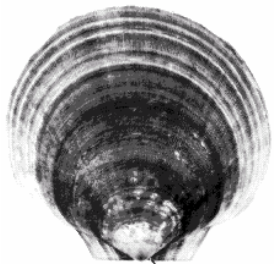

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Atlantic Sea Scallops

by

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Distribution, Biology and Management

Sea scallops *Placopecten magellanicus* are distributed in the northwest Atlantic Ocean from Newfoundland to North Carolina, mainly on sand and gravel sediments where bottom temperatures remain below 20^{o}C (68^{o}F). North of Cape Cod, concentrations generally occur in shallow water less than 40 m (22 fathoms) deep. South of Cape Cod and on Georges Bank, sea scallops typically occur at depths between 25 and 200 m (14 to 110 fathoms), with commercial concentrations generally between 35 and 100 m (19 to 55 fathoms) (Figure 36.1).

Sea scallops are filter feeders, feeding primarily on phytoplankton, but also on microzooplankton and detritus (Hart and Chute 2004). Sea scallops grow rapidly during the first several years of life. Between ages 3 and 5, they commonly increase 50 to 80% in shell height and quadruple their meat weight. During this time span, the number of meats per pound is reduced from greater than 100 to about 23. The largest observed size is about 23 cm (9 in.) shell height, but sea scallops rarely grow larger than 17 cm (6.7 in.) shell height. Sea scallops have been known to live more than 20 years. They usually become sexually mature at age 2, but individuals younger than age 4 probably contribute little to total egg production. Sexes are separate and fertilization is external. Spawning usually occurs in late summer and early autumn; spring spawning may also occur, especially in the Mid-Atlantic Bight. Sea scallops are highly fecund; a single large female can release hundreds of millions of eggs annually. Larvae remain in the water column for four to seven weeks before settling to the bottom. Sea scallops attain commercial size at about four to five years old, though historically, three year olds were often exploited.

The commercial fishery for sea scallops is conducted year round, primarily using offshore New Bedford style scallop dredges. A small percentage of the fishery employs otter trawls, mostly in the Mid-Atlantic, and divers and Digby dredges are sometimes used in near-shore areas in the Gulf of Maine. The principal U.S. commercial fisheries are in the Mid-Atlantic (from Virginia to Long Island, New York) and on Georges Bank and neighboring areas, such as the Great South Channel and Nantucket Shoals. There is also a small, primarily inshore fishery for sea scallops in

the Gulf of Maine. Recreational fishing is insignificant.

Most of the sea scallop landings in the federal E.E.Z (> 3 miles from shore) are harvested by vessels with limited-access permits that typically undertake fishing trips of one to two week duration. Each of these vessels has an annual days-at-sea allocation for the open areas, and is allotted a number of trips, each under a trip limit, to former closed areas that have been reopened. There is also an increasing amount of landings from vessels operating with open access general category permits that allow landings of up to 400 lbs. of meats per trip. Other measures under the current management plan (Amendment 10) include gear restrictions (4" rings and 10" twine top for dredges), crew limits (no more than a 7 man crew on open area trips), and rotational and long-term closed areas. The Gulf of Maine sea scallop fishery occurs primarily in state waters managed by the state of Maine using gear and seasonal restrictions. The Canadian Georges Bank sea scallop fishery is managed using enterprise allocations, a form of individual transferable quotas (ITQs).

Total landings of Atlantic sea scallops from NAFO areas 5 and 6 (all U.S. landings together with those from the Canadian portion of Georges Bank) averaged 30,800 mt meats during 2003-2005, more than triple the 1996-1998 average (Table 36.1, Figure 36.2). The highest recorded U.S. landings occurred in 2004, when 29,321 mt meats were taken. Historically, a majority of the landed meats were in the smaller market categories (>30 meats per pound), but improved management has caused most recent landings to be in larger market categories (Figure 36.3), so that the mean weight of a landed scallop meat in 2005 was about twice that which occurred in the 1990s. The recent high landings can be attributed to the increase in landed meat weight together with favorable environmental conditions in the Mid-Atlantic. The U.S. Atlantic sea scallop fishery is one of the most valuable fisheries in the United States and the most valuable wild scallop fishery in the world; its ex-vessel value exceeded $430 million in 2005.

GULF OF MAINE SEA SCALLOPS

The Fishery

The Gulf of Maine sea scallop fishery occurs primarily in Maine waters, within three miles of shore. The vessels in this fishery are relatively small (typically around 40'), and fish for scallops during the state sea scallop season, December 1 through April 15. During the remainder of the year, many of these vessels fish for other species (e.g., lobsters). A few vessels also harvest scallops in Gulf of Maine federal waters throughout the year, but in recent years, the landings from these waters have been minimal.

Gulf of Maine scallop landings have averaged about 500 mt meats per year, and peaked at 1614 mt meats in 1980 (Figure 36.4). During the most recent period (2000-2005), landings have been low, averaging about 290 mt meats per year.

GEORGES BANK SEA SCALLOPS

The Fishery

During the past 50 years, annual Georges Bank sea scallop landings (U.S. and Canada combined) have ranged between 3,000 and 15,000 mt meats. U.S. landings averaged about 5,000 mt meats during 1999-2004, but rose to about 9,900 mt in 2005 (Figure 36.5). The fishery has been strongly affected in recent years by the closure of three large areas on Georges Bank to groundfish and scallop gear in December 1994, and limited reopenings of portions of these areas since June 1999.

Research Vessel Survey Indices

The Georges Bank NEFSC sea scallop survey biomass index remained low from 1982 through 1994 (Figure 36.6). Subsequently, the index increased markedly, and has remained at a high, roughly stable level since 2000. The percentage of Georges Bank sea scallops in the larger size categories has also increased considerably since 1994 (Figure 36.7).

Assessment Results

Between 1982 and 1993, fishing mortality on sea scallops in the U.S. portion of Georges Bank averaged around 1.1, with a low of about 0.6 in 1985 and a high of about 1.7 in 1991 (Figure 36.5). Fishing mortality declined markedly between 1993 and 1998, first due to a shift in effort to the Mid-Atlantic, and later to effort reduction measures and the closure of three areas to scallop fishing. Fishing mortality on sea scallops averaged about 0.1 during 1998-2005, and was about 0.15 in 2005. The slight increase in 2005 was largely due to limited reopenings of portions of the closed areas.

Recruitment has been highly variable, with periods of strong recruitment during 1988-1990 and 1996-1999 (Figure 36.8). Egg production increased considerably after the 1994 closures, but recent year classes (2000-2003) have all been below average, suggesting that the increased egg production has had little effect on recruitment.

MID-ATLANTIC SEA SCALLOPS

The Fishery

Prior to 1987, annual landings of sea scallops from the Mid-Atlantic ranged from less than 1000 mt meats to a maximum of about 4000 mt meats (Figure 36.9). Landings increased in subsequent years, ranging between 2000 and 9000 mt meats from 1987 and 2000, and between 15,000 and 25,000 mt meats since 2001. About 94% of these landings were taken with scallop dredges, with nearly all of the remainder taken with otter trawls.

Research Vessel Survey Indices

The Mid-Atlantic NEFSC sea scallop survey biomass index remained low from 1979 through 1998 (Figure 36.6), and then increased about ten-fold between 1998 and 2003. The increase was

due to strong recruitment combined with conservation measures such as reduced fishing mortality, increased dredge ring requirements, and the implementation of rotational closures that allowed many scallops to grow to larger sizes. Prior to 1999, most scallops were captured during the first few years after they recruited to the fishery (at about 75 mm shell height), so that very few survived to grow beyond 100 mm (Figure 36.10). Since then, reduced fishing mortality together with a shift in fishery selectivity toward larger scallops has resulted in substantial numbers of larger scallops in the landings (Figure 36.3) and in the population as a whole.

Assessment Results

Fishing mortality increased during the 1980s and early 1990s, reaching a peak of over 1.6 in 1992 (Figure 36.9). Fishing mortality subsequently declined, averaging around 0.5 during 1999-2004. It declined further to about 0.3 in 2005, mostly due to the rotational closure of an area off of southern New Jersey and Delaware (the Elephant Trunk closed area).

Prior to the mid-1980s, sea scallop productivity was low in the Mid-Atlantic, as evidenced by the relatively low landings and recruitment (Figure 36.11). Subsequently, recruitment and landings in the Mid-Atlantic have been increasing. Since 1998, biomass has more than doubled due to a combination of strong recruitment and reduced fishing mortality. As a result, egg production has increased more than an order of magnitude from 1998-2005.

OVERALL ASSESSMENT AND BIOLOGICAL REFERENCE POINTS

Fishing mortality for the combined Mid-Atlantic and U.S. Georges Bank sea scallop resource averaged about 1.1 during 1982-1994, and peaked at about 1.6 in 1991 (Figure 36.12). Fishing mortality decreased considerably during 1994-1998 due to effort reduction measures and the implementation of closed areas. Fishing mortality averaged about 0.3 during 1998-2004, and was about 0.2 in 2005.

Yield and spawning stock biomass per recruit curves for Mid-Atlantic and Georges Bank sea scallops are fairly similar (Figure 36.13). Maximum yield per recruit occurs at $F_{max} = 0.24$ for Georges Bank sea scallops, and $F_{max} = 0.25$ for Mid-Atlantic sea scallops (Table 36.2). The overfishing threshold, based on using F_{max} as a proxy for F_{msy}, is specified at F = 0.24, with a target fishing mortality of 80% of the threshold ($F_{target} = 0.20$). Similarly, the biomass target of $B_{target} = 5.6$ kg/tow, computed as B_{max} times median recruitment, is used as a proxy for B_{msy}. The threshold for being in an overfished condition is specified as one half the target, or 2.8 kg/tow.

Closed Areas and Spatial Management

Sea scallops have a somewhat uncommon combination of life-history attributes: low mobility, rapid growth, and low natural mortality. These attributes enable sea scallop populations to respond rapidly after areas have been closed to fishing. This has been observed in the Georges Bank closed areas, where sea scallop biomass increased almost 25-fold between 1994 and 2000 (Figure 36.14), and in the Hudson Canyon South rotational closed area in the Mid-Atlantic, where sea scallop biomass increased about five times during its three year (1998-2001) closure.

Significant increases have also occurred in the Elephant Trunk rotational area since it was closed in 2004. These observations are consistent with rotational theory which predicts that rotational closed areas can increase sea scallop yield and biomass (Hart 2003).

Summary

Biomass survey indices for both Georges Bank and Mid-Atlantic sea scallops were at or near their historical maximums in 2005. The combined survey index for 2005 was 7.7 kg/tow, well above the biomass target of 5.6 kg/tow. Sea scallops were therefore not overfished in 2005. Fishing mortality has declined considerably from its peak in 1991. Fishing mortality in 2005 was 0.22, slightly above the target fishing mortality rate of 0.2, but below the overfishing threshold of 0.24. Therefore, overfishing was not occurring in the sea scallop fishery in 2005.

Table 36.1. Landings of sea scallops, NAFO areas 5 and 6 (thousand metric tons, meats).

Category	1986-95 Average	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gulf of Maine											
United States	0.6	0.8	0.7	0.5	0.3	0.2	0.4	0.5	0.3	0.1	0.2
Georges Bank [1,2]											
United States [2]	5.5	2.1	2.4	2.1	5.2	5.5	5.0	5.7	5.0	4.5	10.0
Canada	5.0	3.0	3.9	4.0	3.7	6.8	6.9	6.7	6.2	3.7	2.7
Total Georges Bank	10.5	5.1	5.3	6.1	8.9	12.3	11.9	12.4	11.2	8.2	12.7
Mid-Atlantic											
United States	5.9	5.0	2.9	2.9	4.7	8.9	15.8	17.6	19.7	24.7	15.3
Total Nominal Catch [1]	17.0	10.9	9.9	9.5	13.9	21.4	28.1	30.5	31.2	33.0	28.2

[1]Includes Canadian portion of Georges Bank

[2]Includes Southern New England and the Great South Channel

Table 36.2 Yield and spawning stock per recruit reference points for Atlantic sea scallops.

Yield and SSB per Recruit-based Reference Points

F_{max}	=	0.24 (F_{msy} proxy)
F_{target}	=	0.20
$F_{0.1}$	=	0.13
B_{target}	=	5.6 kg/tow
$B_{threshold}$	=	2.8 kg/tow

For further information

Hart, D.R. 2003. Yield- and biomass-per-recruit analysis for rotational fisheries, with an application to Atlantic sea scallop (*Placopecten magellanicus*). *Fishery Bulletin*, **101**:44-57.

Hart, D.R. 2005. Georges Bank scallops and fishery closures. MPA News 64:6.

Hart, D.R. 2006. Sea scallop stock assessment update for 2005. NEFSC Ref. Doc. 06-20, Woods Hole, MA.

Hart D.R. and A.S. Chute. 2004. Essential Fish Habitat Source Document: Sea Scallop, *Placopecten magellanicus*, Life History and Habitat Characteristics (2nd edition) NOAA Tech Memo NMFS NE-189, Woods Hole, MA.

Hart, D.R. and P.J. Rago. 2006. Long-term dynamics of U.S. sea scallop (*Placopecten magellanicus*) populations. *North American Journal of Fishery Management* **26**:490-501.

Naidu, K.S., and G. Robert. 2006. Fisheries sea scallop, *Placopecten magellanicus*. Pgs. 869-905 in S. Shumway and J. Parsons (eds.), *Scallops: Biology, Ecology and Aquaculture,* 2nd ed. Elsevier.

NEFMC [New England Fishery Management Council]. 2003. Final Amendment 10 to the Atlantic sea scallop fishery management plan with a supplemental environmental impact statement, regulatory impact review, and regulatory flexibility analysis. New England Fishery Management Council, Newburyport MA.

NEFSC [Northeast Fisheries Science Center]. 2004. 39th Northeast Regional Stock Assessment Workshop (39th SAW) Assessment Summary Report & Assessment Report, Northeast Fisheries Science Center Reference Document 04-10.

Orensanz, J.M., A. M. Parma, T. Turk and J. Valero. 2006. Dynamics, assessment and management of exploited natural populations. Pgs 765-867 in S. Shumway and J. Parsons (eds.), *Scallops: Biology, Ecology and Aquaculture*, 2nd ed. Elsevier.

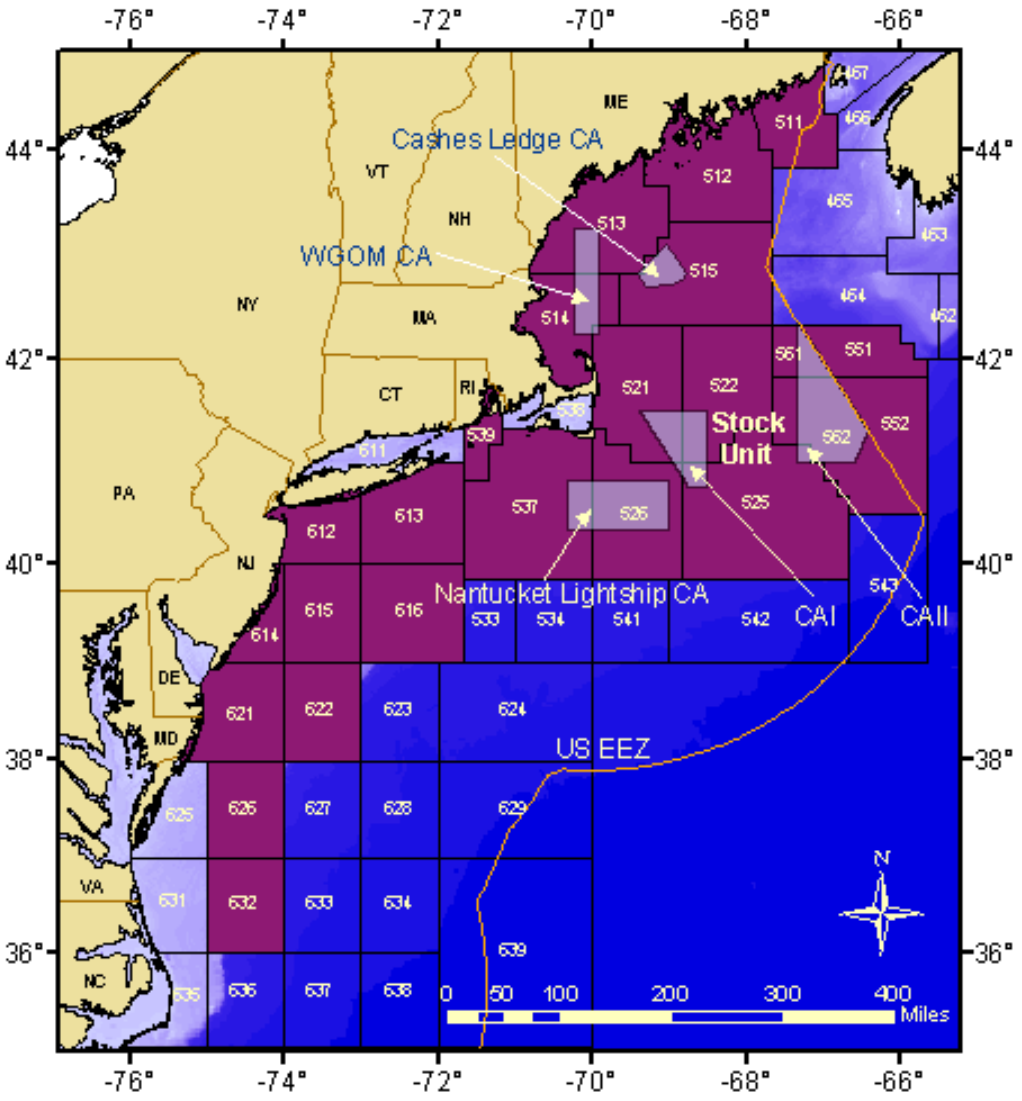

Figure 36.1. Statistical areas used to define the U.S. sea scallop management units.

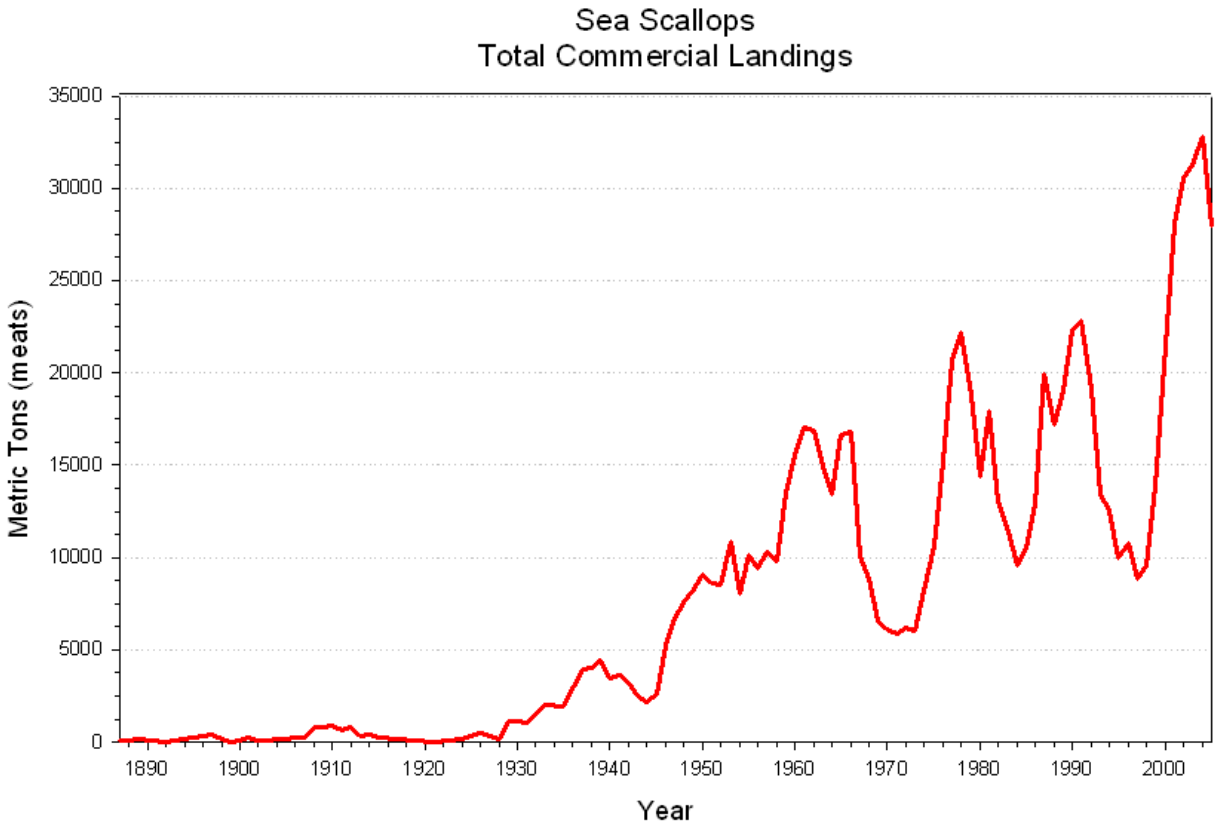

Figure 36.2 Total (US and Canada) commercial landings of Atlantic sea scallops in NAFO divisions 5-6, 1887-2005.

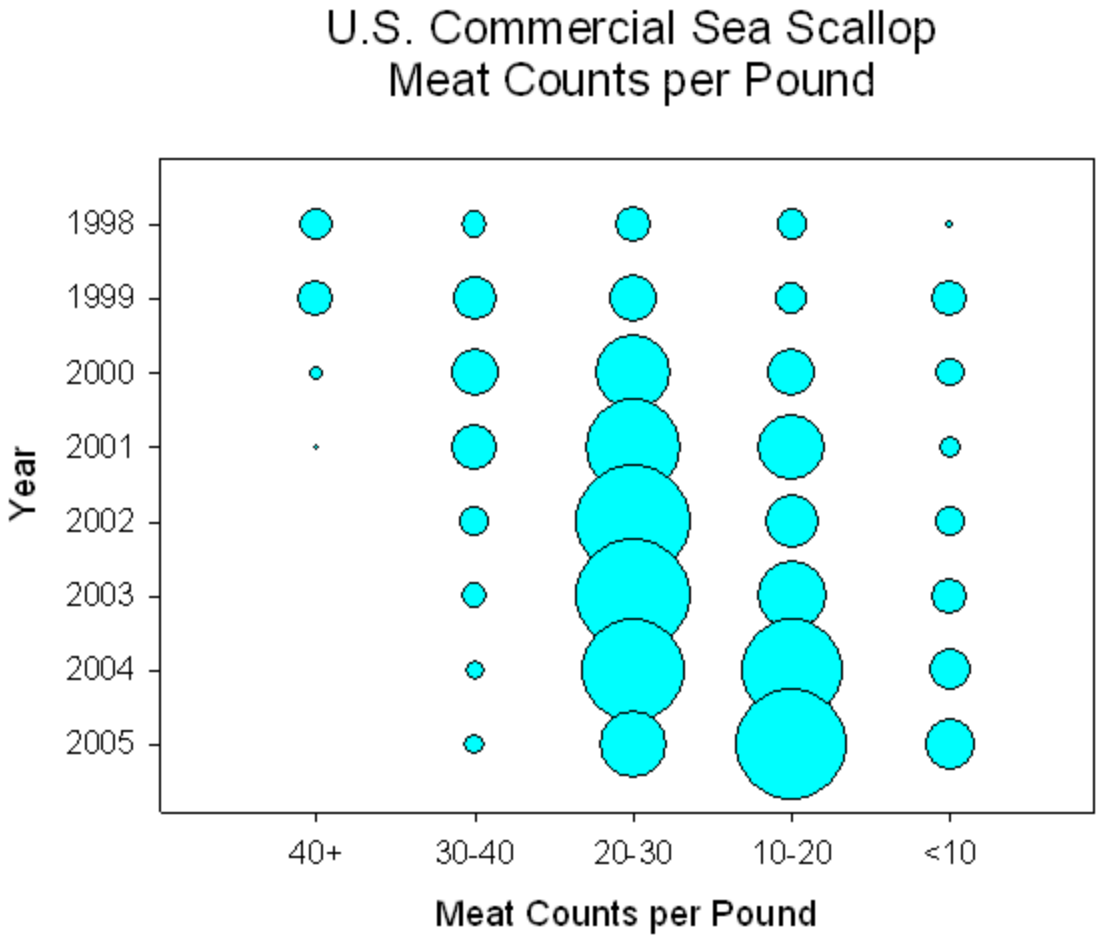

Figure 36.3. Meat count per pound composition (by weight) of U.S. commercial sea scallops, 1998-2005.

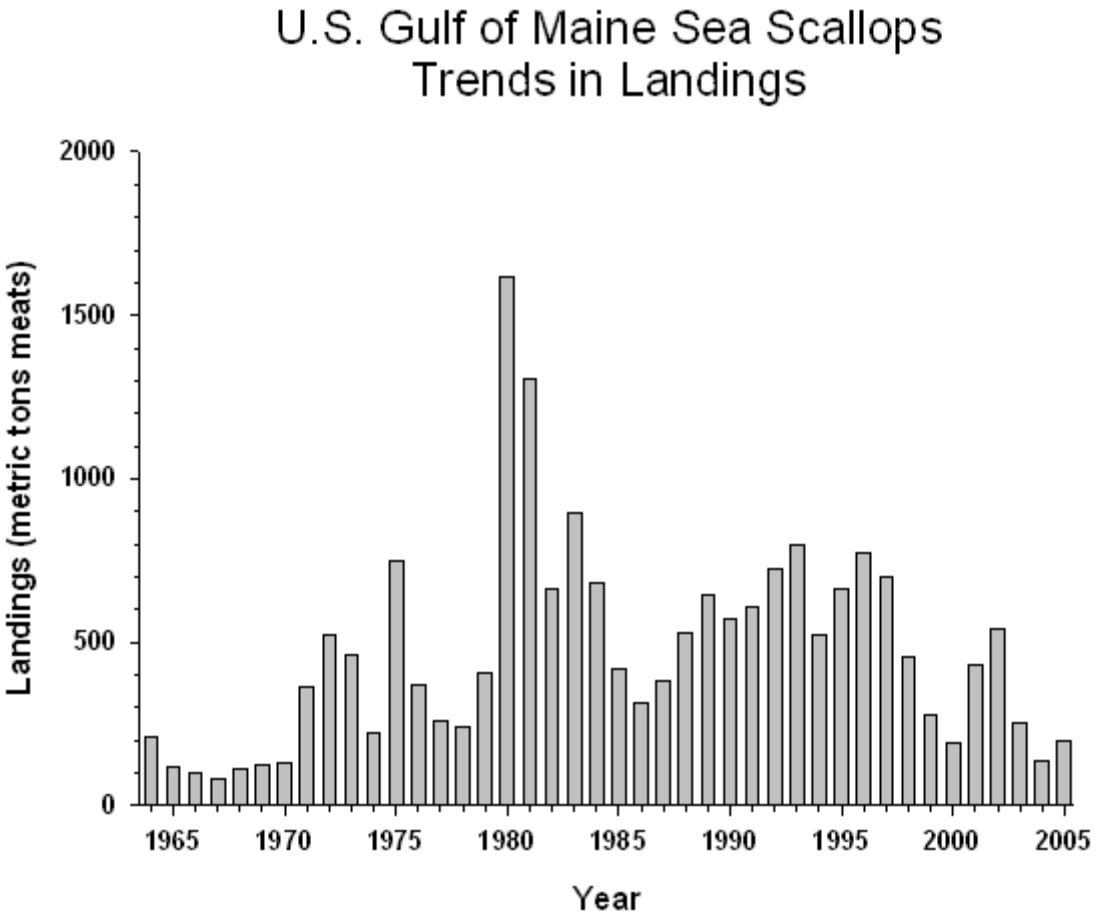

Figure 36.4. Trends in landings for Gulf of Maine sea scallops.

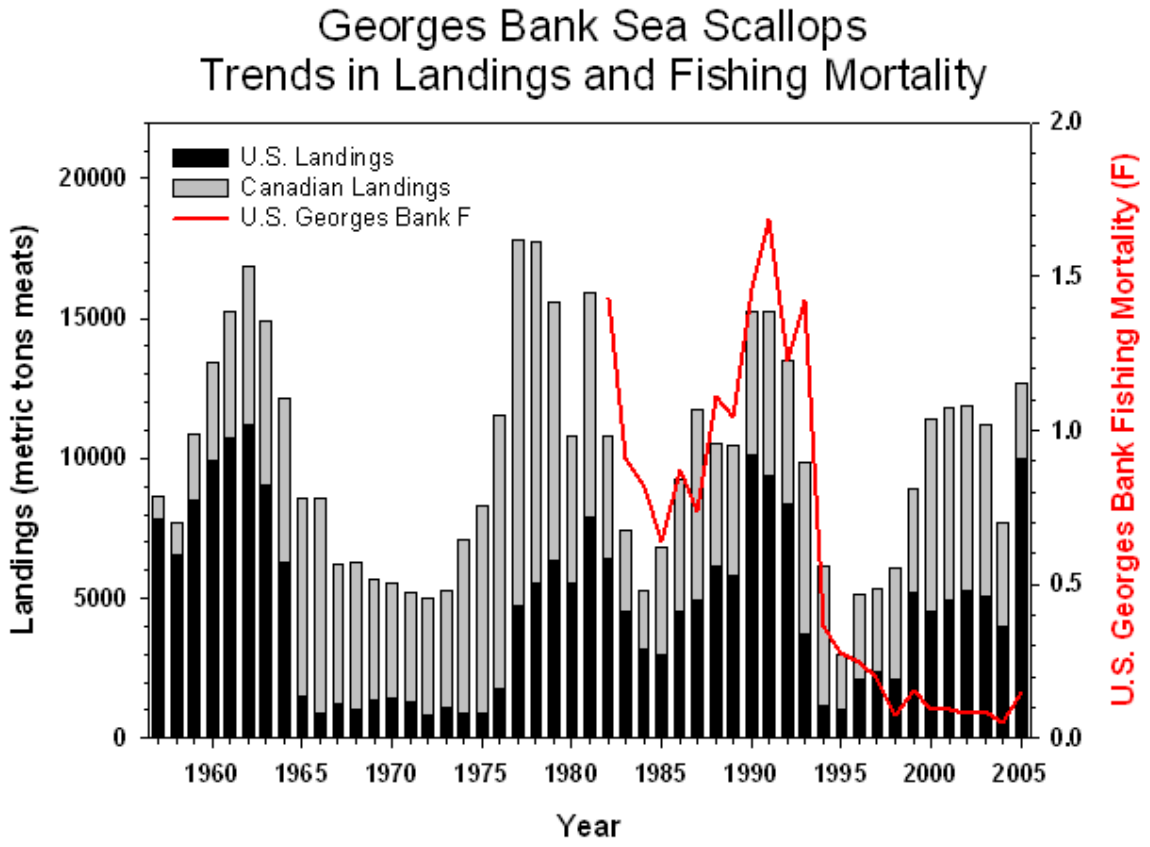

Figure 36.5. Trends in catch and fishing mortality for Georges Bank sea scallops.

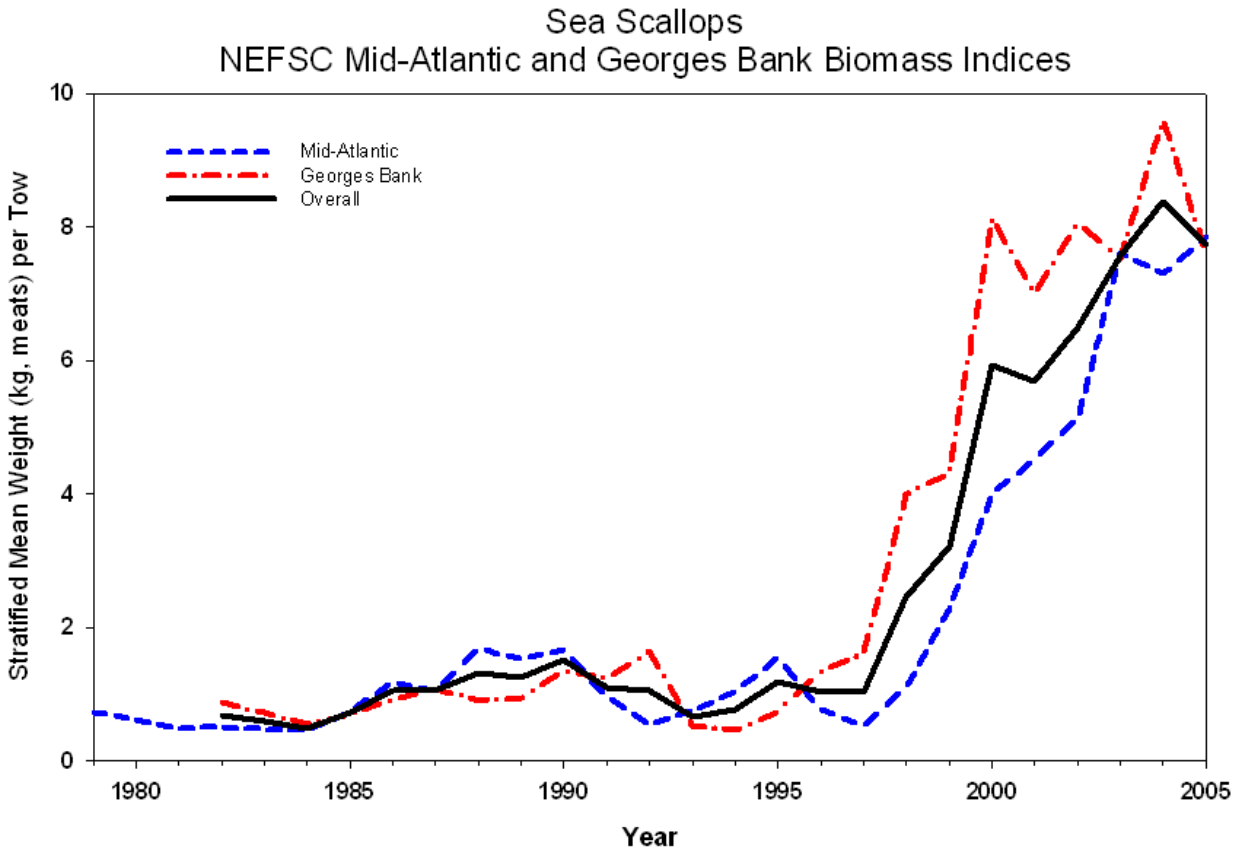

Figure 36.6. Biomass indices (stratified mean weight per tow) for sea scallops in the Mid-Atlantic andGeorges Bank regions, and in the two regions combined, from NEFSC sea scallop research vessel surveys.

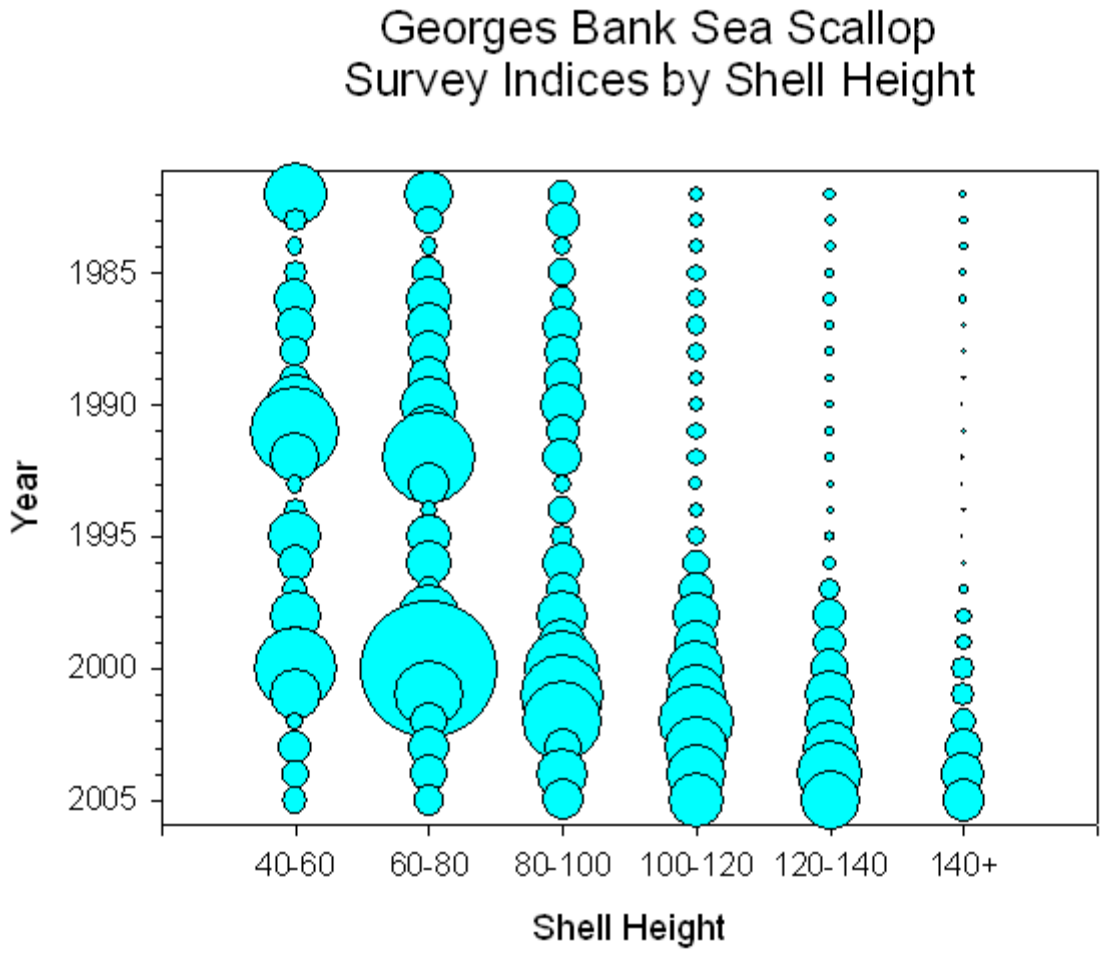

Figure 36.7. Shell height composition of the Georges Bank sea scallop resource, 1982-2005.

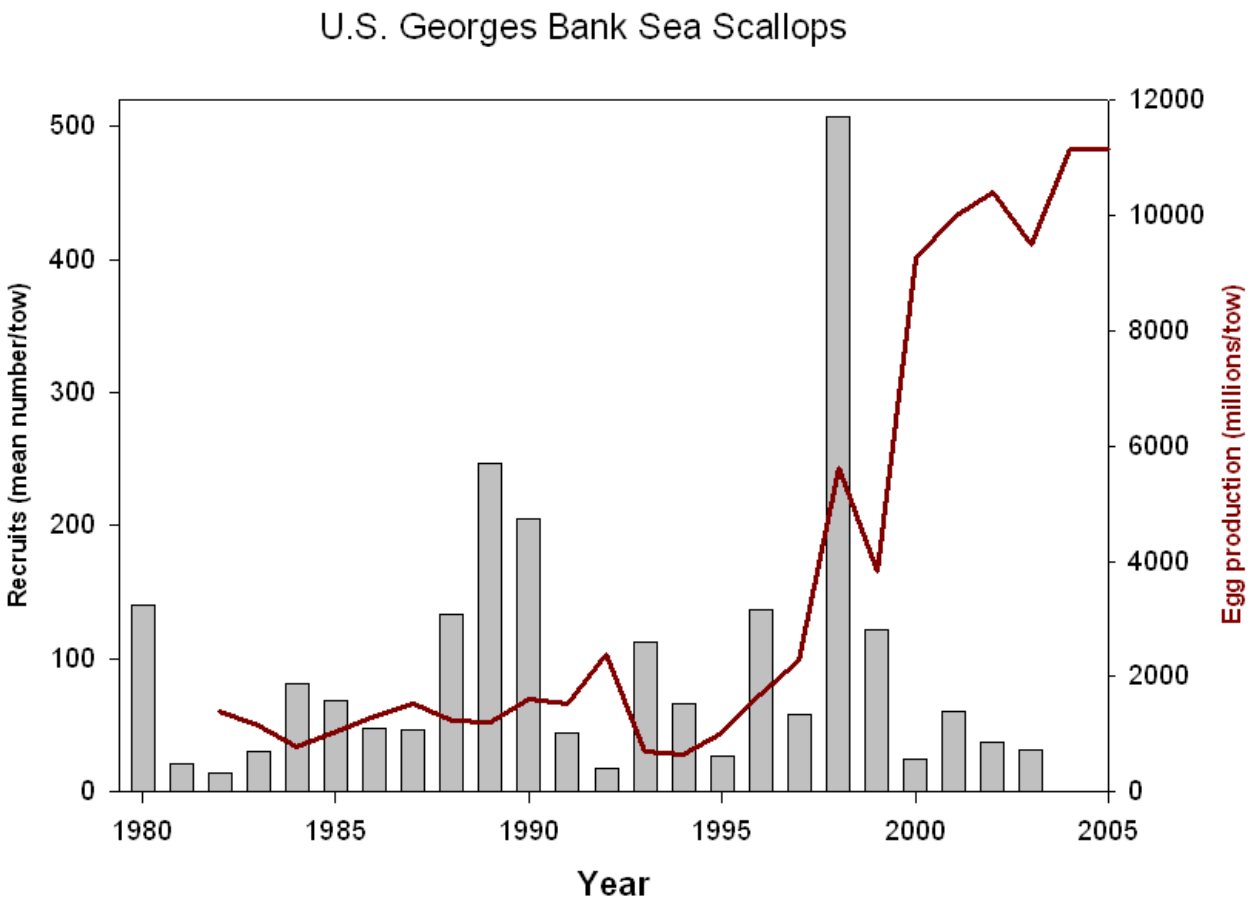

Figure 36.8. Recruitment (bars, at year spawned) and egg production for U.S. Georges Bank sea scallops (Canadian Georges Bank is included in the egg production estimate).

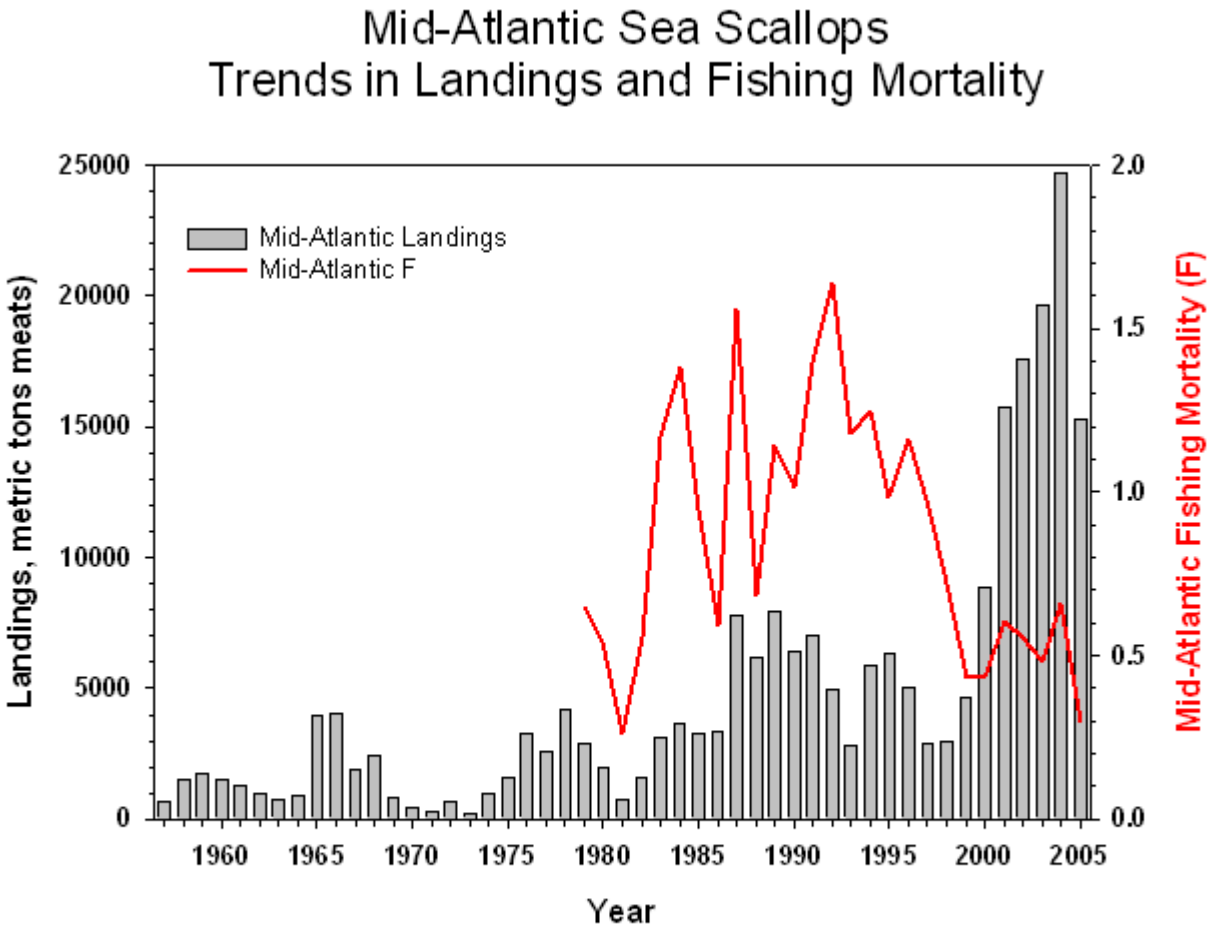

Figure 36.9. Trends in landings and fishing mortality for Mid-Atlantic sea scallops.

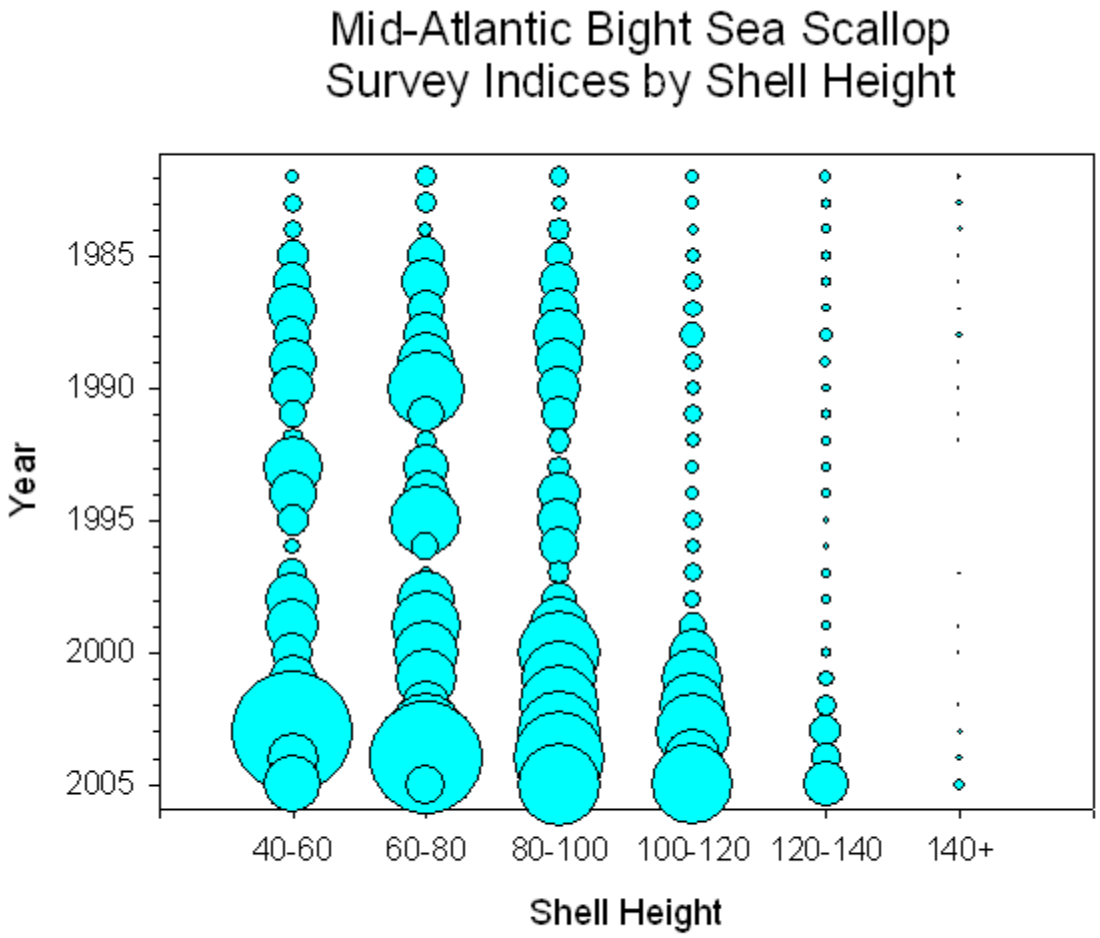

Figure 36.10. Shell height composition of the Mid-Atlantic Bight sea scallop resource, 1982-2005.

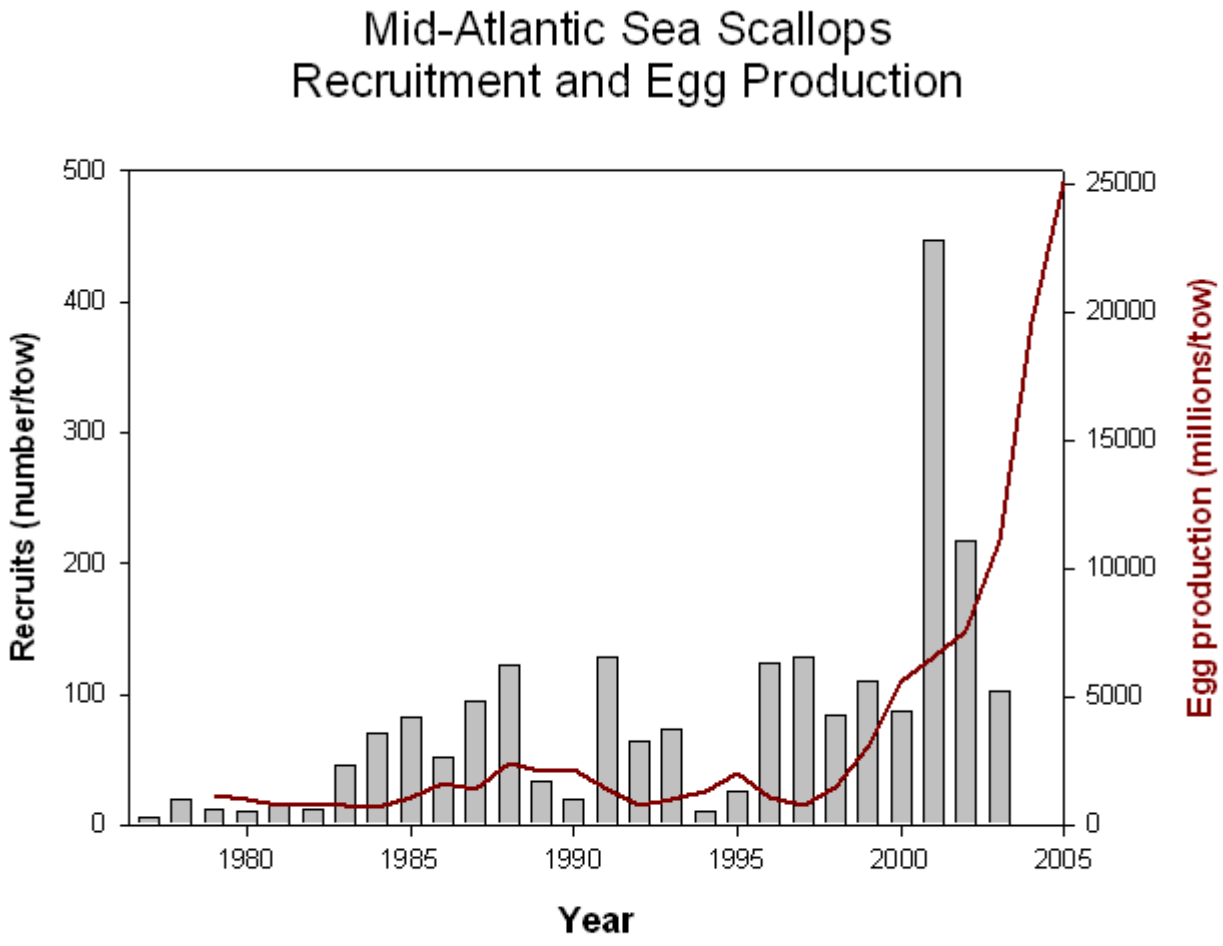

Figure 36.11. Recruitment (bars, in year spawned) and egg production (solid line) for Mid-Atlantic sea scallops.

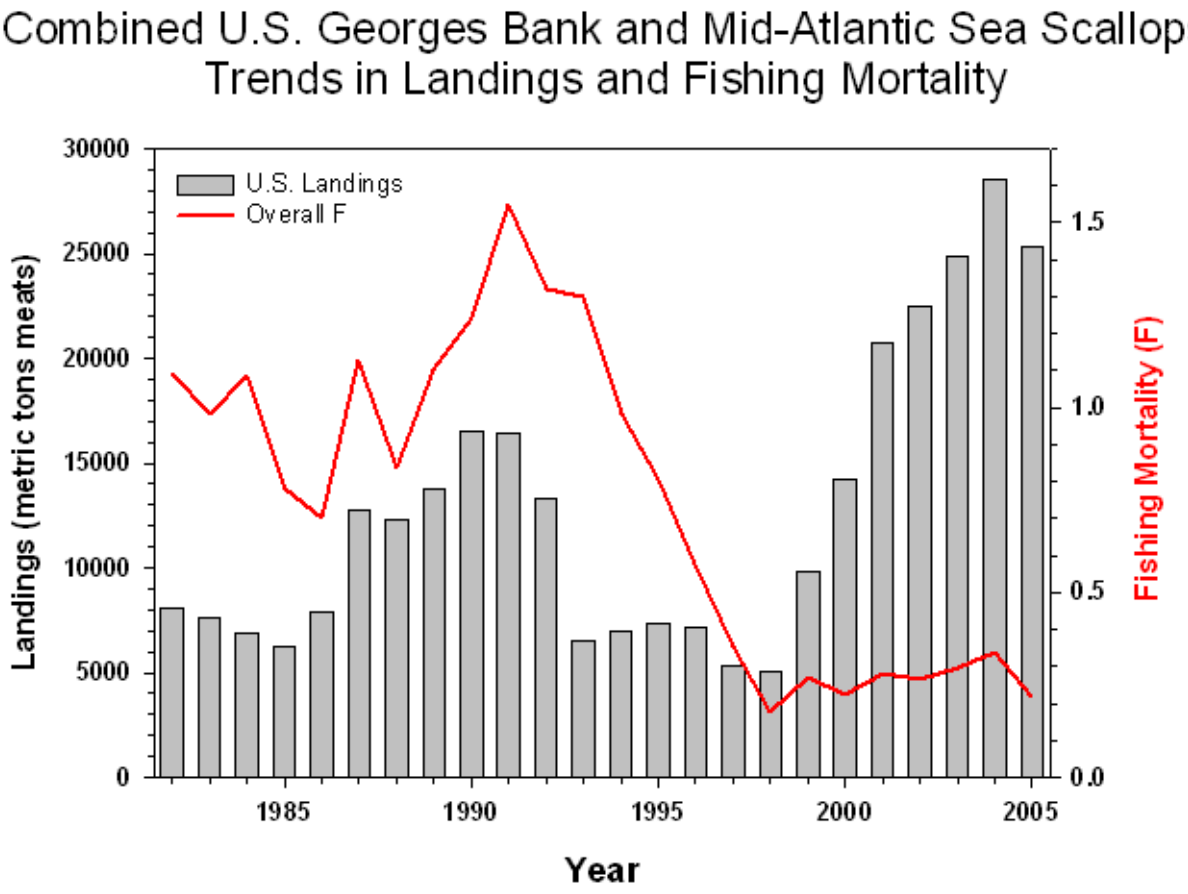

Figure 36.12. Trends in catch and fishing mortality for combined U.S. Georges Bank and Mid-Atlantic sea scallop resources.

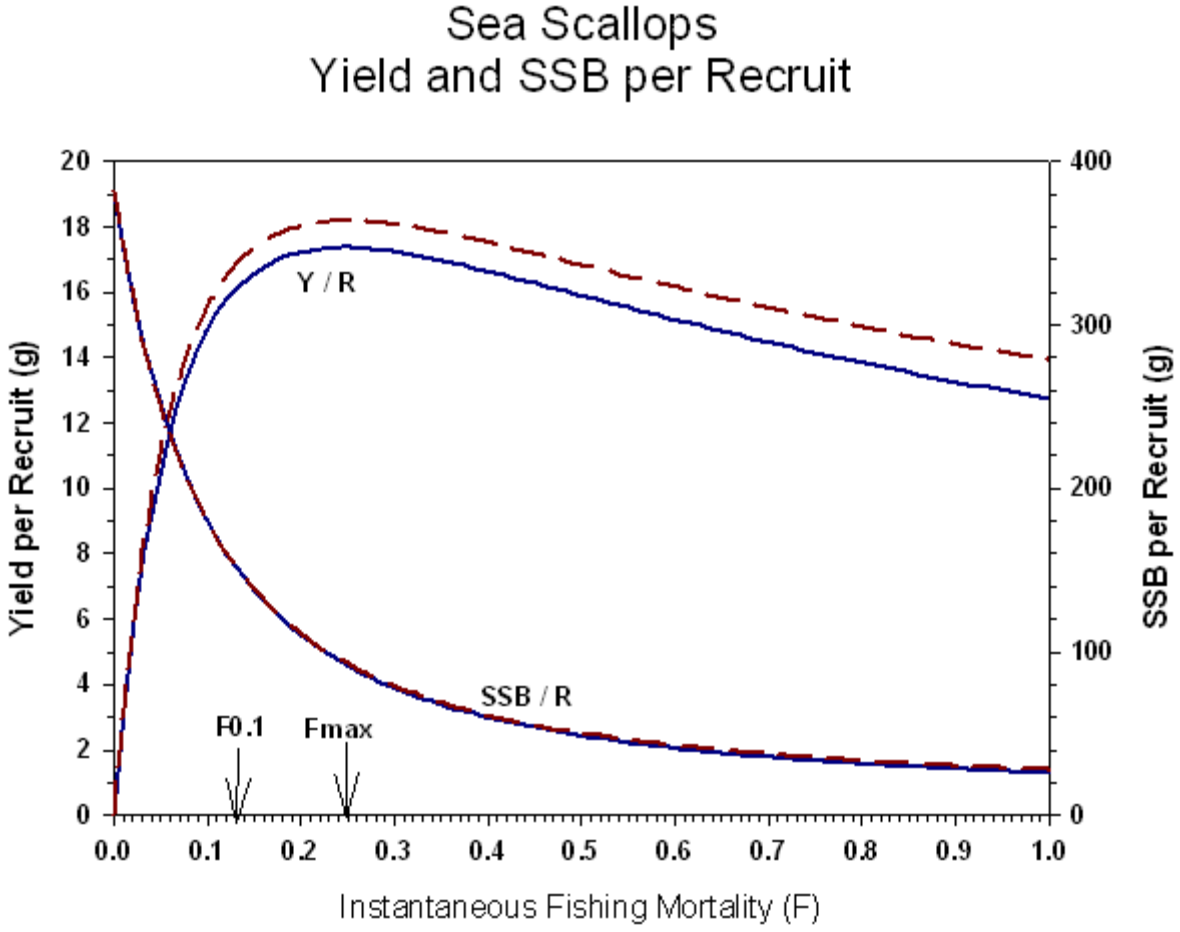

Figure 36.13. Yield and SSB per recruit results for sea scallops. Georges Bank - solid line, Mid-Atlantic - dashed line.

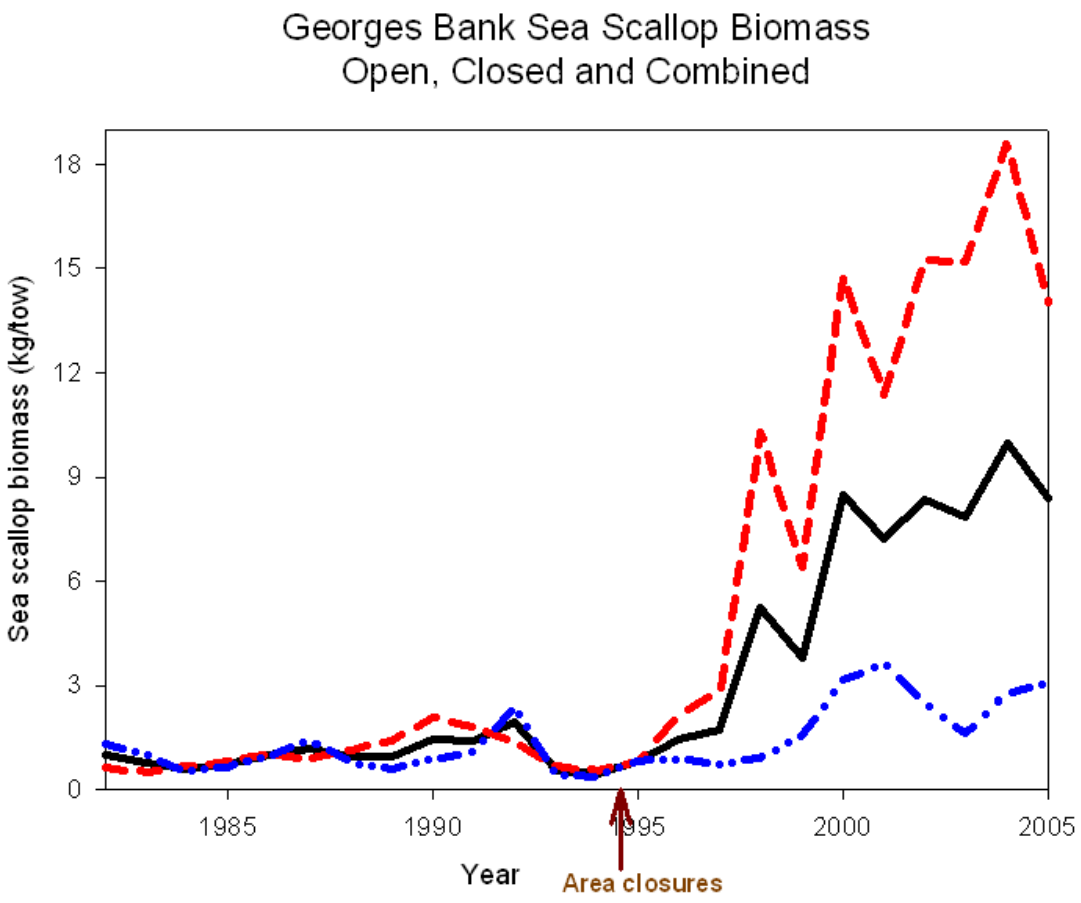

Figure 36.14. U.S. Georges Bank sea scallop biomass in the groundfish closed areas (dashed line), open areas (dashed-dotted line), and overall (solid line).