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**Understanding the Long-Term Dynamics of Non-Traditional Species in  
Bentho-Demersal Communities**

NOT TO BE CITED WITHOUT PRIOR REFERENCE TO THE AUTHOR

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**Abstract**

The demersal component of many fish communities usually consists of high profile and commercially valuable species that are targets of fisheries, plus a diverse group of lesser known species that have minimal commercial value and focus. Yet ecologically these traditionally non-targeted species are often a major biomass sink in marine ecosystems and can also be critical in the functioning of benthic-demersal food webs. I examined the biomass trajectories of several species of skates, cottids, lophiids, anarhichadids, zooarcids and similar species in the U.S. northwest Atlantic ecosystem to determine if their relative abundance has changed across the past four decades. Distribution and stomach contents of these species were also evaluated over time to further evaluate the relative importance of these species. Of particular emphasis was testing the hypothesis of a possible competitive release from gadids and pleuronectiformes, groups which have both experienced a high degree of population decline due to overfishing during this period. I also explored the hypothesis that despite a large amount of bottom disturbance from mobile fishing gear, the benthos and forage fish communities provided a consistent amount of food to maintain and expand populations of these non-traditional species. Results indicate that some of these fish species are the dominant piscivores, benthivores, and scavengers in this ecosystem, and in general have either maintained a rather consistent population size or have increased in abundance (and expanded in distribution) over the past several decades. Non-traditional fish species are an often overlooked but important component of benthic-demersal fish communities.

**KEYWORDS:** benthos, food web dynamics, benthic-demersal community, Georges Bank, habitat

**Introduction**

When one thinks of fisheries in the north Atlantic, species such as cod or haddock or halibut or plaice are prominent. Yet many of these historically targeted stocks are at biomass minima, do not comprise a large market share, do not dominate landings in terms of poundage or value, and are not the ecologically dominant species in north Atlantic marine ecosystems (e.g., Garcia and Newton 1997, Fogarty and Murawski 1998, NEFSC 1999, DOC 2000, Link and Garrison 2002). In many respects the question begs, what is taking their place in the face of delayed or non-occurring stock recovery?

There are non-traditional species that functionally have already begun to take the place, both economically and ecologically, of the historically targeted species. In many places in the north Atlantic the role of historically dominant demersals such as gadids or pleuronectiformes is being or has already been supplanted by a suite of other demersal species that are relatively unstudied. For instance, in New England waters of the U.S., goosefish is currently the most valuable commercially landed finfish species (DOC 2000). Many of these fish are unaesthetic (Figure 1), and I term them “ugly fish” throughout the manuscript as a collective form of shorthand, and also to convey their historical lack of appeal visually and commercially. A cultural shift needs to take place in recognition of the novel importance of these species.

Additionally, given the call for ecosystem based approaches in fisheries management (e.g., Larkin 1996, Link 2002a, b) and the particular emphasis on benthic-demersal community response to edaphic perturbations to the ocean floor (e.g., Jennings and Kaiser 1998, Benaka 1999; Kaiser and de Groot 2000), it is wise to understand the role of the non-traditional benthic-demersal fish species in the north Atlantic. Here I examine 13 species of “ugly fish” from U.S. waters of the northwest Atlantic, evaluating trends in abundance, trophic ecology, distribution, and the potential

interactions of these species among demersal communities and habitats.

## Methods

I emphasized 13 species of “ugly fish” in this study (Figure 1), including the Atlantic torpedo, five species of skate (barndoor, winter, little, smooth, and thorny), longhorn sculpin, sea raven, northern sea robin, Atlantic wolffish, ocean pout, fawn cusk-eel, and goosefish. These species range in size from 10 cm to > 2m and represent a diverse set of taxa from elasmobranch, cottid, lophiid, anarhichadid, and zooarcid groups. Summary details of these species are seen in Table 1.

### *Abundance*

To evaluate trends in abundance, I calculated a stratified mean average of biomass (kg) per tow for each year from the NEFSC bottom trawl survey. The time series runs from 1963 to present; for further details of the NEFSC BTS, see Azarovitz (1981) and NEFC (1988). I present yearly averages with 95% confidence intervals, the long term arithmetic average, and a smoothed five year moving average. I also calculated the average percent of the total catch comprised by each species. Whether or not the time series of abundance was stationary or not was tested; if significant, any trends were noted.

### *Trophic ecology*

To evaluate the feeding ecology of these fish, the total stomach contents were calculated in five year blocks (i.e., 1973-1975, 1976-1980, 1981-1985, etc.) and presented with 95% confidence intervals. The five year time blocks were chosen over shorter time frames to ensure

sufficient sample sizes for most species. Some species did not have adequate sampling for portions of the entire time series and in those cases only the time blocks with sufficient sample sizes are shown. The food habits time series runs from 1973 to present; for further details of the food habits sampling, see Link and Almeida (2000). Additionally, I also calculated percent diet composition (based upon mass) of the major prey items for each of these species. Although done in five year blocks, for the sake of space I only present a summary of the major prey of these species and note if any major changes in diet have occurred across the time series.

Coupled with the abundance trajectory, the amount of total amount of food consumed by these species was evaluated as a proxy to determine potential food limitation. In cases when the amount of food eaten notably declined concurrent with or immediately prior to a decline in population abundance, I interpreted such an occurrence as a possible case of insufficient food availability, principally because none of these species (with a few exceptions in recent years) has been the persistent and directed target of a fishery. This was principally with respect to the benthivores, as one part of a series of analyses exploring the hypothesis that mobile, bottom tending gear have altered benthic communities such that there may be insufficient food available for benthic and demersal fish species.

### *Distribution*

To evaluate the distribution and potential dynamics thereof for these species, I averaged the weight per tow taken from the NEFSC bottom trawl survey in ten minute squares. This was done for the entire northeast U.S. shelf ecosystem for each five year block, with obvious shifts in distribution or range contraction or expansion noted. Although the full time series is available, I only present alternating five year blocks from the 1960s to more recent years (i.e., 1966-1970,

1976-1980, 1986-1990, 1996-2000).

### *Competition with Historically Targeted Species*

To evaluate the potential interaction among these “ugly fish” species and gadids, pleuronectiformers, and similar historically targeted species, I calculated a spatial overlap index using the methods of Garrison (2000), Garrison and Link (2000a, b) and Link et al. (2002). Additionally, I calculated a diet overlap index on the percent diet compositions of these organisms (see Garrison 2000 and Link et al. 2002, for further details on methodology). Both of these indices range from 0 to 1, with 0 being no overlap and 1 being total overlap. Values of 0.6 and higher are generally acknowledged to be an important overlap (Pianka 1976, Ross 1986). Values from 0.4 to 0.6 represent a moderate overlap and were also noted. This information helps to explore the hypothesis that differential fishing mortalities on the historically targeted species resulted in a decline in those populations, allowing for a competitive release of other benthodemersal fish species (Fogarty and Murawski 1998).

## **Results**

### *Abundance*

Only four of the 13 species examined showed a stationary time series (Table 1; Figures 2A-15A). Most other species exhibited some degree of trend. Of these, the majority exhibited an increasing trend in more recent years. Many of these species experienced a peak biomass in the late 1970s-1980s, with a secondary trend in more recent years. Atlantic wolffish, thorny skate, and smooth skate exhibited a decline in biomass compared to earlier periods of the time series.

The 13 “ugly fish” on average account for over 25% of the total biomass caught in the

bottom trawl survey (Table 1, Figures 2B-15B). When at their maximum percentages, all these species combined account for over 80% of the total catch. Clearly these species are important in terms of the biomass flux of the northeast U.S. shelf marine ecosystem.

### *Trophic ecology*

Five of the 12 species with adequate stomach data showed a stationary amount of food eaten (Table 1, Figures 2C-15C). Little skate, longhorn sculpin, and ocean pout consumed more food than earlier in the time series. Goosefish and barndoor skate consumed less food than earlier in the time series. Despite these changes, the order of magnitude of biomass consumed by all these species generally ranged from 10-30 g, with goosefish and barndoor skate consumption often exceeding 40 g per capita.

There were eight benthivores and five piscivores, with two echinoderm specialists and two known scavengers. Most of these organisms did not exhibit any notable change in diet across the time series. Of those that did change, for most there was a shift in specific prey type within a broader prey category (e.g., the type of forage fish for piscivores). The exception is that winter skate and ocean pout have both shifted broad prey categories across the time series.

Combining the abundance information with the amount of food eaten, it does not appear that any of these species are food limited. Of the few species that exhibited a declining trend in the amount of food eaten, or during periods of low food consumption, the concurrent or following biomass trend did not show a decline.

### *Distribution*

The majority of these species exhibited a stationary distribution across the past 40 years

(Table 1, Figures 2D-G:15D-G). Only one species, the little skate, exhibited a distribution shift. Three species exhibited a range expansion and two exhibited a range contraction. Of those exhibiting an expansion, barndoor skate, winter skate, and thorny skate, the expansion occurred during a period of increasing abundance.

Most species occurred in the southern New England-Georges Bank region, with northern sea robin clearly a mid-Atlantic species. Smooth skate, thorny skate, and Atlantic wolffish were distributed principally in the Gulf of Maine, and fawn cusk-eel was found principally on the southern flank of Georges Bank. Goosefish was widespread across the different regions.

#### *Competition with Historically Targeted Species*

Spatial overlap was usually low among the “ugly fish” and historically targeted species (Table 2). When any of the non-traditional fish were caught, most of the historically targeted species did not occur in the same place. The one exception was silver hake, which was ubiquitous. Some of the “ugly fish”, particularly the skates, and the flatfishes have some notable high overlap values. Yet the same is much less so among the “ugly fish” and gadids.

Additionally, diet overlap was even lower among the demersal fish community (Table 3). There were only two species interactions between the “ugly fish” and historically targeted species that were greater than 0.6. These results are suggestive that competition for space and food may not a major factor influencing non-traditional fish populations.

#### **Discussion**

Non-traditional species are an important component of the northwest Atlantic ecosystem. Several of the “ugly fish” species studied here are becoming increasingly dominant in terms of



biomass in the system, usually comprising more than 25% of the total finfish biomass caught at any given time. Additionally, many of these species consume consistently more amounts of food than historically targeted species (Link and Almeida 2000). This suggests that a notable amount of energy flows through these species. Conversely, many of the historically targeted species are no longer biomass dominants, have a much smaller fraction of the energy in the ecosystem passing through them than what once did (e.g., Link and Garrison 2002), and they are no longer the dominant finfish species landed (e.g., Garcia and Newton 1997, NEFSC, 1999, DOC 2000). Fisheries have already been initiated for many of the non-traditional species (e.g., goosefish, ocean pout, wolffish, skate wings, etc.) and more are being contemplated (e.g., longhorn sculpins as a source of aphrodisiac). The question remains, have we learned lessons from the traditionally targeted species that we can apply to these non-traditional species, or will Graham’s Law of Fishing be upheld yet again (Graham 1943)? Understanding the importance of these non-traditional species will continue to be increasingly valuable yet is also not a trivial endeavor.

In this study I note how the dynamics of these species has changed (or not), but only explore the reasons why in a cursory manner. The hypothesis of insufficient food leading to a limitation of the benthic-demersal fish community does not appear to be viable. Although the amount of food available for the benthic and demersal communities has changed in composition, the amount of total energy available, at least to these “ugly fish”, has not altered significantly. Link (in press) notes that despite the heavy degree of mobile bottom tending gear in U.S. waters of the northwest Atlantic, on a broad scale much of the benthic macroinvertebrate community has not exhibited notable declining trends. This is contrary to the observation that fishing pressure can cause a notable decline in benthic macrofauna and habitat complexity (Jennings and Polunin 1996; Collie et al. 1997, 2000; Auster and Langton 1999). If the benthos were significantly and widely

impacted, one would expect a decline in populations of benthivorous “ugly fish”, but most of these species have exhibited a stationary or slightly increasing trend in abundance.

Competitive release may not be the main factor causing the increase in many of these “ugly fish” populations. The hypothesis that pleuronectiformes and gadids, presumed to be competitive dominants, have declined thus allowing a release of competitive pressure for non-traditional species (Fogarty and Murawski 1998) remains a difficult question to evaluate. The evidence from this study suggests that if we assume that food (or other resources) are even limiting, the spatial and dietary overlap necessary for the potential of strong competitive interactions is weak. Certainly the question merits more examination, but other than perhaps the skates and flatfish, it appears unlikely that the prominence of “ugly fish” is solely due to a release in competitive pressure. Rather, like Jennings and Kaiser’s (1998) conclusion, the most likely explanation for many of the biomass trends in this and similar demersal fish communities is differential fishing mortality.

These “ugly fish” occupy a wide range of habitats and fill a wide range of functional roles in the ecosystem. Goosefish are one of the more prominent demersal piscivores in the ecosystem, and sea raven and barndoor skate also eat a large proportion of fish. Sculpins in particular are known to be an important scavenger in the ecosystem (Link and Almeida 2002). Much of the benthic production ultimately results in the production of these non-traditional fish. As the abundance of these species continues to increase, their importance in the energy flow of the ecosystem will continue to outpace that of historically targeted species.

Finally, non-traditional species are likely to be important in other areas of the north Atlantic. There are obvious counterparts to the organisms in this study for other ecosystems. Most of these species are relatively under-studied, yet should not remain so given the increasing

importance of these species in terms of biomass, energy flux, and economics of current and future fisheries.

### **Acknowledgments**

I thank members of the Food Web Dynamics Program, past and present, for their dedicated efforts at maintaining one of the premier food habits databases in the world. I also thank all who have participated on and maintained the NEFSC Bottom Trawl Survey and associated databases- the full extent of 40+ years of effort in many respects are just now beginning to be fully explored and appreciated.

**Literature Cited**

- Azarovitz, T. R. 1981. A brief historical review of the Woods Hole Laboratory trawl survey time series. Pages 62-67 in W.G. Doubleday and Rivard, D. (eds.). Bottom trawl surveys. Canadian Special Publication of Fisheries and Aquatic Sciences 58.
- Auster, P.J., and Langton, R.W. 1999. The effects of fishing on fish habitat. AFS Symposium 22:150-187.
- Benaka, L., ed. 1999. Fish habitat: essential fish habitat and rehabilitation. AFS Symposium 22.
- Collie, J.S., Escanero, G.A. and Valentine, P.C. 1997. Effects of bottom fishing on the benthic megafauna of Georges Bank. Mar. Ecol. Prog. Ser. Vol. 155:159-172.
- Collie, J.S., Escanero, G.A. and Valentine, P.C.. 2000. Photographic evaluation of the impacts of bottom fishing on benthic epifauna. ICES J. Mar. Sci. Vol. 57:987-1001.
- DOC (Department of Commerce). 2000. Fisheries of the United States, 1999. USDOC, NOAA, NMFS, OST, FSED. Silver Spring, MD.
- Flesher, D.D. 1980. Guide to some trawl-caught marine fishes from Maine to Cape Hatteras, North Carolina. NOAA Tech. Rep. NMFS Circ. 431.
- Fogarty, M.J. and Murawski, S.A. 1998. Large-scale disturbance and the structure of marine systems: fishery impacts on Georges Bank. Ecol. Appl. S8(1):S6-S22.
- Garcia, S. and Newton, C. 1997. Current situation, trends, and prospects in world capture fisheries. Pages 3-27 in Pikitch, E.K., Hupper, D.D., and Sissenwine, M.P. (eds.). Global trends: Fisheries Management. AFS Symp. 20.
- Garrison, L.P. 2000. Spatial and dietary overlap in the Georges Bank groundfish community. Can. J. Fish. Aquat. Sci. 57:1679-1691.
- Garrison, L.P. and Link, J.S. 2000a. Fishing effects on spatial distribution and trophic guild

structure of the fish community in the Georges Bank region. ICES J. Mar. Sci. 57:723-730.

Garrison, L.P. and Link, J. 2000b. Dietary guild structure of the fish community in the Northeast United States Continental Shelf Ecosystem. *Mar. Ecol. Prog. Ser.* 202:231-240.

Graham, M. 1943. The fish gate. Faber, London.

Jennings, S. and Polunin, N.V.C. 1996. Effects of fishing effort and catch rate upon the structure and biomass of Fijian reef fisheries. J. Fish Biol. 46:28-46.

Jennings, S. and Kaiser, M.J. 1998. The effects of fishing on marine ecosystems. *Adv. Mar. Biol.* 34:201-352.

Kaiser, M.J. and deGroot, S.J. 2000. Effects of fishing on non-target species and habitats. Blackwell Science, Oxford.

Larkin, P.A. 1996. Concepts and issues in marine ecosystem management. *Rev. Fish Biol. Fish.* 6:139-164.

Link, J.S. 2002a. Ecological Considerations in Fisheries Management: When Does It Matter?  
Fisheries 27(4):10-17.

Link, J.S. 2002b. What Does Ecosystem-Based Fisheries Management Mean? *Fisheries* 27(4):18-21.

Link, J.S., Garrison, L.P. and Almeida, F.P. 2002. Interactions between elasmobranchs and groundfish species (Gadidae and Pleuronectidae) on the Northeast U.S. Shelf. I: Evaluating Predation. N. Am. J. Fish. Man. 22:550-562.

Link, J.S. and Almeida, F.P. 2002. Opportunistic Feeding of Longhorn Sculpin: Are Scallop Fishing Discards an Important Food Subsidy on Georges Bank? Fish. Bull. 100:381-385.

Link, J. and Almeida, F. 2000. An overview and history of the food web dynamics program of the

Northeast Fisheries Science Center, Woods Hole, Massachusetts. NOAA Technical Memorandum NMFS-NE-159, Woods Hole, Massachusetts.

Link, J.S. and Garrison, L.P. 2002. Changes in piscivory associated with fishing induced changes to the finfish community on Georges Bank. *Fish. Res.* 55:71-86.

Link, J.S. (In press). Using fish as samplers of the benthos: integrating long-term and broad scales. *Mar. Ecol. Prog. Ser.*

NEFC (Northeast Fisheries Center). 1988. An evaluation of the bottom trawl survey program of the Northeast Fisheries Center. NOAA Technical Memorandum NMFS-F/NEC-52, Woods Hole, Massachusetts.

NEFSC (Northeast Fisheries Science Center). 1999. Status of of fishery resources off the northeastern United States for 1998. NOAA Tech. Memo. NMFS-NE-115, 149 pp.

Pianka, E.R. 1976. Competition and niche theory. Pages 114-141 in May, R.M. (ed.). *Theoretical ecology: principals and applications*. WD. Saunders, Philadelphia, PA.

Ross, S.T. 1986. Resource partitioning in fish assemblages: a review of field studies. *Copeia* 1986:352-368.

Table 1. Summary of information for the 13 non-traditional species in this study.

Common Name	Specific Name	Abundance Stationary	Trend	Peak Years	Avg % Catch	Max % Catch	Stomach Contents		Peak Years	Notes	Main Prey	Notable Changes in Major Prey	Distribution "Epicenter"	Stationary	Directionality
Atlantic Torpedo	<i>Torpedo nobiliana</i>	Yes	No	N/A	1.3%	4.8%	Yes	No	N/A	Limited Sample Size	Scup, other Sparidae, misc. Fish	No	GB (Rare)	Yes	N/A
Barndoor Skate	<i>Dipturus laevis</i>	No	Yes (2)	early 1960s, early 2000s mid 1980s	0.8%	4.4%	No	Yes	1991-95	Limited Sample Size	Cancer crabs, Pandalid shrimp, hermit crabs, other crabs, small skates, hakes, herrings	Yes, more fish in recent years	GB	No	Range contract then expand
Winter Skate	<i>Luecoraja ocellata</i>	No	Yes		6.6%	18.8%	Yes	No	N/A		Sandlance, bivalves, squid, polychaetes, hakes, misc. fish, gammarid amphipods, Cancer crabs, herring, eels, cusk-eels	Generally no, more herring, eels and gammarids and less sandlance currently than in earlier years	GB	No	Range expanded to the W & S
Little Skate	<i>Leucoraja erinacea</i>	No	Yes (2)	late 1970s, late 1990s-2000s	6.5%	15.1%	No	Yes	late 1980s-2000s		Gammarid amphipods, polychaetes, Cancer crabs, hermit crabs, other crabs, Crangon shrimp, Isopods, bivalves, Caprellids, other crustaceans	No	GB, SNE	No	Range Shift to the W & S
Smooth Skate	<i>Malacoraja senta</i>	No	Yes	early 1970s	0.5%	3.3%	Yes	No	N/A		Euphasiids, Pandalid shrimp, Cancer crabs, Crangon shrimp, isopods, other crustaceans, polychaetes, hakes, misc. fish	Yes, more fish in recent years	GoM	Yes	N/A
Thorny Skate	<i>Amblyraja radiata</i>	No	Yes	1960s	2.4%	7.9%	No	Yes	1980s-late 1990s		Sandlance, squid, herring, misc. fish, polychaetes, Euphasiids, misc. shrimp, hakes, octopods, sea mouse, sculpins, wrymouth	No (but specific fish species alter in diet over time)	GoM, ScS	Yes	N/A
Longhorn Sculpin	<i>Myoxocephalus octodecemspinosus</i>	Yes	No	N/A	1.4%	4.6%	No	Yes (2)	1981-1985, 2000s		Cancer crabs, Gammarid amphipods, Pandalid shrimp, Crangon shrimp, hermit crabs, other crustaceans, Sandlance, sea mouse, misc. fish, bivalves	No	GB, ringing GoM	No	Range expanded to the N
Sea Raven	<i>Hemitripterus americanus</i>	No	Yes	2000s	0.5%	1.5%	Yes	No	N/A		Zoarcids (wolffish, ocean pout), squid, sculpins, cod, herring, hakes eels, Cancer crabs, cusk eels, cusk, other fish	No	Ringling GoM, GB	Yes	N/A
Northern Sea Robin	<i>Prionotus carolinus</i>	Yes	No	N/A	1.2%	5.4%	Yes	No	N/A	Limited Sample Size	Polychaetes, misc. crabs, amphipods	No	MAB, SNE	Yes	N/A
Atlantic Wolffish	<i>Anarhichas lupus</i>	No	Yes	late 1960s, early 1970s	0.8%	2.6%	No	Yes	1981-1995		Scallops, brittle stars, sand dollars, other bivalves, other echinoderms, misc. crabs, misc. fish	No (shift from brittle stars to other echinoderms in more recent years)	ScS, GSC	Yes	N/A
Ocean Pout	<i>Macrozoarces americanus</i>	Yes	No	N/A	1.3%	6.0%	No	No	1981-1985, 2001-2003		Sand dollars, brittle stars, scallops, starfish other bivalves, other echinoderms, amphipods, snails, polychaetes, Cancer crabs, other crabs	Yes, less echinoderms and more bivalves and crustaceans in recent years; more starfish than sand dollars in late 1990s-2000s	SNE, GB	No	Range contracted
Fawn Cusk-eel	<i>Leophidium profundorum</i>	No	Yes	1980s	0.2%	1.7%	ND	ND	ND	Limited Sample Size	Polychaetes, amphipods, Crangon shrimp, misc. shrimp	ND	S Flank of GB, SNE	Yes	N/A
Goosefish	<i>Lophius americanus</i>	No	Yes (2)	1970s	1.9%	7.0%	No	Yes	1980s		Squid, herring, sculpin, hakes, goosefish, skates, cod, mackerel, various flatfish, scup, misc. fish	No (but specific fish species alter in diet over	Widespread	Yes	N/A

time)

Table 2. Spatial overlap indices among the non-traditional and historically targeted demersal fish species. When species is found in a row, what percent of those tows contain the species in each column. This is a non-symmetric matrix. Significant values are bold (green), moderate values are italicized (yellow).





Table 3. Dietary overlap indices among the non-traditional and historically targeted demersal fish species. This is a symmetric matrix.

Significant values are bold (green), moderate values are italicized (yellow).



**Figure Captions**

Figure 1. Line drawings of non-traditional benthic-demersal fish species (adapted from Flescher 1980). Figures not to scale. A. Atlantic torpedo. B. Barndoor skate (dorsal and ventral views). C. Winter skate. D. Little skate. E. Smooth skate. F. Thorny skate. G. Longhorn sculpin. H. Sea raven. I. Northern sea robin. J. Atlantic wolffish. K. Ocean pout. L. Fawn cusk-eel. M. Goosefish.

Figure 2. A. Time series of biomass for Atlantic torpedo. Dark solid line is the 5-year moving average, the dotted line is the long-term average biomass. B. Percent of total bottom trawl survey catch comprised by the Atlantic torpedo. Solid line is the 5-year moving average. C. Mean stomach contents (0.1 g) of the Atlantic torpedo. D. Average biomass of Atlantic torpedo in 10 minute squares over the five year time block of 1966-1970. Units are in kg per tow, and are color coded using a geometric split of the data range. E. Same as D but for 1976-1980. F. Same as D but for 1986-1990. G. Same as D but for 1996-2000.

Figure 3. Same as Figure 2 but for barndoor skate.

Figure 4. Same as Figure 2 but for winter skate.

Figure 5. Same as Figure 2 but for little skate.

Figure 6. Same as Figure 2 but for smooth skate.

Figure 7. Same as Figure 2 but for thorny skate.

Figure 8. Same as Figure 2 but for longhorn sculpin.

Figure 9. Same as Figure 2 but for sea raven.

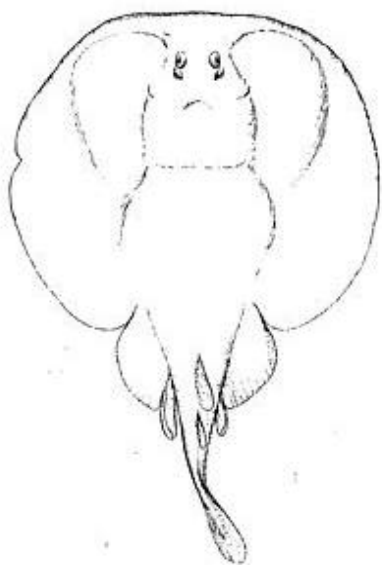
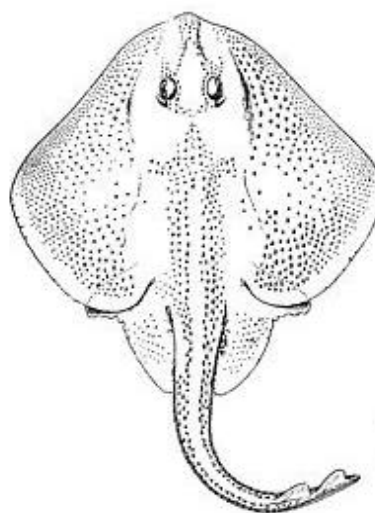
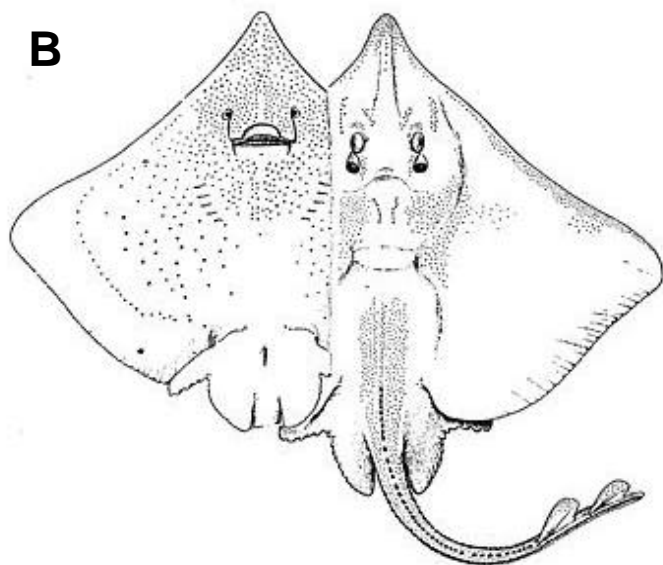
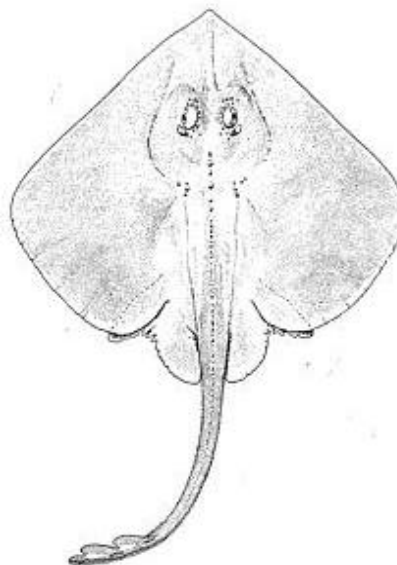
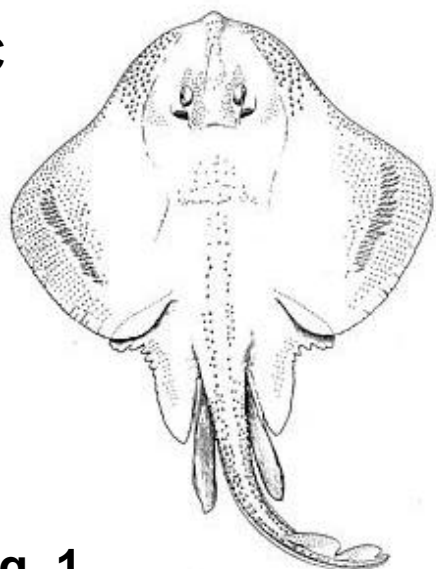
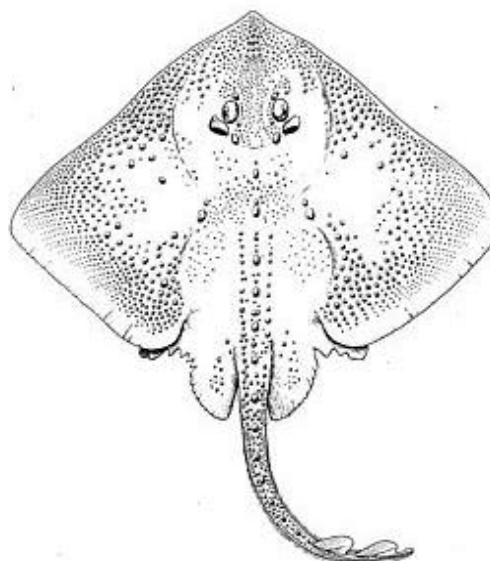
Figure 10. Same as Figure 2 but for northern sea robin.

Figure 11. Same as Figure 2 but for Atlantic wolffish.

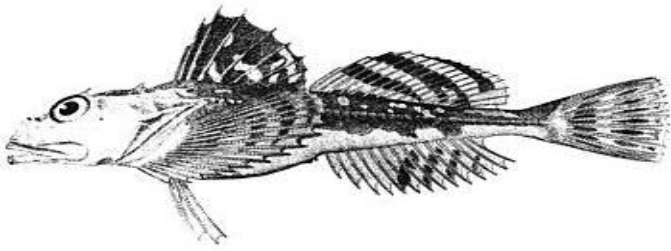
Figure 12. Same as Figure 2 but for ocean pout.

Figure 13. Same as Figure 2 but for fawn cusk-eel.

Figure 14. Same as Figure 2 but for goosefish.

**A****D****B****E****C****F****Fig. 1**

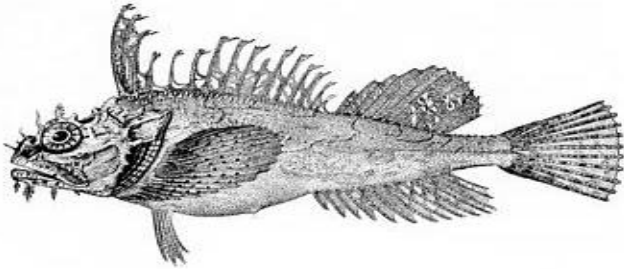
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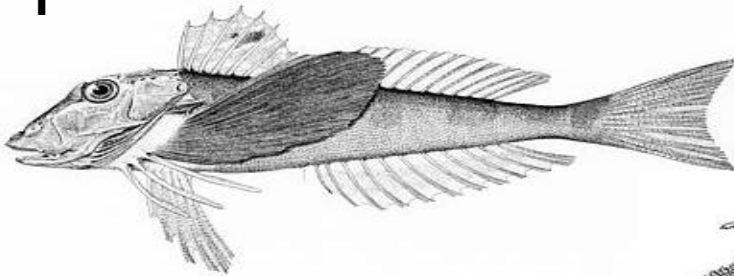
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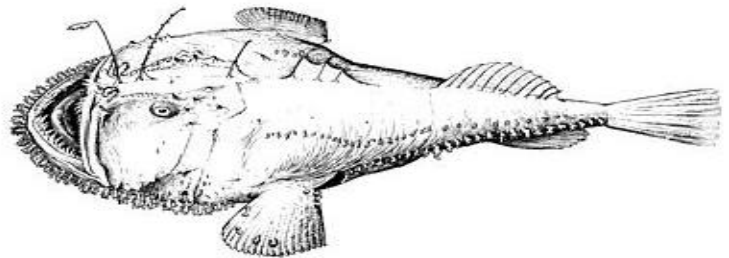
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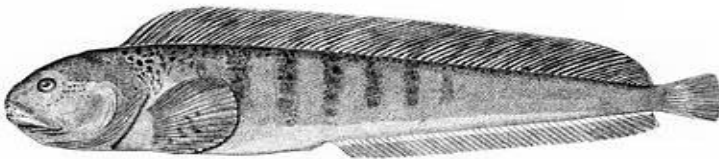
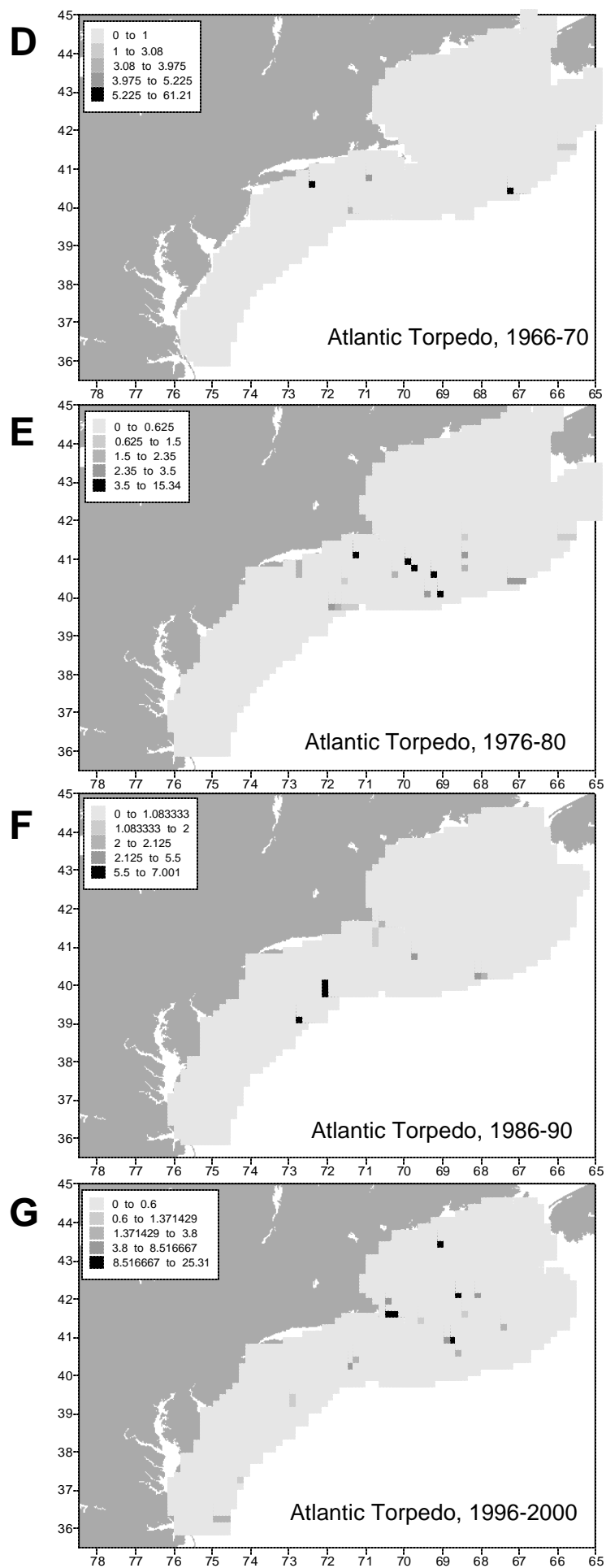
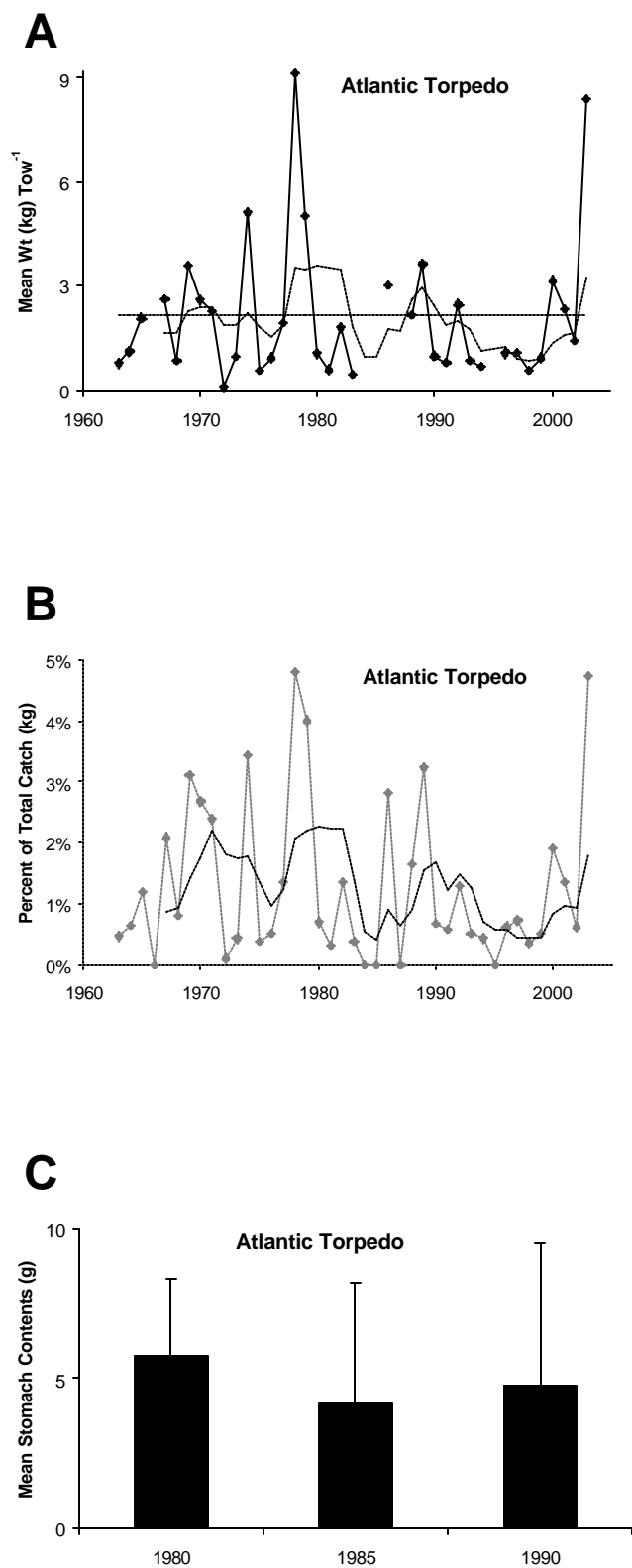
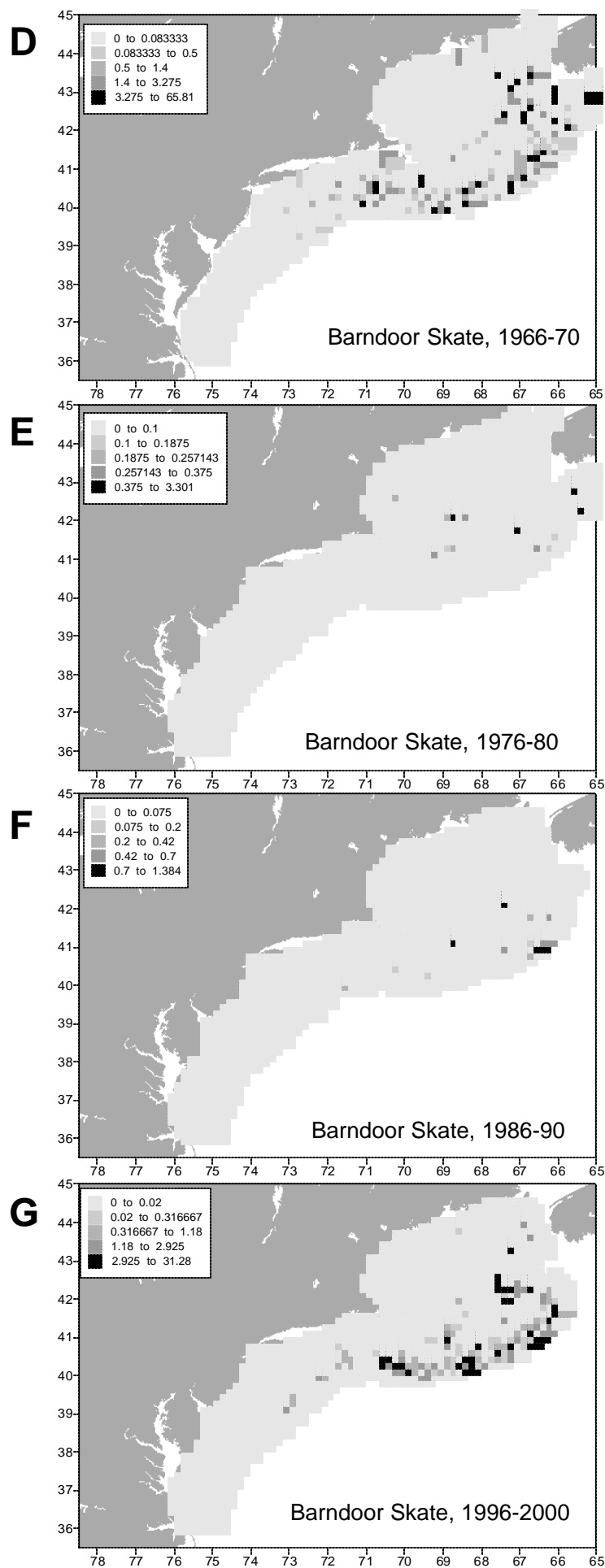
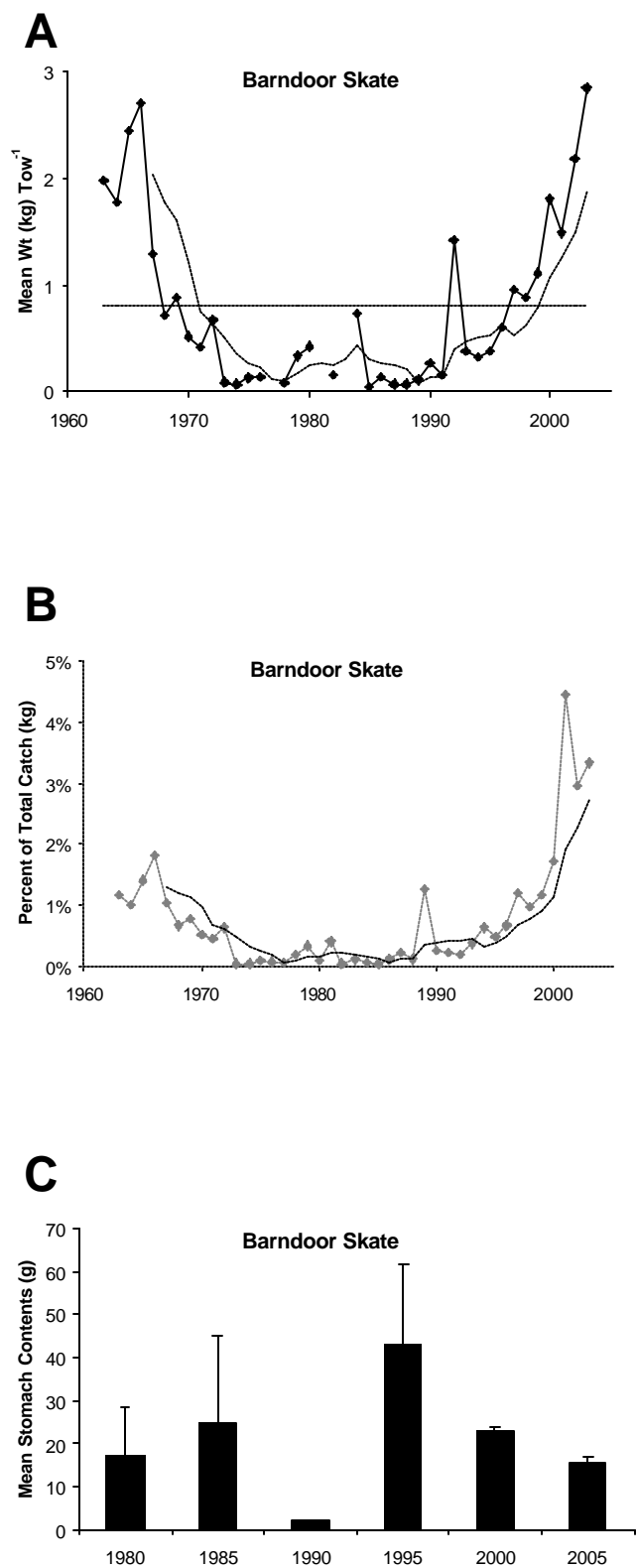


Fig. 1

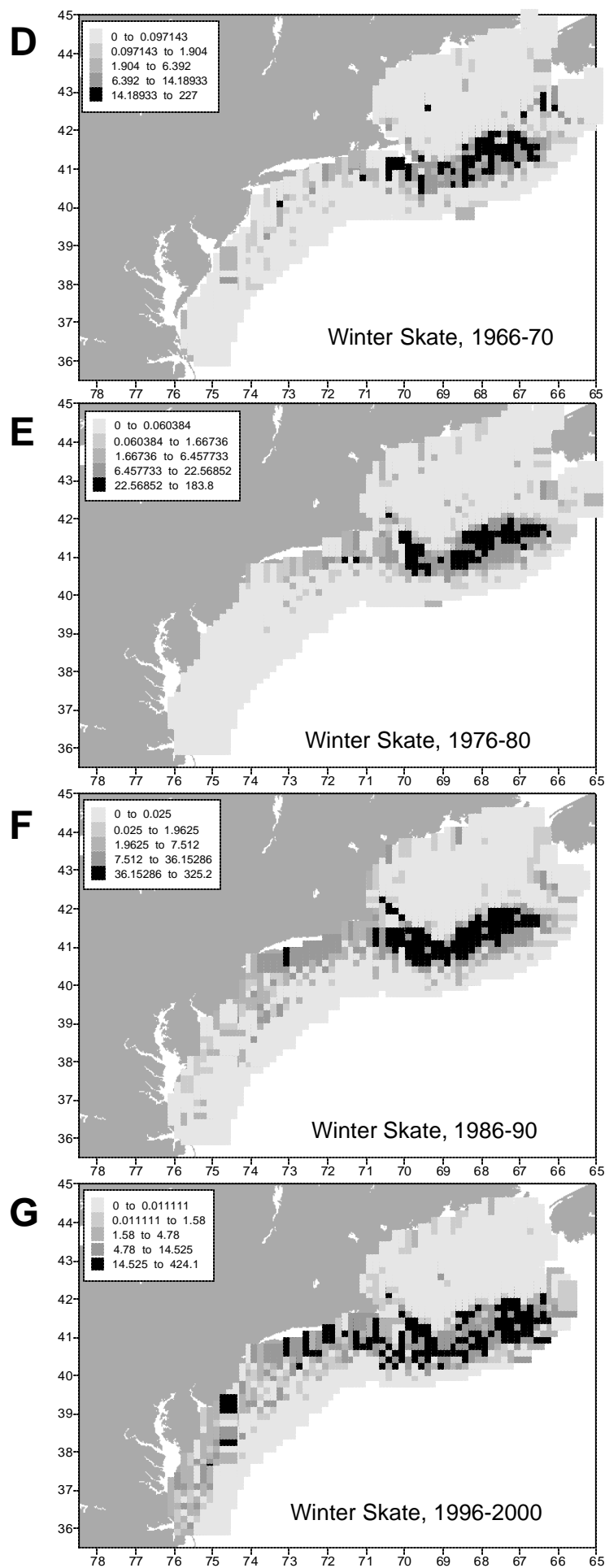
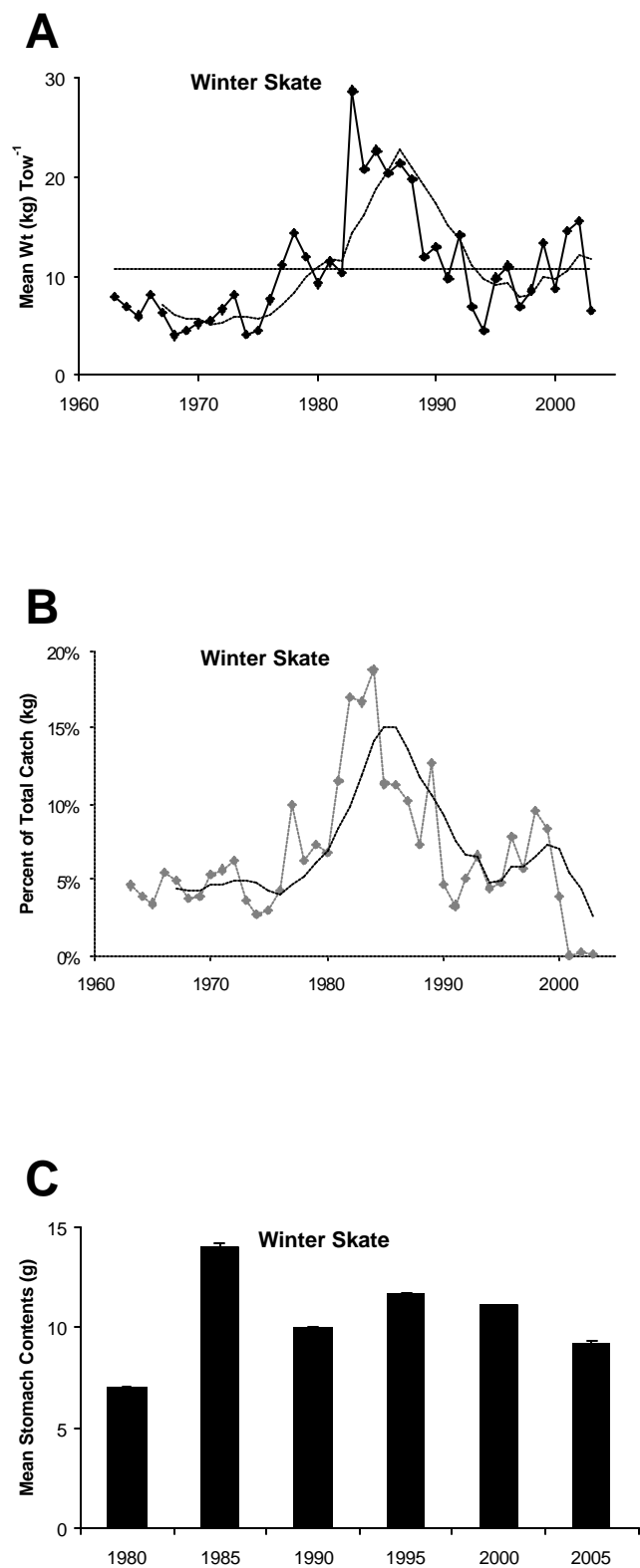


**Fig. 2**

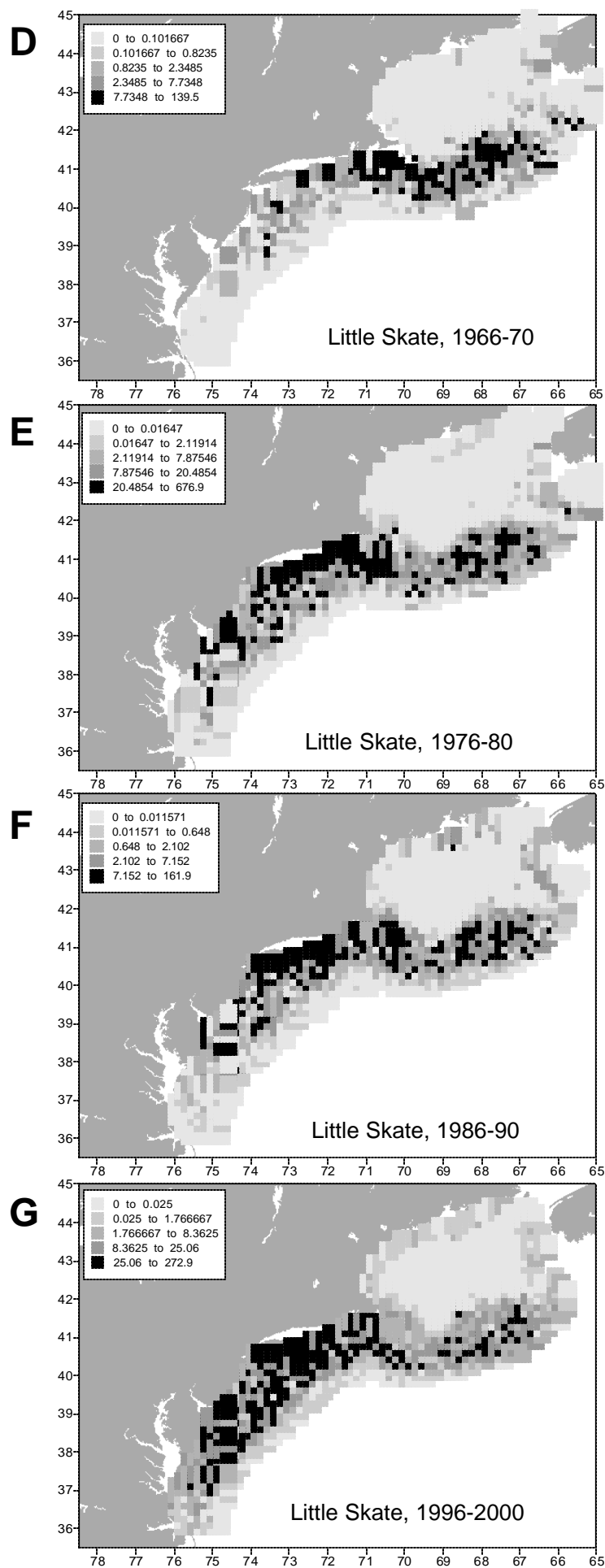
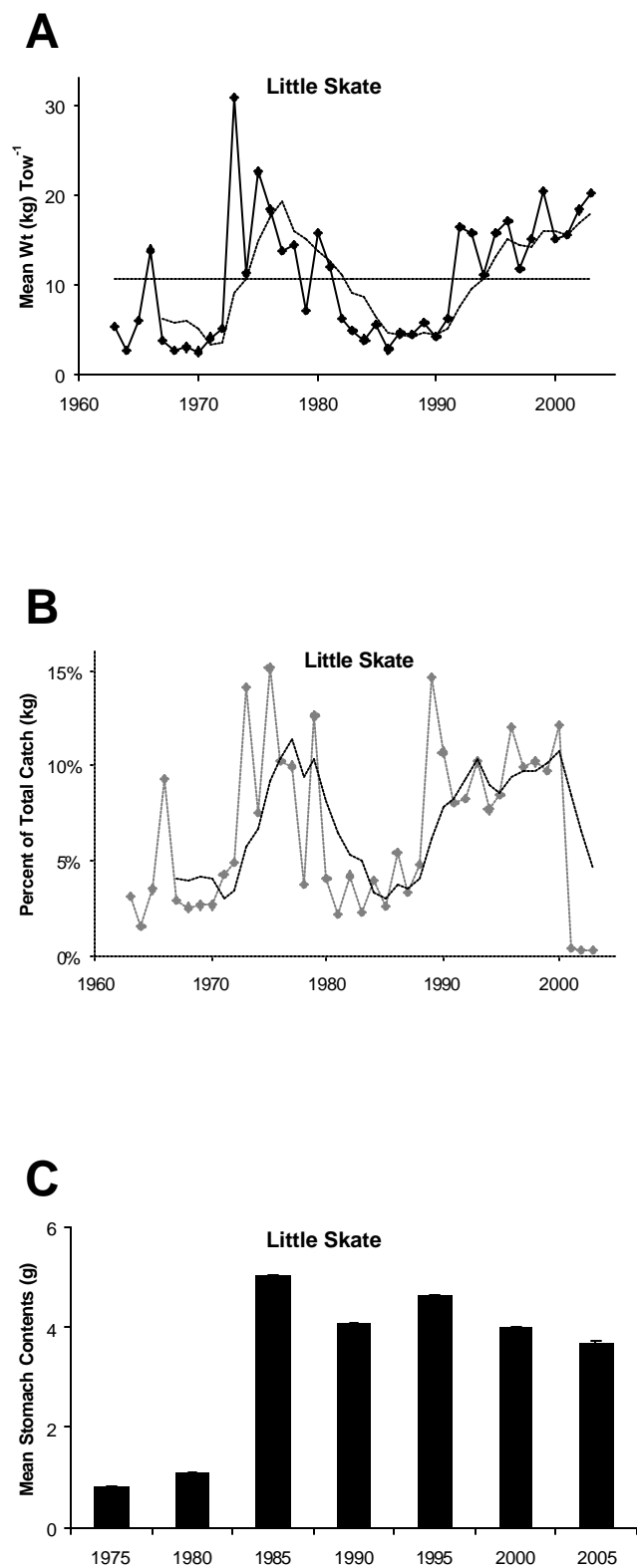


**Fig. 3**

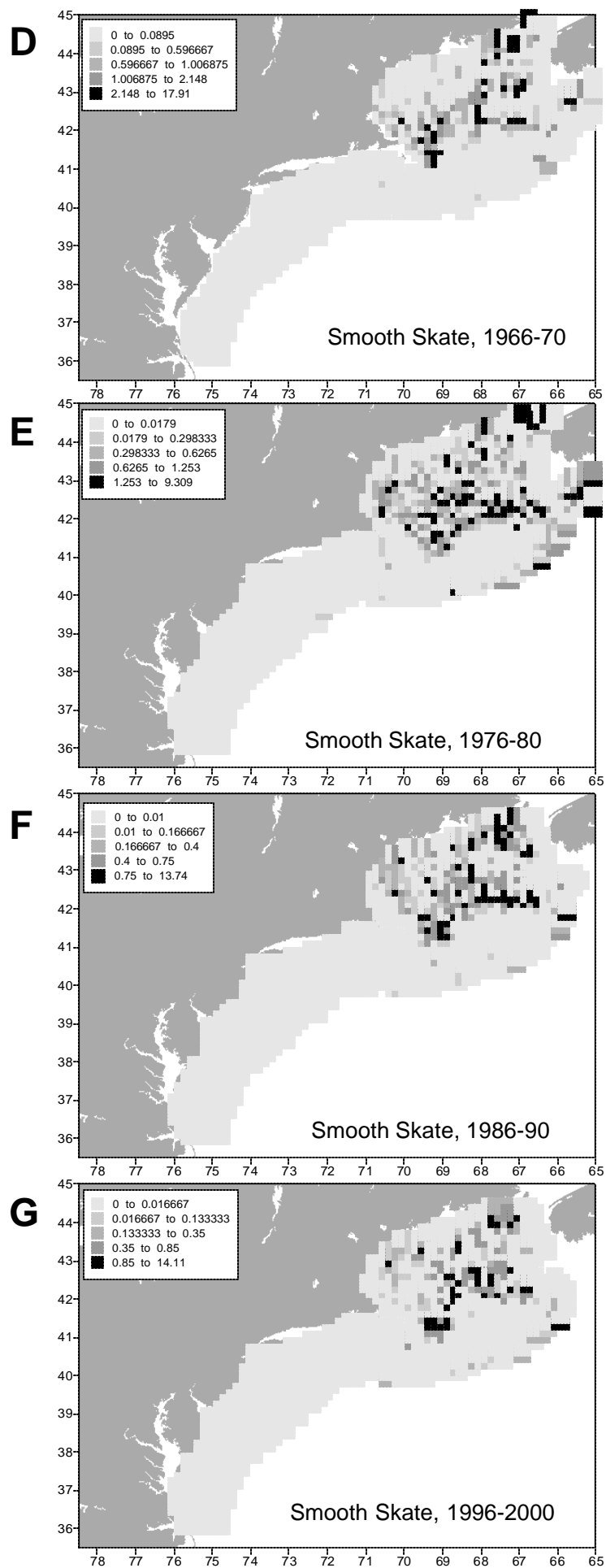
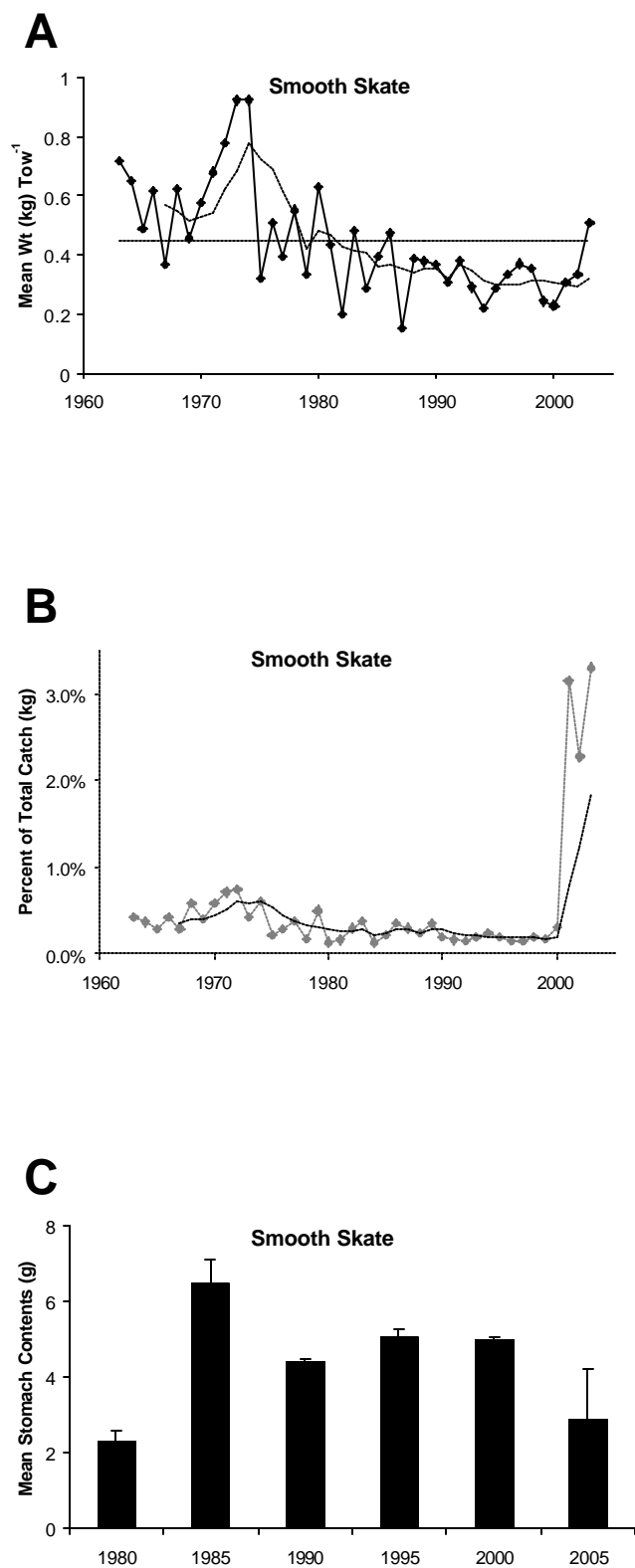




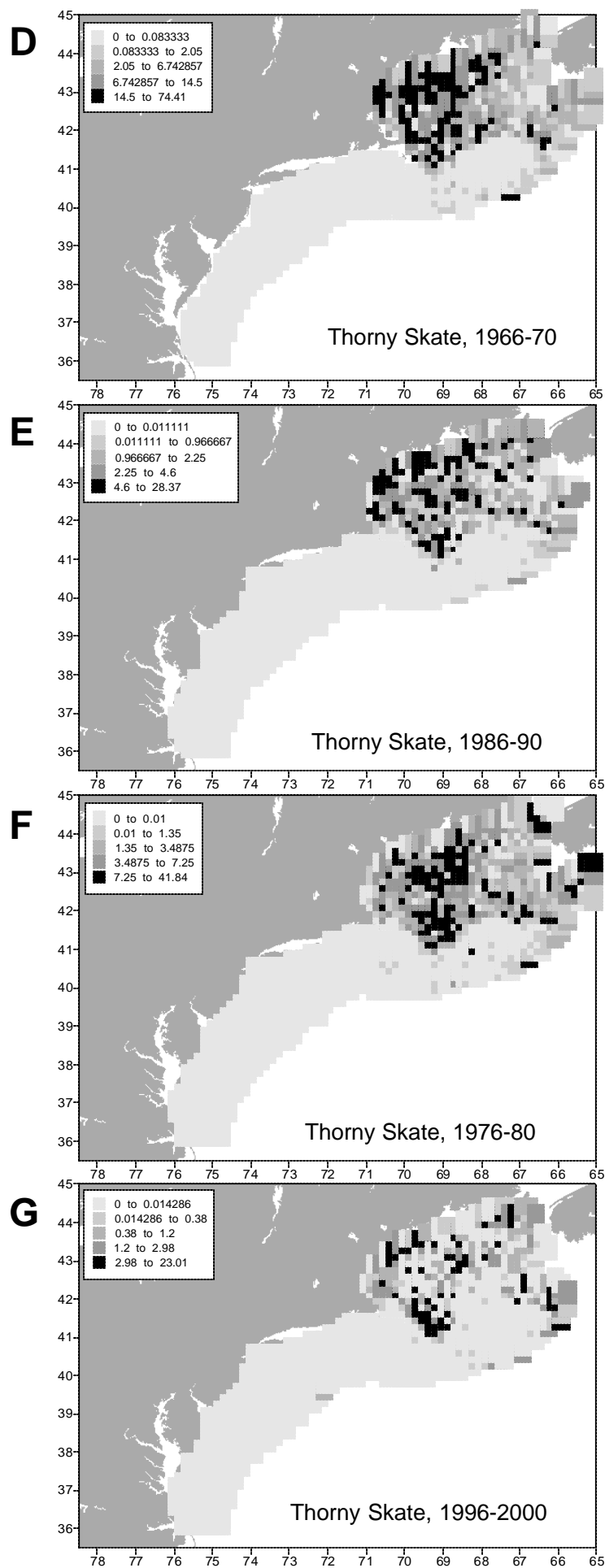
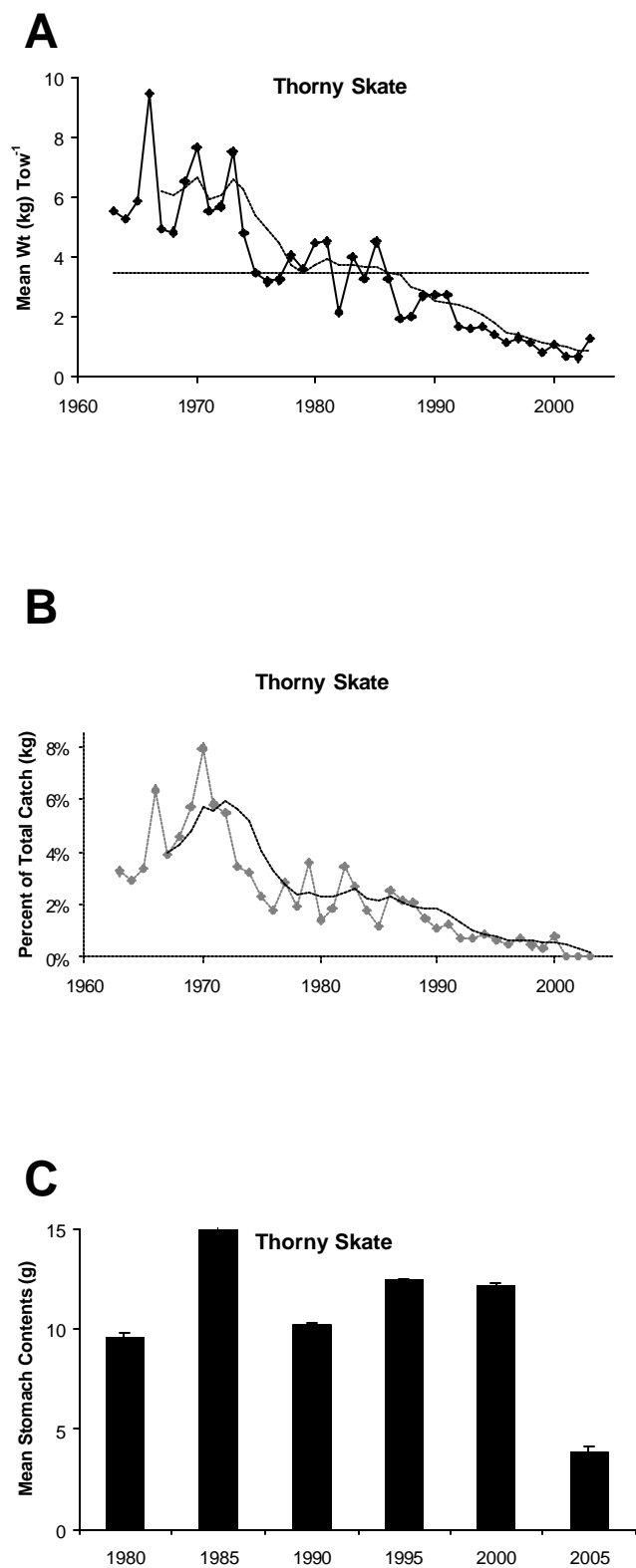
**Fig. 4**



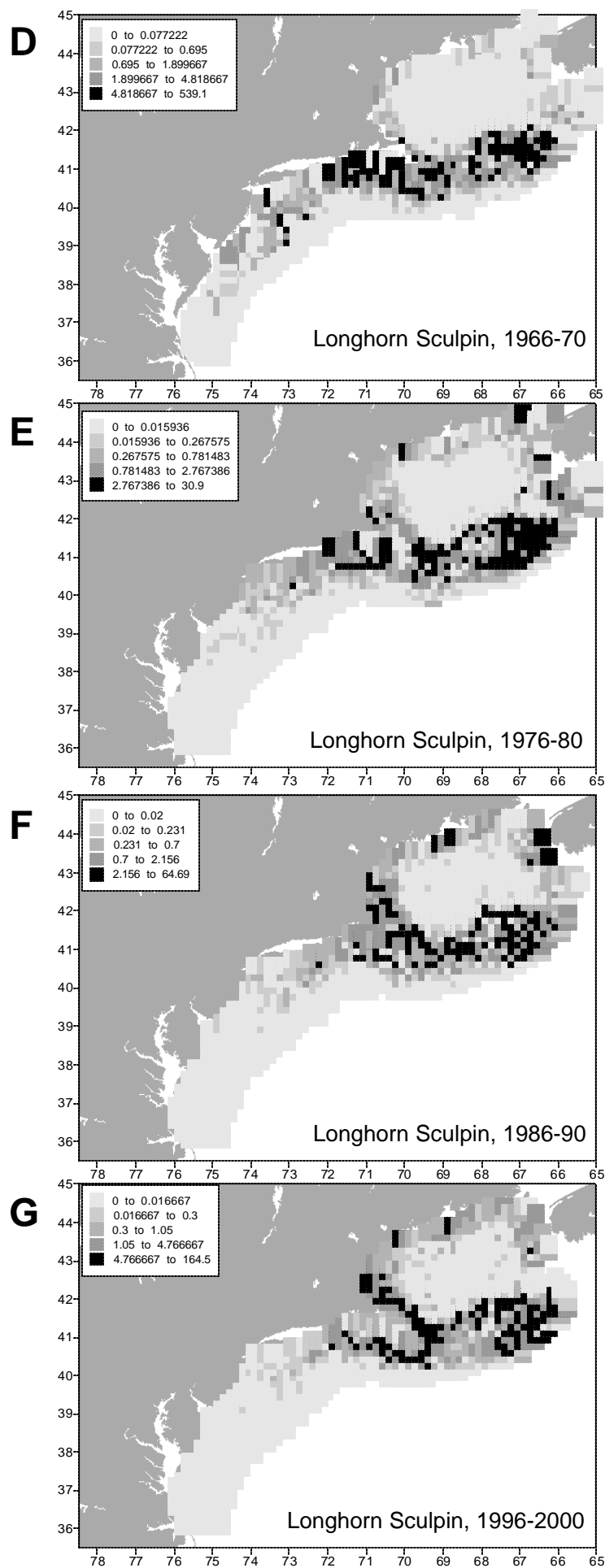
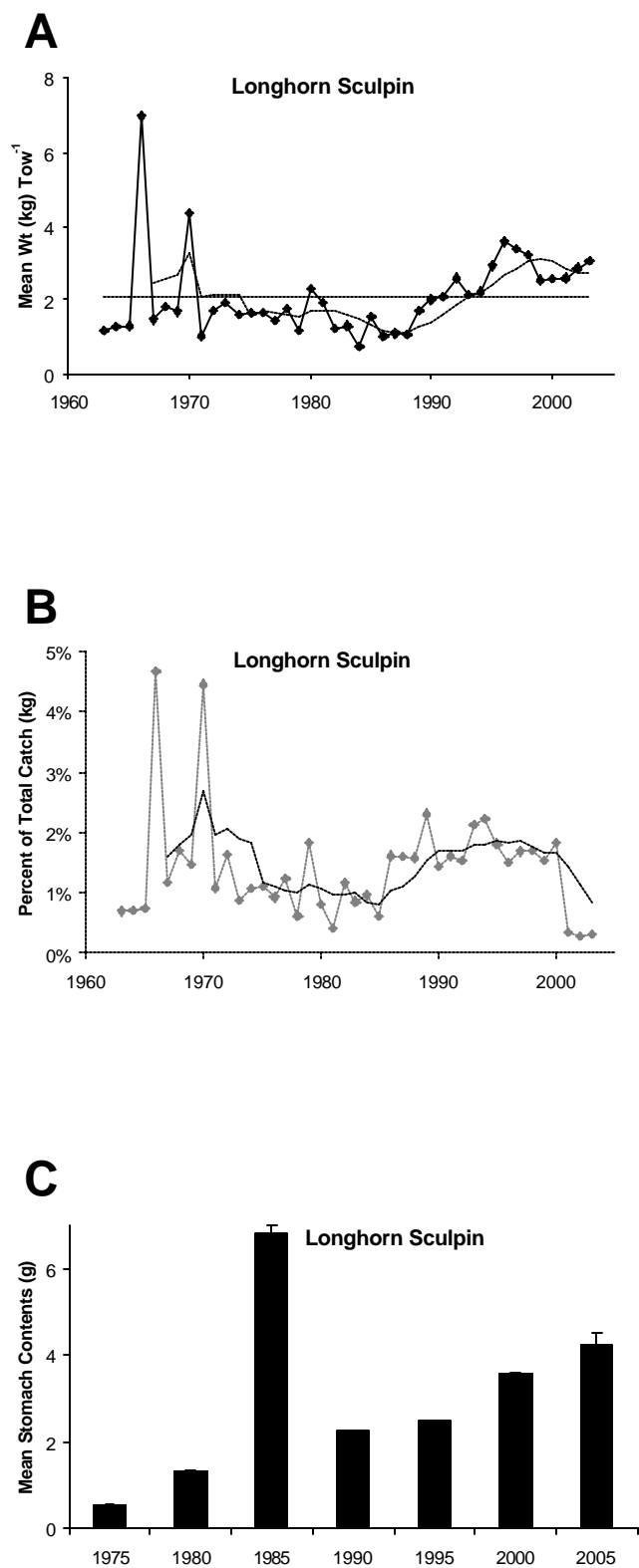
**Fig. 5**



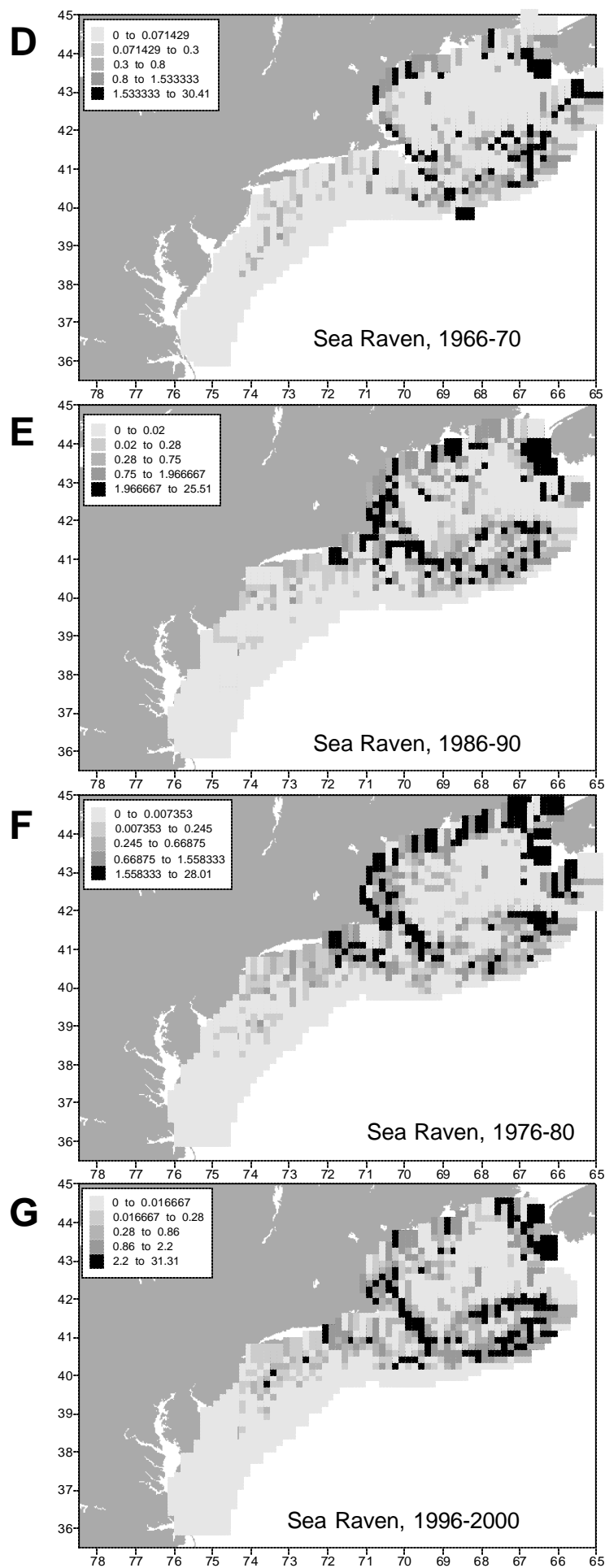
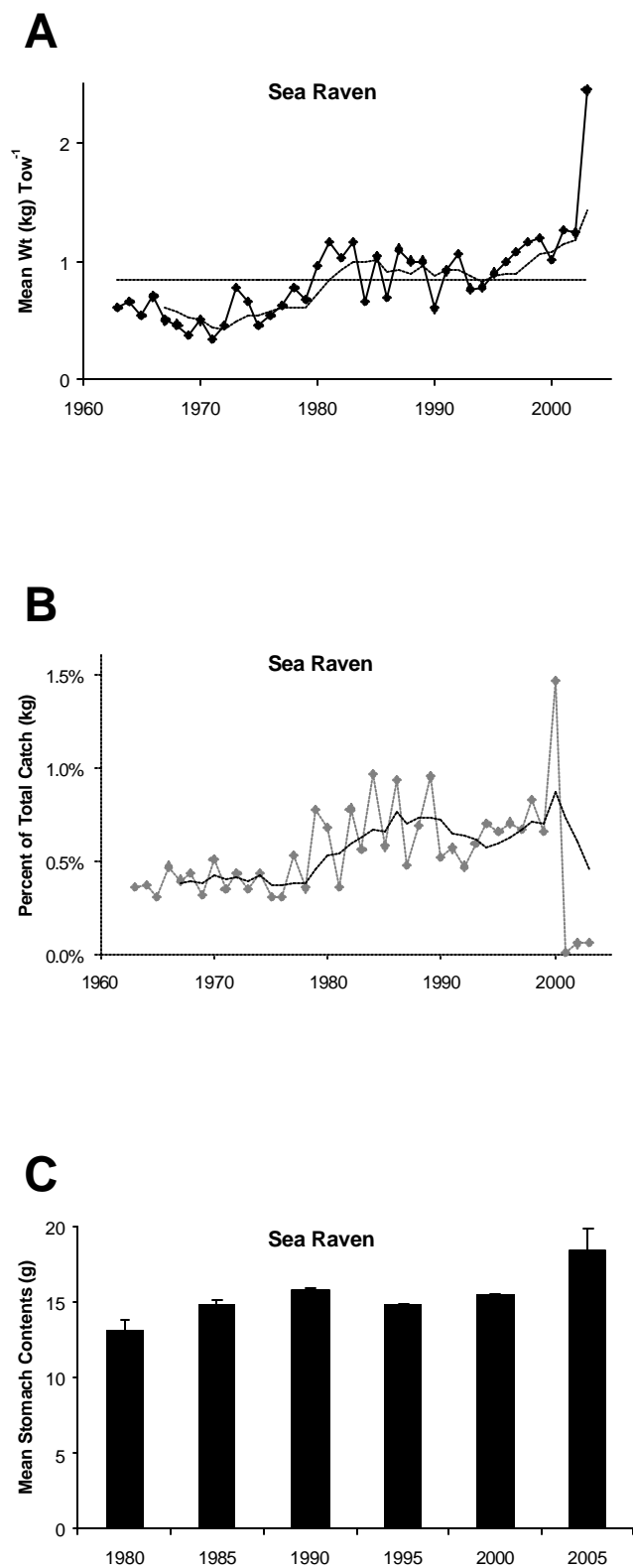
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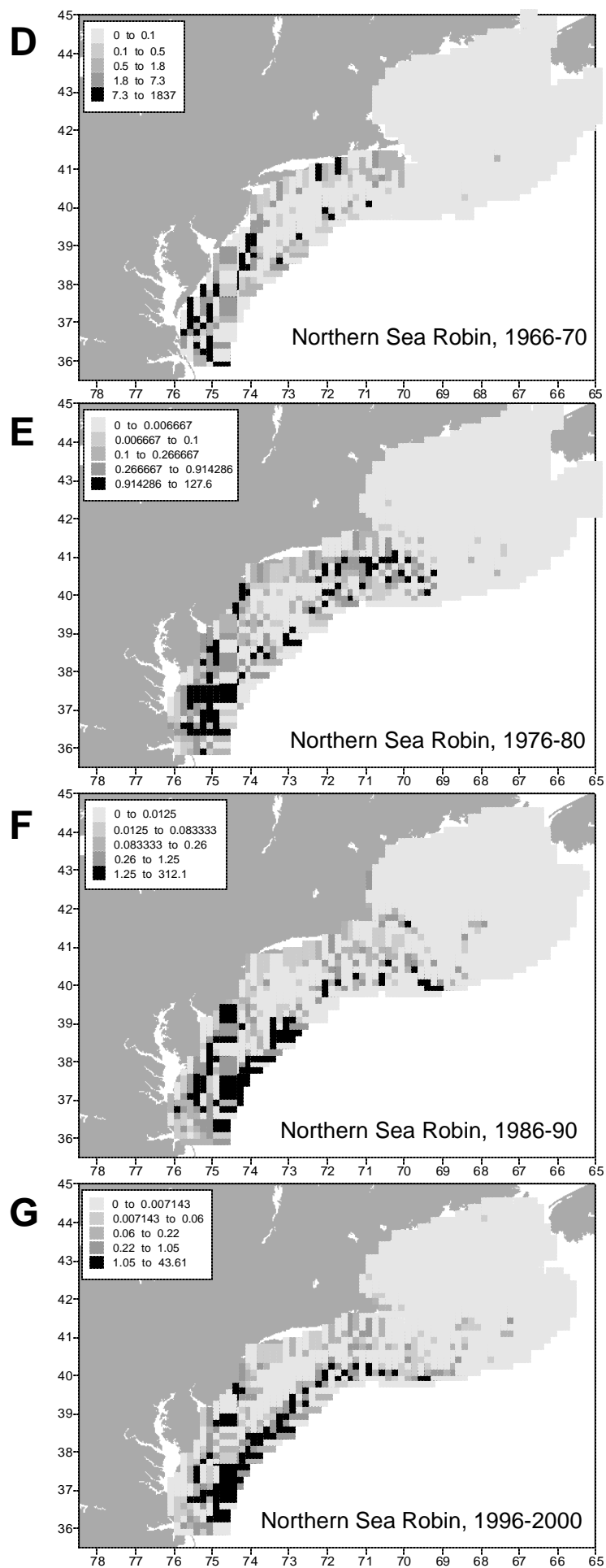
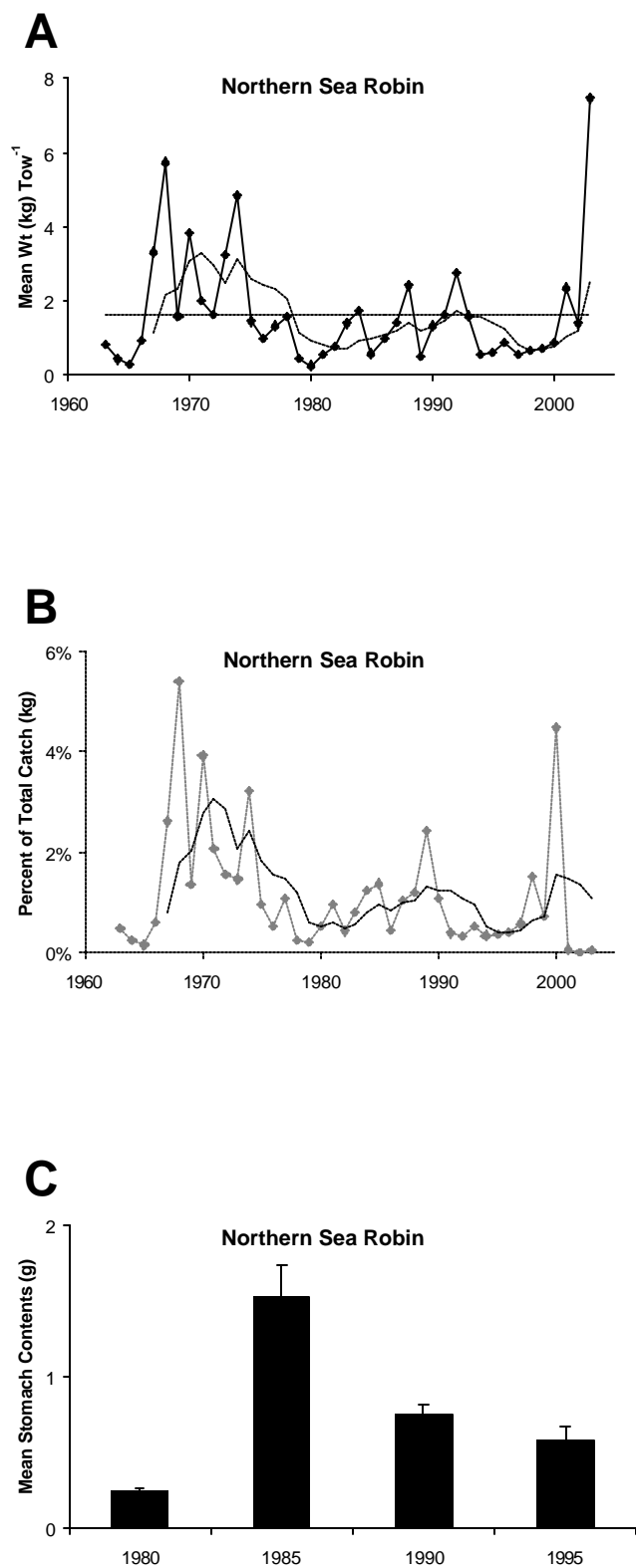
**Fig. 7**



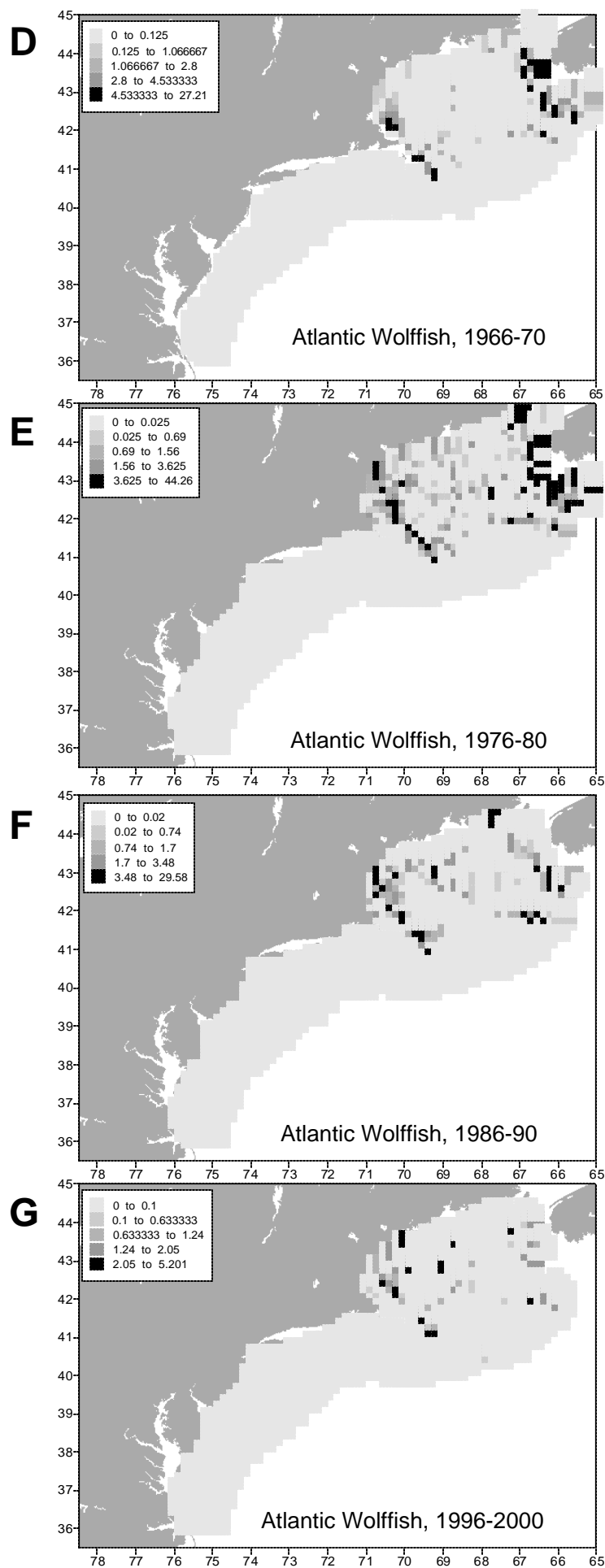
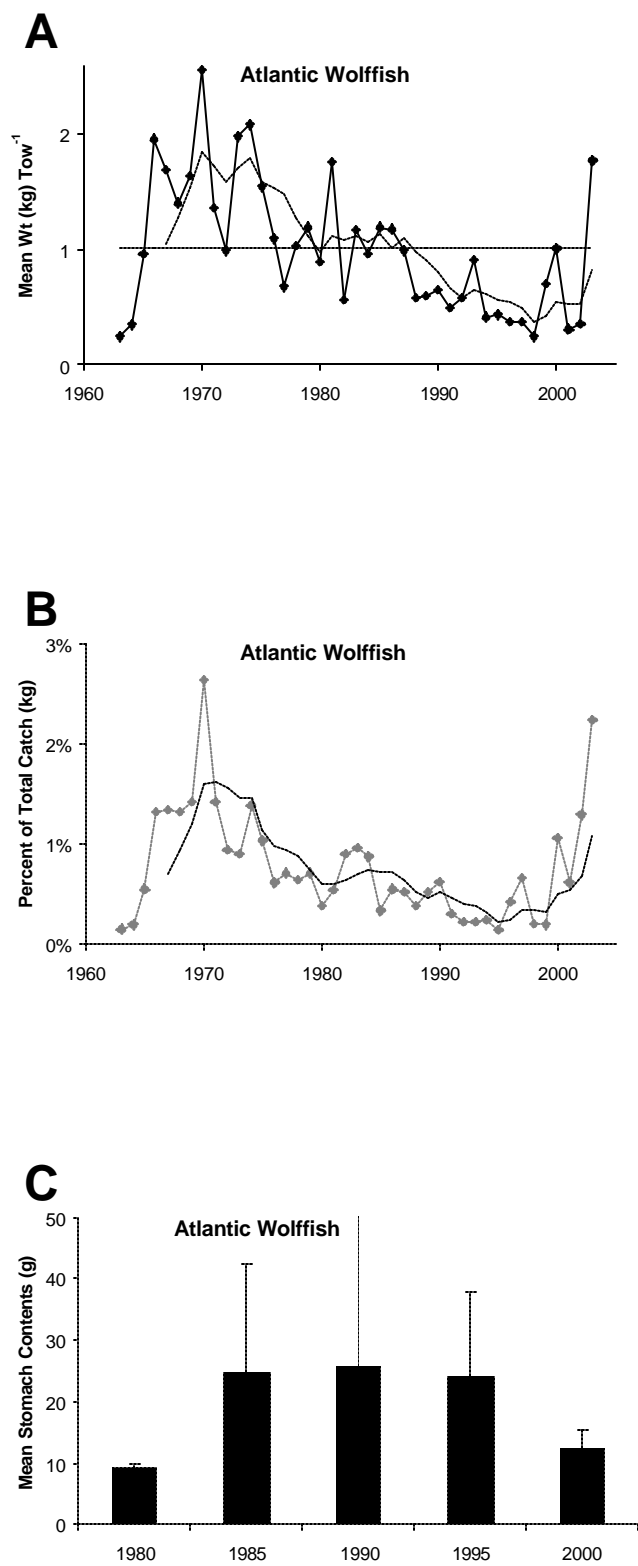
**Fig. 8**



**Fig. 9**

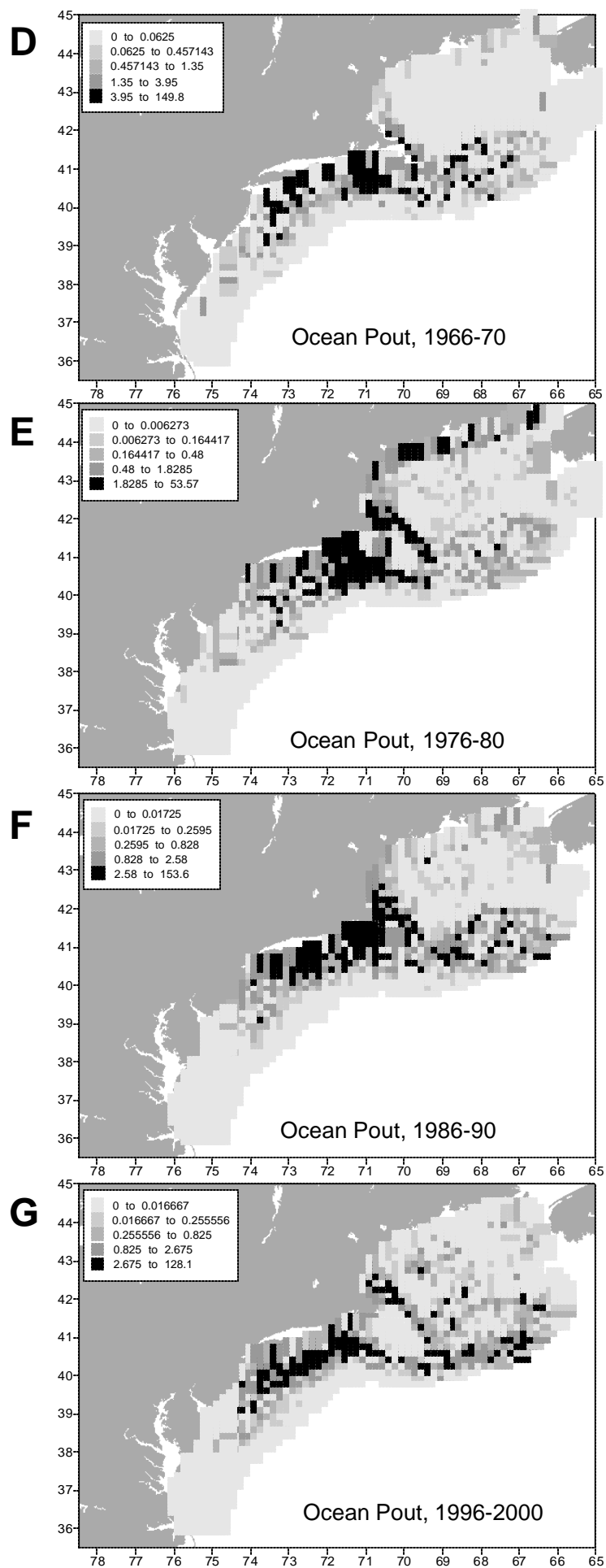
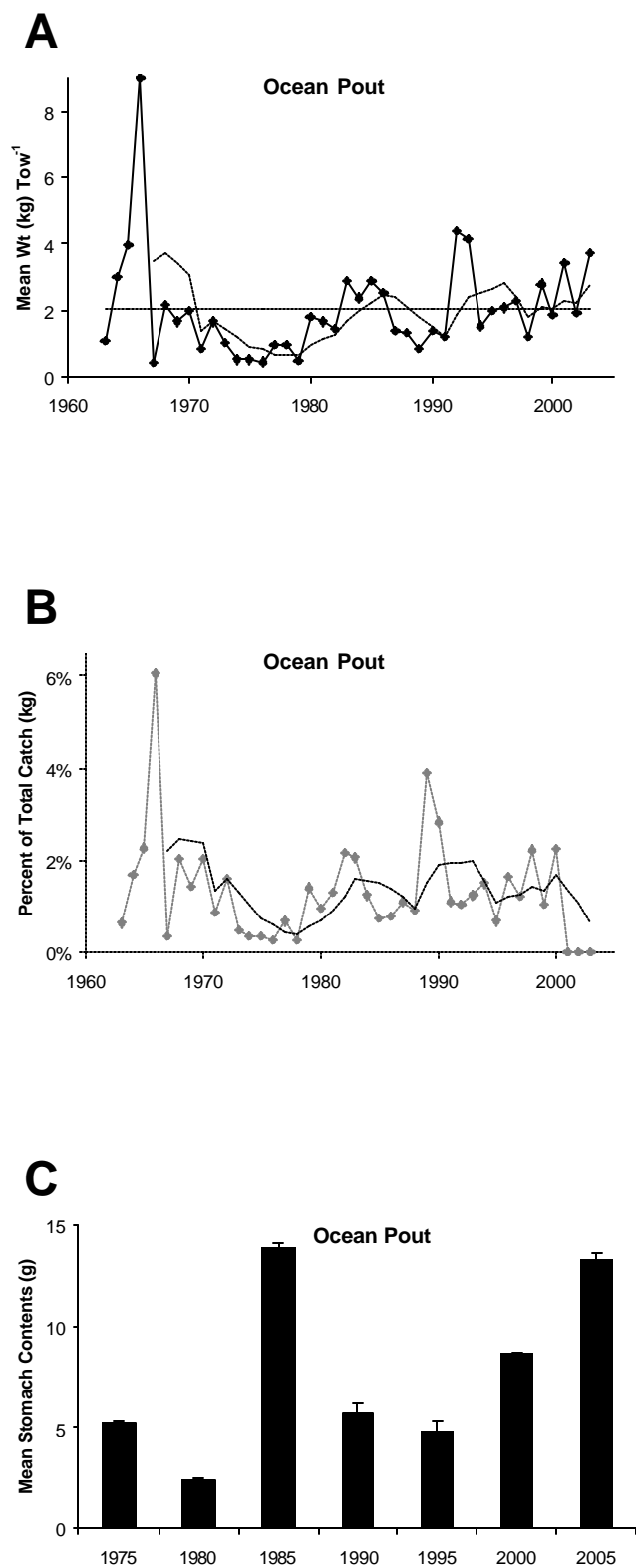


**Fig. 10**

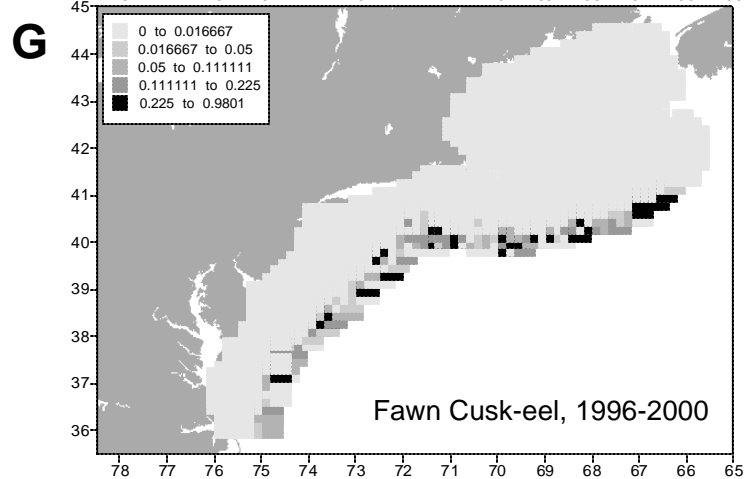
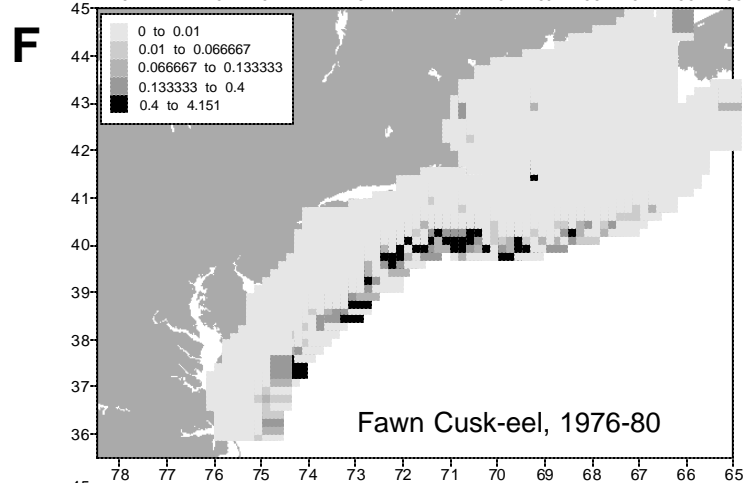
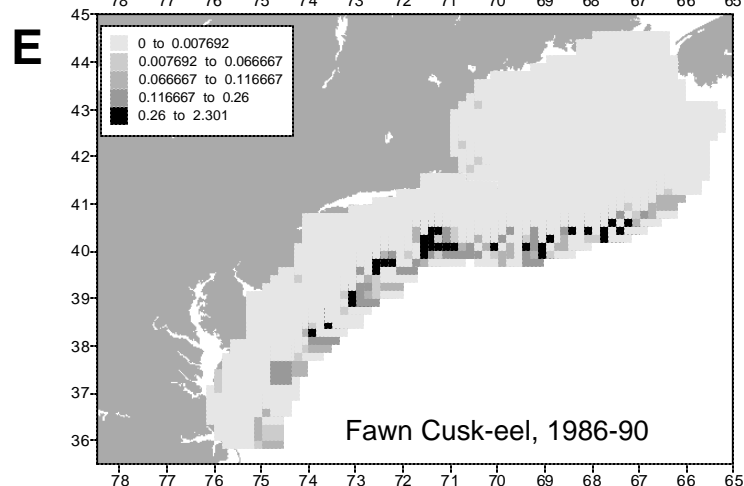
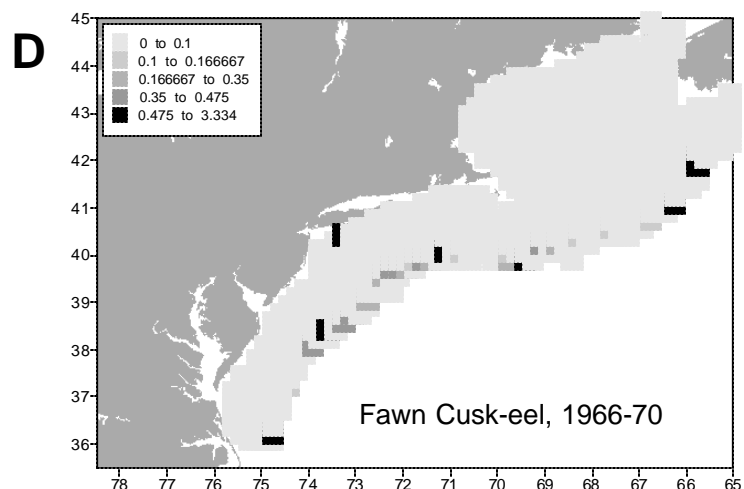
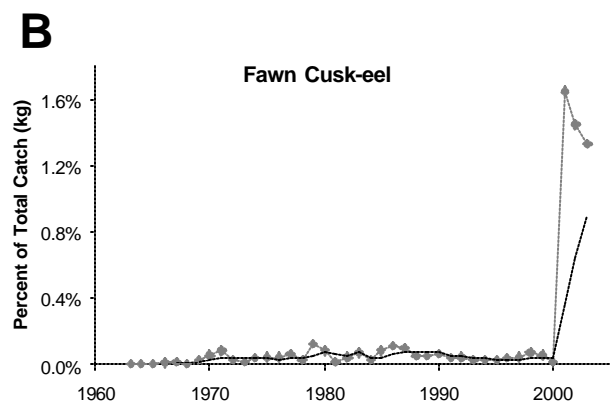
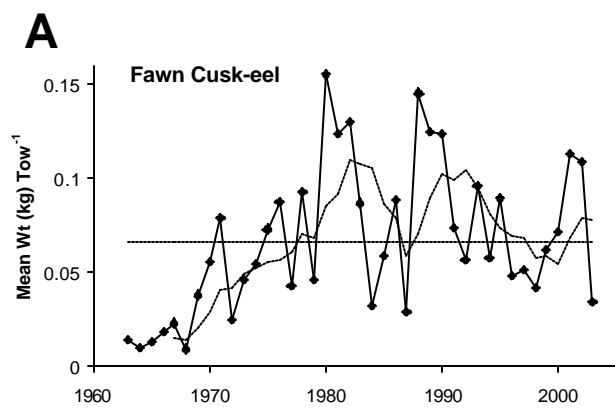


**Fig. 11**

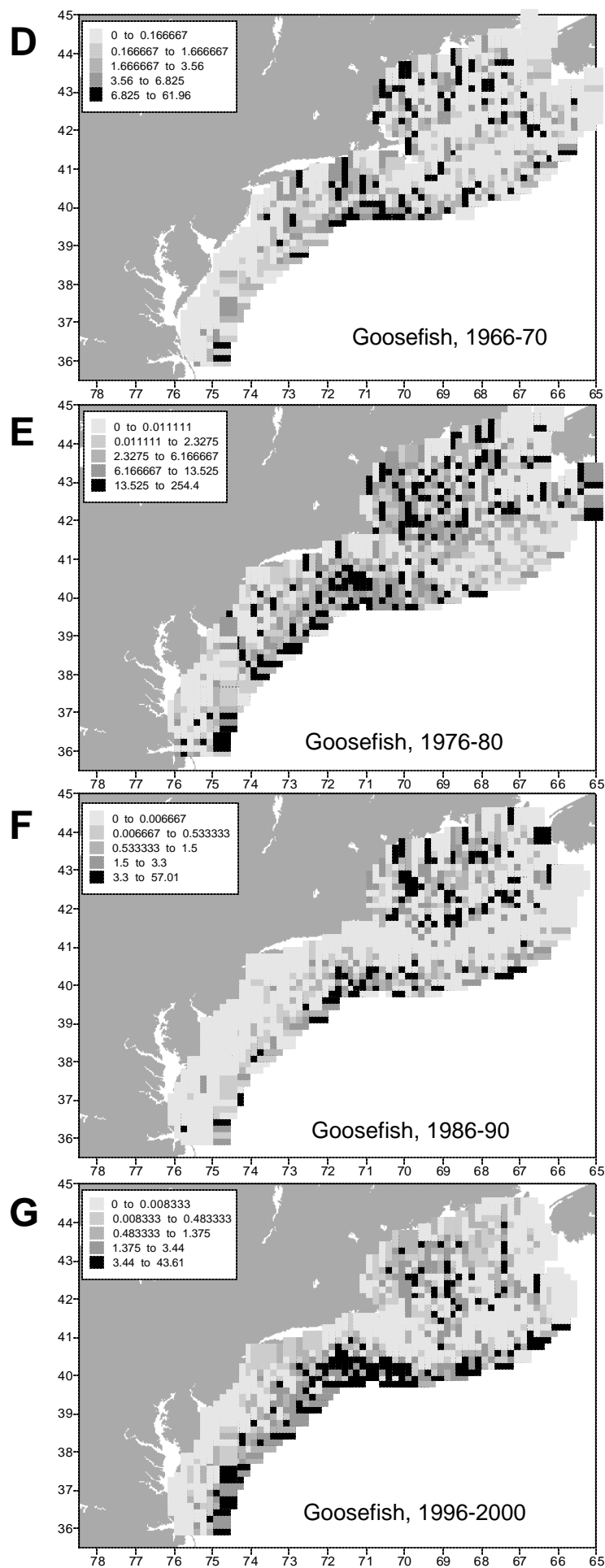
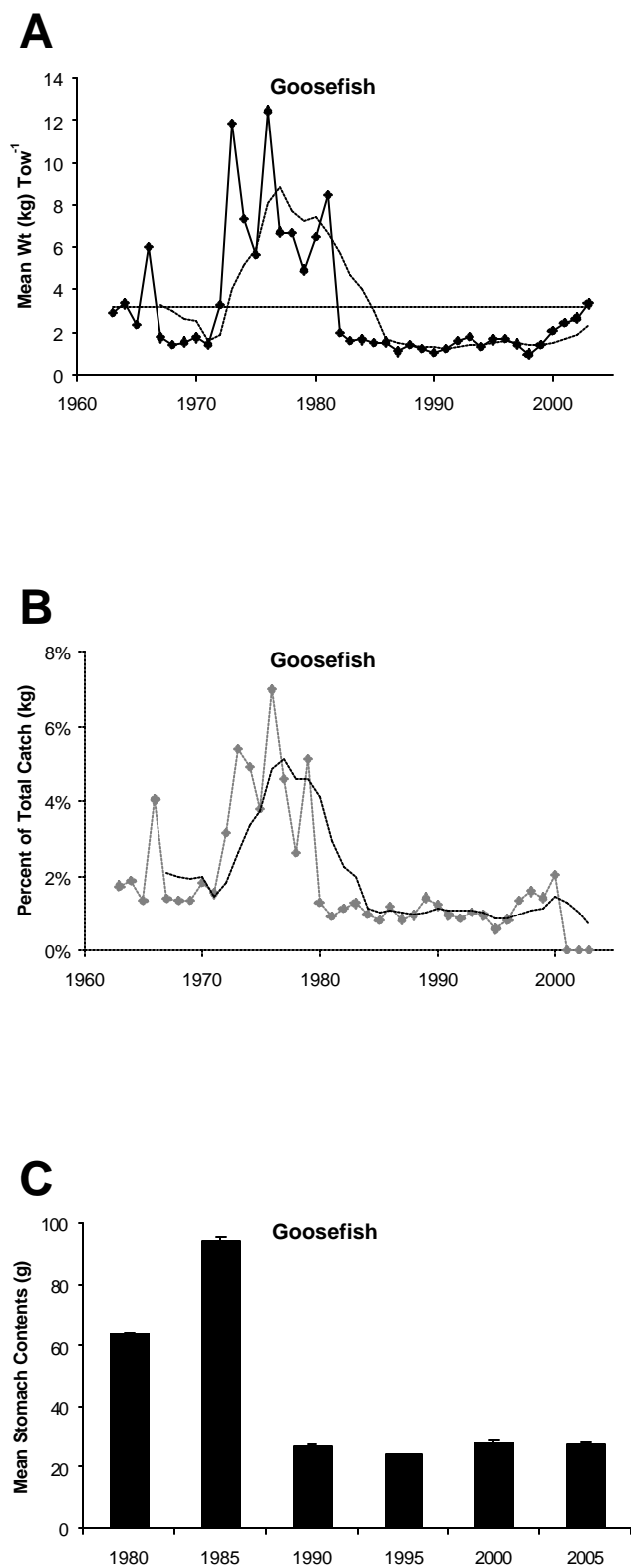




**Fig. 12**



**Fig. 13**



**Fig. 14**