

## Development of Trawl and Shrimp Fisheries at the Egyptian Mediterranean Area

A. Alsayes, Sh. Fattouh, S. Abu Enin and T. Soliman

National Institute of Oceanography and Fisheries, Alexandria, Egypt

---

**Abstract:** Trawling is the most important fishing method for catching demersal fish and shrimp along the Mediterranean coast of Egypt. The landed catch of trawling comprise 43.6% by weight of the total yearly landed catch. Experimental fishing operations were carried out in the present study using the Italian trawl net at the area off the Nile delta during Spring and Summer, 2008. This study indicated that shrimp comprised 49.52% of the trawl catch. *Pagellus erythrinus*, *Merluccius merluccius* and *Siganus rivulatus* comprised high percentages in that catch. Most of the commercial fish species are caught with average sizes below 15.0 cm., therefore they are mostly caught before attaining their first sexual maturity. Fisheries management and fish stock conservation for sustainable fish and shrimp production is strongly recommended in the study area. This can be achieved through the application of minimum landing size of fish, trawl net cod-end mesh regulation and closed season for all fishing activities.

**Key words:** Trawling % Shrimp fisheries % Fisheries management % Mediterranean % Egyptian fisheries % Socio-economics

---

### INTRODUCTION

The most economically important fishing gear along the Mediterranean coast, of Egypt is trawling. Among the yearly total catch taken from such coast some 36.600 tons of fish are the estimated landings of trawling, comprising about 43.6% of that total. [1]

The fishing boats using trawl nets at the Egyptian Mediterranean water are 1220 in number with sizes range from 10 to 24 m [1]

The central part of the Mediterranean coast of Egypt – from Alexandria to Port Said – is the richer fishing area, falling off the Nile delta. The continental shelf is the widest at this area and provides ample opportunity for fishing, though the fishery seems to have suffered considerably from over exploitation during the last two decades.

The increased exploitation levels of demersal fish resources at the continental shelf off the Nile delta have resulted in the need for improved fishery management program at such fishing area.

The goal of management program is to reduce fishing mortality to levels which allow stocks within the complex to initially rebuild above minimum biomass [2].

The basic data required for fisheries management in the study area are very limited. Knowledge of total catch removed from each stock is essential and little can be done without some estimate of the effort or catch per unit effort and of the sizes or ages of fish being caught.

The present investigation was carried out to survey the demersal fish populations in the study area, collecting data on the size composition, breeding season and catch per unit effort of these populations. Moreover, experimental fishing operations were carried out at the area of study during 2008 where bottom trawl net was used in these experimental surveys.

### MATERIAL AND METHODS

Bottom trawl surveys were undertaken at the Mediterranean coast of Egypt during spring and summer of 2008. Fishing depths ranged between 20 and 215 m during spring while these depths were between 28 and 225 m in summer.

The trawl net used in these surveys was of the Italian design. The mesh sizes of various parts of the net ranged between 10.0 cm at the wing to 1.5 cm mesh bar measure at the cod end. The whole net is manufactured from nylon twines.

The length of fishing rope ranged between 1.89 to 7.44 times the water depth during Spring fishing while it ranged between 1.30 to 5.00 times the water depth during Summer surveys.

Approximately 25 stations were sampled during each survey. Stations were allocated to strata approximately in proportion to the area of each stratum.

Sub samples of the catch were transplanted to the laboratory for species identification as well as weight and lengths measurement.

Length frequencies of fish were recorded to determine whether the trawl net affected the size composition of fish populations at the area of study.

## RESULTS

Results of the catch taken by trawl net from the area off the Nile delta during spring are shown in Table 1. Weights of various species (g) caught at each sector are given in the table.

The given data indicated that the highest catch was taken from Rosetta area, whereas it reached 57.74 kg followed by that caught from Abu Qir area amounting 54.22 kg. The depths of water at these two sectors ranged between 170 to 210 m at Rosetta sector, while it was about 95 m at Meadia area.

Table 2 shows data relevant to the weight of fish caught from the various areas during Summer. It appears from the figures given that the highest catch was taken from Borollus sector at a depth of 30 m. This catch comprised 37% by weight of the total catch taken off the Nile Delta during Summer. Comparatively high catches were taken also from Abu Qir and Rosetta sector, whereas these catches comprised 22.89 and 21.57% by weight of the whole taken catch.

The target catch taken by trawl net in Summer was categorized as fish and invertebrates as shown in Table 3. The finfish comprised 42.83% by weight of the catch, while the invertebrates formed 57.17% of that catch. Shrimp was the major component of invertebrates comprising 42.52% of the whole catch.

Data concerning the average lengths (cm) of the various commercial fish species caught from the area of study are given in Table 4.

As indicated in the table these lengths were compared with the lengths of fish at which they attain their first maturity. This comparison may contribute in understanding the effects of trawl fisheries on the breeding processes of the fish populations living in the Egyptian water. The given data show that many of the demersal species are caught with small sizes. These sizes appear to be in most cases below the marketable sizes. It is indicated also that most of the species are caught with sizes less than their sizes at first maturity.

Table 1: Species composition of the catch taken by trawl net during spring as weights in g

Species	Abu Qir 30m	Abu Qir 150-190m	Meadia 95m	Rosetta 30m	Rosetta 170-210m	Bor. 20m	Dam. 30m	Total	%
<i>Pagellus erythrinus</i>		5340	24000	2000				31340	15.40
<i>Mullus surmulatus</i>		6280	8000		5000			19280	9.48
<i>Merluccius merluccius</i>		5695	328		37500			43523	21.39
<i>Trigla lucerna</i>		1603			1137	560		3300	1.62
<i>Boops boops</i>	23	420	230					673	0.33
<i>T. mediterraneus</i>		482		48				530	0.26
<i>Teroon puta</i>		295	8000			82		8377	4.12
<i>Serranus hepatus</i>	424	151	704		12	171		1462	0.72
<i>Citharus linguatua</i>		1437	500					1937	0.95
<i>Trigla lastoviza</i>		280		2000				2280	1.12
<i>Centropristis SP.</i>		394						394	0.19
<i>Trachinus draco</i>		212						212	0.10
<i>Arisoma balearicum</i>	873	769	562	1074	72	510	24	3884	1.91
<i>Sporisoma cutaneus</i>		600						600	0.29
<i>Bothus podas</i>	2000	82			282	1405	640	4409	2.17
<i>S. notata</i>	26	248						274	0.13
<i>Raja SPP.</i>		1500						1500	0.74
<i>Spicara flexusa</i>	3000		406	408				3814	1.87
<i>Synodus saurus</i>	2000		1500					3500	1.72
<i>Callionymus filamentosus</i>	49			239	168	91		547	0.27
<i>Solea impar</i>	165			185				350	0.17
<i>Gobius niger</i>	583		2046	1984	110	3455	1656	9834	4.83
<i>Pagrus pagrus</i>	17							17	0.01
<i>Trigla cavillone</i>	65		2384				864	3313	1.63

Table 1: Continued

<i>Trigla lyra</i>	24							24	0.01
<i>Trachurus trachurus</i>			2000					2000	0.98
<i>Sepia</i>	1000	1500			10000		2016	14516	7.13
<i>Octopus</i>		2000	402			300		2702	1.33
<i>Penaeus kerathurus</i>	2000		3000	3000		3000		11000	5.41
<i>Metapenaeus monaceras</i>	13000							13000	6.39
<i>Penaeus stibbing</i>			142					142	0.07
<i>T. curvirostrus</i>				3000	3000	4000	4000	14000	6.88
<i>Crabs</i>			16		460	120	128	724	0.36
Total	25249 (12.41)	29288 (14.40)	54220 (26.65)	13938 (6.85)	57741 (28.38)	13694 (6.73)	9328 (4.58)	203458	

Table 2: Species composition of commercial species caught at various experimental fishing localities during Summer

Species	Abu Qir 100m	Rosetta 50m	Rosetta 105m	Rosetta 150m	Rosetta 200m	Borollus 30m	Total	%
<i>Pagellus erythrinus</i>	400	58					458	0.24
<i>Bothus podas</i>	1900		500	200			2600	1.37
<i>Serranus hepatus</i>	541					94	640	0.34
<i>Boops boops</i>	6000	3500				291	9791	5.15
<i>Spicara flexusa</i>	5200		250				5450	2.84
<i>Trigla lastoviza</i>	8383	3357	3000	2000	442	672	17854	9.39
<i>Trigla cavillone</i>	6928						6928	3.64
<i>Trigla lyra</i>	5500						5500	2.89
<i>Mullus surmuletus</i>	2500	1250	1000			2373	7123	3.75
<i>Synodus saurus</i>	850					4200	5050	2.66
<i>Solea impar</i>	1500	500				450	2450	1.29
<i>Pagrus pagrus</i>	700	1250		100			2050	1.08
<i>Sparus aurata</i>	700					500	1200	0.63
<i>Scomber japonitus</i>	900	480			44		1424	0.73
<i>Epinephalus</i>	1500					13000	14500	7.63
<i>Merluccius merluccius</i>			35000	4000	10300		49300	25.94
<i>Sargus sargus</i>		90					90	0.47
<i>Trachurus trachurus</i>		650			95		745	0.39
<i>Pagellus acarne</i>		89					89	0.05
<i>Spicara smaris</i>			250	500		389	1139	0.60
<i>Trigla lucerna</i>				2000		850	2850	1.50
<i>Lepidopus caudatus</i>			1000	4000	318		5318	2.80
<i>Stephanolepis hispidus</i>						250	250	0.13
<i>Seriola dumerili</i>						700	700	0.37
<i>Siganus rivulatus</i>						45500	45500	23.94
<i>Crenidens crenidens</i>						300	300	0.16
<i>Mullus barbatus</i>						273	273	0.14
<i>Diplodus anularis</i>						250	250	0.13
<i>Sphyraenu</i>						250	250	0.13
Total	43502 (22.89)	11224 (5.91)	41000 (21.57)	12800 (6.73)	11199 (5.89)	70342 (37.00)	190072	

Table 3: Weights of finfish and invertebrates caught through the experimental fishing

Locality	Depth (m)	Fish	Invertebrates		Total
			Shrimp	others	
Abu Qir I	122	16030 (85.58)	700 (3.74)	2000 (10.68)	18730
Abu Qir II	107	10040 (41.76)	12000 (49.91)	2000 (8.32)	24040
Abu Qir III	81	13250 (70.67)	1500 (8.00)	4000 (21.33)	18750
Rosetta I	54	6953 (83.97)	120 (1.45)	1207 (14.58)	8280
Rosetta II	65	8463 (48.46)	2500 (14.32)	6500 (37.22)	17463
Rosetta III	225	11235 (13.52)	67500 (81.24)	4352 (5.24)	83087
Borollus I	26	70300 (90.36)	6000 (7.71)	1500 (1.92)	77800

Table 3: Continued

Borollus II	30	1884 (32.07)	2500 (42.55)	1503 (25.58)	5887
Borollus III	27	5730 (41.73)	8000 (58.27)	-	13730
Borollus IV	28	6292 (47.70)	2800 (21.22)	4100 (31.08)	13192
Rosetta V	153	16558 (14.10)	97500 (83.05)	3345 (2.85)	117403
Rosetta VI	104	16500 (58.20)	4200 (14.81)	7650 (26.98)	28350
Abu Qir IV	81	12193 (62.79)	2500 (12.87)	4725 (24.33)	19418
Rosetta VII	108	44845 (39.05)	70000 (60.95)	-	114845
Total		240273 (42.83)	277820 (49.52)	42882 (7.64)	560975

## DISCUSSION

Trawl is recognized as one of the most efficient fishing gears for harvesting finfish and shrimps. This method has become popular in the Egyptian water since more than 30 years.

Catch assessment of the Italian trawl net was carried out at the Egyptian water off the Nile Delta during Spring and Summer seasons. In Spring, *Merluccius merluccius* and *Pagellus erythrinus* dominated the catch, whereas the two species comprised about 36% by weight at the catch. In Summer, *M. merluccius* extended its abundance in the catch and comprising about 25% of the catch while *Siganus rivulatus* appeared with considerable percentage constituting about 24% by weight of the catch. It is a matter of fact that the variations in species composition of trawl catch can be attributed to various factors, the most important of which are the environmental conditions with special reference to water temperature. In this concern, Matsushita [3] pointed out that the quality of the trawled fish depends to large extent on time of fishing, water temperature and type of substrate.

The current data indicated that the catch taken from Abu Qir Sector is characterized by its high species diversity either during Spring or Summer seasons. The high bio-diversity of Abu Qir bay catch may be attributed to the fertility of its water as a result of the high rates of agriculture water discharge into that Bay. The deeper water in some sectors of the study area exhibited higher catch rates in both seasons. In fact, the fish populations living in the shallow water are exposed to high rates of exploitation due to the use of large number of simple fishing methods, specially trammel and gill nets.

It can be pointed out that shrimp species which are belonging to family *Penaeidae* comprise a high

percentage of the catch. This can be attributed to the high efficiency of Italian trawl in catching shrimp. The heavy sweep line of the net, small mesh size of the cod end as well as the low vertical opening of the net, all contribute in increasing the efficiency of the net in catching shrimps.

Because most fishing gears have imperfect size selection they may retain fish that are too small to have any commercial value. Trawls for example usually retain a range of sizes below the minimum target size and these are typically discarded [4,5].

In agreement with the average sizes of 28 of the commercial fish species caught by the Italian trawl net from different depths and sectors of the study area are given in Table 4. The data given in the table show that the average sizes of six fish species were 10.0 cm or below. The other fish species were mostly caught with average sizes below their marketable sizes.

The average lengths at first maturity of some commercial fish species are shown in Table 4 [6].

Comparing the average lengths of some species having commercial value caught by trawl net in the present study with their lengths at first maturity it can be concluded that these species are caught without reaching the size at first maturity. However, it is believed that fishing with trawl net with its present design and mesh sizes affects to large extent the breeding success of the following commercial species: *Pagellus erythrinus*, *Trigla lastoviza*, *Pagellus acarne*, *Trigla lucerna*, *Siganus rivulatus* and *Sphyræna Sphyræna*. Actually the data given in the present study show that these species comprise respected percentage of the catch. In this concern, Shepherd, [7] pointed out that killing juveniles removes potential yield and unless taken into account in assessment will detract from assessments and effective management decisions.

Table 4: Average lengths et commercial species compared to their lengths at first maturity.

Species	Abu Qir 100m	Rosetta 50m	Rosetta 105m	Rosetta 150m	Rosetta 200m	Boro. 30m	Average length	Length at 1 <sup>st</sup> maturity	
								m.	f.
<i>Pagellus erythrinus</i>	9.70	13.50					10.03	14.3	13.2
<i>Bothus podas</i>	11.92		9.0	17.30			11.34		
<i>Serranus hepatus</i>	8.71					8.55	8.61		
<i>Boops boops</i>	14.50	12.36				9.75	13.18	11.0	13.0
<i>Spicara flexusa</i>	13.37		10.00				13.08		
<i>Trigla lastoviza</i>	14.91	12.19	8.48	15.10	18.77	12.68	12.41	14.5	15.3
<i>Trigla cavillone</i>	9.14						9.14		
<i>Trigla lyra</i>	15.00						15.00		
<i>Mullus surmuletus</i>	15.36	15.68	9.00			15.33	12.57	12.51	11.50
<i>Synodus saurus</i>	17.24					20.22	19.87	17.5	17.0
<i>Solea impar</i>	15.23	11.50				16.50	14.41		
<i>Pagrus pagrus</i>	14.13	14.25		14.0			14.20		
<i>Sparus aurata</i>	21.00					14.00	16.95		
<i>Scomber japonitus</i>	13.00	17.00			20.0		115.83		
<i>Epinephalus</i>	15.80					18.41	18.06		
<i>Merluccius merluccius</i>			26.70	26.20	26.50		25.81		
<i>Sargus sargus</i>		10.00					10.00		
<i>Trachurus</i>		20.00			22.0		20.18		
<i>Pagellus acarne</i>		11.50					11.50	13.4	14.0
<i>Spicara smaris</i>			10.27			11.43	10.95		
<i>Trigla lucerna</i>				15.20		13.55	13.55	15.6	17.0
<i>Lepidopus caudatus</i>			41.60	43.60	42.50		43.14		
<i>Stephanolepis hispidus</i>						11.20	11.20		
<i>Seriola dumerili</i>						22.91	22.91		
<i>Siganus rivulatus</i>						14.81	14.81	17.0	24.0
<i>Crenidens crenidens</i>						13.00	13.00		
<i>Mullus barbatus</i>						11.25	11.25	10.0	12.0
<i>Diplodus anularis</i>						10.00	10.00		
<i>sphyraenu</i>						14.00	14.00	23.0	26.0

In the same trawl it was indicated that fishing of small sized fish caused by over fishing and discarding may change the balance between species within a multispecies population. It is a matter of fact that prior to the introduction of shrimp trawling on the coast of Malaysia the families of *Leiognathidae*, *Carangidae* and *Nemipteridae* dominated the marine community. After the introduction of shrimp trawling the population of *Leiognathidae* dropped sharply [8].

A similar situation was noted in the population of *Leiognathidae* and *Dasayatidae* in the Gulf of Thailand over ten years of shrimp trawling [9]. It has also been noted that in the Gulf of Carpentaria (Australia) the balance between demersal and pelagic fish species has changed over a twenty year period with demersals declining and pelagics increasing in abundance [10].

It appears therefore that fisheries management is necessary for the development and conservation of fish resources along the Mediterranean coast of Egypt. Such management can be achieved through the application of:

a- Minimum landing size, below which, fish may not be landed for sale. This approach encourages fishermen to avoid concentration on juveniles and using nets with optimum mesh sizes to catch larger fish. The main problem that may face the application of this method is the complications that may result from mixed fisheries. The problem is that where one species has a minimum landing size another species may have a different one.

b- Minimum mesh sizes can reduce the fishing mortality of under sized or juvenile fishes. It is a matter of fact that the main disadvantage of Italian trawl net used in the Egyptian water is the narrowness of net mesh while in operation where the meshes in most parts of the net are stretched or even closed specially at the cod-end. The angle between the bars of the stretched mesh was found to reach 15° or even less [11]. Attachment of side lines along the net body is recommended to avoid this problem. The increase of cod-end mesh size to 40 mm mesh bar will on the other hand contribute in increasing the average lengths of retained fish.

Table 5: Funding program conducted at Meadia region

Aspect	Number	Total Expenditure (LE)
Motors maintenance	89	2707000
Replacement of boat body	37	1865000
Establishment of new boats	67	2176000
Nets supply	36	779000
Shops for fishing gears supply	9	280000
Fish marketing shops	4	117000
Establish fish smoking factory	1	50000
Ice producers	1	200000
Net making workshop	1	35000
Boat maintenance workshop	2	135000
Total	247	8344000

c- The establishment of closed season in the Egyptian water seems to be a step in the right direction. It is believed that the protection of breeding process of the commercial demersal species is an accepted and significant strategy including plans for increasing the abundance of the spawning stock through better protection of juvenile fish.

In this concern Pascoe, [4] pointed out that area and seasonal closures have been implemented in some fisheries to reduce over fishing and unwanted catch. In some fisheries particularly shrimp fisheries seasonal closures have proved beneficial in both reducing the catch of juvenile fish and increasing the value of the catch.

In their study on breeding seasons of commercial fish species in the Egyptian water, Allam *et al.* [12] indicated that most of these species spawn during Spring and early Summer. Based on this information it is recommended to close fishing during this period.

As for the management of shrimp fisheries at the Italian water of the Mediterranean, Bianchini *et al.* [13] concluded that the adoption of a mesh size of 56 mm in the codend employed for red shrimp fisheries is strongly recommended.

On the other hand, the management and development of trawl fisheries in the Egyptian waters also need to face and deal with the following problems encountering fishing industry in the Egyptian waters.

- C Absence of suitable fishing ports for entry and sailing of fishing boats through their fishing trips. Partial damage of the boats may occur from such problem.
- C Lack of optimum platforms for boats to resort in cases of unloading the catch or to be provided with ice and trip requirements.

- C Difficulty in performing the regular yearly maintenance to the wooden body of the boats due to the absence of modern tools to be used to lift or bring down the boats while being maintained.
- C Construction and setting of engine and winches to the fishing boat is carried out through small undeveloped workshops. Workers in these workshops depend mainly on their inherited experience to design and establish these fishing boats, without following the advanced theories and techniques in boat manufacture. Therefore these boats perform with moderate or even low efficiency compared to the boats constructed in advanced workshops.
- C Absence of updated motorized gears on board to operate the fishing nets. On the other hand, fishermen are mostly not highly qualified to deal with the developed fishing techniques adopted to bottom or midwater trawling.

However, the governmental authorities in Egypt attempted to deal with the above mentioned difficulties within a limited part of the fishing area in Egypt. In this concern a funding program was conducted at El-Media region in a way of giving loans to the owners of some fishing boats to maintain or reconstruct their boats (Table 5).

These loans were offered through a governmental organization for social development in Egypt during the period 1989-1999. This organization also contributed in developing the fishing industry through supporting some other activities as indicated in Table (5).

It is believed that the financial supports in these activities may have contributed in the partial development of trawl fisheries through the following aspects.

- C Decline in the depreciation rate and accidental fishing boat sinkage due to either maintenance or replacement of boat engines.
- C Increased duration of fishing trips and possibility to cover wide fishing areas situated at far distances.
- C Giving the chance for further number of fishermen to be owners of new fishing boats.
- C Establishment of well equipped workshops that are able to maintain the fishing boats within short periods of time.
- C Establishment of ice producing factory able to cover the needs of fishing boats for ice.
- C Conducting a number of training courses for fishermen at Meadia region where these courses concentrated on net making and maintenance as well as care of nets during the fishing operations.

Based on the above mentioned achievements it is recommended to conduct similar funding programs at other fishing areas in Egypt. This will with no doubt contribute in developing the yearly fish production of the country.

### CONCLUSIONS

In conclusion the following aspects have to be considered

- C Improve the design characteristics of the Italian trawl net specially the mesh size of cod end as well as the use of side lines along the net body.
- C Conserve the fish stocks of demersal species at the area of study through the application of:
  - C Minimum landing size of fish.
  - C Closed season. The period from April to June is believed to be the most optimum for that.
- C Conduct funding programmes through allowing loans to fisheries and boats owners.
- C Dealing with the problems retarding fisheries development specially the care of fishing ports.

### REFERENCES

1. GAFRD, 2007. General Authority of Fisheries Resources Development Bulletin. Year book of fisheries statistics of Egypt, pp: 168.
2. Shijie, Z., 2008. Fishing by-catch and discards: a positive perspective from ecosystem based fishery management. Fish and Fisheries, 9: 308-315.
3. Matsushita, Y., 2000. Development of by-catch reducing technologies in trawl fishery. Bulletin of Natural Research Institute for Fisheries and Engineering, 21: 1-57.
4. Pascoe, S., 1997. By-catch management and the economics of discarding. FAO Fisheries Technical Paper N° 370. pp: 137.
5. Hall, S.J., 1999. The effects of fishing on marine ecosystems and communities. Blackwell Science, London, pp: 274.
6. Alsayes, A., 2009. Impacts of commercial fishing activities on pelagic and demersal fish resources along Mediterranean coast of Egypt. Technical report N° 5. Workshop on Fisheries Resources of Egypt. Alexandria May, 2009: pp: 25.
7. Shepherd, J.G., 1990. Stability and the objectives of fisheries management: The Scientific background (MAFF Directorate of Fisheries Research), Lowestoft Laboratory Leaflet, N° 64, pp: 16.
8. Chan, E.H. and H.C. Liew, 1986. Characteristics of an exploited tropical shallow water demersal fish community in Malaysia. In proceedings of the first Asian Fisheries Forum. Asian Fisheries Society, (Maclean J.L., Dizon, L.B. and Hosillos L.V. eds). 26-31 May 1986 Manilla, pp: 349-67.
9. Pauly, D., V. Christensen, S. Cruenette, T.J. Pitcher and C.J. Walters, 2002. Towards sustainability in world fisheries. Nature, 418: 689-95.
10. Harris, A.N. and I.R. Poiner, 1990. By-catch of the prawn fishery of the Torres Strait, composition and partitioning of discards into components that float or sink. Australian Journal of Marine and Freshwater Research, 41: 37-52.
11. Shaheen, A. and A. Alsayes, 1978: Studies on trawl fishing gears in Egypt. Bulletin Institute Oceanography and Fisheries. Egypt, 7: 549-558.
12. Allam, S., A. Ezzat and E. Mohamed, 1998. Perspectives of fish landings along Alexandria coast. Bulletin Faculty of Science, Alexandria University. Egypt, 38: 67-84.
13. Bianchini, M.L., S. Ragonese and D. Levi, 2003. Management hypotheses to improve yield-per-recruit and economic returns in the red shrimp (*Aristaomorpha folicea*) fishery of southern sicily (Mediterranean Sea). Journal of Northwest Atlantic Fishery Science, 31: 233-243.