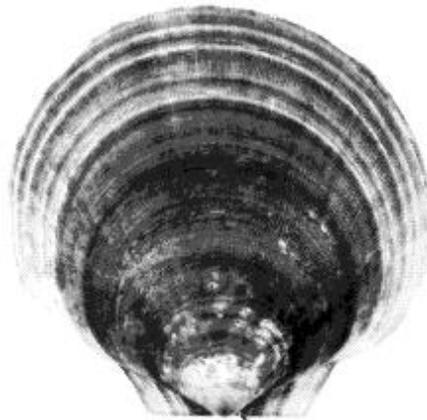


PROSPECTUS

Throughout your paper,
use metric (but it's OK to
put English units in
parentheses if you want).

The Performance of a Scallop Dredge with 102 mm (4") Rings in the Context of an Area Rotation Management Scheme

Title should be tight and
direct. Nothing clever or
creative here, please!



There's really no need to
include a picture on the
title page. I just tossed it
in so you guys would know
what a scallop looks like.

Kevin Goff
July 2001

CBGS Students, Alert! This is an example of an actual research proposal in marine & environmental science. It's actually a much trimmed down version of my own VIMS prospectus, translated here for the younger crowd. I believe reading it will be helpful to you. Your own prospectus needn't be quite so long, nor have so many sources ...but you should still give a good, thorough description of your proposed study, with plenty o' relevant background info!

-Goff

To save paper, I used single spacing, but you should use double

You **MUST** use Times New Roman font, size 12, with 1" minimum margins all around. No exceptions!

Abstract

During the 1990's, five large areas on Georges Bank and the Mid-Atlantic Bight were closed to all scalloping gear. Under those closures, Atlantic sea scallops (*Placopecten magellanicus*) grew tremendously both in individual size and in population density, revealing the great potential for managing the scallop stock through a program of rotating closures and openings. Such a management scheme would require an amendment to the Sea Scallop Fishery Management Plan administered by the New England Fishery Management Council, and as in past amendments, this would probably include new regulations to define the dimensions of the fishing gear. This study proposes to investigate the performance in closed areas of a scallop dredge fitted with a collecting bag made of steel rings 102 mm (4.0") in diameter relative to the performance of a dredge with the standard 89 mm (3.5") rings, which is currently the legal minimum. The research will be conducted aboard a commercial fishing vessel on a series of trips to several of the five closed areas. The boat will fish for scallops using both types of dredges simultaneously, one towed from the starboard gallows and the other from the portside gallows. The catch on each tow will be sampled systematically and randomly, and the researchers will collect data on the relative harvest efficiency of older, optimal size scallops, as well as the relative escapement (through the rings) of younger, pre-optimal scallops. The scientists will also compare the bycatch of unwanted finfish by the two dredges, plus the volume of "trash" (invertebrates and debris) retained by the two collecting bags. Data will be analyzed to assess whether 102 mm rings might better serve a rotational management scheme's primary objective of delaying the age of harvest in order to improve yield per recruit, while at the same time diminishing both bycatch and damage to the benthic habitat.

Genus & species names in italics

The Abstract briefly summarizes - in broad strokes - your proposed research. (Next year you'll add results & conclusions to your Abstract.)

Introduction & Literature Review

In 1996, Congress passed the Sustainable Fisheries Act, outlawing overfishing in federal waters and mandating the restoration of all fish and shellfish stocks within ten years. In response, the nation's eight regional Fishery Management Councils began amending the Fishery Management Plans under their jurisdiction according to a new binding standard: "Optimum Yield" (Magnuson-Stevens, 1996). For many commercial fisheries, including that of the Atlantic Sea Scallop (*Placopecten magellanicus*), this meant first rebuilding the population to a size that would allow the maximum possible harvest year after year. This ideal harvest, in which the population is always able to grow and reproduce just enough to replace whatever fishermen have removed the previous year, is known as Maximum Sustainable Yield (MSY). Optimum Yield is simply MSY minus any shortfalls dictated by social, economic, or ecological constraints. It is the yield that gives the greatest overall benefit to fishing communities and the nation, given the natural limitations of the stock itself and the fishery's inevitable effects on other fisheries and the ecosystem (Magnuson-Stevens, 1996). To accomplish this, a

Citation by Law & Year

Genus & species names in italics

Historical & social context

Management Council must find ways to optimize the Yield Per Recruit (Y/R), which is the harvest weight that each new recruit (that is, each new juvenile entering the population) will, on average, ultimately provide. And this in turn requires the manipulation of two variables: fishing mortality and age of harvest (Cushing, 1981; Everhart & Youngs, 1981).

Fishing mortality (F) is the instantaneous “force” of fishing effort, a value that ranges from zero (no fishing at all) to infinity (perfect fishing that catches every last fish). The age of first capture (t_c) is the age at which an animal first becomes available to the fishing gear. For any given age of first capture, there is some corresponding fishing mortality that will produce the best Yield Per Recruit. In short, one must allow young members of the population to achieve their growth potential before being captured. In the case of sea scallops, the fishery must sort out young scallops from older ones. Such sorting may occur by one of three general mechanisms: (1) passive mechanical sorting by the fishing gear, (2) active sorting (“culling”) by the crew on deck, and (3) geographical sorting through temporary legal closures of specific scallop grounds. This study proposes to examine the possibility of sorting young scallops from old through a combination of the first and third mechanisms. Specifically, it proposes to quantify the effects of increasing the diameter of a scallop dredge’s collecting rings from 89 mm (3.5 inches, the current legal minimum) to 102 mm (4.0 inches) inside areas that have long been closed to scallop fishing.

Nearly ninety percent of the annual U.S. scallop harvest is taken by offshore dredges (NEFMC, 1999b; NEFMC, 2000), heavy metal frames typically 4.6 m (15 ft) in width, towed in pairs across the seafloor – one from a starboard galleys and one from port – and trailed by collecting “nets” or “bags” made of circular steel rings (Figure A). Smaller scallops may pass through and between these rings and so escape capture. Those that do not escape end up on the fishing vessel’s deck, where the crew culls the catch for scallops of some desired size (bigger ones command a higher dockside price) and then shovels the remainder, often still alive and viable, back into the water.

Small scallops might also escape capture through governmental opening and closing of certain geographic areas to fishing. Those inhabiting a closed area would evade harvest. Such closures would allow scallops to grow both in population density and in individual size. But the government can protect small scallops by *opening* areas as well. Opening an area after a prolonged closure would instantly draw fishing boats to the denser, larger scallops of the freshly opened area and away from the sparser, smaller scallops outside it (NEFMC, 1999a; NEFMC, 1999b; NEFMC 2000). With this sort of “area management,” the idea would be to “rotate” the opening and closing of scallop grounds in order to attract fishing boats to the stock’s largest, oldest scallops while restricting them from areas where there are strong crops of young new recruits.

Citation of 2 different papers, separated by a semicolon.

Scientific background & Theory (model)

Important background info

More background info pertinent to the study

Give a “nutshell” statement of your research proposal near both the start & the end of the Intro section

Citations by Agency and Year

When citing a paper by three or more authors, use "et al." (Latin for "and others")

When citing a paper by two authors, name them both

Data from previous studies

Goals & Benefits

Modern satellite technology and vessel tracking devices are now making it easy to enforce the closure of fishing grounds. Consequently, the New England Fishery Management Council (NEFMC), which devises and oversees the Sea Scallop Fishery Management Plan (SSFMP), will probably adopt a rotational strategy in the next few years. Three life history traits make the sea scallop a good candidate for optimizing Yield Per Recruit through area rotations: (1) they are essentially sessile, (2) grow quite rapidly, and (3) have only a modest natural mortality rate (Murawski et al., 2000). The Atlantic sea scallop is an epifaunal bivalve, resting atop the benthic substrate of the continental shelf in the Northwest Atlantic Ocean from the Gulf of St. Lawrence to Cape Hatteras, where it supports large offshore fisheries on Georges Bank and the Mid-Atlantic bight (Bourne, 1964; Serchuk et al., 1979; Lai & Rago, 1998). Scallops possess a thick, round adductor muscle that they use not only to seal themselves shut, but also to swim by clapping their two shells together and jetting out water. This muscle, the "meat" or "eye," is the sole part of the animal that is marketable, and most boats shuck the animal while at sea. Although capable of swimming short distances, recapture of tagged individuals shows that scallops do not conduct mass migrations (Bourne, 1964) and so could feasibly be managed by closing certain areas within their range. The main causes of natural mortality are predation and parasitism, perhaps exacerbated by occasional thermal shocks that weaken the animal (Medcof & Bourne, 1962), at an estimated rate of 10% annually (Merrill & Posgay, 1964). Such a low mortality rate would permit significant numbers of scallops, if unfished, to reach sizes close to their asymptotic height and weight. And scallops grow toward that asymptotic height and weight very rapidly (Figure B). Between ages 3 and 5 they increase their shell height by as much as 80% while quadrupling their meat weight (Serchuk et al., 1979). Area closures would therefore need to last only a few years to return substantial gains in Yield Per Recruit.

A scallop's annual growth rate falls below 10%, the estimated natural mortality rate, at age 8 or 9. At this age, then, gains in the population's biomass due to growth are exactly counterbalanced by losses due to natural death. Therefore, delaying harvest to age 8 should, with perfect fishing, give the maximum possible yield (Serchuk et al., 1979; Posgay, 1979). In the current fishery, however, boats still land substantial numbers of scallops at age 4 or less. While theoretically the harvest would improve by delaying the age of capture (t_c) to as late as age 8, the gains beyond age 6 would be slight, and fishing on age 6 scallops at moderate fishing mortality rates (F) should generate a near optimal yield (Figure C). Thus age 6, which corresponds to a shell height of about 115-120 mm (dorsal hinge to ventral margin), may be defined as the "optimal" size and age at which to begin harvesting scallops.

These theoretical predictions were recently validated by a series of actual scallop ground closures. In 1998, the NEFMC took "emergency action" to protect a strong set of recruits by closing two productive scallop grounds in the Mid-Atlantic region: the Hudson Canyon Area off the coast of New Jersey and Delaware, and the Virginia Beach Area off the coast of

Abbreviations spelled out the first time

Some biology of the target species, especially as it's relevant to the proposed study

Data from previous studies

More Context

Virginia and North Carolina (Figure D). Since 1994, three large regions on Georges Bank – Closed Area I, Closed Area II, and Nantucket Lightship – had also been closed to all mobile bottom gear (trawls and dredges), not with the aim of rebuilding scallops but to protect collapsed stocks of groundfish (cod, haddock, yellowtail flounder, etc.). Under these five closures, scallop stocks flourished, dramatically demonstrating the promise of area rotations as an effective management strategy. Even though scallop biomass on Georges Bank had plunged in 1993 to its lowest level in decades, by the summer of 1996, only twenty months into the closures, scallop densities in the three Georges Bank closed areas were triple that of the open areas (Lai & Rago, 1998). In the years to follow, those same stocks built to historic highs (Figure E-1) (Murawski et al., 2000). A similar pattern of rapid recovery took place from 1998 to 2001 in the Hudson Canyon and Virginia Beach closed areas (Figure E-2). Meanwhile, the closures swiftly curtailed the overall fishing mortality (Figure F).

Helpful map of study area

It is important to observe, however, that in the late 90's, about two-thirds of the total scallop biomass lay behind closed area borders and was unavailable to fishing. Consequently, fishing mortality in the *open* areas remained extremely high (NEFMC, 1999a; NEFMC 2000), something that could only be alleviated by lifting some of the closures and drawing the fleet's effort onto the rebuilt grounds. The first such opening occurred in the summer of 1999, when the NEFMC opened the southern portion of Closed Area II for a limited scalloping season. High catch rates and large meats attracted 187 vessels, taking a total of 644 trips and harvesting \$36 million worth of scallops (NEFMC, 2000). The following year the Council temporarily opened Closed Area I and Nantucket Lightship with similar results, and in 2001 the Mid-Atlantic areas were opened as well.

More social relevance

These openings have revealed the tremendous promise of using a rotating harvest to maximize profits from what is now the east coast's second most valuable fishery (after lobster). An area management scheme would work by way of a three-step "rotation." First, an area bearing a strong juvenile year class is closed before the animals recruit to the fishing gear. Several years later the area opens, thereby gravitating the fleet away from younger scallops elsewhere. Once fished down, the area may close again to allow the small, young scallops *left behind* to grow up. Thus with any rotating harvest, measures should be taken to protect small, young individuals *during* each opening (Caddy, 1993). The more successfully this is done, the shorter will be the minimum duration of each closure.

Important background info

One way to reduce deaths of scallops under the age of 6 might be to widen the diameter of the steel rings that make up a scallop dredge's collecting bag. This might improve the escapement of underage scallops and so diminish their mortality during area openings. Even if the crew selects only the oldest scallops for shucking and shovels the rest back into the sea, many of the discarded scallops inevitably die on deck due to crushing when the bag is dumped out, exposure to air and heat, or human handling during

Potential significance & benefits

culling. And after reentering the water, more may die due to injury, physiological stress, increased vulnerability to predators, or being returned to an inhospitable benthic habitat (Medcof & Bourne, 1962; Smolowitz & Serchuk, 1989; DuPaul & Kirkley, 1995). Clearly it is better if underage scallops are never brought on deck to begin with. Unfortunately, the rings in a scallop dredge's collecting bag cannot accomplish a sharp size selection. Even with 127 mm (5") rings, some young scallops will be captured, especially once the collecting bag has become congested with animals (Bourne, 1964). Nevertheless, widening the diameter of rings can at least improve the size selectivity, however imperfectly. Caddy (1971) demonstrated that escapement of small scallops does indeed occur through both the rings and the inter-ring spaces. Bourne (1965) found that increasing the ring diameter from 77 mm (3") to 102 mm (4") cut the capture of discards (small scallops deliberately culled out by the crew) by 20 to 30%. DuPaul et al. (1989) contrasted the performance of 77 mm (3") and 89 mm (3.5") rings, and found that the wider rings increased the average shell height of captured scallops from 88.2 mm to 98.5 mm. Brust (1996) determined that raising the ring diameter from 3.25" (83 mm) to 3.5" (89 mm) might delay harvest by as much as a year. Thus ring restrictions can reduce, although not eliminate, the harvest and mortality of younger scallops.

If you name an author in the sentence itself, just cite the year in parentheses

At present, the NEMFC sets 3.5" (89 mm) as the minimum legal ring diameter that a scallop boat may use. This study proposes to examine the performance of a dredge with 4.0" (102 mm) rings in comparison with the standard 3.5" rings, within the context of an area rotation strategy, and to explore this gear's potential as an instrument for leaving small scallops behind and in good health while still efficiently harvesting the large scallops during a typical closed area fishery, all in the interest of optimizing Yield Per Recruit in the fishery.

The theoretical reasoning behind the specific hypotheses

Wider rings – specifically, 4.0" (102 mm) rings in contrast to 3.5" (89 mm) – should permit greater escapement of smaller, younger scallops, but not larger scallops, thereby pushing the size/age distribution of the catch in the positive direction. Average shell heights and meat weights should increase. The trend seen with past ring studies (DuPaul et al., 1999) suggests that the size of 100% retention (that is, the size above which no scallops can escape the bag) will be close to the optimal harvest size of 120 mm (age 5-6). The mean catch of underage scallops should decline, but not that of optimal-age scallops. In other words, boats will not lose any efficiency on older scallops, but overall efficiency on younger scallops will diminish.

Null & Alternative Hypotheses

With respect to the mean shell height (S) of the catch:

$$H_0: S_{3.5} = S_{4.0}$$

$$H_a: S_{3.5} < S_{4.0}$$

Relevant work of other scientists ... proof that the student did his homework!!!

End the Intro with one last "nutshell" restatement of the proposed research

(The only reason I'm using English units here instead of metric is that the government regulates scallop gear in inches)

Hypotheses are usually predictions about the MEANS of each RESPONSE Variable(s). Subscripts indicate treatment levels within the INDEPENDENT Variable. Notice that this study has only one I.V. (3.5" vs. 4.0"), yet several RV's.

With respect to the mean meat weight (W) of the catch:

$$H_0: W_{3.5} = W_{4.0}$$

$$H_a: W_{3.5} > W_{4.0}$$

With respect to the mean overall efficiency (E) on each sub-optimal size class (<120mm):

$$H_0: E_{3.5} = E_{4.0}$$

$$H_a: E_{3.5} > E_{4.0}$$

With respect to the mean overall efficiency (O) on each optimal size class (\geq 120mm):

$$H_0: O_{3.5} = O_{4.0}$$

$$H_a: O_{3.5} \leq O_{4.0}$$

Materials and Methods

This study will conduct approximately eight research trips aboard the commercial scallop vessel *Celtic* into several or all of the Closed Areas of the Northwest Atlantic: Area I, Area II, and Nantucket Lightship on Georges Bank, and Hudson Canyon and Virginia Beach in the Mid-Atlantic (Figure D). The target will be dense, well-developed populations of the Atlantic sea scallop, *Placopecten magellanicus*. The purpose will be to evaluate the performance of the experimental gear in a variety of closed area fisheries, on different bottom types with different scallop distributions, similar to those expected under an area rotation management scheme.

In this study there will be one independent variable – ring diameter – with two treatment levels: 3.5" (89 mm) versus 4.0" (102 mm). The experiment will employ a paired design: two dredges, one fitted with 3.5" rings and the other fitted with 4.0" rings, will both be towed simultaneously, one from the starboard gallows, one from the port side. The dredge with the standard 3.5" rings will serve as the control, while the experimental group will comprise the tows with the new 4.0" rings.

All other conditions will be held constant. Both dredges will be the standard 4.6 m (15') wide offshore New Bedford dredges, with the collecting bags configured as identically as possible, except for the size of the rings themselves. On any single tow, the crew will deploy both dredges for the same duration, letting out an identical amount of cable; thus the depth and towing velocity will always be identical for both dredges. The crew will keep the catch from each side separate, but fishing will otherwise follow standard commercial practices, with the captain and crew selecting the tow sites, the tow dimensions and characteristics, the culling size, and so on.

Clear statement of the population to be sampled

Statement of IV and treatment levels (incl. Control)

Helpful map of study sites

List of Constants

Statement of RV's

On each tow the scientists will take random sub-samples of the catch and collect data on the following response variables: (1) Shell Height Frequency (millimeters from dorsal hinge to ventral extreme; grouped into size classes of 5 mm intervals), (2) Basket Count (bushels of harvest size scallops deliberately retained by the crew for shucking and landing), (3) Volume of other invertebrates (in bushels), and (4) Finfish Bycatch Frequencies (with the total length of all fish except skates measured to the nearest centimeter). They will also record the vessel position at the start and end of each tow, as well as the tow duration, velocity, and heading. And they will monitor water depth, sea state, wind conditions, and tidal currents.

Sampling should be **RANDOM!**

Plans for graphical and statistical analysis of data

Since all sampled tows will be "paired" (duplicates in terms of harvest site, gear dimensions, tow duration, tow velocity, and so on), data will be analyzed in a tow-by-tow fashion. Relative harvest (4.0" catch relative to 3.5" catch) will be calculated at each scallop size class on a tow-by-tow basis, and the means will be graphed. A paired t-test will be used to check for statistically significant differences (at the 95% confidence level) in the mean catch at each size class. Paired t-tests will also be run on the mean shell height per tow, mean meat weight per tow, mean volume of trash, and mean frequency of small finfish.

Statement of the statistical test to be used

Thoughts on interpreting results and potential significance

Patterns in the data may reveal potential benefits of using wider rings with respect to bycatch and habitat integrity, as well as possible economic gains to be won by the fishery by way of improved yield per recruit, improved meat weight, and improved fishing efficiency. And most importantly, the data may shed light on the role that 4.0" rings could play in a future rotational strategy for managing the sea scallop fishery.

Science papers usually use a format different from that in English papers ...Author or Agency first, then Year, then Title, then publishing info last.

This is **NOT** a bibliography! You cite **ONLY** those works that you made actual reference to in the **TEXT** of your paper!

Literature Cited

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Article from a science journal

Once again I'm single-spacing to save paper. But YOU should double space these and use a hanging indent (simply highlight this entire section of your paper, then go to the Format menu... Paragraph... and set the indentation to "Hanging" by 0.5")

A Website ...try to find author & "date last modified."
Otherwise, cite the agency and the year you accessed it.

Caddy, J. F. 1971. Efficiency and selectivity of the Canadian offshore scallop dredge. ICES CM 1971/K:25. 8 pp.

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A Book

Article w/
two authors

A Law

Multiple authors (do NOT use "et al." here ...list ALL their names!)

Two sources by the same author in the same year ...so designated as "a" & "b"

NEFMC 1999a. 1999 Scallop Fishery Management Plan SAFE Report (Stock Assessment and Fishery Evaluation). Saugus, MA. 184 pp.

NEFMC 1999b. Framework Adjustment 12 to the Atlantic Seas Scallop FMP, with options for Framework Adjustment 33 to the Northeast Multispecies FMP. Saugus, MA. 160 pp.

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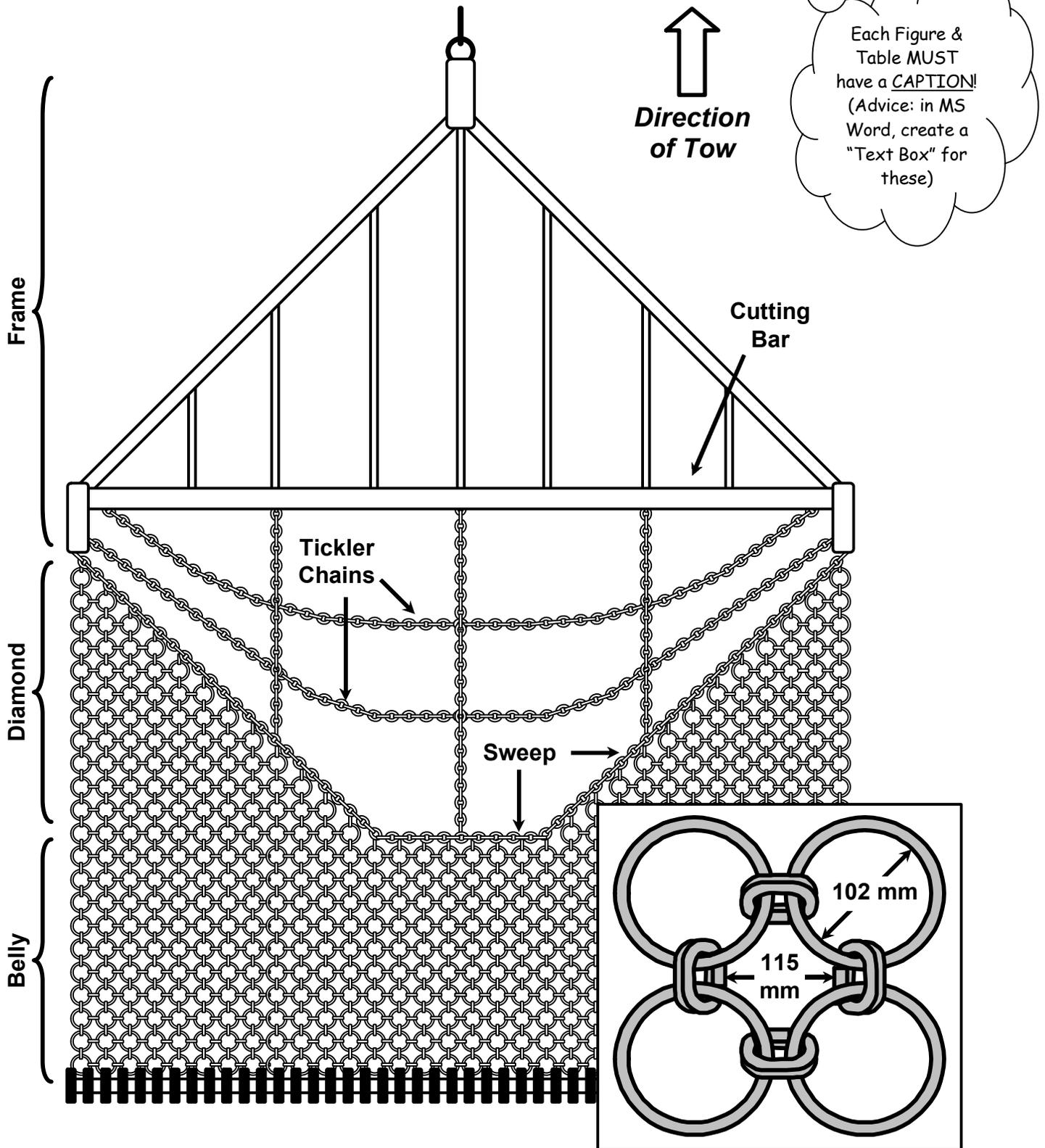
Shumway, S. E. and Schick, D. F. 1987. Variability of growth, meat count and reproductive capacity in *Placopecten magellanicus*: Are current management policies sufficiently flexible? ICES C.M. 1987/K.2.

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Article in a book rather than a science journal or periodical

Paper by an agency rather than an author

Figure A – Underside of a “New Bedford” scallop dredge. Inset: Four-inch rings with split links.



Source cited in the caption

Figure B – Growth rate of scallops for both the Georges Bank and Mid-Atlantic stocks, in terms of both shell height and meat weight. Data from Serchuk et al. 1979.

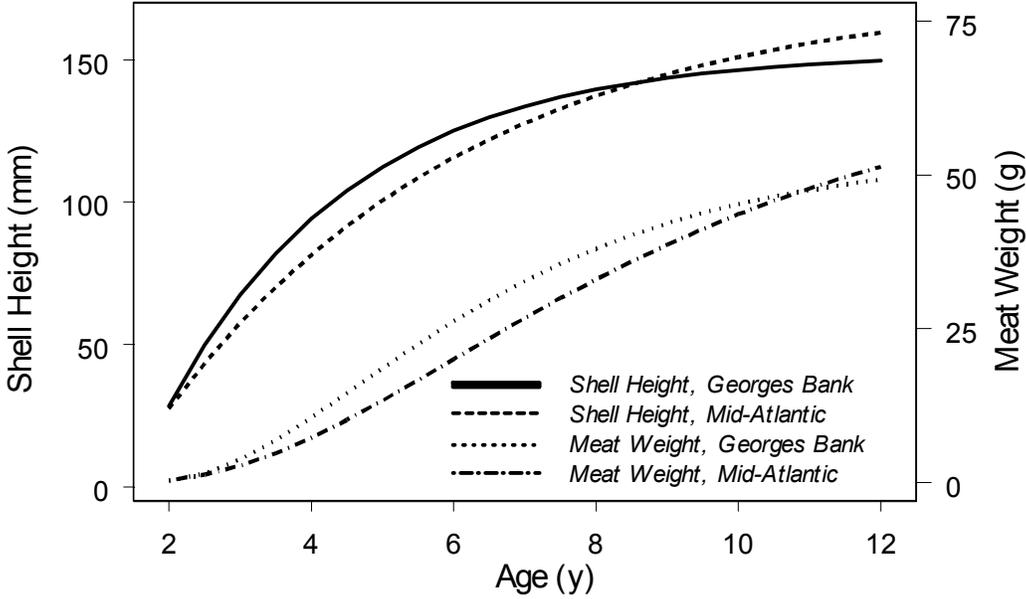
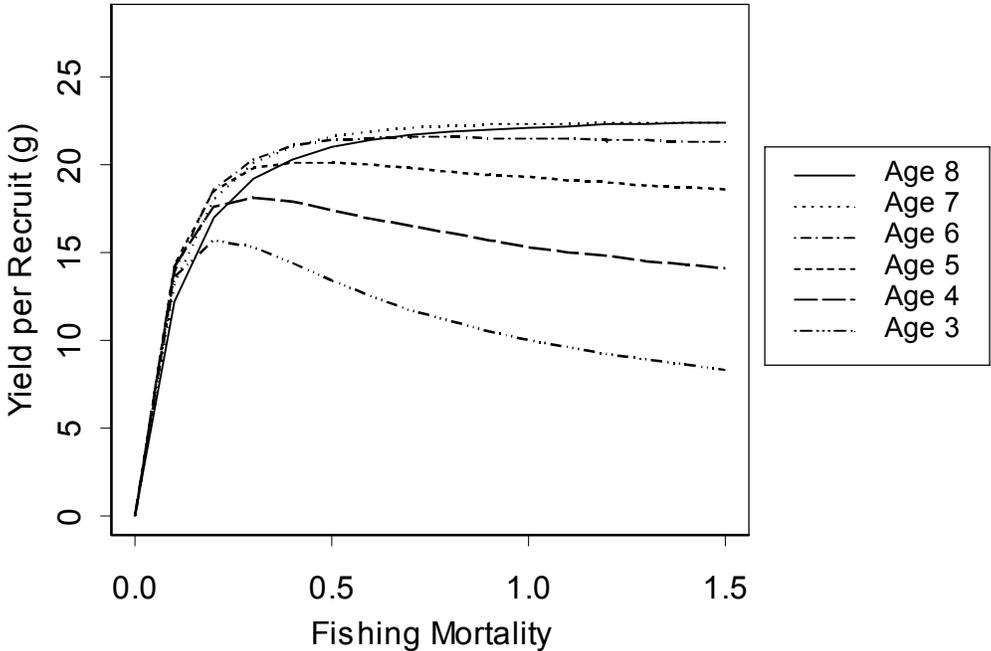
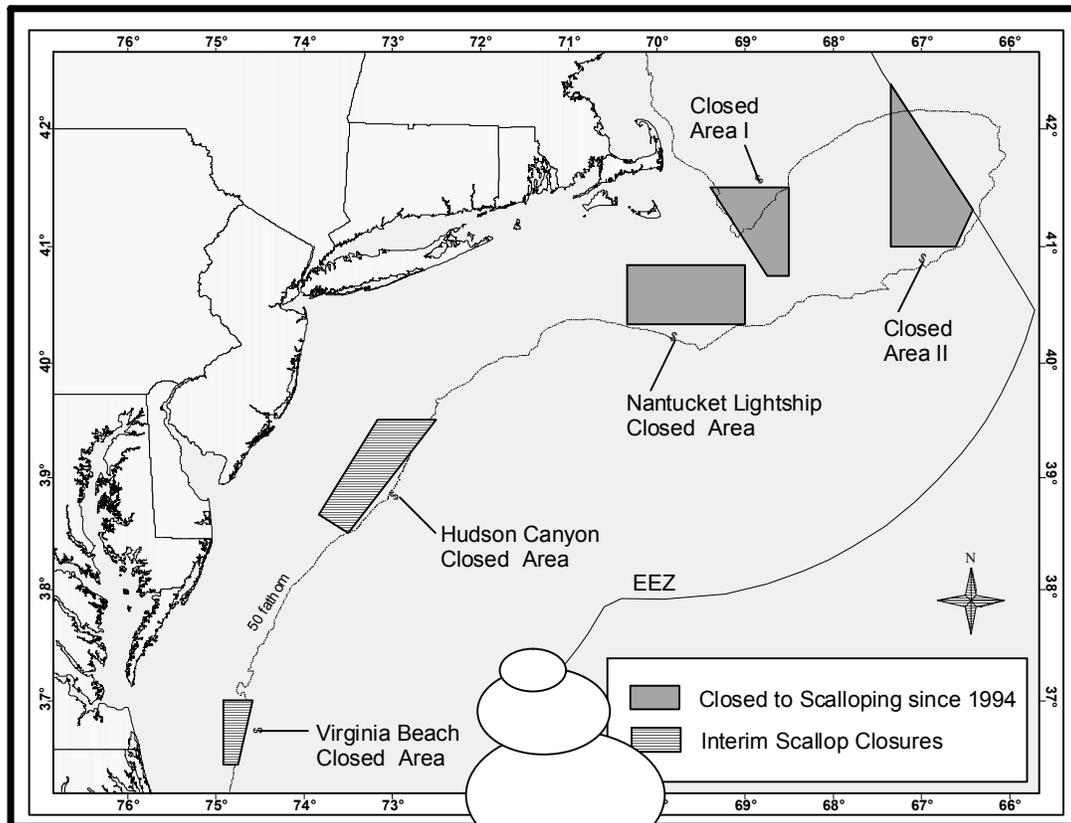


Figure C – Yield Per Recruit as function of fishing mortality (F) for different ages of first capture (t_c). Data from Serchuk et al. 1979.



Helpful map of study sites

Figure D – Closed Areas on Georges Bank and the Mid-Atlantic bight.



For studies with a spatial aspect, you should give the reader a map of the study area, even if it's a hand-drawn or computer-drawn schematic.

CBGS has a scanner for your use.

Also, you can create your own topographical maps online at www.digital-topo-maps.com ...just zoom in and navigate left, right, up, & down to center your study area on the screen. When you're ready to save your map, click "Print from your computer: Landscape/Portrait" down below. A larger picture will download. Then right-click on the picture and "Save picture as..."

If you swipe a map from somewhere, be sure to acknowledge the source!!! Also, you'll probably want to add your own labels to the map using MS Word Text Boxes, Arrows, and Autoshapes.

Figure E – NMFS Survey Biomass estimates for the Georges Bank and Mid-Atlantic scallop stocks, 1990-2000. Units are kilograms of scallop meat harvested per ten minute tow with the NMFS *Albatross* survey dredge. B_{MSY} is the biomass which would enable fishing at maximum sustainable yield. Data from NEFMC 1999a and NEFMC 2000.

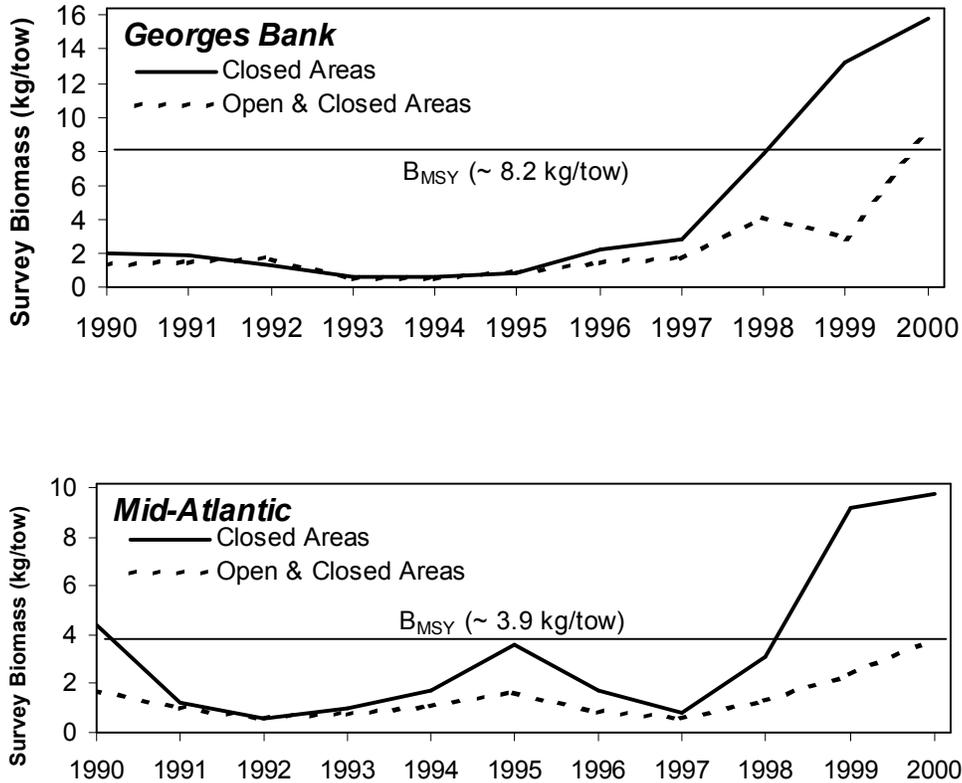


Figure F – Fishing Mortality on the Georges Bank and Mid-Atlantic scallop stocks, 1990-1999. Data from NEFMC 1999a and NEFMC 2000.

