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An Evaluation of Finfish Bycatch Rates Inside the Great South Channel Scallop Dredge Exemption Area for the General Category Scallop Fishery

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EXECUTIVE SUMMARY

In August 2006, the Great South Channel Scallop Dredge Exemption Area (GSCDEA) was created for vessels using general category scallop dredge gear. This exemption area was created based on analyses conducted by NMFS that suggested this gear would be able to harvest marketable scallops within acceptable groundfish bycatch levels. However, the bycatch rate analysis for this area was based on data collected up to 10 years ago by vessels using dredges with different gear characteristics. Fishery managers expressed the need for more current data and a thorough analysis in order to adequately predict and assess general category fleet impacts. Further, access to the GSCDEA is limited to the general category fleet on a seasonal basis due to concerns about fishing activity during peak spawning times for yellowtail flounder. However, little is know about the likely impacts to yellowtail flounder in the GSCDEA during these seasonal closures. In addition, fishery managers have identified a need for more research to provide quantitative information and analysis of the species and size selectivity of the 10-inch twine top mesh escapement panel in scallop dredges.

The overall goal of this project was to provide managers and fishing communities with information to manage scallop and finfish resources in the GSCDEA with less uncertainty and greater stakeholder confidence. Objectives included describing current catch and bycatch rates for the general category fleet in the GSCDEA. Additional objectives included documenting and analyzing the quantity and composition of finfish bycatch in the study area, especially during the seasonal yellowtail spawning closures (April - June) to provide information unavailable from other sources. Other objectives included analyses of the quantity, distribution and maturity stages of yellowtail flounder in the area during the seasonal spawning closures. An examination of the species and size selectivity of 10-inch mesh twine top in a 10.5 foot scallop dredge was also attempted.

Field work for this project was conducted between March and September 2007 aboard three commercial fishing vessels using scallop dredge gear typical of the general category scallop fishing fleet. A total of 53 days of sampling were accomplished inside the GSCDEA for a total of 244 tows. Field sampling for the month of March covered the entire GSCDEA in an attempt to assess the whole GSCDEA for suitable sea scallop bottom. Field sampling for the remaining months focused only in areas which had commercial quantities of exploitable sea scallop biomass to reflect commercial fleet activity. Species and size selectivity information was collected on approximately 1/3 of the completed tows, by means of a small mesh cover net that captured the fish and other organisms that passed through the large mesh twine top.

Results from this study indicate that the addition of the GSCDEA to the list of current scallop dredge exemption areas was an appropriate action. Sea scallops can be harvested from portions of the exemption area in commercial quantities using general category scallop dredge gear with very low finfish bycatch rates. Commercial quantities of sea scallops were found in waters ranging in depth between 20 and 50 fathoms. A total of 33,471 pounds of whole sea scallops were caught over the duration of the project. Sea

scallop catch rates averaged 311 pounds per hour for months where sampling was focused on commercially exploitable sea scallop bottom. Analysis of scallop catch data indicated consistent sea scallop catch rates in the months of April – June. A decline in catch rates was observed in September possibly as a result of increased commercial scallop effort in the GSCDEA during the summer months.

Bycatch rates for all species were consistently low, regardless of the month in which sampling took place. Skates proved to be the greatest finfish bycatch species. For the project, they accounted for 10% of the total catch with a range between 2% and 23% on a monthly basis. Monkfish and individual flounder species, typically considered the most significant sea scallop dredge bycatch species, proved to have consistent bycatch rates of less the 3% of the total catch. In particular, the overall bycatch of yellowtail flounder was observed to be only 76.4 pounds or 0.23% of the total scallop catch.

Based on observed bycatch rates, it appears that this fishery has little impact on the yellowtail flounder resource in general or during the seasonal yellowtail spawning closure in particular. In addition, analysis of maturity data for yellowtail flounder, while of limited value due to low bycatch rates, also did not suggest a significant impact on spawning yellowtail flounder. A total of 99 maturity samples were collected from yellowtail flounders between the months of April and June. Only 25 fish were in a spawning condition of ripe or ripe and running; most of which were caught in May. It would seem that reconsideration of the need for seasonal yellowtail flounder spawning closures or revisions to the timing of these closures for the GSCDEA may be appropriate based on these results. However, specific actions based on the results of this study are not recommended. The collection of more data complementary to those collected by this study would likely lead to a more meaningful analysis of impacts on spawning yellowtail flounder.

Analyses of species selectivity data for the scallop dredges revealed that this gear is very efficient at retaining most species. For sea scallops, dredge retention was extremely high at 97.4% and varied between 96.9% and 99.0% between the three vessels over the duration of the project. Many other species showed high retention rates as well but most were poorly represented in the catch. This combination of high retention rates in conjunction with low bycatch rates seems to indicate that there were either few finfish species in the study area or that finfish were avoiding the approaching scallop dredge.

Analyses of species size selectivity data revealed that the dredge twine top cover was releasing significantly smaller sized sea scallops, monkfish and yellowtail flounder. No significant size differences were found between the dredge and twine top cover catch for either winter flounder or windowpane flounder. It should be noted, however, that because of the low bycatch rates all selectivity analyses should not be treated as conclusive.

INTRODUCTION

The Atlantic sea scallop, *Placopecten magellanicus*, is a commercially important shellfish species that is found along the continental shelf of the United States from the Gulf of Maine to North Carolina (Hart and Chute 2004). Based on NEFSC resource survey data and fishery patterns, the two main portions of the sea scallop stock and fishery are located on Georges Bank in the north and in the Mid-Atlantic in the south (NEFSC 2007). Historically, the scallop fishery on Georges Bank has occurred on the northern edge, the southeast part and in the Great South Channel [GSC] (Figure 1; Sinclair et al. 1985).

Amendment 4 to the Atlantic sea scallop Fishery Management Plan established a limited access program in the NE scallop fishery. Amendment 4 also established a general category scallop permit for those vessels not qualifying for a limited access permit. Amendment 4 restricted general category scallop permits to landing no more than 400 lbs of scallop meats or 50 US bushels of shell-stock per trip (NEFMC 1994).

Amendment 7 to the Northeast Multispecies Fishery Management Plan (NE Multi-FMP) established a "certification of bycatch fisheries process" which provides the Northeast Regional Administrator with the authority to certify a fishery that meets multispecies bycatch standard of less than 5 percent of the total catch. Amendment 7 also identified a number of "exempted gears" that were not subject to the certification requirement including pelagic gears, hand gears, pots and traps, purse seines, shrimp trawls (with a separator grate), and midwater trawls (NEFMC 1996a).

Following implementation of Amendment 7, scallop fishermen who fished under the general category scallop permit asked the Regional Administrator to certify an exempted fishery for certain types of scallop dredges in the Gulf of Maine. The Regional Administrator did not have sufficient information to certify the less than 5% bycatch standard, and therefore asked the New England Fishery Management Council (NEFMC) to consider the request under a framework adjustment to the NE Multi-FMP. Accordingly, Framework Adjustment 21 to the NE Multi-FMP established a scallop dredge exemption area within the Gulf of Maine Regulated Mesh Area defined in the multispecies fishery management plan (NEFMC 1996b).

While the boundaries established for the Gulf of Maine Scallop Dredge Exemption Area (GoMDEA) made sense at the time, the abundance and distribution of the sea scallop resource had since changed. Portions of statistical areas 521 and 526 in the GSC, located adjacent to the GoMDEA, contained high concentrations of older and larger scallops. Therefore, in October 2005, representatives from the general category scallop fishery requested to NMFS and the NEFMC that the GSC area be considered for inclusion into the list of scallop dredge exemption areas due to its historical importance to the scallop industry. In response, NMFS performed quantitative analysis of fishery dependant data collected by the Northeast Fishery Observer Program in these areas and concluded that this gear was indeed able to harvest marketable scallops within acceptable groundfish

bycatch levels[1]. In August 2006, the Great South Channel Scallop Dredge Exemption Area (GSCDEA, Figure 2) was created for use by general category vessels.

However, NMFS acknowledges that the bycatch rate analysis for this area was based on very little data. Further, the data used was collected from the limited access fleet, which uses scallop dredges of similar design but much larger in size (two 15' wide dredges vs. one 10.5' dredge). While NMFS is confident that bycatch rates for the general category fleet will be similar enough to the limited access fleet to justify and grant access to the area, they have expressed the need for better data and a thorough analysis in order to adequately predict and assess general category fleet impacts (NMFS Northeast Regional Office (NERO), per. comm.).

Access to the GSCDEA is limited to the general category fleet on a seasonal basis due to concerns about fishing activity during peak spawning times for Cape Cod/Gulf of Maine yellowtail flounder (statistical area 521) and Southern New England/Georges Bank yellowtail flounder (statistical area 526). The portion of the GSCDEA that lies within statistical area 521 is closed from June 1 through June 30 and the portion of the GSCDEA that lies within statistical area 526 is closed from April 1 through June 30. [2]

However, little is known about expected bycatch rates of yellowtail flounder in the GSCDEA during these times for the general category fleet. Indeed, during this same time period, the same area is open to multispecies otter trawl vessels (except for the May Georges Bank Seasonal Closure) as well as the limited access scallop fleet. It is currently unknown what the impacts of the general category scallop fleet on yellowtail flounder might be in this area compared to the impacts from the other fishing sectors. Clearly, more data is needed regarding bycatch rates for yellowtail flounder during these times.

Further, the Sea Scallop FMP Development Team has identified a need for more research in general that would provide quantitative information and analysis of the species and size selectivity of the 10" twine top in scallop dredges (NMFS NERO, per. comm.). Amendment 10 to the Atlantic sea scallop FMP included an increase in mesh size of the regulated twine top for scallop dredges from 8" to 10" in order to minimize bycatch and bycatch mortality by improving escapement of some species of finfish, particularly flounders. Yet, there is little published on the methods for reducing finfish bycatch in the sea scallop dredge fishery. The only formal analysis of the effects of twine top mesh size on bycatch and bycatch mortality were done in 1998 for Framework Adjustment 11 (NEFMC 2004). More recently, NMFS staff has confirmed that little data exist that quantify finfish bycatch retention rates using 10" mesh twine tops in open areas under recent fishing conditions (NMFS NERO, per. comm.).

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[1] "Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Great South Channel Scallop Dredge Exemption Area," 71 Federal Register 129 (6 July 2006), 38352-38355.
[2] NOAA Fisheries Sea Scallop Permit Holders Letter, August 25, 2006.

GOALS and OBJECTIVES

The original goal of this project was to determine whether an experimental scallop fishery could be conducted by the general category scallop fleet in the Great South Channel in portions of statistical areas 521 and 526, outside of the Gulf of Maine Scallop Dredge Exemption Area from March through December within acceptable groundfish bycatch levels. Thus, project design was to conduct sampling in March, June, September and December. However, after the project proposal, submitted on November 18, 2005, was funded, the area in question was designated the GSCDEA and opened to the general category fleet on a seasonal basis on August 30, 2006.

As a result of this change in regulations, the project goals were modified. The overall goal of providing current catch and bycatch rates for the general category fleet in this area was still appropriate. However, since portions of the area were still closed during times desirable to the industry, the project sampling schedule was amended to focus effort during the closures, April – June, as well as during March, September and December to provide a seasonal aspect to the sampling. This was done in order to provide information unavailable from other sources on catch and bycatch rates and yellowtail flounder interactions.

Most of the specific objectives from the original proposal remained including:

- Describe the catch rates of scallops in the study area by small scallop dredges (max 10.5' width) with 10" mesh twine tops.
- Document and analyze the quantity and composition of finfish bycatch in the study area by small scallop dredges (max 10.5' width) with 10" mesh twine tops.
- Compare catch rates of scallops and finfish across seasons to estimate the average finfish bycatch percentages in the study area.
- Examine the species and size selectivity of 10" mesh twine top in a 10.5' scallop dredge.
- Provide managers and fishing communities with information to manage the scallop resource with less uncertainty and greater stakeholder confidence.
- If appropriate, provide greater access to the scallop resource in nearshore areas for general category permit holders.

One objective was modified by adding a temporal component:

- Provide a recommendation to NMFS and the NEFMC for use of current regulated scallop gear outside the GoM Scallop Dredge Exemption Area and within the study area between April and June.

Two new objectives were included in the revised proposal to:

- Document the maturity stages of yellowtail flounder caught as bycatch in the study area during April – June.
- Document and analyze the quantity and distribution of yellowtail flounder in relation to commercially exploitable scallop beds in the study area during April – June.

METHODS

Approximately four tows per day for 11 days per month were scheduled to be completed in the GSCDEA. To gather information on a seasonal basis, sampling was to be conducted between March and June, in September and in December. Tow allocations within the study area were anticipated to be divided between statistical areas 521 and 526 with an approximate distribution of tows of 75% and 25%, respectively based on the relative sizes of areas covered by statistical areas in the GSCDEA.

Field work was accomplished aboard three commercial sea scallop vessels. F/V Donna Jean II (U.S. Coast Guard Doc. # 656499), F/V Donna Marie (State Reg. # MS9191AH) and F/V Mistress II (State Reg. # ME6781B) (Figure 3a, 3b, 3c) are vessels that are typical of the general category scallop fishing fleet. Table 1 lists the scallop dredge gear characteristics employed by each vessel for the study. The twine top hanging ratio (E_{tt}) refers to the number of twine top meshes (m) mounted or attached per ring (r):

$$E_{tt} = m : r.$$

	dredge frame		twine top			
	width (ft)	height (in)	Length (ft)	width (ft)	average mesh size (mm / in)	hanging ratio
Donna Jean II	7.8	15	4.4	6.1	255.6 / 10.1	4:1 (Mar – Jun) 3:1 (Sept.)
Donna Marie	8.1	10.8	3.4	5.9	265.0 / 10.4	3:1
Mistress II	8.9	15	4.3	6.7	275.4 / 10.8	3:1

Table 1. Scallop dredge gear characteristics.

Precise tow locations were based on captains' knowledge gained through participation in the sea scallop fishery. The tow direction, vessel speed and scope of wire used were typical of the general category scallop fleet standard practices and were influenced by depth and bottom substrate. Tow durations of 30 minutes were the goal. For all tows, sampling of the catch entailed recording total weights (to tenths of pounds) for all species captured in the dredge as well as length frequency (to nearest whole cm according to NEFSC protocols for length type) information for finfish bycatch species.

Selectivity

For approximately one third of the total number of tows, the vessels towed their scallop dredge with a small mesh twine top cover net (Figure 4) in order to obtain species and size selectivity information for the twine top. Additional biological data were collected during these tows. This included finfish length measurements and sea scallop shell

height frequencies (in 5 mm intervals) from both the catch in the scallop dredge as well as from the twine top cover net.

The twine top cover net employed in this study was designed and constructed based on escapement panel cover net designs used to measure selectivity of trawl codends (Wileman et al. 1996). The twine top cover net used was a 12′ x 8′ two seam codend and has 3.5″ mesh size netting constructed with 4 mm polyethylene twine. A welded steel frame with a minimum height of 24″ was mounted on the pressure plate to prevent masking of the 10″ twine top by the smaller meshed cover net. Two days of field trials with video equipment were conducted prior to the project to fine tune the performance of the twine top cover net and to ensure the cover net did not affect scallop dredge or twine top performance. Each vessel had their own custom steel frame made to accommodate the width of their individual dredges.

Yellowtail Flounder Maturity

Detailed information on sex and maturity stages were recorded for all yellowtail flounder caught. Yellowtail flounder maturity was based on staging criteria described in O'Brien et al. (1993). Data from all dredge and twine top cover net catches were pooled for an analysis of yellowtail flounder maturity information. Yellowtail flounder maturity data collection and analysis included the months of April, May and June only.

RESULTS & DISCUSSION

Sampling Tows

Table 2 indicates the total number of days and tows completed for each month during the study period. As proposed, eleven days per month of sampling were completed between March and June. In September, only nine days were completed, and no sampling occurred in December.

	Number of Days	Number of Tows Total	Number of Hours Towed	Number of Tows Stat Area 521	Number of Tows Stat Area 526
projected	11	44	22	32	12
March	11	38	17.7	28 (73.7%)	10 (26.3%)
April	11	64	29.8	50 (78.1%)	14 (21.9%)
May	11	54	27.2	36 (66.7%)	18 (33.3%)
June	11	47	23.6	26 (55.3%)	21 (44.7%)
September	9	41	19.8	23 (56.1%)	18 (43.9%)
December	0	0	0	0	0
Total	**53**	**244**	**118.2**	**163 (66.8%)**	**81 (33.2%)**

Table 2. Number of days and tows completed by month and statistical area.

Due to a budget short fall, September's sampling had to be cut short by two days and December sampling had to be omitted entirely. This short fall was the result of a lower than expected catch of sea scallops during compensation fishing on the allotted 5 open area days-at-sea trip. Also, sea scallop catch rates on research days were lower than expected resulting in a lower cost offset of the vessel charter fees from the sale of the catch. In the proposal, project participants anticipated catching and landing 200 lbs of scallop meats per research day and using the proceeds towards the per day vessel charter fee. In reality, the vessels caught and landed significantly less per day than this figure. At the time the proposal was written (November 2005), 200 lbs per day was considered a reasonable landing estimate given scallop abundance inside the study area. However, by the time the field work began (March 2007), scallop abundance inside the area was significantly lower and vessels did not achieve this catch rate.

For the month of March, the study area was divided into 10 minute squares (Figure 5). Tows were to be conducted within each grid square in an attempt to assess the whole GSCDEA for suitable sea scallop bottom. In the northeast portion of the study area, depth proved to be a limiting factor as the contracted vessels could not fish deeper than 70 fathoms due to the amount of wire each vessel carried. In the western portion of the GSCDEA, much of the area was untowable due to unsuitable bottom topography. The results of the March survey led the project partners to decide that fishing effort in the following months should be dedicated to areas which had commercial quantities of

exploitable sea scallop biomass to reflect commercial fleet activity. Tow locations for the remaining months can be seen in Figures 6 – 9.

The lower than projected number of tows completed in the month of March was the result of an extensive amount of search time used to cover the study area. The lower than expected number of tows in September was the result of fewer days on the water. However, the average number of tows per day (4.6) was higher than the expected average of 4 per day resulting in only 3 fewer total tows (41) than the target (44).

The original tow distribution allotted between statistical areas 521 and 526 was approximately 75% : 25%, respectively. Overall, actual tow distribution was 66.8% : 33.2% between areas 521 and 526, respectively. March and April followed the original tow distribution, but the following months had an increasing trend of effort in area 526. This was the result of allowing the vessel captains to focus on areas with higher densities of sea scallops to reflect the likely true effort pattern of the general category scallop fleet.

Figure 10 is a representation of the scope of wire used by the three vessels. The scope refers to the ratio of the amount of wire paid out for the haul as a function of the depth of bottom. All three vessel captains stated that a scope of 3:1 plus an additional 10 fathoms of wire is a common practice for the general category scallop fleet. The calculated combined scope utilized by the three vessels was 2.93 : 1 + 9.3. Factors that had an influence on the scope of wire used included wire capacity of the vessel (an issue on tows over 60 fathoms) and bottom topography (vessels would use less wire on bottom with large sand humps).

Sea Scallop Catches

Table 3 lists the total amount of whole sea scallops and the catch rate in pounds per hour by month. The lowest amount of sea scallops caught was observed in March. This was the result of the manner in which March sampling was conducted. As stated above, this time period was dedicated to determining the extent of commercially suitable sea scallop fishing grounds in the GSCDEA; thus resulting in tows with lower sea scallop catches.

	whole sea scallop (lbs)	whole sea scallop (lbs/hr)
March	2,291.4	129.5
April	9,390.5	315.1
May	9,029.9	332.0
June	8,166.7	346.0
September	4,593.0	232.0
Project Total (all months)	**33,471.4**	**283.2**
Project Total (April – September)	**31,180.1**	**310.6**

Table 3. Whole sea scallop weights and catch rates (lbs/hr) by month.

Sampling in other months was focused on commercially exploitable sea scallop bottom resulting in high catches in April, May and June. The lower catch of sea scallops in September may partially be attributed to two fewer days of sampling, but the decrease in catch rate per hour indicate a potential decrease of sea scallop abundance in the study area. All three vessel captains stated that they saw a dramatic increase in fishing effort in the GSCDEA after the July closure of both the Nantucket Lightship and Closed Area I scallop access areas to general category scallop fleet. Project total catches (April – September) more likely reflect commercial catch rates because of the different sampling strategy employed in March.

Figures 11 – 15 display the distribution by whole weight of sea scallop for each month. These figures show that concentrations of commercial quantities of sea scallops were located only in portions of the GSCDEA. This was particularly evident in March when sampling was conducted to assess suitable sea scallop bottom in the study area. Figure 16 indicates that higher scallop densities were generally found between 30 and 50 fathoms of water in the area which is a slightly deeper range than 25 – 41 fathoms (45–75 m) as reported in Hart and Chute (2004).

Bycatch

The bycatch data reflect the catch from the dredge only and do not include any species weights from the twine top cover net catch. Bycatch rates of almost all species were observed to be extremely low for the project. These findings are consistent with the analysis of federal observer catch data used to assess the GSCDEA for access by the general category scallop boat fleet.[3] Individual species weights and their percentage of the total catch for the project and on a monthly basis can be found in Appendix II.

For the project, blue mussels accounted for the highest bycatch of any one particular species at 11% (Figure 17). The high bycatch of blue mussels can be attributed to two separate tows. One tow in March yielded 3500 lbs and another tow in April had 1500 lbs. However, this high bycatch of blue mussels does not appear to be a usual occurrence during commercial scalloping operations as these two tows were conducted in non-traditional scalloping grounds.

The largest finfish bycatch was all skate species combined. For the project, they accounted for 10% of the total catch and on a monthly basis, all skates were observed to be between 2% and 23% of the total catch (Figures 18 – 22). Flounders and monkfish, other species considered to be prominent bycatch in the sea scallop fishery (Harrington et al. 2005), were a minimal part of the project's total catch at 1% each. The highest percentage of monkfish bycatch occurred in June and in September with 2% of the catch in both months. The largest percentage of flounder bycatch occurred in September with all flounders combined accounting for 2% of the total catch. Yellowtail flounder in particular accounted for only 0.16% of the project's total catch and on a monthly basis

[3] "Fisheries of the Northeastern United States; Northeast Multispecies Fishery; Great South Channel Scallop Dredge Exemption Area," 71 Federal Register 129 (6 July 2006), 38352-38355.

was observed to be 0.09%, 0.11%, 0.14%, 0.17% and 0.28% in March, April, May June and September, respectively.

Data collected on all skate species in this study have been combined. Sea samplers were asked to identify skates as best as possible; however, there was still some difficulty in species identification. In particular, it is difficult to distinguish between little and winter skate species under 35 cm. As such, there were multiple records of unidentified skate species (skate, nk) recorded in the catch data. Table 4 lists the catch rates in pounds per hour for individual skate species. The majority (97%) of the skate species encountered in the study were little and winter skates and skate, nk.

	March	April	May	June	September	**Total**
skate, nk	2.9	0.2	18.4	44.9	11.8	**15.7**
little skate	5.7	9.0	8.4	19.8	23.0	**12.8**
winter skate	1.7	0.6	2.6	17.7	42.2	**11.6**
barndoor skate	-	-	-	0.5	3.3	**0.6**
thorny skate	0.3	-	0.1	0.3	1.9	**0.5**
smooth skate	-	-	0.1	-	0.6	**0.1**
all skates combined	**10.6**	**9.8**	**29.7**	**83.1**	**82.9**	**41.4**

Table 4. Catch rates (lbs/hr) of individual skate species by month.

Table 5 is a listing of catch rates in pounds per hour for a selected number of species that were consistently part of the scallop dredge catch throughout the project. For the flounders, bycatch rates were, for the most part, minimal throughout the study period. Only September had a significant increase in windowpane flounder catch rates. Monkfish and skate bycatch was highest in the months of June and September. The

	sea scallop	monkfish	yellowtail flounder	winter flounder	windowpane flounder	skates, all combined
March	129.5	0.1	0.4	1.1	0.3	10.6
April	315.1	0.0	0.4	0.6	0.6	9.8
May	332.0	0.7	0.6	1.3	1.2	29.7
June	346.0	8.2	0.9	0.8	1.6	83.1
September	232.0	8.6	1.1	0.5	4.7	82.9
Project Total (all months)	**283.2**	**3.2**	**0.6**	**0.9**	**1.6**	**41.4**
Project Total (April – September)	**310.6**	**3.8**	**0.7**	**0.8**	**1.8**	**46.8**

Table 5. Catch rates (lbs/hr) of selected species by month.

changes in catch rates for these species are likely due to individual seasonal migration patterns and not changes in fishing practices. Monkfish (Steimle et al. 1999),

windowpane flounder (Chang et al. 1999), little skate (Packer et al. 2003a) and winter skate (Packer et al. 2003b) all have inshore / offshore migration patterns that are related to water temperature.

Distribution plots were also developed for the above finfish bycatch species that were commonly encountered during the project. Monkfish distributions (Figures 23 – 27) show that they were concentrated in statistical area 526 in June while in September more monkfish were found along the slope in the northern portion of statistical area 521. Yellowtail flounder distributions (Figures 28 – 32) indicate higher abundances along the southern boarder of the GSCDEA in May and June. In September, the yellowtail flounder distribution was more evenly divided between the two statistical areas. Winter flounder distributions (Figure 33 – 37) were spread throughout the study area in March and April but were more concentrated in statistical area 526 in May and June. Windowpane flounder distributions (Figures 38 – 42) were concentrated in the southern portion of the study area from April through June, and in September they were captured in both statistical areas in high abundance. All skates combined (Figures 43 – 47) were pretty well distributed throughout the GSCDEA during the study.

Length frequency distributions were plotted for a selected number of finfish bycatch species by month for an indication of the size ranges of fish as encountered in the study area. These length frequencies reflect the catch from the dredge only and do not include any lengths from the twine top cover net catch. Lengths of monkfish (Figure 48) indicate larger sized fish were captured in the study area in June and in September which accounts for the increase in monkfish catch rates for these months. The yellowtail flounder length frequencies (Figure 49) indicate that most fish caught were above the minimum landing size of 33.02 cm (13 inches). Lengths for winter flounder (Figure 50) indicate that most caught were also above their respective minimum landing size, 30.48 cm (12 inches). Windowpane flounder (Figure 51) were mostly between 25 and 35 cm in length in all months.

Selectivity

Table 6 indicates the number and percentage of twine top covered tows completed for the project. The project averaged 36.1% of the tows completed with the twine top cover net for selectivity purposes. In general, twine top covered tows were completed by one vessel each month. In September, a second vessel also used the twine top cover net for half of its allotted tows, resulting in a higher percentage (48.8%) of selectivity tows being completed.

Table 7 displays species selectivity from all twine top covered tows by species category. Individual species selectivity information for the project and for each vessel can be found in Appendix III. Extremely high retention of species by the dredge was observed for all skate, sea scallop, monkfish and other invertebrates. Retention rates were lower for all flounders and much lower for other fish. Overall, many individual species caught showed high retention rates within the dredge regardless of weight recorded. Those

species that had retention rates of 50% or less were found to be poorly represented within the catch.

	Number of Total Tows	Number of Twine Top Covered Tows	Percentage of Twine Top Covered Tows
March	38	14	36.8%
April	64	22	34.4%
May	54	15	27.8%
June	47	17	36.2%
September	41	20	48.8%
Total	**244**	**88**	**36.1%**

Table 6. Number of total tows and twine top covered tows completed.

	Catch weight (lbs)		% retained
	dredge	cover	by dredge
all skates	1354.7	15.4	98.9%
sea scallops	13439.3	354.6	97.4%
monkfish	93.1	3.1	96.8%
other invertebrates	981.0	50.5	95.1%
all flounders	192.0	52.7	78.5%
other fish	10.3	26.8	27.7%

Table 7. Categorical species selectivity for all twine top covered tows.

The predominant species observed during the selectivity tows in both the dredge and twine top cover net was sea scallops, 13439.3 lbs and 354.6 lbs respectively for the project. The retention of sea scallops by the dredge was 97.4% for the project and varied little between vessels, 96.9 - 99.0%. Figure 52 displays the amount of sea scallops retained by the dredge versus the twine top cover net. For this figure the catch data in pounds was transformed by: Log(weight + 0.1) to account for extreme and zero pound catches. No direct relationship was found ($r^2 = 0.1651$) between sea scallop retention and loss by the dredge. It is believed by the vessel captains that irregular bottom topography (i.e. sand humps) can cause the dredge to suddenly jump or stop which creates back pressure resulting in significant losses of sea scallops through the twine top.

For skates and monkfish, it is believed that morphology was the major factor that influenced retention. Skates, which are characterized by broad wing-like pectoral fins, have a high disk width to total length percentage. For winter skates, disk width has been observed to be 57.1 - 66.3% of total length (Sulikowski et al. 2003) and for thorny skates, disk with is 69.1 - 73.6% of total length (Sulikowski et al. 2005). Therefore, even relatively small skates with respect to total length have wide profiles which will not fit through the twine top mesh. For monkfish, the maximum girth has been observed to be

81% - 95% of total length (GMRI and MCCS 2005) which also results in relatively small monkfish being robust in overall size.

Overall, retention of all flounders was observed to be 78.5% for the project. However, individual flounder species showed a wide range of retention rates. For the four most prominent flounder species (by weight) that occurred during the selectivity tows, summer flounder (95.8%) and windowpane flounder (89.4%) exhibited the highest retention by the dredge for the project. It would appear that yellowtail flounder and winter flounder were better able to escape through the twine top with lower retention rates of 62.4% and 62.3 %, respectively.

For flounders, the combination of low bycatch rates and high retention of the dredge would seem to indicate two possibilities. One is that there were few in the area during the project. Another possibility is that gear avoidance behavior by flounders may be occurring. The evidence for gear avoidance behavior is that a number of flounders were observed on the outside of the leading edge of the twine top cover net upon haul back. This could indicate that flounders will typically go up and over the dredge as they encounter it, but with the twine top cover net extending the overall height of the gear these fish were now being "caught". All three captains also related that they tend to see more finfish bycatch at faster dredge speeds signifying that fish may be able to avoid a slower moving dredge but have difficulty evading a faster moving one. It is proposed that further investigations into finfish behavioral interactions with general category scallop dredge gear be conducted.

Size selectivity data from all twine top covered tows was analyzed for a number of species. The percent length frequency distributions from both the dredge and twine top cover net catch were plotted for sea scallops (Figure 53). The results of a Kolmogorov-Smirnov two sample test indicated a significant size difference ($\alpha = 0.05$) in length distributions between the dredge and twine top cover net catch for sea scallops (Table 8). The dredge retained significantly larger sea scallops while smaller ones were found to pass through the twine top.

Percent length distributions were also plotted for four prominent finfish species: monkfish (Figure 54), yellowtail flounder (Figure 55), winter flounder (Figure 56) and windowpane flounder (Figure 57). Kolmogorov-Smirnov two sample tests ($\alpha = 0.05$) were also applied to these distributions. Results indicated a significant size difference in length composition between the dredge and twine top cover net catch for monkfish and yellowtail flounder but not for winter flounder or windowpane flounder (Table 8).

Significantly smaller sized yellowtail flounders and monkfish escaped through the twine top. Smaller winter flounder were recorded in the twine top cover net catch but not at a significant level. The percent length frequency distribution for windowpane flounder indicated that all sizes were found both in the dredge and within the twine top cover net. These results, however, should be treated as preliminary for all four finfish species. As seen throughout the project, only sea scallops were caught in significant quantities during twine top covered selectivity tows. Low bycatch rates resulted in low sample size

numbers for the finfish selectivity analysis. It is recommended that size selectivity of finfish for the twine top be further investigated with a more comprehensive study dedicated to twine top selectivity.

	D	$D_{.05}$	significant
Sea Scallop	0.388	0.050	yes
Monkfish	1.000	0.536	yes
Yellowtail Flounder	0.565	0.318	yes
Winter Flounder	0.280	0.363	no
Windowpane Flounder	0.118	0.328	no

Table 8. Observed and expected ($\alpha = 0.05$) values of D from Kolmogorov-Smirnov two sample tests.

Yellowtail Flounder Maturity

A total of 99 maturity stage samples were collected from the dredge and twine top cover net for the months of April, May and June (Table 9). The majority of yellowtail flounder sampled from the study area were mature fish in April (78.1%), May (66.7%) and June (89.3%). Of these 99 fish sampled only 25 were considered to be in spawning condition (ripe/ripe-running). Of these 25 spawning condition fish, 14 were collected in May. In April, 13 out of the 32 yellowtail flounders sampled were in the spent condition.

	immature	developing	ripe/ ripe-running	spent	resting	**total**
April	7	5	7	13	0	**32**
May	13	11	14	1	0	**39**
June	3	5	4	5	11	**28**
total	**23**	**21**	**25**	**19**	**11**	**99**

Table 9. Number of yellowtail flounder by maturity stage.

Table 10 represents the number of spawning yellowtail flounder caught by statistical area. Table 11 represents the number of spent yellowtail flounder caught by statistical area. The shaded regions of Tables 10 & 11 reflect seasonal closures with respect to statistical area in the GSCDEA to protect all yellowtail flounder stocks during their peak spawning periods. For statistical area 521, spawning fish were observed in greater amounts in April and May. Also in April, the most spent yellowtail flounders were observed. For statistical area 526, May showed the highest number of spawning fish and the most spent fish were observed in June.

	statistical area 521		statistical area 526		**total**	
	# of fish	# per tow	# of fish	# per tow	**# of fish**	**# per tow**
April	7	0.14	0	0	**7**	**0.11**
May	5	0.14	9	0.50	**14**	**0.26**
June	1	0.04	3	0.14	**4**	**0.09**

Table 10. Number of spawning yellowtail flounder by statistical area.

	statistical area 521		statistical area 526		**total**	
	# of fish	# per tow	# of fish	# per tow	**# of fish**	**# per tow**
April	13	0.26	0	0	**13**	**0.20**
May	1	0.03	0	0	**1**	**0.02**
June	1	0.04	4	0.19	**5**	**0.11**

Table 11. Number of spent yellowtail flounder by statistical area.

It is difficult to draw hard conclusions based on this small sample size of fish; however, these results suggest that there were two peak spawning events, one in April in statistical area 521 and one in statistical area 526 in May. These findings are not in complete alignment with O'Brien et al. (1993), who report that the spawning season for all yellowtail flounder stocks is between April and August and peak spawning occurs in May and June, or with the regulated seasonal closures for the GSCDEA. Due to the low numbers of yellowtail flounder caught by this project, it is unknown whether or not these results reflect the true spawning pattern of yellowtail flounder in the study area. Further, it is unknown whether or not yellowtail spawning activity in the year that this project was conducted followed the typical seasonal pattern.

It should be noted that the low number of yellowtail flounder, spawning or otherwise, is reflective of the low bycatch rates encountered throughout the project. Whether this is because of the lack of yellowtail flounder in the area or a result of gear avoidance behavior is not known at this time. It is proposed that a more comprehensive study, using gear(s) more appropriate to capturing flounders, that would yield more maturity samples be initiated to determine the true temporal and spatial extent of yellowtail flounder spawning in the GSCDEA.

CONCLUSIONS

Results from this study indicate that the addition of the Great South Channel Scallop Dredge Exemption Area to the list of current scallop dredge exemption areas was an appropriate action. Sea scallops can be harvested from portions of the exemption area in commercial quantities using general category scallop dredge gear with low finfish bycatch rates. The total project catch of whole sea scallops was 33,471.4 pounds. In contrast, bycatch of all regulated northeast multispecies[4] totaled 391.5 pounds and monkfish bycatch was 383.8 pounds for the project. All regulated northeast multispecies were 1.17% and monkfish were 1.15% of the total scallop catch. Bycatch rates for all species were consistently low, regardless of the month in which sampling took place.

In particular, the overall bycatch of yellowtail flounder, a key bycatch species for the scallop fleet, was observed to be 76.4 pounds and only 0.23% of the total scallop catch. In terms of catch weight per hour yellowtail flounder bycatch was also very low. Overall, during months where sampling focused on commercially exploitable scallop beds (April – September), 0.7 lbs per hour of yellowtail were caught versus 310.6 lbs per hour of whole scallops.

Based on these catch rates, it appears that this fishery has little impact on the yellowtail flounder resource in general or during the seasonal yellowtail spawning closure in particular. While bycatch rates were consistently low regardless of the month in which sampling took place, the highest bycatch rate in any given month occurred in September (1.1 lbs per hour), not during any of the months that are closed to the fleet due to yellowtail spawning. In addition, analysis of maturity data for yellowtail flounder, while of limited value due to low bycatch rates, did not suggest a significant impact on spawning yellowtail flounder. Of the 99 yellowtail flounder sampled for sex and maturity stage recorded between April and June, only 25 fish were in a spawning condition of ripe or ripe and running; most of which were caught in May.

It would seem that reconsideration of the need for seasonal yellowtail flounder spawning closures or revisions to the timing of these closures for the GSCDEA may be appropriate based on these results. However, it is important to remember that these results represent only a relatively small sample of the general category scallop fleet during a limited time frame. In addition, the absence of yellowtail flounder from the scallop catch does not necessarily mean that there were no flounder in the area; it is unknown how many flounder were encountered but not captured by the dredge. There is little doubt that scallop dredging could disrupt yellowtail spawning activity even if few individuals are captured in the dredges.

The analysis of twine top selectivity led to several interesting results but strong conclusions were confounded by the low bycatch rates. Overall, bycatch species retention of the scallop dredge was observed to be higher than expected. The data does show that the twine top did allow for escapement of some smaller sized fish. For most

[4] Regulated northeast multispecies bycatch included: windowpane flounder, winter flounder, yellowtail flounder, witch flounder, American plaice flounder, Atlantic cod, red hake, silver hake and white hake.

species however, what little amount of finfish bycatch entered the dredge, stayed in the dredge. The same appeared true for the scallop catch, over 97% of the catch overall was retained in the dredge.

It should be noted that this was the first cooperative research project (that the authors are aware of) conducted with the general category scallop fleet. Cooperation between industry members and researchers was excellent. Considering the relative inexperience of these scallop industry members with scientific research, an impressive number of sea days (53) and tows (244) over 5 months were accomplished by this study. This would not have been possible without the continued interest and dedication of industry partners. This study represents the first documentation of catch and bycatch rates and twine top selectivity for this important segment of the scallop industry. This should be considered an important result in itself.

While this study has led to the collection of much interesting data, it has perhaps led to even more interesting questions for further study. It is proposed that further investigations into finfish behavioral interactions with general category scallop dredge gear be conducted. Placing video camera equipment on a scallop dredge would likely lead to a better understanding of bycatch rates and the important distinction between species encountered and species captured. It is also suggested that future research be dedicated to collecting more data on the species and size selectivity of the twine top in general category scallop dredges. Relative to the GSCDEA, more comprehensive yellowtail flounder maturity studies to determine the true temporal and spatial extent of spawning in this area would be useful to maximize the utility and value of seasonal yellowtail spawning closures.

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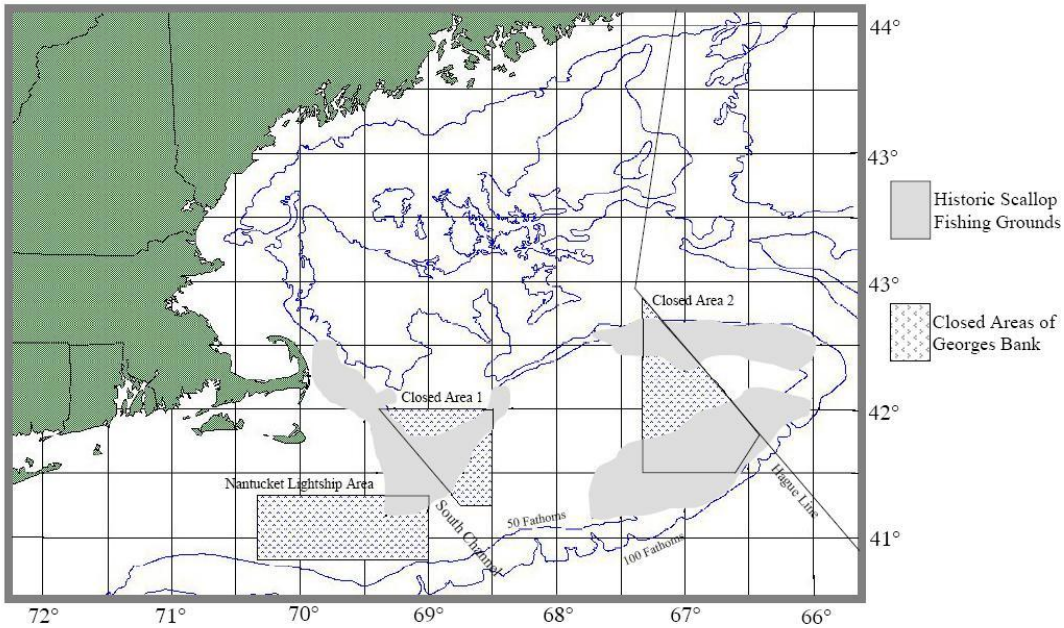

Figure 1. Historic scallop fishing grounds and closed areas of Georges Bank (from Sinclair et al. 1985).

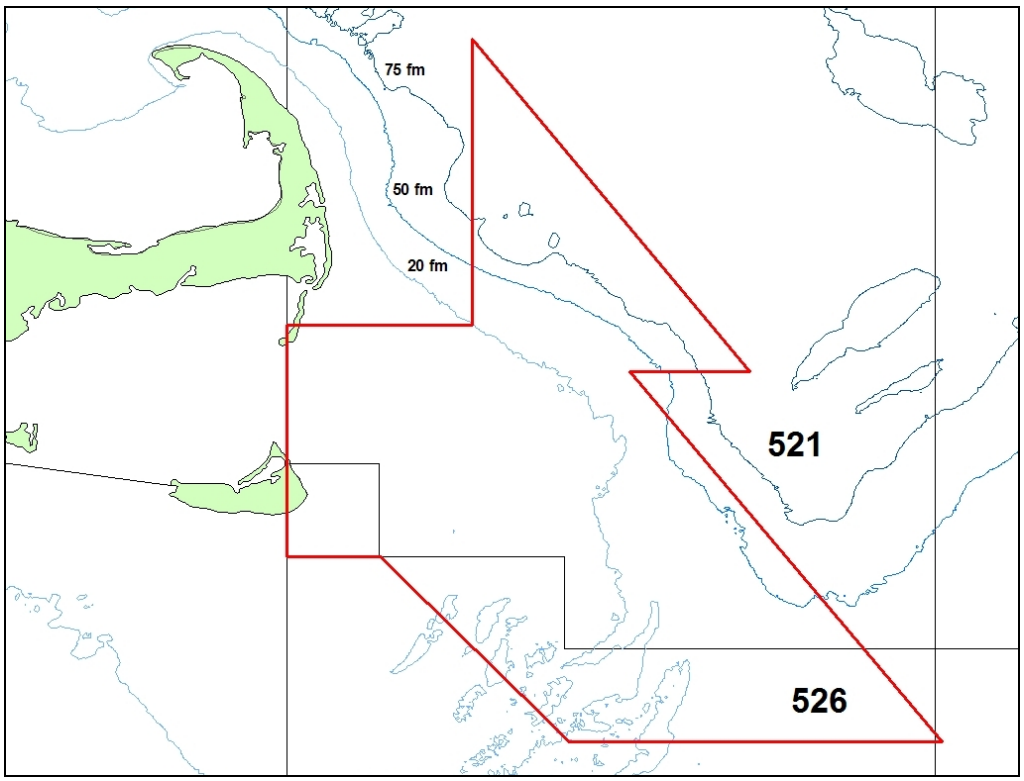

Figure 2. Great South Channel Scallop Dredge Exemption Area with statistical areas.

Figure 3a. F/V Donna Jean II, Hull, Massachusetts (50’ LOA).

Figure 3b. F/V Donna Marie, Gloucester, Massachusetts (40’ LOA).

Figure 3c. F/V Mistress II, Bucks Harbor, Maine (38’ LOA).

Figure 4. Twine top cover net attached to a scallop dredge.

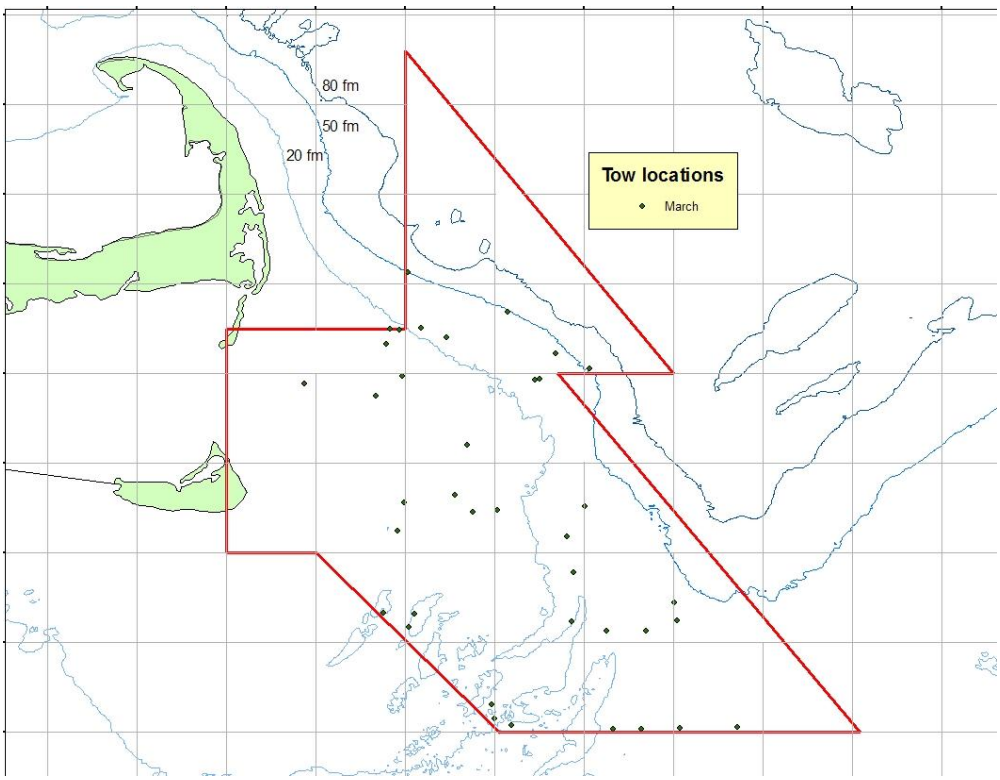

Figure 5. Tow locations in the study area during March sampling.

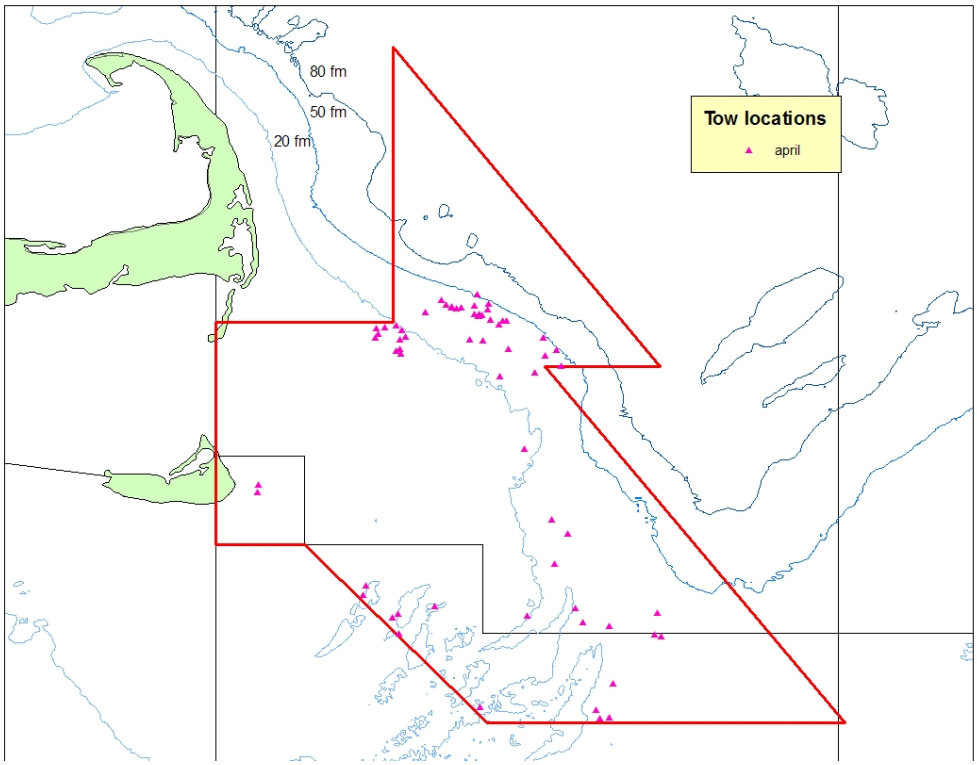

Figure 6. Tow locations in the study area during April sampling.

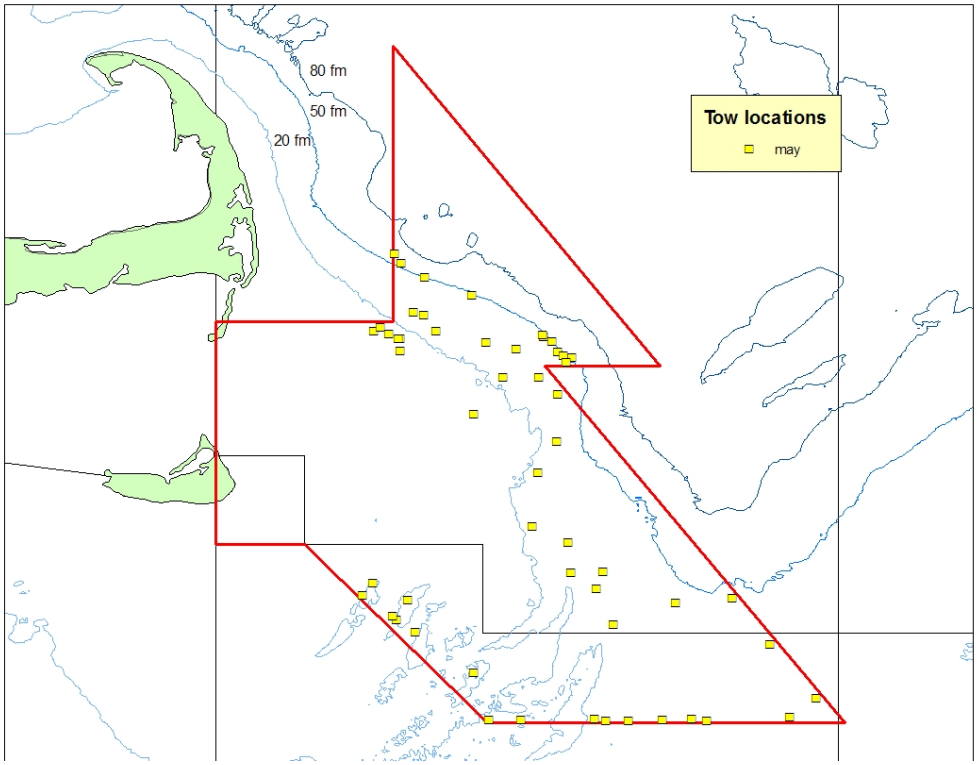

Figure 7. Tow locations in the study area during May sampling.

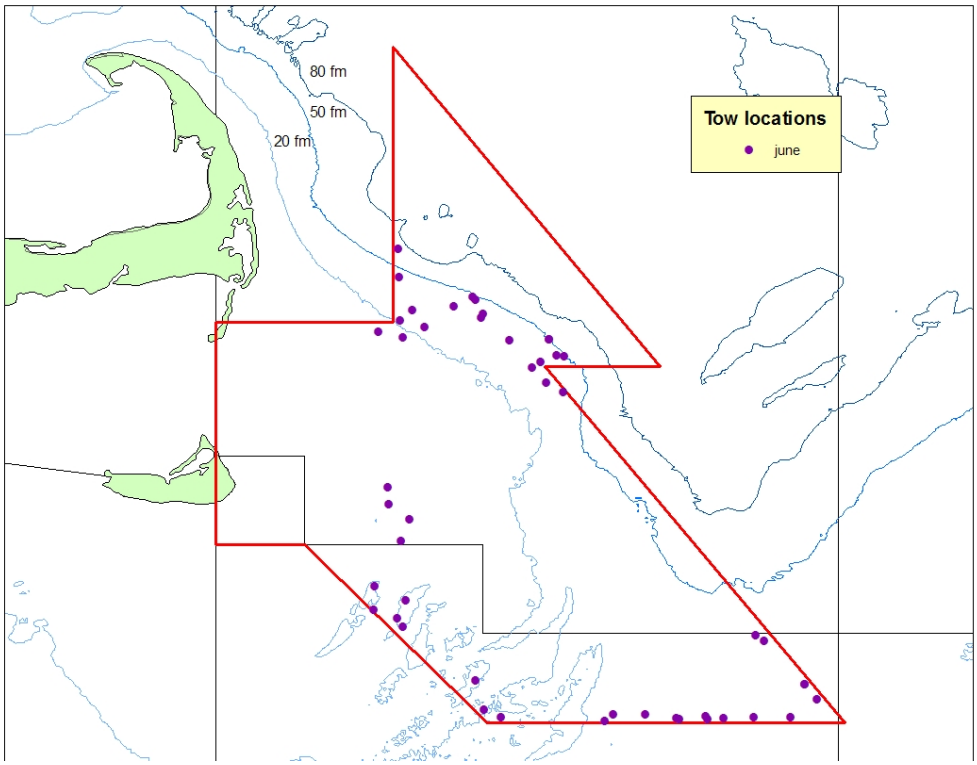

Figure 8. Tow locations in the study area during June sampling.

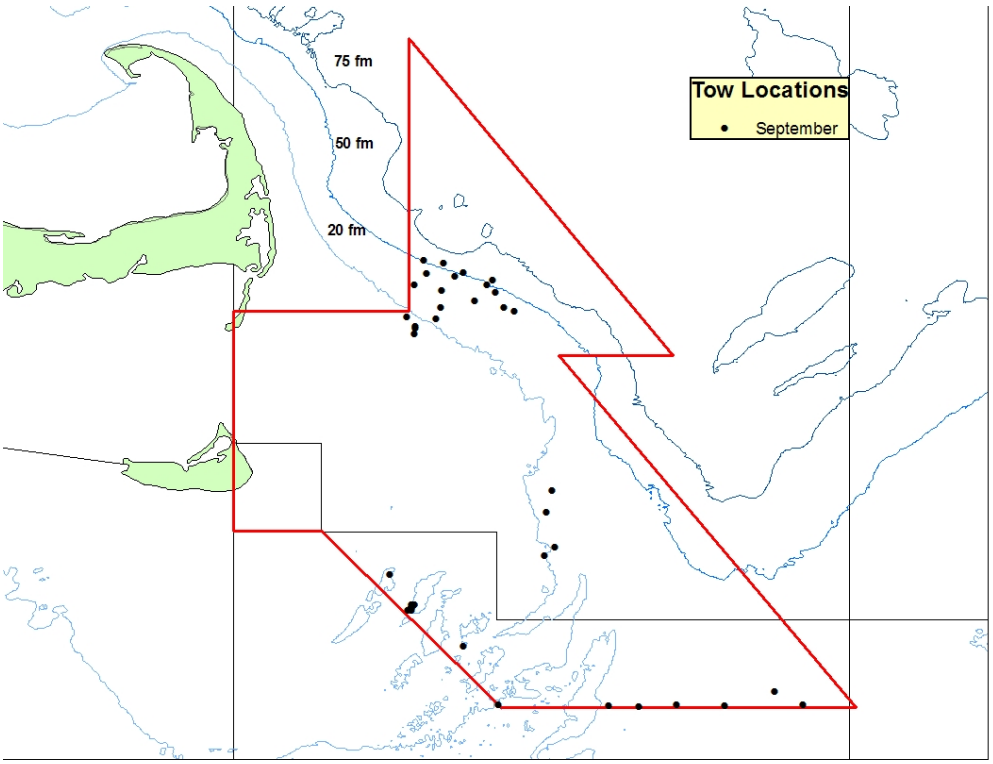

Figure 9. Tow locations in the study area during September sampling.

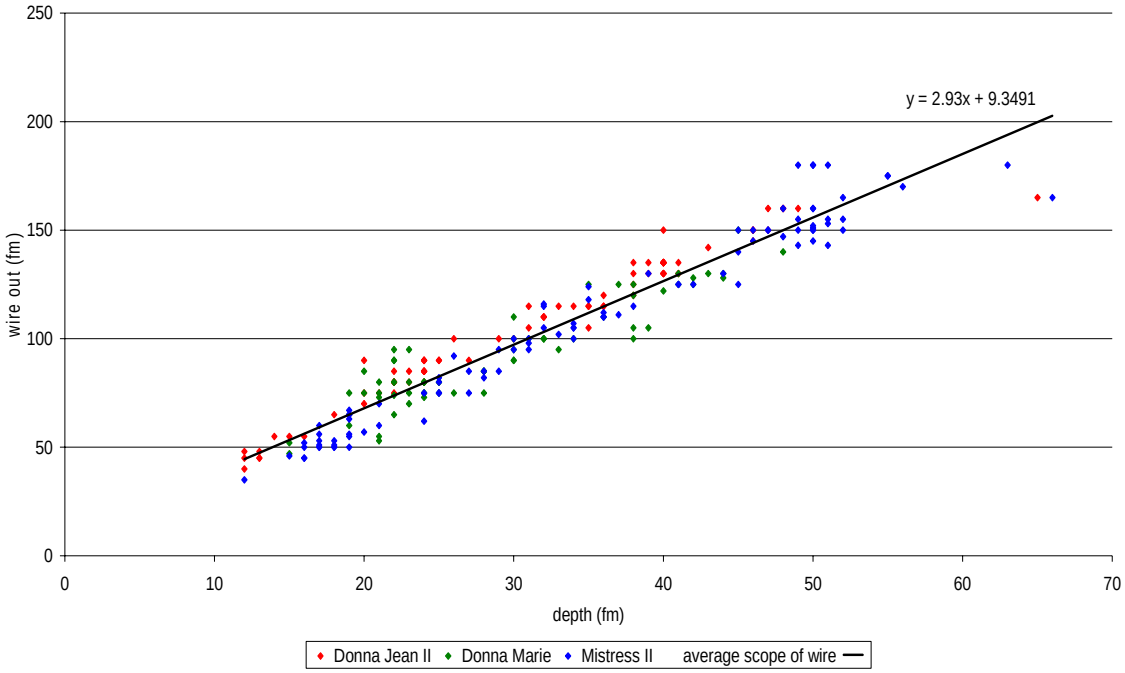

Figure 10. Scope of wire utilized by the three vessels for the project.

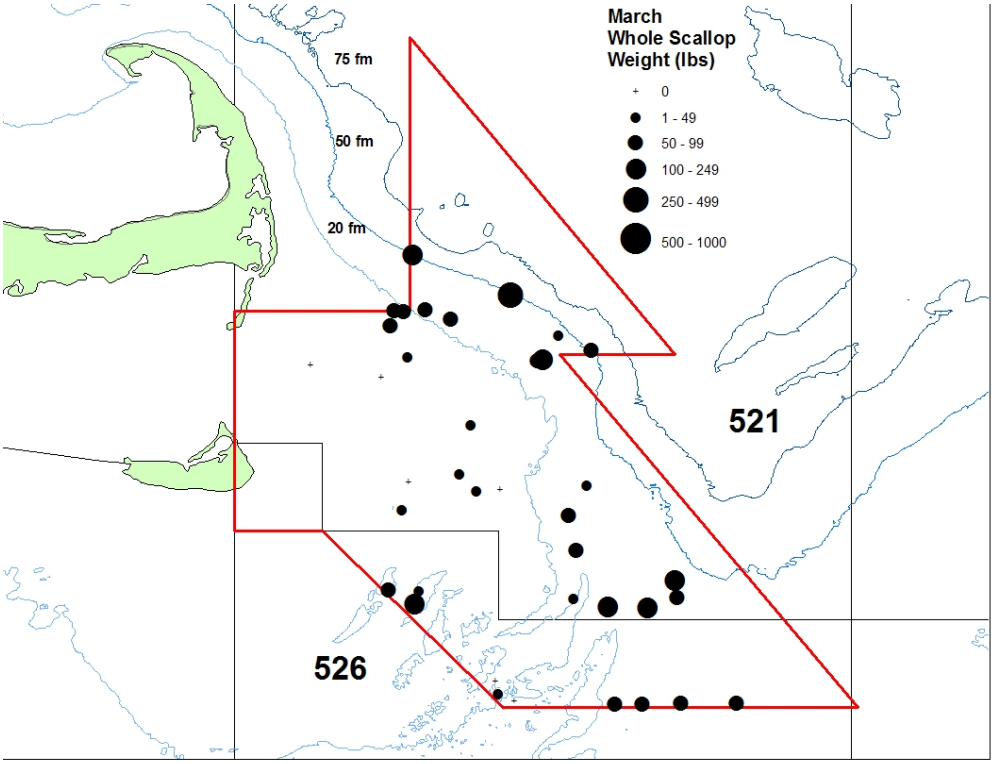

Figure 11. Sea scallop distribution by weight, March.

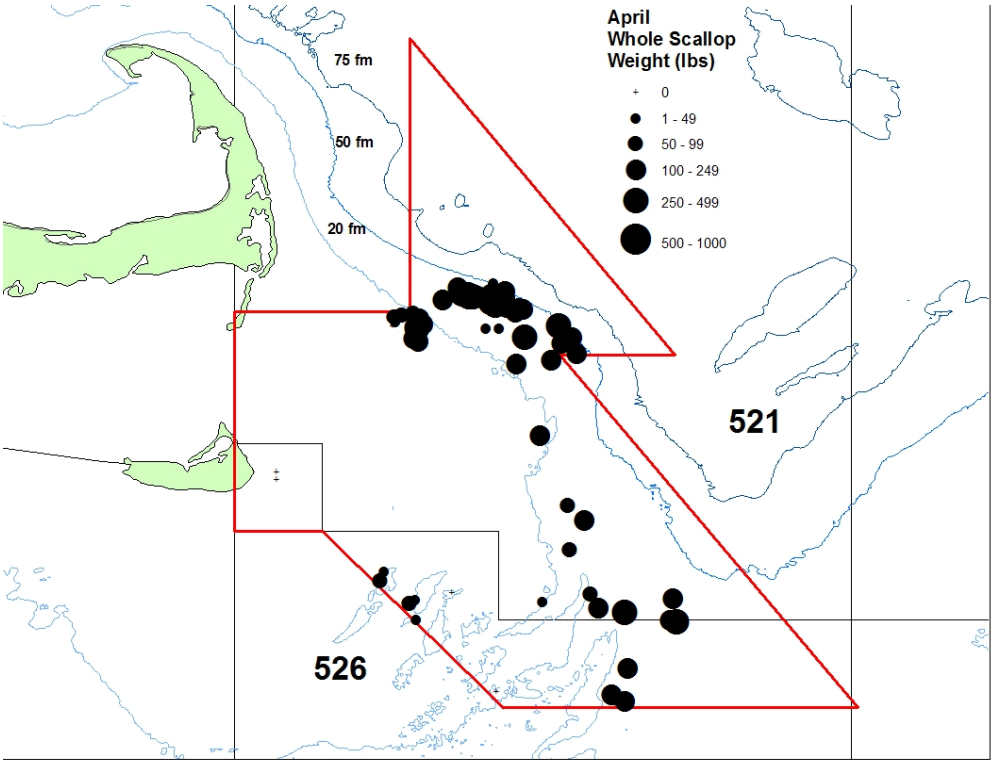

Figure 12. Sea scallop distribution by weight, April.

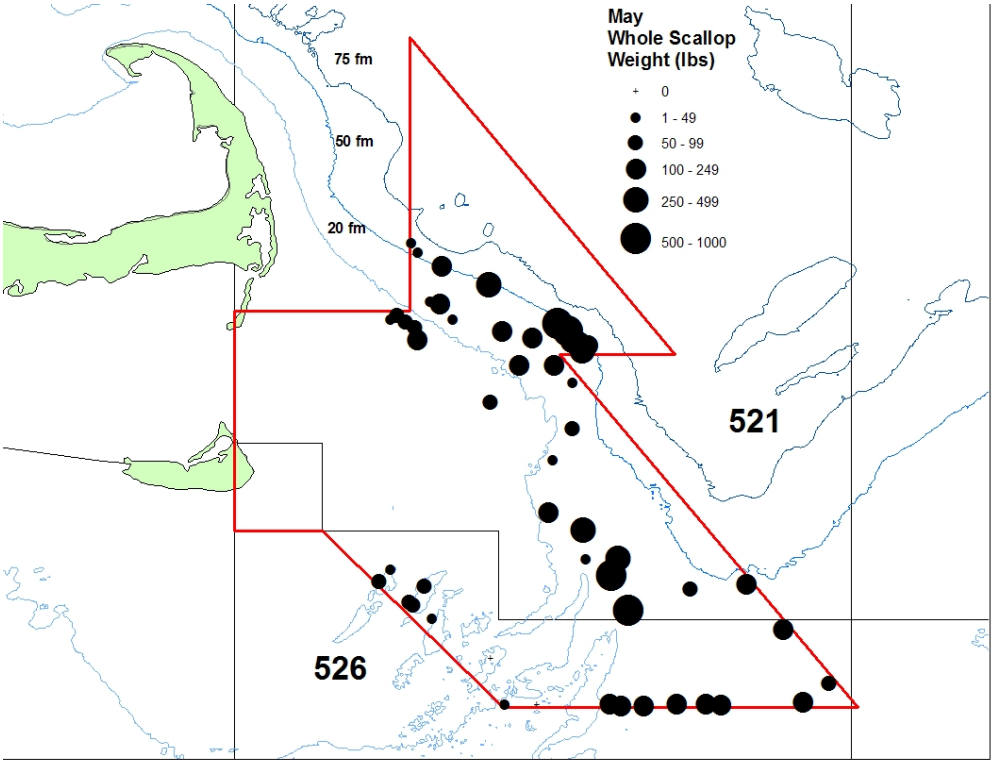

Figure 13. Sea scallop distribution by weight, May.

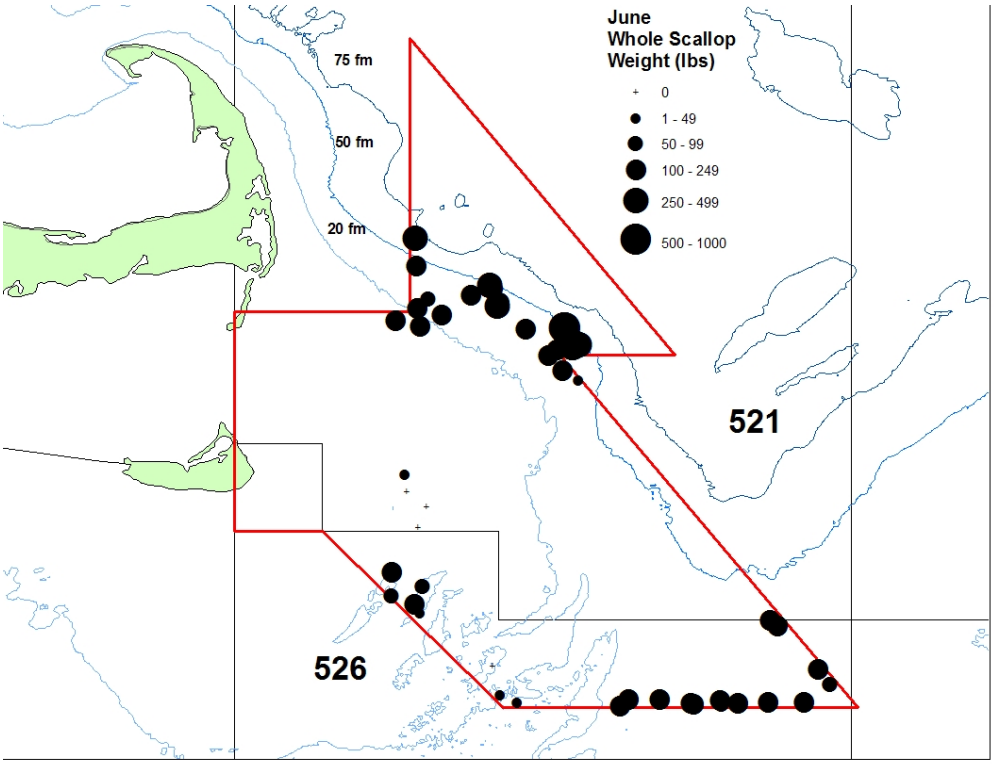

Figure 14. Sea scallop distribution by weight, June.

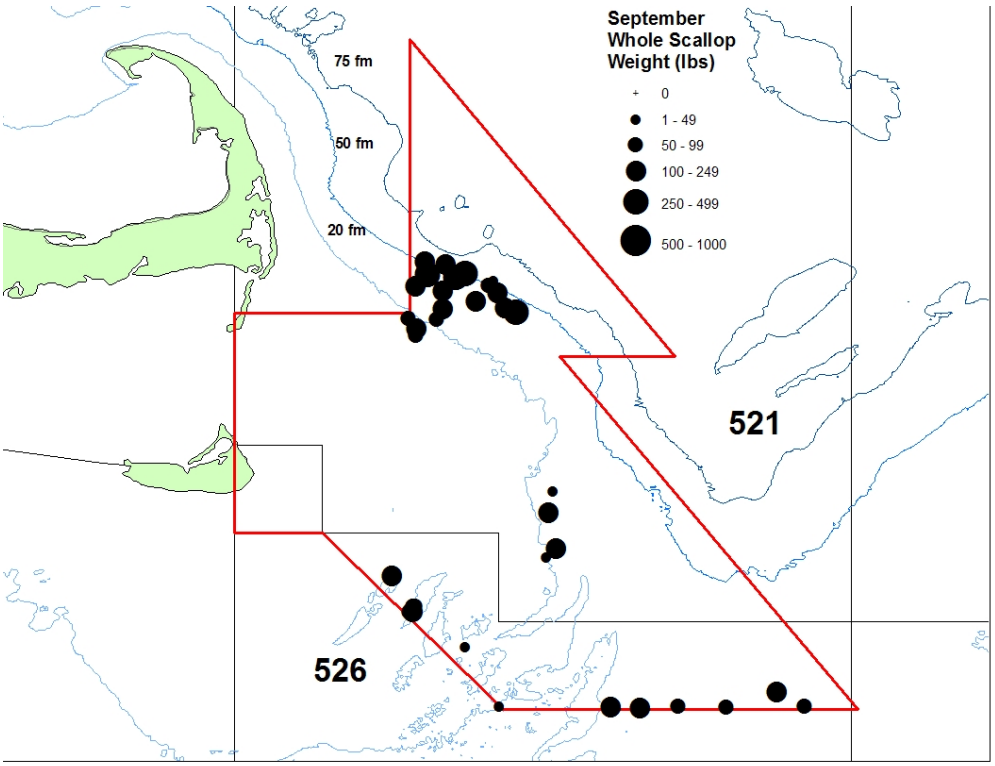

Figure 15. Sea scallop distribution by weight, September.

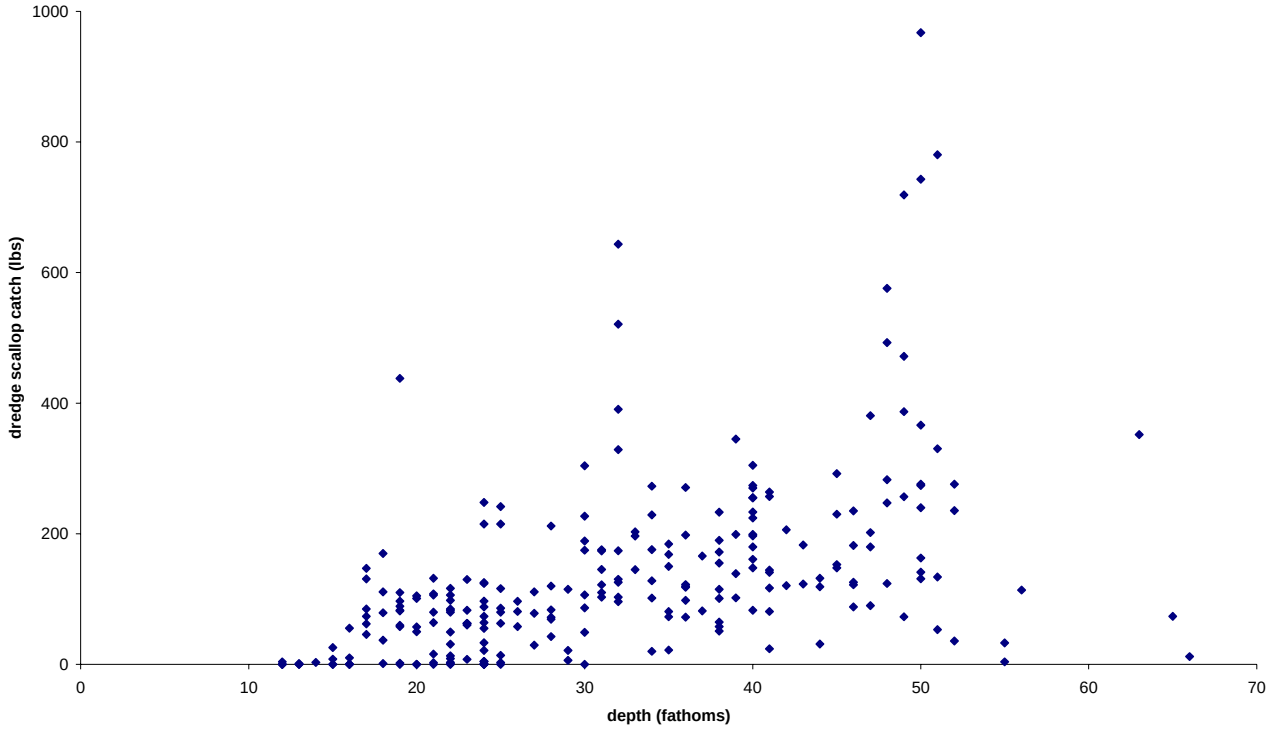

Figure 16. Tow depth versus dredge sea scallop weight.

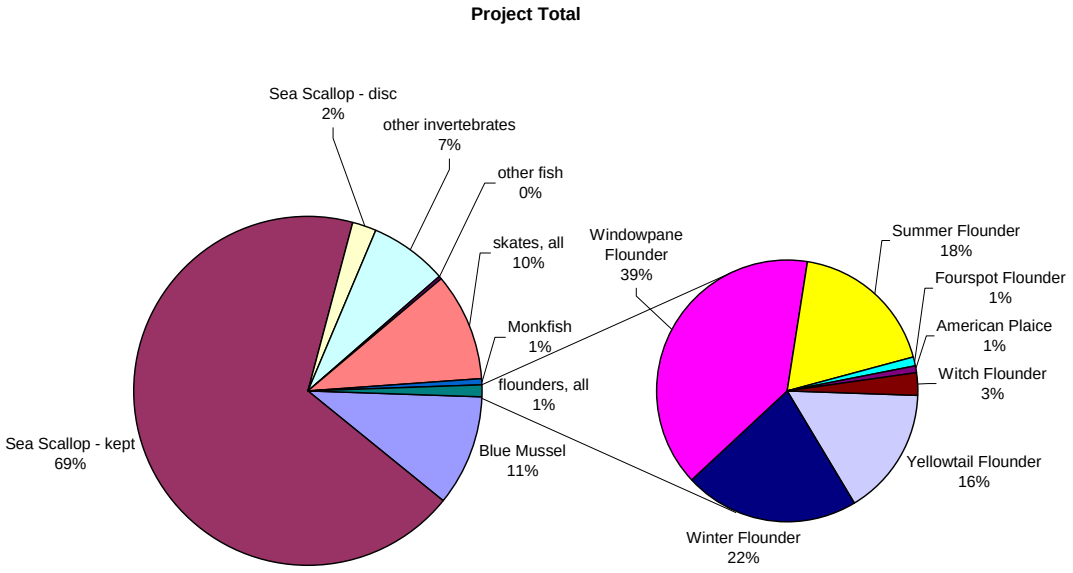

Figure 17. Project total catch composition by species category.

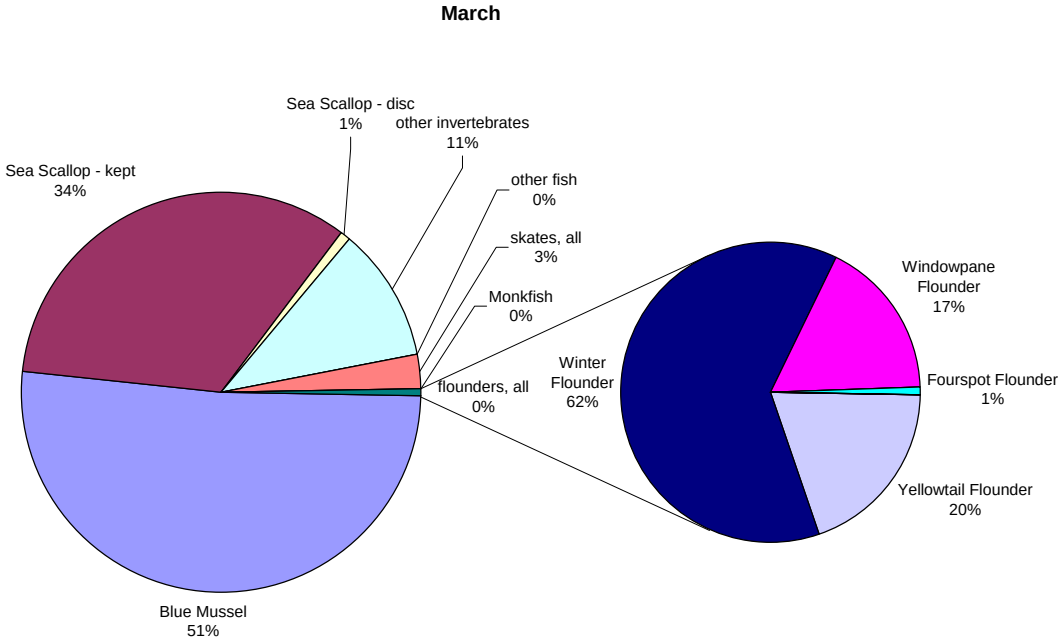

Figure 18. March catch composition by species category.

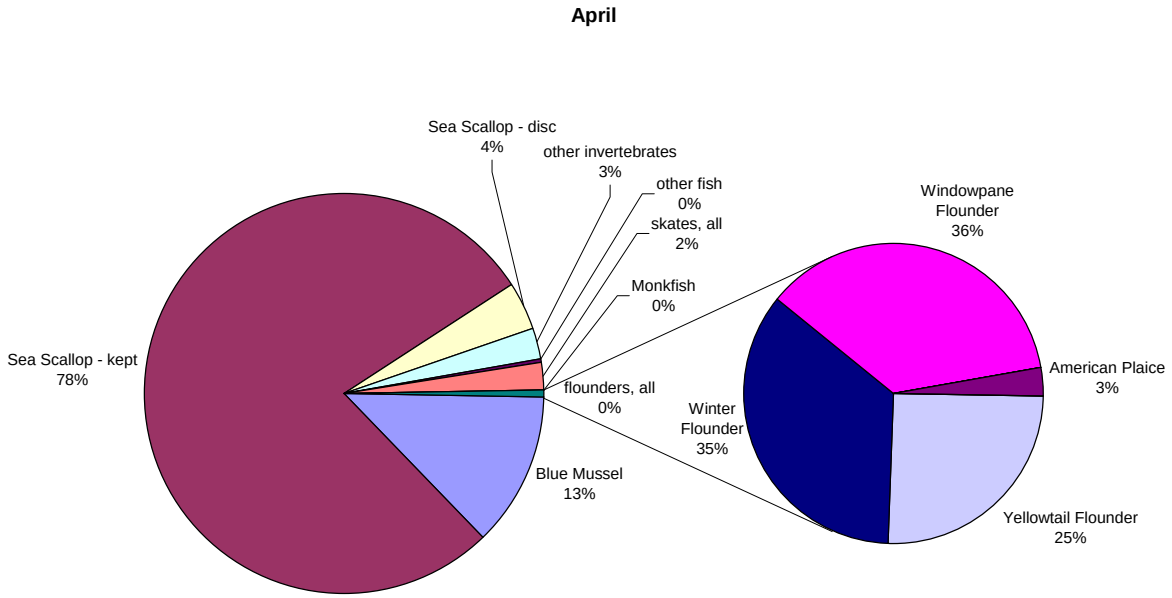

Figure 19. April catch composition by species category.

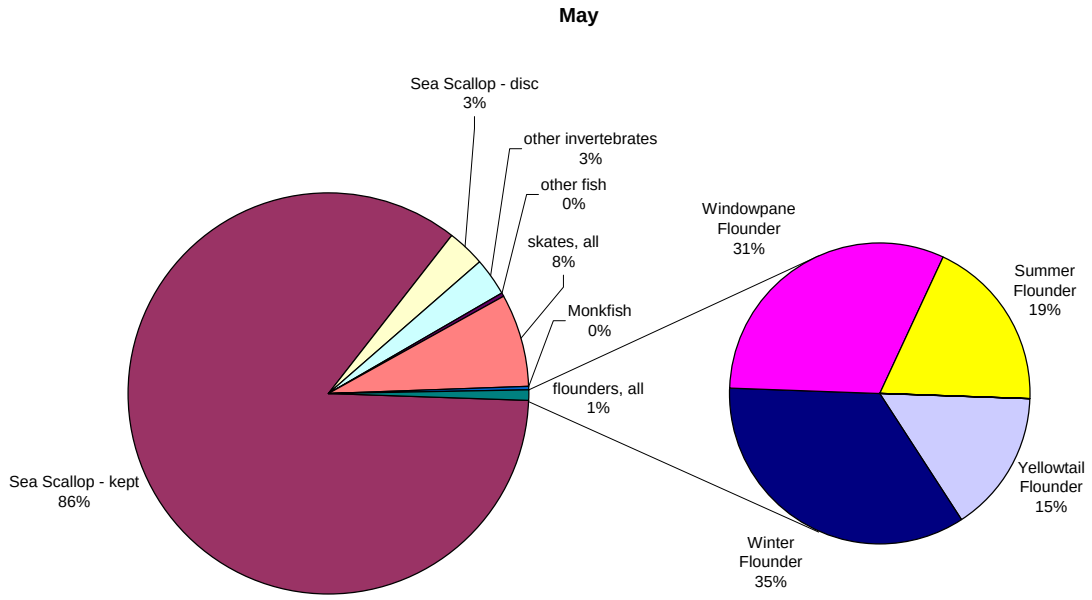

Figure 20. May catch composition by species category.

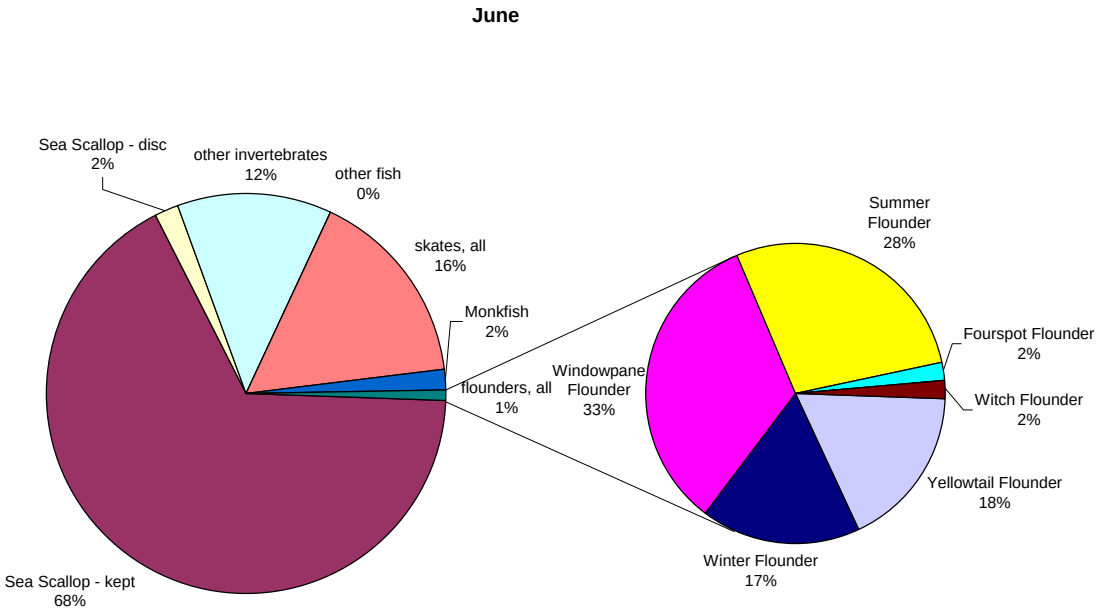

Figure 21. June catch composition by species category.

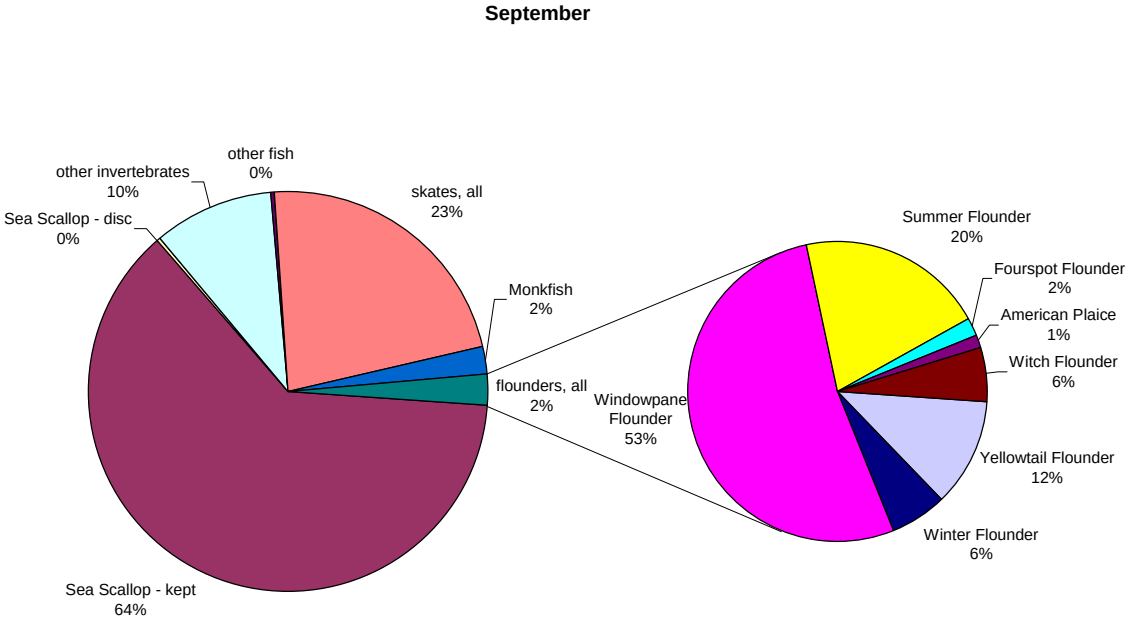

Figure 22. September catch composition by species category.

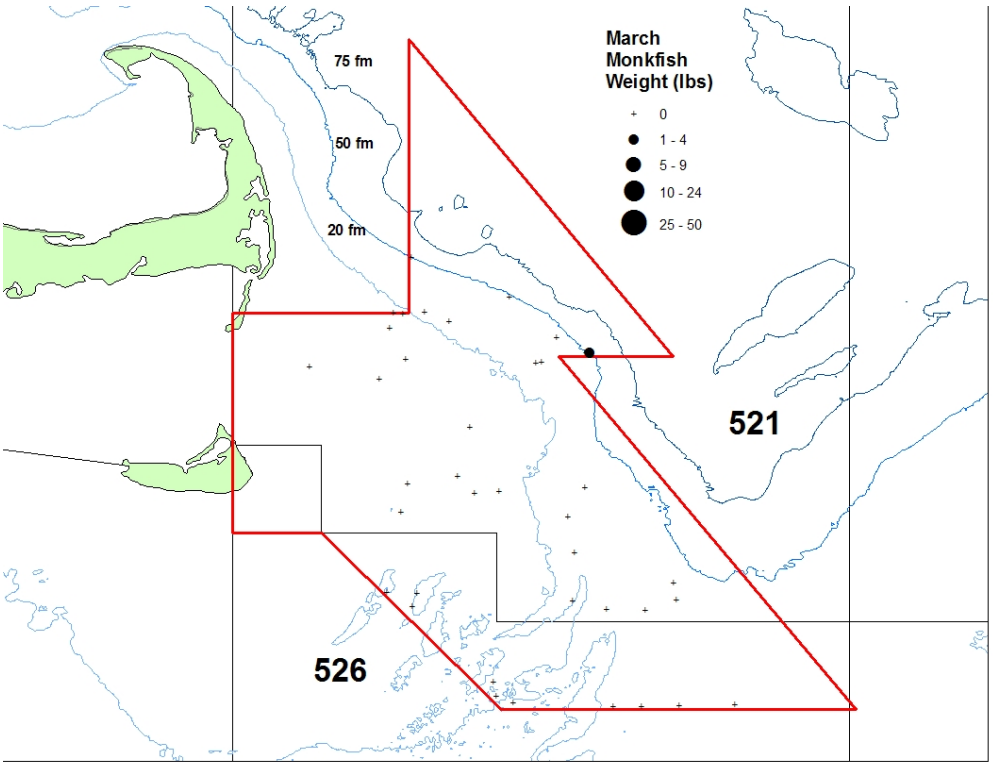

Figure 23. Monkfish distribution by weight, March.

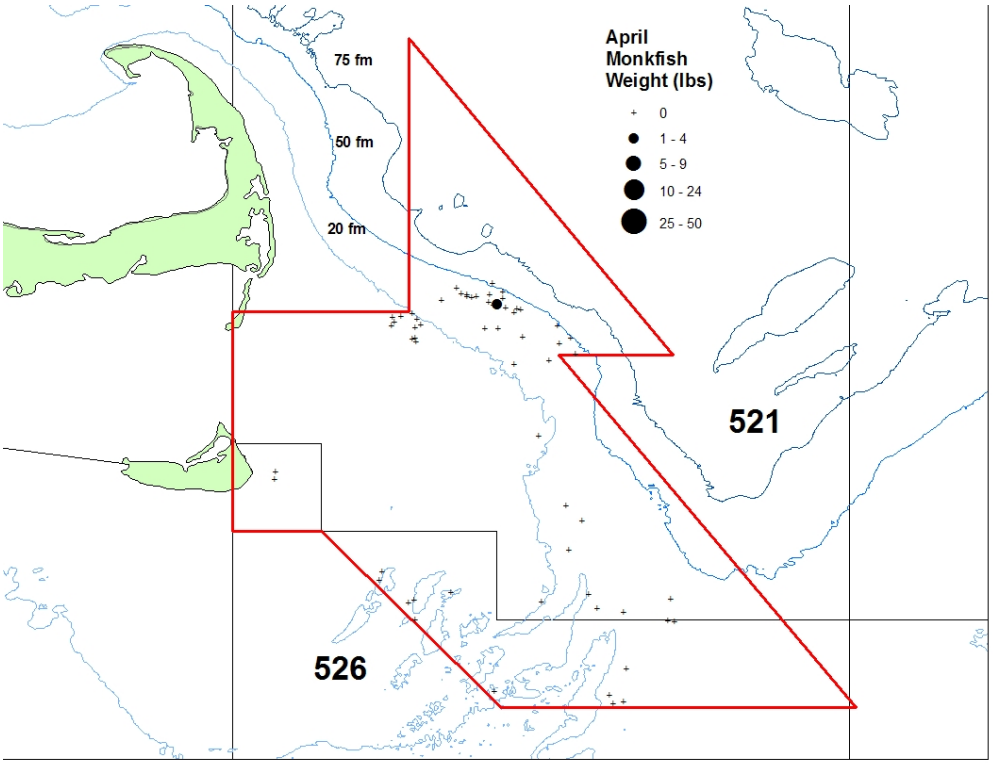

Figure 24. Monkfish distribution by weight, April.

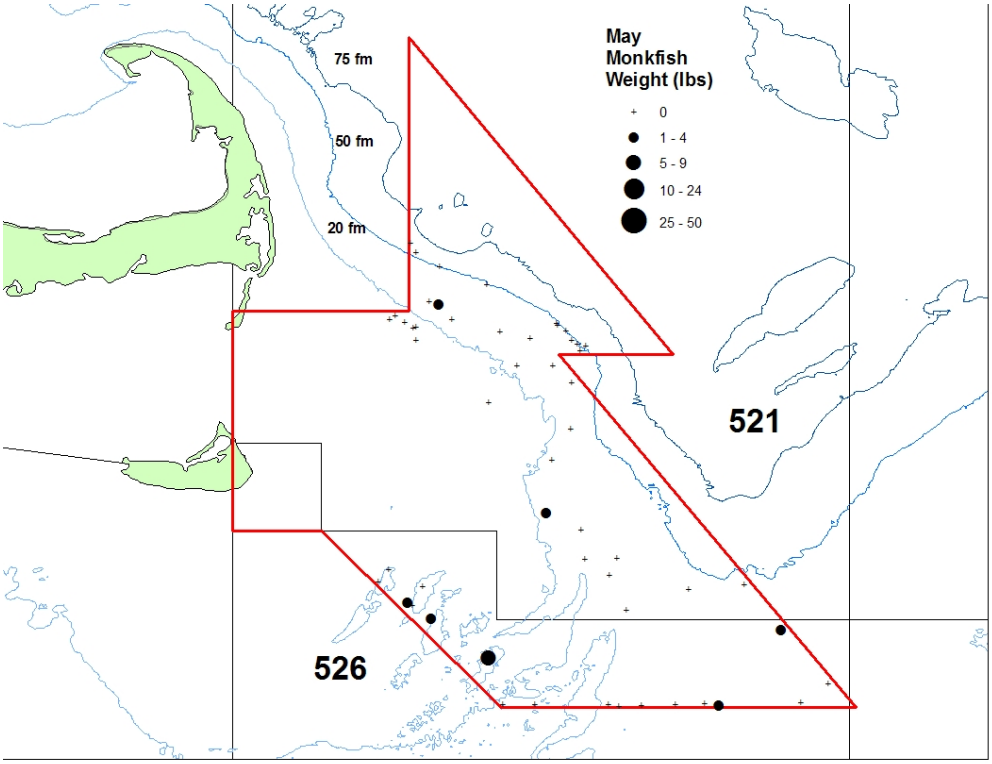

Figure 25. Monkfish distribution by weight, May.

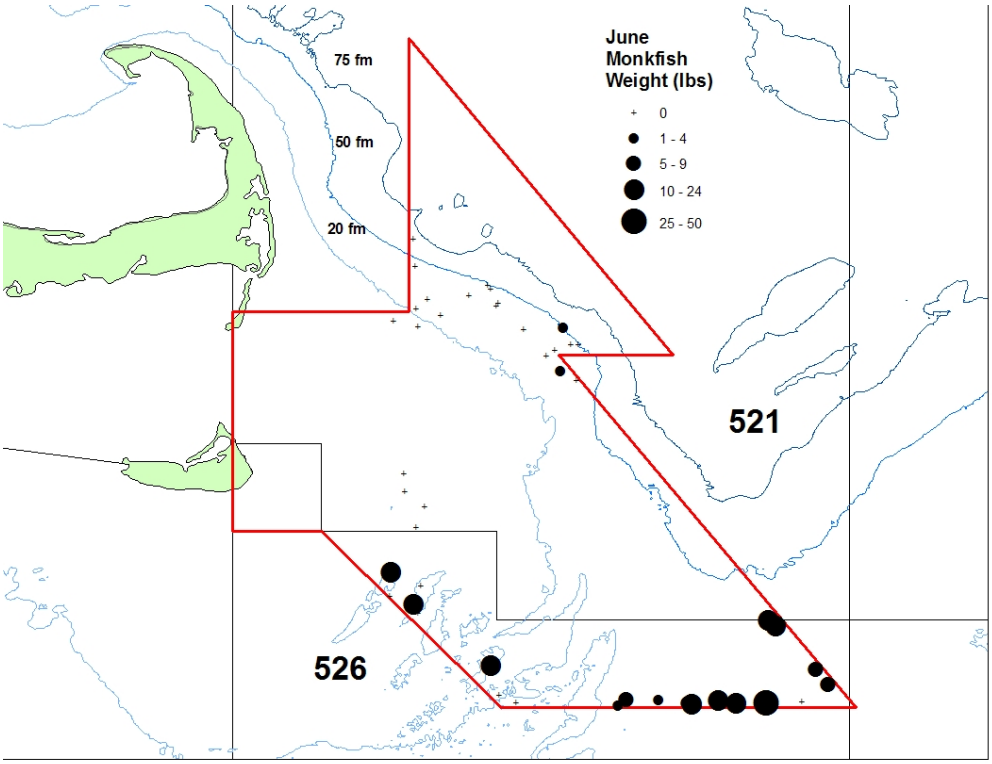

Figure 26. Monkfish distribution by weight, June.

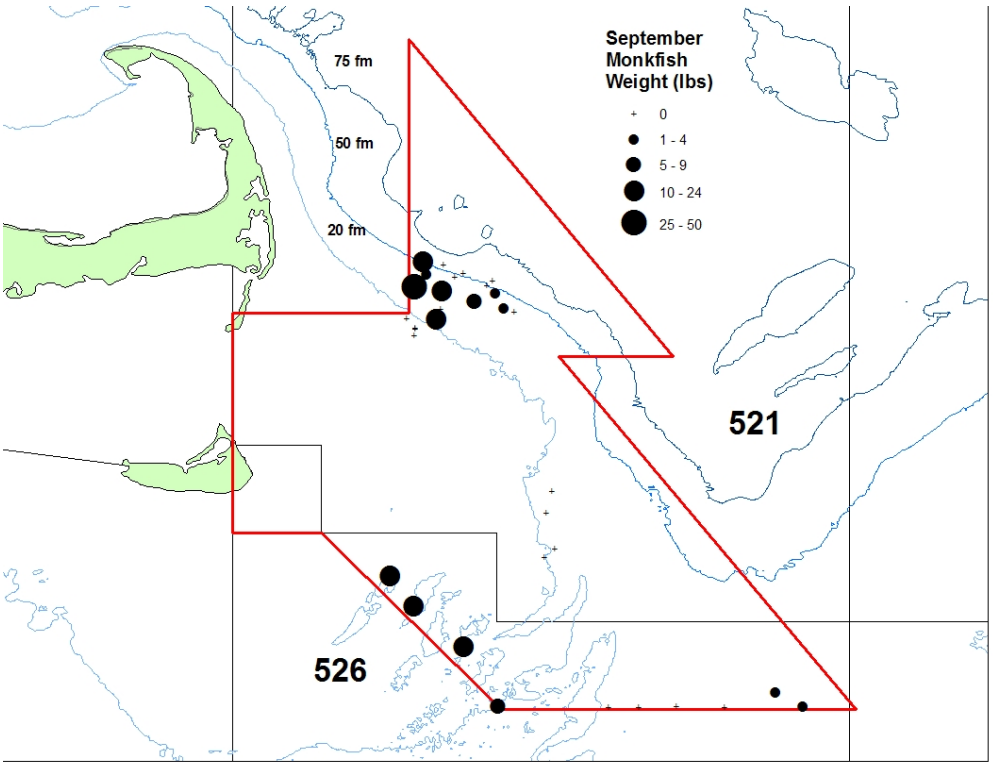

Figure 27. Monkfish distribution by weight, September.

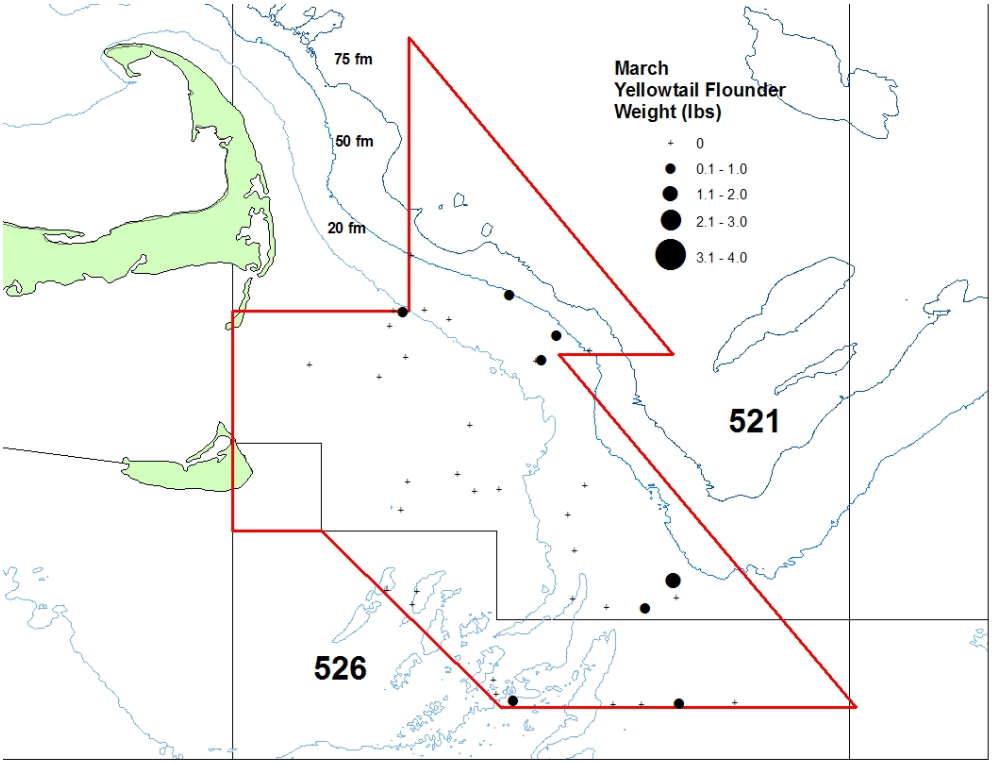

Figure 28. Yellowtail flounder distribution by weight, March.

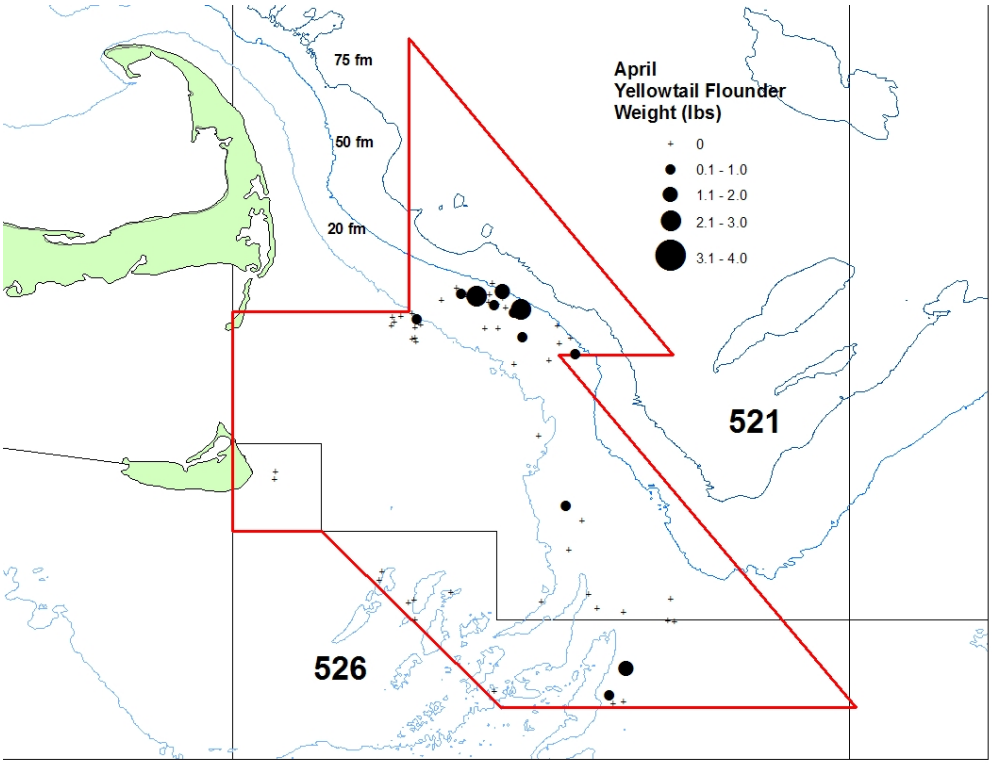

Figure 29. Yellowtail flounder distribution by weight, April.

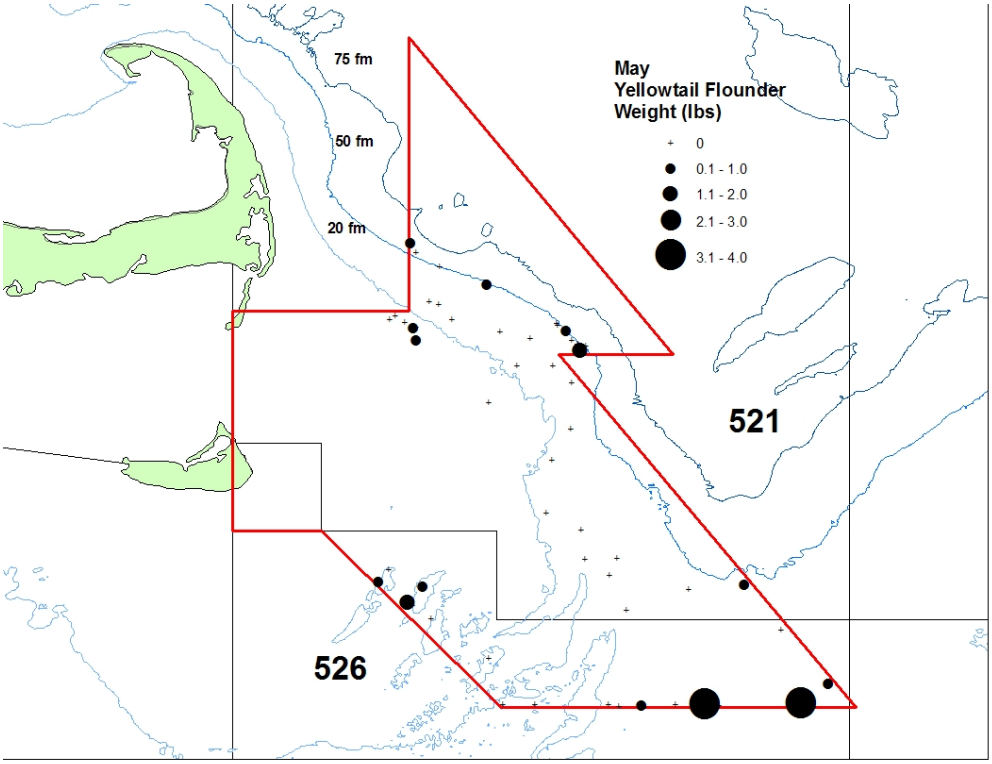

Figure 30. Yellowtail flounder distribution by weight, May.

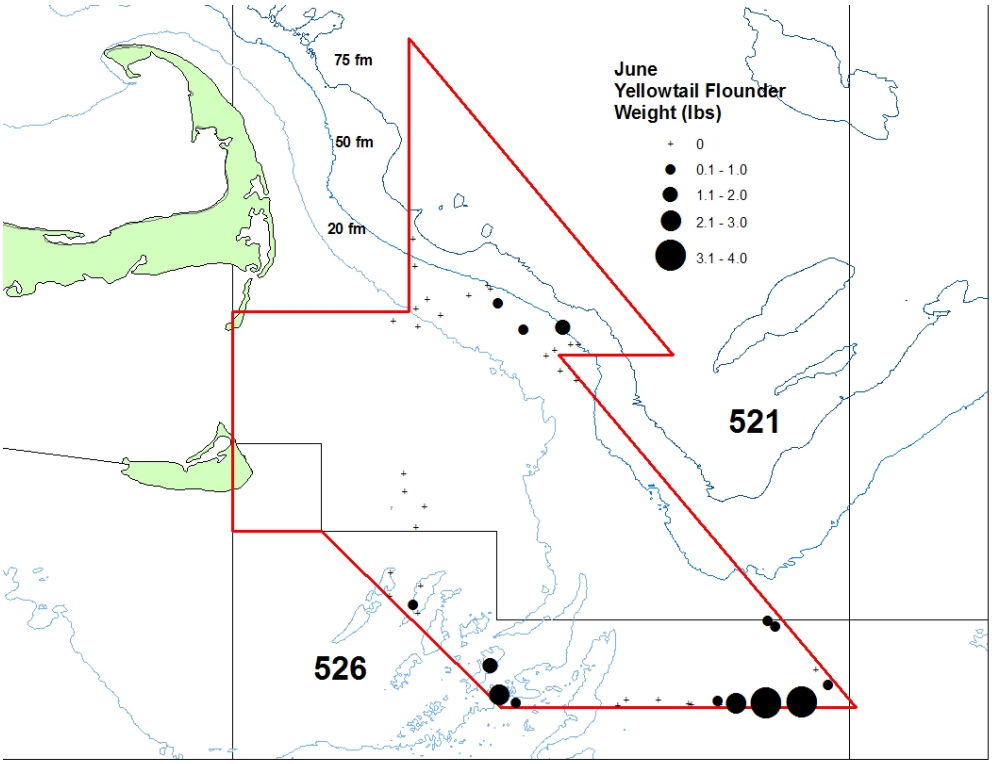

Figure 31. Yellowtail flounder distribution by weight, June.

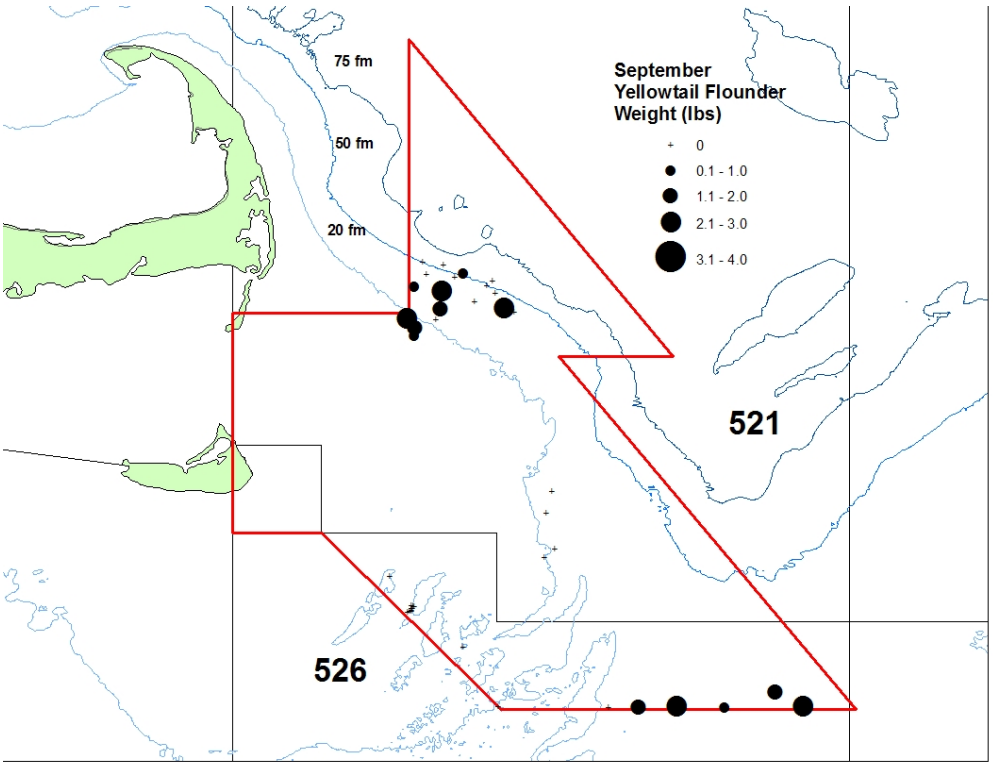

Figure 32. Yellowtail flounder distribution by weight, September.

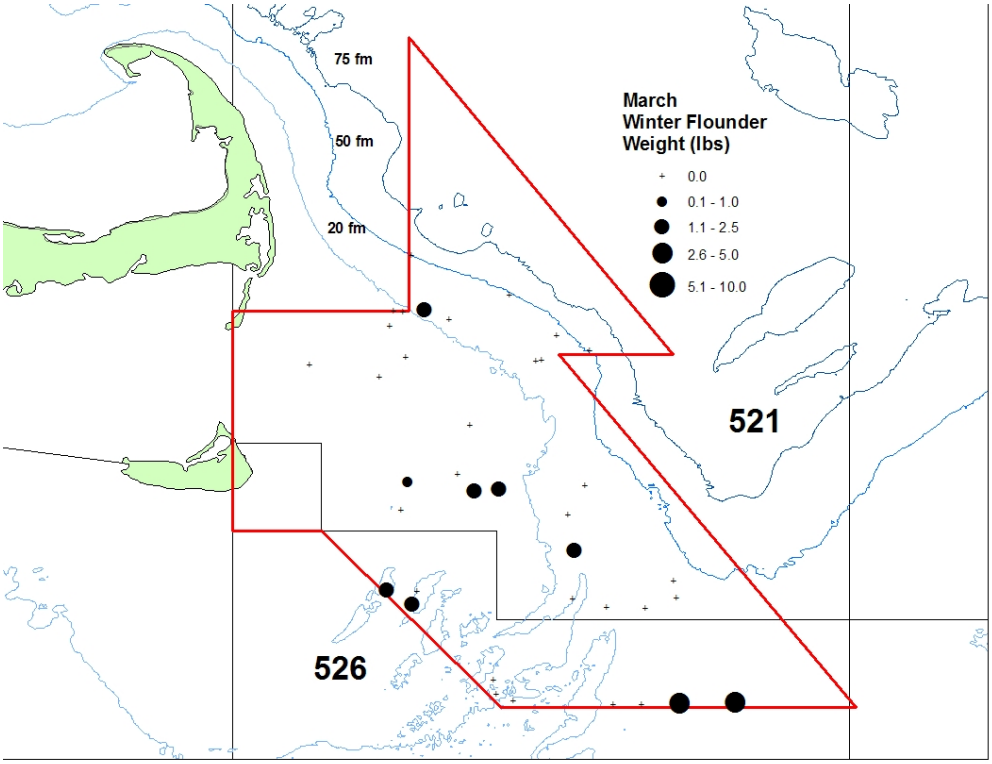

Figure 33. Winter flounder distribution by weight, March.

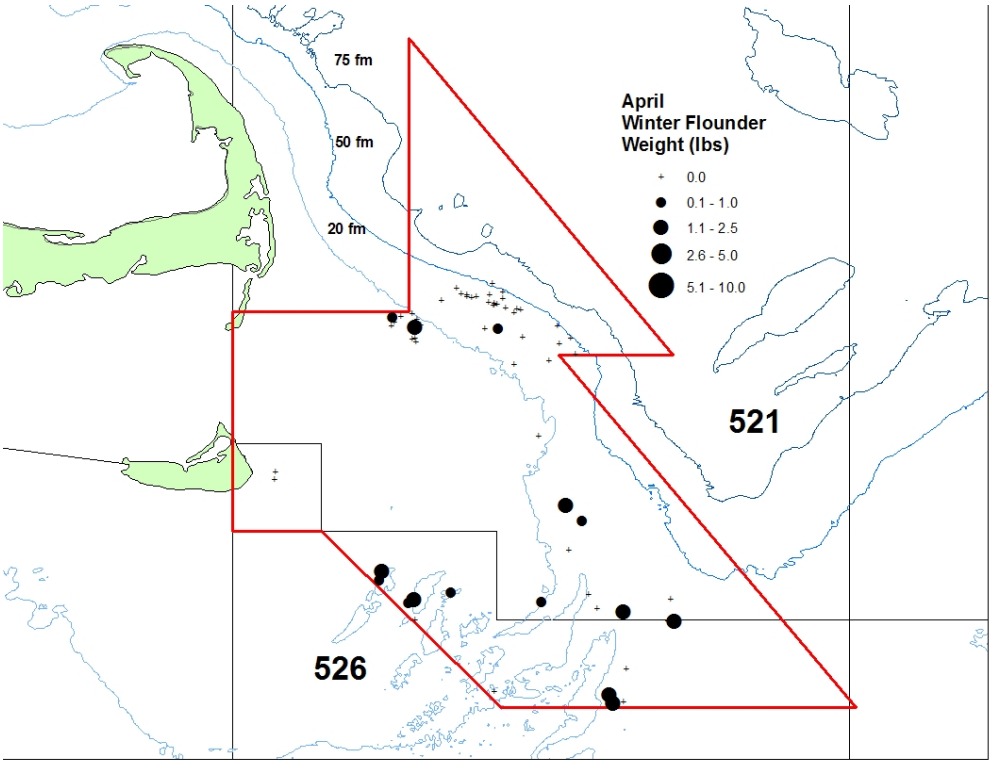

Figure 34. Winter flounder distribution by weight, April.

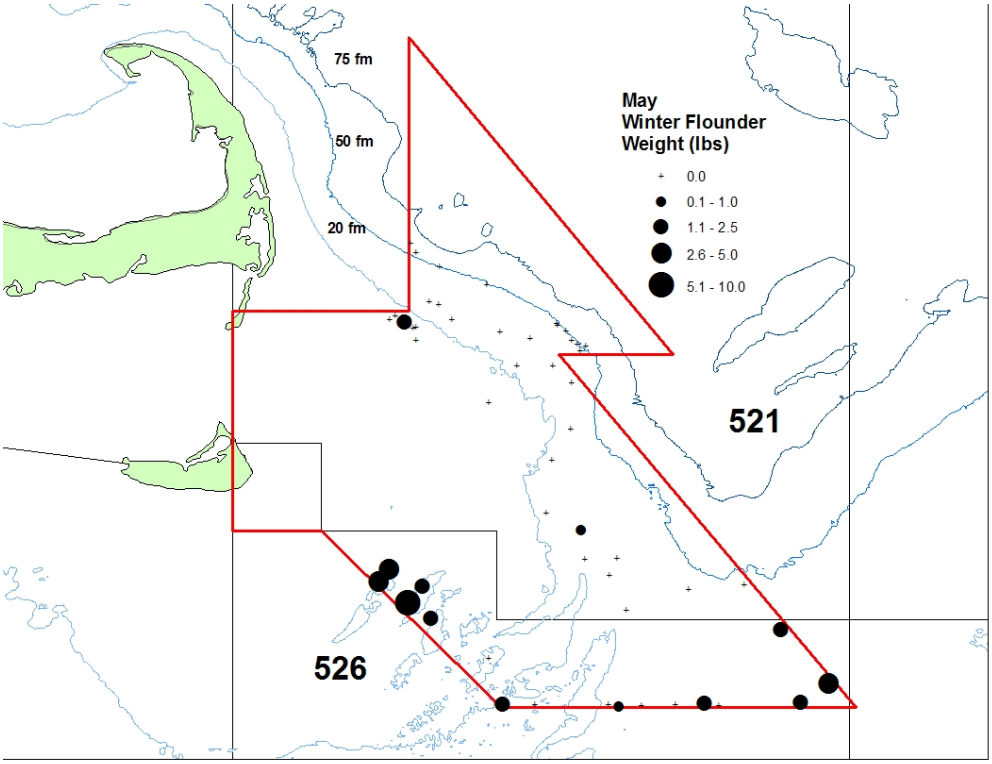

Figure 35. Winter flounder distribution by weight, May.

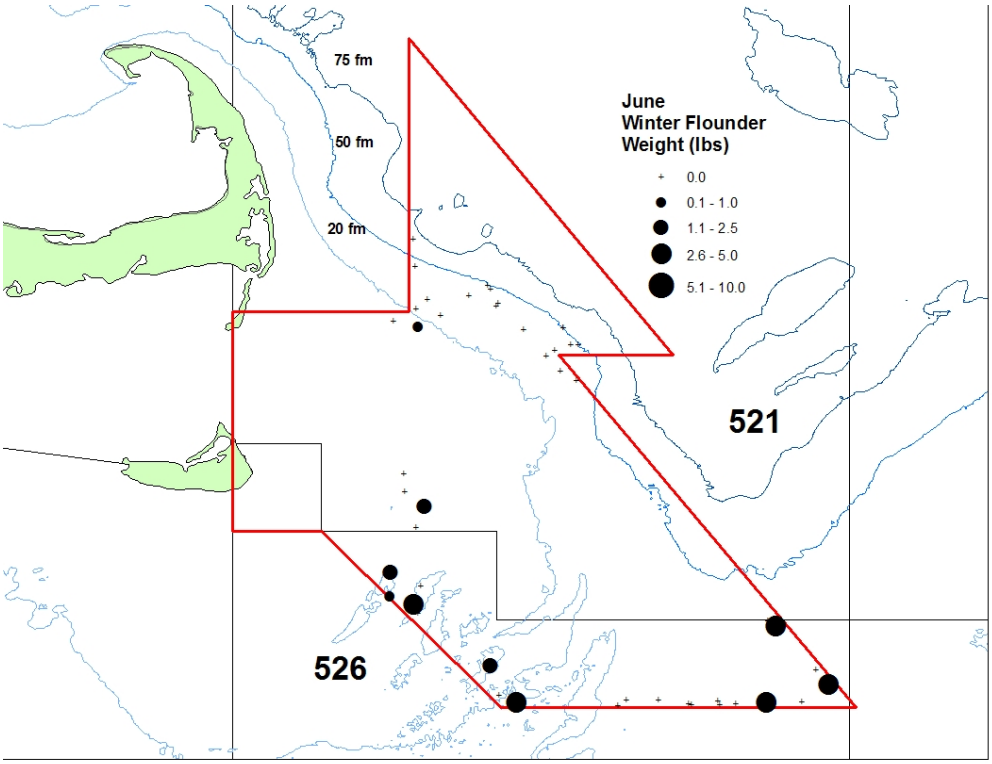

Figure 36. Winter flounder distribution by weight, June.

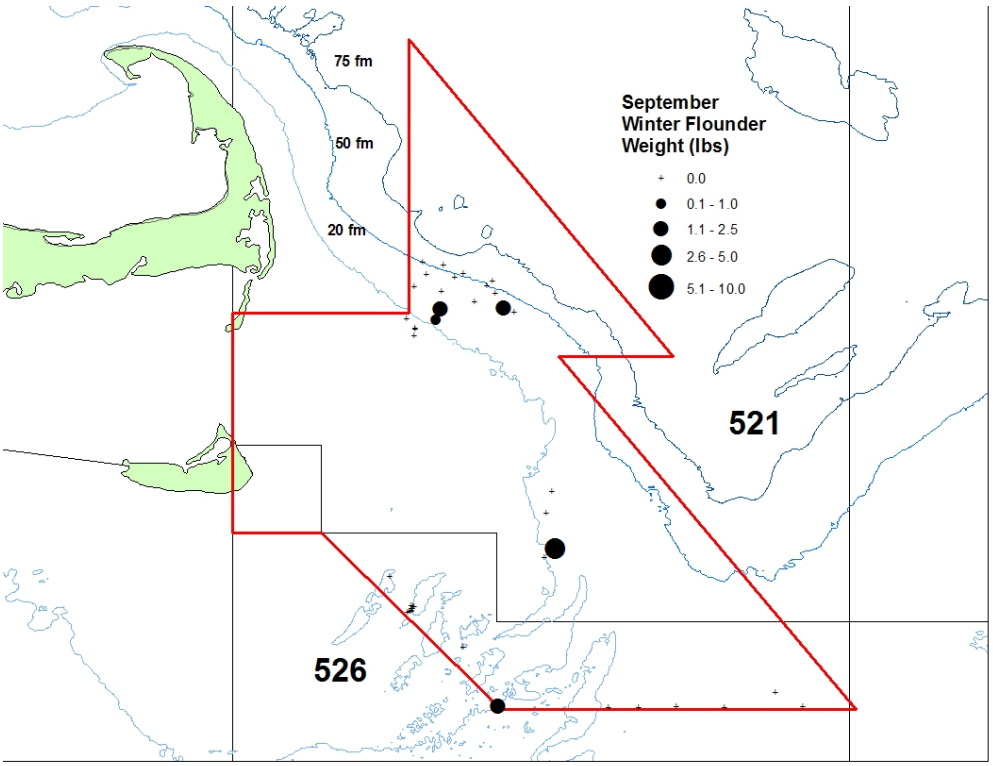

Figure 37. Winter flounder distribution by weight, September.

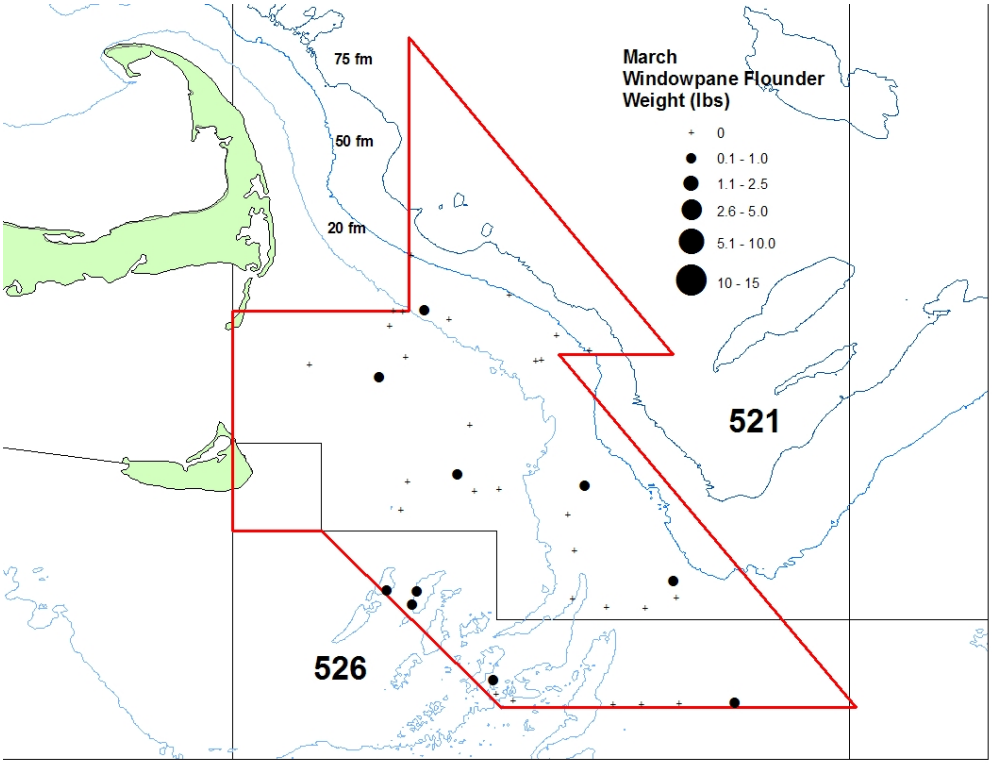

Figure 38. Windowpane flounder distribution by weight, March.

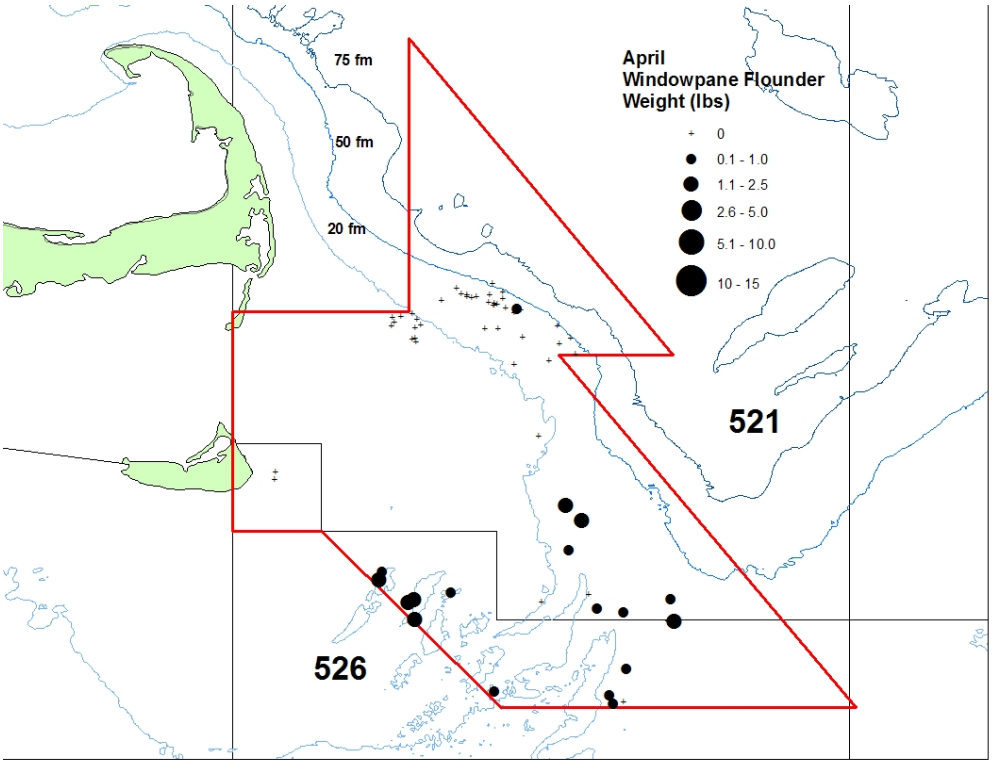

Figure 39. Windowpane flounder distribution by weight, April.

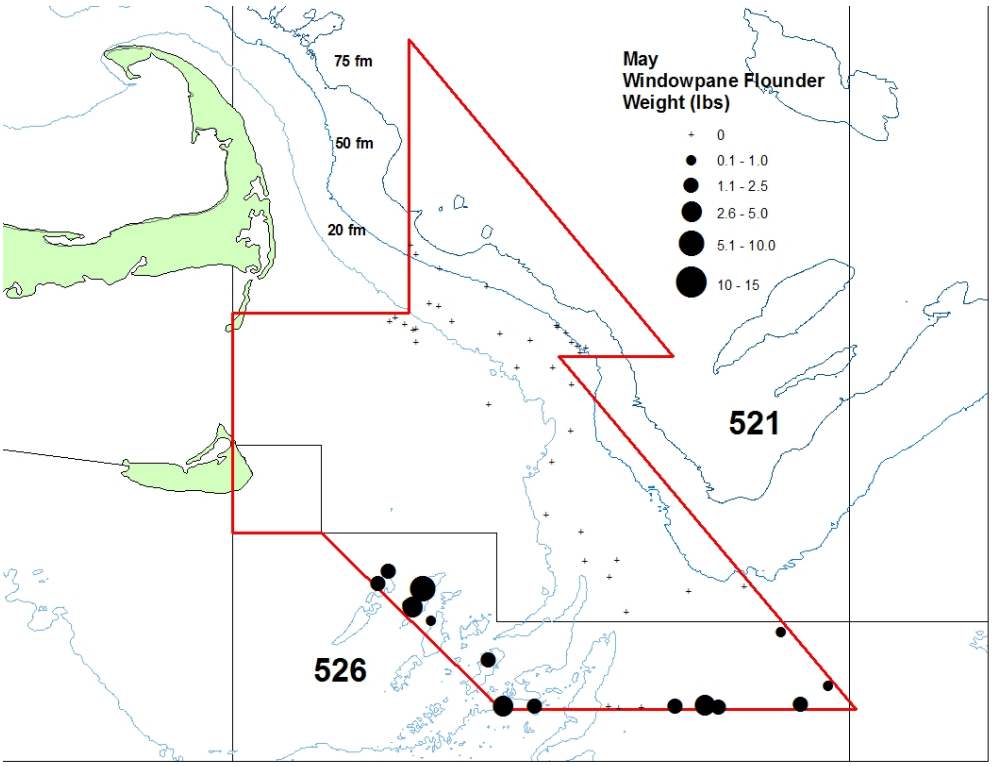

Figure 40. Windowpane flounder distribution by weight, May.

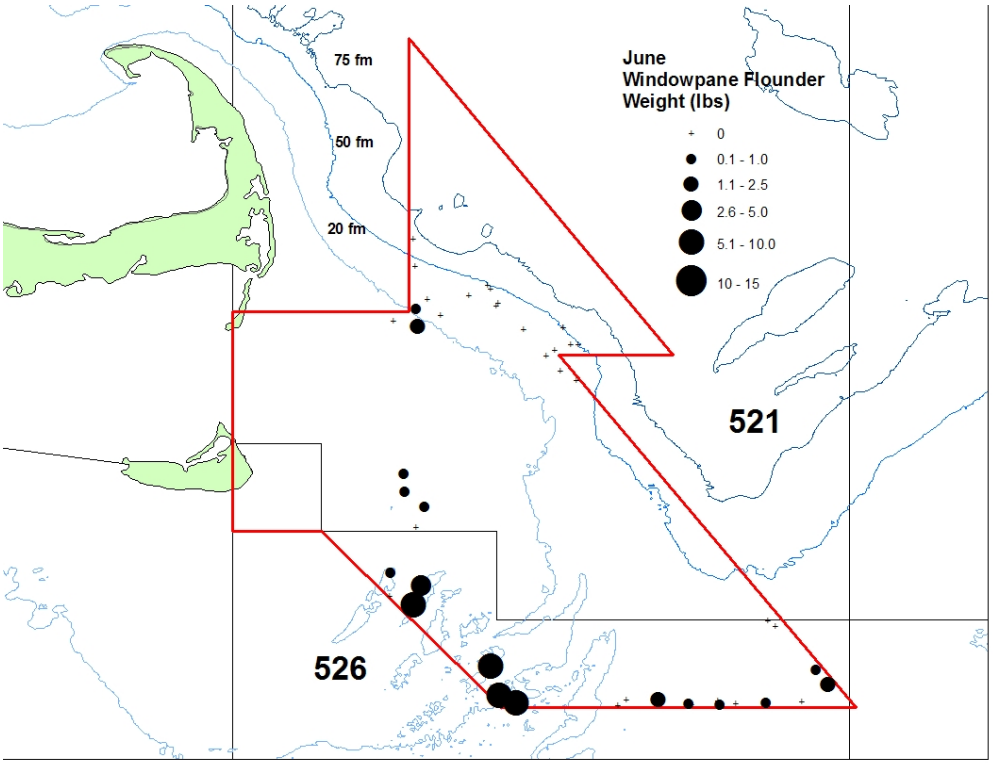

Figure 41. Windowpane flounder distribution by weight, June.

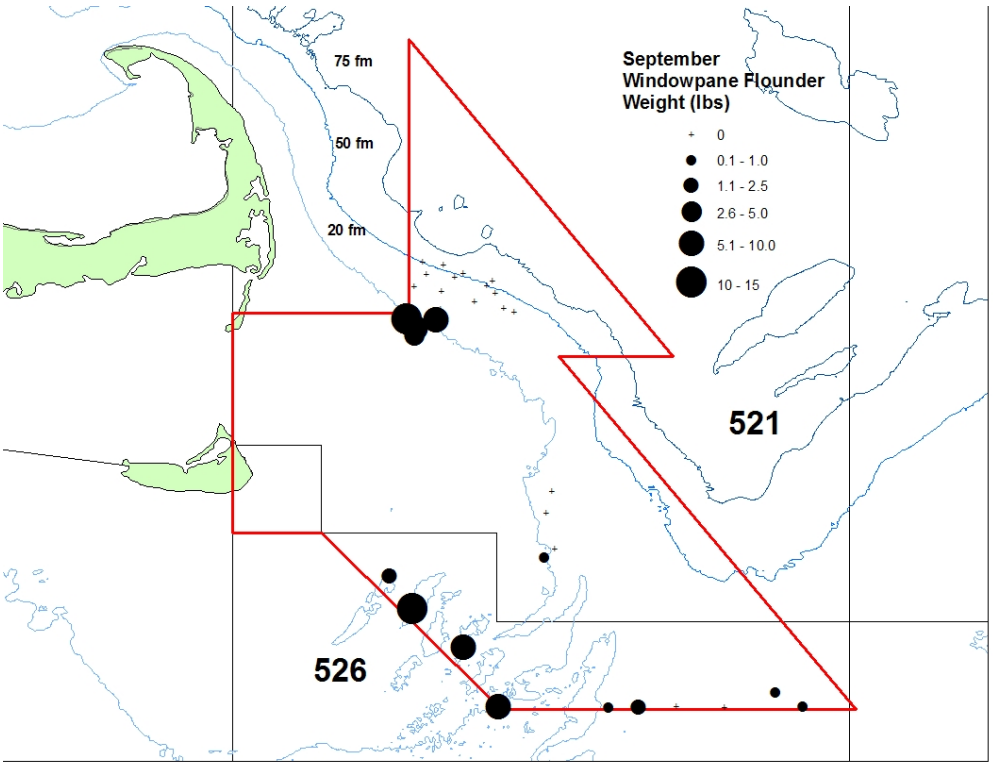

Figure 42. Windowpane flounder distribution by weight, September.

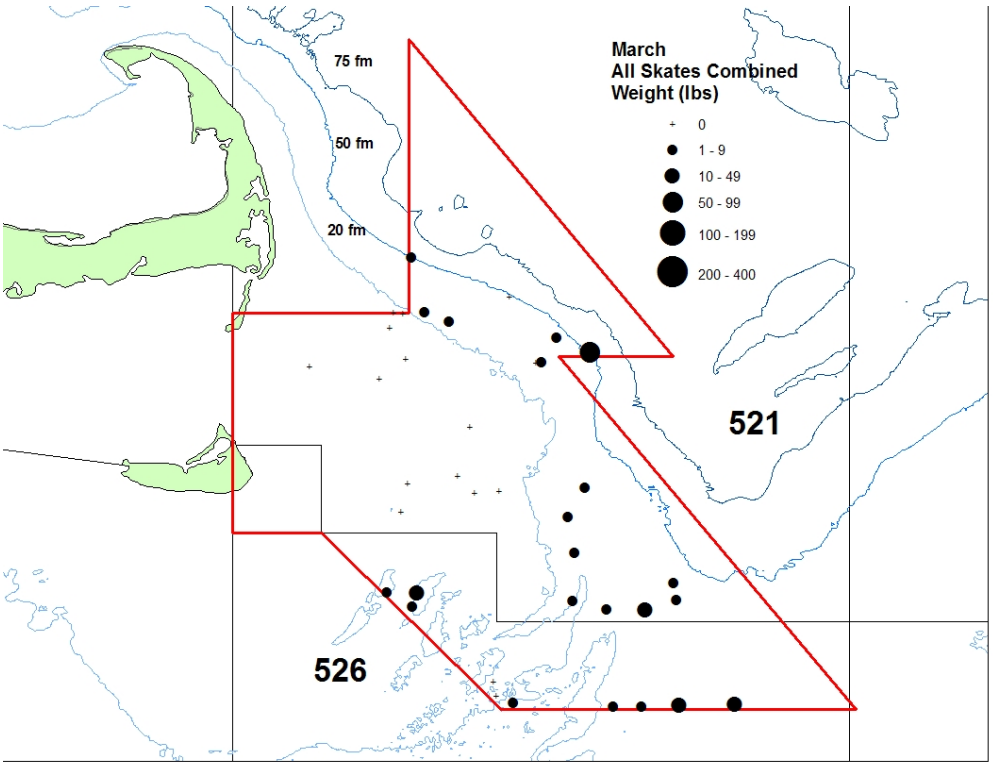

Figure 43. All skates combined distribution by weight, March.

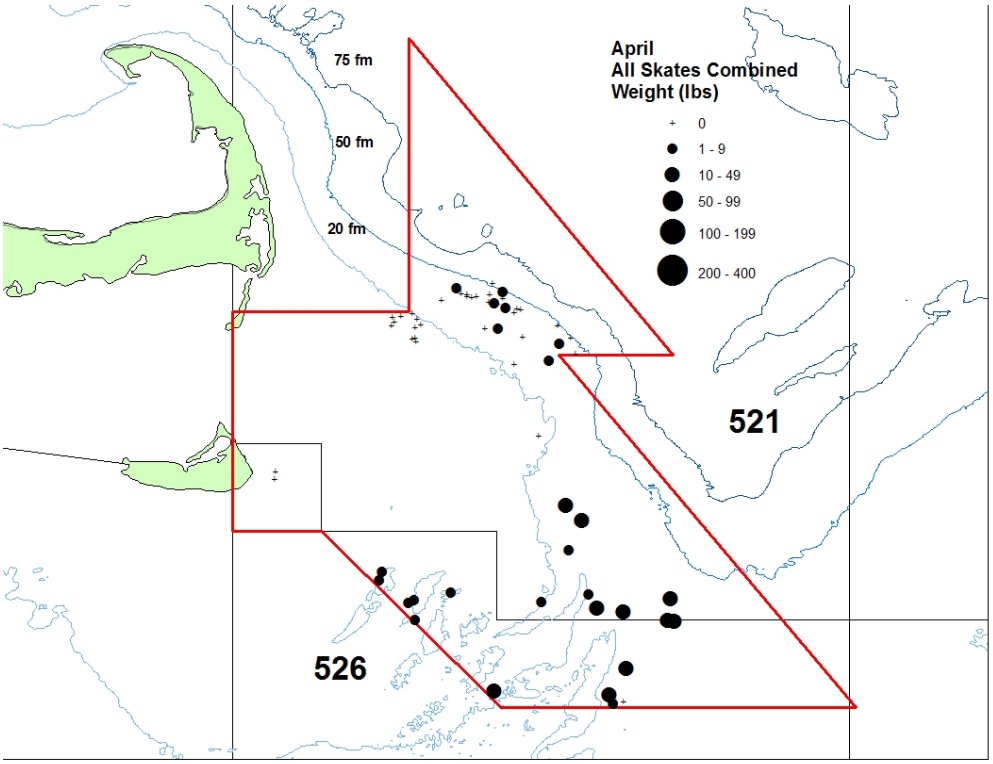

Figure 44. All skates combined distribution by weight, April.

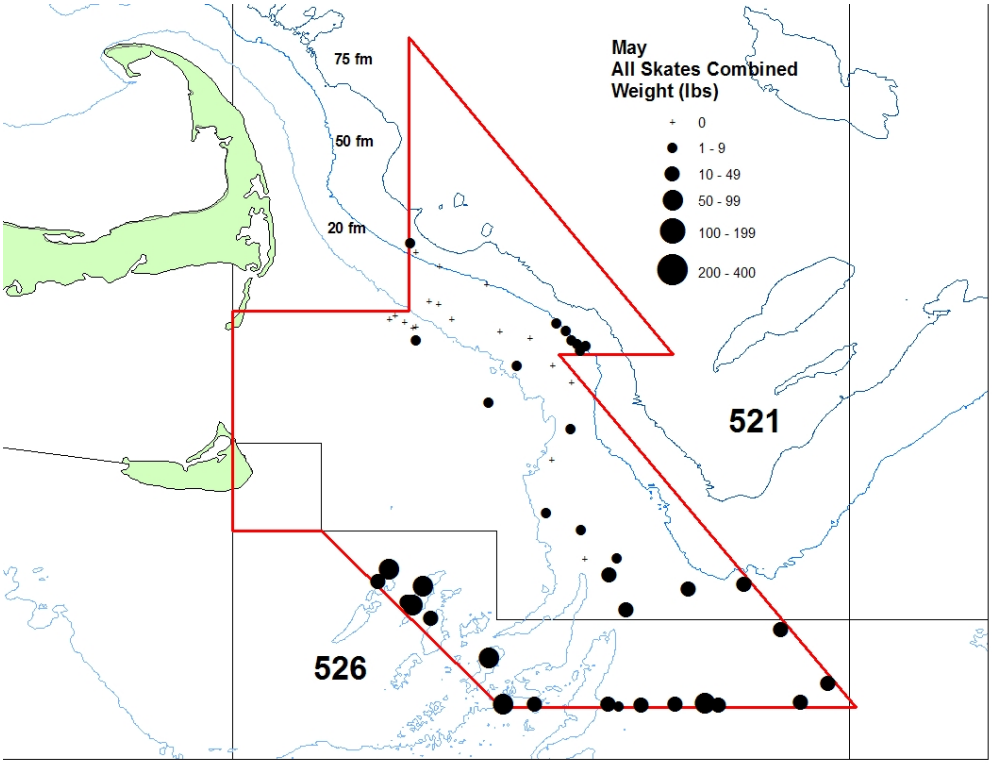

Figure 45. All skates combined distribution by weight, May.

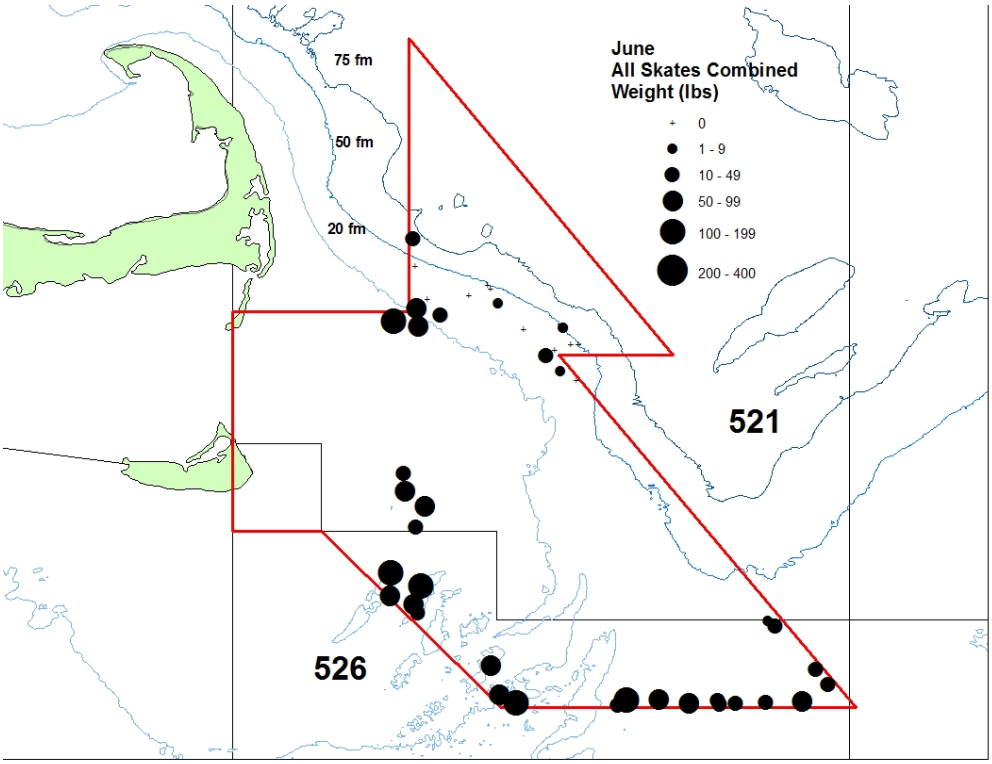

Figure 46. All skates combined distribution by weight, June.

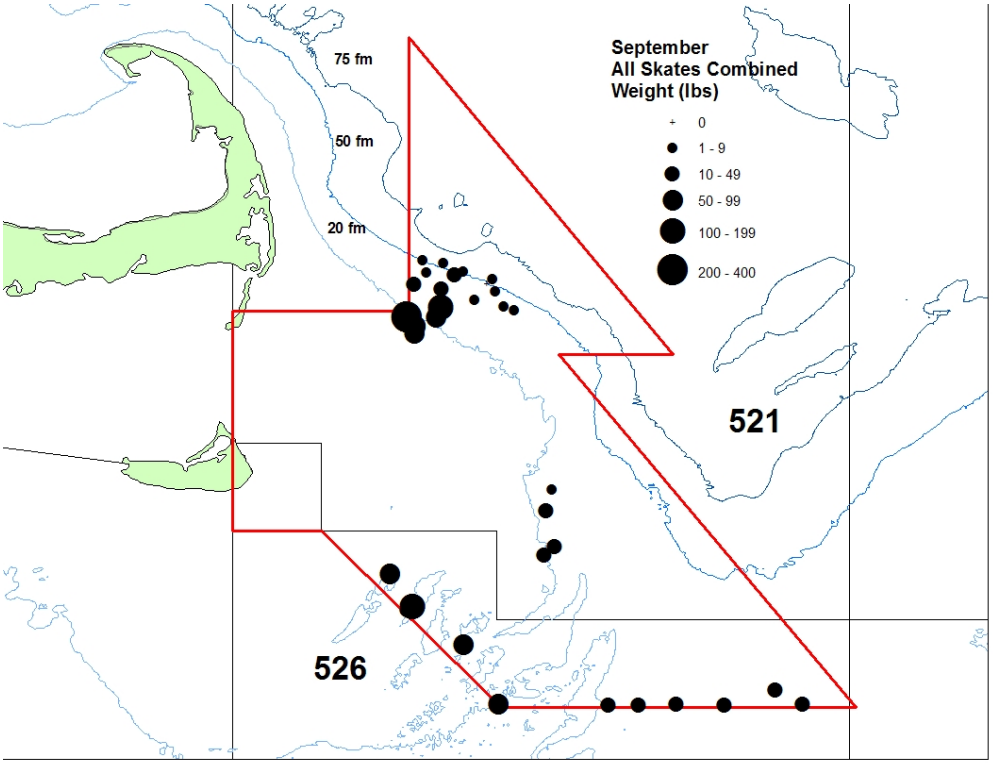

Figure 47. All skates combined distribution by weight, September.

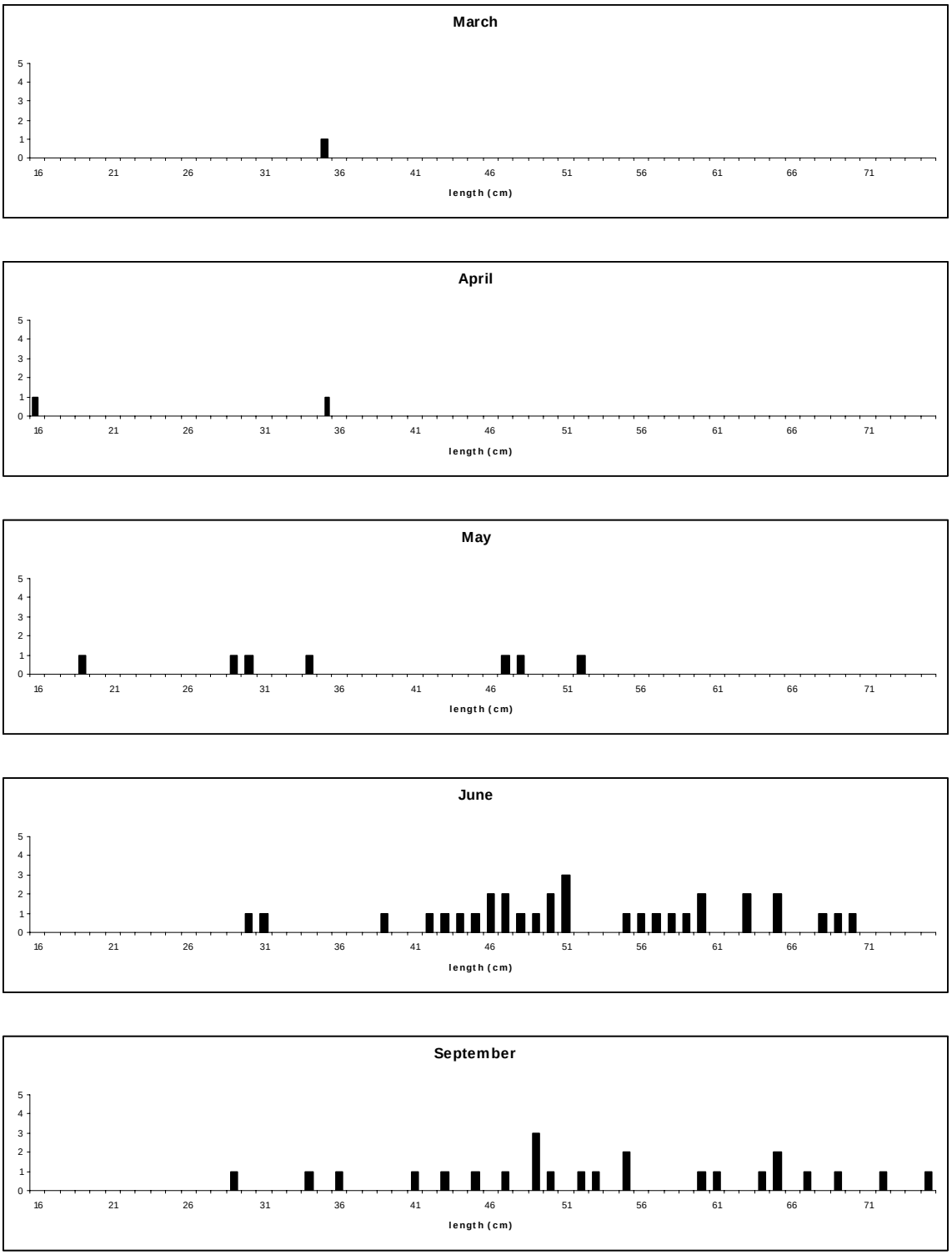

Figure 48. Dredge caught monkfish length frequencies by month.

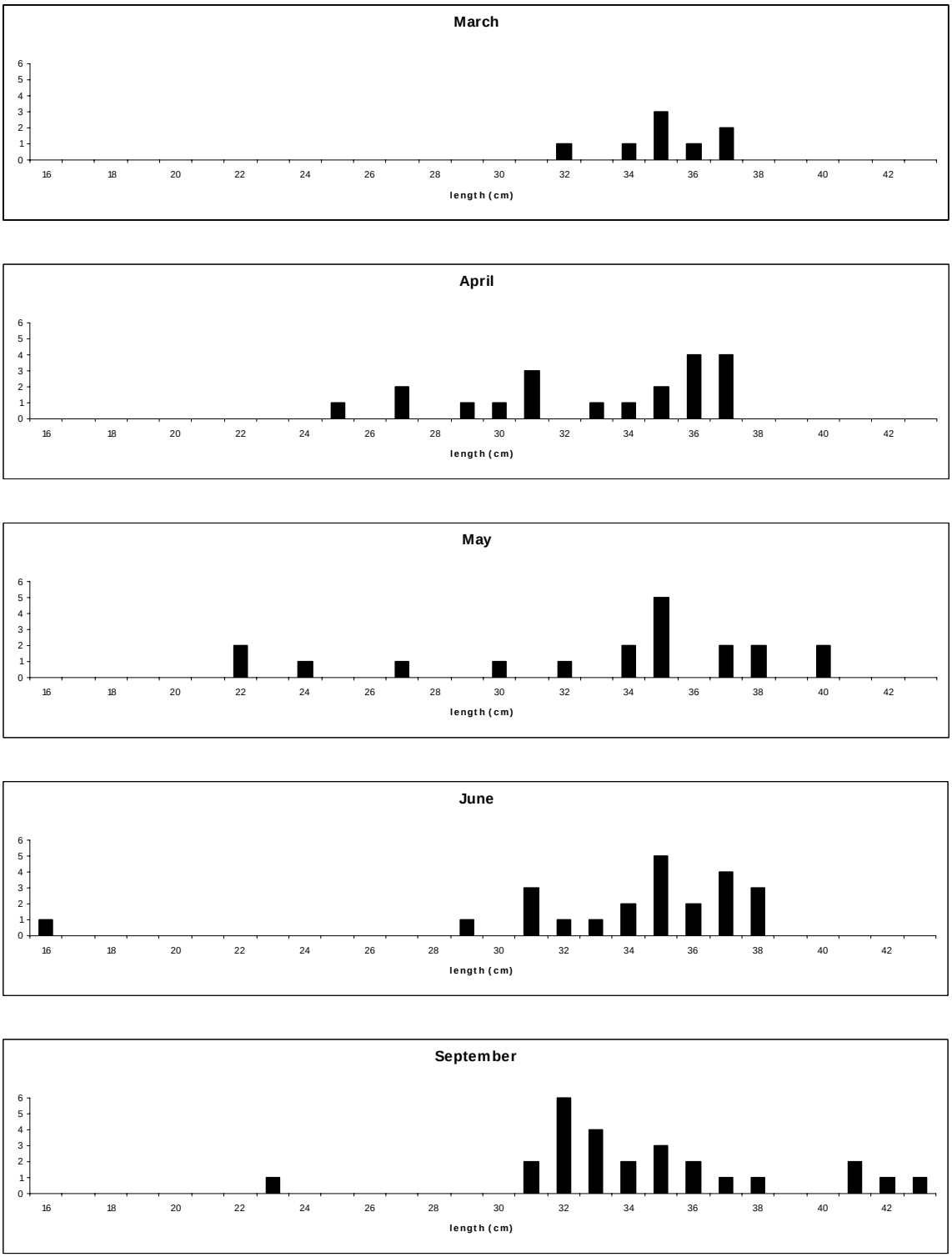

Figure 49. Dredge caught yellowtail length frequencies by month.

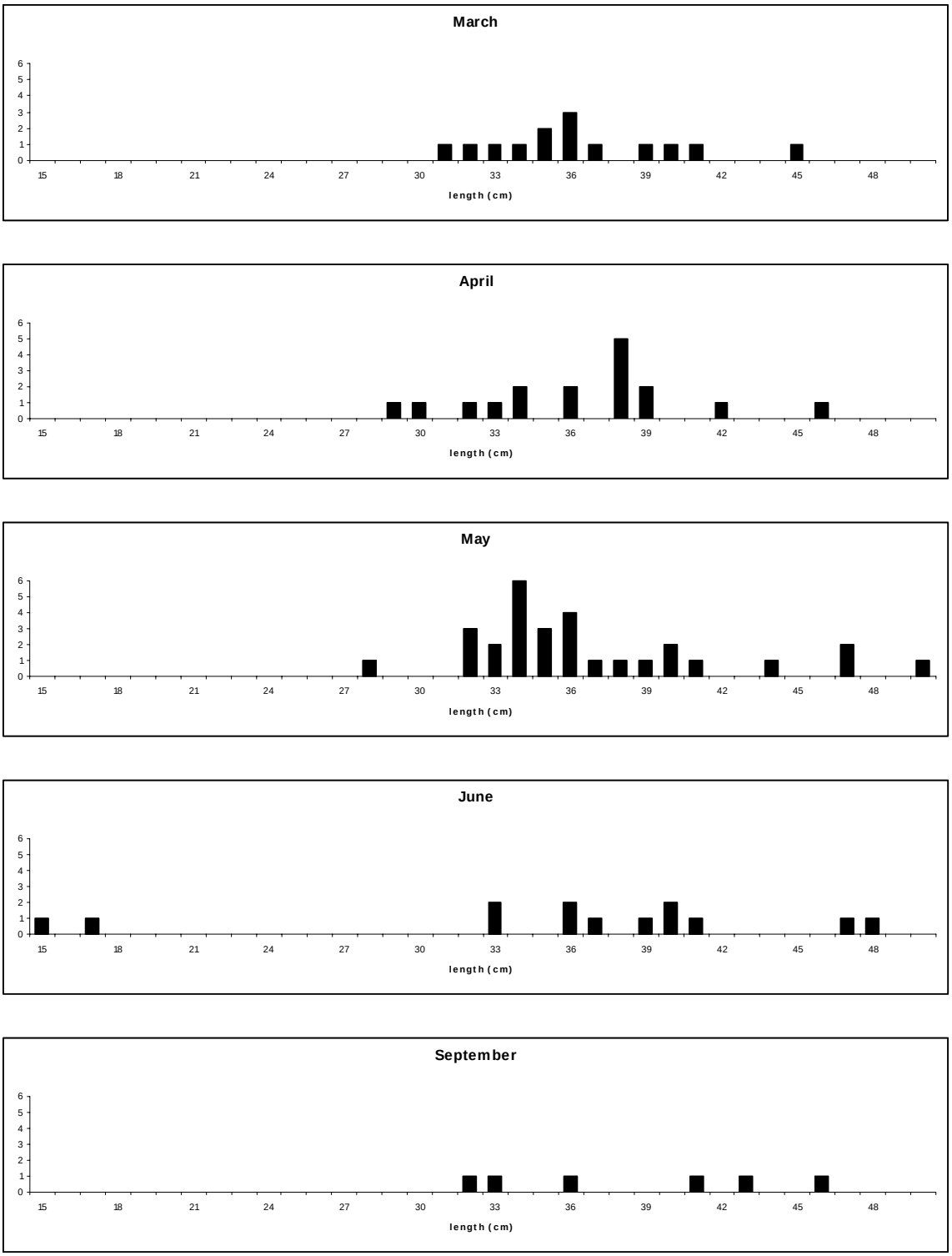

Figure 50. Dredge caught winter flounder length frequencies by month.

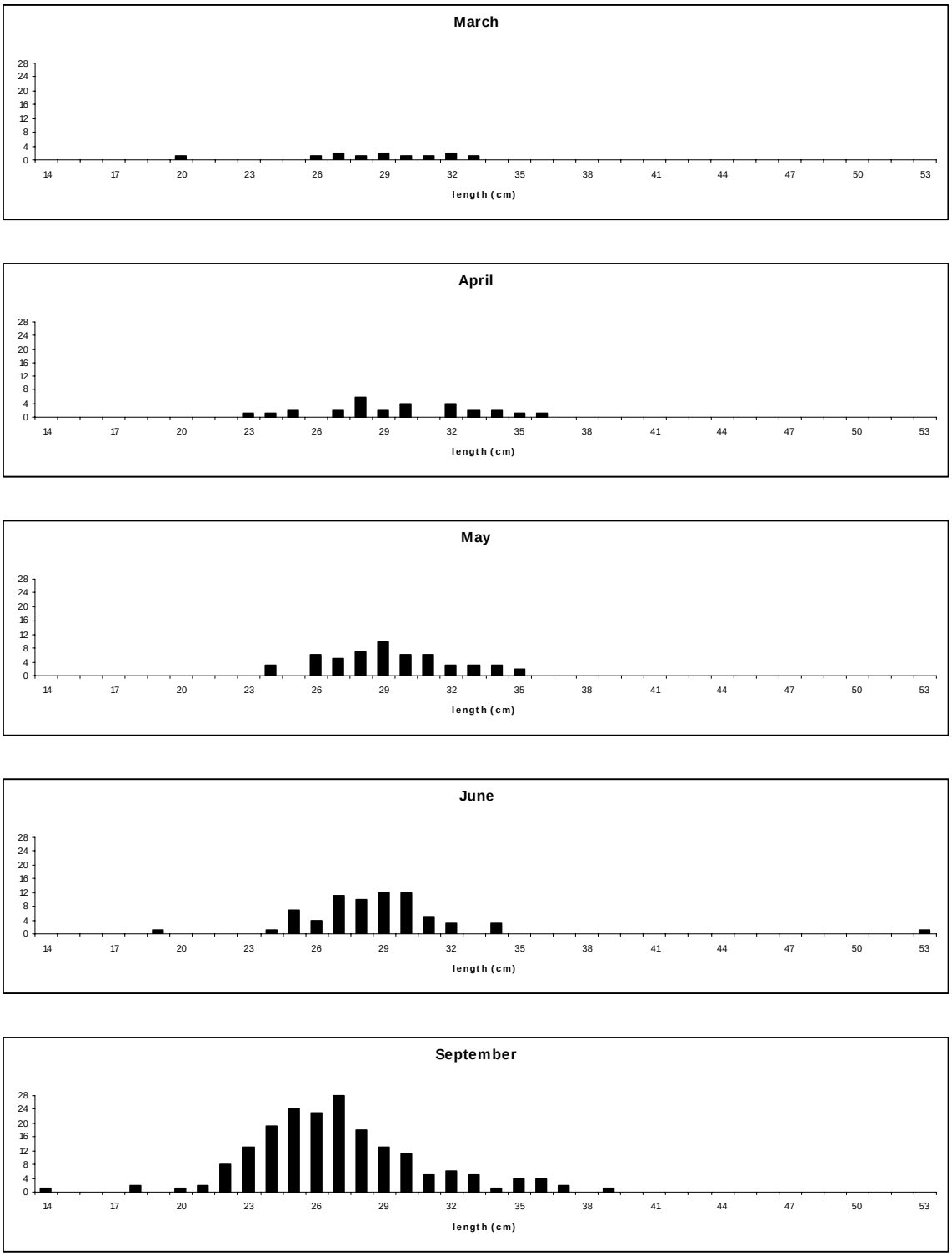

Figure 51. Dredge caught windowpane flounder length frequencies by month.

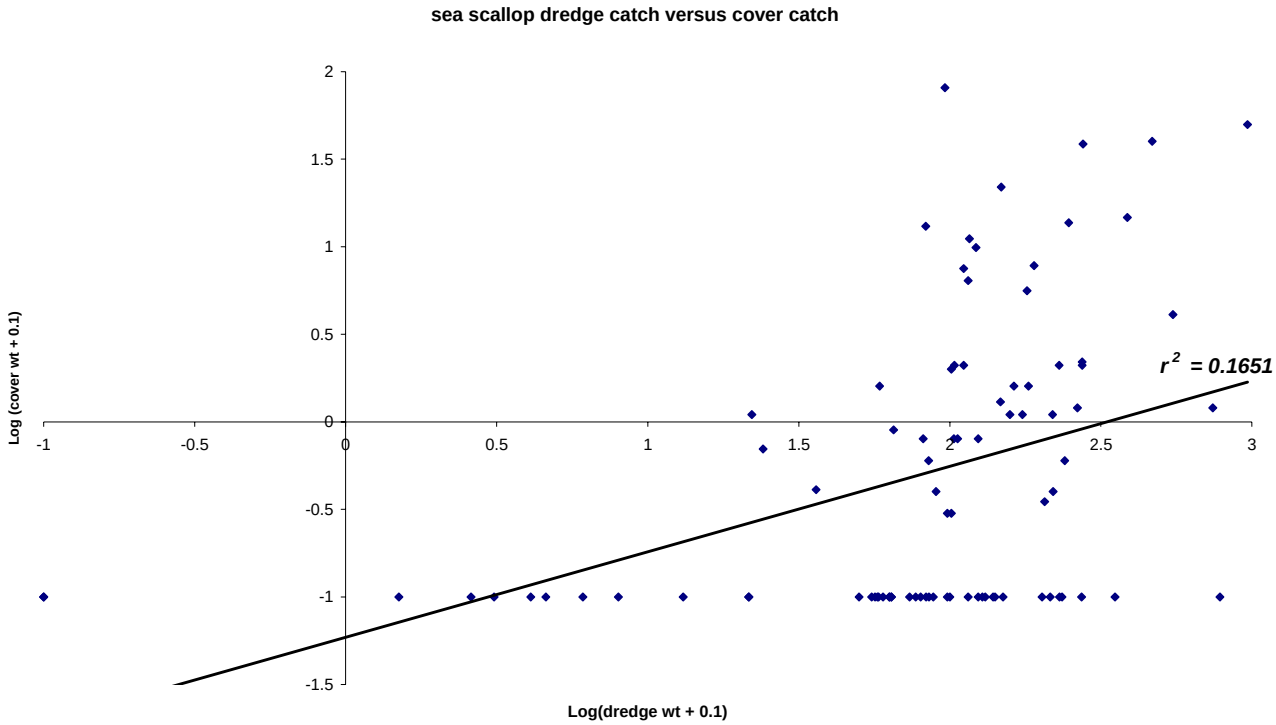

Figure 52. Sea scallop dredge catch versus twine top cover net catch. (Sea scallop weight in pounds was transformed by: Log (weight + 0.1) to account for extreme and zero pound catches).

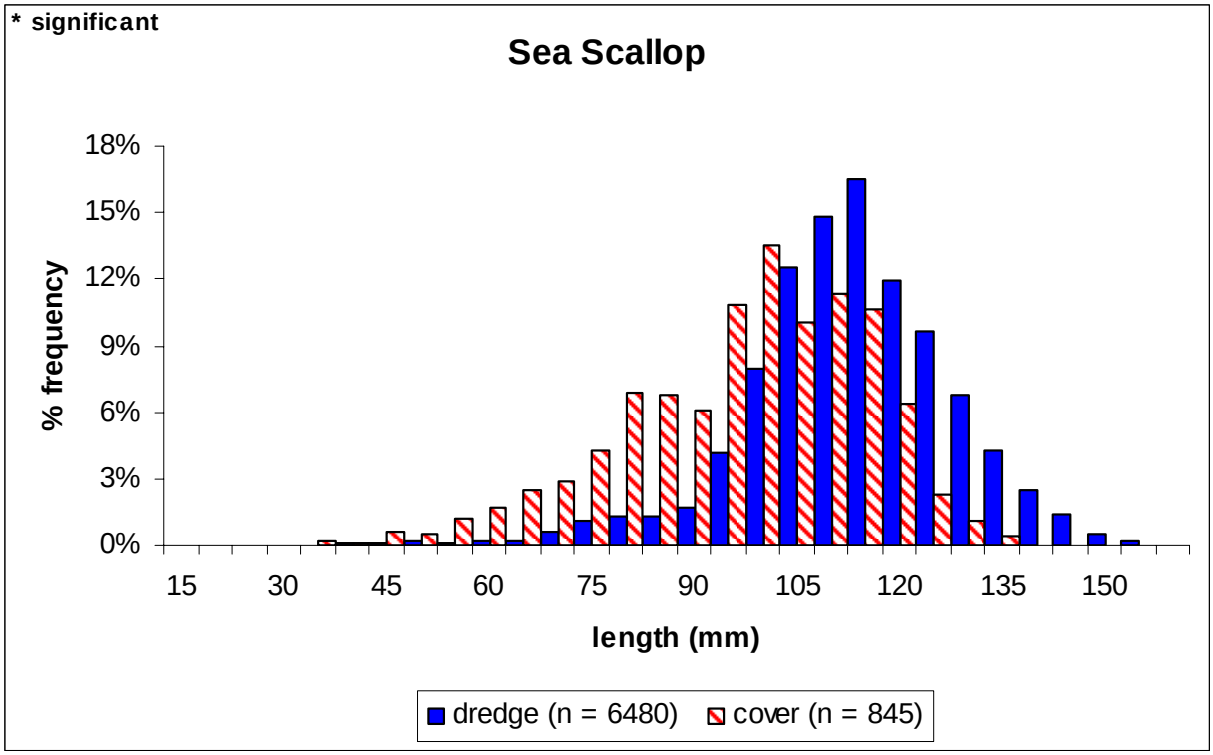

Figure 53. Percent length frequency distributions of dredge and twine top cover net caught sea scallops.

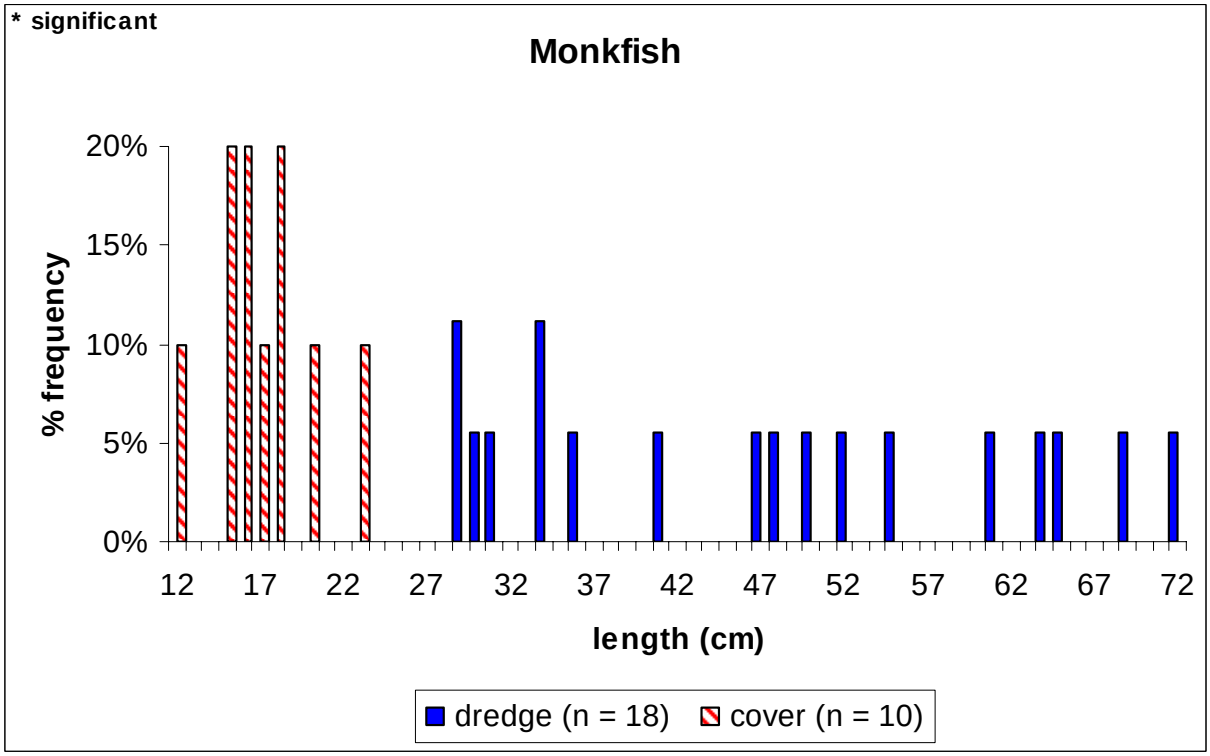

Figure 54. Percent length frequency distributions of dredge and twine top cover net caught monkfish.

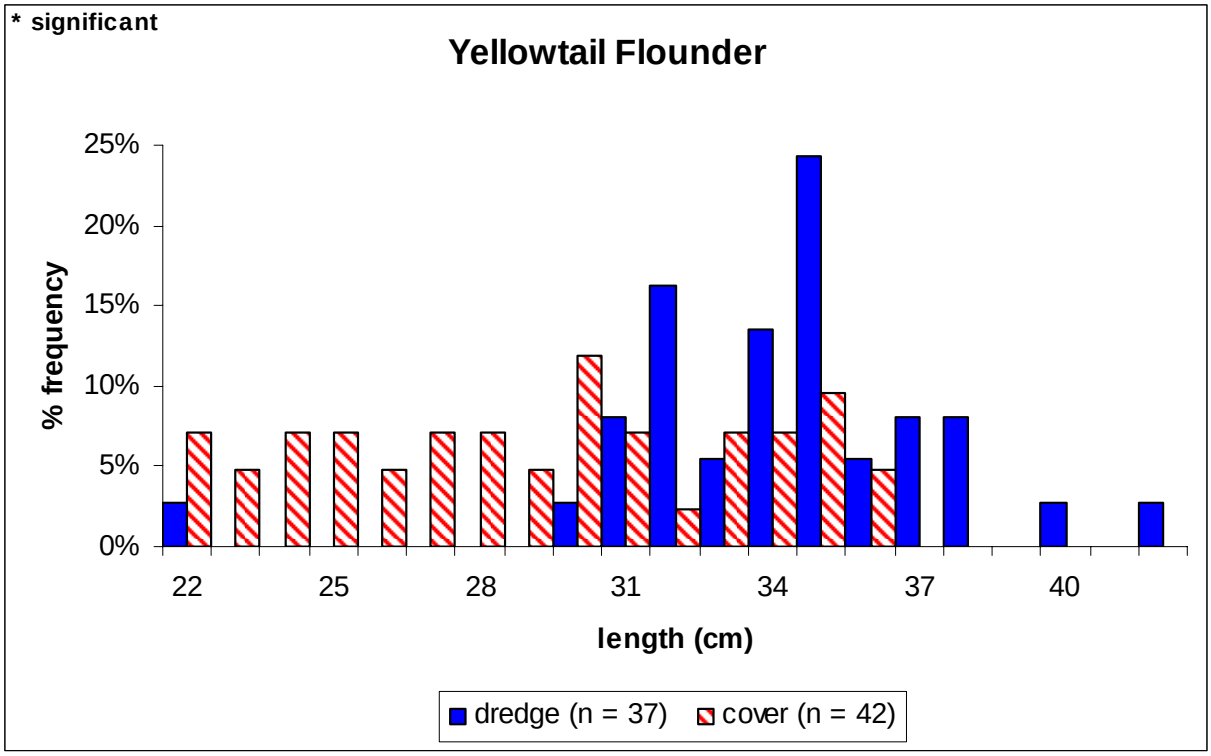

Figure 55. Percent length frequency distributions of dredge and twine top cover net caught yellowtail flounder.

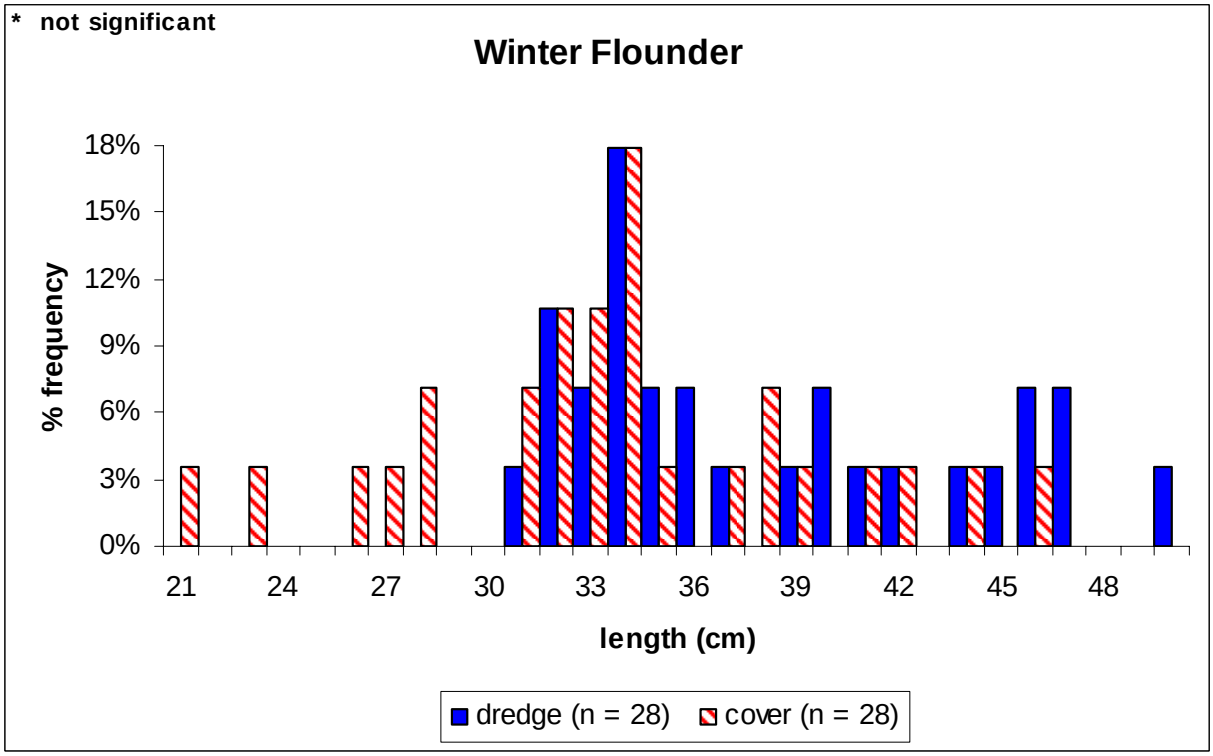

Figure 56. Percent length frequency distributions of dredge and twine top cover net caught winter flounder.

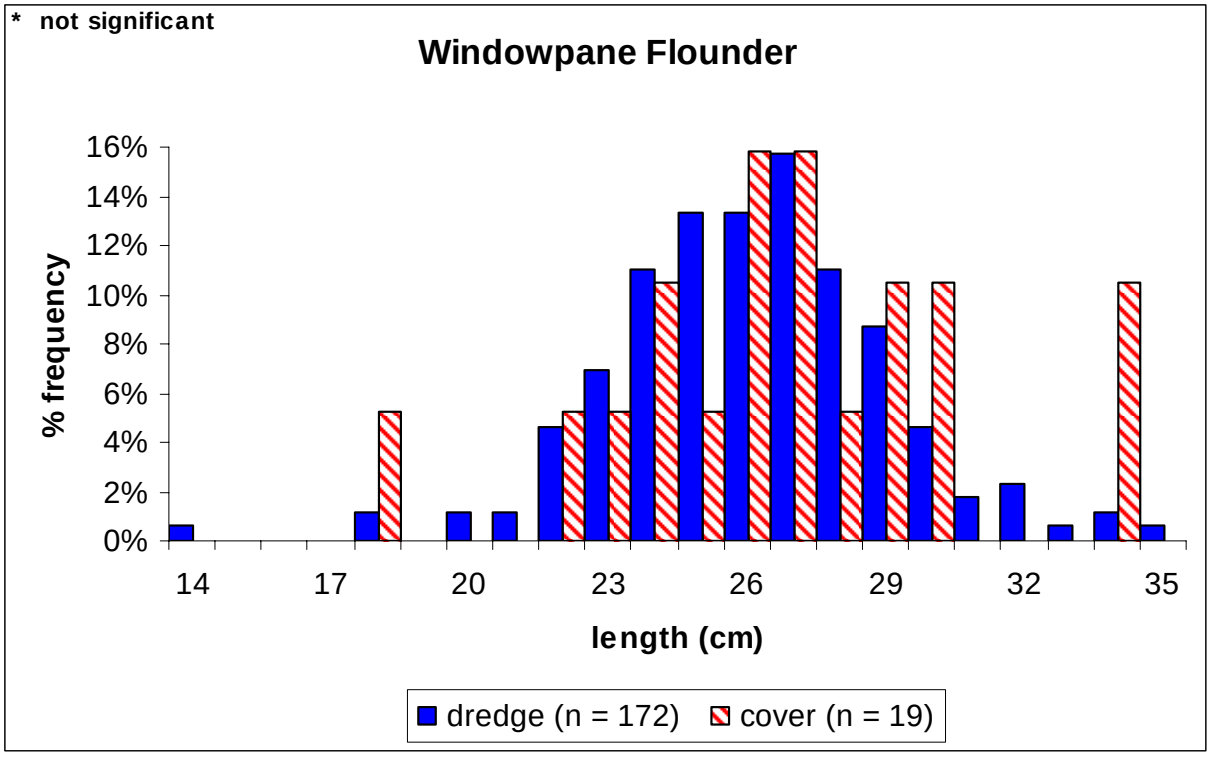

Figure 57. Percent length frequency distributions of dredge and twine top cover net caught windowpane flounder.

APPENDIX I

Common and Scientific Names of Species Captured

Common Name	**Scientific Name**
ALLIGATORFISH	*Aspidophoroides monopterygius*
ANEMONE	Anthozoa
CLAM, SURF	*Spisula solidissima*
COCKLE, NK	Bivalvia
COD, ATLANTIC	*Gadus morhua*
CRAB, CANCER, NK	Cancridae
CRAB, HERMIT, NK	Paguroidea
CRAB, JONAH	*Cancer borealis*
CRAB, NORTHERN STONE	*Lithodes maja*
CRAB, ROCK	*Cancer irroratus*
CRAB, SPIDER	Majidae
DOGFISH, SPINY	*Squalus acanthias*
FLOUNDER, AMERICAN PLAICE	*Hippoglossoides platessoides*
FLOUNDER, FOURSPOT	*Paralichthys oblongus*
FLOUNDER, SUMMER	*Paralichthys dentatus*
FLOUNDER, WINDOWPANE	*Scophthalmus aquosus*
FLOUNDER, WINTER	*Pseudopleuronectes americanus*
FLOUNDER, WITCH	*Glypyocephalus cynoglossus*
FLOUNDER, YELLOWTAIL	*Limanda ferruginea*
HAGFISH, ATLANTIC	*Myxine glutinosa*
HAKE, RED	*Urophycis chuss*
HAKE, SILVER	*Merluccius bilinearis*
HAKE, WHITE	*Urophycis tenuis*
LOBSTER, AMERICAN	*Homarus americanus*
MONKFISH	*Lophius americanus*
MUSSEL, BLUE	*Mytilus edulis*
MUSSEL, HORSE	*Modiolus modiolus*
MUSSEL, NK	Mytilus or Modiolus
QUAHOG	*Mercenaria mercenaria*
QUAHOG, OCEAN	*Arctica islandica*
SAND DOLLAR	Clypeasteroida
SAND LANCE	Ammodytidae
SCALLOP, BAY	*Argopecten irradians*
SCALLOP, ICELANDIC	*Chlamys islandica*
SCALLOP, SEA	*Placopecten magellanicus*
SCULPIN, LONGHORN	*Myoxocephalus octodecemspinosus*
SEA CUCUMBER	Holothuroidea
SEA RAVEN	*Hemitripterus americanus*
SEA ROBIN, NORTHERN	*Prionotus carolinus*
SEA URCHIN	Echinoidea
SHRIMP, NORTHERN	*Pandalus borealis*
SKATE, BARNDOOR	*Dipturus laevis*
SKATE, LITTLE	*Leucoraja erinacea*
SKATE, NK	Rajidae
SKATE, SMOOTH	*Malacoraja senta*
SKATE, THORNY	*Amblyraja radiata*
SKATE, WINTER	*Leucoraja ocellata*
SNAIL, MOONSHELL	*Lunatia heros*
SQUID, SHORT FINNED	*Illex illecebrosus*
STARFISH, SEA STAR	Asteroidea
WHELK, NK	Nassariidae, Buccinidae or Melongenidae

APPENDIX II

Individual Species Total Weights

A. Project Total

Species	Weight (lbs)	% of total catch
SCALLOP, SEA (kept)	**33471.4**	**68.32%**
MUSSEL, BLUE	5010.7	10.23%
SKATE, NK	**1851.8**	**3.78%**
SKATE, LITTLE	**1518.9**	**3.10%**
SKATE, WINTER	**1370.7**	**2.80%**
STARFISH, NK	1082.9	2.21%
SCALLOP, SEA (discarded)	**1070.2**	**2.18%**
SEA URCHIN	713.1	1.46%
MUSSEL, HORSE	574.7	1.17%
SAND DOLLAR	455.9	0.93%
MONKFISH	**383.8**	**0.78%**
FLOUNDER, WINDOWPANE	**189.0**	**0.39%**
SCALLOP, ICELANDIC	179.5	0.37%
CLAM, SURF	115.0	0.23%
MUSSEL, NK	113.4	0.23%
FLOUNDER, WINTER	**103.7**	**0.21%**
FLOUNDER, SUMMER	**87.2**	**0.18%**
FLOUNDER, YELLOWTAIL	**76.4**	**0.16%**
SKATE, BARNDOOR	**75.6**	**0.15%**
SEA CUCUMBER	65.1	0.13%
CRAB, CANCER, NK	63.9	0.13%
SEA RAVEN	59.7	0.12%
SKATE, THORNY	**56.0**	**0.11%**
CRAB, JONAH	53.0	0.11%
LOBSTER, AMERICAN	50.4	0.10%
CRAB, HERMIT, NK	29.9	0.06%
SCALLOP, BAY	28.8	0.06%
CRAB, ROCK	21.1	0.04%
WHELK, NK	17.9	0.04%
SKATE, SMOOTH	**17.6**	**0.04%**
SCULPIN, LONGHORN	15.3	0.03%
FLOUNDER, WITCH	**12.8**	**0.03%**
CRAB, NORTHERN STONE	9.5	0.02%
SQUID, SHORT FINNED	7.0	0.01%
QUAHOG, OCEAN	6.8	0.01%
FLOUNDER, FOURSPOT	5.9	0.01%
DOGFISH, SPINY	5.8	0.01%
SAND LANCE	4.7	0.01%
FLOUNDER, AMERICAN PLAICE	**4.0**	**0.01%**
COD, ATLANTIC	2.9	0.01%
SNAIL, MOONSHELL, NK	2.8	0.01%
HAKE, RED	1.8	0.00%
CRAB, SPIDER	1.7	0.00%
QUAHOG	1.2	0.00%
SEA ROBIN, NORTHERN	1.0	0.00%
HAKE, SILVER	0.6	0.00%
HAKE, WHITE	0.3	0.00%
ALLIGATORFISH	0.2	0.00%
ANEMONE	0.2	0.00%
COCKLE, NK	0.2	0.00%
SHRIMP, NORTHERN	0.1	0.00%
HAGFISH, ATLANTIC	0.1	0.00%
total	48991.9	

B. March

Species	Weight (lbs)	% of total catch
MUSSEL, BLUE	3500.0	51.35%
SCALLOP, SEA (kept)	**2291.4**	**33.62%**
STARFISH, NK	428.1	6.28%
SEA URCHIN	140.0	2.05%
SKATE, LITTLE	**100.3**	**1.47%**
MUSSEL, NK	76.5	1.12%
SCALLOP, SEA (discarded)	**63.7**	**0.93%**
SKATE, NK	**51.8**	**0.76%**
CLAM, SURF	30.4	0.45%
SKATE, WINTER	**30.0**	**0.44%**
FLOUNDER, WINTER	**19.9**	**0.29%**
SEA CUCUMBER	16.8	0.25%
SAND DOLLAR	10.0	0.15%
CRAB, ROCK	8.1	0.12%
SEA RAVEN	7.7	0.11%
CRAB, JONAH	7.5	0.11%
FLOUNDER, YELLOWTAIL	**6.3**	**0.09%**
SKATE, THORNY	**6.1**	**0.09%**
SCULPIN, LONGHORN	6.1	0.09%
FLOUNDER, WINDOWPANE	**5.5**	**0.08%**
SCALLOP, ICELANDIC	5.1	0.07%
MONKFISH	**1.8**	**0.03%**
MUSSEL, HORSE	1.6	0.02%
CRAB, NORTHERN STONE	0.8	0.01%
FLOUNDER, FOURSPOT	0.3	0.00%
total	6815.6	

C. April

Species	Weight (lbs)	% of total catch
SCALLOP, SEA (kept)	**9390.5**	**78.02%**
MUSSEL, BLUE	1510.0	12.55%
SCALLOP, SEA (discarded)	**450.4**	**3.74%**
SKATE, LITTLE	**268.7**	**2.23%**
STARFISH, NK	184.3	1.53%
SCALLOP, ICELANDIC	80.3	0.67%
FLOUNDER, WINDOWPANE	**19.3**	**0.16%**
FLOUNDER, WINTER	**18.7**	**0.16%**
SEA RAVEN	18.6	0.15%
SKATE, WINTER	**17.0**	**0.14%**
FLOUNDER, YELLOWTAIL	**13.4**	**0.11%**
SEA CUCUMBER	12.0	0.10%
CRAB, JONAH	11.1	0.09%
CRAB, ROCK	8.1	0.07%
SCULPIN, LONGHORN	5.6	0.05%
MUSSEL, NK	5.0	0.04%
SKATE, NK	**5.0**	**0.04%**
CLAM, SURF	3.7	0.03%
SAND LANCE	2.4	0.02%
SAND DOLLAR	2.0	0.02%
FLOUNDER, AMERICAN PLAICE	**1.6**	**0.01%**
LOBSTER, AMERICAN	1.5	0.01%
COD, ATLANTIC	1.5	0.01%
SEA URCHIN	1.4	0.01%
QUAHOG	1.2	0.01%
CRAB, NORTHERN STONE	1.0	0.01%
SKATE, SMOOTH	**1.0**	**0.01%**
CRAB, SPIDER	0.3	0.00%
ALLIGATORFISH	0.2	0.00%
COCKLE, NK	0.2	0.00%
HAKE, SILVER	0.1	0.00%
MONKFISH	**0.1**	**0.00%**
total	12035.8	

D. May

Species	Weight (lbs)	% of total catch
SCALLOP, SEA (kept)	**9029.9**	**85.13%**
SKATE, NK	**501.2**	**4.72%**
SCALLOP, SEA (discarded)	**321.2**	**3.03%**
SKATE, LITTLE	**228.4**	**2.15%**
STARFISH, NK	124.2	1.17%
SKATE, WINTER	**69.7**	**0.66%**
SAND DOLLAR	64.0	0.60%
FLOUNDER, WINTER	**34.5**	**0.32%**
FLOUNDER, WINDOWPANE	**31.4**	**0.30%**
SCALLOP, BAY	28.8	0.27%
SEA URCHIN	19.2	0.18%
LOBSTER, AMERICAN	18.6	0.18%
FLOUNDER, SUMMER	**18.6**	**0.18%**
MONKFISH	**18.1**	**0.17%**
SEA CUCUMBER	17.7	0.17%
FLOUNDER, YELLOWTAIL	**15.3**	**0.14%**
CRAB, HERMIT, NK	13.8	0.13%
WHELK, NK	10.4	0.10%
MUSSEL, NK	7.1	0.07%
SQUID, SHORT FINNED	7.0	0.07%
SEA RAVEN	5.2	0.05%
SKATE, SMOOTH	**4.0**	**0.04%**
SKATE, THORNY	**3.9**	**0.04%**
CLAM, SURF	3.7	0.03%
CRAB, JONAH	2.7	0.03%
SAND LANCE	1.8	0.02%
QUAHOG, OCEAN	1.4	0.01%
SCULPIN, LONGHORN	1.3	0.01%
SCALLOP, ICELANDIC	1.3	0.01%
CRAB, ROCK	1.3	0.01%
CRAB, NORTHERN STONE	1.0	0.01%
COD, ATLANTIC	0.9	0.01%
HAKE, RED	0.4	0.00%
total	10607.6	

E. June

Species	Weight (lbs)	% of total catch
SCALLOP, SEA (kept)	**8166.7**	**66.98%**
SKATE, NK	**1059.3**	**8.69%**
MUSSEL, HORSE	570.7	4.68%
SKATE, LITTLE	**466.2**	**3.82%**
SKATE, WINTER	**417.5**	**3.42%**
SEA URCHIN	383.9	3.15%
STARFISH, NK	263.2	2.16%
SCALLOP, SEA (discarded)	**227.1**	**1.86%**
MONKFISH	**193.1**	**1.58%**
CLAM, SURF	77.2	0.63%
CRAB, CANCER, NK	63.9	0.52%
FLOUNDER, WINDOWPANE	**38.9**	**0.32%**
FLOUNDER, SUMMER	**32.7**	**0.27%**
SAND DOLLAR	29.9	0.25%
MUSSEL, NK	24.8	0.20%
CRAB, JONAH	21.0	0.17%
FLOUNDER, YELLOWTAIL	**20.6**	**0.17%**
FLOUNDER, WINTER	**20.0**	**0.16%**
LOBSTER, AMERICAN	18.9	0.16%
SEA CUCUMBER	18.6	0.15%
CRAB, HERMIT, NK	16.1	0.13%
SKATE, BARNDOOR	**11.2**	**0.09%**
SEA RAVEN	9.3	0.08%
WHELK, NK	7.5	0.06%
SKATE, THORNY	**7.5**	**0.06%**
SCALLOP, ICELANDIC	6.4	0.05%
QUAHOG, OCEAN	4.5	0.04%
SNAIL, MOONSHELL, NK	2.8	0.02%
FLOUNDER, FOURSPOT	2.3	0.02%
FLOUNDER, WITCH	**2.2**	**0.02%**
SCULPIN, LONGHORN	2.0	0.02%
CRAB, ROCK	1.5	0.01%
CRAB, SPIDER	1.4	0.01%
MUSSEL, BLUE	0.7	0.01%
HAKE, RED	0.6	0.00%
COD, ATLANTIC	0.5	0.00%
SAND LANCE	0.4	0.00%
HAKE, WHITE	0.3	0.00%
HAKE, SILVER	0.2	0.00%
ANEMONE	0.2	0.00%
SHRIMP, NORTHERN	0.1	0.00%
CRAB, NORTHERN STONE	0.1	0.00%
total	12192.1	

F. September

Species	Weight (lbs)	% of total catch
SCALLOP, SEA (kept)	**4593.0**	**62.57%**
SKATE, WINTER	**836.5**	**11.40%**
SKATE, LITTLE	**455.3**	**6.20%**
SAND DOLLAR	350.0	4.77%
SKATE, NK	**234.6**	**3.20%**
MONKFISH	**170.7**	**2.33%**
SEA URCHIN	168.6	2.30%
FLOUNDER, WINDOWPANE	**94.0**	**1.28%**
SCALLOP, ICELANDIC	86.4	1.18%
STARFISH, NK	83.1	1.13%
SKATE, BARNDOOR	**64.4**	**0.88%**
SKATE, THORNY	**38.5**	**0.52%**
FLOUNDER, SUMMER	**35.9**	**0.49%**
FLOUNDER, YELLOWTAIL	**20.9**	**0.28%**
SEA RAVEN	18.9	0.26%
SKATE, SMOOTH	**12.6**	**0.17%**
LOBSTER, AMERICAN	11.4	0.16%
CRAB, JONAH	10.7	0.15%
FLOUNDER, WINTER	**10.6**	**0.14%**
FLOUNDER, WITCH	**10.6**	**0.14%**
SCALLOP, SEA (discarded)	**7.9**	**0.11%**
CRAB, NORTHERN STONE	6.6	0.09%
DOGFISH, SPINY	5.8	0.08%
FLOUNDER, FOURSPOT	3.3	0.04%
FLOUNDER, AMERICAN PLAICE	**2.4**	**0.03%**
MUSSEL, HORSE	2.4	0.03%
CRAB, ROCK	2.2	0.03%
SEA ROBIN, NORTHERN	1.0	0.01%
QUAHOG, OCEAN	0.9	0.01%
HAKE, RED	0.8	0.01%
SCULPIN, LONGHORN	0.4	0.01%
HAKE, SILVER	0.3	0.00%
HAGFISH, ATLANTIC	0.1	0.00%
total	7340.8	

APPENDIX III

Individual Species Selectivity for Twine Top Covered Tows

A. Project Total

species	catch weight (lb) dredge	catch weight (lb) cover	% retained by dredge
SCALLOP, SEA	**13439.3**	**354.6**	**97.4%**
SKATE, LITTLE	**592.0**	**8.7**	**98.6%**
SKATE, WINTER	**443.4**	**5.4**	**98.8%**
SAND DOLLAR	360.0	1.2	99.7%
STARFISH	256.7	27.7	90.3%
SKATE, NK	**248.6**	**0.9**	**99.6%**
SEA URCHIN	200.5	5.2	97.5%
MONKFISH	**93.1**	**3.1**	**96.8%**
SCALLOP, ICELANDIC	91.4	6.3	93.6%
FLOUNDER, WINDOWPANE	**68.2**	**8.1**	**89.4%**
SKATE, BARNDOOR	**50.0**	**0.0**	**100.0%**
FLOUNDER, SUMMER	**46.1**	**2.0**	**95.8%**
FLOUNDER, WINTER	**38.9**	**23.6**	**62.3%**
FLOUNDER, YELLOWTAIL	**29.0**	**17.5**	**62.4%**
CRAB, JONAH	16.2	0.9	94.7%
SEA CUCUMBER	14.2	0.9	94.0%
SKATE, THORNY	**13.2**	**0.4**	**96.8%**
LOBSTER, AMERICAN	12.7	2.0	86.4%
CRAB, ROCK	11.8	1.3	90.0%
SKATE, SMOOTH	**7.5**	**0.0**	**100.0%**
FLOUNDER, WITCH	**6.5**	**0.0**	**100.0%**
SEA RAVEN	5.1	2.0	72.3%
QUAHOG, OCEAN	4.6	0.3	93.9%
MUSSEL, HORSE	4.0	0.0	100.0%
FLOUNDER, FOURSPOT	3.3	0.7	82.5%
WHELK, NK	3.2	1.5	68.1%
SCULPIN, LONGHORN	3.0	18.4	13.8%
CRAB, HERMIT	2.7	1.0	73.0%
CRAB, SPIDER	1.7	0.0	100.0%
CRAB, NORTHERN STONE	1.1	0.2	84.6%
COD, ATLANTIC	0.8	0.3	76.2%
SAND LANCE	0.5	0.0	100.0%
HAKE, RED	0.5	6.2	7.5%
SEA ROBIN, NORTHERN	0.3	0.0	100.0%
ANEMONE	0.2	1.3	13.3%
SHRIMP, NORTHERN	0.1	0.0	100.0%
HAKE, SILVER	0.1	0.0	100.0%
SQUID, ILLEX	0.0	0.4	0.0%
MUSSEL, NK	0.0	0.3	0.0%
FLOUNDER, AMERICAN PLAICE	**0.0**	**0.9**	**0.0%**

B. F/V Donna Jean II

	catch weight (lb)		
species	**dredge**	**cover**	**% retained by dredge**
SCALLOP, SEA	**2209.5**	**22.3**	**99.0%**
SAND DOLLAR	360.0	0.6	99.8%
SKATE, NK	**232.0**	**0.9**	**99.6%**
SEA URCHIN	198.6	1.8	99.1%
SKATE, LITTLE	**186.8**	**0.0**	**100.0%**
STARFISH	99.1	2.3	97.7%
SCALLOP, ICELANDIC	85.8	3.9	95.7%
MONKFISH	**65.6**	**1.1**	**98.4%**
SKATE, WINTER	**58.9**	**0.0**	**100.0%**
FLOUNDER, WINDOWPANE	**40.3**	**3.4**	**92.2%**
FLOUNDER, SUMMER	**20.0**	**0.0**	**100.0%**
SKATE, BARNDOOR	**16.7**	**0.0**	**100.0%**
FLOUNDER, WINTER	**16.6**	**1.2**	**93.3%**
CRAB, JONAH	12.5	0.0	100.0%
FLOUNDER, YELLOWTAIL	**12.4**	**2.8**	**81.5%**
CRAB, ROCK	9.6	0.1	99.0%
SKATE, THORNY	**5.7**	**0.0**	**100.0%**
FLOUNDER, WITCH	**4.3**	**0.0**	**100.0%**
MUSSEL, HORSE	4.0	0.0	100.0%
SKATE, SMOOTH	**3.5**	**0.0**	**100.0%**
FLOUNDER, FOURSPOT	2.8	0.6	82.4%
LOBSTER, AMERICAN	2.5	0.0	100.0%
SEA CUCUMBER	2.2	0.0	100.0%
CRAB, NORTHERN STONE	1.1	0.0	100.0%
SCULPIN, LONGHORN	0.8	0.0	100.0%
SEA RAVEN	0.3	0.3	50.0%
HAKE, RED	0.2	3.8	5.0%
QUAHOG, OCEAN	0.1	0.0	100.0%
SQUID, ILLEX	0.0	0.4	0.0%
FLOUNDER, AMERICAN PLAICE	**0.0**	**0.9**	**0.0%**

C. F/V Donna Marie

	catch weight (lb)		
species	**dredge**	**cover**	**% retained by dredge**
SCALLOP, SEA	**2764.7**	**64.3**	**97.7%**
SKATE, LITTLE	**376.9**	**6.2**	**98.4%**
SKATE, WINTER	**64.5**	**0.0**	**100.0%**
SKATE, BARNDOOR	**33.3**	**0.0**	**100.0%**
MONKFISH	**26.4**	**0.1**	**99.6%**
FLOUNDER, SUMMER	**26.1**	**2.0**	**92.9%**
FLOUNDER, WINDOWPANE	**25.1**	**4.7**	**84.2%**
FLOUNDER, WINTER	**21.2**	**16.5**	**56.2%**
FLOUNDER, YELLOWTAIL	**7.5**	**6.9**	**52.1%**
SKATE, SMOOTH	**4.0**	**0.0**	**100.0%**
LOBSTER, AMERICAN	3.3	0.0	100.0%
SEA RAVEN	1.5	0.7	68.2%
CRAB, ROCK	0.5	1.2	29.4%
FLOUNDER, FOURSPOT	0.5	0.0	100.0%
SCULPIN, LONGHORN	0.5	11.5	4.2%
COD, ATLANTIC	0.3	0.0	100.0%
SEA ROBIN, NORTHERN	0.3	0.0	100.0%
SCALLOP, ICELANDIC	0.1	0.0	100.0%
SAND LANCE	0.1	0.0	100.0%
HAKE, RED	0.0	0.9	0.0%

D. F/V Mistress II

	catch weight (lb)		
species	**dredge**	**cover**	**% retained by dredge**
SCALLOP, SEA	**8465.1**	**268.0**	**96.9%**
SKATE, WINTER	**320.0**	**5.4**	**98.3%**
STARFISH	157.6	25.4	86.1%
SKATE, LITTLE	**28.3**	**2.5**	**91.9%**
SKATE, NK	**16.6**	**0.0**	**100.0%**
SEA CUCUMBER	12.0	0.9	93.0%
FLOUNDER, YELLOWTAIL	**9.2**	**7.8**	**54.0%**
SKATE, THORNY	**7.5**	**0.4**	**94.5%**
LOBSTER, AMERICAN	6.9	2.0	77.5%
SCALLOP, ICELANDIC	5.5	2.4	69.6%
QUAHOG, OCEAN	4.5	0.3	93.8%
CRAB, JONAH	3.7	0.9	80.4%
SEA RAVEN	3.3	1.0	77.6%
WHELK, NK	3.2	1.5	68.1%
FLOUNDER, WINDOWPANE	**2.8**	**0.0**	**100.0%**
CRAB, HERMIT	2.7	1.0	73.0%
FLOUNDER, WITCH	**2.2**	**0.0**	**100.0%**
SEA URCHIN	1.9	3.4	35.6%
CRAB, ROCK	1.7	0.0	100.0%
CRAB, SPIDER	1.7	0.0	100.0%
SCULPIN, LONGHORN	1.7	6.9	19.4%
MONKFISH	**1.1**	**1.9**	**37.3%**
FLOUNDER, WINTER	**1.1**	**5.9**	**15.8%**
COD, ATLANTIC	0.5	0.3	66.7%
SAND LANCE	0.4	0.0	100.0%
HAKE, RED	0.3	1.5	16.7%
ANEMONE	0.2	1.3	13.3%
SHRIMP, NORTHERN	0.1	0.0	100.0%
HAKE, SILVER	0.1	0.0	100.0%
CRAB, NORTHERN STONE	0.0	0.2	0.0%
MUSSEL, NK	0.0	0.3	0.0%
SAND DOLLAR	0.0	0.6	0.0%
FLOUNDER, FOURSPOT	0.0	0.1	0.0%