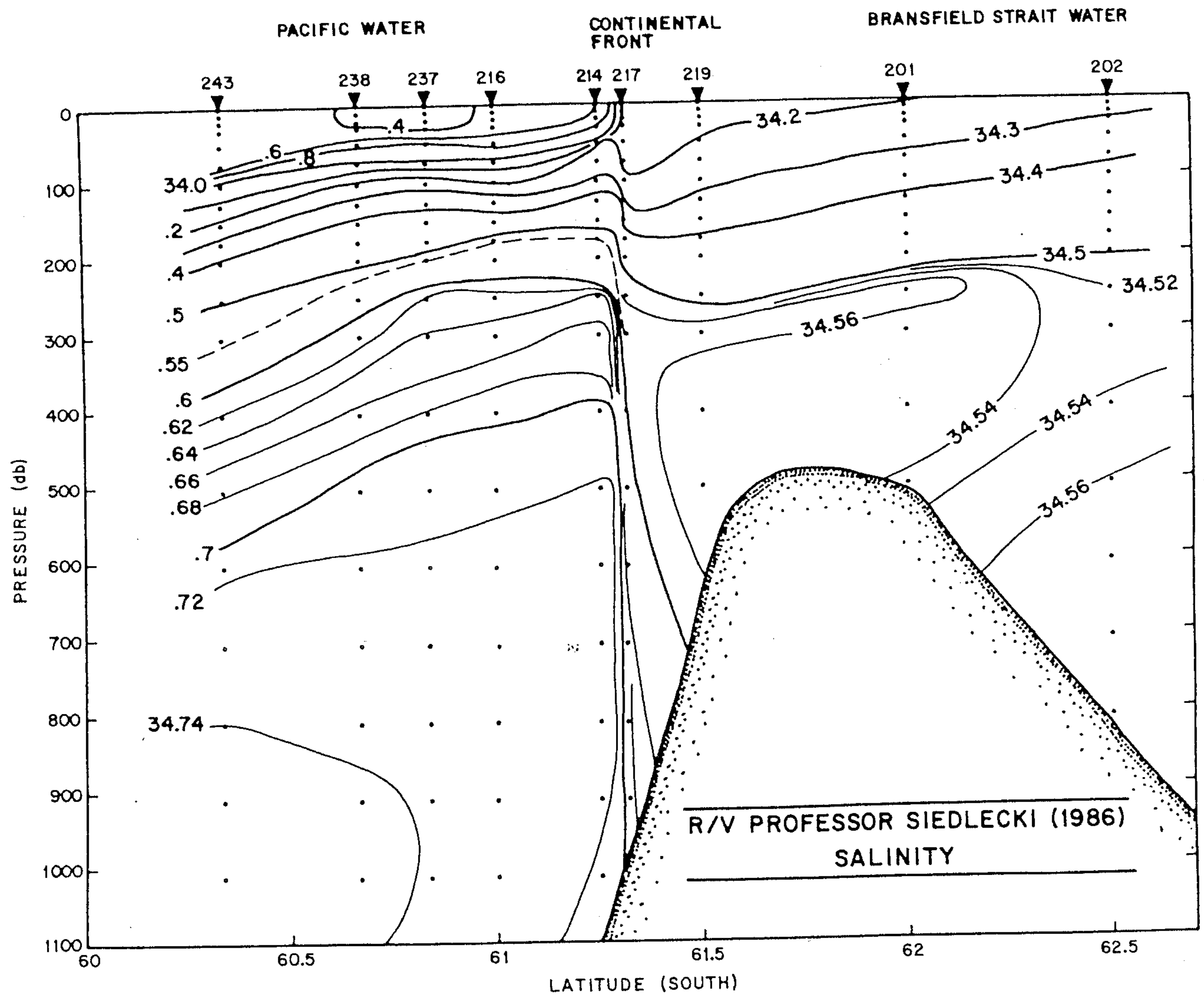

Figure 3b: Salinity section along 57°W

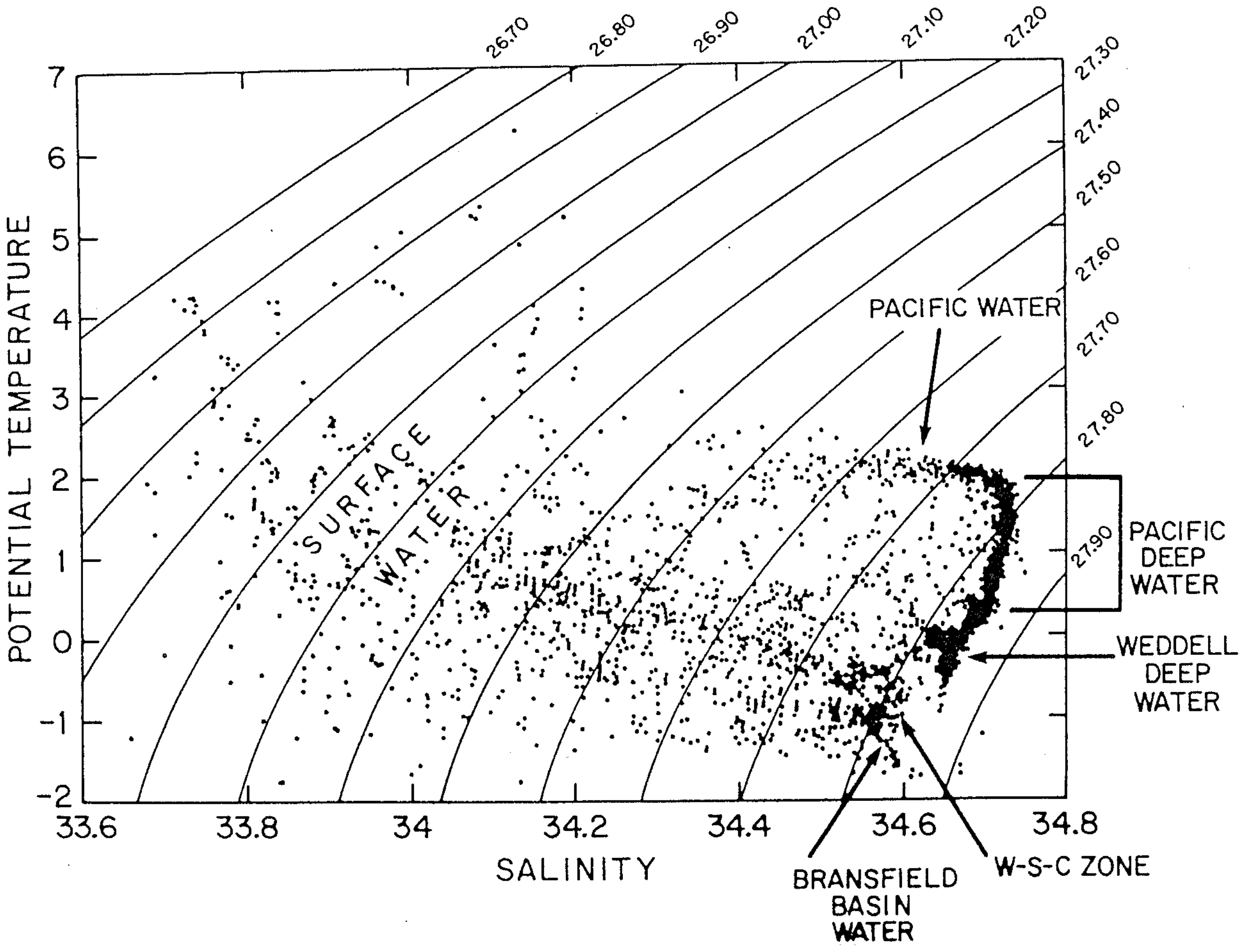

Figure 4: Potential temperature/salinity distribution for the January and February data from the Southern Ocean Atlas for the region : 50°-65°S and 20°-90°W. Various water mass regimes are labelled.

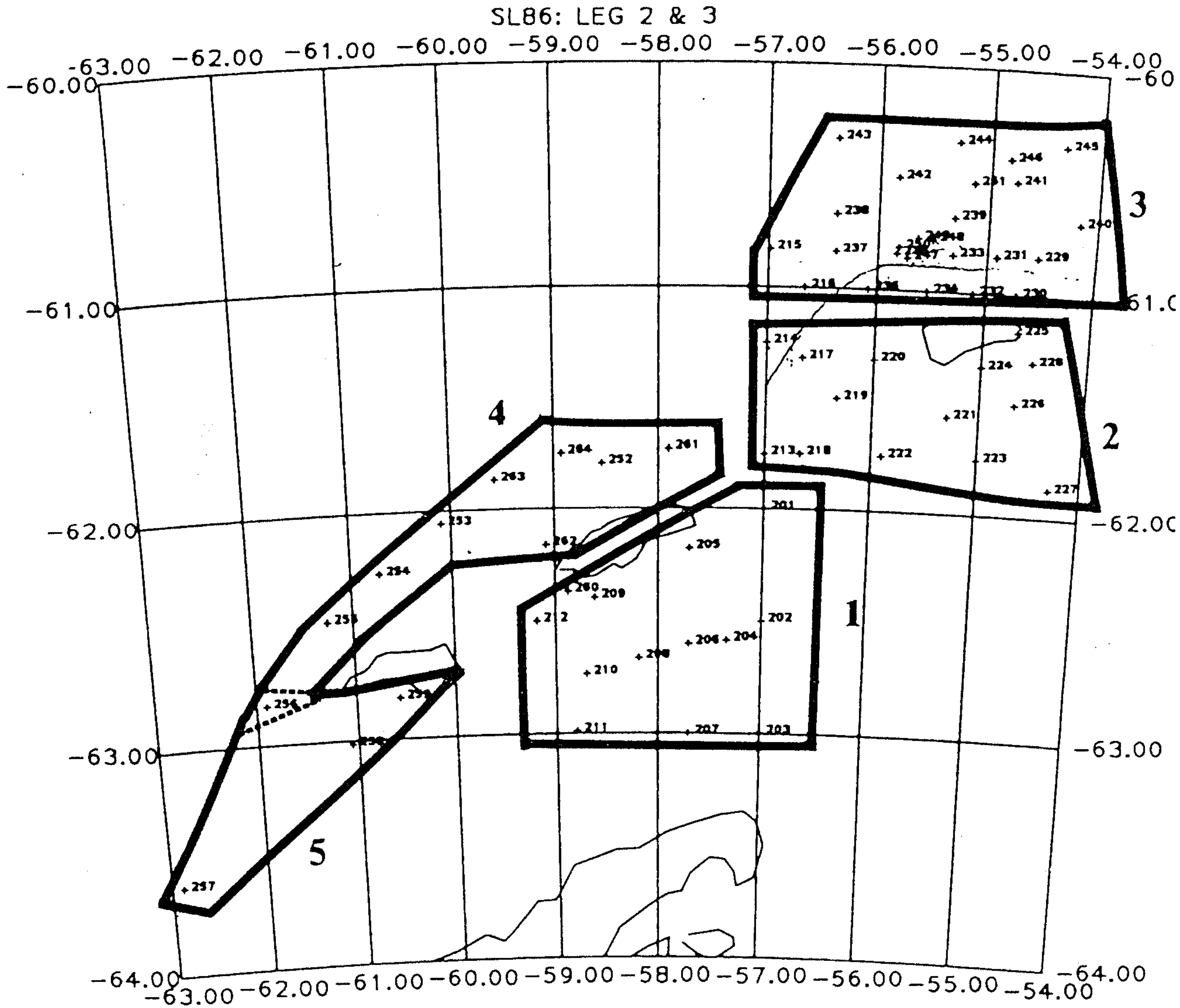

Figure 5: Five groupings of the R/V *Professor Siedlecki* 1986 data in the South Shetland Island region

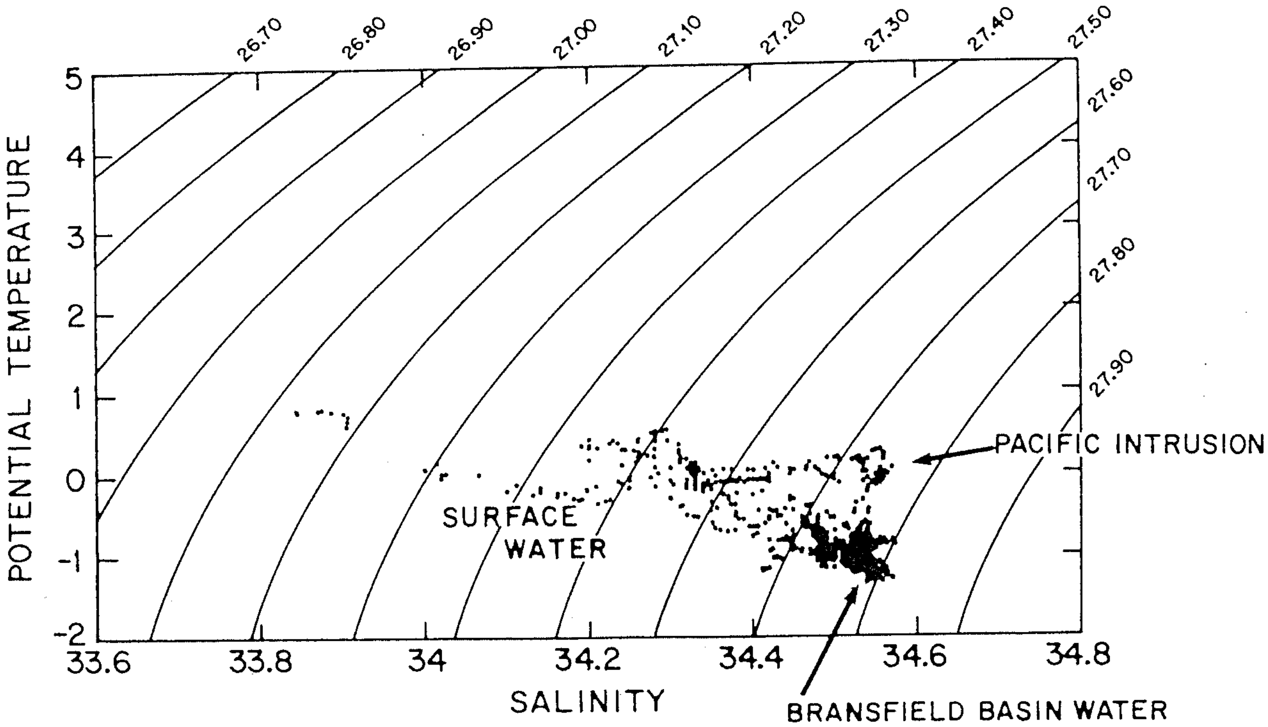

Figure 6: Potential temperature/salinity for area #1 (see Figure 5)

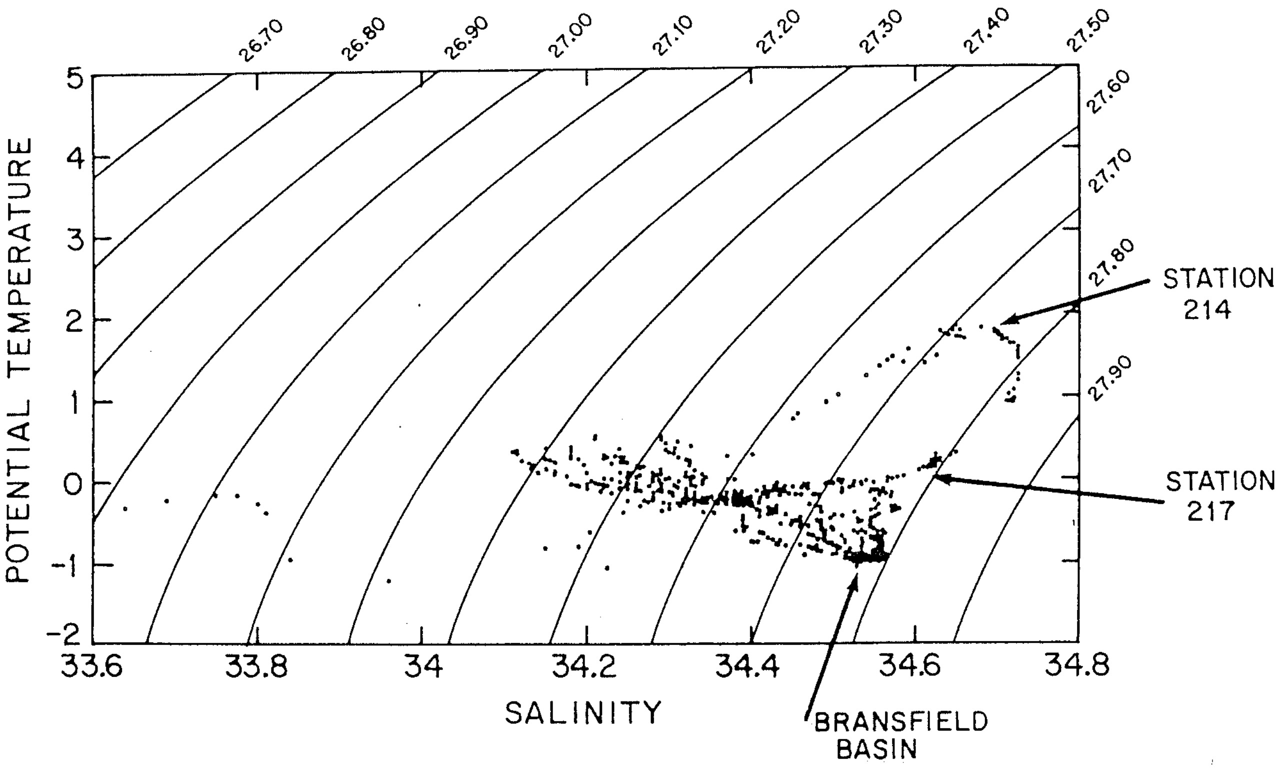

Figure 7: Potential temperature/salinity for area #2 (see Figure 5)

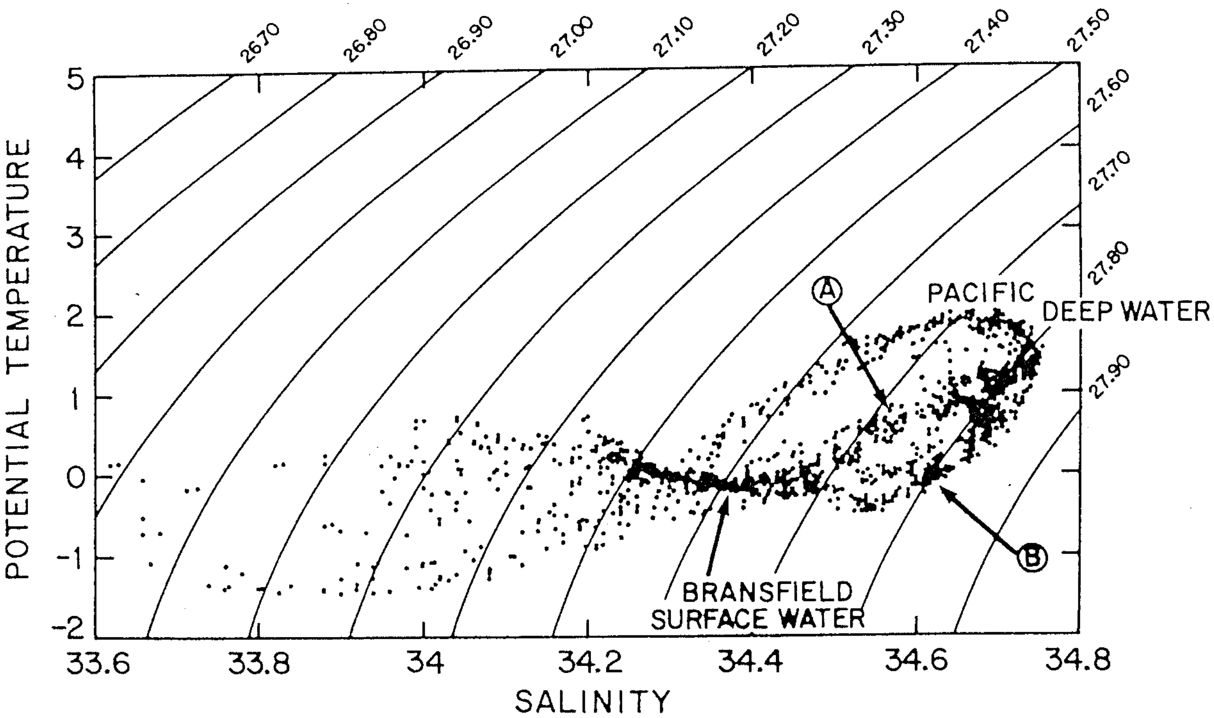

Figure 8: Potential temperature/salinity for area #3 (see Figure 5)

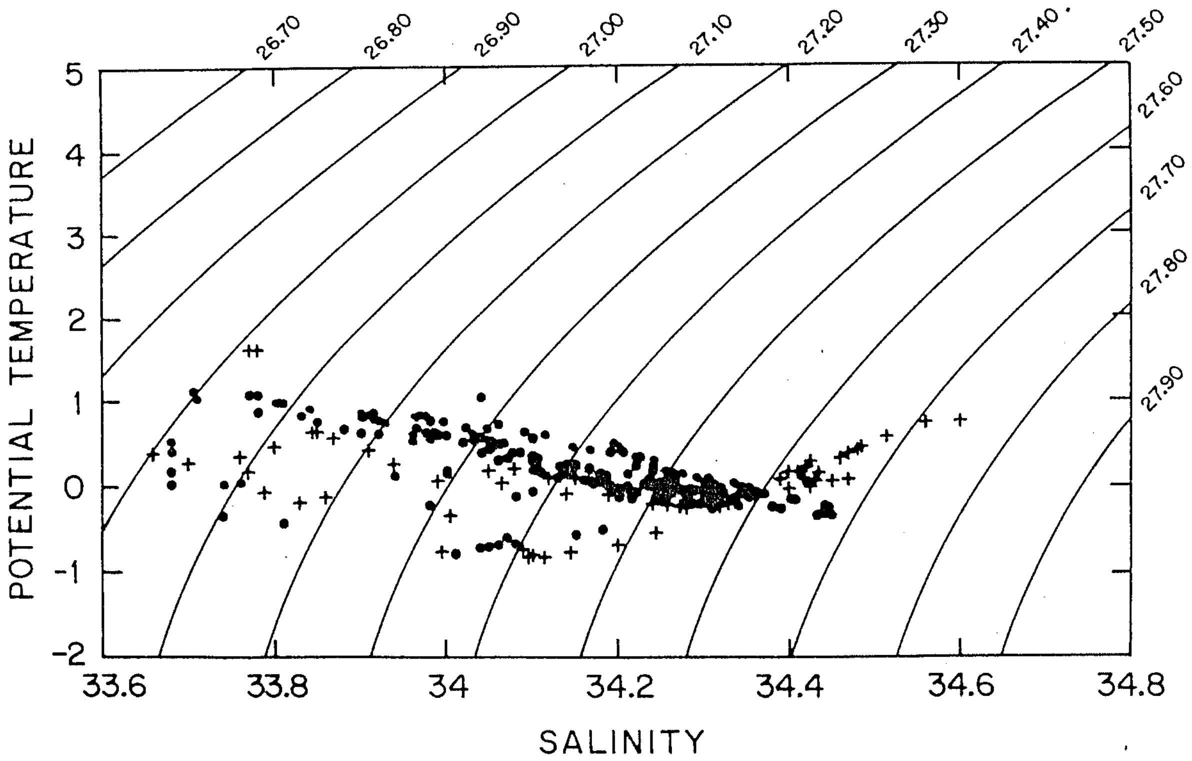

Figure 9: Potential temperature/salinity for area #4 and 5 (see Figure 5).

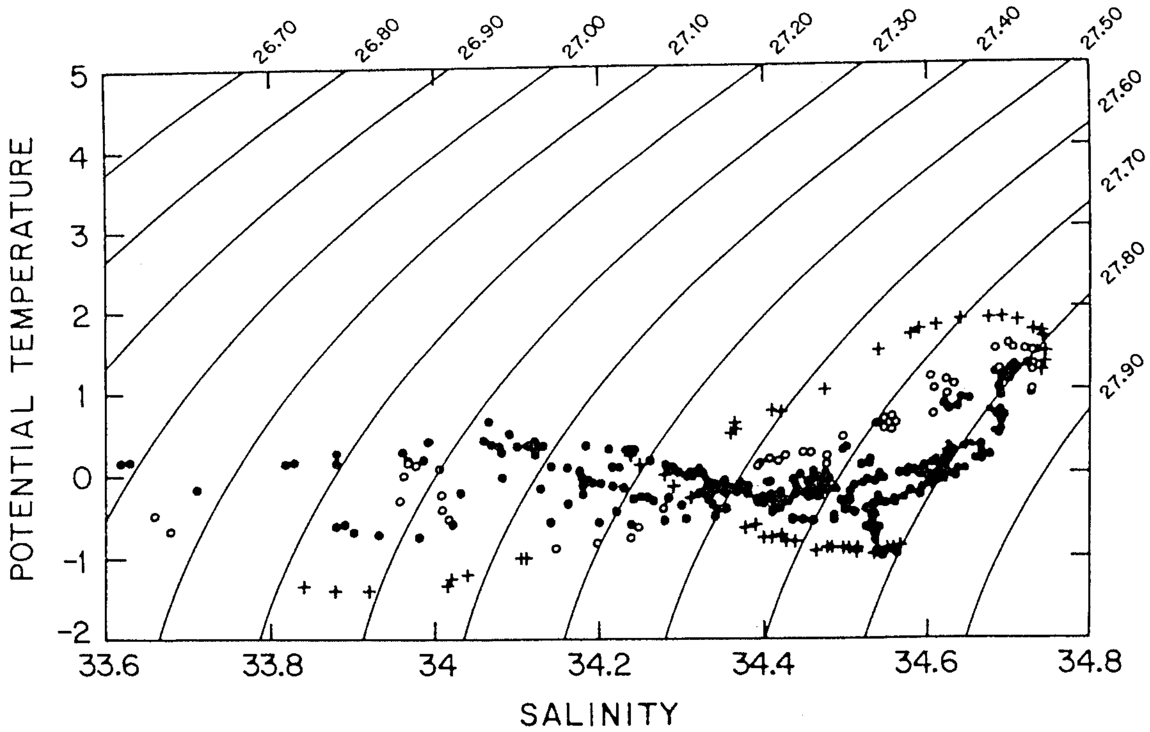

Figure 10: Potential temperature/salinity for stations 217, 226, 231, 235, 236 and 250 (representing stations with the mixture labelled "B" on Group #3 θ/S) shown by •; Stations 223 (Bransfield Strait station) and 244 (Pacific water column station), represented by +; and station 241 (with mixture "A" labelled in group #3 θ/S) represented by ∘ . The type A and B blends appear to be mixtures of Bransfield and Pacific water, products of mixing across the Scotia Front (see Figure 1).

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Figura 2b Mapa de las estaciones hidrográficas del *Siedlecki* en 1986/87.

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Figura 8 Temperatura potencial/salinidad para el área #3.

Figura 9 Temperatura potencial/salinidad para el área #4 & #5.

Figura 10 Temperatura potencial/salinidad para las estaciones 217, 226, 231, 235, 236, y 250.

PRELIMINARY RESULTS OF A BOTTOM TRAWL SURVEY AROUND ELEPHANT ISLAND IN OCTOBER AND DECEMBER 1987

K.-H. Kock

Abstract

A total of 40 bottom trawl hauls was carried out onboard RV *Polarstern* in October and December 1987. Preliminary results indicate rather stable stock compositions in *Chaenocephalus aceratus, Notothenia gibberifrons* and *N. neglecta* at least since February 1985. In *N. rossii* the proportion of larger (= older) fish in the catches increased. Composition of the catches of *C. gunnari* differed significantly from that in previous seasons which argues for an exchange with *C. gunnari* from other shelf areas of the Peninsula region.

Résumé

Un total de 40 traits de chalut de fond a été effectué à partir du navire de recherche *Polarstern* en octobre et décembre 1987. Les résultats préliminaires indiquent une composition plutôt stable des stocks de *Chaenocephalus aceratus, Notothenia gibberifrons* et *N. neglecta* au moins depuis février 1985. En ce qui concerne *N. rossii*, la proportion de poissons plus âgés dans les prises était en augmentation. La composition des prises de *C. gunnari* était nettement différente de celle des saisons précédentes, ce qui dénoterait un échange avec *C. gunnari* d'autres plateaux de la zone de la péninsule.

Резюме

В октябре и декабре 1987 г. НИС "Поларштерн" было произведено в общей сложности 40 тралений донным тралом. Предварительные данные показали довольно устойчивый, по крайней мере, с февраля 1985 г., состав запасов *Chaenocephalus aceratus, Notothenia gibberifrons* и *N. neglecta.* В уловах *N. rossii* увеличилась доля рыб большего размера (т.е. более старшей). Состав уловов *C. gunnari* сильно отличался от составов уловов в предыдущих сезонах, что является доводом в пользу той точки зрения, что имеет место обмен с запасами *C. gunnari* других участков шельфа в районе Антарктического полуострова.

Resumen

Se llevó a cabo un total de 40 lances de arrastre de fondo a bordo del B/I *Polarstern* en octubre y diciembre de 1987. Los resultados preliminares indican composiciones bastante estables en las poblaciones de *Chaenocephalus aceratus* , *Notothenia gibberifrons* y *Notothenia neglecta* por lo menos desde febrero de 1985. En *N. rossii* aumentó la proporción de peces de mayor tamaño (= de más edad). La

composición de las capturas de *C. gunnari* fue significativamente diferente a la de temporadas anteriores, lo cual indica un intercambio con *C. gunnari* de otras áreas de la plataforma de la región de la Península.

1. INTRODUCTION

Since 1975/76 the Federal Republic of Germany has been carrying out a long-term program to study the biology and dynamics of fishes around Elephant Island as well as their interactions with the environment and their trophic links with plankton and benthos. In the first years (1975/76, 1977/78, 1981) investigations focussed on the commercially exploitable species *Notothenia rossii, N. gibberifrons, Champsocephalus gunnari* and *Chaenocephalus aceratus.* During SIBEX in 1983 the program was extended to all fish species. Since then, surveys have been carried out in November 1983, February 1985, May/June 1986 and October and November 1987. Results of the surveys until 1986 have been described by Kock (1986) and Nast et al. (1988).

Results of the most recent survey in October and December 1987 are described as follows.

2. MATERIAL AND METHODS

Based on the stratification of the shelf by depth and fish abundance (Kock, 1986), 40 sampling stations were chosen randomly but restricted to areas where trawling conditions were moderate to good. Additionally 6 shallow water stations were carried out off the south coast of the island between Isla Rowett and Endurance Glacier.

From 28 October to 1 November and 13-16 December 1987, 21 and 19 hauls (Stat. Nos 67-89 and 218-236) were carried out by RV *Polarstern* using a 140' bottom trawl with a small meshed liner of 20 mm. Sampling depth varied from 65-458 m. Standard trawling time was 30 minutes. The location of fishing stations is set out in Figure 1.

The shallow water area southwest of Endurance Glacier was sampled by the launch *Polarfuchs* on 12 December 1987 using a 4 m beam trawl with a mesh size of 10 mm. Fishing depth varied from 10-60 m. Trawling time was 15 minutes.

Total length of the specimens sampled was measured to the nearest cm below. Age determinations in *Notothenia rossii* were carried out by means of scales following methods and results of Freytag (1980). Maturity stages were determined according to Everson's (1977) five-point-scale.

3. RESULTS

3.1 Catch Composition

A total of 40 species was present in the catches (Table 1). Except for *Akarotaxis nudiceps* (Bathydraconidae) and *Paraliparis sp.* (Liparididae) all had been reported on previous cruises (see Nast et al., 1988). The catch of a number of egg capsules of *Bathyraja sp.* (most probably *B. maccaini*) containing embryos close to hatching at 295-426 m depth (Stat. Nos. 234-236) is the first record of rajid egg capsules with developing embryos in the Peninsula region.

The 40 hauls yielded a total catch of 18.04 tonnes. The most abundant species in terms of biomass were *Notothenia gibberifrons* (57.7%), *Chaenocephalus aceratus* (17.1%), *Notothenia neglecta* (8.8% mainly in December), *Notothenia rossii* (5.4%, mainly in December) and *Champsocephalus gunnari* (5.2%).

The beam trawl catches in shallow waters were predominated by small *N. gibberifrons* (3-5 cm and 8-13 cm total length) which probably represent age classes

1+ and 2+. Other species present were *Harpagifer antarcticus*, 2 pelagic fingerlings of *N. neglecta* (62 and 70 mm total length) at 20 and 40 m depth, *Chaenocephalus aceratus, Trematomus* and *Parachaenichthys charcoti.*

3.2 Catches and Length (Age) Compositions of the Most Abundant Species

3.2.1 *Notothenia gibberifrons*

The species was present on all stations fished. Catches were mostly in the order of 50-250 kg. Catches of more than 1 000 kg were only obtained west of the island and northwest of Seal Rocks (Figure 2).

Catches consisted mostly of individuals of 22-45 cm length. Length compositions were very similar for both fishing campaigns (Figure 7). Gonads of adult fish were all in resting stage (stage 2).

3.2.2 *Chaenocephalus aceratus*

More than 70% of the catches contained less than 100 kg. Higher catches with a maximum of 407 kg were primarily taken northwest, north and northeast of Seal Rocks (Figure 3).

Fish of 10-70 cm were present in the catches. Individuals > 56 cm were exclusively females. The first 3 peaks in the length frequency composition (Figure 8) most probably represent age classes 1+, 2+ and 3+.

The shift in these peaks by about 2 cm within a 6 weeks period gives some indication on the growth performance in late spring/early summer. Gonads of sexually mature fish were all in stage 2.

3.2.3 *Notothenia neglecta*

Catches of *N. neglecta* exceeded 100 kg only twice, when 885 and 353 kg were taken northwest and east of Seal Rocks in December (Figure 4).

Length frequency composition was similar in October and December. The bulk of fish was 40-50 cm long (Figure 7).

More than 95% of the fish were sexually mature. Their gonads were all in resting stage.

3.2.4 *Notothenia rossii*

Notothenia rossii were only observed on 16 out of the 40 stations fished. Only single specimens were caught except in a haul off the north coast of the island where 858 kg were taken in December (Figure 5).

Fish of 43-59 cm predominated in the catches. They mostly belong to age classes 7 and 8 (Figure 8 and Table 2).

Females up to 50 cm were mostly juveniles. Larger females were mainly in stage 2. About 20% of the mature females had developing ovaries. Males were almost exclusively sexually mature. About 30% of them had developing testes.

3.2.5 *Champsocephalus gunnari*

Catches of *C. gunnari* rarely exceeded 50 kg. The maximum catch was 372 kg taken northwest of Seal Rocks in December (Figure 6), which consists almost exclusively of age class 1+ fish.

In October individuals of 26-32 cm predominated (Figure 7), which were also present in December. Then, however, the bulk of specimens was 11-14 cm long (Figure 7) and belonged to age class 1+.

Most of the fish were juveniles. Sexually mature fish were from 28 cm onwards. Nearly all gonads were in resting stage.

4. DISCUSSION

Elephant Island is an area where two ichthyofaunal groups mix: those with a lesser Antarctic or seasonal pack ice zone type of distribution and those with a greater Antarctic type of distribution. Species with a lesser Antarctic type of distribution which are represented by the genus *Notothenia* and the icefish *Chaenocephalus aceratus* and *Champsocephalus gunnari*, however, made up more than 98% of the catches (i.e. biomass).

Except for *Notothenia gibberifrons* catches of all species were in same order as during previous surveys, indicating little or no change in their biomass. Catches of *N. gibberifrons* were lower than during a previous survey in May/June 1986, when the species was found to form prespawning aggregations. This may have influenced the amount of catches.

Analysis of length frequency distributions indicate little or no changes in the stock compositions of *N. gibberifrons, Ch. aceratus* and *N. neglecta* since the previous survey in May/June 1986. Information on *N. rossii* which was the target species in the commercial fishery in 1979/80 (total catch: 18 753 tonnes) is based on only one haul and should thus be regarded with care. Since the previous surveys in 1985 and 1986 the proportion of individuals >50 cm has increased. Age classes 7+ and to a lesser extent 8+ predominated compared to 1985 and 1986 when age class 6+ was the most dominant in the catches. Length composition of *C. gunnari*, which was the target species in the fishery from 1978/79 to 1982/83, differed significantly from that in 1985 and 1986 arguing for an exchange with individuals from other shelf areas of the Peninsula region.

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Table 1: List of fish species caught during *Polarstern* ANT VI/2 around Elephant Island

Nototheniidae

Dissostichus mawsoni
Pleuragramma antarcticum
Notothenia rossii marmorata
N. gibberifrons
N. neglecta
N. kempi
Nototheniops larseni
N. nudifrons
Trematomus eulepidotus
T. newnesi
Pagothenia bernacchii
P. hansoni

Harpagiferidae

Harpagifer antarctius

Muraenolepidae

Muraenolepis microps

Zoarcidae

Lycodichthys antarcticus
Ophthalmolycus amberensis (?)
Zoarcidae sp.

Trichiuridae

Paradiplospinus gracilis

Myctophidae

Electrona sp.
Gymnoscopelus nicholsi

Channichthyidae

Champsocephalus gunnari
Chaenocephalus aceratus
Chionodraco rastrospinosus
Cryodraco antarcticus
Chaenodraco wilsoni
Pseudochaenichthys georgianus
Neopagetopsis ionah
Pagetopsis macropterus

Bathydraconidae

Akarotaxis nudiceps
Parachaenichthys charcoti
Prionodraco evansii
Racovitzia glacialis
Gymnodraco acuticeps
Gerlachea australis

Rajidae

Bathraja eatonii
B. maccaini
B. species 2
Bathyraja sp. egg capsules

Liparididae

Paraliparis sp. 1
Paraliparis sp. 2

Paralepididae

Notolepis coatsi

Table 2: Age length of *Notothenia rossii marmorata* from Elephant Island in December 1987

length group (cm)	age class 5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+
37	1										
38											
39	1										
40		2									
41			1								
42	1	1	4								
43		1	4								
44		3	9	1							
45		2	18	1							
46		3	22	3							
47		1	30								
48		2	35	1							
49		1	17	3							
50			15	6							
51			9	11	1						
52			4	11	1						
53			4	11	3						
54				2	4						
55				4	5	1					
56				1	4	1					
57				1	3	1					
58					3	2	1				
59					1	2					
60							2	1			
61											
62						1	2				
63											
64											
65											
66											
67											
68											
69											
70											
71											
72											1
n	3	16	172	56	25	8	5	1			1

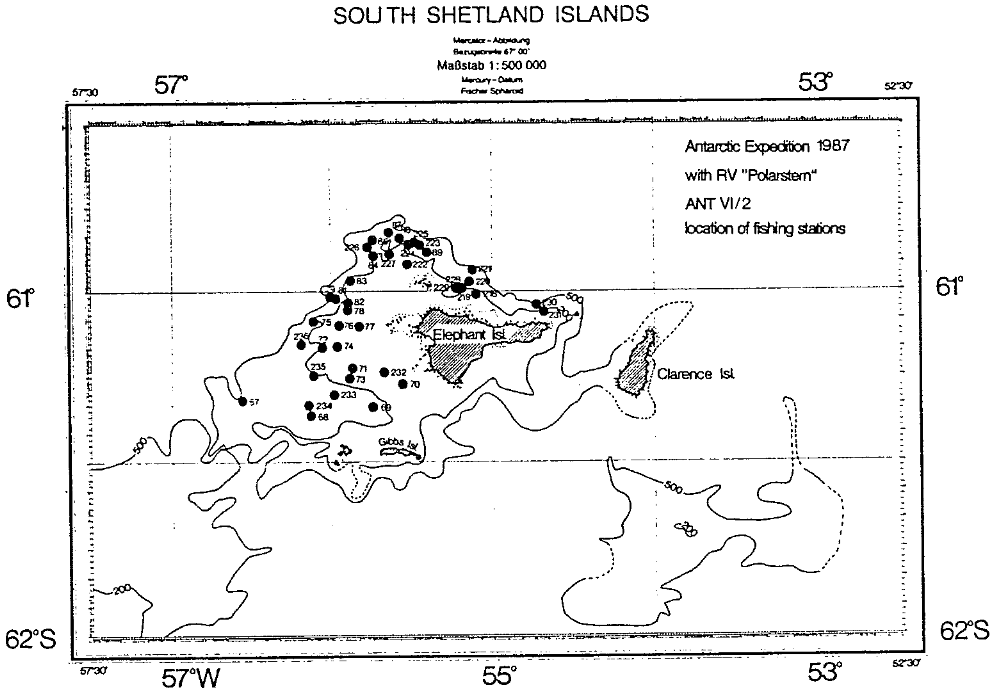

Figure 1: Location of fishing stations.

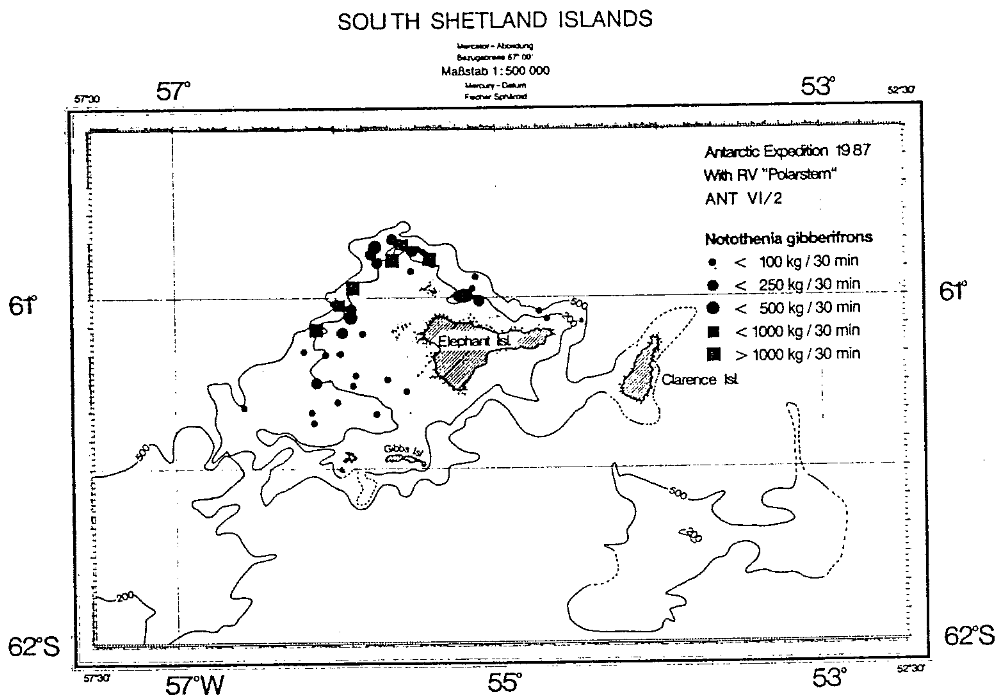

Figure 2: Catches of *Notothenia gibberifrons* around Elephant Island in October and December 1987.

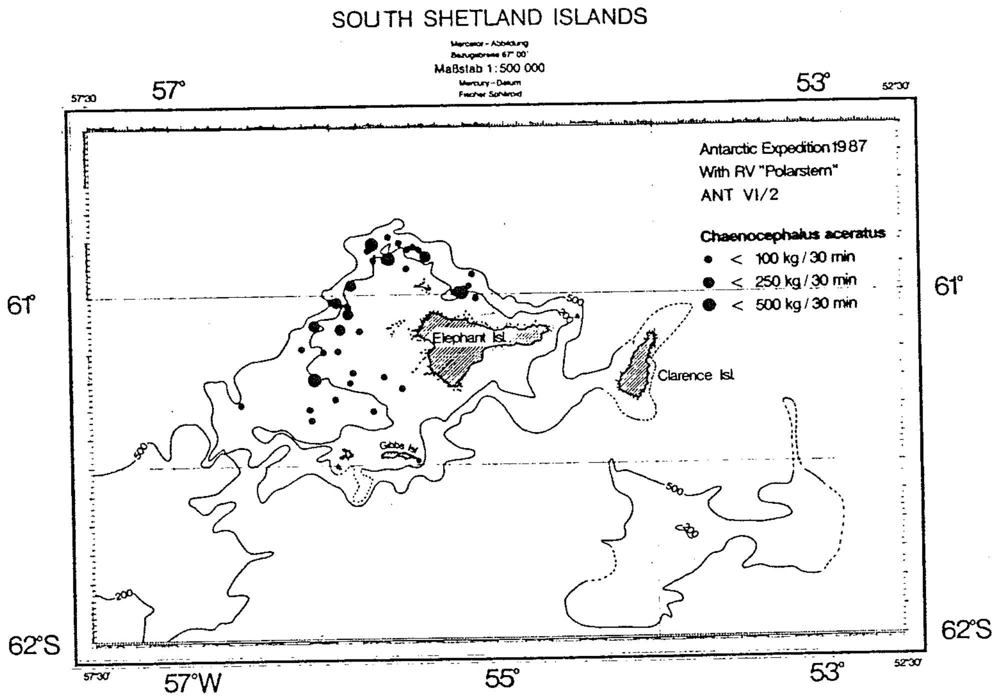

Figure 3: Catches of *Chaenocephalus aceratus* around Elephant Island in October and December 1987.

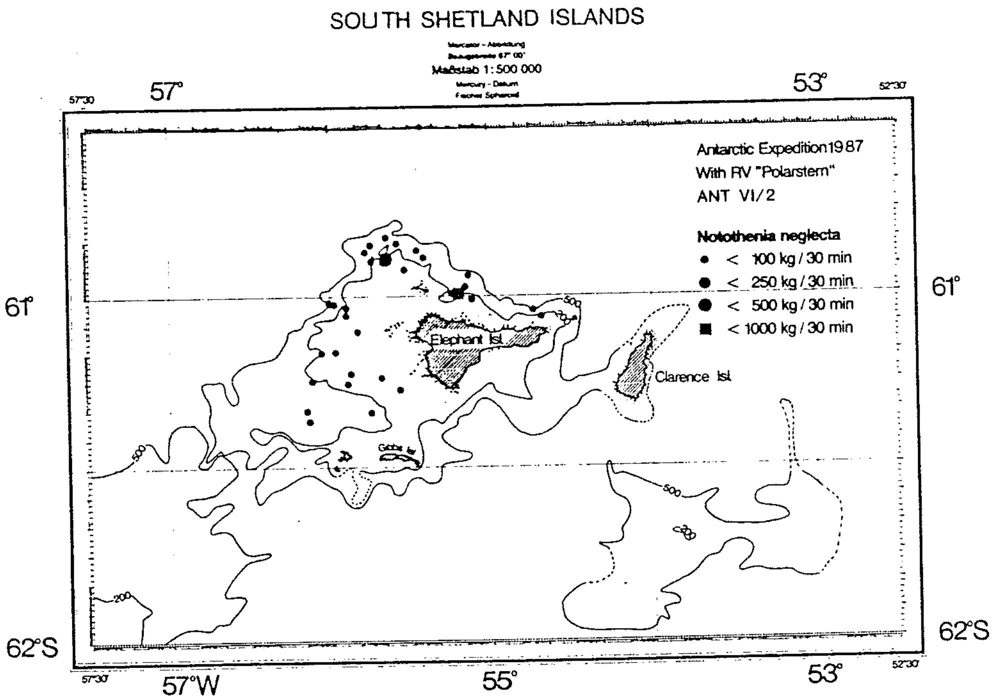

Figure 4: Catches of *Notothenia neglecta* around Elephant Island in October and December 1987.

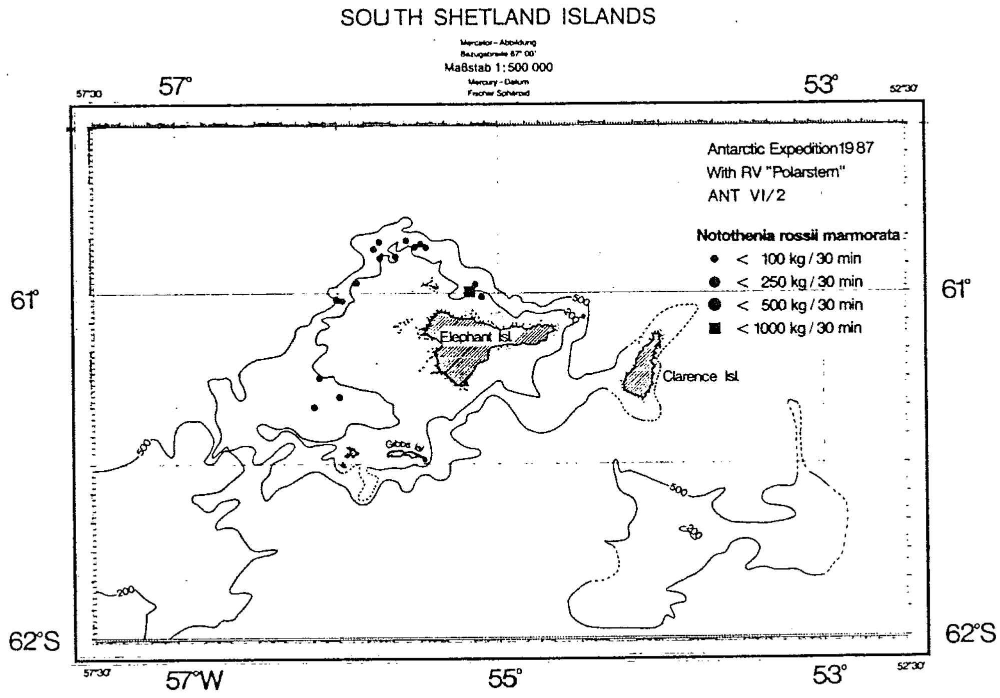

Figure 5: Catches of *Notothenia rossii* around Elephant Island in October and December 1987.

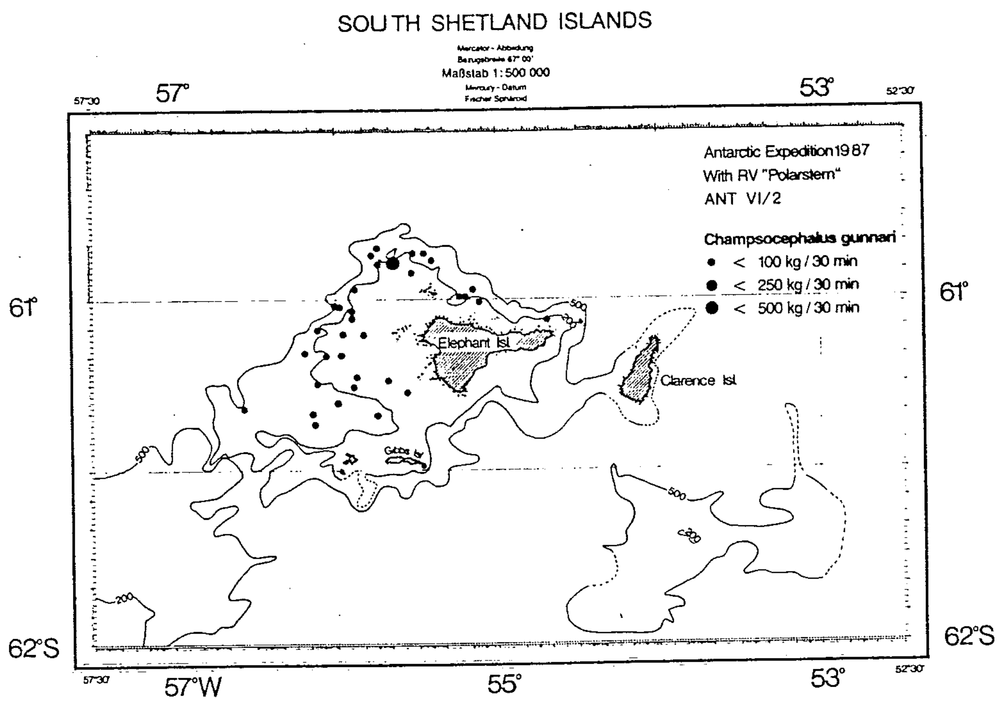

Figure 6: Catches of *Champsocephalus gunnari* around Elephant Island in October and December 1987.

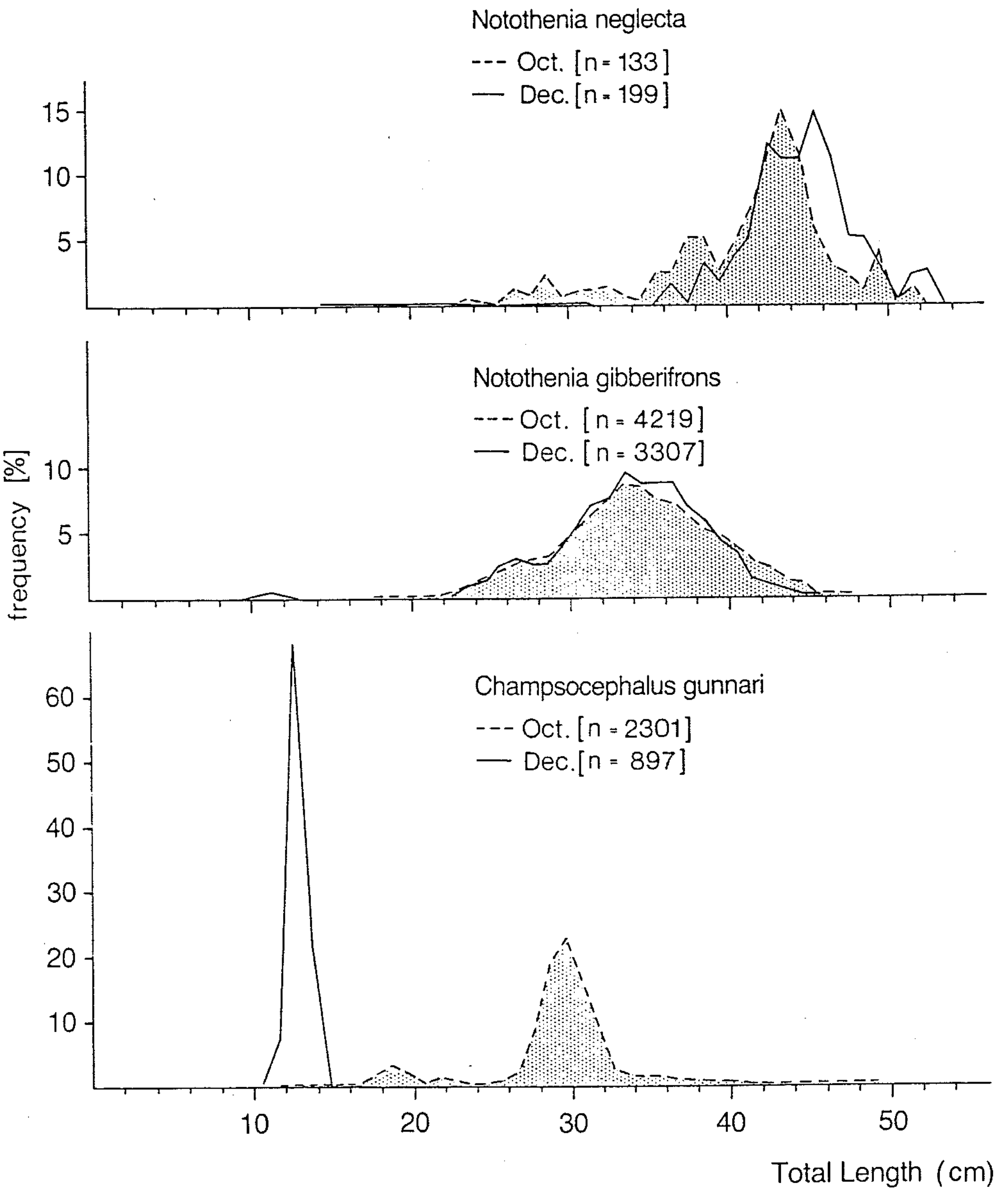

Figure 7: Length composition of *Champsocephalus gunnari, Notothenia gibberifrons* and *Notothenia neglecta* around Elephant Island in October and December 1987.

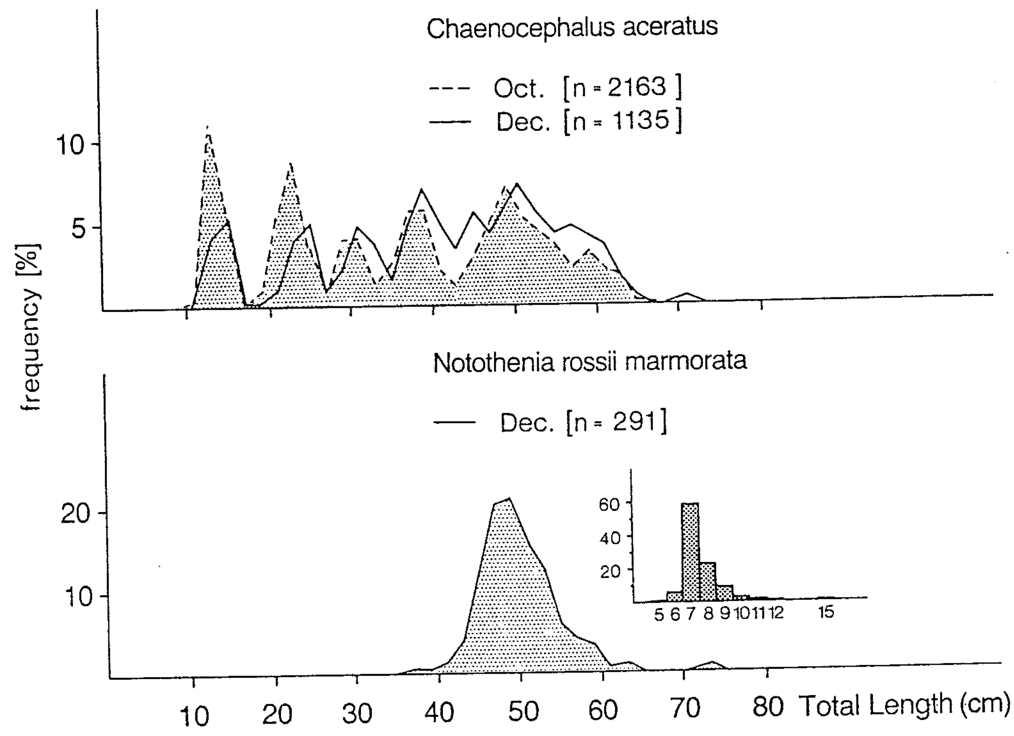

Figure 8: Length composition of *Notothenia rossii marmorata* and *Chaenocephalus aceratus* around Elephant Island in October and December 1987.

Légendes des tableaux

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Tableau 2 Clef âges-longueurs de *Notothenia rossii marmorata* près de l'île de l'Eléphant au mois de décembre 1987.

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Figure 2 Prises de *Notothenia gibberifrons* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 3 Prises de *Chaenocephalus aceratus* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 4 Prises de *Notothenia neglecta* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 5 Prises de *Notothenia rossii* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 6 Prises de *Champsocephalus gunnari* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 7 Compositions en longueurs de *Champsocephalus gunnari*, *Notothenia gibberifrons* et *Notothenia neglecta* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

Figure 8 Compositions en longueurs de *Notothenia rossii marmorata* et *Chaenocephalus aceratus* autour de l'île de l'Eléphant aux mois d'octobre et décembre 1987.

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Рисунок 3 — Уловы *Notothenia neglecta* в районе о. Элефант в октябре и декабре 1987 г.

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Figura 4 — Capturas de *Notothenia neglecta* alrededor de la isla Elefante en octubre y diciembre de 1987.

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Figura 7 — Composiciones por talla de *Champsocephalus gunnari*, *Notothenia gibberifrons* y *Notothenia neglecta* alrededor de la isla Elefante en octubre y diciembre de 1987.

Figura 8 — Composiciones por talla de *Notothenia rossii marmorata* y *Chaenocephalus aceratus* alrededor de la isla Elefante en octubre y diciembre de 1987.

LARGE-SCALE PECULIARITIES OF PHYTOCENOSIS SPECIES COMPOSITION IN THE SURFACE LAYER IN THE ANTARCTIC ATLANTIC AND INDIAN OCEAN SECTORS

R.R. Makarov and K.P. Fedorov

Abstract

In surface phytoplankton samples (layer between 0 and 1 m) taken with a sampler towed by RV *Professor Vize*, *Corethron criophilus* dominated over vast areas within the distribution of the south peripheral waters and the centre of the Weddell Gyre. In the eastern Weddell Gyre a great change in the composition of phytoplankton species was registered. Variability in phytoplankton species composition occurred mainly in the Antarctic Convergence Zone. A seasonal shift in species composition was observed in the same regions (sub-Antarctic waters, the Convergence Zone proper, south periphery of the Antarctic Circumpolar Current). A great change in phytoplankton composition was also found near the continent (Alasheev Bay). During the observation season maximum biomass values of surface phytoplankton were registered in the south periphery of the Antarctic Circumpolar Current.

Résumé

Parmi les échantillons de phytoplancton prélevés en surface (couche 0 - 1 m) à l'aide d'un échantillonneur remorqué par le navire de recherche *Professor Vize*, les *Corethron criophilus* prédominaient sur de vastes zones correspondant aux eaux méridionales de la périphérie du courant circumpolaire antarctique et du tourbillon central de la mer de Weddell. Dans la partie orientale du courant tourbillonnaire de la mer de Weddell, un changement important dans la composition par espèces du phytoplancton fut enregistré. La diversité de la composition par espèces du phytoplancton a surtout été observée dans la zone de la Convergence antarctique. Des changements saisonniers dans la composition par espèces furent aussi observés aux abords du continent (baie d'Alasheev). Pendant la saison d'observation, les valeurs maximales exprimant la biomasse du phytoplancton de surface furent relevées dans la périphérie méridionale du courant circumpolaire antarctique.

Резюме

Образцы фитопланктона поверхностного слоя (глубиной от 0 до 1 м) взятые пробоотборником по курсу следования НИС "*Профессор Визе*", показали, что в тех акваториях, куда заходили воды южной периферии Антарктического циркумполярного течения и центральной циркуляции моря Уэддела, на огромных пространствах доминировал вид *Corethron criophilus*. В восточной части циркуляции моря Уэддела было отмечено сильное изменение видового состава фитопланктона. Неустойчивость видового состава фитопланктона проявлялась в основном в зоне Антарктического конвергенции. Сезонный сдвиг в видовом составе наблюдался в тех же районах (Субантарктические воды, центр зоны конвергенции, южная периферия Антарктического циркумполярного течения) .Большие изменения в видовом составе фитопланктона также наблюдались у материка (залив Алашеева). За период проведения наблюдений максимальные величины биомассы фитопланктона поверхностного слоя были отмечены в районе южной периферии Антарктического циркумполярного течения.

Resumen

Las muestras de fitoplancton de aguas superficiales (capa entre 0 y 1 m) tomadas con un muestreador remolcado por el B/I *Professor Vize*, *Corethon criophilus*, predominaron en vastas zonas de la distribución de las aguas periféricas del sur y el centro de las vortices de Weddell. Al este de las vortices de Weddell se registró un gran cambio en la composición de las especies fitoplancton. Hubo variabilidad en la composición de las especies fitoplancton principalmente en la Zona de la Convergencia Antártica. Se observó un cambio estacional en la composición de las especies en dichas regiones (aguas subantárticas, zona de la convergencia misma, periferia sur de la Corriente Circumpolar Antártica). También se observó un gran cambio en la composición de las especies fitoplancton cerca del continente (bahía Alasheev). Durante la temporada de observación se registraron valores máximos de la biomasa del fitoplancton de la superficie en la periferia sur de la Corriente Circumpolar Antártica.

To study plankton over vast areas with the help of routine oceanographic surveys is practically impossible. Recorders towed by the vessel and various kinds of pumps providing continuous recordings of plankton composition are used for these purposes. Such studies were implemented during cruises of Japanese ice-breakers in the Indian Ocean sector on their route to Syowa Station (Lützow Holm Bay). Interesting results on spatial fluctuations of C^{14} were obtained (Taniguchi et al, 1986).

Similar studies were conducted during the 1987/88 season by RV *Professor Vize* (AANII Research Institute) during the cruise in the Atlantic and Indian Ocean sectors. A sampler inserted into a special outboard arm was designed out of the tube of the pitometer log and used to take plankton samples (Zhokhov, Maksimov, 1973; Zhokhov, Fedorov, 1987). A special filtration device with changeable filters (plankton net N 70) fitted to the reception hose made it possible to take plankton samples. Filtration was usually conducted at a speed of 1 litre per 1-2 minutes. The inlet of the device was submerged to a depth of 1 m for collection of surface phytoplankton. Zooplankton samples (copepods, Hyperiidae, euphausiids, pteropods) were usually small and therefore could not be analysed. Comparisons showed that species composition of dominating diatoms in samples taken with the sampler did not differ greatly from that of samples taken by nets in the layer between 0 and 100 m.

In February to April 1988 five tacks (8 520 miles) were made (Figure 1). Specific analysis of samples was done with quick methods (see Vladimirskaya et al, 1976). Raw weight of phytoplankton in samples was determined and later recalculated per g/m³. Species compositions of phytocenosis estimated by key and subordinate forms were compared by their abundance. Sampling was accompanied by continuous recording of surface water temperature.

Distribution of phytocenosises along the tacks is indicated in Figure 1; notches indicate sampling points. Detailed data on phytocenosis composition, phytoplankton biomass and surface temperatures for every tack are shown in Figures 2 to 6.

One of the most important circulation systems in the Antarctica, the Weddell Gyre, was surveyed. The mere change of phytocenosis composition usually indicates the location of boundaries between different types of waters (Vladimirskaya et al, 1976; Makarov, 1983). The general location of the latter, which fully corresponds with modern views on the system of circulation and the composition of waters in the region (Deacon, 1979; Comiso and Gordon, 1987; Bagryantsev and Guretsky, 1986), makes it possible to characterize each water type of the surveyed area by their phytocenosis compositions.

The tacks I, II and III (see Figures 2 to 4) crossed the west area of the South Polar Front. A wide range of phytoplankton species was typical for this region. It is quite natural because at least waters of three types are present there. In the waters of the south (Antarctic) periphery of the Antarctic Circumpolar Current *Chaetoceros criophilis* dominated in samples. The sub-Antarctic part of the Antarctic Circumpolar Current was characterized by the successive substitution (in the course of time) of *Corethron criophilum* for *Rhizosolenia spp* (see also, for instance, Hart 1934). The same plankton community was recorded north of the South Polar Front on tack V. Regular occurrences of *Thalassiothrix antarctica* were recorded in the frontal waters. *C. criophilum* was dominant in samples taken at later dates. A substantial proportion of *T. antarctica* was also found in the south Scotia Sea. Differences of phytocenosis composition on each tack (in the same waters) could be related to regional features of phytoplankton distribution. Seasonal succession is evidently responsible for these differences too.

C. criophilus almost solely prevailed eastwards along tacks I and II (see Figures 2 and 4). On certain parts of tack I this species was associated with the southern branch of the Antarctic Circumpolar Current, while on tack 3 as well as on tack II (southern part,

Figure 3) it was associated with the central part of the Weddell Gyre, which consisted exclusively of the waters of the Weddell Sea. High biomass of *C. criophilus* (up to 24 g/m^3) was recorded only in the waters of the Antarctic Circumpolar Current. In other regions phytoplankton biomass was lower.

In the eastern part of the Weddell Gyre where, as it is known, the system flow turns southward (Deacon, 1979), the warm Weddell counter-current is formed and then turns southwestward (Bagryantsev and Guretsky, 1986). Environment conditions for the phytoplankton development evidently undergo significant changes in the waters south of 50°S (10°E). In these waters phytocenosises were characterized by a wider species composition (see Figure 1). *C. criophilus* lost its importance. Two other species, *T. antarctica* and *R. hebetata,* prevailed in the community, but a substantial drop in phytoplankton biomass was observed (eastern part of tack III, tacks IV and V, see Figures 4 to 6). As one can see, changes in the community along the tacks were traced only in the south, while in the central part across the south of the Antarctic Circumpolar Current, *C. criophilus* dominated and phytoplankton biomass was increasing.

Tack V was made in the area where waters of the Antarctic Circumpolar Current extend into the southern latitudes, with *C. criophilus* dominating in the plankton community. The exchange of characteristics between boundary waters occurs due to the separation of meanders and formation of eddies. Higher phytoplankton biomass on tack V at 58° to 59°S (see Figure 6) and on tack VI at 59°S (see Figure 5) was a particular sign of the impact of the inflow of the rather cold water of the south periphery of the Antarctic Circumpolar Current. Simultaneous changes occurred in the composition of the community (*C. criophilus* dominated again) and the surface temperature increased. The community of mixed waters extended evidently far eastward into the higher latitude waters (southern part of section V) following the main system of currents which is typical for this part of the Antarctic Indian Ocean sector (Comiso and Gordon, 1987).

In distant south areas *C. criophilus* is also important (southern part of tack IV, see Figure 5). However, the prevalence of this species in these waters was as large as compared to other areas. This area was occupied by coastal waters of the Cosmonaut Sea, which were not affected by the transformed waters of the Weddell Gyre.

The tacks crossed the Antarctic Circumpolar Current ((south of Tack IV, see Figure 5) on their way to the shore at Molodezhnaya Station (Bibik et al, 1988). In association with it a new change in the community was manifested by the appearance of a substantial proportion of *C. criophilum.* Phytoplankton abundance went somewhat up in these waters, but it was accompanied by a significant drop of temperature. During observations, offshore waters in Alashejev Bay had been covered by pancake ice. Only algae of genus *Coscinodiscus* vegetated under the ice during that time.

One species, *C. criophilus* which can reproduce in such different waters, was characteristic for the whole area surveyed. It is obvious that in different waters different stages of the seasonal succession of the planktoin communities were observed, with the same species prevailing. All over the surveyed area the phytoplankton is more abundant in the far north areas (waters of the Antarctic Circumpolar Current) and less abundant in the south areas (coastal part of tack IV). Taking into account the time of observations, higher abundance in the first case corresponded most likely to the autumn bloom of the plankton, while indications of the spring or the coastal waters bloom could be responsible for high abundance of phytoplankton offshore.

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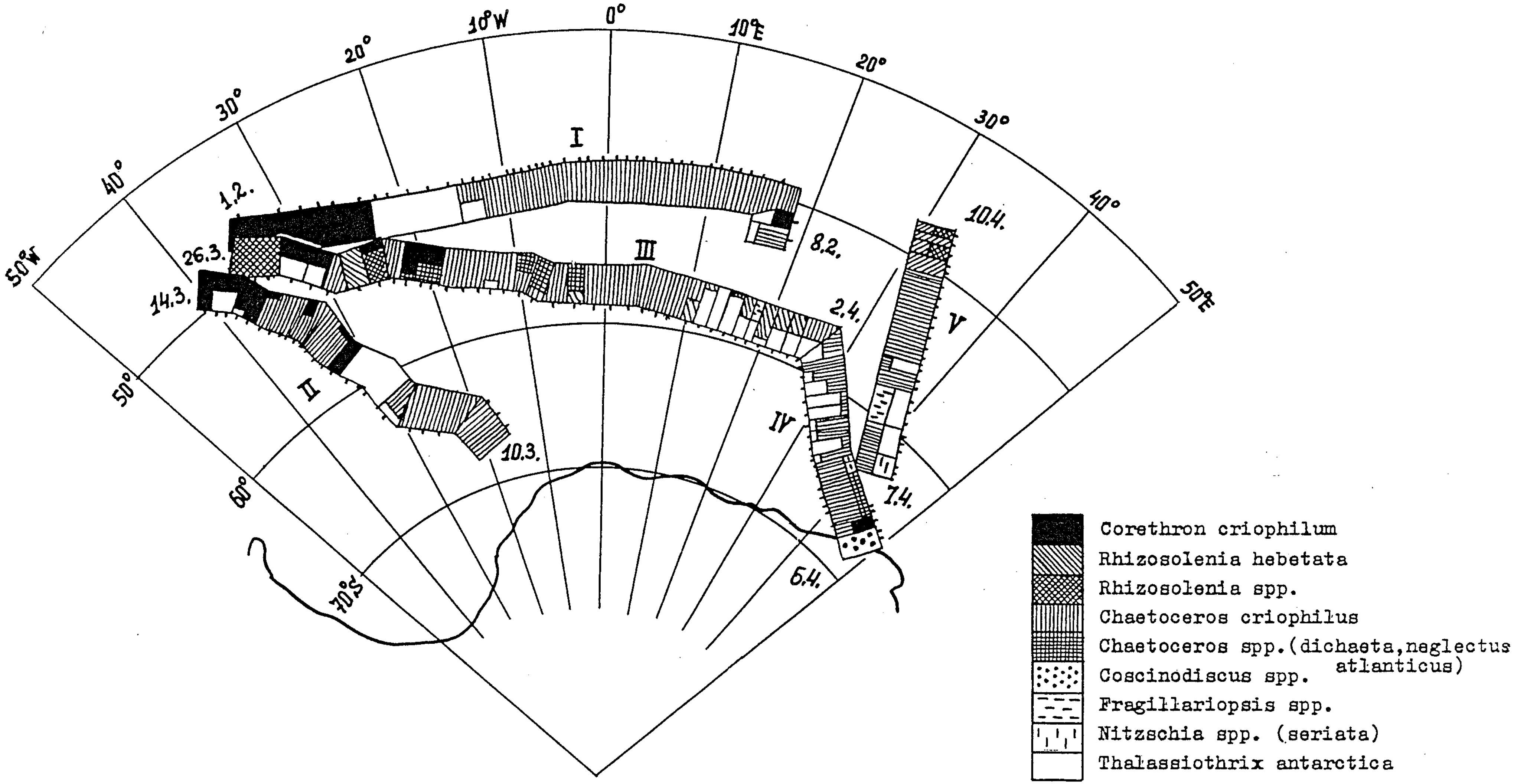

Figure 1: Distribution of phytocenosises of surface plankton on tacks of RV *Professor Vize* (February to April 1988). Number of tacks and dates are indicated.

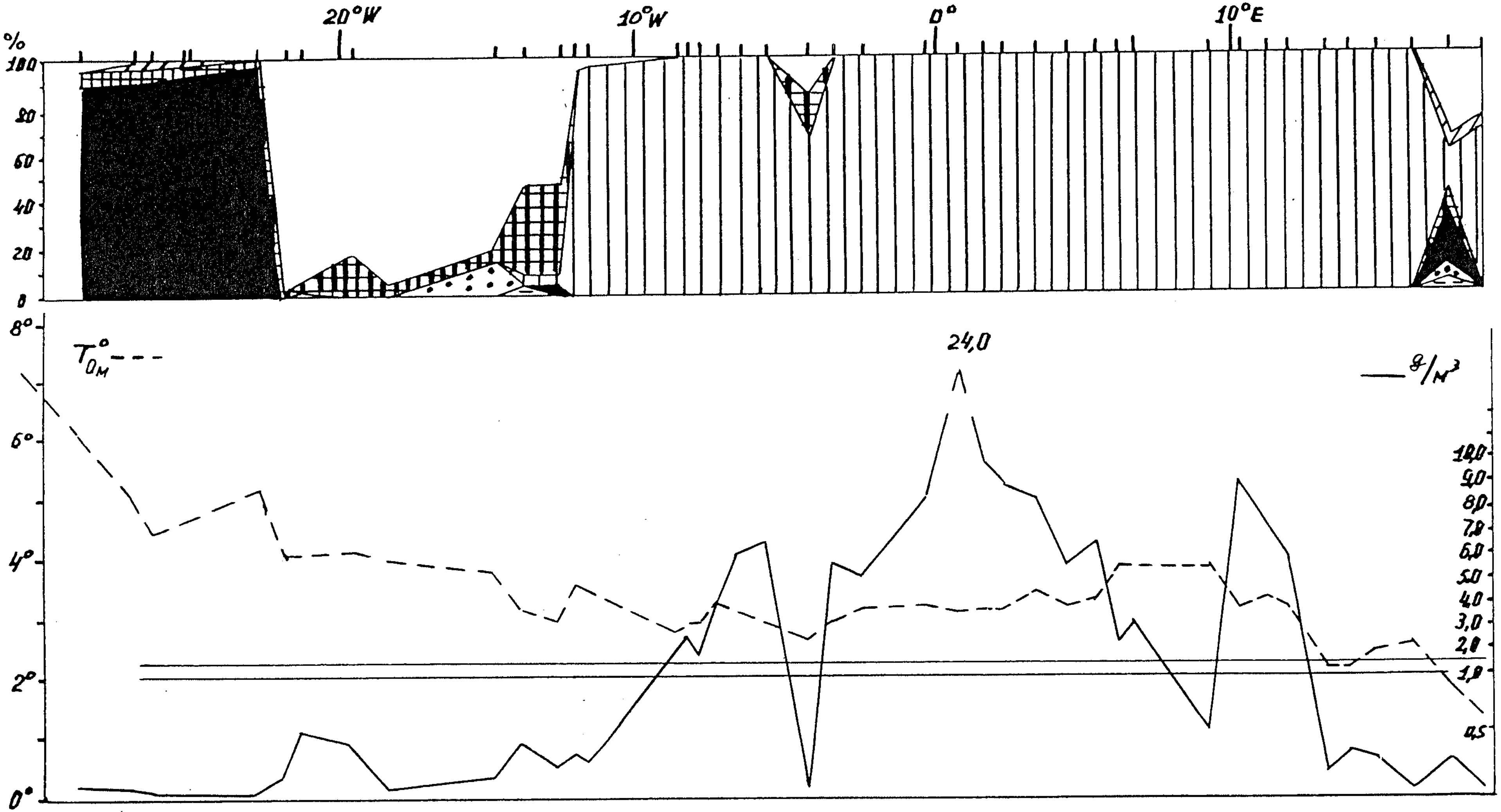

Figure 2: Variations of species composition of phytocenosises (%, key see in Figure 1), biomass (g/m³), surface temperature on tack I (1-8.2.88).

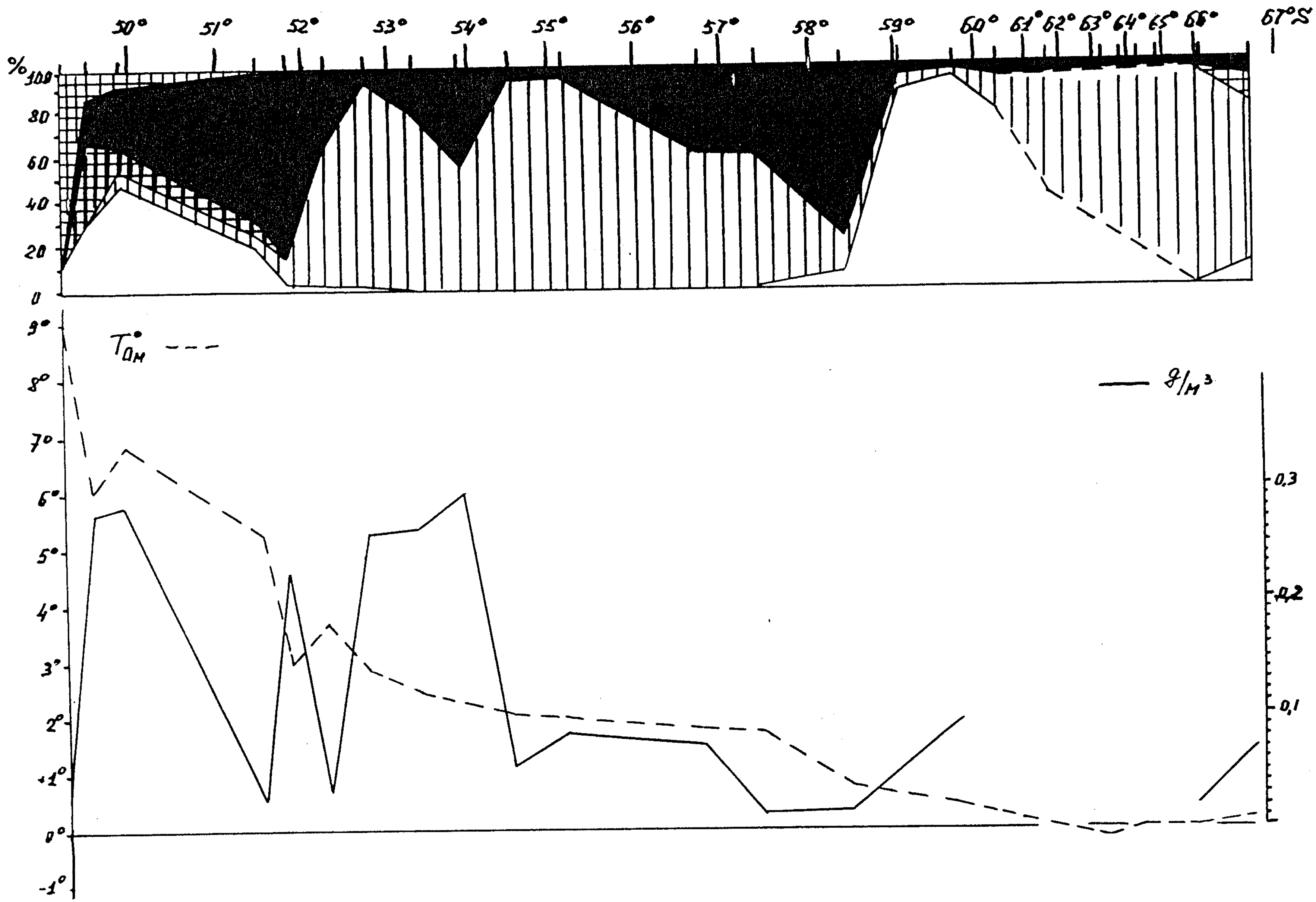

Figure 3: Variations of species composition of phytocenosises (%, key see in Figure 1), biomass (g/m³), surface temperature on tack II (10-14.3.88).

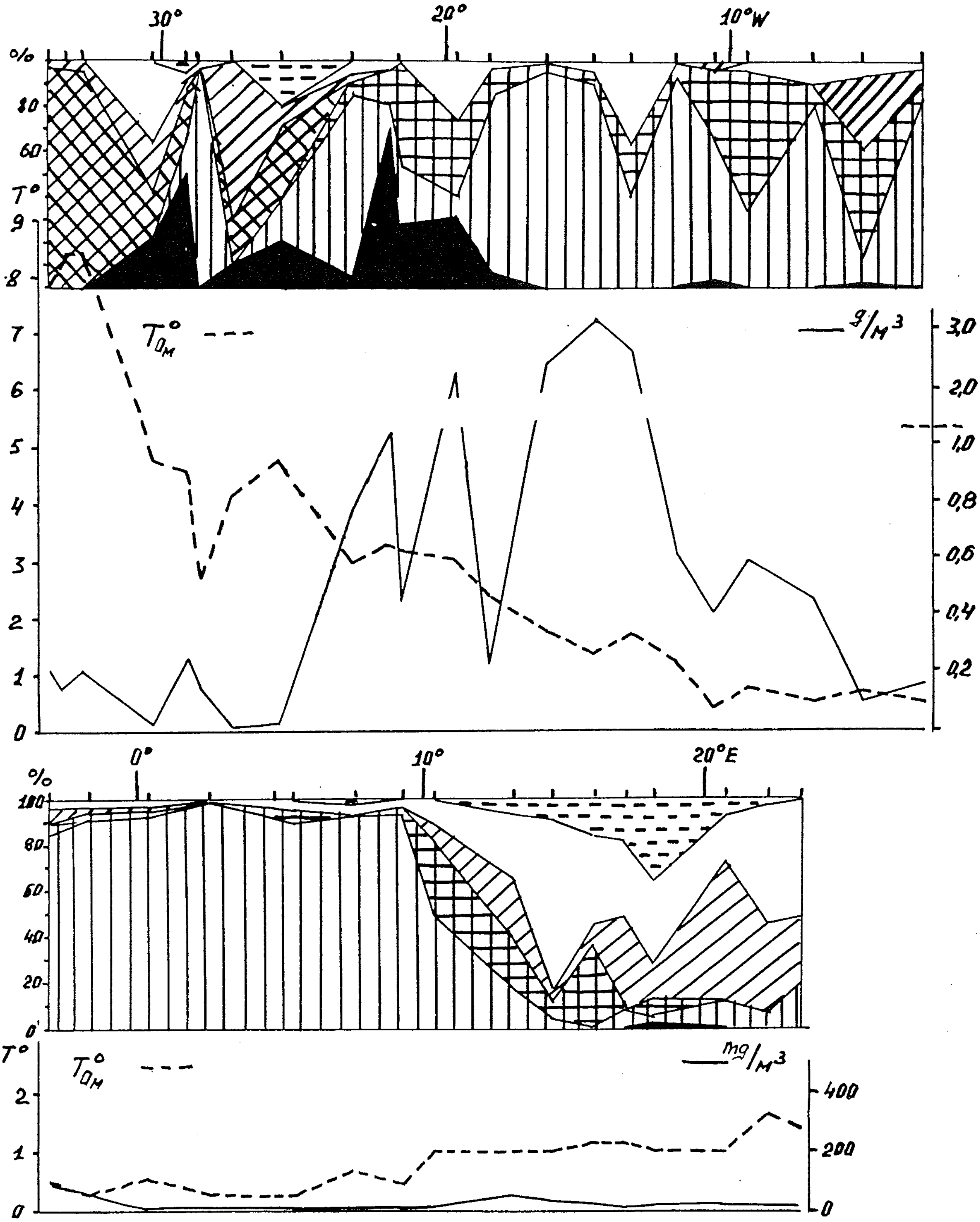

Figure 4: Variations of species composition of phytocenosises (%, key see in Figure 1), biomass (g/m³), surface temperature on tack III (26.3-2.4.88).

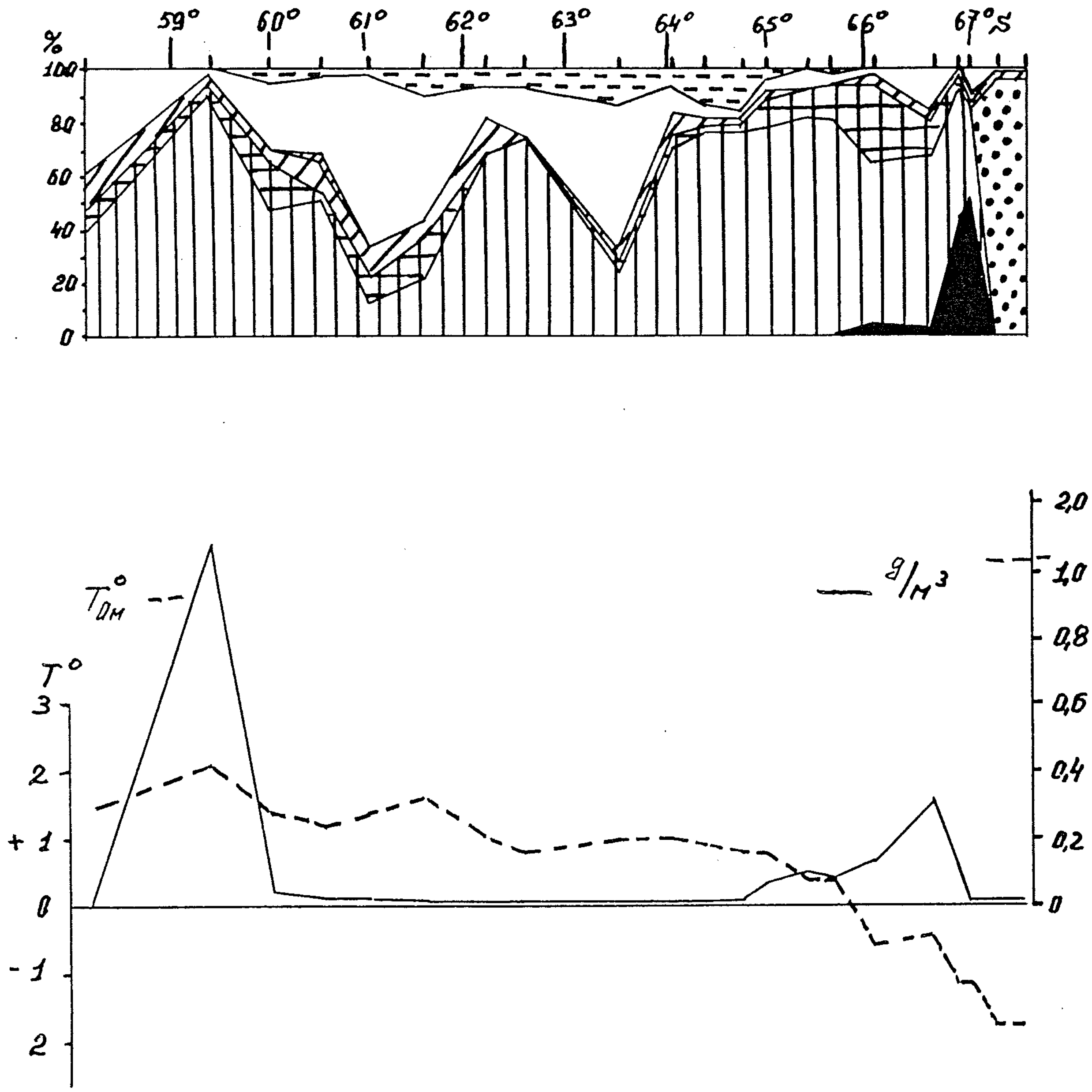

Figure 5: Variations of species composition of phytocenosises (%, key see in Figure 1), biomass (g/m³), surface temperature on tack IV (2-6.4.88).

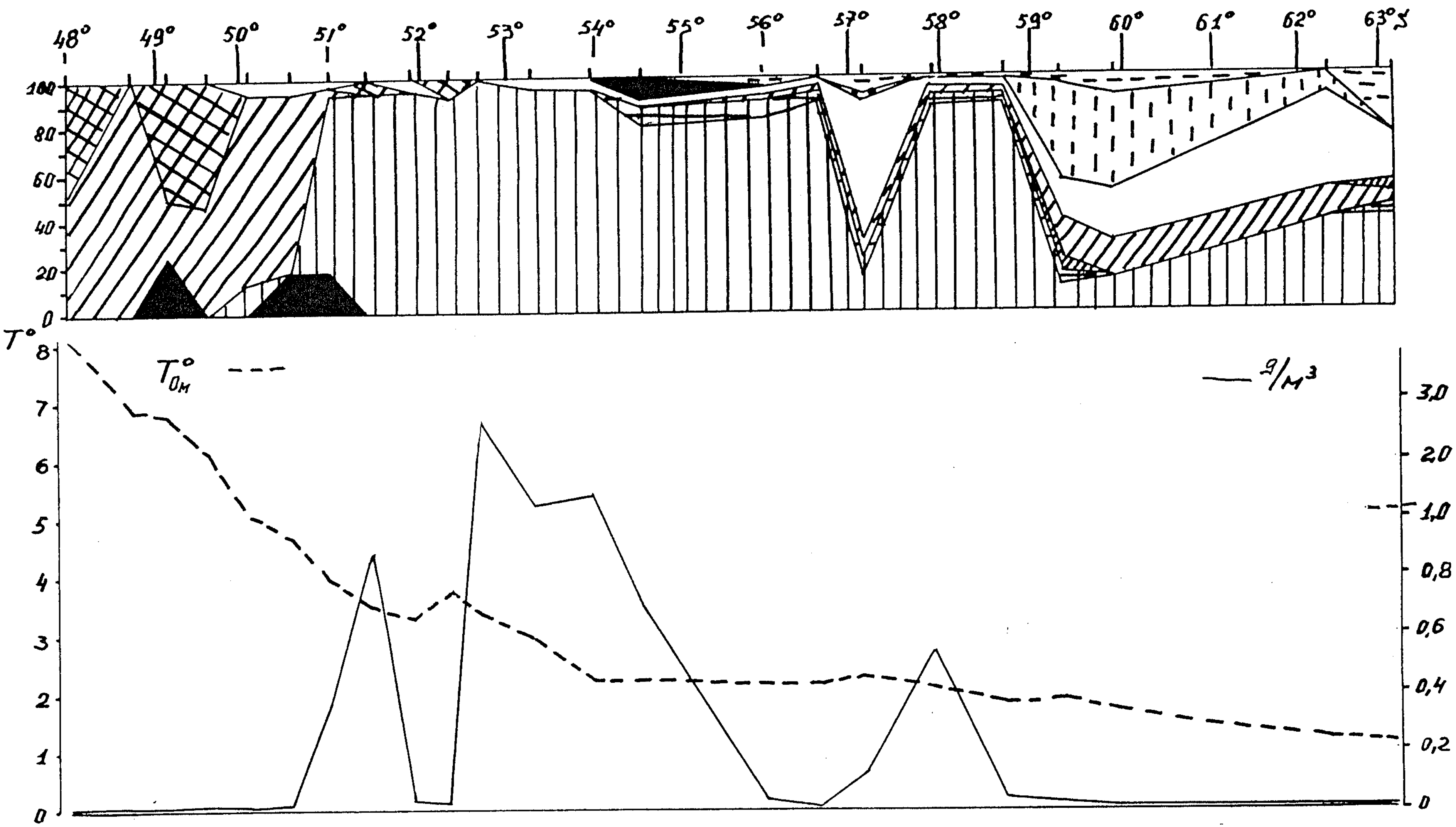

Figure 6: Variations of species composition of phytocenosises (%, key see in Figure 1), biomass (g/m³), surface temperature on tack V (7-10.4.88).

Légendes des figures

Figure 1 — Répartition des phytocénoses de plancton de surface sur les bordées du navire de recherche *Professor Vize* (février-avril 1988). Le nombre de bordées et les dates sont indiqués.

Figure 2 — Variations de composition des espèces de phytocénoses (%, voir clé sur la Figure 1), biomasse (g/m^3), température de surface sur la bordée I (1-8.2.88).

Figure 3 — Variations de composition des espèces de phytocénoses (%, voir clé sur Figure 1), biomasse (g/m^3), température de surface sur la bordée II (10-14.3.88).

Figure 4 — Variations de composition des espèces de phytocénoses (%, voir clé sur Figure 1), biomasse (g/m^3), température de surface sur la bordée III (26.3-2.4.88).

Figure 5 — Variations de composition des espèces de phytocénoses (%, voir clé sur Figure 1), biomasse (g/m^3), température de surface sur la bordée IV (2-6.4.88).

Figure 6 — Variations de composition des espèces de phytocénoses (%, voir clé sur Figure 1), biomasse (g/m^3), température de surface sur la bordée V (7-10.4.88).

Подписи к рисункам

Рисунок 1 — Распределение фитоценозов поверхностного слоя планктона по галсам НИС "Профессор Визе" (февраль- апрель 1988 г.) Указано количество галсов и даты.

Рисунок 2 — Изменения видового состава фитоценозов (%, см. обозначение на Рисунке 1), биомассы (г/м^3), поверхностной температуры по галсу I (1 - 8.2.88 г.).

Рисунок 3 — Изменения видового состава фотоценозов (%, см. обозначение на Рисунке 1), биомассы (г/м^3), поверхностной температуры по галсу II (10 - 14.3.88 г.).

Рисунок 4 — Изменения видового состава фототенозов (%, см. обозначение на Рисунке 1), биомассы (г/м^3), поверхностной температуры по галсу III (26.3 - 2.4.88 г.).

Рисунок 5 — Изменения видового состава фотоценозов (%, см. обозначение на Рисунке 1), биомассы (г/м^3), поверхностной температуры по галсу IV (2-6.4.88 г.).

Рисунок 6 — Изменения видового состава фотоценозов (%, см. обозначение на Рисунке 1), биомассы (г/м^3), поверхностной температуры по галсу V (7-10. 4.88 г.).

Leyendas de las Figuras

Figura 1 — Distribución de fitocenosos del plancton de superficie en las bordadas del B/I *Professor Vize* (febrero - abril de 1988). El número de bordadas y datos están indicados.

Figura 2 — Variaciones de la composición de las especies de fitocenosis (%, clave véase en Figura I), biomasa (g/m^3), temperatura de superficie en la bordada I (I-8.2.88).

Figura 3 — Variaciones de la composición de las especies de fitocenosis (%, clave véase en Figura I), biomasa (g/m^3), temperatura de la superficie en la bordada II (10-14.3.88).

Figura 4 — Variaciones de la composición de las especies de fitocenosis (%, clave véase en Figura I), biomasa (g/m^3), temperatura de la superficie en la bordada III (26.3-2.4.88).

Figura 5 — Variaciones de la composición de las especies de fitocenosis (%, clave véase en Figura I), biomasa (g/m^3), temperatura de la superficie en la bordada IV (2-6.4.88).

Figura 6 — Variaciones de la composición de las especies de fitocenosis (%, clave véase en Figura I), biomasa (g/m^3), temperatura de superficie en la bordada V (7-10.4.88).

PRELIMINARY RESULTS OF RESEARCH ACTIVITIES OF RV *EVRIKA* IN THE SCOTIA SEA IN JANUARY-MARCH 1988

L.I. Maklygin , A.S. Fedorov, V.N. Shnar, Yu.A. Shulyakovsky, I.V. Krasovsky, Yu.D. Shuvaev, A.V. Kromsky

Abstract

In 1987/88 a multi-disciplinary survey was conducted of the Scotia Sea and adjacent waters, accompanied by regular trawlings with an Isaac-Kidd trawl. The waters off South Georgia in particular were surveyed twice. Research activities are part of the program implemented in areas of the Atlantic Sector of the Southern Ocean identified for monitoring by CCAMLR. During the observation season the zonal drift of waters of the Antarctic Circumpolar Current and Second Frontal Zone became stronger, causing the krill to drift eastwards. Krill concentrations were observed in the waters to the southeast of South Georgia where relatively small crustaceans of less than 35 mm dominated. In the east Scotia Sea a higher abundance of primary production was registered. The analysis of data on phytoplankton, zooplankton and krill (biological parameters) is now under way.

Résumé

En 1987/88 une étude multidisciplinaire dans la mer de Scotia et des eaux voisines ainsi que des opérations régulières de chalutage, à l'aide d'un chalut de type Isaacs-Kidd, furent effectuées. Les eaux au large de la Géorgie du Sud en particulier furent prospectées à deux reprises. Les activités de recherche font partie du programme poursuivi dans les zones désignées pour la surveillance par la CCAMLR du secteur atlantique de l'océan Austral. Pendant la saison d'observation, la dérive zonale des eaux du courant circumpolaire antarctique et de la seconde zone frontale s'amplifia, provoquant la dérive du krill vers l'est. Des concentrations de krill furent observées au sud-est de la Géorgie du Sud. Des crustacés relativement petits, d'une taille inférieure à 35 mm, y prédominaient. Dans la partie est de la mer de Scotia, une abondance plus élevée de production primaire fut observée. L'analyse des données sur le phytoplancton, le zooplancton et le krill (paramètres biologiques) est maintenant en cours.

Резюме

В 1987/88 г. В море Скотия и прилегающих водах проводилась многоотраслевая съемка,сопровождавшаяся регулярными тралениями с помощью трала Айзакса-Кидда. Съемка в этой акватории, в частности в водах вокруг Южной Гергии, проводилась дважды. Эта научно-исследовательская деятельность является частью программы работ, проводимой в атлантическом секторе Южного океана на выделенных АНТКОМом участках

мониторинга. За период проведения наблюдений зональное перемещение вод Антарктического циркумполярного течения и второй фронтальной зоны усилилось, что вызвало перемещение криля к востоку. Концентрации криля наблюдались в водах к юго-востоку от Южной Георгии. Здесь доминировали относительно небольшие рачки размером до 35 мм. В восточной части моря Скотия был отмечен повышенный уровень первичной продукции. Анализ данных по фитопланктону, зоопланктону и крилю (биологические параметры) продолжается.

Resumen

En 1987/88 se realizó una prospección multidisciplinaria del mar de Scotia y aguas adyacentes, acompañada de arrastres periódicos con el arrastre Isaacs-Kidd. En particular se prospeccionaron dos veces las aguas a la altura de Georgia del Sur. Las actividades de investigación forman parte del programa que se está realizando en aquellas zonas que fueron identificadas para seguimiento por la CCAMLR, en el sector atlántico del océano Austral. Durante la temporada de observación, la deriva zonal de las aguas de la Corriente Circumpolar Antártica y de la Segunda Zona Frontal se hizo más fuerte causando un desplazamiento del krill hacia el este. Se observaron concentraciones de krill en aguas al sureste de Georgia del Sur. Allí predominaban crustáceos relativamente pequeños de un tamaño menor de 35 mm. Al este del mar de Scotia se registró una mayor abundancia de la producción primaria. Actualmente se está realizando el análisis de datos sobre fitoplancton, zooplancton y krill (parámetros biológicos).

During the survey the location of the Second Frontal Zone was similar to long-term averages. On the whole, surface water dynamics in the Scotia Sea contributed to the drift of krill to South Georgia and the formation of its stable concentrations (see Figure 3). Waters from the Weddell Sea penetrated the eastern part of the area from the east and were characterized by surface temperatures ranging from 1.0°C to 1.4°C, the minimum temperature being -1.2° and -1.4°C. The temperature of the warm deepwater "core" dropped to 0.8°-1.2°C and high silicon content at the surface (40-50 μ g at/1) were characteristic for these waters. Many icebergs were sighted in the area.

Closed water circulation was found around the archipelago off the South Orkney Islands. To the north of the archipelago the dynamic relief was rather smoothed, hence there were no required conditions for the formation of abundant krill concentrations. At the same time circulation patterns were registered off Elephant Island, which facilitated krill concentration.

The highest concentrations of chlorophyll-a (112 mg/m^2) were recorded in the waters off South Georgia which corresponded with the high dynamic activity of waters in the area during the observation period. Feeding so-called "green krill" was in catches. Low chlorophyll-a concentrations were recorded in the south-east Scotia Sea (see Figure 4).

In most of the surveyed area, primary production in the photosynthetic layer made 0.1-0.2 $gC/m^2/day$ (see Figure 5). Photosynthesis intensity fluctuated. The waters north of South Georgia, in the east Scotia Sea and off Elephant Island were characterized by high assimilation values. In the photic layer, bacterioplankton production fluctuated between 1.4 g $C/m^2/day$, and it ranged from a fraction of a percent to several percent of the primary production being in a reverse proportion to photosynthesis production values.

As compared with previous seasons, specific features were typical for spatial and qualitative distribution of krill. High krill concentrations were found off South Georgia and south of the island towards the Second Frontal Zone (see Figure 6). Small crustaceans of 29-35 mm prevailed in catches (see Figure 7).

In February, off South Orkney Islands, concentrations occurred only in the small area south of Coronation Island. When the western drift of the Atlantic Circumpolar Current became weaker in March, more abundant concentrations were sighted to the north-west of Coronation Island over the area of 560 m^2 northwestward in the so-called "shadow" area (as related to the main direction of water movement) (see Figure 8a).

In April rather dense concentrations formed off the South Georgia (see Figure 9). Mature crustaceans distributed over the eastern part of the surveyed area in the Scotia Sea, were in prespawning and spawning condition. Spawning krill concentrations were dominant in the waters north of the Second Frontal Zone. Near islands, they were found in the areas over high sea depths outside shelf zones.

In the Weddell Sea the spawning came to an end by the time of the survey.

In May the proportion of post-spawning crustaceans increased near the Elephant and Coronation Islands indicating the end of krill spawning in those areas. Due to the stronger Antarctic Circumpolar Current drift westward to the Scotia Sea in 1988, most krill concentrations apparently to extended eastward of 30°W, outside the area surveyed.

The analysis of samples, mass collections of phyto- and zooplankton, euphausiid larvae and, in particular, krill biological samples, in particular, are under way. Their results will be available later.

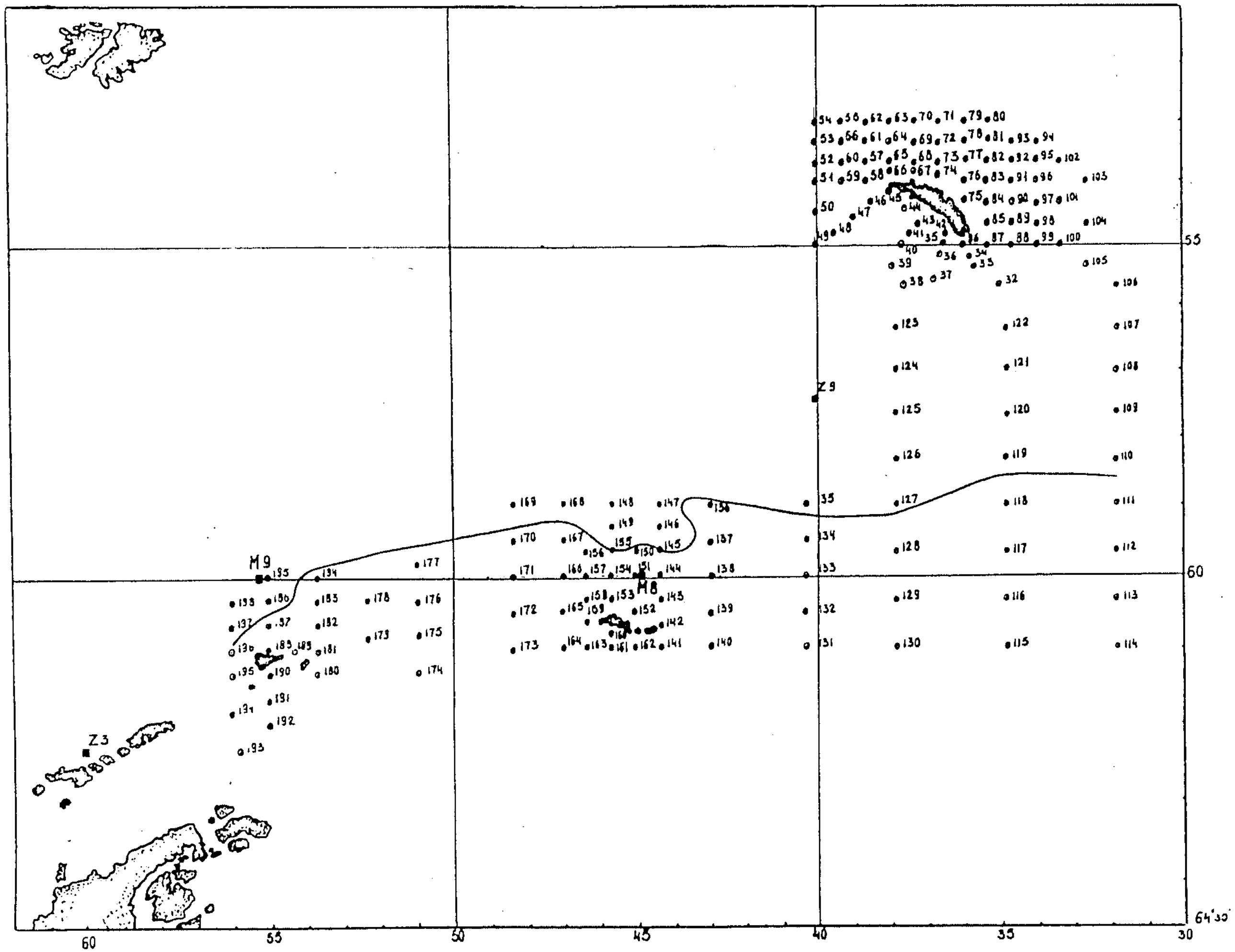

Figure 1: Network of survey stations (20 January-9 March 1988).
Key: —Second Frontal Zone
M8, M9, Z3, Z9 - control points for estimation of meridional and zonal air drift.

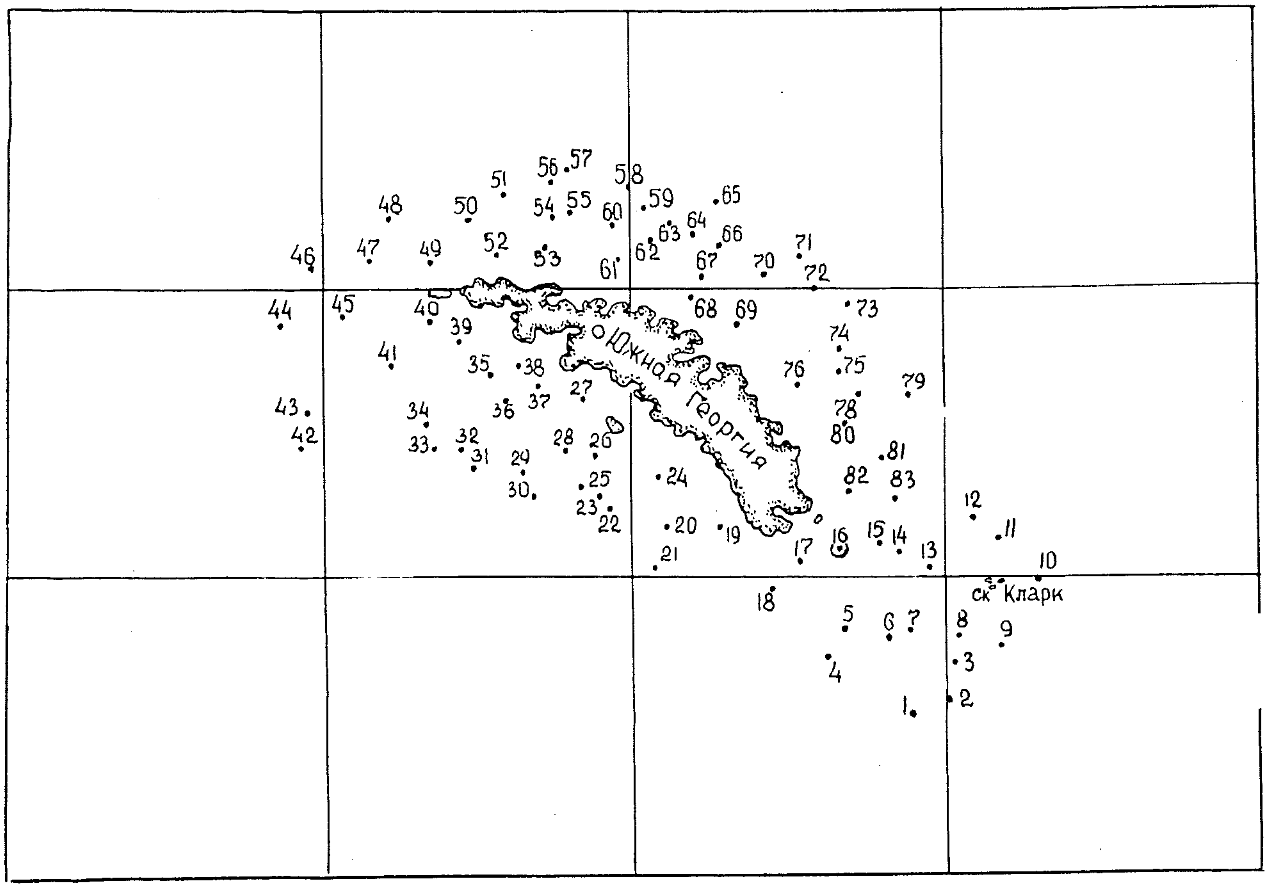

Figure 2: Network of survey stations (30 March-9 April 1988) off South Georgia.

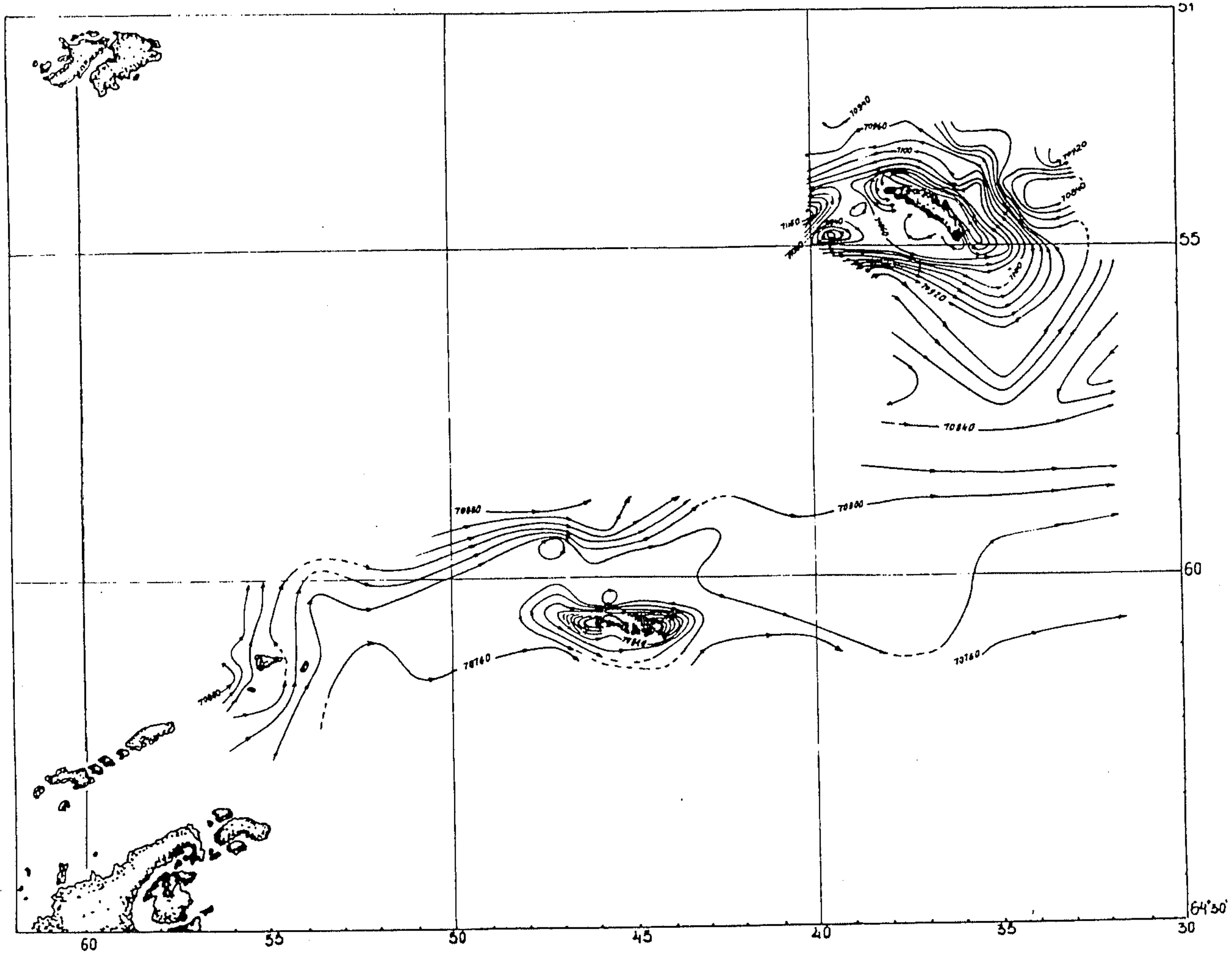

Figure 3: Geostrophic circulation on the surface in relation to 1 000 decibar (20 January-9 March 1988).

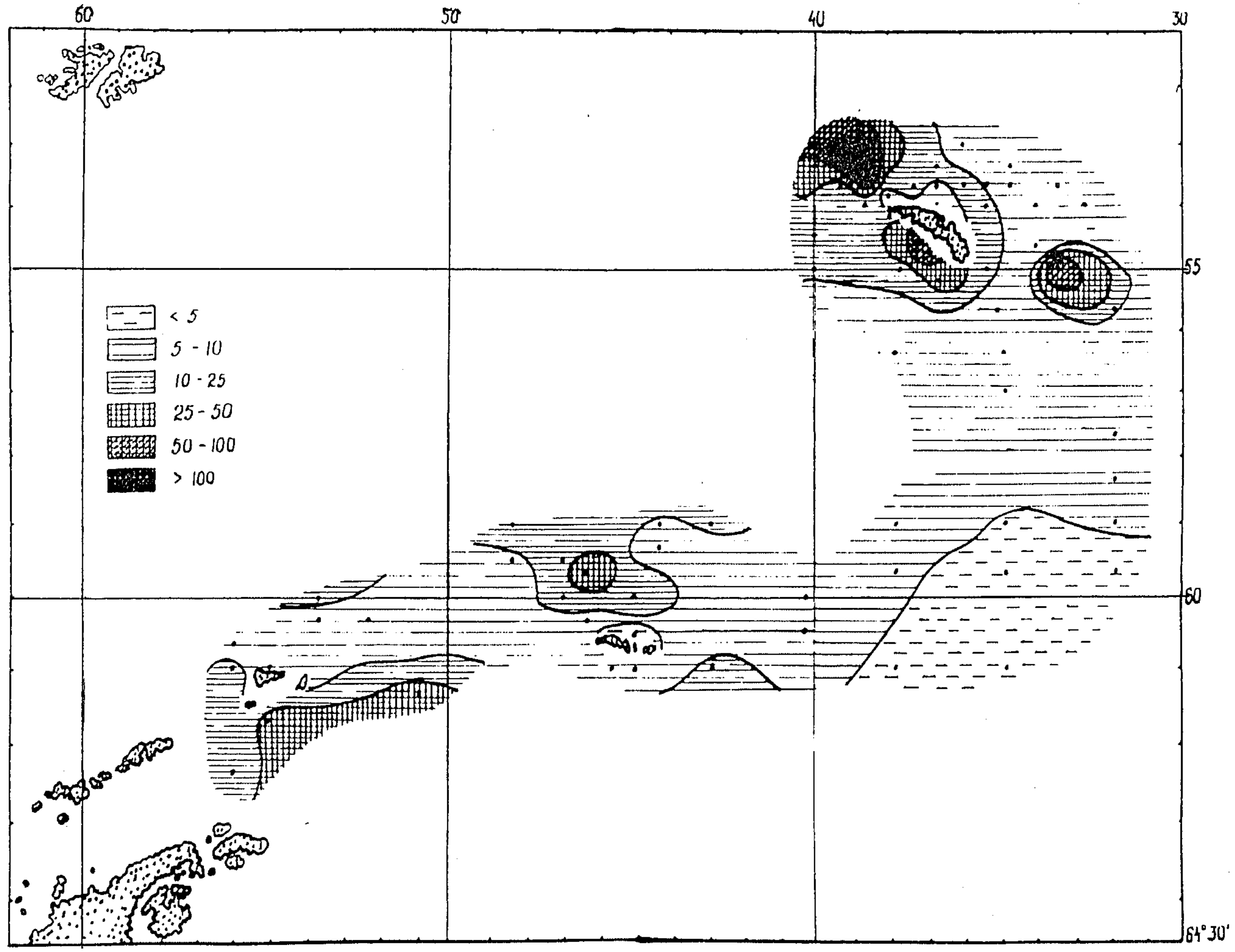

Figure 4: Distribution of chlorophyll-a (mg/m²) in the photic layer.

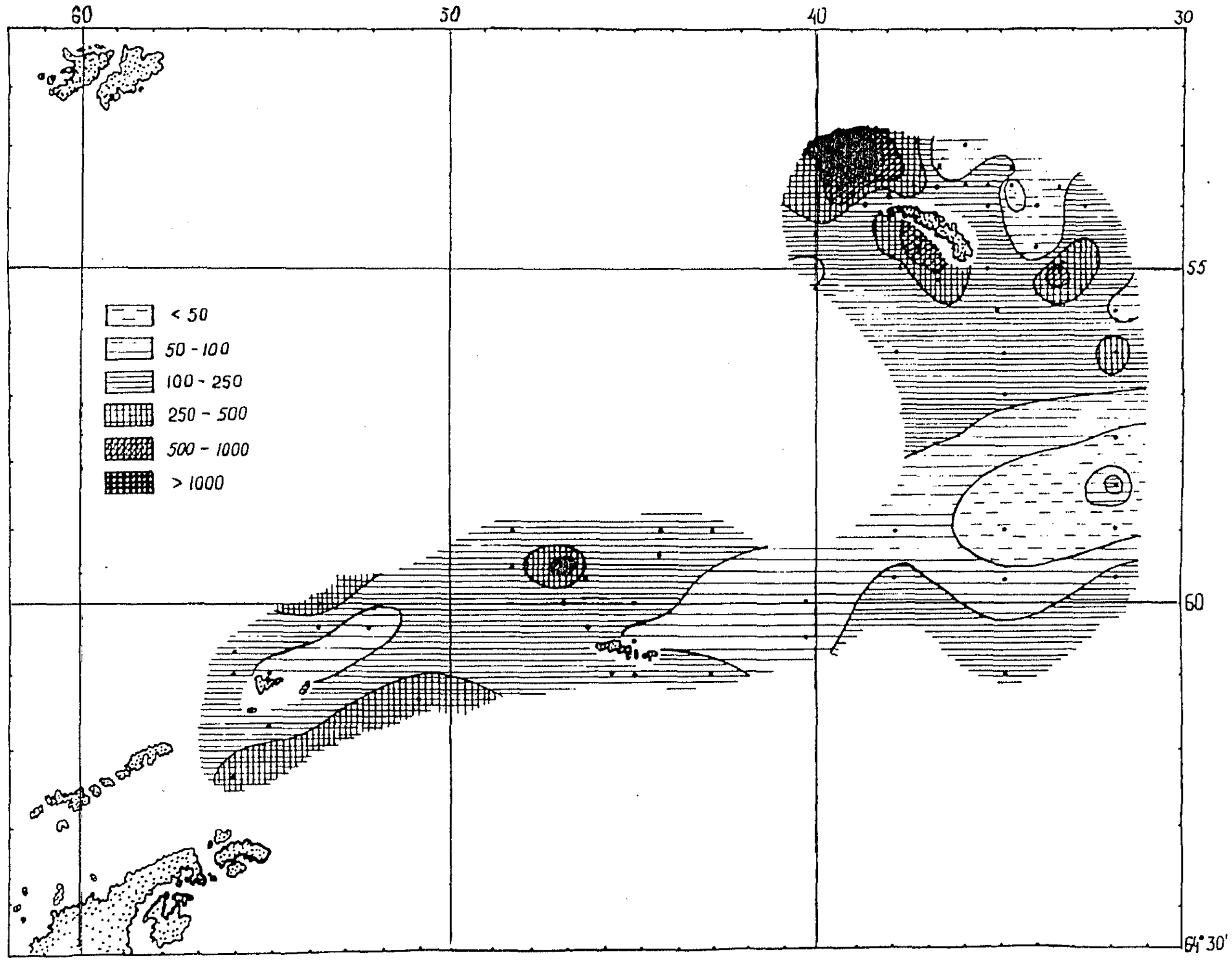

Figure 5: Distribution of primary production (mg C/m^{-2}/d^{-1}) in the photosynthetic layer.

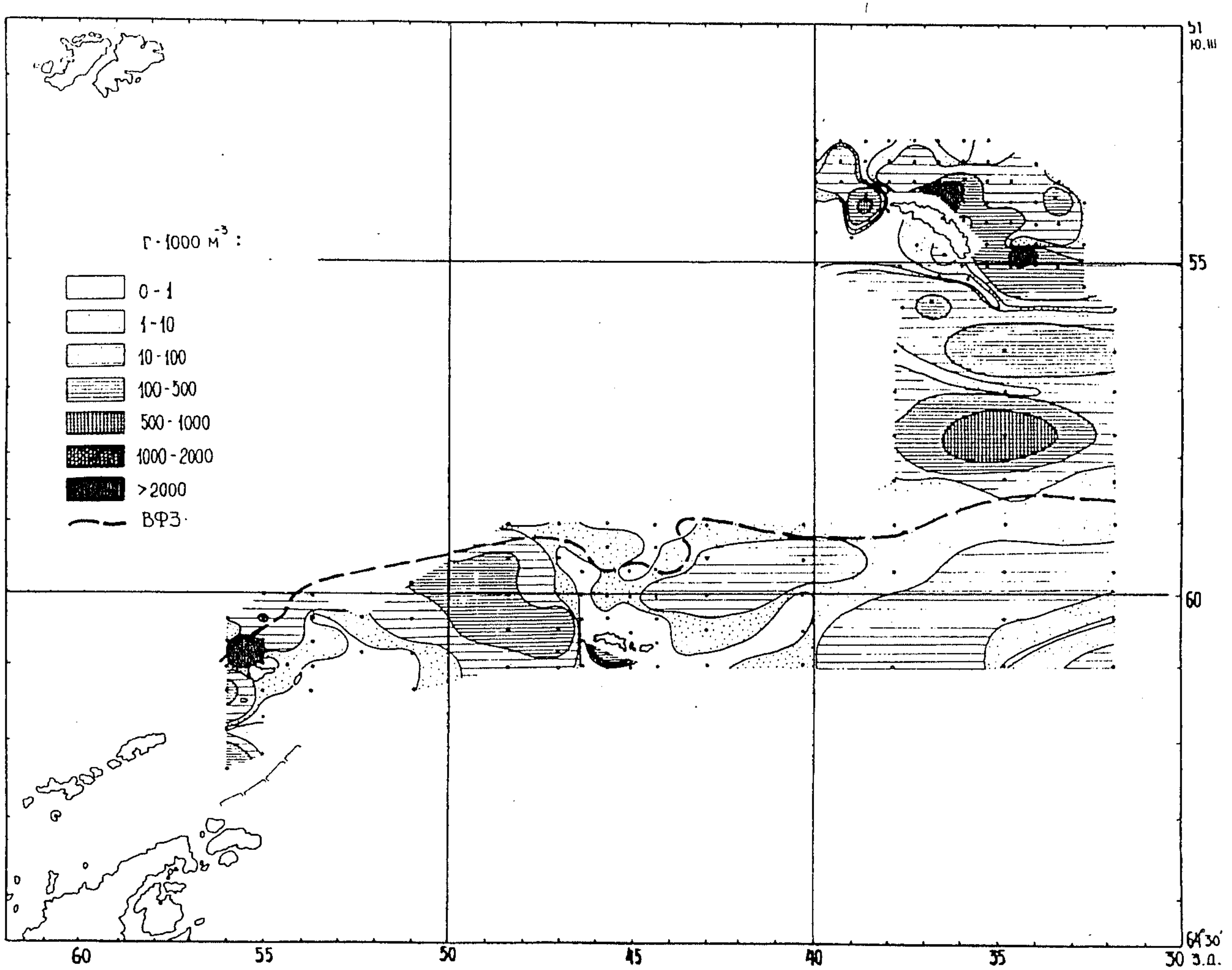

Figure 6: Distribution of *Euphausia superba* (g/1 000 m^{-3}) in the layer of 0-100 m (20 January-9 March 1988).

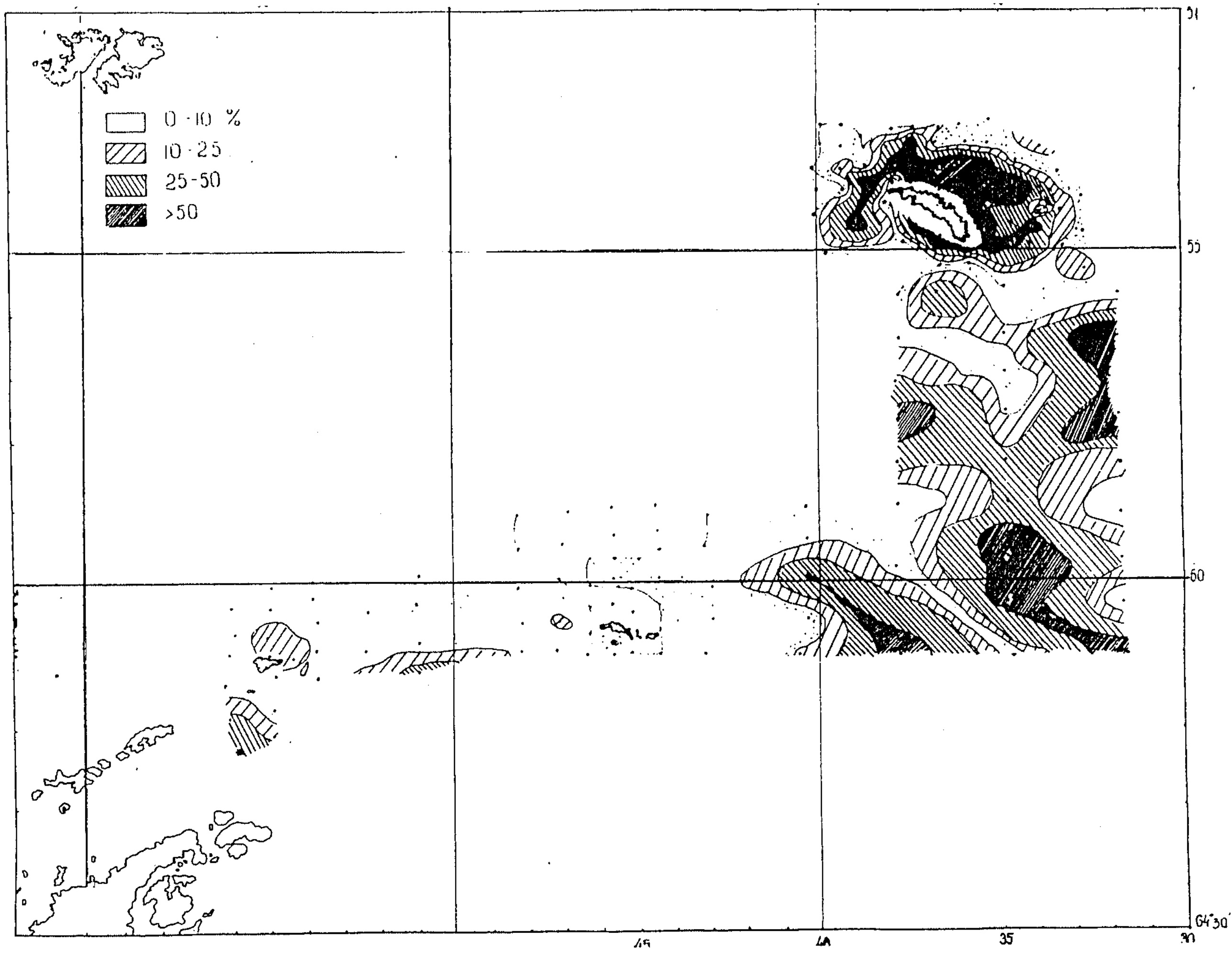

Figure 7: Distribution of crustaceans of 29-36 mm long presented as percentage to the catch size (survey data).

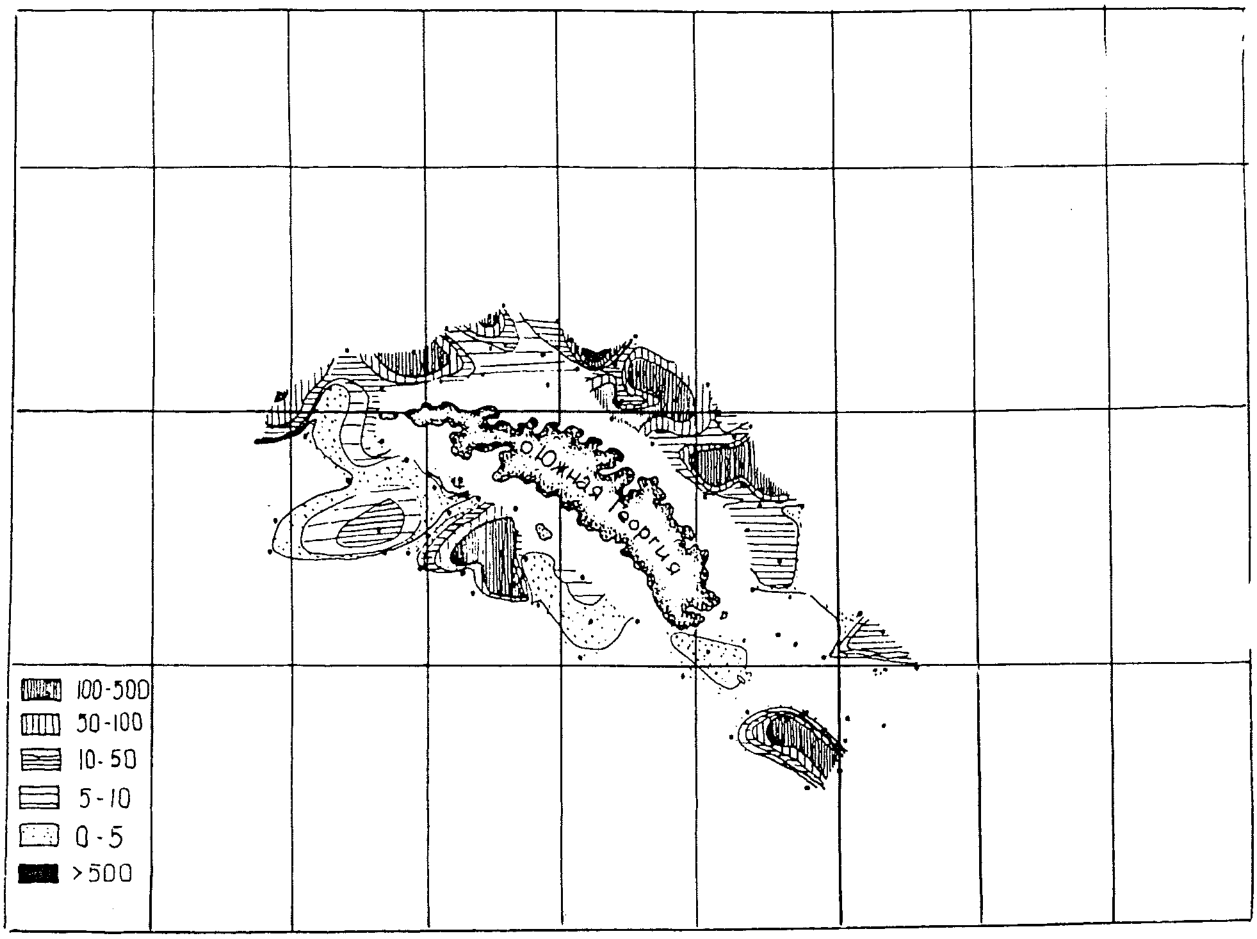

Figure 8: Krill concentrations off South Shetland Islands (a) and South Orkney Islands (b) - March 1988.

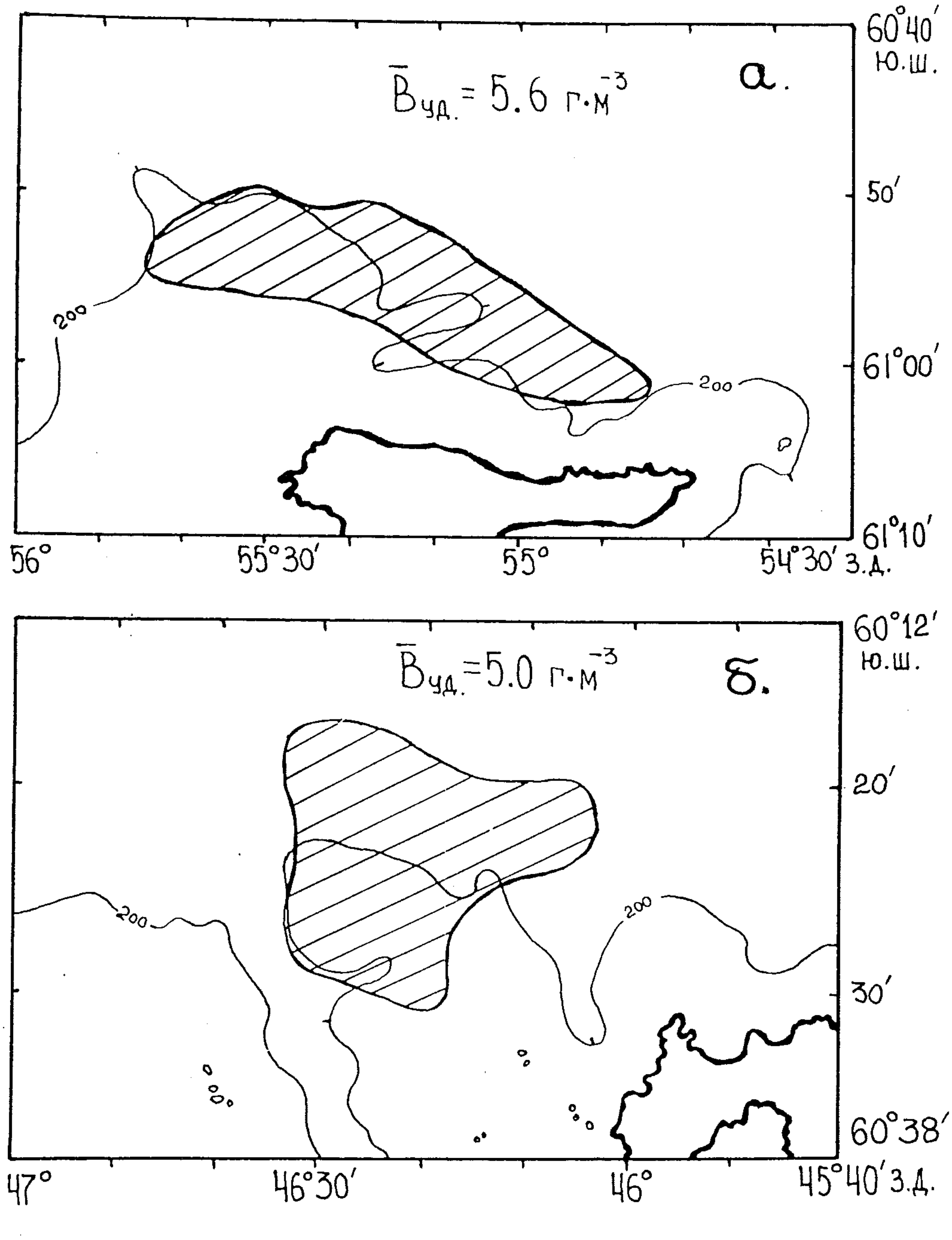

Figure 9: Distribution of *Euphausia superba* off South Georgia (g/m [2]) from 30 March to 9 April 1988.

Légendes des figures

Figure 1 Réseau des stations de recherche (20 janvier - 9 mars 1988)
Clé: - Seconde zone frontale;
M8, M9, Z3, Z9 - points de contrôle pour l'estimation du courant aérien méridional et zonal.

Figure 2 Réseau des stations de recherche (30 mars - 9 avril 1988) au large de la Géorgie du Sud.

Figure 3 Circulation géostrophique en surface sur une base de 1 000 décibar (20 janvier - 9 mars 1988).

Figure 4 Répartition de chlorophylle A (mg/m^2) dans la couche photique.

Figure 5 Répartition de production primaire (mg C/m^2/jour) dans la couche photosynthétique.

Figure 6 Répartition d'*Euphausia superba* (g/1000 m^{-3}) dans la couche de 0-100 m (20 janvier - 9 mars 1988)

Figure 7 Répartition des crustacés de 29-36 mm de long en pourcentage de la pêche (données d'étude).

Figure 8 Concentrations de krill au large des îles Shetland du Sud (a) et des îles Orcades du Sud (b) - mars 1988.

Figure 9 Répartition d'*Euphausia superba* au large de la Géorgie du Sud (g/m^2) du 30 mars au 9 avril 1988.

Подписи к рисункам

Рисунок 1 Сеть океанографических станций по сбору проб (20 января - 9марта 1988 г.)
Обозначение: - Вторая фронтальная зона;
M8, M9, Z3, Z9 - Контрольные точки для оценки меридионального и зонального перемещения воздуха.

Рисунок 2 Сеть океанографических станций по сбору проб (30 марта - 9апреля 1988 г.) около Южной Георгии.

Рисунок 3 Геострофическая циркуляция на поверхности по отношению к 1000 децибар (20 января - 9 марта 1988 г.)

Рисунок 4 Распределение хлорофилла А ($мг/м^2$) в фотическом слое.

Рисунок 5 Распределение первичной продукции (мг $С/м^2$/сутки) в фотосинтетическом слое.

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Figura 1 Red de estaciones de prospección (20 de enero - 9 de marzo de 1988)
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AUSTRALIAN RESEARCH ON ANTARCTIC BIRD AND SEAL DIETS

R. Williams

Abstract

Many data on the diets of important vertebrate predator species in Prydz Bay and around the sub-Antarctic Heard and Macquarie Islands have been collected during the last seven years. Published and unpublished results are collated and summarised, and several important points emerge.

In Prydz Bay, on which is centered the CCAMLR Ecosystem Monitoring Programme's priority study area, *Euphausia superba* forms a rather low proportion of the diet of most vertebrate predators. *Euphausia crystallorophias* and the fish *Pleuragramma antarcticum* are important in most diets, and many predators can switch between prey species. The use of these predators to monitor the state of prey populations is thus very limited, although continuing studies will be useful to assess the natural variability of the system.

Around the sub-Antarctic islands, the four penguin species feed more heavily on fish, especially myctophids, than at other comparable localities.

Résumé

Au cours des sept dernières années, ont été recueillies de nombreuses données relatives aux régimes alimentaires d'importantes espèces de vertébrés prédateurs dans la baie de Prydz et autour des îles subantarctiques Heard et Macquarie. Plusieurs considérations émergent après la confrontation et la récapitulation de résultats publiés et non publiés.

Dans la baie de Prydz, centre de la zone d'étude prioritaire du Programme de contrôle de l'écosystème de la CCAMLR, *Euphausia superba* entre en relativement faible proportions dans le régime alimentaire de la plupart des prédateurs vertébrés. *Euphausia crystallorophias* et le poisson *Pleuragramma antarcticum* sont importants dans la plupart des régimes alimentaires, et de nombreux prédateurs peuvent passer d'une espèce-proie à une autre. L'utilisation de ces prédateurs pour contrôler l'état des populations-proies est donc très limitée, bien qu'il soit utile de poursuivre ces études pour évaluer la variabilité naturelle du système.

Autour des îles subantarctiques, les quatre espèces de manchots se nourissent davantage de poissons - de myctophidés principalement - que dans d'autres lieux comparables.

Резюме

За последние семь лет было собрано большое количество информации о режиме питания ключевых видов позвоночных хищников, обитающих в районах залива Прюдз и субантарктических островов Херд и Маккуори. Опубликованные и неопубликованные данные сведены воедино, в результате чего возникает ряд важных вопросов.

В заливе Прюдс, который является центром района исследований первостепенной важности Программы АНТКОМа по мониторингу экосистемы, в рационе большинства позвоночных хищников *Euphausia superba* составляет довольно небольшую часть В большинстве случаев в рационе большое место занимает. *Euphausia cristallorophias* и рыбы *Pleuragramma antarcticum*, и многие хищники могут переключаться с одного потребляемого вида на другой. поэтому исползование этих хищников при мониторинге состояния популяций потребляемых видов весьма ограничено, однако продолжение исследовательских работ явится полезным при оценке естественной изменчивости системы.

В рацион четырех видов пингвинов в районе субантарктических островов входит гораздо больше рыбы, особенно миктофидов, чем в других похожих районах.

Resumen

Durante los últimos siete años se han reunido muchos datos sobre las dietas de importantes especies predadoras vertebradas en la bahía de Prydz y alrededor de las islas subantárticas de Heard y Macquarie. Se compilan y resumen los resultados publicados y no publicados, de los cuales surgen varios puntos importantes.

En la bahía de Prydz, lugar donde se centra la zona de estudio prioritaria del Programa de Seguimiento de la CCRVMA, la especie *Euphausia superba* constituye una proporción bastante baja de la dieta de la mayoría de predadores vertebrados. *Euphausia crystallorophias* y el pez *Pleuragramma antarcticum*, son importantes en la mayoría de dietas, y muchos predadores pueden pasar de una especie-presa a otra. El uso de estos predadores en el control del estado de las poblaciones de especies-presa es, por lo tanto, muy limitado, si bien, continuar con dichos estudios será muy útil para la evaluación de la variabilidad del sistema.

Alrededor de las islas subantárticas, las cuatro especies de pingüinos de alimentan mayoritariamente de peces, especialmente mictófidos, mucho más que en otras localidades comparables.

1. INTRODUCTION

Australia has been conducting research on the diets of Antarctic birds and seals since 1982. This was initially in response to the need identified by the BIOMASS Programme for data on the diets of vertebrate predators of krill (*Euphausia superba*). Latterly, the requirements of the CCAMLR Environmental Monitoring Programme (CEMP) have been a stimulus to continue and expand the work. This paper summarises the results obtained to date, and lists the papers already published or in preparation.

Most work has been done at Davis Station (68°30'S:77°50'E), in the south-eastern corner of the Prydz Bay Priority Area of CEMP, although more recently, considerable work has been done at sub-Antarctic Heard and Macquarie Islands as well as other locations in Prydz Bay. Most work has concentrated on the Adelie penguin, *Pygoscelis adeliae*, because of its supposed value to ecosytem monitoring and its accessiblity and ease of handling. Seven seasons of data are now available for this species. Other major, although shorter term studies, have been conducted on the Weddell seal (*Leptonychotes weddelli*) and Emperor penguin (*Aptenodytes forsteri*), in Prydz Bay; the four penguins at Macquarie and Heard Islands (Gentoo, *Pygoscelis papua*, King, *Aptenodytes patagonicus*, and Rockhopper, *Eudyptes chrysocome* plus Royal, *Eudyptes schlegeli* at Macquarie Island and Macaroni, *E. chrysolophus* at Heard Island). A few data are available also on the diets of Crabeater seals (*Lobodon carcinophagus*) and Leopard seals (*Hydrurga leptonyx*) and various petrel species in Prydz Bay.

Work in the 1987/88 season has concentrated on Adelie and Emperor penguins at Mawson, and on Antarctic Fur seals (*Arctocephalus gazella*) at Heard Island, but results are not yet available from these studies.

2. SUMMARY OF FINDINGS

2.1 Adelie Penguin

Location: Davis Station (68°30'S: 77°50'E)
Time: December 1981 to January 1982
Source of material: Six samples obtained from each of two sampling periods using Ipecac (emetic)
Reference: Whitehead, Johnstone and Burton (in preparation)
Mean weight of all food: 450g (post-hatching period only)

Diet composition (% by weight):

Euphausia crystallorophias	44
Euphausia superba	24
Fish	28
Amphipods	4

Location: Davis Station (68°30'S: 77°50'E)
Time: December 1982 to February 1983 and October to December 1983
Source of material: 574 stomach samples obtained by single water offloading
Reference: Puddicombe and Johnstone (1988)
Mean weight of all food: Pre-hatching 2-20g, post hatching 90-100g, creche stage 110-215g

Diet composition (% by weight):

	Overall	Prehatch	Posthatch
E. crystallorophias	41.99	46.02	41.69
E. superba	23.21	5.49	24.51
Fish	30.32	3.29	32.32
Amphipods	3.73	39.43	1.09
Others	0.75	5.76	0.38

Fish were mostly *Pleuragramma antarcticum* (frequency of occurrence, F = 36.2%), *Trematomus/Pagothenia* benthic species (F = 20.7%), and channichthiid juveniles (F = 17.1%). Amphipods were mostly *Hyperia macrocephala*, *Cyllopus magellanicus*, other Lysianassidae and Eusiridae.

Prey size (length range, mean ±SD millimetres):

E. superba	20-57	40.63±7.85
E. crystallorophias	21-34	27.36±1.83

Location: Davis Station (68°30'S: 77°50'E)
Time: January to February 1984; October 1984 to January 1985
Source of material: 10 stomach samples per week obtained by single water offloading
Reference: Green and Johnstone (1988)
Mean weight of all food: Prehatch 4-53g, posthatch (1984) 138-276g, posthatch (1985) 94-135g

Diet composition (% by weight):

	Overall	Prehatch	Posthatch (1984)	Posthatch (1985)
E. crystallorophias	12.10	6.20	18.00	13.30
E. superba	42.60	5.20	76.90	66.30
Fish	4.15	3.60	4.70	20.00
Amphipods	29.15	58.20	0.10	0.50
Others	13.60	26.80	0.30	0.00

Fish were mostly *Pleuragramma antarcticum* (F = 97.2%) and benthic inshore species (F = 8.3%).

Prey size (mean ±SD millimetres):

	Prehatch	Posthatch (1984)	Posthatch (1985)
E. superba	40.7±4.7	40.1±4.3	36.6±4.6
E. crystallorophias		28.3±1.8	26.3±2.1
P. antarcticum		139.1±16.5	

Location: Davis Station (68°30'S: 77°50'E)
Time: January to February 1986; October 1986 to March 1987; October 1987 to February 1988
Source of material: 10 stomach samples per week obtained by repeated water offloading until empty. 10 samples per 3 weeks in 1987/88 summer. These results present a preliminary analysis of between 25 and 50% of samples.
Reference: Whitehead, Johnstone and Burton (in preparation)

Mean weight of all food (g):

	Posthatch (1985/86)	Prehatch (1986/87)	Posthatch (1986/87)	Prehatch (1987/88)	Posthatch (1987/88)
	200	20	400	25	450

Diet composition (% by weight):

	Posthatch (1985/86)	Prehatch (1986/87)	Posthatch (1986/87)	Prehatch (1987/88)	Posthatch (1987/88)
E. crystallorophias	25	38	39	52	55
E. superba	5	3	29	4	0
Fish	24	1	32	3	25
Amphipods	46	58	0	41	0

2.2 Emperor Penguin

Location: Sea ice off Davis Station (68°30'S: 77°50'E)
Time: August to October 1984
Source of material: Faeces collected monthly from sea ice - 51 in August, 61 in September and 39 in October.
Reference: Green (1986d)

Diet composition (% frequency of occurrence):

	Aug	Sept	Oct
Fish	88.2	100	100
Fish eggs		54.1	69.2
Cephalopods	4.0	1.6	5.1
Isopods	7.8	26.2	33.3
Hyperiids	2.0	6.6	15.4
Gammarids		14.8	25.0
Unid. crustaceans	66.7	44.3	48.7

Prey size: Of the 27 fish otoliths recovered, 21 were of *Pleuragramma antarcticum*. Standard lengths calculated from otolith size were between 72 and 183 mm, mean 129.5±23.8 mm.

Location: Amanda Bay (69°19'S: 76°46'E).
Time: 14 August, 15 September and 10 October 1986
Source of material: 15 stomach samples per visit obtained by repeated water offloading until empty, plus 100 faeces collected each visit.
Reference: Gales et al. (in preparation).

Mean weight of all food: Calculated weight of original contents before digestion (mean ±SD grammes)

Aug	690±783
Sept	1565±1013
Oct	1762±1331

No identifiable material from faeces

Diet composition (% by calculated original weight):

P. antarcticum	78.15
Trematomus/Pagothenia spp	9.50
Channichthyid	7.89
Bathydraconid	1.13
Psychroteuthis glacialis	2.08
Amphipods and euphausiids	0.47

monthly variation, % by number:

	Aug	Sept	Oct
P. antarcticum	78.1	75.6	81.4
Other fish	18.5	3.6	0.3
Cephalopods	2.5	6.5	2.6
Amphipods	0.8	14.2	9.9
Euphausiids	0	0	6.5

Prey size (mean length and weight ±SD, length range):

P. antarcticum	101.0±10.3 mm, 7.4±2.6g, 70-135 mm
Trematomus/Pagothenia	101.4±155.8 mm, 23.5 to 66.1g
Channichthyids	113.7±150.8 mm, 25.8 to 68.3g
Bathydraconids	61.9±116.0 mm, 1.7 to 10.8g
P. glacialis	45.3±21.5 mm DML, 3.75±6.17g

2.3 King Penguin

Location: Macquarie Island (54°30'S: 158°57'E), Lusitania Bay.
Time: November 1984 to November 1985
Source of material: At least 10 stomach samples per month obtained by repeated water offloading until empty.
Reference: Hindell (1988a)

Mean weight of all food: Calculated weight of original contents before digestion (mean ±SD and range)

923g ±518.4 range 4.9 - 2342.0

Mean weight increased from 117g in November 1984 to 1186g in April, then decreased to a low in July of 764g and recovered to 1290g in September, remaining ±steady until November 1985

Diet composition (% by calculated original weight):

Krefftichthys anderssoni	37.7 (dominant Oct-Apr)
Electrona carlsbergi	53.2 (dominant May-Sept)
Other myctophids	1.3
Magnisudis prionosa	4.5
Other fish	1.2
Cephalopods	2.2

Prey size (mean length and weight):

E. carlsbergi	76 mm, 6.5g 2 classes - small 40-50 mm, 1-2g (Jan-Jul) and large 80-100 mm, 10-15g (Aug-Nov)
K. anderssoni	55 mm, 2.5g
Martialia hyadesi	259.5g
Moroteuthis sp	32.4g

2.4 Royal/Macaroni Penguin

Location: Macquarie Island (54°30'S: 158°57'E), Nuggets Beach
Time: November 1984 to February 1985; September to November 1985
Source of material: 10 stomach samples per week obtained by repeated water offloading until empty
Reference: Hindell (1988b)

Mean weight of all food: Calculated weight of original contents before digestion (mean ±SD, range grammes)

Overall	249±238g range 1-973g
Pre hatching	<100g
Guard stage	300-700g
Creche stage	700-300g

Diet composition (% by calculated original weight):

Euphausia vallentini	32.13
Thysanoessa gregaria	10.34
Other euphausiids	8.87
Krefftichthys anderssoni	23.69
Electrona carlsbergi	9.64
Other myctophids	7.87 (*Protomyctophum* and *Gymnoscopelus* spp)
Other fish	4.47 (*M. prionosa, P. magellanica*)
Cephalopods	2.95 (*Martialia hyadesi, Moroteuthis* sp)

Seasonal variation:

E. vallentini	dominant Oct-Nov and Feb
T. gregaria	most common Dec-Jan
K. anderssoni	dominant late Nov-early Dec common Dec and Feb
E. carlsbergi	most common Dec

Prey size (mean length, length range and weight ±SD):

E. vallentini	overall 15.6 mm±4.7, smallest in Nov		
T. gregaria	13.3±3.8 mm		
K. anderssoni	25.1	(13.9-31.8 mm)	2.1±0.8g
E. carlsbergi	23.6	(16.2-44.8 mm)	1.62±1.7g
Moroteuthis spp.			30.5±47.4g
M. hyadesi			51.6±54.3g

Location: Heard Island (53°01'S: 73°23'E)
Time: 15 December 1986 to 7 January 1987
Source of material: Total of 66 stomach samples obtained by repeated water offloading until empty
Reference: Klages, Gales and Pemberton (in preparation)
Mean weight of all food: Calculated weight of original contents before digestion of the 48 contents containing food.

mean wt 95.5±65.4g

Diet composition (% by calculated original weight):

Fish	23.2
Crustacea	76.8

(composition by % frequency of occurrence and size distribution (mm):

	%F	size range
K. anderssoni	75.0	15-70
Protomyctophum bolini	8.33	
E. carlsbergi	6.25	
Champsocephalus gunnari	27.08	100-200
Fish larvae	10.4	
E. vallentini	64.58	11-25
Thysanoessa macrura	87.5	9-23
Parathemisto gaudichaudi	27.1	
Squid	8.33	

2.5 Rockhopper Penguin

Location: Macquarie Island (54°30'S: 158°57'E)
Time: November 1984 to February 1985 and October 1985
Source of material: 8 stomach samples per week obtained by repeated water offloading until empty
Reference: Hindell (1988c)

Mean weight of all food: Calculated weight of original contents before digestion (mean ±SD)

Overall	197g±147
Prehatch	<100g
Guard	100-320
Creche	200-300g

Diet composition (% by calculated original weight):

Euphausia vallentini	62.3
Other euphausiids	6.8
Krefftichthys anderssoni	16.0
Other myctophids	7.1
Other fish	5.5
Cephalopods	1.7

seasonal variation:

E. vallentini	Low early Dec, peak early Jan, partial decline to mid Feb then ± steady
Other euphausiids	Only common after mid Jan
K. anderssoni	Very variable, most common mid Dec and Feb
Other myctophids	More important than inshore fish
Other fish	Minor amounts Jan

Prey size (mean length and weight ±SD):

E. vallentini	18.1±5.0 mm,	0.05±0.01g (largest in Jan-Feb)
T. gregaria	13.5±3.1 mm,	0.05±0.01g
K. anderssoni	54.5±20.5 mm,	3.42±2.98g
E. carlsbergi	53.0±5.9 mm,	2.17±0.78g
Moroteuthis spp		15.66±8.61g
M. hyadesi		60.77±39.04g

Location: Heard Island (53°01'S: 73°23'E)
Time: 15 December 1986 to 7 January 1987
Source of material: Total of 58 stomach samples obtained by repeated water offloading until empty
Reference: Klages, Gales and Pemberton (in preparation)

Mean weight of all food (calculated weight of original contents before digestion):

26 stomach contents - mean wt 42.5±17.4g

Diet composition (% by calculated original weight):

Crustacea	90.8
Fish	8.0
Squid	1.2

(% frequency of occurrence (F%) and size distribution (mm)):

	%F	size range
Krefftichthys anderssoni	46.2	30-80
Protomyctophum bolini	3.9	
Notothenia cyanobrancha	3.9	
Fish larvae	11.5	
Euphausia vallentini	92.3	15-26
Thysanoessa macrura	80.8	9-29
Parathemisto gaudichaudi	23.1	
Squid	23.1	

2.6 Gentoo Penguins

Location: Macquarie Island (54°30'S: 158°57'E), Bauer Bay
Time: April to November 1985
Source of material: 12 stomach samples obtained per month by repeated water offloading until empty.
Reference: Hindell (in press)

Mean weight of all food (calculated weight of original contents before digestion):

Overall	240.3g±188.9g
Apr-Jun	<200g
Jun-Nov	ca. 350g regardless of breeding stage

Diet composition (% by calculated original weight) and seasonal variation (periods of dominance in diet underlined):

Krefftichthys anderssoni	15.1	May-June, Sept, Oct-Nov
Electrona carlsbergi	27.5	Apr and July
Gymnoscopelus sp	15.7	Nov (Apr,Aug)
Paranotothenia magellanica	18.4	Aug

Prey size (mean length and weight ±SD):

K. anderssoni	37.5±15.2 mm,	1.3±1.9g
E.. carlsbergi	45.9±11.6 mm,	1.7±2.4g
Gymnoscopelus sp	88.2±33.4 mm,	6.7±8.4g
P. magellanica	84.8±50.6 mm,	23.8±27.9g
Moroteuthis spp		27.9±88.8g
Martialia hyadesi		229.3±117.0g

Comments:

K. anderssoni small (<1g) Apr-July, and larger (2-3g) Aug-Nov.
E. carlsbergi increased from 1g to 11g July-Oct.

2.7 Cape Petrel

Location: Vicinity Davis Station (68°30'S: 77°50'E), Bluff Island and Rauer Islands
Time: 26 January to 20 February 1984
Source of material: Vomit samples (63 from Bluff, 10 from Rauers)
Reference: Green (1986a)

Diet composition (% by weight):

Fish	23.4		
Euphausiids	75.9	Frequency of occurrence:	
		E. superba	60.7%
		E. crystallorophias	7.1%
Others	0.7		

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands
Time: 16 January to 12 February 1988
Source of material: About 10 stomach samples per week by repeated water offloading until empty
Reference: Arnould and Whitehead (in preparation)
Mean weight of all food: 8.3±3.55g no significant variation during study period

Diet composition (% by weight):

Pleuragramma antarcticum	13.8
Euphausia superba	85.5
Cephalopods	0.5
Others	0.2

P. antarcticum comprised 50% of the diet in the first week after chick hatch, but declined to 10% by the 4th week and never subsequently exceeded this proportion.

Prey size:

P. antarcticum	144.5±12.1 mm
E. superba	46.6±4.3 mm

2.8 Antarctic Petrel

Location: Prydz Bay (67°31'S: 74°39'E)
Time: 16 December 1982
Source of material: Stomach contents of 17 birds shot at sea
Reference: Montague (1984)
Mean weight of all food: 31g, range 2-72g

Diet composition (% frequency of occurrence):

Pleuragramma antarcticum	6
Euphausia superba	100
Cephalopods	18

E. superba were 100% of contents in all but one stomach, and the mean number per stomach was 42, range 1-117. Two specimens of *P. antarcticum* were found in one stomach, constituting 95% of the contents.

Prey size:

E. superba	48 mm, range 41-55 mm
P. antarcticum	160 mm

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands
Time: 16 January to 12 February 1988

Source of material: About 10 stomach samples per week by repeated water offloading until empty
Reference: Arnould and Whitehead (in preparation)
Mean weight of all food: 49.3±37.5g   no significant variation during study period

Diet composition (% by weight):

Pleuragramma antarcticum	77.5
Euphausia superba	22.3
Cephalopods	0
Others	0.2

Generally no significant differences with time, but *P. antarcticum* tended to increase slightly through the study period, with a consequent slight decrease in *E. superba*.

Prey size:

P. antarcticum	125.4±35.2 mm
E. superba	46.6±4.1 mm

2.9 Antarctic Fulmar

Location: Vicinity Davis Station (68°30'S: 77°50'E), Rauer Islands
Time: 16 January to 12 February 1988
Source of material: About 10 stomach samples per week by repeated water offloading until empty.
Reference: Arnould and Whitehead (in preparation)
Mean weight of all food: 72.7±32.35g   no significant variation during study period

Diet composition (% by weight):

Pleuragramma antarcticum	63.2
Euphausia superba	36.2
Cephalopods	0.4
Others	0.2

P. antarcticum decreased from >80% in week 2 to about 55% by week 5 after chick hatch. *E. superba* increased from about 15% to about 45% in the same period.

Prey size:

P. antarcticum	142.1±33.4 mm
E. superba	47.0±3.8 mm

2.10 Weddell Seal

Location: Sea ice off Davis Station (68°30'S: 77°0'E), Mawson, and McMurdo Stations
Time: 1983 to 1984
Source of material: Stomachs (Mawson 5, McMurdo 20), vomits (Mawson 2, Davis 14) and faeces (unknown age Mawson 18 1984, Davis 150 1983 and Jan 84) and known age Jan 84-Jan 85 from near shore (423) and offshore (422).
Reference: Green and Burton (1987)

Diet composition (% frequency of occurrence for faeces, % by weight for vomit):

	vomit	faeces		
		(1984)	(1-4/84)	(5/84-1/85)
Fish	77.1	69.4	58.2	73.5
Prawns	20.6	54.5	69.8	49.4
Cephalopods	2.0	10.5	6.8	11.0
Amphipods		16.5	15.9	16.6
Isopods		18.7	20.6	18.7
Other crusts		11.5	18.0	22.3
Others	0.6			

During January-April prawns (69.8%) were more common than fish (58.2%) when the inshore areas were ice free, then fish were more common (73.5%) than prawns (49.4%) until January 1985 when sea ice was present. Crustaceans were *Chorismus antarcticus* and *Notocrangon antarcticus* in approximately a 3:1 ratio.

Fish were *P. antarcticum* and a range of benthic nototheniids. The latter dominated in faeces from the inner zone, but in the outer zone both types fluctuated.

Prey size: Average carapace length of *Chorismus* was steady through year at 13.3±1.4 mm, but longer (14.2±1.9 mm) in the outer zone than in the inner (13.1±1.2 mm): *Notocrangon* carapace length was 14.1±1.7 mm. The length of *P. antarcticum* was similar in faeces from the inner and outer zones (146.9±11.8 and 145.1±13.4 mm respectively) and there was little difference between sites although Mawson fish were smaller (116±23.3 mm).

2.11 Leopard Seals

Location: Sea ice off Davis Station (68°30'S: 77°50'E)
Time: August to October 1984
Source of material: Total of 15 faeces
Reference: Green and Williams (1986)

Diet composition (% frequency of occurrence):

Pleuragramma antarcticum	73.3
Trematomus sp	20.0
Decapods	6.7
Amphipods	20.0
Unid. crustaceans	13.3

P. antarcticum length range was 88-175 mm. After October, Adelie penguin remains were common in faeces. No krill were observed - the most common crustacean was gammarid amphipods.

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3. DISCUSSION

It is not the intention of this paper to discuss the above results in detail, as this is a task already accomplished in the individual publications. The aim of this paper is rather to bring to CCAMLR's attention the large body of data already obtained on vertebrate predator diets and to summarise briefly the important conclusions relevant to ecosystem monitoring.

3.1 Prydz Bay Area

Most predator species have a rather low dependence on *E. superba* for food, and in many cases on euphausiids in general. Conversely fish, and in particular *Pleuragramma antarcticum*, are important in most diets. This is summarised Table 1.

Thus utilising any of these species to monitor the state of *E. superba* populations would be unreliable. Indeed in the Adelie penguin, breeding success is inversely correlated with the amount of *E. superba* in the diet, except in the disastrous 1985/6 season when all the usual diet components had low occurrences, as shown in Table 2.

Table 2 also shows the extent to which prey switching can occur in Adelie penguins, with high levels of *P. antarcticum* and *E. crystallorophias* alternating with dominance of the diet by *E. superba*. Whitehead et al. (in press) discuss fully the possible causes for reduced breeding success and diet changes, and for the Adelie penguin suggest that the extent of sea ice is important. In "bad" years, extensive sea ice forces the penguins to forage further away from the breeding colonies, thus lengthening the intervals between chick feeding and hence the amount of food the chick receives. Much of this inter annual variation may, however, be due to more general oceanographic conditions, as in the 1985/6 season the petrel species, which have much easier access to foraging grounds and which feed much more heavily on other organisms such as fish (eg. Antarctic Fulmar), also had very low reproductive success. Although none of the species studied (with the possible exception of the Cape Petrel) seems to be a reliable indicator of the state of local *E. superba* stocks because of prey switching and/or low dietary importance, such studies are valuable to indicate the underlying variability of the ecosystem.

Almost all the diet studies show that the predators are feeding exclusively on the continental shelf, because all the major diet components (*E. crystallorophias*, *P. antarcticum* and amphipods) are exclusively shelf species. Although *E. superba* occurs both on and off the shelf, it is likely that most have been taken near the shelf margin, where they are usually abundant. Typically off-shelf species, such as myctophid fish, almost never occur. There seems little partitioning by size within a prey species. All predators studied take adult *E. superba* (36-48 mm length) and sub-adult *P. antarcticum*, between 90 and

160 mm SL, with Emperor penguins taking generally smaller fish than Adelie penguins or petrels! Some rather surprising food items were the high proportion of decapods (especially near shore) in the Weddell seal diet, and the dependence on amphipods by Adelie penguins before laying.

Most diet work to date has been done in the South Atlantic region, from South Georgia to the Antarctic Peninsula and Weddell Sea. The Prydz Bay work summarised here shows consistent differences in diets of vertebrate predators from those in the South Atlantic sector. Chief among these is the virtual absence of cephalopods in diets of all species, and the much lower dependence on *E. superba*, with other euphausiids and *P. antarcticum* replacing it. Results from Adelie Land and McMurdo tend to resemble those from Prydz Bay, which underlines the importance of assessing ecological relationships from a series of widely spaced localities. In East Antarctic coastal sites at least, it is also important to study the ecology of the other major prey species such as *E. crystallorophias* and *P. antarcticum.*

3.2 Sub-Antarctic Islands

The diets of the four species of penguins at Heard and Macquarie Islands again stresses the differences between areas. Macaroni and Gentoo penguins feed largely on *E. superba*, and King penguins on cephalopods in the South Atlantic sector, whereas at Macquarie and Heard Islands Royal/Macaroni penguins take other euphausiids (*E. vallentini* and *T. gregaria*) and fish, and King and Gentoo penguins feed almost entirely on fish. Penguin diets at these islands generally resemble those at Marion Island, but a feature of the diets, especially at Macquarie Island is the dominance of myctophid fish, probably reflecting the very narrow shelf area and proximity to deep water feeding grounds.

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Table 1: Summary of mean % composition by weight of euphausiids and fish from all sources.

	E. superba	*E. crystallorophias*	Fish
Adelie Penguin*	35.1	33.8	23.7
Emperor Penguin	<1		96.7
Cape petrel	80.7 (nearly all *E. superba*)		18.6
Antarctic petrel	22.3		77.5
Antarctic fulmar	36.2		63.2
Weddell Seal			77.1

*Post hatch period only

Table 2: Annual variability in diet during posthatch period and breeding success* of Adelie penguins (by split year).

	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Overall weight(g)	450	141	202	114	200	400	450
E. crystallorophias (%wt)	44	42	18	13	25	39	55
E. superba (%wt)	24	25	77	66	5	29	20
Fish (%wt)	28	32	5	20	24	32	25
Amphipods(%wt)	4	1	0.1	0.5	46	0	0
Chicks hatched in reference colonies	502	692	398	395	240	600	630

*Data from Whitehead et al. (in press)

Légendes des tableaux

Tableau 1 Résumé du pourcentage moyen de composition par poids des euphausiacés et des poissons de toutes les origines.

Tableau 2 Variabilité annuelle du régime alimentaire pendant la période suivant l'éclosion, et réussite de la reproduction des manchots Adélie (par année fractionnée).

Заголовки к таблицам

Таблица 1 Сводка среднего процентного состава антарктического криля и рыбы по весу на основании данных, полученных из всех источников.

Таблица 2 Годовая изменчивомть в диете в течение постынкубационного периода и репродуктивный успех пингвинов Адели.

Encabezamientos de las Tablas

Tabla 1 Resumen de la composición media % por peso de eufáusidos y peces de todos los orígenes.

Tabla 2 Variabilidad anual en la dieta durante el período posterior a la incubación y éxito de reproducción de los pingüinos Adelia (por año dividido).