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Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

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# Catch rates and total removals in the 4WX herring purse seine fisheries.

by

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#### Abstract

Results of a two-year observer program on herring purse seiners are summarized. In 1983 and 1984 the purse seine fishery has been characterized by an increase in directed effort on juveniles, a substantial increase in markets for herring roe, and a limited demand for other types of adult herring products. This has resulted in changes in the temporal and spatial distribution of fishing activity, forcing it later into the season and onto the spawning grounds and juvenile feeding areas. Catch rate indices were therefore computed for market/fishing-ground categories that were comparable between years. All such indices indicate an increase in stock biomass between 1983 and 1984.

Estimates of the discrepancies between recorded purse seine landings and total removals were derived for the period 1973-84. They were based on extensive interviews with members of the fishing industry, as well as comparison between observer information and recorded landing statistics. Purse seine catches were corrected for the estimated discrepancies and recombined with the catches by other gears to generate an adjusted catch matrix. A cohort analysis based on the adjusted matrix results in a substantial increase in the estimate of current population biomass.

## Résumé

On résume les résultats d'un programme d'observation de deux ans portant sur la pêche du hareng à la senne coulissante. En 1983 et en 1984, la pêche à la senne coulissante a été caractérisée par un effort accru à l'égard des juvéniles, par un élargissement substantiel du marché de la rogue de hareng et par une demande limitée en ce qui concerne les autres produits de hareng adulte. Cette situation a entraîné une redistribution temporelle et spatiale de la pêche qui s'est poursuivie plus tard dans la saison et qui s'est étendue aux frayères et aux endroits où se nourrissent les juvéniles. On a donc calculé les indices du taux de capture pour les catégories marché/lieux de pêche qui étaient comparables d'une année à l'autre. Ces indices dénotent tous une augmentation de la biomasse des stocks entre 1983 et 1984.

On a estimé les écarts entre les débarquements de pêche à la senne coulissante et les prises totales enregistrées pour la période 1973-1984. Ces estimations ont été basées sur des entretiens exhaustifs avec des membres de l'industrie de la pêche ainsi que sur une comparaison entre l'information fournie par des observateurs et les statistiques des débarquements. Les valeurs obtenues pour les prises à la senne coulissante ont été corrigées en foncton des écarts calculés, puis recombinées aux quantités pêchées au moyen d'autres engins pour donner une matrice ajustée des prises. Une analyse par cohorte, basée sur la matrice ajustée, met en évidence une augmentation substantielle du chiffre de la biomasse actuelle de la population.

## Introduction

In terms of landed catch, purse seiners are the most important gear component of the 4WX herring fisheries. They usually account for more than 80% of the quota-regulated landings. Knowledge of factors affecting their overall fishing success, their ability to concentrate fishing mortality on selected age groups, and the size and age distributions of fish removals is therefore essential to proper assessment of the fishery and predictions of potential changes in stock structure.

A project to gather detailed information pertaining to the interaction between purse seine fishermen and the herring resource has been conducted during the last two years, concentrating on the main summer 4Xa component. It has involved deployment of observers on the seiners to record search paths, distribution of fishing effort, factors affecting fleet movements, school sightings, estimates of school sizes, area searched, amounts of time spent searching and setting, proportions of sets abandoned, reasons for abandonment, catch composition, and other related variables. A summary of the extent of sampling during 1983 and 1984 is given in Table 1. The primary purpose of the study is to obtain a better understanding of the purse seine fishing mortality-fishing effort relationship, the factors that affect it, and its consequences in terms of stock assessments.

In this paper I summarize the major factors affecting fishing effort, fishing success, and catch composition, with particular emphasis on the changes that have occurred between 1983 and 1984. I then derive a series of estimates of total removals based partly on observer information, construct an adjusted catch matrix for 4WX herring and show how the new matrix can affect estimates of stock size.

# Description of the Fishery

The main driving variables that affect fishing patterns are the markets for the various herring products and changes in the density, distribution, and size composition of herring schools over the course of the season. Weather may also have an effect but is not a major factor in the summer fishery. Its effects on the percentage of unsuccessful nights appear to have been quite similar over the two years (Figure 1).

Market effects are much more significant. There are many different types of herring products each requiring a somewhat different size or age composition of fish (Table 2). Markets for these can vary dramatically from year to year. This affects the relative desirability and selectivity of particular age classes so that landings reflect not only relative year class size but also relative market demand. It also affects the temporal and spatial distribution of fishing activity. In 1983, there was a moderate amount of fishing for each of the product categories in Table 2, with the possible exception of barrel product. Fillets, frozen round, and over-the-side sales were the dominant categories for the period late May - mid August. The roe fisheries predominated from mid-August to late September. Juveniles were fished throughout August and September and herring were sold for lobster bait at the end of September and beginning of October. The pattern was similar in 1984 but the relative importance of each category changed markedly due to the occurrence of substantial markets for herring roe coupled with a limited demand for other types of adult herring products. There was also a continuation in the demand for seine-caught juveniles, to compensate for low catches in New Brunswick weirs. This meant that much of the fishing effort was concentrated in juvenile feeding areas and on the spawning grounds, and focused on the latter part of the season.

There was therefore less effort on the mixed aggregations of herring that are present at the beginning of the summer season, and much of this catch was sold to foreign over-the-side sales where the acceptable size range of fish is less restrictive. Boats fishing for domestic processors often had limited nightly markets and so spent less time searching and made fewer sets (Tables 3a-d). One result was a decrease in the proportion of sets abandoned, particularly in July (Figure 2). A total of 3.0% of all 1984 sets were rejected because fish were too small, compared to 11.1% in 1983. The proportion of sets rejected for other reasons was comparable between years (Table 4a). Overall, 13.6% of the catch was rejected in 1983 and 10.5% was rejected in 1984 (Table 4b).

## **Catch Rates**

The overall average catch per fishing night increased slightly in 1984 (Table 5a). There was a somewhat greater increase (12%) in kept catch per successful night (Table 5b) reflecting the lower rate of set rejection. The increase in nightly catches is at least partly due to market effects, particularly in September when much of the effort was concentrated on the spawning grounds. Catchability is obviously higher in spawning areas where fish are densely concentrated, but in 1983 this often meant short fishing nights whereas in 1984 it meant that fishing activity was frequently limited only by holding capacity or the availability of carriers, and the number of hours of darkness.

Catch per set also increased, again particularly in September (Tables 6a and 6b). One reason for the increase may have been greater use of large seines (approximately  $340 \times 40 \text{ cf } 250 \times 25 \text{ fathoms}$ ) in conjunction with a change in the relative distribution of effort between the Trinity and German Bank spawning grounds. In 1984, Trinity Ledge was closed to purse seiners for a two-week period in the middle

of the spawning season. The closure, gear conflicts with gill netters, and problems associated with setting in shoal waters led many fishermen to redirect their effort to the deeper, less-congested waters of German Bank. The fish tended to be further down in the water column on German Bank and so a deeper net was necessary to reach the schools.

Jackknife estimates (Smith, 1980) of mean catch per hour of searching suggest an even greater increase in CPUE than the other two measures (Tables 7a and 7b). Searching time was defined as the period spent actively looking for fish and excluded the time it took to steam to the fishing grounds, set times, and other non-search activities. Indices based on this measure should not be confounded by the amount of nightly market as much as catch per night but will certainly be affected by net size and catchability.

## Fishing Ground - Time of Season Comparisons

In an attempt to control for net size and catchability effects, catch per hour of searching was computed separately for the three fishing ground - time of season strata with the largest sample sizes (Table 8). These were: (i) the area south of Yarmouth to Seal Island during July and early August prior to the formation of spawning aggregations, (ii) the Trinity and Lurcher spawning grounds during the spawning season, and (iii) the German Bank spawning ground also during the spawning season. The time periods were defined slightly differently in each year because of an earlier and longer spawning period in 1984. Significant numbers of mature fish were not detected until mid-August in 1983 but were found as early as the last few days of July in 1984. In both years spawning activity continued through to the end of September.

Two vessel size categories: small (31 boats of 50-60') and large (15 boats in 1983 and 12 in 1984 of 74-111', but only two boats less than 90') were defined for each stratum. Small sample sizes (Table 8) are a reflection of differences in the distribution of effort by the two sizes of boats. During the spawning season in 1983 small boats fished mainly in Trinity while large boats went to German Bank. In 1984, a number of small boats left Trinity and joined the large-vessel fleet on German Bank. This invalidates several of the possible comparisons, but the rest all indicate an increase in catch rates in 1984 over 1983 that is substantial in some cases. It seems that the most reasonable inter-year comparisons are those involving small boats on Trinity Ledge and large boats on German Bank. These both suggest a moderate increase in the size of the Trinity stock and a substantial increase for the German Bank stock.

The importance of the German Bank spawning stock has generally been overlooked in the past. If the catch rates in Table 8 are truly a reflection of abundance, they suggest that it may be at least as large as the Trinity component. Preliminary analysis of the observer data on numbers and sizes of schools indicates a substantial resource on German Bank with a higher average school size than the Trinity area, although somewhat less densely packed.

## Estimation of Herring Removals

When one is interested in improving estimates of fishing mortality, it is impossible to ignore the discrepancy between herring removals and recorded landings. A number of related phenomena contribute to this loss of information about total fishing mortality: a portion of the fish released from unsuccessful sets may subsequently die, fish may be dumped after being loaded onboard due to equipment malfunction or realization that the port market is oversupplied, they may be rejected at dockside because of poor quality, processing plants may only pay for a certain percentage of the catch, fishermen and processors may agree to record an even smaller amount on the purchase slip and, finally, purchase slips may be withheld resulting in the alternative use of fishery officer hails which are sometimes imprecise and do not cover all landings.

In the 1984 fishery the difference between removals and recorded landings was widely believed to have been substantial. This was partly the result of a runaway roe fishery, the establishment of a number of small processing operations set up exclusively to extract roe, an increase in the number of intermediate buyers, insufficient monitoring, and refusal by many plants to provide purchase slips to DFO. In fact, more than 90% of the recorded landings are based on fishery officer hails unsubstantied by purchase slips. This means that landings not observed by fishery officers most likely never entered the Statistics and it is probably more appropriate to talk of missingreporting rather than misreporting.

Because of the potential significance of the removals/recorded landings ratio, its magnitude, reportedly large year-to-year variation, and consequent effects on estimates of stock size, I have put a considerable amount of effort into attempting to derive reasonable estimates of the discrepancies for each year from 1973 to 1984. These estimates are based on many hours of conversation with participants in the fishery as well as my own direct involvement over the last two years. They are intended to apply to total removals, not just the misreporting element, and to apply to all purse seine fisheries (4Xa, 4Xb, and 4W). For 1983 and 1984, the final estimates are based on direct comparisons of observer trip reports from the summer 4Xa fishery with landings recorded over the same period by Statistics Branch. These estimates were assumed to apply to all purse seine fisheries because the summer component accounts for at least 80% of the total purse seine catch and there was no reason to believe that the situation was any different in the 4Xb and 4W fisheries.

The observer records were collected under an agreement with the seiner captains of confidentiality of information, and the observer database would have been severely compromised had this agreement not been in effect. In keeping with the confidentiality pledge, estimates of removals: recorded landings have not been calculated for individual boats (nor, in fact, are there sufficient records for any one boat to make this possible), but rather for the fleet as a whole. Further, I agreed not to use the information in any way that might lead to a reduction in projected quota levels, unless supporting evidence for a downward trend in stock size could be found. The fishermen were after all one of the main sources of data for the computations that follow and the most likely to be affected by it.

## 1984 Estimate

Five estimates of the ratio removals/recorded landings were calculated by comparing observer records with Statistics Branch records under somewhat different assumptions for each case (Table 9). Observer nights of zero landings were excluded from the analysis, leaving 195 successful nights for the comparisons. The number of Statistics Branch records over the same period was 1,483. Observer records accounted for a total of 12,558 t compared to Statistics Branch records of 58,354 t (Table 1).

The first estimate in Table 9 was thought to be too low as it assumes that all landings were recorded by DFO. Estimates 2 and 3 are more reasonable because they include an adjustment for unrecorded landings. Estimate 4 is probably too high because it is based on the assumption that catch rates in the domestic and over-the-side-sales (0.S.S.) fisheries are identical. It is more likely that overall domestic catch rates were higher as the 0.S.S. fishery was concentrated over the period prior to the roe fishery. Further analysis was not attempted because of the complexity of pooling arrangements for 0.S.S. and lack of availability of the required information.

Estimate 5 was the most elaborate index derived. It involved night-by-night comparisons of observer reports and recorded landings. Cases where there was uncertainty about how much of the catch should be credited to a particular boat were excluded from the analysis. In total, 135 observer records were used. The final estimate of 1.77 was calculated as the average of estimates 2, 3, and 5. It indicates that true removals by purse seiners were 124,560 t, rather than the recorded 70,373 t.

All estimates assume representative coverage by observers. However there are many different aspects to cover "representatively". As the primary purpose of my study is an investigation of the fishing mortality-fishing effort relationship I was mainly concerned with obtaining adequate coverage of the various categories of boat size, fishing skill, fishing ground-time of season interactions, and market categories. Had I wanted to focus on misreporting I would have added port of landing to the list. Estimates calculated by omitting some of the highliners from the analysis indicated that the observer coverage may have been slightly biased towards skippers with superior fishing skills. Such estimates are not recorded in Table 9 because observer coverage was strongly biased towards the most accessible ports, concentrating almost exclusively in the Yarmouth-Pubnico area where the resources for monitoring the fishery exceed those in outlying areas. The latter bias was thought to more than compensate for the former.

## 1983 Estimate

It was not possible to conduct such a detailed analysis for the 1983 observer data because: (i) there were fewer records and (ii) the observer data format made it difficult to determine whether catches should be credited only to the boat that caught them or whether some portion was given away or pooled with another vessel. An estimate equivalent to No. 2 in Table 9 was the only one derived. Based on 125 observer records from successful nights, 8.80% of the landings were unrecorded. The product of the observed catch and the ratio of the number of Statistics records adjusted for missing records to the observed number of successful nights was 1.63 of the total recorded summer purse seine landings. The similarity between estimate 2 and the more accurate estimate 5 in Table 9, as well as information from other sources (see below), suggests that this estimate is reasonable.

## 1973-82 Estimates

The 1983 and 1984 computations indicate that the discrepancy between removals and recorded landings may sometimes be substantial. But it would be unreasonable to combine these with an unadjusted 1973-82 catch series unless the estimates were similar from year to year.

As I had no sources of "hard data" to derive estimates prior to 1982, I relied upon personal communications with people involved in the industry and scattered pieces of literature that allude to the subject. My information comes from more than 30 sources including fishermen, fish buyers, plant employees, government personnel, and others closely associated with the fishery. Estimates differed in magnitude between sources but the pattern of change was almost invariably the same. The final estimates were computed as a "weighted average" of the sources. The weighting was subjective, based on my personal opinions about the credibility and scope of knowledge of each source. Although the "weighted averages" were sometimes biased towards the higher estimates, they were always less than the highest. The same is true for the 1983 and 1984 estimates calculated from the observer data: they are lower than some of the estimates obtained from other sources.

# Summary 1973-1984

The factors by which recorded purse seine landings should be multiplied to obtain total removals is summarized in the following text table:

<u>1973</u>	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1.35	1.30	1.35	1.20	1.15	1.15	1.20	1.45	1.55	1.55	1.63	1.77

Although it seems likely that the discrepancies vary between age classes there was insufficient information to make this distinction, even at the simple level of juveniles vs adults. The overall pattern of discrepancies is "average" during the last years of the meal fishery (1973-75), low during the initial years following the formation of the Atlantic Herring Fishermen's Marketing Cooperative (1976-79), and high and increasing steadily from 1980 to the present.

The only other attempts to estimate true purse seine removals in CAFSAC assessments are those by Sinclair and Iles (1981) and Iles et al. (1984). In the former case, Sinclair and Iles (1981) adjusted the 1980 4Xa purse seine catch to account for 40% underreporting based on a study conducted by Kearney (1983). This translates to a multiplying factor of 1.67 which, although higher than the number in the text table, leads to a similar estimate of total purse seine landings (respectively, 85,377 t and 80,311 t) because the text table numbers are intended to apply to the entire domestic purse seine fishery. The multiplying factor of 1.35 for the 1975 fishery is also similar to an estimate utilized by Kearney (1.43 or 30% underreporting).

In the two assessments following Sinclair and Iles (1981), the adjusted 1980 numbers were retained but the recorded 1981 and 1982 landings were not modified. In last year's assessment, Iles et al. (1984) prepared two separate catch matrices: one based on nominal landings and one that included adjustments for underreporting during the years 1980-83. Their purpose was to reflect the growing concern over the widely-acknowledged discrepancy between removals and recorded landings and highlight the resultant limitations on the feasibility of producing accurate stock assessments. The estimates for 1981-83 (respectively 30% or 1.43, 20% or 1.25, and 30% or 1.43) were preliminary and the higher estimates of the present paper are the result of more intensive investigation of the problem.

## Incorporation of Removals in the Catch-at-age Matrix

To incorporate total removals into the catch-at-age matrix. the first task was to subdivide the matrix into catches by purse seiners and catches by other gears. For the years 1973-76 inclusive. the main source of information was a series of data files resulting from a major revision of catch-at-age undertaken in 1976-78 (see Miller and Stobo (1976) and Stobo et al. (1978). Unfortunately, it proved impossible to reconcile the purse seine and other gear totals derived from the data files with the catch matrix totals used in recent CAFSAC Res. Docs. (see for example Iles et al. (1984)). The data file information was preferred because it appeared to be the most logical and consistent: there has reportedly been no additional revision of the pre-1977 statistics since 1978, the pre-1975 records correspond closely to estimates in Miller and Iles (1975) (on which the revisions were based), rounding errors in age-length-weight keys were generally minor, the revised catch at age by gear was not presented in any Res. Doc., and there was no other source of information to indicate that the numbers in the data files needed to be adjusted.

Discrepancies were also noted for 1977 onwards but in these cases it was assumed that additional information obtained after running age-length keys had been incorporated into the appropriate Research Document tables but not used to update the original data files. Therefore for these years the catch at age by gears was taken directly from Stobo et al. (1978), Sinclair et al. (1979), Sinclair and Iles (1980), (1981), Sinclair et al. (1982), Iles and Simon (1983), Iles et al. (1984), and Stephenson et al. (1985). For 1973-76, the catch at age in Table 8a of Iles et al. (1984) was disregarded and replaced with catch estimates from the data files with minor alterations to adjust for rounding errors or to match totals to those in Table 2 of Iles et al. (1984). The revised catch at age for purse seiners and other gears is shown in Tables 10a and 10b.

Differences between the revised total catch (Table 11) and Table 8a of Iles et al. (1984) (Table 12a) were usually less than 5-6% (Table 12b), except in some cases where adjustments to the 1970 and 1971 year classes were made due to an ageing problem (see Miller and Stobo (1977)). Reassignment between the two year classes for the 1976 catch at age, when the problem first occurred, was based on identical assumptions to those used by Miller and Stobo (1977). For subsequent years the assumptions also correspond to those in the appropriate Res. Docs. but the numbers differ because the 1976 catches and partial recruitment estimates formed the basis for each year's reassignment.

## Herring Removals vs Recorded Landings

The final estimates for total removals (Table 13) were obtained by multiplying the purse seine catches (Table 10a) by the

appropriate factors (text table) and adding them to the catches for other gears (Table 10b). They are compared with the revised nominal landings of Table 11 in Figure 3a. To demonstrate the potential effect of basing an assessment on total removals rather than recorded landings, an SPA was run for each of Tables 11 and 13 using a terminal F of 0.3 (Tables 14-16 and Figure 3b). The catch-at-age series from 1965-72 (Iles and Simon (1983)) was added to each matrix, with no adjustments for underreporting in either case. Weights at age and the partial recruitment vector (PR=1 for ages 3+) were identical to those used by Stephenson et al. (1985). Geometric mean recruitment-at-age 1 from 1965-81 was recalculated as 1,518,440 thousand for the nominal matrix and 1,846,300 thousand for the adjusted matrix. These values were used to fix total mortality for one- and two-year-olds in the final year. The estimated 1984 3+ biomasses differ by a factor of 1.71 between the two runs (Tables 15a and b). (When the SPAs are fine-tuned using the larval abundance index, this difference reduces to 1.33 - see Stephenson et al. (1985).) The 3+ biomass estimate based on the adjusted matrix (Table 15b) is about 20% lower than the acoustic estimate of 545,000 t derived by Buerkle (1985) for overwintering (beginning-of-year) herring in the Chedabucto Bay region.

# A Cautionary Note

It must be emphasized that Table 13 is intended to represent total removals from the 4WX herring stock complex. Any catch projections based on estimates of population biomass such as those in Table 15b cannot be taken at face value unless dumping, the buyer practice of discounting a portion of the landings, and misrepresentation of the amount purchased are all reduced to low levels. Dumping is probably not a significant problem in most years although it may be more prevalent when the dominant size range or maturity stage of fish is unsuitable for the current market, or when "red feed" is abundant and results in spoilage of fish before they can be processed. Discounting practices are believed to be common and may be substantial for certain plants or for certain types of herring products. Misreporting of sales to processing plants is widespread and appears to be highly variable from year to year.

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	June	July	Aug.	Sept.	Oct.	Total
<u>1983</u>						
Number of trips	2 '	51	54	46	5	158
Number of sets	3	61	87	77	6	234
Total catch (t)	250	2179	2966	2692	194	8281
Kept catch (t)	250	1611	2611	2588	98	7158
	Tota	l Landings	Recorded	by Statistics	Branch	63379 t
1984						
Number of trips	-	81	93	69	8	251
Number of sets	-	91	173	94	6	364
Total catch (t)	-	3401	5795	4630	209	14035
Kept catch (t)	-	2860	5024	4465	209	12558
	Tota	l Landings	Recorded	by Statistics	Branch	58354 t
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Table 1. Observer sampling of the 4Xa summer purse seine fishery.

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Market Category	Type of Herring Sought
Brit	Age 1, empty stomachs
Sardines	Age 2, empty stomachs
Other canned products	Ages 2-3, empty stomachs
Lobster bait	Age 3
Bloaters (smoked whole)	Ages 5+, empty stomachs
Fillet	Ages 4+
Frozen round	Ages 4+, empty stomachs
Barrel product	Ages 3-4
Roe	Ages 3-4+, mature females
Foreign over-the-side sales	Ages 3+, some feed tolerated

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Table 2. Types of herring products and approximate age and condition of fish considered ideal for each market category.

Table 3. Average numbers of sets and time spent searching (hours). Searching time is defined as trip time minus travel, set, and waiting times.

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a. Average sets per night (all nights).						
	July	Aug.	Sept.	A11		
1983	1.20	1.61	1.67	1.48		
1984	1.12	1.86	1.36	1.		

b. Successful sets per successful night.

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	July	Aug.	Sept.	A11	
1983	1.24	1.56	1.50	1.46	
1984	1.38	1.82	1.46	1.58	

# c. Average time searching (all nights).

	July	Aug.	Sept.	A11
1983	5.32	4.45	3.28	4.43
1984	3.62	4.68	3.49	4.00

d. Average time searching on successful nights.

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	July	Aug.	Sept.	A11
1983	4.59	3.96	3.36	3.95
1984	3.33	4.29	3.01	3.65

1983	1984
11.1%	3.0%
0.4%	-
1.3%	1.9%
-	1.1%
7.4%	8.8%
2.5%	_1.9%
22.7%	16.7%
	1983 11.1% 0.4% 1.3% - 7.4% <u>2.5%</u> 22.7%

Table 4a. Percentage of sets rejected for particular reasons.

Table 4b. Percentage of catch rejected.

	July	Aug.	Sept.	A11
1983	26.05	11.98	3.87	13.55
1984	15.90	13.30	3.55	10.52

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	July	Aug.	Sept.	A11
1983	42.72 (6.23)	54.93 (5.27)	58.52 (6.26)	52.41 (3.46)
1984	41.99 (4.04)	62.31 (4.89)	67.10 (6.01)	55.91 (2.91)
Ratio 84/83	0.98	1.13	1.15	1.07
	•.	<u>1</u>	.983	1984
	Small vessels Large vessels	44.60 (3.57) 60.03 (5.78)		53.18 (3.00) 65.22 (7.70)

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Table 5a. Mean and (s.e.) of total catch per night (tonnes) including all fishing nights.

Table 5b. Mean and (s.e.) of kept catch per successful night (tonnes).

	July	Aug.	Sept.	A11
1983	48.82 (6.82)	59.33 (5.06)	58.82 (6.33)	57.27 (3.58)
1984	51.07 (3.68)	63.59 (4.68)	78.34 (5.92)	64.40 (2.89)
Ratio 84/83	1.05	1.07	1.33	1.12
		1	.983	1984
	Small vessels Large vessels	51.04 63.60	4 (3.33) ) (6.31)	59.22 (2.86) 85.10 (8.17)

	July	Aug.	Sept.	A11
1983	35.72 (4.27)	34.09 (2.50)	34.96 (3.75)	35.39 (2.04)
1984	37.37 (2.41)	33.49 (2.13)	49.26 (4.09)	38.56 (1.63)
Ratio 84/83	1.05	0.98	1.41	1.09
		<u>1983</u> 29.73 (1.83) 41.04 (3.58)		<u>1984</u>
	Small vessels Large vessels			36.33 (1.61) 46.47 (4.61)

Table 6a. Mean and (s.e.) of total catch per set (tonnes) including all sets.

Table 6b. Mean and (s.e.) of kept catch per successful set (tonnes).

	July	Aug.	Sept.	A11
1983	39.30 (5.66)	37.84 (2.83)	39.21 (4.07)	39.12 (2.40)
1984	37.14 (2.16)	34.89 (1.99)	53.80 (4.13)	40.64 (1.62)
Ratio 84/83	0.95	0.92	1.37	1.04
		<u>1</u>	1983	1984
	Small vessels Large vessels	32.48 46.94	3 (1.95) 4 (4.57)	38.50 (1.52) 48.10 (4.86)

	July	Aug.	Sept.	<u>A11</u>		
1983	7.96 (1.45)	12.26 (1.62)	17.61 (2.72)	11.79 (1.05)		
1984	11.54 (1.51)	13.27 (1.42)	18.93 (3.15)	13.96 (1.05)		
Ratio 84/83	1.45	1.08	1.07	1.18		
		<u>_1</u>	<u>1983</u>			
	Small vessels Large vessels	9.50 14.21	13.93 (1.11) 13.87 (2.54)			

Table 7a. Mean and (s.e.) of total catch per hour of searching (tonnes) including all fishing nights (jackknife estimates).

Table 7b. Mean and (s.e.) of total catch per hour of searching (tonnes) including only successful nights (jackknife estimates).

	July	Aug.	Sept.	A11	
1983	10.83 (2.03)	16.22 (1.86)	17.99 (2.79)	15.33 (1.31)	
1984	17.59 (1.92)	16.87 (1.58)	25.82 (4.10)	19.25 (1.32)	
Ratio 84/83	1.62	1.04	1.44	1.26	
		<u>1</u>	.983	<u>1984</u>	
	Small vessels Large vessels	12.42 18.87	2 (1.13) 7 (2.64)	17.98 (1.30 23.64 (4.21	

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	Voon	Small Poats	Lance Reste	All Posto
Area/Thile	Tear	Sillati Duals	Large Duals	ALL DUGLS
Feeding aggregations,	1983	7.33 + 1.59(9)	12.93 + 3.64(15)	9.97 + 1.82(24)
Seal Island/Gannet,	1984	14.50 + 3.68(19)	13.07 + 4.10(8)	14.38 + 2.78(27)
July-early Aug.	84/83	-	-	1.44
Decenturing and converteg	1002	12 52 ± 1 06/22)	27 02 + 14 14(6)	15 42 + 2 20/20)
Prespawning and spawning,	1903	13.52 + 1.90(55)	2/.03 + 14.14(0)	10.45 + 2.29(39)
Trinity/Lurcher,	1984	16.71 + 1.86(72)	9.48 + 13.20(4)	16.56 + 1.84(76)
AugSept.	84/83	1.24	-	1.07
Prespawning and spawning,	1983	4.91 + 1.96(2)	18.85 + 6.11(15)	16.37 + 4.93(17)
German Bank/Seal Island,	1984	21.14 + 3.76(32)	33.77 + 9.77(17)	26.25 + 4.09(49)
AugSept.	84/83	-	1.79	1.60

Table 8. Mean + s.e. (sample size) of catch per hour of searching (tonnes) for different areas and times of season (jackknife estimates).

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• <u>••</u> •	Assumptions	Ratio Estimate/ Statistics Records
ESTIMATE NO. 1	One Stats. record for each landing. Ignore O.S.S. pooling. Representative coverage by observers. Simple proportional adjustment based on observed successful nights: # Stats. records.	1.637
* ESTIMATE NO. 2	Some landings not recorded (8.72% of observer records). Ignore O.S.S. pooling. Representative coverage by observers. Simple proportional adjustment based on observed successful nights: adjusted # Stats. records.	1.793
* ESTIMATE NO. 3	Some landings not recorded as for 2. Adjust for 0.S.S. pooling by including observer records where boats fishing for 0.S.S. caught nothing but were credited by the pool. Simple proportional adjustment based on adjusted observed successful nights: adjusted # Stats. records.	1.723
ESTIMATE NO. 4	0.S.S. landings excluded from analysis. Some domestic landings not recorded (13.08% of observer records). Representative coverage by observers. Catch rates for 0.S.S. and domestic identical. Simple proportional adjustment based on observed successful domestic nights: adjusted # Stats. records.	2.019
* ESTIMATE NO. 5	Representative coverage by observers. Direct night-by-night comparisons between (kept) catches recorded by observers and Stats. landings. Ratio observed catches: Stats. landings.	1.798
* FINAL ESTIMATE	Average of estimates 2, 3, and 5.	1.77

Table 9. Estimates of the ratio of herring removals: landings recorded in official Statistics for the 1984 summer purse seine fishery.

	REVISED NOMINAL LANDINGS BY PURSE SEINERS (HOS X 1073)														
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984			
1 2 3 4 5 6 7 8 9 10	754 115375 456587 48892 13171 11017 5684 5647 9229 4544	14162 535000 63966 498384 41949 10496 6147 3804 5145 4073	939 108950 142215 76535 312249 37618 6981 2921 3191 2631	0 34443 120517 112663 50707 203771 16186 4067 3002 1508	37 99512 19418 170131 87823 36424 115338 10071 1983 1080	0 245944 31402 10456 96539 53194 23479 83428 8296 1705	157 67295 119753 37101 3953 17235 13671 8763 30523 3467	1592 6527 44353 254693 13270 1755 2634 3575 1669 6277	0 49705 32199 51685 263211 20454 1431 1550 1002 249	0 53712 51608 9890 45783 102729 6759 991 686 686 661	3367 100483 78271 120044 11963 30271 42086 4790 599 330	0 20951 133085 120913 79449 11796 10196 15585 5321 1195			
01	ONNES LAN	NDED:													
	72288	114466	107787	96337	93025	81755	43177	55387	73755	50031* (76722)	59522* (73762)	70373			

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Table 10a. Revised recorded landings by purse seiners, 1973-84.

Table 10b. Revised recorded landings by other gears, 1973-84.

REVISED NOMINAL LANDINGS BY OTHER GEARS (NOS x 10-3)

	1973	1974	1975	1975	1977	1978	1979	1980	1981	1982	1983	1984
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0 11698 164669 64847 22347 15461 14373 12626 11412 5496	0 70554 10450 155752 13742 5448 2241 1620 6097 1807	1931 170558 47837 21277 93069 15518 2874 466 470 295	240 14264 61915 19586 7958 24314 2037 691 349 249	1127 50982 9241 22827 18238 9285 44608 2395 890 173	35381 100775 4775 892 11088 7237 4087 13033 1542 464	154 103228 106689 10079 686 2460 1850 1320 4761 347	31 3039 16206 104801 8688 1828 873 1376 565 1539	0 26008 975 7131 43505 1274 200 364 364 157	3589 18879 70772 8876 27242 51813 4151 544 291 275	0 27895 22746 48335 4983 11336 21382 2544 752 104	0 51350 7982 10339 5471 1837 3607 714 97 49
ΘT	ONNES LAN 50399	DED: 35204	35921	18941	24146	14115	15844	24197	13951	34702* ( 8011)	24863* (10523)	7710

0 INCLUBES AGES 11+

\* UNBRACKETTED WEIGHTS ARE TABLE TOTALS; BRACKETTED WEIGHTS ARE ACTUAL GEAR CLASS TOTALS. 0.5.5. PURSE SEINE LANDINGS OF 26691T IN 1982 AND 14240T IN 1983 HAVE DEEN INCLUDED WITH THE 'OTHER GEAR' CATEGORY BECAUSE IT IS DELIEVED THAT THESE WERE ACCURATELY REPORTED. THE 'OTHER GEAR' CATEGORY ALSO INCLUDES LANDINGS BY FOREIGN PURSE SEINERS BURING THE YEARS 1973-77. (I.C., IN THIS CONTEXT 'LANDINGS BY OTHER GEARS' REPRESENTS THE PORTION OF THE LANDINGS THAT HAS NOT DEEN UNDER-ESTIMATED OR, MORE CORRECTLY, THE PORTION ADOUT WHICH THERE IS INSUFFICIENT INFORMATION TO CALCULATE APPROPRIATE MULTIPLICATION FACTORS.). Table 11. Revised recorded landings by all gears, 1973-84.

REVISED NOMINAL LANDINGS,	ALL GEARS (	MOS X 1	073)
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	1	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	-+	754	14162	2870	240	1164	35381	311	1623	0	3589	3367	0
2		127073	605564	279508	48707	140494	346719	170523	9566	75713	72591	128378	72301
3	1	621256	74415	190052	182432	28659	36177	226442	60559	33174	122380	101017	141067
4	1	113739	654136	97812	131249	192958	11338	47200	359484	68816	17756	168379	131251
5	1	35518	55691	405318	58663	106061	107627	4639	21958	306716	73025	16946	84920
6	I	25479	15944	53136	228085	45709	60431	19695	3583	21729	154542	41607	13633
7	ļ	20057	8388	9855	18223	159946	27566	15521	3507	1631	10910	63468	13803
8	1	18273	5424	3387	4758	12466	96461	10083	4951	1914	1535	7334	16299
9	I	20541	11242	3661	3351	2873	9838	35284	2234	1366	977	1351	5418
10	1	10040	5830	2926	1757	1253	2169	3834	7816	401	886	434	1263
6	5T0	NNES LAN	DED:			,							
		122687	149670	143708	115178	117171	95882	59021	79584	87706	84733	84385	78093

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Table 12a. Nominal catch matrix used in the 1984 assessment.

NOMINAL CATCH MATRIX FROM TABLE 84 OF CAFSAC RES, DOC, 84/72

	1	1773	1974	1975	1976	1977	1776	1979	1980	1781	1782	1983
1		754	14151	0	0	0	0	311	1623	0	3587	3367
2	I	126421	396153	264491	48470	140474	346719	170523	9566	75713	72591	128376
3	ł	595792	72381	180878	176226	28659	36177	226442	60559	33174	122380	101017
4	1	109530	616622	92487	130598	192958	11338	47200	359484	68316	17756	168379
5	1	34422	53199	383650	72334	106061	107627	4637	21958	306716	73025	16746
6	1	25562	15254	50599	219788	55066	60431	19695	3583	21728	154542	41607
- 7	ł	19361	8120	9357	18960	150588	27286	15521	3507	1631	10710	63468
8	1	17604	5313	3238	4967	12466	96741	9981	4951	1914	1535	7334
9	1	19336	10764	3481	3556	2873	9838	35386	2009	1366	977	1351
10	ł	9661	5787	2842	1835	1253	2169	3834	8179	361	886	434

Age	1973	1974	1975	1976	1977	1978	1979	1980	198 <b>1</b>	1982	1983
1		0.1	00	œ	œ	8					
2	0.5	1.6	5.7	0.5							
3	4.2	2.8	5.1	3.5							
4	3.8	6.1	5.8	0.5							
5	3.2	4.7	5.6	-18.9							
6	3.6	4.5	5.0	3.8	-17.0						
7	3.6	3.3	5.3	-3.9	6.2	1.0					
8	3.8	2.1	4.6	-4.2		-0.3	1.0				
9	4.1	2.5	5.2	-5.8			-0.3	11.2			
10	3.9	1.6	3.0	-4.3				-4.4	11.1		

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Table 12b. Difference between revised catch matrix (Table 11) and nominal catch matrix used in previous assessments (Table 12a), as a percentage of the latter. Blanks represent no difference.

	1	1973	1974	1975	1976	1977	1978	1977	1780	1981	1782	1983	1784
1	-+-	1018	18411	3199	240	1170	35381	342	2339	0	3589	5488	0
2	1	167454	765064	317640	55596	153921	383611	183982	12503	103051	102133	191682	88433
3	ł	781061	73606	239827	206535	31572	40887	250393	80518	50883	150764	150328	243542
4	1	130851	803651	124599	153782	218478	12706	54620	474091	102743	22640	244007	224354
-5	ł	40128	68276	514605	68804	119234	122108	5430	27929	451482	98206	24483	146096
ó	1	30334	19093	66302	268837	51173	68410	23142	4373	32978	211043	60678	2271á
- 7	l	22046	10232	12298	21460	177247	31088	18255	4692	2418	14627	89982	21654
8	i	20249	6565	4409	5571	13977	108975	11836	6560	2766	2080	10352	28299
9	1	23871	12785	4778	3951	3170	11082	41389	2985	1917	1354	1728	9515
10	1	11630	7102	3847	2059	1415	2425	4527	10641	538	1250	642	2183
,	oto	TAL TONN	ES REMOV	/ED:									
		147988	184010	181433	134445	131125	108147	67656	104508	128271	112250	121884	132270
1	OTC	nnes rem	OVED DY	DOMESTIC	PURSE S	EINERS;				*			
		97589	148806	145512	115604	103779	74031	51812	80311	114320	104239*	111261*	124560

a INCLUDES AGES 11+

A INCLUDES FISH LANDED FOR 0,5,5, THAT WERE ORIGINALLY INCLUDED IN THE 'OTHER GEAR' CATEGORY (SEE TABLE 10 FOOTHOTE),

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Table 14a. Population numbers at age estimated from nominal catch matrix (Table 11) with  $F_t = 0.3$ .

	population munders																			
1	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1961	1982	1783	1984
1   2   3   5   5   5   7   10	3472619 3855672 793326 1321275 349286 92797 45763 4164 1365 413	2730479 2614866 2175263 781747 869690 240797 66392 35936 2901 1069	6135154 2095890 1313766 1374737 573641 420614 155602 41716 22435 846	1267989 4369558 1160426 936614 884442 370080 200480 74962 30085 17998	1734251 889113 1415780 746528 691635 461459 236864 82146 32440 10660	2183111 1321371 465243 677939 491478 419282 275898 137370 46811 20818	6369688 1154247 559850 311660 296015 220322 234445 124601 75138 19078	942035 5135821 579261 291970 158683 139598 111985 107236 56753 28384	1939497 771273 3617386 409125 104662 60059 46083 47289 43732 22590	1440199 1586425 516485 2399529 232048 53552 25214 19581 22183 17128	213800 1166321 750918 355527 1372662 139593 29413 13053 11124 7990	650461 172448 701993 442834 202577 757110 66210 15168 7623 5795	3299082 532335 97116 409672 243862 112776 413489 37719 8114 3209	1006432 2699188 308715 53580 160816 103641 50974 193811 19602 4043	302360 791983 1896184 220020 33609 34280 30173 16791 71398 7147	1445380 247270 494125 1347571 137429 23319 10245 10660 4624 26529	1277554 1161909 193792 349759 778023 92649 15850 5215 4248 1764	1068676 1045973 899157 118646 224071 359463 56194 11501 2538 2242	1518538 871710 790687 625434 89261 117395 154468 36136 8027 1194	1518550 1240227 597535 555956 359706 57747 58467 69040 22950 5350
1+1 2+1 3+1 4+1	10156680 6664061 2808389 1615063	9519140 6788661 4173795 1998532	12134600 5999447 3903557 2589791	9312635 8044646 3675088 2514661	6300875 4566624 3677511 2261731	6037321 3856210 2534837 2067576	9365042 2995356 1841109 1281259	7551726 6609691 1473870 894609	7060996 5122498 4351225 733840	6312343 4872144 3285719 2769235	4060426 3846626 2680305 1929387	3022218 2371757 2199309 1497316	5156315 1858233 1325897 1228781	4600802 3594370 895182 586467	3403945 3101584 2309602 413418	3747153 2301772 2054502 1560377	3900763 2623209 1441300 1247508	3798482 2729806 1683833 784676	4212650 2694312 1822602 1031914	4485527 2966977 1726750 1129215

Table 14b. Population numbers at age estimated from adjusted catch matrix (Table 13) with  $F_t = 0.3$ .

	POPULATION HUNDERS																			
1	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1784
1 2 3 4 5 6 7 8 9 10	3533515 3878732 1002858 1324529 351122 93296 46173 4172 1374 415	2760572 2648350 2194142 789551 872354 242300 66800 36271 2708 1076	6159590 2120528 1341180 1390194 580031 422995 156832 42051 22709 852	1297868 4389565 1180599 959059 897097 375311 202266 75970 30359 16223	1774003 913575 1432160 763044 710011 471820 241147 83608 33265 10864	2326911 1353917 485272 691350 505000 434327 284381 140676 48063 21494	7564070 1271981 586496 328058 306994 231392 246763 131547 78009 20059	1152712 6113700 675653 313787 172108 148587 121049 117321 62440 30735	2367059 943761 4418005 488044 122524 71051 53443 54710 51989 27546	1648280 1937063 621167 2910423 281177 64005 30724 23807 26471 20965	266715 1332839 892770 423871 1655679 168430 35127 15896 13551 10104	852901 215474 803823 513933 234294 8899921 77906 17631 9025 6771	4447392 698079 126110 471234 281626 129567 485350 44366 9394 3814	1355463 3640158 432266 74683 188127 122688 59777 236992 23677 4823	468512 1077745 2633204 316913 49467 43537 38548 20812 95428 9358	2258871 383276 715909 1929321 210044 35587 14706 15043 6330 40680	2117316 1847291 302486 513281 1150619 146698 25180 7794 6380 2482	1801681 1733512 1419189 201614 327274 533529 90267 16427 3678 3487	1346392 1471844 1326866 1025517 144582 179089 245857 60669 13205 13205 1750	1847760 1506732 1031603 550324 618836 96221 91722 119871 40305 9247
1+  2+  3+  4+	10236186 6702670 2923939 1821081	9614325 6853753 4205403 2011261	12236962 6077372 3956843 2615664	9426316 8128448 3738883 2558284	6433517 4659514 3745938 2313778	6291535 3964624 2610707 2125436	10765368 3201299 1929318 1342822	8708091 7755379 1641679 966026	6578131 6231072 5287311 869306	7564082 5915802 3978739 3357572	4814981 4548266 3215427 2322657	3621681 2768779 2553306 1749463	6696932 2249540 1551460 1425351	6138654 4783191 1143032 710767	4753525 4285012 3207267 574063	5609766 3350695 2967619 2251710	6119527 4002211 2154920 1852434	6132560 4331179 2597667 1178475	6315971 4469578 2997734 1670868	6312621 4464861 2958129 1926526

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Table 15a. Mean population biomass estimated from nominal catch matrix (Table 11) with  $F_t = 0.3$ .

# MEAN POPULATION BIDHASS (1)

1	1765	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1781	1962	1983	1984
1   2   3   5   5   5   7   8   10	30326 120366 98932 185724 63586 20030 11626 1129 429 138	23792 77501 175383 115642 134797 47558 15187 9256 571 335	52025 64876 124832 191200 101250 75478 31577 11474 7128 239	10674 107460 105091 136766 141739 75828 37932 16398 6628 5210	15185 26833 112222 104745 118624 91633 52230 20294 9275 3227	16144 36358 42934 79275 73676 80762 54435 33315 10938 5922	57306 34173 46086 38981 45366 40663 46513 27867 17002 5186	8538 177626 54799 31403 22129 21431 21463 22868 13202 7116	17566 18299 313603 44747 17131 10097 8642 10985 10215 5793	12984 53284 47497 322483 37403 9665 5120 4817 4759 4391	1924 19024 55013 48674 223049 23572 5755 3364 2924 2166	5374 4270 61731 53056 35784 141680 14036 3578 1751 1758	27886 26759 8274 46360 35015 21340 34943 9004 1917 936	8549 64357 29356 7742 18714 15396 9299 40477 4333 983	2737 25887 179905 30186 6137 5055 5364 3047 16044 1703	13072 8797 46773 178337 24757 4714 2130 2251 1051 7795	11577 42378 17805 48552 118172 18517 3878 1201 1111 543	9667 37408 84452 16534 35977 61647 12993 3120 631 609	13747 29767 74642 62626 15775 21472 30339 9382 2336 333	13749 40859 62100 83739 64726 11775 12875 16092 5580 1533
1+1 2+1 3+1 4+1	532287 501961 381596 282664	622241 598249 520748 325364	660100 608075 543199 418367	645925 635251 527792 422701	554467 539283 512450 400228	433758 417614 381256 338322	359162 301856 267663 221577	380575 372037 194411 139613	457278 439712 421413 107810	502406 489421 436137 388639	385464 383540 364517 309504	323959 318064 313774 251843	264455 234567 207809 199515	179607 190658 126301 96945	276066 273327 247440 67535	290121 277029 268032 221239	263761 252182 209784 191976	265040 255372 217964 133512	280418 266672 236705 162263	313030 277231 258422 196322

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Table 15b. Mean population biomass estimated from adjusted catch matrix (Table 13) with  $F_t = 0.3$ .

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## MEAN POPULATION BIOMASS (t)

	1965	1966	1967	1968	1967	1970	1971	1972	1773	1974	1975	1976	1977	1978	1979	1780	1981	1782	1983	1784
1   2 3 4   5   5   7 8   10	30697 121232 97879 186233 63951 20145 11733 1131 431 139	24265 78770 197310 116859 135335 49905 15294 9355 593 337	52247 65803 127620 173621 102518 75992 31706 11592 7216 241	10945 108258 107148 142468 144281 77038 33414 16703 6721 5290	15545 27757 113925 107529 122281 74037 53351 20727 7541 3306	17467 37610 44973 81434 76426 84266 56697 34356 11337 6164	68132 38646 48834 41582 47588 43257 47771 29955 17967 5540	10448 214021 64578 34982 24701 23633 23871 25928 15074 7976	21449 22212 381781 53759 20241 12098 10229 12883 12295 7316	14850 64308 56871 370156 45234 11547 6237 5862 5817 5374	2402 21760 64670 57237 265729 28131 6770 4044 3496 2708	7729 5455 71061 61445 41263 166430 16513 4151 2313 2053	40303 36160 11122 53709 40876 24738 101513 10717 2250 1130	12113 88000 41658 11067 22585 18794 11157 51387 5414 1214	4245 36266 253461 44690 9168 6747 7144 3730 22730 2351	20462 13993 68207 259131 38473 7641 3114 3262 1455 12237	19170 66576 27849 71072 175040 29517 6186 1812 1696 770	16312 62367 135712 27501 53580 94311 21304 5062 773 977	16708 50787 126352 136462 25871 33165 50161 16084 3733 558	16733 49628 107211 143137 111358 19621 20197 27940 9800 2649
1+  2+  3+  4+	535593 504876 383664 283764	628024 603759 524989 327679	668755 616508 550705 423085	657266 646321 538064 430715	568000 552455 524678 410773	450729 433263 395652 350679	391293 323161 284515 235681	445472 435025 221004 156405	554261 532813 510600 128820	606297 571447 527140 470249	457189 454787 433027 368337	375414 370685 365230 274167	322516 282213 246053 234731	263389 251276 163276 121618	390752 386507 350241 96780	427974 407513 393520 325313	379728 380538 313960 286112	420119 403807 341441 205729	462120 445412 374625 268273	508276 471544 441916 334705

# FISHING MORTALITY

1	1965	1766	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1973	1979	1780	1781	1962	1783	1784
1   2   3 4   5 6   7 8   10	0.069 0.372 0.040 0.218 0.172 0.135 0.042 0.161 0.045 0.104	0.064 0.488 0.259 0.110 0.526 0.237 0.265 0.271 1.032 0.250	0.137 0.391 0.138 0.241 0.238 0.541 0.530 0.127 0.020 0.483	0.155 0.927 0.241 0.103 0.451 0.246 0.692 0.638 0.838 0.838 0.423	0.072 0.448 0.536 0.218 0.301 0.314 0.345 0.362 0.244 0.325	0.437 0.659 0.201 0.629 0.602 0.381 0.595 0.403 0.698 0.462	0.015 0.489 0.451 0.475 0.552 0.477 0.582 0.586 0.773 0.565	0.000 0.150 0.148 0.826 0.772 0.908 0.662 0.697 0.708 0.708 0.754	0.000 0.201 0.210 0.367 0.470 0.656 0.557 0.737 0.652	0.011 0.548 0.173 0.359 0.363 0.365 0.365 0.821 0.471	0.015 0.308 0.328 0.362 0.375 0.546 0.462 0.338 0.452 0.512	0.000 0.374 0.339 0.397 0.386 0.405 0.405 0.426 0.426 0.465 0.404	0.000 0.345 0.375 0.735 0.655 0.554 0.558 0.455 0.496 0.557	0.040 0.153 0.137 0.266 1.346 1.034 0.710 0.799 0.809 0.876	0.001 0.272 0.142 0.271 0.166 1.008 0.840 1.090 0.770 0.876	0.001 0.044 0.146 0.349 0.194 0.186 0.475 0.720 0.763 0.390	0.000 0.073 0.210 0.245 0.572 0.300 0.121 0.520 0.439 0.287	0.004 0.080 0.163 0.166 0.447 0.645 0.242 0.160 0.554 0.566	0.002 0.178 0.152 0.353 0.235 0.477 0.605 0.254 0.206 0.507	0.002 0.066 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300
4+1	0.200	0.316	0,303	0.320	0.282	0,553	0.542	0.783	0,468	0.360	0.401	0.400	0.636	0.952	0.498	0.338	0.453	0.473	0.393	0.300

Table 16b. Fishing mortalities estimated from adjusted catch matrix (Table 13) with  $F_t = 0.3$ .

#### FISHING MORTALITY

	1965	1966	1967	1768	1767	1970	1971	1772	1973	1974	1975	1976	1977	1978	1977	1930	1931	1982	1783	1784
1 2 3 4 5 6 7 8 9	0.088 0.370 0.218 0.171 0.134 0.041 0.161 0.044 0.103	0.064 0.480 0.256 0.108 0.524 0.235 0.263 0.268 1.028 0.249	0.139 0.386 0.135 0.238 0.235 0.538 0.525 0.525 0.126 0.020 0.479	0.151 0.920 0.236 0.101 0.443 0.242 0.683 0.626 0.826 0.826 0.417	0.070 0.433 0.528 0.213 0.271 0.306 0.355 0.355 0.237 0.317	0.404 0.637 0.192 0.612 0.580 0.365 0.571 0.391 0.673 0.444	0.013 0.433 0.425 0.445 0.526 0.526 0.544 0.545 0.545 0.731 0.529	0.000 0.125 0.125 0.740 0.665 0.823 0.574 0.613 0.613 0.673	0.000 0.218 0.217 0.351 0.447 0.636 0.607 0.526 0.703 0.615	0.012 0.575 0.182 0.364 0.312 0.400 0.457 0.364 0.763 0.763 0.463	0,013 0.306 0.352 0.373 0.421 0.571 0.489 0.366 0.494 0.538	0.000 0.336 0.334 0.402 0.372 0.406 0.363 0.430 0.661 0.405	0.000 0.279 0.324 0.718 0.631 0.574 0.517 0.428 0.467 0.521	0.029 0.124 0.110 0.212 1.263 0.958 0.355 0.755 0.710 0.728 0.773	0.001 0.209 0.111 0.211 0.127 0.685 0.741 0.990 0.453 0.749	0.001 0.037 0.133 0.317 0.159 0.146 0.435 0.658 0.736 0.338	0.000 0.064 0.206 0.250 0.569 0.286 0.112 0.478 0.404 0.272	0.002 0.067 0.125 0.133 0.403 0.575 0.133 0.403 0.133 0.488 0.497	0.003 0.155 0.134 0.305 0.207 0.207 0.469 0.207 0.209 0.156 0.447	0.002 0.067 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300 0.300
4+	0,200	0.313	0,299	0,314	0,275	0,534	0.510	0,699	0.445	0.365	0.428	0.403	0.608	0.860	0,401	0.304	0.450	0.415	0.341	0.300

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FIGURE 1. Percentages of fishing nights that were unsuccessful (no loaded catch). Shaded areas represent nights when no sets were made.

29 -

I.



1984

1983

FIGURE 2. Percentages of sets that were abandoned. Shaded areas represent sets abandoned because fish were too small.

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Figure 3a. Nominal and adjusted 1+ catch biomass, 1965-84.

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Figure 3b. Nominal and adjusted 1+ population biomass, 1965-84 (from Tables 15a,b).