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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.


## Rēsumē

On résume les résultats d'un programme d'observation de deux ans portant sur la pēche du hareng à la senne coulissante. En 1983 et en 1984, la pêche à la senne coulissante a êté caractêrisée 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 entraīnē une redistribution temporelle et spatiale de la pêche qui s'est poursuivie plus tard dans la saison et qui s'est êtendue aux frayères et aux endroits oü se nourrissent les juvéniles. On a donc calculé les indices du taux de capture pour les catégories marché/lieux de pèche 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 dēbarquements de pêche à la senne coulissante et les prises totales enregistrées pour la période 1973-1984. Ces estimations ont êté 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 dëbarquements. Les valeurs obtenues pour les prises à la senne coulissante ont été corrigēes en foncton des écarts calculés, puis recombinees aux quantitēs pēchëes au moyen d'autres engins pour donner une matrice ajustēe des prises. Une analyse par cohorte, basée sur la matrice ajustēe, 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 4 Xa 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 $3 \mathrm{a}-\mathrm{d}$ ). 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 $340 \times 40$ cf $250 \times 25$ 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 $74-111^{\prime}$, but only two boats less than $90^{\prime}$ ) 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 ( $4 \mathrm{Xa}, 4 \mathrm{Xb}$, and 4 W ). For 1983 and 1984, the final estimates are based on direct comparisons of observer trip reports from the summer $4 \times a$ 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 4 Xb and 4 W 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 $12,558 \mathrm{t}$ compared to Statistics Branch records of $58,354 \mathrm{t}$ (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 O.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 O.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:

| 1973 | 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, $85,377 \mathrm{t}$ and $80,311 \mathrm{t}$ ) 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 ( $P R=1$ 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 $19843+$ biomasses differ by a factor of 1.71 between the two runs (Tables $15 a$ 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 $545,000 \mathrm{t}$ derived by Buerkle (1985) for overwintering (beginning-of-year) herring in the Chedabucto Bay region.

## A Caútionary 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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Table 1. Observer sampling of the 4 Xa summer purse seine fishery.

|  | June | July | Aug. | Sept. | Oct. | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1983 |  |  |  |  |  |  |
| 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 |
| Total 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 $(\mathrm{t})$ | - | 3401 | 5795 | 4630 | 209 | 14035 |
| Kept catch ( t$)$ | - | 2860 | 5024 | 4465 | 209 | 12558 |
|  | Total Landings Recorded by Statistics | Branch 58354 t |  |  |  |  |

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

| 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 |

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

|  | July | Aug. | Sept. | All |
| :--- | :--- | :--- | :--- | :--- | :--- |
| 1983 | 1.20 | 1.61 | 1.67 | 1.48 |
| 1984 | 1.12 | 1.86 | 1.36 | 1.45 |

b. Successful sets per successful night.

|  | July | Aug. | Sept. | All |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  | 1.24 | 1.56 | 1.50 | 1.46 |
| 1984 | 1.38 | 1.82 | 1.46 | 1.58 |

c. Average time searching (all nights).

1983
1984

| July | Aug. | Sept. | All |
| :--- | :--- | :--- | :--- |
| 5.32 | 4.45 |  |  |
| 3.62 | 4.68 | 3.28 | 4.43 |
|  |  |  | 4.00 |

d. Average time searching on successful nights.

| July | Aug. | Sept. | All |
| :--- | :--- | :--- | :--- |
|  |  |  |  |
| 4.59 | 3.96 | 3.36 | 3.95 |
| 3.33 | 4.29 | 3.01 | 3.65 |

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

|  | 1983 | 1984 |
| :--- | ---: | ---: |
| Too small | $11.1 \%$ | $3.0 \%$ |
| Too large | $0.4 \%$ | - |
| Red feed | $1.3 \%$ | $1.9 \%$ |
| Not ripe | - | $1.1 \%$ |
| Skunk | $7.4 \%$ | $8.8 \%$ |
| Gear problems and misc. | $2.5 \%$ | $1.9 \%$ |
| TOTALS | $22.7 \%$ | $16.7 \%$ |

Table 4b. Percentage of catch rejected.

|  | July | Aug. | Sept. | Al1 |
| :--- | :---: | :---: | :---: | ---: |
| 1983 | 26.05 | 11.98 | 3.87 | 13.55 |
| 1984 | 15.90 | 13.30 | 3.55 | 10.52 |

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

|  | July | Aug. | Sept. | All |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  | . | 1983 |  | 1984 |
|  | Small vessels <br> Large vessels | 44.6 60.0 | $(3.57)$ $(5.78)$ | $53.18(3.00)$ $65.22(7.70)$ |

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

|  | July | Aug. | Sept. | All |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  | 1983 |  | 1984 |
|  | Small vessels Large vessels | $\begin{aligned} & 51.04 \quad(3.33) \\ & 63.60(6.31) \end{aligned}$ |  | $59.22(2.86)$ $85.10(8.17)$ |

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

|  | July | Aug. | Sept. | All |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  | 1983 |  | 1984 |
|  | Small vessels Large vessels | 29.73 | $(1.83)$ $(3.58)$ | $36.33(1.61)$ $46.47(4.61)$ |

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

|  | July | Aug. | Sept. | All |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  | 1983 |  | 1984 |
|  | Small vessels <br> Large vessels | $46.94(4.57)$ |  | $\begin{array}{ll} 38.50 & (1.52 .) \\ 48.10 & (4.86) \end{array}$ |

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

|  | July | Aug. | Sept. | All |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
|  |  | $\underline{1983}$ |  | 1984 |
|  | Small vessels Large vessels | $\begin{array}{r} 9.50(1.03) \\ 14.21(1.91) \end{array}$ |  | $13.93(1.11)$ $13.87(2.54)$ |

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

|  | July | Aug. | Sept. | All |
| :--- | :---: | :---: | :---: | :---: |
| 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 |
|  |  |  | 1983 | 1984 |
|  |  |  | $12.42(1.13)$ | $17.98(1.30)$ |
|  |  |  | $18.87(2.64)$ | $23.64(4.21)$ |

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

| Area/Time | Year | Small Boats | Large Boats | All Boats |
| :---: | :---: | :---: | :---: | :---: |
| 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 |
| Prespawning and spawning, | 1983 | $13.52+1.96(33)$ | $27.83+14.14(6)$ | $15.43+2.29(39)$ |
| Trinity/Lurcher, | 1984 | $16.71+1.86(72)$ | $9.48+13.20(4)$ | $16.56+1.84(76)$ |
| Aug.-Sept. | 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 | $21.14+3.76(32)$ | $33.77+9.77(17)$ | $26.25+4.09(49)$ |
| Aug.-Sept. | 84/83 | - | 1.79 | 1.60 |

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

|  | Assumptions | Ratio Estimate/ Statistics Records |
| :---: | :---: | :---: |
| ESTIMATE NO. 1 | One Stats. record for each landing. Ignore O.S.S. pooling. <br> 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). <br> Ignore O.S.S. pooling. <br> 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 O.S.S. pooling by including observer records where boats fishing for O.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 | O.S.S. landings excluded from analysis. Some domestic landings not recorded (13.08\% of observer records). Representative coverage by observers. Catch rates for O.S.S. and domestic identical. <br> 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 10a. Revised recorded landings by purse seiners, 1973-84.

REVISED HOMIMAL LAMDIHGS EY FURSE SEINERS (HOS $\times 10^{-3}$ )

|  | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1990 | 1981 | 1992 | 1993 | 1984 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 754 | 14162 | 939 | 0 | 37 |  | 157 | 1592 | 070 | - ${ }^{0}$ | 3357 | 0 |
| 2 | 115375 | 535000 | 108950 | 34443 | 99512 | 245944 | 67295 | 6527 | 49705 | 53712 | 100483 | 20951 |
| 3 | 456597 | 53956 | 142215 | 120517 | 19419 | 31402 | 119753 | 44353 | 32199 | 51608 | 78271 | 133085 |
| 4 | 48892 | 498394 | 75535 | 112553 | 170131 | 10456 | 37101 | 254693 | 61685 | 8980 | 120044 | 120913 |
| 5 | 13171 | 41949 | 312249 | 50707 | 87323 | 95539 | 3953 | 13270 | 263211 | 45783 | 11953 | 79449 |
| 6 | 11017 | 10496 | 37518 | 203771 | 36424 | 53194 | 17235 | 1755 | 20454 | 102729 | 30271 | 11796 |
| 7 | 5694 | 6147 | 5981 | 16186 | 115338 | 23479 | 13671 | 2634 | 1431 | 6759 | 42086 | 10196 |
| 8 | 5547 | 3804 | 2921 | 4067 | 10071 | 83429 | 8763 | 3575 | 1550 | 991 | 4790 | 15595 |
| 9 | 9239 | 5145 | 3191 | 3002 | 1993 | 8296 | 30523 | 1659 | 1002 | 686 | 599 | 5321 |
| 10 | 4544 | 4073 | 2531 | 1509 | 1080 | 1705 | 3467 | 6277 | 249 | 861 | 330 | 1195 |
| Q fonnes lammed; |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 72289 | 114456 | 107797 | 95337 | 93025 | 91755 | 43177 | 55387 | 73755 | 50031* | 59522* | 70373 |
|  |  |  |  |  |  |  |  |  |  | (75722) | (73762 |  |

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

FEVISED MOMIHAL LAHDIHGS BY OTHER GEARS (MOS x 10³)

|  | 1973 | 1974 | 1975 | 1975 | 1977 | 1978 | 1979 | 1980 | 1981 | 1992 | 1983 | 1984 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0 | 0 | 1931 | 240 | 1127 | 35381 | 154 | 31 | 0 | 3509 | 0 | 0 |
| 2 | 11698 | 70564 | 170559 | 14264 | 50982 | 100775 | 103228 | 3039 | 26008 | 18979 | 27895 | 51350 |
| 3 | 154659 | 10450 | 47837 | 61915 | 9241 | 4775 | 106689 | 16205 | 875 | 70772 | 22743 | 7982 |
| 4 | 64847 | 155752 | 21277 | 19586 | 22827 | 892 | 10099 | 104801 | 7131 | 8876 | 49335 | 10339 |
| 5 | 22347 | 13742 | 93059 | 7956 | 18238 | 11088 | 686 | 8688 | 43505 | 27242 | 4983 | 5471 |
| 6 | 15451 | 5448 | 15518 | 24314 | 9285 | 7237 | 2460 | 1828 | 1274 | 51913 | 11335 | 1837 |
| 7 | 14373 | 2241 | 2374 | 2037 | 44608 | 4097 | 1850 | 873 | 200 | 4151 | 21382 | 3607 |
| 8 | 12525 | 1620 | 465 | 691 | 2395 | 13033 | 1320 | 1376 | 364 | 544 | 2544 | 714 |
| 9 | 11412 | 5097 | 470 | 349 | 890 | 1542 | 4751 | 555 | 364 | 291 | 752 | 97 |
| 101 | 5496 | 1807 | 295 | 249 | 173 | 464 | 367 | 1539 | 152 | 225 | 104 | 89 |
| GTOMHES LAMDED: |  |  |  |  |  |  |  |  |  |  |  |  |
| 50399 |  | 35204 | 35921 | 18941 | 24146 | 14116 | 15844 | 24197 | 13951 | $\begin{aligned} & 34702 * 24853: \\ & (8011)(10523) \end{aligned}$ |  | 7710 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

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Table 11. Revised recorded landings by all gears, 1973-84.


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

|  | 1 | 1773 | 1774 | 1775 | 1976 | 1777 | 1776 | 1979 | 1700 | 1731 | 1782 | 1783 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | 754 | 14151 | 0 | 0 | 0 | 0 | 311 | 1623 | 0 | 3537 | 3367 |
| 2 | 1 | 126421 | 596153 | 264471 | 48470 | 140494 | 346719 | 170523 | 9566 | 75713 | 72571 | 128376 |
| 3 |  | 595972 | 72381 | 160896 | 176226 | 28657 | 36177 | 2264,2 | 60557 | 33174 | 122330 | 101017 |
| 4 | 1 | 109530 | 616622 | 92437 | 130598 | 172553 | 11338 | 47200 | 359434 | 65316 | 17756 | 165379 |
| 5 |  | 34422 | 53177 | 333650 | 72334 | 106061 | 107627 | 4637 | 21753 | $306716^{\circ}$ | 73025 | 16946 |
| 6 |  | 25562 | 15254 | 50599 | 219786 | 55066 | 60431 | 19695 | 3583 | 21726 | 154542 | 41607 |
| 7 |  | 17361 | 2120 | 7357 | 18960 | 150528 | 27236 | 15521 | 3507 | 1631 | 10710 | 43468 |
| 8 | 1 | 17604 | 5313 | 3238 | 4967 | $1246{ }^{\text {a }}$ | 95741 | 9981 | 4951 | 1914 | 1535 | 7334 |
| 7 |  | 17336 | 10764 | 3481 | 3556 | 2373 | 9833 | 35385 | 2007 | 13 ¢́6 | 777 | 1351 |
| 10 | 1 | 9óó | 5787 | 2842 | 1835 | 1253 | 2169 | 3834 | 8179 | 361 | 836 | 434 |

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.

| Age | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| 1 |  | 0.1 | $\infty$ | $\infty$ | $\infty$ | $\infty$ |  |  |  |  |  |
| 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 |  |  |

Table 13. Adjusted total removals by all gears, 1973-84.

|  | 1 | 1973 | 1974 | 1775 | 1776 | 1977 | 1978 | 1977 | 1980 | 1781 | 1722 | 1783 | 1784 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 1 | 1018 | 18411 | 3199 | 240 | 1170 | 35381 | 342 | 2339 | 0 | 3587 | 5488 | $\hat{6}$ |
| 2 | 1 | 167454 | 766064 | 317640 | 55576 | 153721 | 353611 | 163982 | 12503 | 103051 | 102133 | 151682 | 68433 |
| 3 | 1 | 781061 | 73606 | 239827 | 206535 | 31572 | 40887 | 250393 | 80518 | 50883 | 150764 | 150326 | 243542 |
| 4 | 1 | 130851 | 803651 | 124597 | 153782 | 213476 | 12706 | 54620 | 474071 | 102743 | 22640 | 244007 | 224354 |
| 5 | 1 | 40128 | 68276 | 514605 | 68604 | 119234 | 122100 | 5430 | 27929 | 451482 | 93206 | 24483 | 146096 |
| $\dot{6}$ | 1 | 30334 | 17073 | 66302 | 268537 | 51173 | 68410 | 23142 | 4373 | 32976 | 211043 | 60676 | 22716 |
| 7 | 1 | 22046 | 10232 | 12278 | 21460 | 177247 | 31086 | 18255 | 4692 | 2418 | 14627 | 89982 | 21654 |
| e | ; | 20249 | 6565 | 4409 | 5571 | 13777 | 103975 | 11836 | 6500 | 2766 | 2080 | 10352 | 28297 |
| 9 | 1 | 23871 | 12785 | 4778 | 3951 | 3170 | 11082 | 41389 | 2965 | 1.917 | 1354 | 1728 | 7515 |
| 10 | - | 11630 | 7102 | 3847 | 2059 | $1+15$ | 2425 | 4527 | 10641 | 538 | 1250 | 642 | 2183 |
| gtotal tommes menoven; |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 147988 | 184010 | 181433 | 134445 | 131125 | 108147 | 67556 | 104508 | 128271 | 112250 | 121884 | 132270 |
| etomme menoven dr nomestic furse seiners: |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 97589 | 148806 | 145512 | 115604 | 103777 | 74031 | 51812 | 80311 | 114320 | 104237* | 111281* | 124500 |

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* thelume rish lamded for $0,5,5$, that were oricthally mbluded in the iother gear' catecory (see TADLE 10 FOOTHOTE:

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

| ron |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1765 | 1966 | 1967 | 1768 | 1969 | 1970 | 1971 | 1772 | 1973 | 1774 | 1975 | 1976 | 1977 | 1970 | 1979 | 1966 | 17\% | $9{ }^{9} 2$ | 1763 | 1984 |
| $\frac{1}{2}$ | ${ }_{3655652} 3$ | ${ }_{26314896}$ | 615154 205689 | ${ }^{12678959}$ | ${ }^{17897511}$ | ${ }_{1218311}^{21371}$ | ${ }^{6369688}$ | ${ }_{5}{ }^{9} 1293853$ | 1838497 71273 | 140199 158625 | ${ }_{1}^{2163800}$ |  | 3298088 | ${ }_{2699188}^{1064}$ | ${ }^{3023969}$ | 2145380 | ${ }^{1751599}$ | ${ }^{10686976}$ | 1516538 | ${ }_{12452785}$ |
| 3 | ${ }^{1937323} 5$ | ${ }^{2158563}$ | $\underset{\substack{1313766 \\ 137777}}{ }$ | ${ }_{\substack{16436 \\ \hline 83614}}$ | 145780 | ${ }^{46524} 3$ |  | 59261 | 3217385 | 515645 |  | ${ }^{7} 701983$ | -9716 | ${ }^{308535}$ | 18966184 | 494125 | ${ }^{175792}$ | 89 |  | 597535 |
| 5 |  |  | 57364 |  |  | 4 |  |  | 10465 |  |  |  |  | 1651 | 33609 | 1 |  |  |  |  |
| 9 | 92997 4787 | 240 | 120614 | 370 | ${ }^{401459}$ | 41 | 22032 | 139598 |  |  |  | \$71 | 112 | 103 | 34880 |  | 920 |  | 117395 | 5774 |
| 8 | 416 | 3599 | 41716 | 72496 | ${ }_{8} 8146$ | 13770 | ${ }_{12401}^{234}$ | ${ }^{107253}$ | ${ }^{467289}$ | ${ }_{15951}^{2595}$ | 130 | ${ }^{66158}$ | ${ }^{13} 719$ | 19381 | ${ }^{30779}$ | 106 | 5 | ${ }^{31504}$ | 边 | 689 |
| 10 | ${ }_{4}^{135}$ | 2969 | ${ }^{22435}$ | ${ }^{300898}$ | 3440 | ${ }^{26818}$ | ${ }^{231589}$ | 58833 | ${ }^{47738}$ | 72788 | $1{ }^{11724}$ | ${ }^{7685}$ | $\frac{8164}{329}$ | ${ }^{19662}$ | 77179 | 26529 | ${ }_{1}^{1248}$ | ${ }_{2538}$ | 1194 | ${ }^{22850}$ |
|  | 10156860 | 951944 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 3798462 |  |  |
| $\stackrel{3+1}{3+1}$ | ${ }_{26888869}{ }^{6686}$ | 4888369 | ${ }_{5}^{57994} 5$ | $\frac{8044446}{3658988}$ | ${ }^{46566515}$ | ${ }^{1353521939}$ | ${ }^{299935169}$ | ${ }^{6098989} 14$ | ${ }^{51224929} 4$ | ${ }^{\text {c }}$ |  | ${ }_{2159359}$ |  | ${ }_{89593182}$ | 3151594 | 230172 | ${ }^{2623299}$ | ${ }^{276939363}$ | ${ }^{2696312}$ | 296677 |
| +1 | 1815063 | 1998532 | 256779 | 251466 | 2251731 | 206555 | 128125 | 884609 | 733840 | 276923 | 1229387 | 1477316 | 1288781 | 556467 | 413418 | 156037 | 1247508 | 764676 | 1031914 | 1122215 |

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

| 1 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1976 | 1979 | 1960 | 1981 | 1762 | 1983 | 1984 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 11 | 3533515 | 276057 | 6159590 | 1277608 | 1774003 | 2326311 | 7564070 | 1152712 | 2367059 | 1648290 | 460 | 852901 | 447372 | 135343 | 468512 | 2258871 | 2117316 | 1801631 | 13.36392 | 1847760 |
| 2 | 3878732 | 2648350 | 2120528 | 4389565 | 913575 | 1353917 | 1271981 | 8113700 | 943761 | 1937063 | 1332839 | 21547 | 698079 | 3640158 | 1077745 | 383276 | 1847291 | 1733512 | 141614 | 1505732 |
| , | 1002958 | 2194142 | 1341160 | 1189599 | 1372260 | 485272 | 585496 | 670653 | 448005 | 621107 | 882770 | 803823 | 126110 |  | 2633204 | 715909 | 302486 | 1417189 |  | 1031603 |
|  | 351 |  | 1380194 | 959059 | 763044 | 691350 | 328058 | 313787 | 488044 | 2910423 | 423871 | 51333 | 47234 | 74683 | 316913 | 1929321 | 513281 | 201614 | 1025517 | 550324 |
| 5 | 351120 | 87255 | 580031 | 897077 | 710018 | 505000 | 306994 | 172108 | 122824 | 281177 | 1655679 | 23224 | 261626 | 188127 | 49467 | 210044 | 1150619 | 32727 | 14456 | 618836 |
| 6 | 932 | 242 | 422995 | 37511 | 471820 | 434327 | 231392 | 146587 | 71051 | 64005 | 168430 | 889921 | 1295 | 122688 | 43537 | 35597 | 146698 | 53329 | 17908 | 96221 |
| 7 |  |  |  | 202266 | 241147 | 284381 | 246763 | 121049 | 3343 | 30724 | 35127 | 779 | 4853 | 59777 | 385 | 14706 | 25180 | 90267 | 24585 | 81722 |
| 8 | 1172 | 36271 | 42051 | 75970 | 83608 | 140876 | 31547 | 117321 | 54710 | 23807 | 15896 | 17831 | 4366 | 236397 | 20812 | 15043 | 7794 | 124 | 6466 | 19871 |
| 9 | 1374 | 2908 | 22709 | 30359 | 33265 | 48003 | 72009 | 62440 | 51969 | 26471 | 13551 | 9025 | 9394 | 23677 | 75426 | 6330 | 6330 | 35 | 13 x | 40305 |
| 101 | 415 | 1076 | 652 | 18223 | 10864 | 21494 | 20059 | 30735 | 27546 | 20965 | 10104 | 6771 | 3614 | 4823 | 9358 | 40504 | 2462 | 340 | 175 | 9247 |
| 1+1 | 10236186 | 9614325 | 12236962 | \$420315 | 6433517 | 6291535 | 10765368 | 8508091 | 6558131 | 7584082 | 4314981 | 3621681 | 8696932 | 6138654 | 4753525 | 5609706 | $6: 17527$ | 6132cti | 63:5771 | 33125:1 |
| $2+1$ | 6702670 | 6853753 | 6077372 | 0126448 | 4659514 | 3964624 | 3201299 | 7753379 | 6231072 | 5915802 | 4548266 | 2768779 | 2249540 | 4783191 | 4285012 | 3350675 | 4002211 | 43119 | 4489512 | 4464881 |
| $3+1$ | 2923939 | 4205403 | 3956843 | 3738883 | 3745938 | 2610707 | 1929318 | 1641679 | 5267311 | 3978739 | 3215427 | 2553306 | 1551460 | 1143032 | 3207267 | 2967619 | 2154920 | 25976 | 2797734 | 2758129 |
| $4+1$ | 1521081 | 2011261 | 2615604 | 2550264 | 2313778 | 2125436 | 1342222 | 968026 | 869300 | 3357572 | 232265 | 1749463 | 1425351 | 710767 | ${ }_{5} 54063$ | 2251710 | 1852434 | 1173473 | 1673803 | 17.3523 |

Table 15a. Mean population biomass estimated from nominal catch matrix (Table 11) with $\mathrm{F}_{\mathrm{t}}=0.3$.

| 1 | 1765 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1774 | 1975 | 1776 | 1977 | 1778 | 1579 | 1960 | 1762 L | 1982 | 1983 | 964 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 30326 | 23792 | 52025 | 10674 | 15185 | 16144 | 57306 | $8{ }^{65} 38$ | 1756 | 12984 | 1324 | 4270 |  | ${ }^{8949} 6$ | ${ }^{27898}$ | ${ }^{13092}$ | 11579 42398 | 3669 37408 | 13747 27767 | 13749 <br> 4685 <br> 189 |
| 21 | 120366 | 77501 | ${ }^{64876}$ | 107450 | 26833 | 36358 | 34193 | 177626 | 18299 | 53284 | 19024 |  |  | ${ }^{64357}$ | 17998 | 48793 | 1780 | 8445 | 27464 | 6200 |
| 3 | ${ }^{988332}$ | 175363 11542 | 124632 | 105991 | 112222 | 42934 | 46086 36981 | 54799 31403 | 313603 | ${ }^{472489}$ | 48564 | 61736 5056 | 46360 | 7742 | 270186 | 178337 | 4855 | 165 | 82626 | 83 |
| 5 | 63595 | 134797 | 101250 | 141737 | 110624 | 73676 | 45366 | 22129 | 17131 | 37403 | 223049 | 3578 | 35015 | 18714 | 6137 | 24759 | 115172 | 35977 | 1577 | 64726 |
| 6 | 20030 | 49558 | 75478 | 75828 | 91633 | 3.762 | 40663 | 21431 | 10097 | 9665 | 23572 | 141660 | 21340 | 15396 | 5055 | 4914 | 1351 | 61647 | 2147 | 11775 |
| 7 | 11526 | 15127 | 31577 | 37332 | 52230 | 54435 | 46513 | 21463 | . 8642 | 5120 | 57 | 1403 | 3494 | 97299 | ${ }_{3} 534$ | 2130 | 36 | 12976 |  |  |
| 7 | 129 | 9256 |  |  | 20294 | 10338 | 27807 | 13208 | 102 | 4 |  |  | 1717 | ${ }_{4}^{4} 835$ | 16644 | 1051 |  | 51 | 23 | 550 |
| 10 | 138 | 335 | 23 | 52 | 3227 | 5722 | 5186 | 7116 | 5793 | 4351 | 2156 | 1758 | 936 | 98 | 1703 | 775 | 343 | 607 | 333 | 1533 |
| 1+1 | 532287 | 62241 | 660100 | 5925 | 554467 | 433758 | 359162 | 380575 | 457278 | 502406 | 325454 | 323959 | 254455 | 179607 | 276066 | 290121 | 637 | 55040 | 280419 | 3130 |
| 2+1 | 501961 | 598249 | 608075 | 635251 | 53929 | 417614 | 301856 | 372037 | 439712 | 489421 | 383540 | 313064 | 234569 | 170558 | 273327 | 277027 | 252182 | 25.812 | 236 |  |
| $3+1$ | 381596 | 520748 | 543179 | 527792 | 512450 | 381256 | 267657 | 174411 | 421413 | 43613 | 304517 |  | 201809 |  | 24,44 | $2{ }^{2}$ | -1717\% | 173512 | 162243 | 1765 |
| +1 | 282664 | 325334 | 418367 | 422701 | 400228 | 338322 | 221577 | 137613 | 107810 | 368637 | 307504 | 251243 | 177315 | 96945 | 6/305 | 22123 | 1777/6 | 13.12 |  | 17032 |

Table 15b. Mean population biomass estimated from adjusted catch matrix (Table 13) with $\mathrm{F}_{\mathrm{t}}=0.3$.

|  | 1965 | 1966 | 1967 | 1968 | 1967 | 1970 | 1971 | 1972 | 1773 | 1974 | 1775 | 1776 | 1977 | 1976 | 1977 | 1780 | 1901 | 1762 | 1983 | 173 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 30697 | 27770 | 5502 | 10945 | 15545 | 17467 | 68132 | 10448 | 21447 | - | 217 | 515 |  | 18010 |  |  |  |  |  |  |
| $\frac{2}{3}$ | 121232 | 78770 |  |  | 27757 | 37610 | 38646 | 214021 | 22212 | 64308 | 21760 |  | 36160 |  | ${ }^{36266}$ |  |  | 62367 |  |  |
| 4 | ${ }_{186233}$ | 117559 | 193621 | 142468 | 107529 | 44773 81434 | 41486 | 6445989 | 3817759 | $3{ }^{3}$ | 57239 | 71061 61445 | 51120 | 416 | 2 444690 | 25913 | 71072 | 27501 | $1364{ }^{\text {a }}$ | 143 |
| 5 | 62951 | 135335 | 102518 | 144281 | 122281 | 76426 | 47583 | 24701 | 20241 | 45234 | 265529 | 41263 | 40276 | 22535 | 915 | 36473 | 175040 | 53560 | 25691 | 111358 |
| 6 | 20145 | 49905 | 75992 | 77038 | 74037 | 84266 | 43257 | 23633 | 12098 | 11547 | 26131 | 166430 | 24738 | 16794 | 6747 | 7641 | 2751 | 94311 | 33165 | 17621 |
| 7 | 11733 | 15274 | 31706 | 33414 | 53351 | 56697 | 47771 | 23671 | 1022 | 6237 | 6770 | 16513 | 101513 | 11157 | 7144 | 3114 | 618 | 2130 | 50161 | 201 |
| 8 | 1131 | 9355 | 11592 | 16703 | 20727 | 34356 | 29955 | 25928 | 12883 | 5862 | 4044 | 4151 | 10717 | 51367 | 3930 | 326 | 1812 | 5062 | 16004 | 27540 |
| 31 |  |  | 16 |  | 41 | 11337 | 17767 | 15074 | 12275 | 5817 | 3496 | 2313 | 2250 | 5414 | 22730 | 145 | 157 | 93 | 3974 | 訨 |
| 10 | 139 | 337 | 241 | 5290 | 06 | 6164 | 5540 | 7976 | 7316 | 5334 | 2706 | 2065 | 1130 | 1214 | 2351 | 12237 | 776 | 7 |  | 64 |
| 1+1 | 535593 | 628024 | 668755 | 657266 | 568000 | 450729 | 391293 | 445472 | 554261 | 608297 | 457189 | 378414 | 322516 | 263389 | 320752 | 427974 | 39972 ¢ | 420119 | 422120 | 50376 |
| $2+1$ | 504876 | 6037 | 616508 | 546 |  | 433263 | 323161 | 435025 | 532813 | 511447 | 454707 | 370 |  | 251276 | 386507 | 407513 |  | 403607 | 445412 | 47545 |
| + ${ }_{4}^{+1}$ | 283364 | 327678 | 423055 | 43073 | 54 | 3550679 | 2845681 | ${ }_{1}^{221004}$ | 128820 | 470249 | 468337 | 324167 | 234731 | 12148 | 396780 | 32531 | 286 | 205729 | ${ }^{366273}$ | 334 |

Table 16a. Fishing mortalities estimated from nominal catch matrix (Table 11)
with $F_{t}=0.3$.

FISHIMG MORTALITY

| 1965 | 1766 | 1967 | 1968 | 1967 | 1970 | 1971 | 1972 | 1773 | 1974 | 1975 | 1776 | 1777 | 1976 | 1979 | 1730 | 1931 | 1582 | 1783 | 1984 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 110.069 | 0.0 | 0.137 | 0.155 |  |  | 0.01 | 0,000 | 0.000 | 0.011 | 0.015 | 0.000 | 0.000 | 0.040 | 0.001 | 1 | 0. |  | 2 | 0.002 |
| 2 0.372 | 0.688 | 0.39 | 0.827 | 0.448 | 0.659 | 0.48 | 0.15 | 0.20 | 0.548 | 0.3 | 0.374 | 0.345 | 0.153 | 0.27 | . 044 | 0.07 |  | 0 | 0.060 |
| 310.040 | 0.259 | 0.138 | 0.241 | 0.536 | 0.201 | 0.451 | 0.148 | 0.210 | 0.173 | 0.329 | 0.339 | 0.375 | 0.137 | 0.142 | 0.146 | 0.210 | 0.163 | 0.152 | 0.300 |
| ${ }^{4} 10.218$ | 0.110 | 0.241 | 0.103 | 0.218 | 0.629 | 0.475 | 0.720 | 0.367 | 0.359 | 0.302 | 0.377 | 0.735 | 0.206 | 0.271 | 0.349 | 0.245 | 0.16 | 0.353 | 0.300 |
| 510.172 | 0.526 | 0.238 | 0.451 | 0,301 | 0.602 | 0.557 | 0.772 | 0.470 | 0.303 | 0.3 | 0.386 | 0.655 | 1.346 | 0.166 | 0.194 | 0.572 | 0.447 | 0.235 | 0.300 |
| 610.135 | 0.237 | 0.541 | 0.246 | 0.314 | 0.381 | 0.477 | 0.906 | 0.668 | 0.399 | 0.546 | 0.405 | 0.574 | 1.034 | 1.008 | 0.186 | 0.300 | 0.645 | 0.477 | 0.300 |
| 710.042 | 0.255 | 0.530 | 0.692 | 0.345 | 0.575 | 0.582 | 0.662 | 0.650 | 0.458 | 0.462 | 0.363 | 0.558 | 0.710 | 0.84 | 0.475 | 0.121 | 0.242 | 0.605 | 0.300 |
| 610.161 | 0.271 | 0.127 | 0.038 | 0.362 | 0.403 | 0.586 | 0.697 | 0.557 | 0.365 | 0.338 | $0.42{ }^{\circ}$ | 0.455 | 0.799 | 1.090 | 0.720 | 0.520 | 0.160 | 0.254 | 0. 300 |
| 910.045 | 1.032 | 0.020 | 0.832 | 0.244 | 0.692 | 0.773 | 0.708 | 0.737 | 0.821 | 0.452 | 0.665 | 0.496 | 0.307 | 0.770 | 0.753 | 0.437 | 0.554 | 0.206 | 0.300 |
| 10 \| 0.104 | 0.250 | 0.483 | 0.423 | 0.325 | 0.462 | 0.565 | . 754 | 0.652 | 0.471 | 0.512 | 0.404 | 0.557 | 0.876 | 0,876 | 0.390 | 0.287 | 0.566 | 507 | 0.300 |
| 0.200 | 0.31 | . 303 | 0.320 | 0.282 | 0.553 | . 542 | 0,783 | 0,468 | . 3 | 0.4 | 0.400 | 0.63 á | 0.952 | . 49 | 38 | 0. 453 |  | 793 | 0.300 |

Table 16b. Fishing mortalities estimated from adjusted catch matrix (Table 13) with $F_{t}=0.3$.
fishing mortality



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

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


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


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

