

A. Goosefish (Monkfish) Assessment Summary

State of Stock: Based on existing reference points, the resource is not overfished in either stock management area (north or south). Fishing mortality rates (F) estimated from NEFSC research and Cooperative survey data are currently not sufficiently reliable for evaluation of F with respect to the reference points.

Reported total landings (converted to live weight) steadily increased from an annual average of 2,500 metric tons (mt) in the 1970s to 8,700 mt in the 1980s, to an average of 23,000 mt in the 1990s and early 2000s (Figure 1). Biomass in the northern area has been above $B_{\text{threshold}}$ (1.25 kg/tow) since 1999 and in 2003 (mean of 2001-2003 = 2.03 kg/tow) was at about 81% of B_{target} (2.50 kg/tow; Figure 2). Given the variance in the survey biomass index, there is a 98% chance that the biomass index is above the northern area $B_{\text{threshold}}$ reference point (Figure 3). Biomass in the southern area increased to $B_{\text{threshold}}$ (0.93 kg/tow) in 2003 (mean of 2001-2003 = 0.93 kg/tow; Figure 4). Given the variance in the survey biomass index, there is a 56% chance that the biomass index is above the southern area $B_{\text{threshold}}$ reference point (Figure 5).

Size distributions in research surveys became truncated during the 1970s and 1980s, and were stable during the 1990s. Indices of egg production have declined by around 80% since the 1970s and the proportion of spawners below the age of full maturity has increased. Egg production indices in both areas show a recent increasing trend (Figures 6 and 7). Survey indices indicate recent improved recruitment in both the northern (1999 year class) and southern areas (2002 year class)(Figure 8).

Forecast for 2005: No forecast was made.

Catch and Status Table (weights in '000 mt): Monkfish

Year	1997	1998	1999	2000	2001	2002	2003	Max ¹	Min ¹	Mean ¹
USA Commercial landings										
Northern area	9.8	7.4	9.3	10.7	13.5	14.0	15.1	15.1	0.2	6.0
Southern area	18.5	19.3	16.0	10.2	9.8	8.9	11.0	19.3	0.1	7.0
Total	28.3	26.7	25.2	20.9	23.3	22.9	26.1	28.3	0.3	13.1
USA Commercial discards										
Northern area	1.3	0.7	0.7	0.9	4.3	2.8	2.8	4.3	0.7	1.9
Southern area	2.2	1.3	1.9	2.8	9.7	2.2	3.4	9.7	1.3	3.2
Total	3.4	2.0	2.6	3.6	13.9	5.0	6.2	13.9	2.0	5.1
Foreign landings ²	0.2	0.2	0.2	0.2	0.2	0.3	0.3	6.8	0.0	0.9
Total Catch	31.8	28.7	27.8	24.5	37.2	27.9	32.3	37.2	24.5	30.1
Northern area										
Biomass index	0.67	0.97	0.83	2.50	2.05	2.10	1.93	5.57	0.67	2.10
Egg production index ³	0.41	0.40	0.38	0.44	0.48	0.58	0.66	2.19	0.38	1.01
Southern area										
Biomass index	0.59	0.50	0.30	0.48	0.7	1.25	0.83	4.92	0.27	1.11
Egg production index ³	0.14	0.17	0.15	0.17	0.19	0.23	0.25	0.11	0.11	0.45

¹1970-2003. Commercial fishery discard estimates not available before 1996; means calculated from 1996-2003.

²Foreign landings are for NAFO Areas 5 and 6.

³Egg production index is a function of mean number per tow at length, proportion mature at length and fecundity at length.

Stock Distribution and Identification: The monkfish resource in US waters is distributed from the Gulf of Maine through Cape Hatteras, NC. Data to definitively distinguish separate stock units of monkfish are unavailable. Differing recruitment patterns suggest the existence of two stock units. However, similar growth and maturity patterns along with genetic testing argue for a single stock unit. Assessment units, as described in previous SAW reports (north and south, separated along the middle axis of Georges Bank), are continued in this assessment.

Catches: Total reported landings (live weight) increased from several hundred mt in the early 1970s to a peak of 28,500 mt in 1997, and have since ranged from 21,100 mt in 2000 to 26,400 mt in 2003 (Figure 1). Landings declined substantially in the south from a peak of 19,300 mt in 1998 to 11,000 mt in 2003. Landings doubled in the north from 7,400 mt in 1998 to 15,100 mt in 2003, the peak of the northern area time series (Figure 1), likely due to changes in management. Landings in the early part of the time series are thought to be under-reported. The accuracy of landings data has likely improved with mandatory reporting beginning in 1994. During 1998-2000, trawls caught 54% of USA landings, scallop dredges 17%, and gill nets 29%. During 2001-2003, trawls caught 55% of USA landings, scallop dredges 8%, and gill nets 37% (Figure 9). While trawl gear still accounts for about 80% of the landings in the northern area (Figure 10), gillnets now account for the majority of the landings (66%) in the southern area (Figure 11). Discarding has increased since the implementation of the FMP in November 1999, likely due to the impact of quota and trip limits, and the recruitment of above average year classes in recent years (2002 year class in the southern area; 1999 year class in the northern area). Estimates of discard rates during 1996-2000 ranged from 7%-15% of the catch in the northern area and 6%-22% of the catch in the southern area. Estimates of discard rates during 2001-2003 ranged from 16%-24% of the catch in the northern area and 20%-50% of the catch in the southern area.

Data and Assessment: Monkfish were last assessed at SAW 34 in November 2001. Data used in the current assessment include NEFSC research survey data, data from Cooperative surveys conducted in 2001 and 2004, commercial fishery data from vessel trip reports, dealer landings records and on-board fishery observers. Fishing mortality rates were calculated from catch-per-tow-at-age indices from NEFSC research surveys and catch-to-biomass exploitation rates from Cooperative surveys. Surplus production modeling integrated fishery catch estimates, research survey indices and Cooperative survey biomass estimates to estimate stock biomass, exploitation rates, and reference points.

Biological Reference Points: The biological reference points for monkfish that were established in the original Fishery Management Plan (FMP) were calculated during SAW 23. These reference points for the Northern Fishery Management Area (northern area; NFMA) were: $F_{\text{threshold}}$ (average F during 1970-1979) = 0.05; $B_{\text{threshold}}$ (33rd percentile of the 1963-1994 NEFSC autumn trawl survey catch (kg) per tow) = 1.46 kg/tow; B_{target} (the median of the 3-year moving average of the 1965-1981 NEFSC autumn trawl survey catch (kg) per tow) = 2.50 kg/tow. F_{target} is undefined. For the Southern Fishery Management Area (southern area; SFMA) the reference points were: $F_{\text{threshold}} = 0.21$, $B_{\text{threshold}}$ (33rd percentile of the 1967-1994 NEFSC autumn trawl survey) = 0.70 kg/tow, $F_{\text{target}} (F_{0.1}) = 0.10$, $B_{\text{target}} = 1.85$ kg/tow.

Based on the conclusions of SAW 31 that the above F proxies were unreliable, SAW 34 recommended changing the fishing mortality rate reference points. In the SAW 34 assessment, a yield per recruit analysis indicated that for $M=0.2$, $F_{\text{max}} = 0.2$. The SAW 34 yield per recruit analysis was adopted in FMP Framework 2 to revise the fishing mortality reference points ($F_{\text{max}} = F_{\text{threshold}} = 0.2$). Framework 2 also revised the biomass threshold reference points ($B_{\text{threshold}}$) to be consistent with National Standard 1 Guidelines ($B_{\text{threshold}} = \frac{1}{2} * B_{\text{target}}$), and to reflect a different year range of survey indices, as recommended by SAW 34. For the northern area, $B_{\text{threshold}}$ is one-half of the mean of 1965-1981 NEFSC autumn trawl survey catch (kg) per tow) = 1.25 kg/tow; for the southern area, $B_{\text{threshold}}$ is one-half of the mean of 1965-1981 NEFSC autumn trawl survey catch (kg) per tow) = 0.93 kg/tow. The revised overfishing definition does not include an F_{target} reference point. Optimum yield is calculated based on a method adopted in Framework 2 that compares the 3 year moving average of the NEFSC autumn survey biomass index to interim annual survey biomass index targets, and adjusts annual TACs and trip limits based on the difference between the observed and target biomass indices.

Fishing Mortality: The SAW 31 and SAW 34 reviews of the assessment concluded that instantaneous fishing mortality rates (F) estimated from NEFSC research survey length frequency distributions were not sufficiently reliable to allow evaluation of current F with respect to reference points. The 2004 Working Group judged that estimates of F from NEFSC survey age frequency distributions (1995-2003) likewise do not provide a clear indication of the magnitude or trend of F rates. Therefore, reliable evaluation of the current level of F with respect to reference points is still not possible using NEFSC research survey data, due mainly to small sample sizes and variable catch rates.

Under the assumptions adopted for this assessment (2001 intermediate net efficiencies and 2001/2004 nominal tow distances), estimates of exploitation rates using the 2001 and 2004 Cooperative survey swept area biomass estimates and estimates of corresponding fishery landings indicate that the exploitation rate increased in the northern area from 20% to 29% from 2000 to 2003, while the exploitation rate in the southern area declined from 23% to 14%. Given the standard conversion from exploitation rate to instantaneous fishing mortality rate, the current (2003) percentage biomass exploitation rates equate to $F = 0.38$ in the northern area and $F = 0.17$ in the southern area. Given the uncertainty of the 2004 Cooperative survey biomass estimates and potential for subsequent revision, the exploitation rates estimated from those data are not sufficiently precise to allow for evaluation of current F with respect to the fishing mortality reference points.

Recruitment: There is evidence of increased recruitment in the northern area during the 1990s, particularly for the 1999 year class (Figure 8). In the southern area, recruitment appears to have fluctuated without trend during the 1990s, although there is an indication that the 2002 year class may be above average (Figure 8).

Total Stock Biomass: The current biomass index (3 year moving average; 2001-2003) for the northern area is 2.03 kg/tow relative to a $B_{\text{threshold}}$ of 1.25 (Figures 2 and 3). The current southern area biomass index (3 year moving average; 2001-2003) is 0.93 kg/tow relative to a $B_{\text{threshold}}$ of 0.93 (Figures 4 and 5). The 2001 Cooperative survey estimated swept area total biomass of 68,680 mt in the northern area and 66,230 mt in the southern area (assuming 2001 intermediate net efficiencies and 2001 nominal tow distances). The 2004 Cooperative survey swept area biomass estimates are 51,766 mt in the northern area and 109,807 mt in the southern area (assuming 2001 intermediate net efficiencies and 2004 nominal tow distances).

Spawning Stock Biomass: Egg production indices for the northern area are at 44% of their 1970-1979 average and 30% of the maximum observed (Figure 6). For the southern area, egg production indices are at 31% of the 1970-1979 average and 11% of the maximum observed (Figure 7). The proportion of egg production generated by females smaller than the size at full maturity increased rapidly from the early 1980s through the mid-1990s and has since declined in the southern area, but remains high in both areas.

Surplus Production Modeling: This assessment extended a surplus production modeling approach first presented in the SAW 31 assessment. Model configuration was very similar to the configurations subsequently developed for the SAW 34 assessment. It was necessary to include estimates of catch during 1964-1979 and to implement a beta function (non-symmetrical) prior for the distribution of the intrinsic rate of population increase (r) in order for the current model to provide realistic results. When 2001 and 2004 biomass estimates were used as inputs for surplus production modeling, the median (50th percentile) model results for the northern area indicated that $F_{\text{msy}} = 0.18$, $B_{\text{msy}} = 60,100$ mt, $F_{2003} = 0.25$, and $B_{2003} = 72,100$ mt. The median model results for the southern area indicated that $F_{\text{msy}} = 0.20$, $B_{\text{msy}} = 82,300$ mt, $F_{2003} = 0.13$, and $B_{2003} = 107,300$ mt. As noted above concerning the current uncertainty of the 2004 Cooperative survey biomass estimates and potential for subsequent revision, the surplus production model results should be considered preliminary and not sufficiently precise for evaluation of the status of the stock with respect to reference points. The Working Group plans to continue development of the surplus production model, since it appears to have the potential to serve as a valuable tool for an integrated estimation of stock biomass, mortality rates and reference points.

Special Comments: The Cooperative surveys conducted from February-April 2001 and March-June 2004 collected substantial new data that have proven valuable in the assessment of the stock. Some findings of note include:

- Growth rates were similar in northern and southern areas.
- Monkfish larger than about 70 cm were all females. The maximum age for males caught was age 8 and for females age 10.
- Nine incidences of cannibalism were detected among 2160 stomachs examined in 2001 (0.42%).
- Blackfin monkfish were not prevalent in 2001 catches, comprising less than 0.01% (8 of over 9000 monkfish examined).
- The size distribution of fish captured in the Cooperative surveys in the southern area was very similar to that observed in the NEFSC winter surveys.
- Catchability of 2001 NEFSC winter survey gear was approximately half that of the gear used to conduct the 2001 Cooperative survey.

- Given the late finish of the 2004 Cooperative survey, analysis of the 2004 Cooperative survey data are not complete. In particular, data collected from bottom contact sensors and experimental net efficiency tows have not been analyzed, and so 2004 biomass estimates were made assuming 2001 intermediate net efficiencies and 2004 nominal tow distances. Analyses of biological data are also incomplete.
- The Cooperative Monkfish Surveys have resulted in a great increase in knowledge of monkfish biology, and have helped improve the reliability and accuracy of the stock assessment. There is also great value in involving the fishing industry in monkfish assessment science by increasing industry confidence in the assessment. However, the Northeast Region's management and science agencies should carefully weigh the benefit and costs of the Cooperative Surveys in considering whether to undertake a survey for 2007. If a survey is conducted in 2007, it is critical that sampling protocols (including sampling intensity, net and ground gear designs, survey timing, and vessels) be examined and standardized to the greatest extent possible to maximize the value of annual cooperative survey estimates.

Sources of Information:

Chikarmane, H.M., Kuzirian, A.M, Kozlowksi, R, Kuzirian, M. and Lee, T. 2000. Population genetic structure of the goosfish, *Lophius americanus*. Biol. Bull. 199: 227-228.

NEFSC 1997. Report of the 23rd Northeast Regional Stock Assessment Workshop (23rd SAW). NEFSC Reference Document 97-05.

NEFSC 2000. Report of the 31st Northeast Regional Stock Assessment Workshop (31st SAW). NEFSC Reference Document 00-15.

NEFSC 2002. Report of the 34th Northeast Regional Stock Assessment Workshop (34th SAW): SARC Consensus Summary of Assessments. NEFSC Reference Document 02-06.

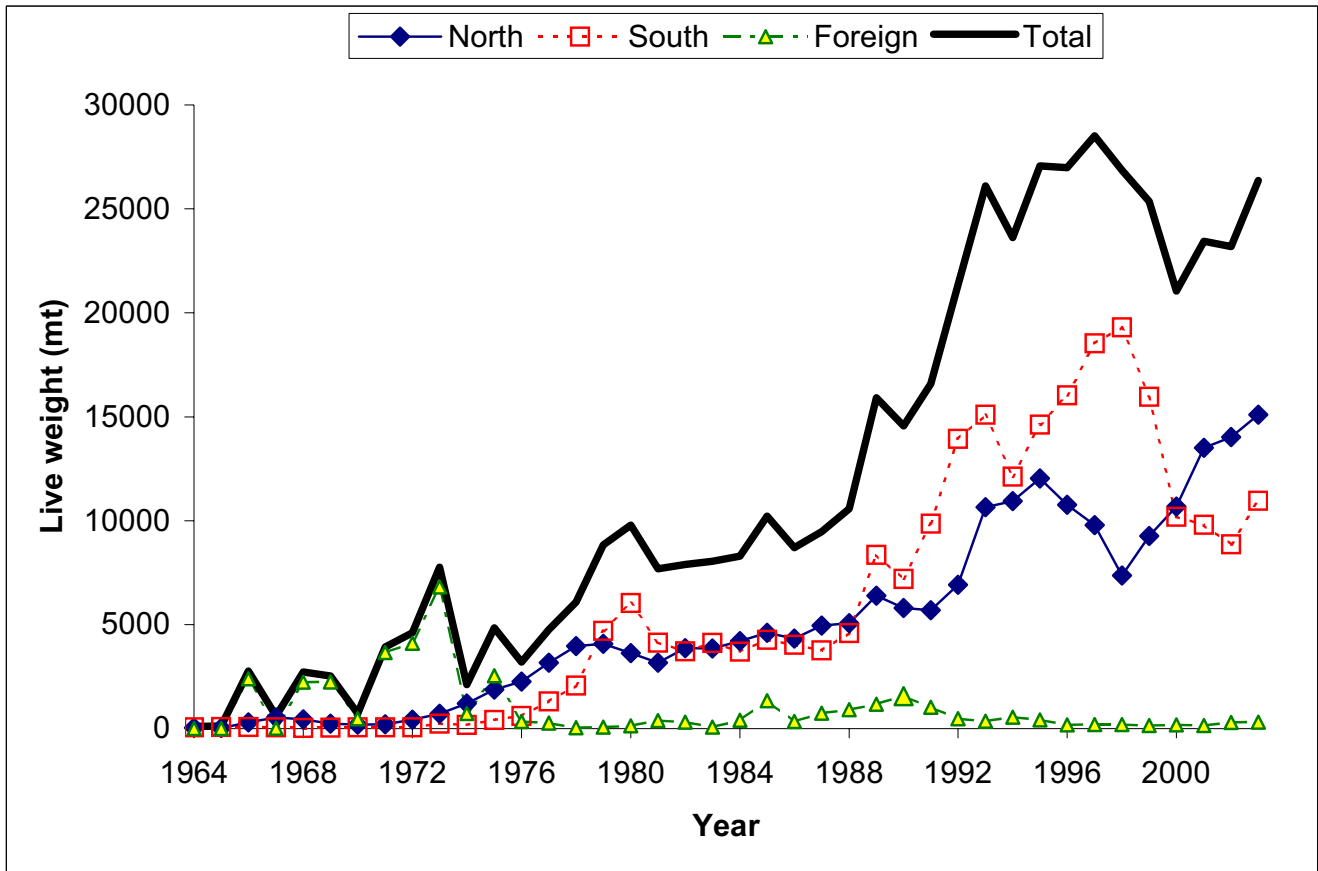


Figure 1. Total monkfish commercial landings.

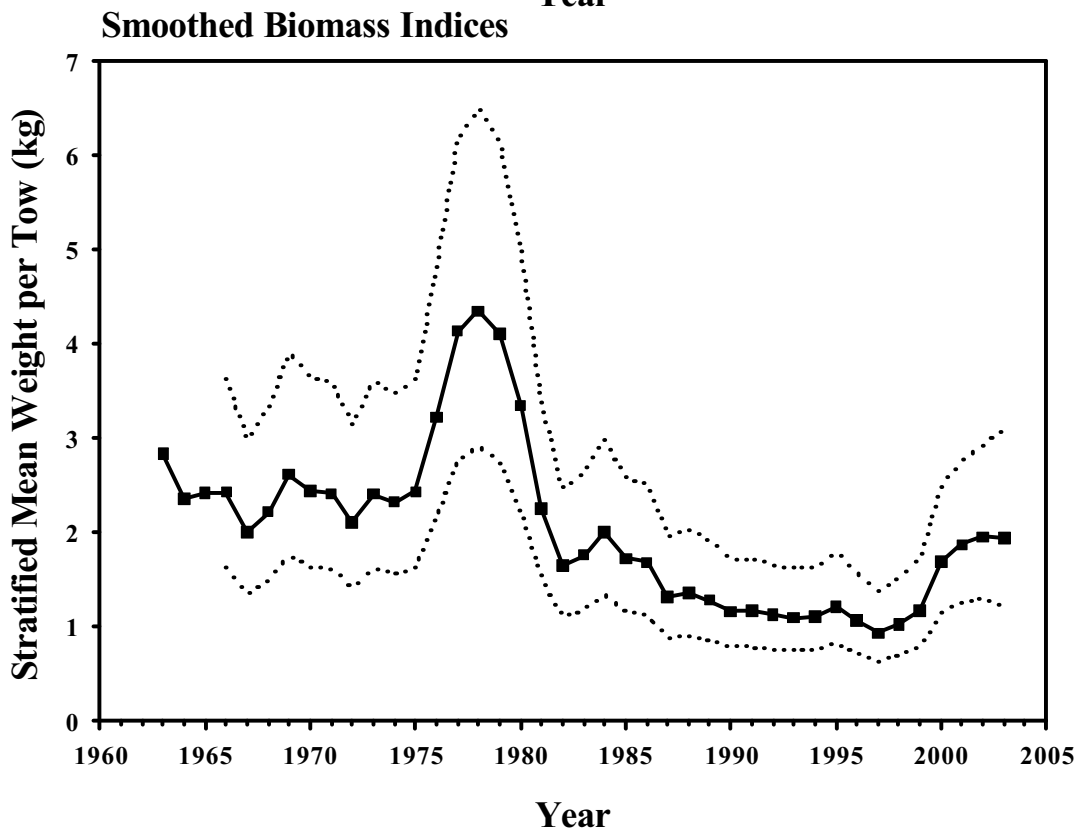
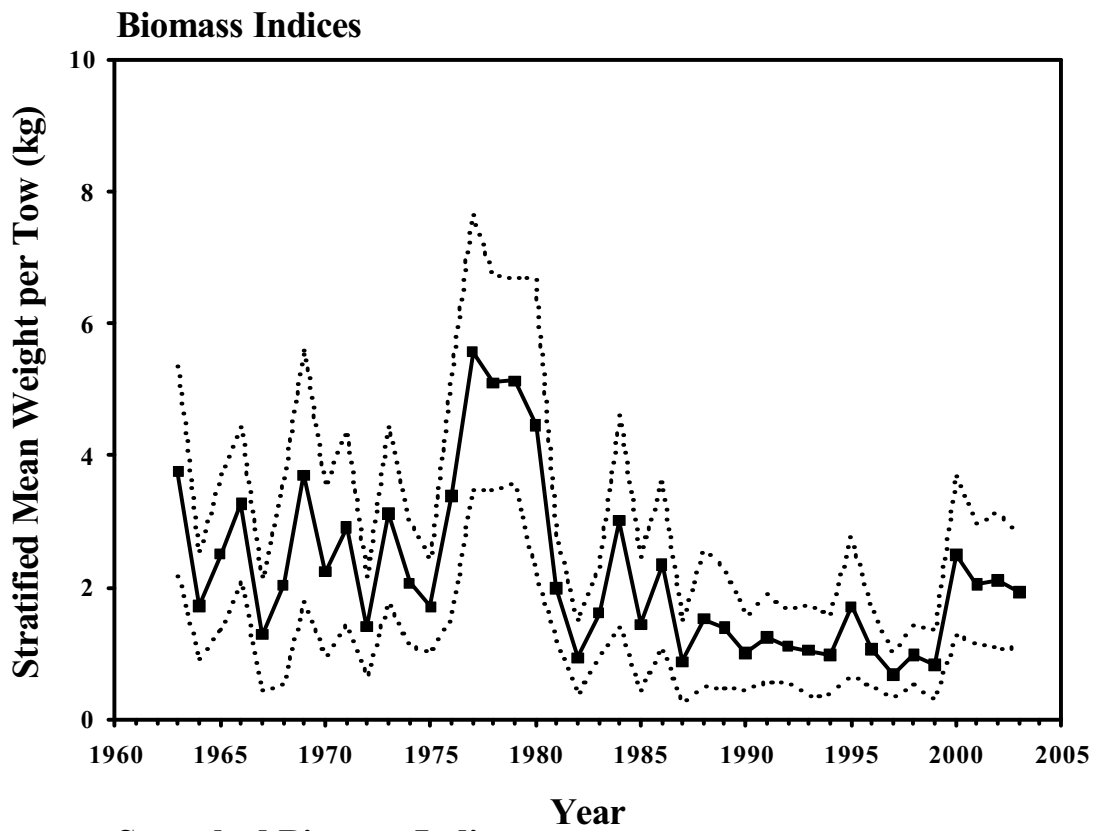


Figure 2. Northern area biomass index.

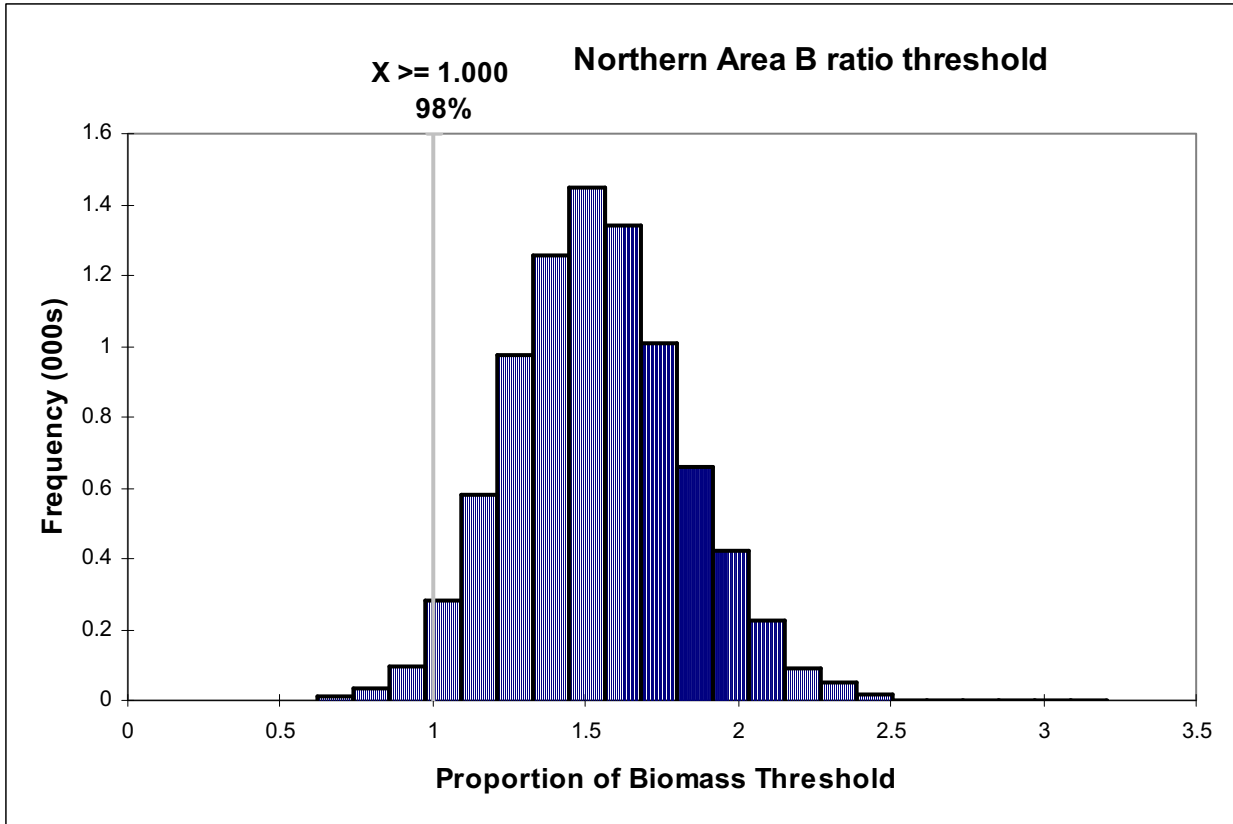


Figure 3. Northern area: probability distribution of 2003 biomass index (indexed to $B_{\text{THRESHOLD}} = 1.0$).

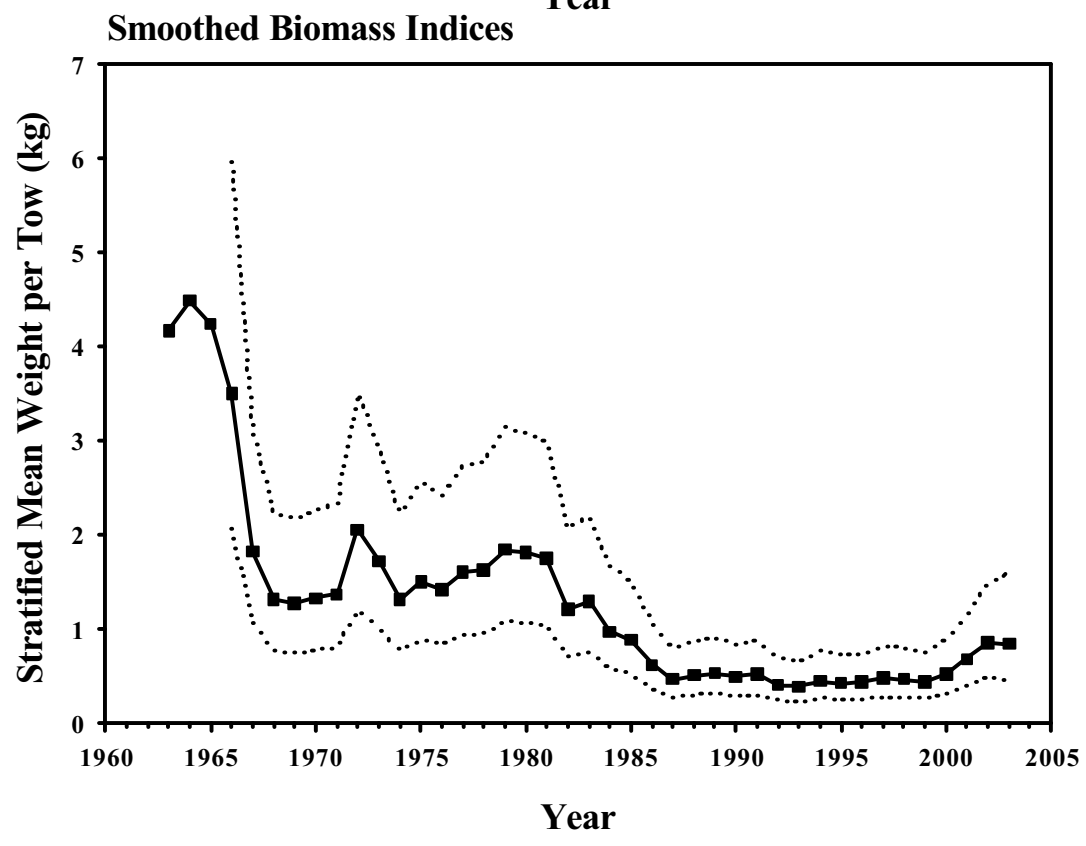
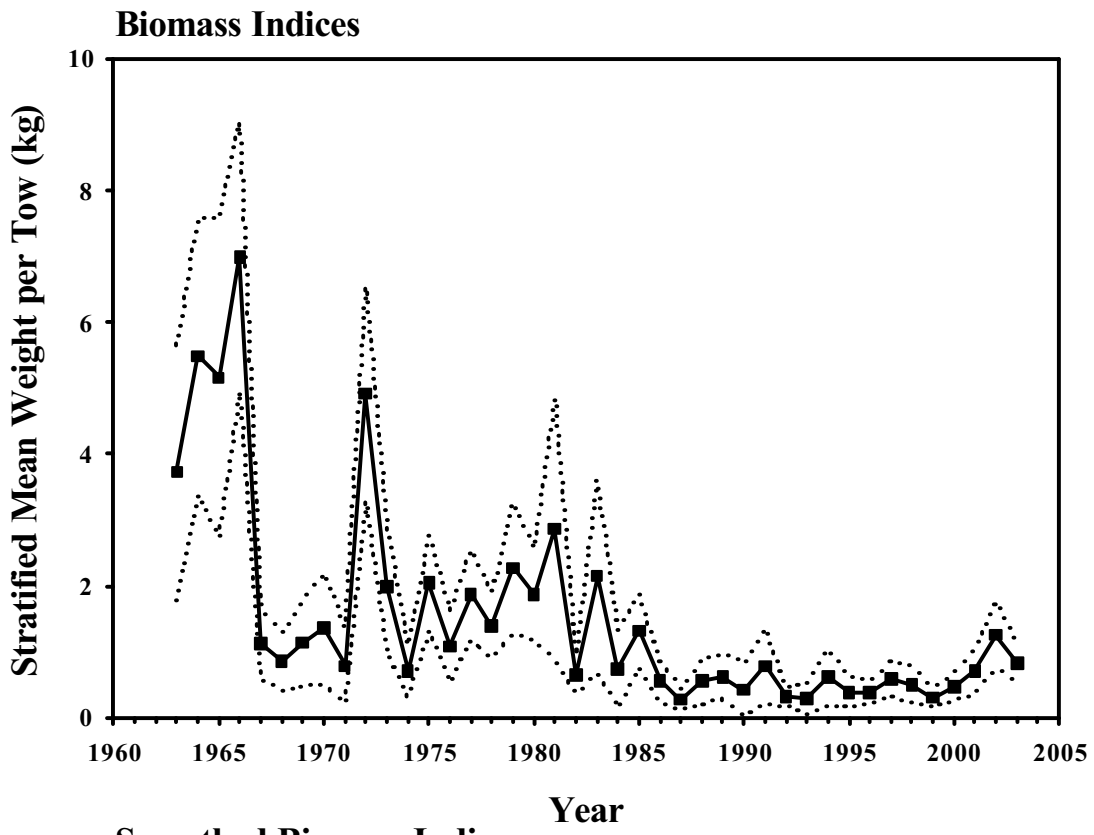
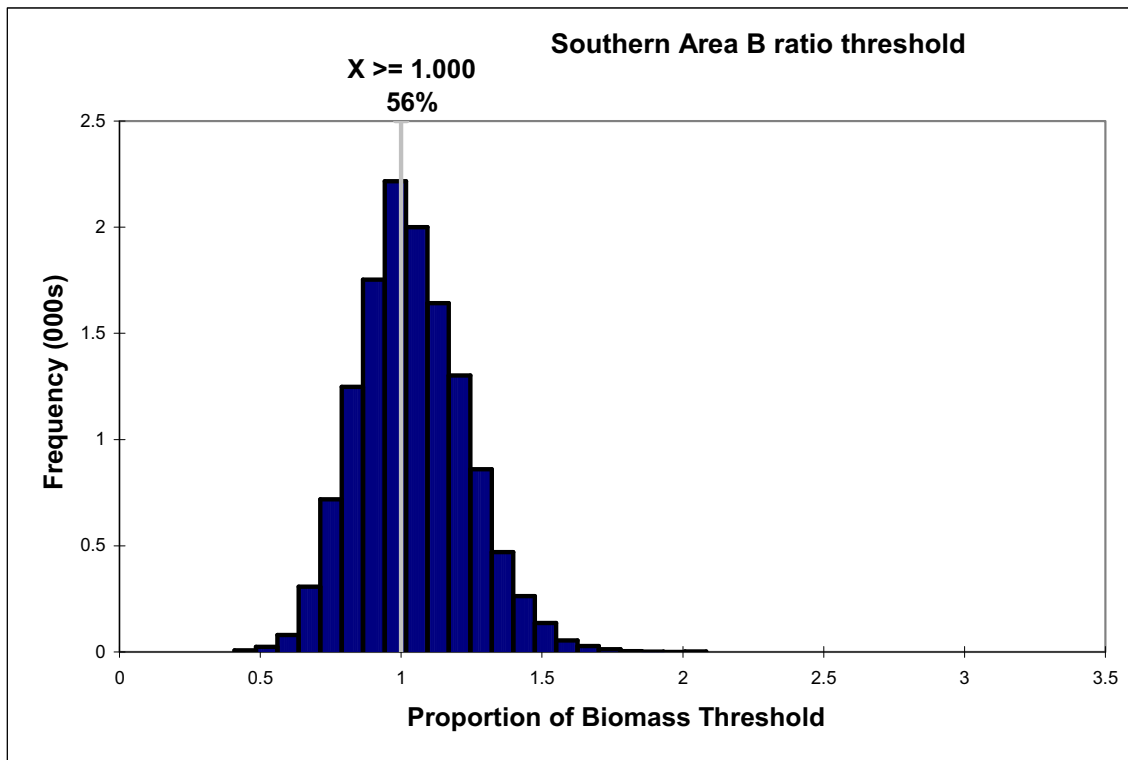


Figure 4. Southern area biomass index.

Figure 5. Southern area: probability distribution of 2003 biomass index (indexed to $B_{\text{THRESHOLD}} = 1.0$).



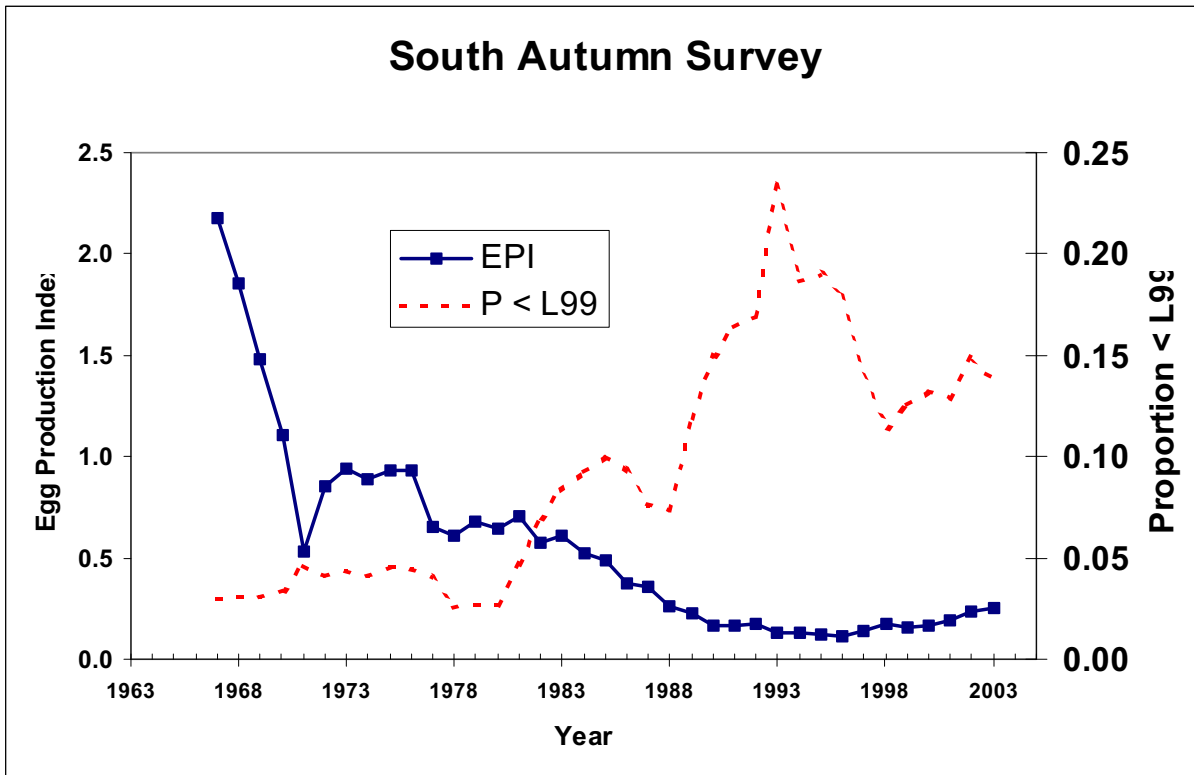
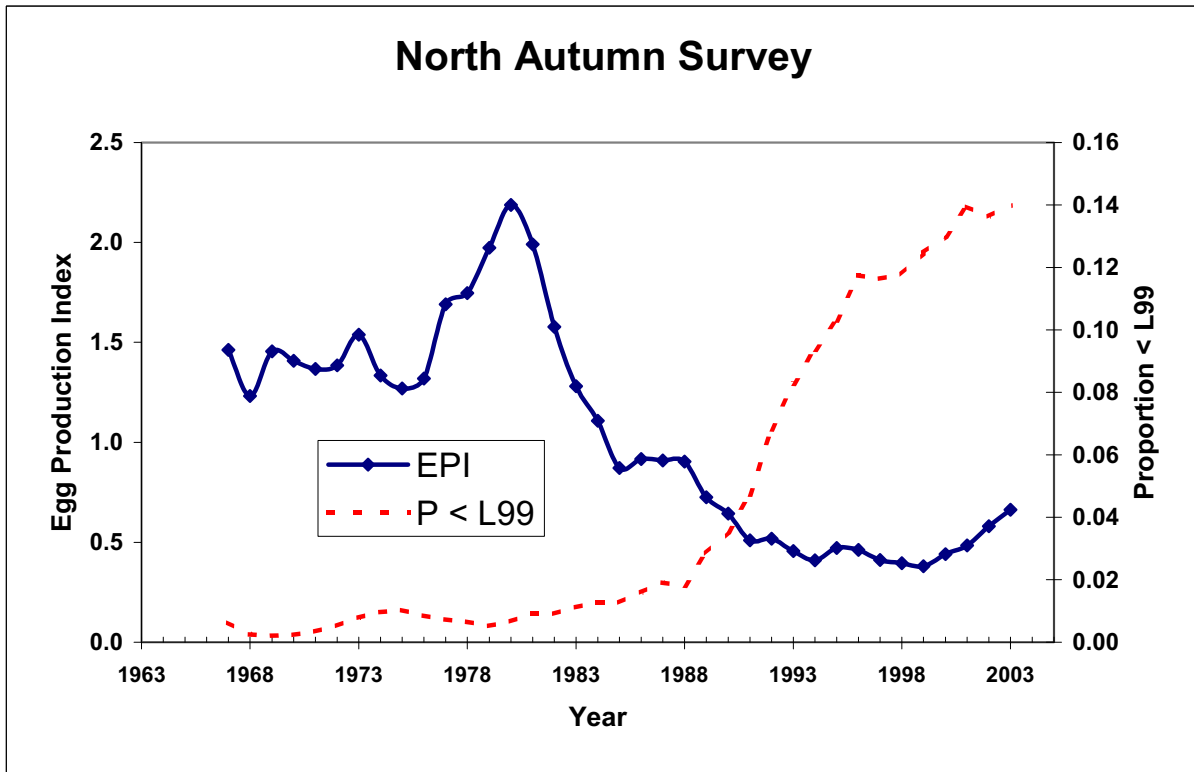


Figure 6 (upper panel). Northern area egg production.
 Figure 7 (lower panel). Southern area egg productions.

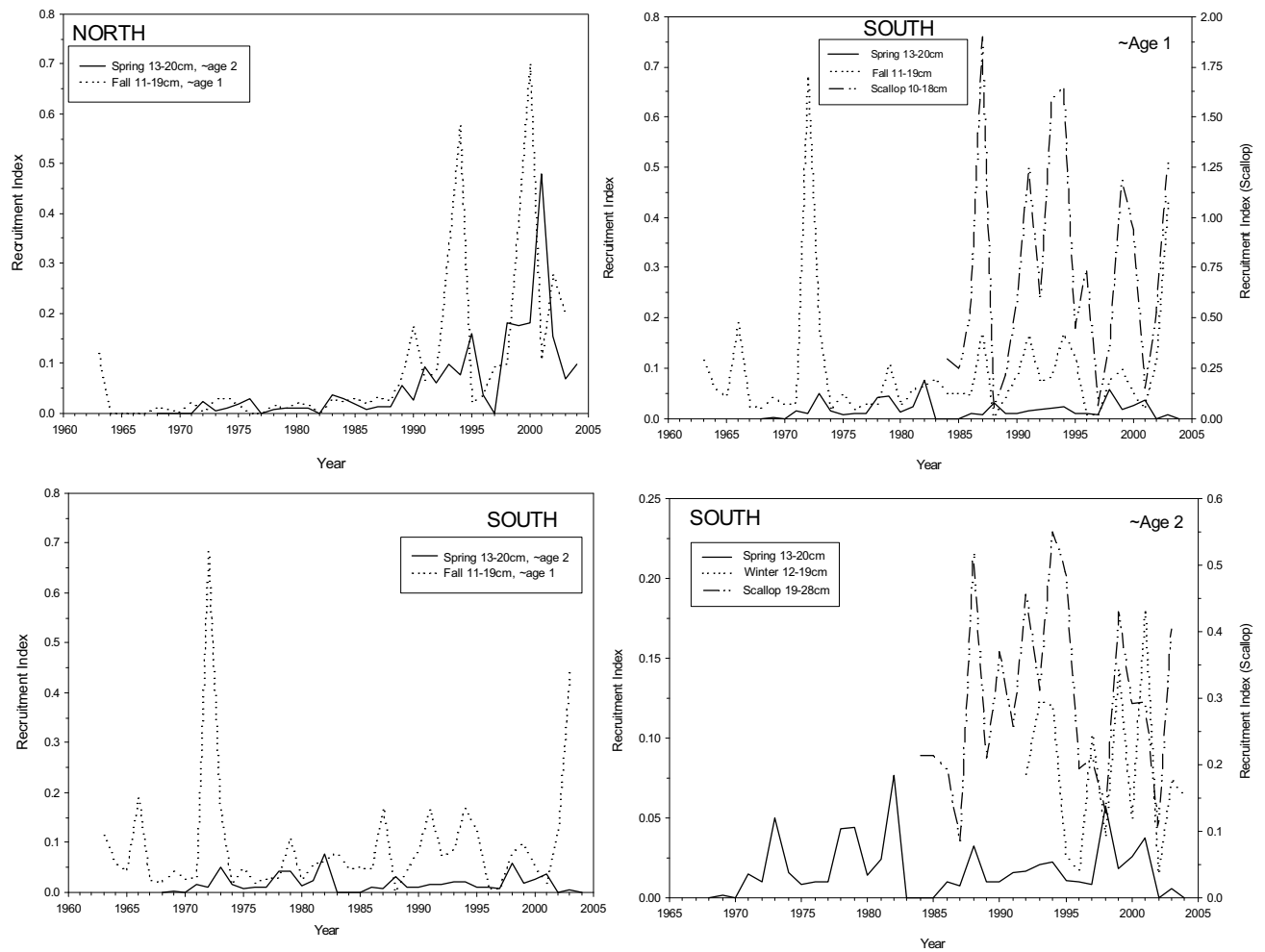


Figure 8. Recruitment indices at ages 1 and 2.

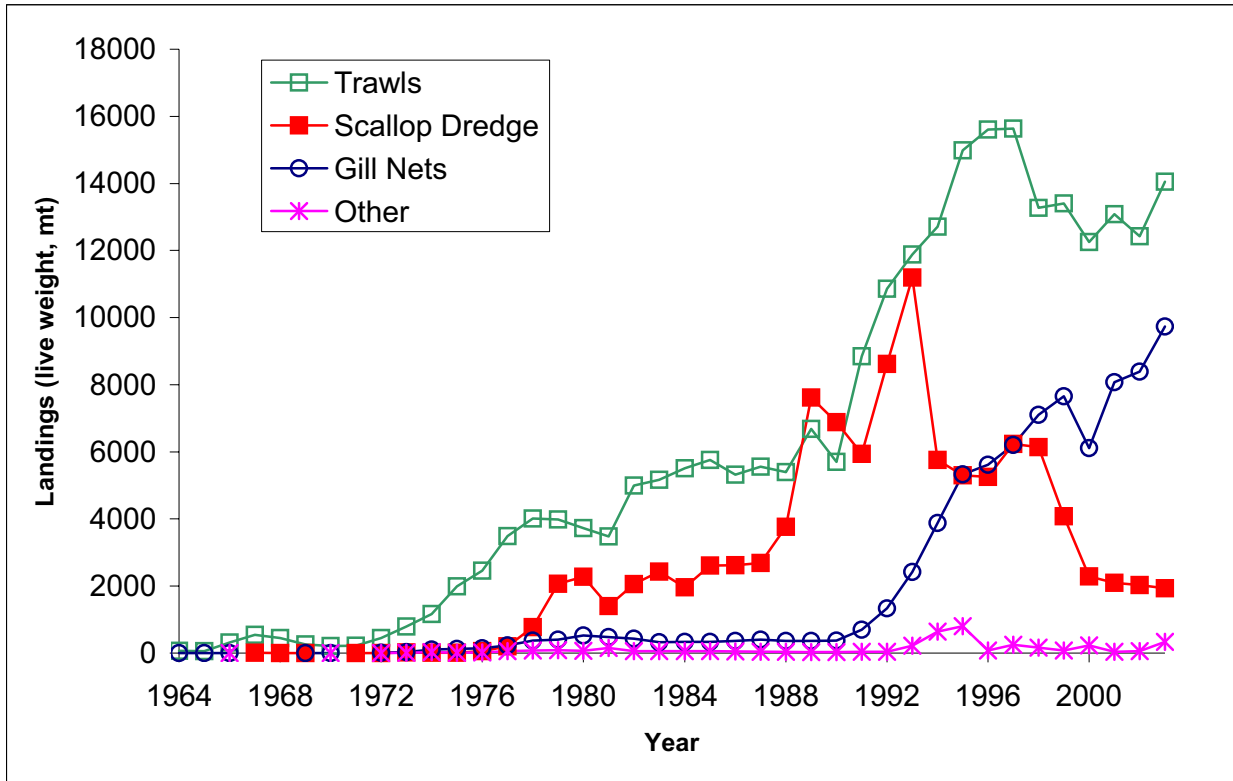


Figure 9. Total landings by gear type.

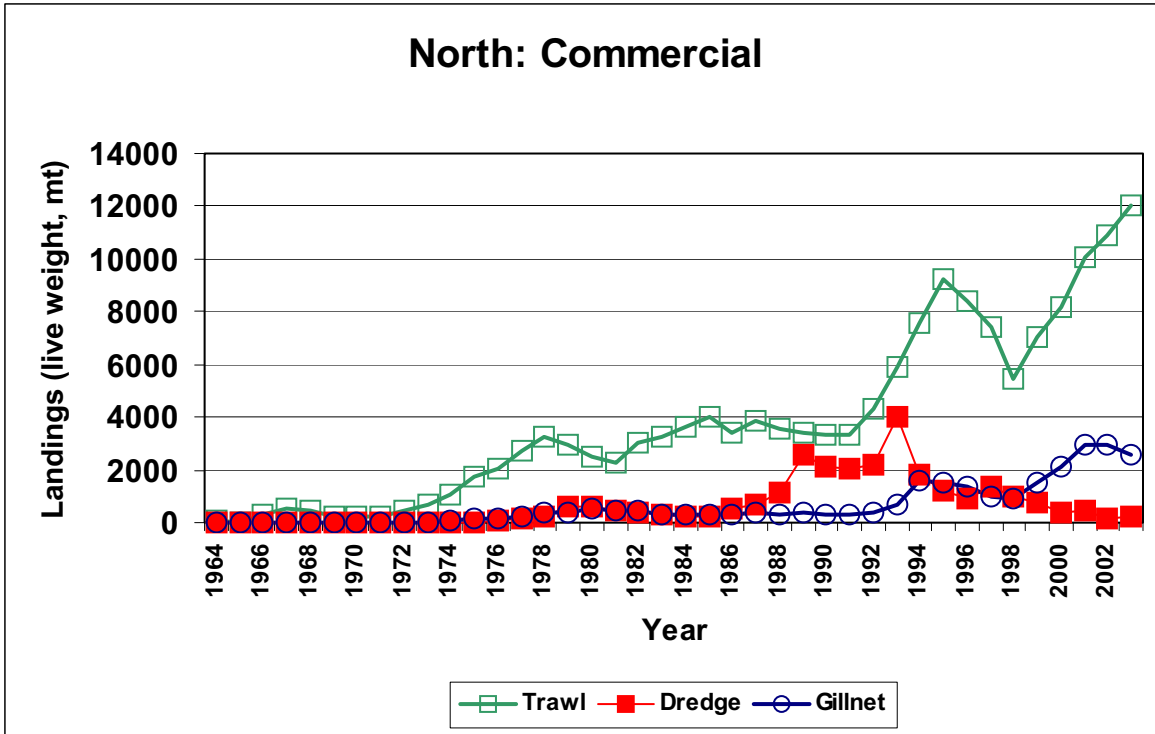


Figure 10. Northern area landings by gear type.

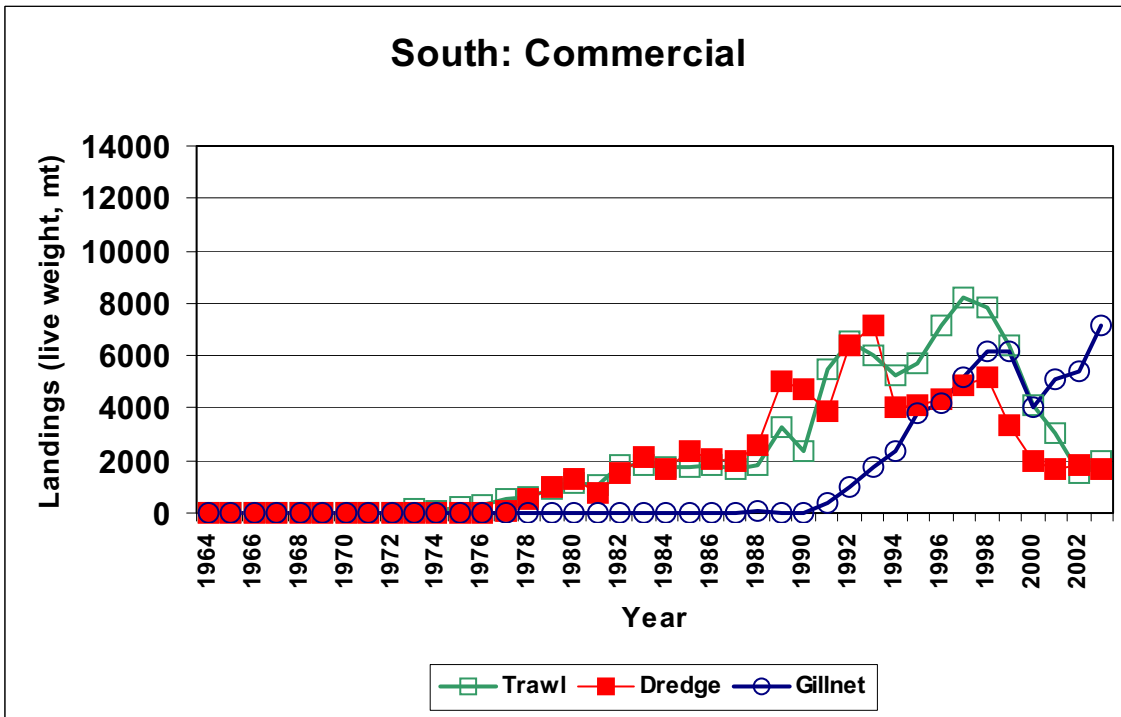


Figure 11. Southern area landings by gear type.