NOAA Technical Report NMFS SSRF-771

Mesh Size and the New England Groundfishery — Applications and Implications

Ronald Joel Smolowitz

July 1983

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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Mesh Size and the New England Groundfishery — Applications and Implications

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ABSTRACT

Mesh size control has been advocated from the earliest days of the otter trawl fishery in the United States. Researchers determined that larger meshes in the cod end of a trawl reduce discarding by allowing small fish to escape; a process known as size-selection. This selectivity is measured by the selection factor — the relationship between the 50% retention length and the stretched length of the mesh. Selection factors vary by species, net material, duration of tow, speed of tow, size of catch, and with variations in mesh size.

Cod end mesh size experiments were conducted aboard eight New England otter trawlers during the period December 1977 to October 1978 to examine the possible effects of increasing the mesh size in that fishery. Selection factors were determined for Atlantic cod, *Gadus morhua* (3.33-3.80), haddock, *Melanogrammus aeglefinus* (3.04-3.47), yellowtail flounder, *Limanda ferruginea* (2.16-2.29), pollock, *Pollachius virens* (3.26-3.33), winter flounder, *Pseudopleuronectes americanus* (2.04-2.27), and American plaice, *Hippoglossoides platessoides* (2.25-2.41). For Atlantic cod, haddock, and winter flounder, there was a reduction of discards, up to 93%, and an increase in landings, by as much as 44%, with the larger mesh (133-138 mm). For yellowtail flounder, there was a reduction of discards and of landings.

Mesh size regulation as a management tool first requires the determination of the objectives in order to choose the size mesh. Enforcement difficulty, especially in the New England mixed fishery, is the greatest obstacle to overcome. The implications of mesh management reach beyond the fishery into the processing and financial sectors of the industry.

HISTORICAL PERSPECTIVE

For hundreds of years men have been harvesting groundfish off of New England, but until 1905 this fishery consisted almost entirely of sailing vessels using hand lines and bottom longlines. In 1905 the Bay State Fishing Co. of Boston built the first American steam otter trawler at Quincy, Mass., the steamer *Spray*. By 1912 there were 11 steam-driven otter trawlers from New England fishing groundfish.

With the rapid rise of this new fishing method, the line fishermen grew apprehensive about the conservation of their fishery. This resulted in a government act, approved 24 August 1912, making appropriations as follows: "To enable the Commissioner of Fisheries to investigate the method of fishing known as beam or otter trawling and to report to Congress whether or not this method of fishing is destructive to the fish species or is otherwise harmful or undesirable, $5,000, or so much thereof as may be necessary."

Alexander et al. (1915) began the work that year. Some of their tasks were to determine: 1) The general effects of trawl nets and hook gear on the fish populations. 2) The nature and extent of the destruction of juvenile fish. 3) The waste of "edible fishes that have no present market value." 4) The extent that trawl nets catch fish not taken by other gear. 5) Any evidence of depletion of fish stocks by trawl nets. 6) The extent of any gear conflicts. 7) The necessity of international agreements to regulate the fisheries.

Results of this study indicated that average mesh sizes (stretched mesh measured between knots) used by otter trawlers were 6 in in the forward parts of the net, 3 in in the bellies, and 2.5 in in the cod end. Between 30 and 40% of the cod and haddock caught by these nets were too small to market, and it was concluded that not only does the otter trawl destroy more undersized fish than line trawls, but it was also more destructive to the fish stocks because of the smaller average size of the landings.

The study's recommendations noted that certain European authorities had proposed increasing the size of the meshes of the net to let the small fish escape. The American authors felt this would not be a feasible approach because they believed that 1) the meshes tend to close as the trawl catches fish, 2) the fish in the cod end block escape, 3) the fish would not attempt to escape until haulback, and 4) more fish would be gilled in the larger meshes. The study recommended against banning otter trawls or limiting entry. It solely proposed area restrictions for otter trawlers, but industry did not support this recommendation and thus no action was taken (Herrington 1935).

During the 1920's, a new market for fresh and frozen haddock fillets was developed. The large demand for this product resulted in the New England otter trawl fleet growing to 323 vessels by 1930. The catch of haddock grew from 93.5 million lb in 1924 to 256 million lb by 1929 (Herrington 1936); then came a rapid decline. Industry grew concerned and funds were allotted to the Bureau of Fisheries to study the haddock fishery.

This study soon identified two major causes of the decline. The first was the failure of annual spawning for several years; the second, a high rate of fishing mortality, this latter factor possibly influencing the spawning failures. A good percentage, as high as 75%, of the haddock being caught were undersized (22-42 cm) and discarded at sea. Herrington (1932) estimated that in 1930, 37 million haddock were landed and as many as 90 million were discarded.

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It was fairly well established by the 1930's, by many European researchers, that a definite relationship existed between cod end mesh size and the escapement of small fish from the trawl. Herrington (1935) conducted mesh experiments aboard the research vessel *Albatross III* and the commercial draggers *Exeter* and *Kingfishery* using "trouser trawls" and large mesh cod ends (about a 5-in mesh). He recommended, from the results of this work, that industry adopted at least a 4¾-in mesh size and that even a 5¼-in mesh should be considered. Many leading captains were already fishing large-mesh trawls.

In 1934 the haddock landings had dropped to 50 million lb and then steadily increased to 122 million lb by 1941. From 1941 to 1951 the average annual landings from Georges Bank was 96 million lb. There were no definite trends in abundance evident, so the fishery was assumed to be in some state of equilibrium (Graham 1952a). During this period the commonly used cod ends averaged 2⅞ in stretched mesh (Graham 1952b).

Graham (1952a) estimated that the annual discard rate of small haddock during this equilibrium period was over 5 million lb. It was felt that if this destruction could be decreased the fishery could be stabilized at a higher level of production, as long as there were not any major changes in the socioeconomic relationships.

At the first annual meeting of the International Commission for the Northwest Atlantic Fisheries (ICNAF) in 1951, the subject of protecting the small haddock received much attention, and by June 1953 a 4.5-in mesh size (stretched mesh) went into effect on Georges Bank and in the Gulf of Maine (Graham and Premetz 1955). The idea was to advance the age of first capture (actually the 50% retention length of first capture) to 3 yr in two steps so as to avoid major short-term reduction in catch. The 4.5-in mesh size was the first step and was calculated to advance the age of first capture to 2.5 yr. This was calculated to increase the annual landings to a level 30% higher than the existing equilibrium if fishing effort remained constant (Graham 1954).

After the first step was taken, the plan was to monitor the effects of the regulation. This was performed by issuing a special license to several trawlers (eight in 1955) to fish small mesh nets while the remainder of the fleet fished the new, larger regulation mesh.

There was objection to the new mesh size by many in the industry. Graham (1954) quoted fishermen as saying, "We can't possibly make a living fishing with a large mesh like that." "This won't hold any fish at all. They'll all get through." However, by the end of the first year of regulation the results were increased landings. The large-mesh nets were more efficient in capturing larger fish. They landed more fish (by weight) than the small mesh in three of the four quarters (Graham and Premetz 1955).

During the 1950's, extensive gear studies were carried out by many nations in ICNAF areas. The majority of the work was on otter trawl (cod end) selectivity for haddock; lesser amounts on cod, redfish, American plaice, and silver hake. Clark et al. (1958) summarized the gear-selection information for the ICNAF area up until 1958. These experiments, along with numerous experiments in Europe, tremendously improved the state of knowledge on selectivity.

Two major publications summarize this state of knowledge. The first contains 24 papers given at the Joint ICNAF/ICES/FAO special scientific meeting in Lisbon in 1957 (ICNAF 1963). The second is the report of the ICES/ICNAF working groups on selectivity analysis edited by M. J. Holden (1971). This report contains an extensive bibliography and tabulation of selectivity experiments.

In 1961 a working group of ICNAF scientists met to discuss the possible effects of increased mesh size (4 to 6 in) on cod, haddock, redfish, and other species (ICNAF 1962). Their conclusions did not take into account the large increase in fishing effort that soon followed, and thus underestimated the benefits of increasing mesh size (Templeman and Gulland 1965). A review of this period in the haddock fishery can be found in Clark et al. (1982).

In March of 1977 the Fisheries Management and Conservation Act became law, forming regional councils to manage the nation's fisheries. Also in 1977 the large 1975 year class of haddock entered the Georges Bank fishery and there was a major discard of undersized fish. A cooperative study, under the auspices of the New England Fishery Management Council, began in late 1977 to study the possible effects of increasing mesh size and is contained in this report following the next section. To better understand this study, a review of selectivity follows.

SELECTIVITY REVIEW

Selectivity is the measure of the process of selection; the process in which a subgroup of a population is distinguished from the whole. The characteristics that create the selection process can be almost anything intrinsic to a particular fish — size, shape, sex, and behavior. The fishing gear and methods used and the area fished will determine what species and size fish will be selected from the overall population.

This paper is primarily concerned with the size selectivity of the cod ends of otter trawls used in the New England groundfishery. The forward parts of the trawl do affect the size selection of the trawl, but the study of these effects is beyond the scope of this paper.

As mentioned previously, Alexander et al. (1915) did not believe the cod end mesh size would affect the escapement of small fish. The research referenced by Herrington (1935) demonstrated this was not the case in fact, but how and when escapement did occur was still unknown. Many fishermen felt that the fish could not escape while the net was being towed but only during haulback when the vessel was not moving (Davis 1934a). Davis went on to prove that greater escapement occurred while under tow as compared with haulback.

Herrington (1935) quantified his data in terms of a coefficient of selection; a measure of the sharpness of selection. He could not determine whether the size of the catch affected the selectivity but did determine that the type of twine played an important role. Using European data and his own, he found that the coefficient of selection over a range of mesh sizes was approximately constant.

Jensen (1949) identified Todd and Buchanan-Wollaston as some of the first users of the 50% retention point (or release point) in describing selectivity. This is the point at which half the fish of a particular size are retained by a certain mesh size and the other half escape. Jensen developed the straight line relationship between 50% release (retention) length (l) and the inner length of the mesh (m):

$$c = \frac{l}{m}.$$

He called c the relative releasing effect; today we call it the selection factor. For cod and haddock he found c to be about 3.0.

As the concept of the selection factor came into standard use, researchers were better able to compare their results on a quantitative basis to gain understanding of those things that affect selection. What follows is a summary of this knowledge in regard to gear-related effects as demonstrated by shifts in the value of selection factors.

The most important aspect of determining a selection factor is the actual method employed. There are two basic methods used for studying the selectivity of an otter trawl cod end: 1) Covered cod end method. A small-mesh cover is placed over the cod end, loosely fitted, so as to capture all those fish that escape through the cod end meshes. The catches of the cod end and cover are then compared. 2) Alternate haul method. Two uncovered cod ends are fished; one being much smaller in mesh size than the one for which the selection curve is being determined. The experiment can be conducted by one vessel alternating cod ends either systematically or randomly, by two vessels parallel fishing the two different meshes, or by one vessel fishing a trouser trawl (a trawl with two cod ends side by side). This latter variant is considered by most as unsatisfactory because the cod end catches may be affected by factors other than mesh size.

The covered cod end method is normally considered the best as it takes the least amount of time to obtain good results and is a true measure of what actually escapes the cod end. The major drawback of this method is the possibility of the cover "masking" the cod end. This masking effect can consist of the cover physically blocking the cod end meshes, fish swimming back into the cod end from the cover, fish perceiving the presence of the cover, and effects on water flow through the cod end.

The main advantage of the alternate tow method is that there is no cover bias. For this reason it may more accurately reflect the real selectivity that would be experienced in the related commercial fishery. However, a larger number of tows is needed to generate comparable selection curves. Assumptions also have to be made on the relative efficiency of the two mesh sizes in order to calculate the selection factor. Alternate tows usually give higher selection factors than covered tows, probably due to the masking effects of the cover and the increased efficiency of uncovered cod ends on the larger size fish. This phenomenon has mostly been observed with cod and haddock but not with plaice (Saetersdal 1963).

Another aspect of the experimental design that ultimately affects the selection factor is the mesh-measuring method used. The two common methods employed are the use of a vertical gauge, such as a wedge-shaped one inserted into the mesh (Clark 1963), or a longitudinal gauge which looks like a slide caliper (Fig. 1). Most of the gauges have a means to exert a known pressure so as to stretch the mesh in a consistent manner. Hodder and May (1965) found that a gauge set for 5.5 kg pressure gave readings 1.04 times higher than one set for 4 kg pressure, providing different selection factors. Beverton and Bedford (1958) discussed variations in measurement between operators and gauge types.

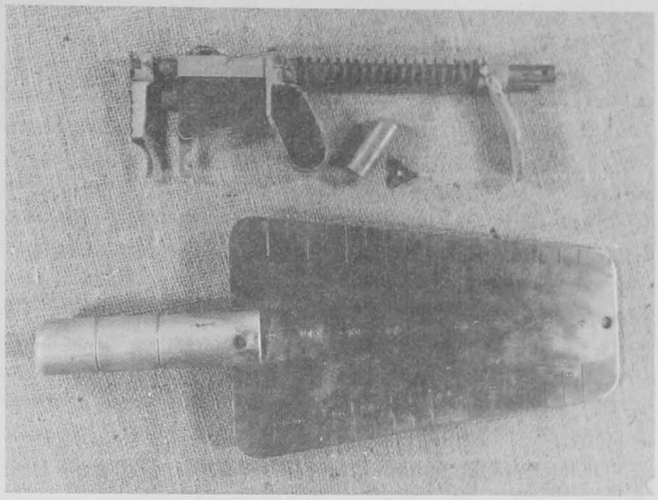

Figure 1. — Mesh gauges.

Once a fish enters the trawl it may escape through the forward netting sections as well as the cod end. Ellis (1951) discussed some unpublished work of Bowman from 1923 that demonstrated that forward escapement does occur, although Clark (1963) determined escapement in the body of the trawl to be small for haddock. Of those that do escape, he estimated 10% escape through the top belly, 30% through the lower belly, 60% through the lower wings, and none through the square and top wings. Nearly all of the smaller haddock escaped through the forward parts. Ellis (1963) reported higher escapement from the forward parts for active swimming fish, the lengths of the fish being similar to those escaping through the cod end.

Margetts (1963) found that escapement varied with species and between the two vessels used in his experiment. He hypothesized that this was due to the rigging of the nets and related fish behavior. He concluded that considerable, and highly variable, quantities of fish can escape from the forward parts of the trawl. For this reason the fish entering the cod end are not necessarily representative of the fish entering the mouth of the trawl. Indications are that due to variations in the forward parts of the trawl the selection factor calculated for a particular cod end mesh size may vary. There are other, more complicated, factors such as the physical condition of the fish entering the trawl and the hydrodynamic relationships between the parts of the trawl that may play an important role (Clark 1960).

There are variations in the cod end itself that affect the selection factor. It has been shown that escapement is mostly from the aft upper portion of the cod end (Beverton 1963; Clark 1963). It is usually this part of the cod end where the meshes have been stretched the most by the weight of the fish when hauled out on deck. When calculating the selection factor, this should be taken into account if these stretched meshes differ from the overall mean cod end mesh size.

The type of material a cod end is made of affects its selectivity, but how and why are still mysteries. Two twines may differ in more than a dozen ways, such as material, type of fiber, method of construction, Rtex value, runnage, treatment, elongation properties, strength, flexibility, and physical size.

The two most common materials used in the New England fishery are nylon (polyamide) and polypropylene. In comparison fishing these two materials, Bohl (1966) found that for haddock a polyamide cod end gave selection factors about 7-10% higher than a polypropylene one. He reasoned this was due to the greater extensibility of the polyamide and the fact the polypropylene webbing had larger knots. In further studies, Bohl (1968) compared three different types of polypropylene twine (splitfiber, continuous, and monofilament); results indicated no significant difference in selectivity even though physical properties were very different. Bohl (1971) also found no significant differences in the selection factor between a "normal" polyamide cod end and an extra-strong one. He also failed to find a correlation between elongation and selectivity. In general, polyamide gives the highest selection factors, followed by polyester, polypropylene, and manila (Pope et al. 1975).

Very little is known about the relationship between towing speed and selectivity. This is probably due to the practical difficulty of accurately measuring the speed of the trawl over the bottom and maintaining other parameters constant. Trawl mensuration studies at the Northeast Fisheries Center on "36" and "41" Yankee trawls indicated that varying towing speed within the range of 2.5-4.0 kn can change the headrope height by several feet. If, for example, the larger fish of a particular species stay further off the bottom than the smaller ones, by varying speed so as to increase headrope height the trawl will select the larger fish. This will ultimately show up in the selection factor calculated for the cod end.

It has also been shown that towing speed affects the hydrodynamics of the trawl. Beverton and Margetts (1963) found the drag increases approximately exponentially with towing speed. They calculated, at speeds of 3-4 kn, drag forces on 53, 69, and 215 mm mesh cod ends of 800, 700, and 150 lb, respectively. There is little doubt that speed affects the tension in the twine of the cod end meshes and thus probably the selectivity. The Russians, realizing this fact, have studied this approach in their trawl design efforts (Treschev 1963). Saetersdal (1960) did find a tendency of the selection factors for cod to increase with decreasing speed in the range of 2-3 kn as indicated by the ship's speed log, but this was not evident for haddock.

Clark (1963) found that the longer the tow the higher the escapement and thus the selection factor for haddock. The selection factors went from 3.0 for 20-min tows to 3.4 for 80-min tows. Pope and Hall (1966) did not find a marked effect, like Clark, for haddock but did see a tendency for higher selection factors in 2-h tows compared with 1-h tows. The general explanation for the above phenomenon is that the longer tow time gives a fish more opportunity to make repeated attempts at escape. As tow time increases so usually does the catch and this may have a counterbalancing effect.

Clark (1963) found that for haddock the selection factor decreased with larger catches; the 50% retention point decreasing by as much as 5 cm. McCracken (1963) reported no change in haddock selection factors for catches up to 1,000 fish/tow; however, there was a slight drop in selection factors for larger tows. He could not demonstrate this effect for cod. Hodder and May (1964) presented data indicating slight decreases in selection factors for cod and haddock with larger catches, but not of a magnitude to affect assessments. There are several papers that report no apparent effects (ICES 1965; Pope and Hall 1966).

There are a number of reasons that have been advanced to explain lower selection factors for larger catches. The fish would have less of a chance to be selected by the larger meshes at the aft end of the cod end. There may be more tension on the meshes making them less flexible, or the meshes may just become blocked. Schooling behavior may even come into play. On the other hand, Pope et al. (1975) reported that this effect has only been observed in covered cod end tows and thus may be an artifact of the method. With larger catches more fish may be swimming back into the cod end from the cover or may be escaping forward of the cover, thus reducing the apparent selectivity.

While it is generally assumed that selection factors are relatively constant through a range of mesh sizes, this has been shown not to hold in certain cases. Clark (1963) demonstrated that for silver hake the selection factor increases with mesh size. He reasoned that this was due to a greater flexibility of the larger mesh allowing more fish to force their way through.

Another aspect of selectivity that varies with mesh size is the selection range, the area between the 25% and 75% retention lengths on the selection curve where most of the escapement occurs. The smaller the selection range, the sharper the selection. Clark et al. (1958) found that for haddock the selection range for a 75 mm mesh was 4 cm compared with 14 cm for a 150 mm mesh.

As mentioned previously, trawl efficiency apparently increases with cod end mesh size for most species. Davis (1934b) was one of the first to observe this phenomenon for haddock. A larger mesh caught more of the larger size fish. Clark (1963) and Templeman (1963) reported similar results. Evidence exists that indicates this increased efficiency is not related to an increase in speed or ground covered by the larger mesh (Beverton and Margetts 1963; Clark 1963). Beverton and Margetts also indicated that the decrease in drag of a trawl caused by having a larger mesh cod end is relatively insignificant.

The escapement ability, hence the selection factor, can vary considerably from one species to another. The relationship between the shape of the mesh and the shape of the fish is considered important. Roundfish tend to have a cross-sectional shape more nearly matching that of a mesh than flatfish, and thus tend to have a higher escapement rate for a particular length. The behavioral response of a particular species to a net is a key factor also. Clark (1963) has demonstrated for silver hake that this species has a lower escape response when compared with other species. In general, for roundfish, when girth is compared with mesh circumference, the majority of the fish that theoretically can fit through do in fact escape. Draganik and Zukowski (1966) found that haddock which escaped from

Table 1. — Selection factors.

Species	Single-twine	
	Polyamide (nylon)	Polypropylene
Atlantic cod	3.6	3.5
Haddock	3.4	3.3
Yellowtail flounder	2.3	NA[1]
Winter flounder	NA	NA
American plaice	2.3	NA
Pollock	NA	NA

[1]NA = Not available.

the cod end, and were retained in the cover, weighed less than fish of equal length retained in the cod end.

In experiments conducted by Pope and Hall (1966), they could find no relationship between selection factor and depth or daylight vs. darkness. It is also the general opinion of researchers that cod end selectivity is not appreciably affected, at least directly, by the size of the vessel or gear (McCracken 1963; Pope and Hall 1966; Bohl 1967).

Table 1 is a summary, from the best information available as reported by Holden (1971), of the selection factors of the species with which this report is concerned for New England waters.

NEW ENGLAND MESH STUDY

This study consisted of four series of experiments in which two commercial fishing vessels performed both covered and uncovered cod end tows. In general, the procedures used were adopted from Pope et al. (1975). All tows were 1-h duration, conducted during daylight hours. The captains followed normal commercial practice of changing course to follow contours, going around hard bottom (rock piles), and pursuing fish traces on the echo sounder. Vessel and gear specifications can be found in Appendices A and B.

The sampling techniques were basically the same in all four experiments. At the conclusion of each tow, the cod end and cover catches (if a cover was used) were kept segregated. The gear was meticulously checked and net damage and other occurrences that may have affected the validity of the tow were recorded. Cod end and cover knots were tied tight and a piece of old webbing was placed in the end to prevent leakage of catch.

After each tow, 30 cod end meshes were measured along the top of the cod end in one row starting aft and running forward. They were measured using an ICES longitudinal-type mesh gauge set at 4 kg pressure. The segregated catches (cod end and cover, when used) were worked up separately. Any fish found forward of the cod end were excluded because they may not have undergone the cod end selection process. The catch was sorted by species into 1- and 2-bu baskets, weighed, and length-frequency data recorded for each species. In many cases, to save time, the catch was not weighed but all lengths were taken and length-weight equations used to determine catch weight. Randomly selected 2-bu subsamples were taken if the catch was too large to handle by this means. Girth data were also recorded at intervals throughout the experiments using tape measures.

In 1975, mesh sizes used in the USA Subarea 5 (Gulf of Maine and Georges Bank) cod and haddock fisheries ranged from 110 to 129 mm (4.3 to 5.1 in), with the majority of cod ends examined (>85%) having mesh sizes from 115 to 124 mm (4.5 to 4.9 in) (ICNAF 1976). Trawl cod end mesh sizes used in the 1975 yellowtail flounder fishery ranged from 110 to 139 mm (4.3 to 5.5 in), with most cod end meshes between 115 and 129 mm (4.5 and 5.1 in).

The small mesh size chosen for these experiments was the most commonly used "large" mesh cod end available in New England. It was constructed of #102 braided nylon twine (runnage 73.76 m/kg) and sold as 4.5-in webbing. The actual average dry-mesh measurement of these cod ends new was 108 mm (4.25 in), due to steam treatment during manufacture. The larger mesh size was chosen on the basis of increasing the minimum size of cod to 52 cm (20.5 in) or an age-at-first-capture of 3 yr. Using a selection factor of 3.6, this indicated a mesh size of 144 mm (5.7 in). As no webbing of this size was available, handmade cod ends of 154 mm (6.06 in) were constructed to allow for shrinkage.

It was noted that measurements for the small "4.5-inch" commercial cod ends used tended to be smaller than the recorded average for the fishing fleet — 4.2 in vs. the fleet's 4.75 in. It was assumed that this was due to differences in methodology and a mesh-measuring comparison test was conducted. A National Marine Fisheries Service (NMFS) enforcement agent, using a wedge-type gauge, measured 10 meshes on one of the large experimental cod ends. The same meshes were then measured using the wedge gauge with a 5 kg weight and the ICES gauge set at 4 kg tension (Fig. 1). The average readings were 144.8 mm (5.7 in), 143.0 mm (5.63 in), and 135.0 mm (5.3 in), respectively. Random measurements were then taken on our commercial-sized cod end. The ICES gauge indicated a little over 4 in. The wedge gauge readings were about 4.5 in; however, the gauge could be wedged in further to read 4.75 in or greater (the NMFS enforcement agent said that this is the routine procedure in the field).

Experiment One

This experiment was conducted from the fishing vessels *Frances Elizabeth* and *Christopher Andrew* on 12, 13, and 15 December 1977 in inshore waters off Scituate, Mass. (Fig. 2). On each of the 3 d four tows were made; small- and large-mesh cod ends fished covered and uncovered. The order of the tows was chosen at random and followed by both vessels together, usually within a kilometer of each other. Vessel speed was maintained at 2.0-2.5 kn.

All cod ends were measured dry before starting the experiment. The small cod ends of machine-made webbing initially

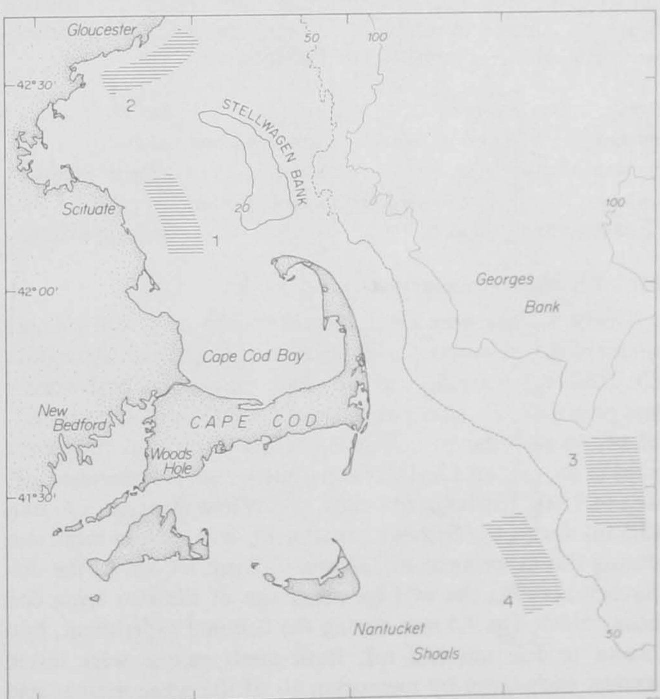

Figure 2. — Location chart of mesh experiments.

averaged 108 mm in size but by the second and third day of the experiment averaged 106 mm. The twine used for the hand-made larger cod ends apparently was not heat-treated. The dry measurements averaged 154 mm and during the experiment the mesh averaged 139 mm, a 10% shrinkage rate. No stretching of the twine was observed during the experiment. There was no consistent variation between meshes of the forward and aft parts of the cod end as would be logically expected with larger catches. In the small mesh there was a maximum range of 16 mm (0.6 in) between mesh sizes. In the large mesh the maximum range was 23 mm (0.9 in). A series of standard error calculations (Appendix C) shows that the 95% confidence limits are within 1 mm of the sample mean.

The tows were conducted as described previously. On the first day a number of problems were encountered. The twine started to freeze before mesh measurements could be taken. During Tow 2 a cover float flooded on the *Christopher Andrew*, causing a marked masking effect. During Tow 3 the *Frances Elizabeth* caught a large object that caused a door (otter board) to capsize. Tow 4 was scrubbed because of darkness and the resulting change in fish population available to the gear. For these reasons the first day's data were not used in the overall analysis. All data presented, unless otherwise indicated, are for only the second and third days of this experiment. Appendix D presents the basic tow information. Appendix E is a listing of the catch by weight per tow. The "flounders" category consisted mostly of winter flounder, though some American plaice were included. The "other" category consisted mainly of skates; sculpin (*Myoxocephalus* sp.), goosefish, *Lophius americanus;* crabs; and windowpane flounder, *Scophthalmus aquosus.*

Experiment Two

This experiment was conducted from the fishing vessels *Linda B* and *Metacomet* on 22, 23, 25, and 28 March 1978, in inshore waters off Gloucester, Mass. (Fig. 2). The experiment consisted of four four-tow series by each vessel. The towing order was chosen to minimize cod-end changes during the experiment and thus consisted of the following:

Day 1	*Day 2*	*Day 3*	*Day 4*
Sm mesh	Lg mesh w/cover	Sm mesh w/cover	Lg mesh
Sm mesh w/cover	Lg mesh	Sm mesh	Lg mesh w/cover
Lg mesh	Sm mesh w/cover	Lg mesh w/cover	Sm mesh
Lg mesh w/cover	Sm mesh	Lg mesh	Sm mesh w/cover

Both vessels towed together at 2.5-3.0 kn.

Thirty meshes were measured after each tow, and means, standard deviations, and standard errors calculated (Appendix C). The mean mesh size for the small cod ends on both vessels was practically the same, equalling 99 mm (3.9 in) when rounded off to the nearest millimeter. These same cod ends were used in the previous Scituate experiment and had averaged 106 mm (4.2 in). The large cod ends, which had averaged 139 mm (5.5 in) during the Scituate experiment, had a mean mesh size during this experiment of 131 mm (5.2 in). However, the difference between the average mesh size of the two large cod ends, which was 3.5 mm during the Scituate experiment, had grown to 5.3 mm (0.2 in). Both mesh gauges were tested against each other by measuring 10 of the same meshes and found to be reading the same. In addition, each gauge was tested by pulling against a calibrated spring scale and found to be calibrated correctly at 4 kg pressure.

There were large variations in catch size and composition between tows, even on a daily basis, making an actual catch comparison between cod end sizes difficult. Many tows came up with lost lobster traps and big pieces of waterlogged wood that were in the area due to a large February storm. The *Linda B* snagged 14 lobster traps in 6 tows, the largest catch being 4 traps. The *Metacomet* snagged 6 traps in 2 tows, one tow accounting for 5 traps. The traps' condition varied from good to broken up. There were no lobsters in any of the traps nor any good buoys or lines attached. The traps were all found on sand or mud bottom. Most of the traps were caught on the twine forward of the trawl extension. No obvious effect on mesh selectivity was apparent.

The basic catch data are presented in Appendix E. The "other" category consisted mainly of windowpane flounder, sculpin, skates, crabs, and sea ravens. The *Metacomet* grouped the ocean pout with the "other" category. There was a small incidental catch of goosefish; lumpfish, *Cyclopterus lumpus*; Atlantic wolffish, *Anarhichas lupus*; grey sole, *Glyptocephalus cynoglossus*; and 12 lobsters (*Homarus americanus*). One small Atlantic halibut, *Hippoglossus hippoglossus,* a 15-lb sturgeon, and a 74 cm haddock were caught. Only a few small pollock were caught throughout the study except for *Metacomet* Tow 11 where 140 pollock (13 kg) were found in the cover, measuring 18-30 cm, the majority being 19-22 cm.

Experiment Three

This experiment was conducted from the Gloucester based fishing vessels *Joseph & Lucia II* and *Joseph & Lucia III,* 13-15 August 1978, in the offshore waters of Georges Bank (Fig. 2). The experiment consisted of three four-tow series by each vessel. The series was initially chosen, as in Experiment Two, to minimize cod end changes. However, due to problems with the covers and a large catch of pollock on board (from commercial fishing at night) that had to be landed early, the experiment consisted of the following:

Day 1	*Day 2*	*Day 3 (J&L II)*	*Day 3 (J&L III)*
Sm mesh w/cover	Sm mesh	Lg mesh	Sm mesh
Sm mesh	Sm mesh w/cover	Sm mesh	Lg mesh
Lg mesh w/cover	Lg mesh	Lg mesh	Sm mesh
Lg mesh	Lg mesh w/cover	Sm mesh	Lg mesh

On the first two days both vessels towed in the same order; on the third day the vessels alternated uncovered tows. The vessels towed within a kilometer of each other at 3.5 kn.

Thirty meshes were measured after each tow; and means, standard deviations, and standard errors calculated (Appendix C). The small cod ends on the *Joseph & Lucia II* and *Joseph & Lucia III* had mean mesh sizes of 103.7 mm (4.1 in) and 109.6 mm (4.3 in), respectively. These same cod ends averaged 99 mm (3.9 in) in the second experiment and apparently stretched during the night fishing that preceded the experiment on this trip. The large cod ends both averaged 140 mm after a 2-h break-in tow. However, during the experiment the mean mesh sizes were 135.9 mm (5.3 in) and 140.8 mm (5.5 in), respectively.

The area fished had very few small fish of any species and the catch was quite "clean" or lacking much "trash" fish.

There was hardly any fish discarded. The lack of small fish did not provide for a good data base for the use of the covered-tow method. In addition, the covers did not seem to function well. The 72-thread twisted cotton twine that the covers were made of apparently filled up with sand and mud particles, causing the covers to become exceptionally heavy. That, and the fact that our catches were large, tended to cause a masking of the cod ends. We thus switched to alternate tows exclusively on the third day. The basic catch data are presented in Appendix E. There was a small incidental catch of goosefish; wolffish; cusk, *Brosme brosme*; *Illex* squid; grey sole; and halibut.

Experiment Four

This experiment was conducted from the New Bedford based fishing vessels *Valkyrie* and *Gen. George S. Patton,* 8-11 October 1978, in the waters east of Nantucket Shoals (Fig. 2). The experiment consisted of four four-tow series and was performed in the same order as Experiment Two. Vessel speed was maintained at 3.0-3.5 kn.

Thirty meshes were measured after each tow, and means, standard deviations, and standard errors calculated (Appendix C). The small cod ends on the *Valkyrie* and *Patton* had mean mesh sizes of 108.3 mm (4.3 in) and 106.0 mm (4.2 in), respectively. The large cod end on the *Valkyrie* averaged 127.4 mm (5.0 in) and on the *Patton* averaged 134.6 mm (5.3 in).

During the nonexperimental commercial tows the vessels fished the hard bottom of Nantucket Shoals, making good catches of Atlantic cod and winter flounder. However, they tore up their nets on almost every tow. Since tear-ups invalidate experimental tows, we had to conduct our selectivity experiment on smoother bottom. Here our catches were poor and highly variable. There were very few small fish.

There were incidental catches of skates, goosefish, sculpins, squid, scallops (*Placopecten magellanicus*), herring, lobster, and halibut. The *Patton* hardly caught any Atlantic cod, compared with the *Valkyrie,* on Tows 5, 7, 14, and 16. In one case it can be attributed to a tear-up (Tow 14) and in another case to a foul-up (Tow 16). Both vessels had numerous small "hangs." All the problems added together make the data from experiment four questionable in regard to catch comparisons and selectivity analysis. The reader must keep this in mind when reviewing the following sections.

RESULTS

The results of the four experiments worked up on an independent basis can be found in the Woods Hole Laboratory reference series as Laboratory Report No. 78-12, 78-24, 78-48, and 78-54 (Smolowitz et al.[2-5]). What follows is a summary and synthesis of the four experiments on a species basis.

[2]Smolowitz, R. J., D. Arnold, and F. Mirarchi. 1978. New England mesh selectivity studies. Experiment one, inshore groundfish. Northeast Fish. Cent., Woods Hole Lab. Ref. 78-12, 44 p.

[3]Smolowitz, R. J., R. Testaverde, and M. DiLiberti. 1978. New England mesh selectivity studies. Experiment two, inshore groundfish. Northeast Fish. Cent., Woods Hole Lab. Ref. 78-24, 82 p.

[4]Smolowitz, R. J., A. Brancaleone, and G. Brancaleone. 1978. New England mesh selectivity studies. Experiment three, offshore groundfish. Northeast Fish. Cent., Woods Hole Lab. Ref. 78-48, 39 p.

[5]Smolowitz, R. J., L. Sovik, and P. Jacobsen. 1978. New England mesh selectivity studies. Experiment four, offshore groundfish. Northeast Fish. Cent., Woods Hole Lab. Ref. 78-54, 31 p.

Atlantic Cod

The selection factors for Atlantic cod were determined from each experiment's data and from combined data (Tables 2-5, Fig. 3). The range of values of these selection factors falls within the range of those reported by Holden (1971). Assuming the true selection factor lies somewhere between those determined from the covered and alternate tow methods, these experiments confirm the average polyamide selection factor of 3.6 for Atlantic cod in the North Atlantic reported by Holden

Table 2. — Atlantic cod selection factor summary.

Experiment	Total no. of fish	Selection factor Small mesh	Large mesh	Alternate tow
One	492	3.21	3.31	3.88
Two	2,510	3.19	3.37	3.59
Three	686	—	—	4.00
Four	2,024	3.64	3.74	3.96
Combined	5,712	3.33	3.41	3.80

Table 3. — Atlantic cod length frequency distributions and percent retained for the small-mesh (105 mm overall average) covered tows — all vessels.

Length interval (cm)	Numbers caught 105 mm	105 mm plus covers	Percent retained
10-12	0	0	0.0
13-15	1	7	14.3
16-18	2	27	7.4
19-21	5	52	9.6
22-24	3	32	9.4
25-27	7	26	26.9
28-30	17	42	40.5
31-33	42	110	38.2
34-36	104	181	57.5
37-39	206	264	78.0
40-42	203	219	92.7
43-45	220	226	97.3
46-48	153	158	96.8
49-51	79	79	100.0
52-54	109	111	98.2
55-57	74	76	97.4
58-60	69	71	97.2
61-63	46	46	100.0
64-66	75	76	98.7
67-69	81	81	100.0
70-72	82	82	100.0
73-75	86	86	100.0
76-78	79	79	100.0
79-81	53	53	100.0
82-84	33	33	100.0
85-87	20	20	100.0
88-90	12	12	100.0
91-93	21	21	100.0
94-96	8	8	100.0
97-99	12	12	100.0
100-102	9	9	100.0
103-105	11	11	100.0
106-108	4	4	100.0
109-111	3	3	100.0
112-114	—	—	—
115-117	1	1	100.0
118-120	—	—	—
121-123	—	—	—
124-126	1	1	100.0
Totals	1,931	2,319	

Table 4. — Atlantic cod length frequency distributions and percent retained for the large-mesh (135 mm overall average) covered tows — all vessels.

Length interval (cm)	Numbers caught 135 mm	Numbers caught 135 mm plus covers	Percent retained
10-12	0	3	—
13-15	0	6	—
16-18	1	25	—
19-21	0	49	—
22-24	1	46	—
25-27	0	44	0.0
28-30	1	50	2.0
31-33	2	71	2.8
34-36	7	71	9.9
37-39	12	61	19.7
40-42	13	60	21.7
43-45	20	59	33.9
46-48	21	32	65.6
49-51	19	26	73.1
52-54	19	26	87.1
55-57	27	31	94.2
58-60	49	52	95.8
61-63	46	48	100.0
64-66	54	54	100.0
67-69	73	73	100.0
70-72	94	94	98.2
73-75	55	56	100.0
76-78	60	60	100.0
79-81	43	43	100.0
82-84	29	29	100.0
85-87	12	12	100.0
88-90	11	11	100.0
91-93	5	5	100.0
94-96	12	12	100.0
97-99	—	—	—
100-102	7	7	100.0
103-105	4	4	100.0
106-108	3	3	100.0
109-111	1	1	100.0
135	1	1	100.0
Totals	702	1,225	

Table 5. — Atlantic cod length frequency distributions and percent retained from uncovered cod end tows — all vessels.

Length interval (cm)	Numbers caught (A) 105 mm	Numbers caught (B) 135 mm	$\frac{B}{A}$		% retained by 135 mm $\frac{B}{1.6A} \times 100$
10-12	0	0	0.00		0.0
13-15	0	0	0.00		0.0
16-18	0	0	0.00		0.0
19-21	1	0	0.00		0.0
22-24	1	0	0.00		0.0
25-27	5	0	0.00		0.0
28-30	16	1	0.06		3.9
31-33	31	2	0.06		4.0
34-36	64	4	0.06		3.9
37-39	83	12	0.14		9.0
40-42	124	14	0.11		7.0
43-45	99	22	0.22		13.9
46-48	59	30	0.51		31.8
49-51	60	33	0.55		34.4
52-54	61	55	0.90		56.4
55-57	51	60	1.18		73.5
58-60	61	80	1.31		82.0
61-63	58	88	1.52		94.8
64-66	50	106	2.12		132.5
67-69	58	108	1.86	Avg.	116.4
70-72	63	109	1.73	1.60	108.1
73-75	55	106	1.93		120.4
76-78	44	60	1.36		85.2
79-81	33	49	1.48		92.8
82-84	15	23	1.53		95.4
85-87	17	12	0.71		44.1
88-90	7	12	1.71		107.1
91-93	8	8	1.00		62.5
94-96	8	7	0.88		54.7
97-99	5	1	0.20		12.5
100-102	1	5	5.00		312.5
103-105	3	1	0.33		20.8
106-108	2	5	2.50		156.3
109-111	2	2	1.00		62.5
112-114	1	1	1.00		62.5
121-123	1	0	0.00		—
135	1	0	0.00		—
Totals	1,148	1,016			
	$\frac{\Sigma A}{55} = 544$	$\frac{\Sigma B}{55} = 843$	$\frac{\Sigma B / 55}{\Sigma A / 55} = 1.55$		

(1971). It is also interesting to note that in each experiment the selection factor determined for the large mesh size was greater than that found for the small mesh. This may indicate a nonlinearity in the selection factor for Atlantic cod similar to that found by Clark (1963) for silver hake. However, there was no appreciable difference in selection range between the two mesh sizes which in each case was about 9 cm.

Atlantic cod girths were taken randomly throughout the experiment and found to have little variance from the published means for girth-length ratios. The girth-length relationships from Margetts (1957) and later confirmed by Messtorff (1958) are represented by the following equations:

$$\text{length} = \text{natural girth} \times 1.95$$

$$\text{length} = (\text{constricted girth} \times 2.03) + 0.7.$$

Most of the sample girths during this series of experiments fell close to the range indicated by the above two equations (Fig. 4).

Table 6 demonstrates an interesting point. For the combined catch during the experiment the large mesh outfished the small mesh, on a weight comparison basis, in all conditions: no discard, 42 cm (16 in) discard, and 52 cm (20 in) discard lengths.

Haddock

The tables and graphs in this section represent the data from 24 tows made during the third experiment. The total catch consisted of 4,463 haddock. Looking at the length frequency distributions (Table 7) of the haddock from cod ends and covers, it can be seen that both vessels and both size cod ends sampled the same populations. This is further demonstrated in Figure 5. Reviewing the "cod ends only" distributions, "masking" can be detected when comparing the 138 mm covered cod ends with the 138 mm uncovered; a higher percentage of smaller fish were caught in the former.

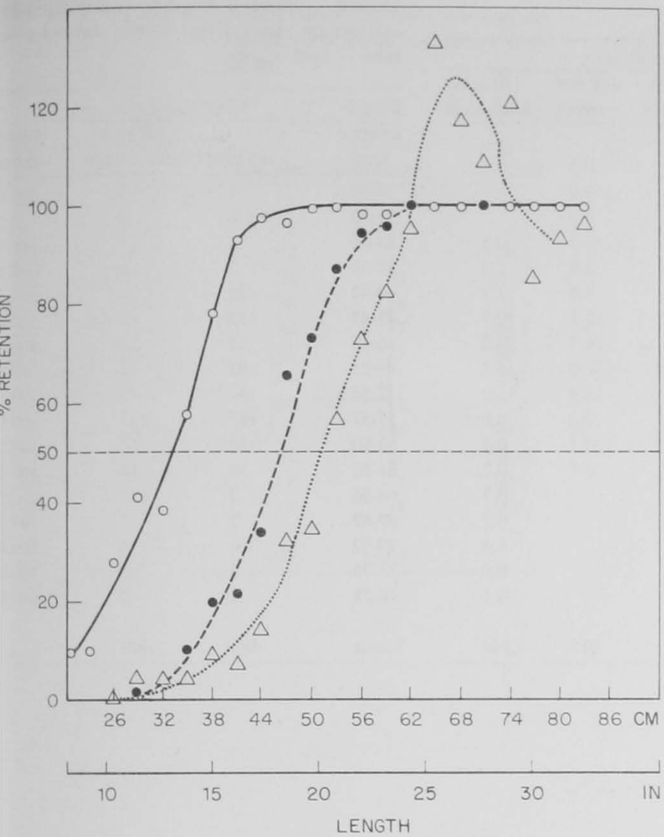

Figure 3. — Selection curves — cod. Solid line = 105 mm covered; dash line = 135 mm covered; dot line = 135 mm uncovered.

Selection data for the 107 mm covered cod end tows are given in Table 8 and the corresponding selection curve, drawn by eye, is shown in Figure 6. The 50% retention length of approximately 34 cm (13.4 in) gives a selection factor of 3.17. Selection data for the 138 mm covered cod end tows are given in Table 9, and the corresponding selection curve is shown in Figure 6. The 50% retention length of approximately 42 cm (16.5 in) gives a selection factor of 3.04. Selection data for the 107 mm and 138 mm uncovered tows are given in Table 10. (For a detailed explanation of the methodology, refer to Pope et al. 1975.) From this method, a 50% retention length of 48 cm (18.9 in) is obtained for the 138 mm cod end which gives a selection factor of 3.47.

The portion of the available population, represented by the cod-ends-plus-covers curve, that each cod end selects is shown in Figure 7. Very few fish were present below the selection range of the 107 mm cod ends. As expected, the larger cod end caught fewer of the smaller fish. A review of the length frequency distributions shows that the larger cod end caught more of the larger size fish than the small cod end. Table 11 shows the effect of this increased efficiency in higher landings of the large cod end.

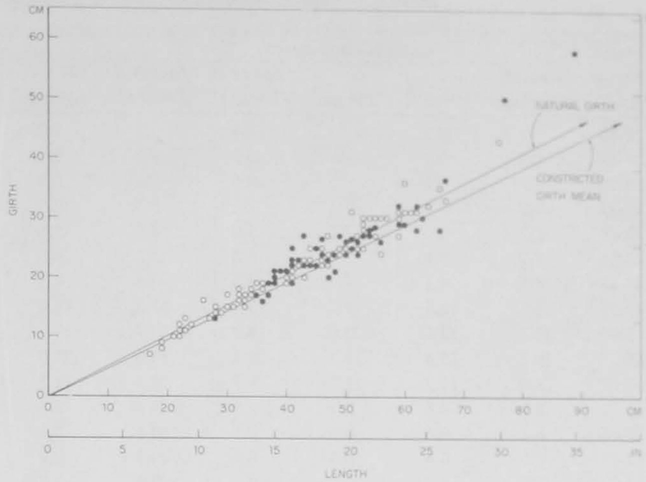

Figure 4. — Cod girth to length relationships. Solid circles = Scituate; open circles = Gloucester.

Table 6. — Atlantic cod landings.

Length interval (cm)	Kg/fish	Small uncovered		Large uncovered	
		No.	Kg	No.	Kg
10-12	0.03				
13-15	0.04				
16-18	0.04				
19-21	0.04	1	0.04		
22-24	0.09	1	0.09		
25-27	0.13	5	0.7		
28-30	0.22	16	3.5	1	0.2
31-33	0.34	31	10.5	2	0.7
34-36	0.45	64	28.8	4	1.8
37-39	0.58	83	48.1	12	7.0
40-42	0.67	124	83.1	14	9.4
43-45	0.85	99	84.2	22	18.7
46-48	1.03	59	60.8	30	30.9
49-51	1.21	60	72.6	33	39.9
52-54	1.44	61	87.8	55	79.2
55-57	1.71	51	87.2	60	102.6
58-60	2.07	61	126.3	80	165.6
61-63	2.30	58	133.4	88	202.4
64-66	2.66	50	133.0	106	282.0
67-69	3.02	58	175.2	108	326.2
70-72	3.38	63	212.9	109	368.4
73-75	4.10	55	225.5	106	434.6
76-78	4.50	44	198.0	60	270.0
79-81	5.40	33	178.2	49	264.6
82-84	5.90	15	88.5	23	135.7
85-87	6.30	17	107.1	12	75.6
88-90	7.20	7	50.4	12	86.4
91-93	7.70	8	61.6	8	61.6
94-96	8.60	8	68.8	7	60.2
97-99	9.90	5	49.5	1	9.9
100-102	10.80	1	10.8	5	54.0
103-105	11.70	3	35.1	1	11.7
106-108	12.60	2	25.2	5	63.0
109-111	13.50	2	27.0	2	27.0
112-114	14.40	1	14.4	1	14.4
121-123	19.40	1	19.11		
135	29.70	1	29.7		
Totals		1,148	2,537.4	1,016	3,203.7
Landings (discard <42 cm)			2,362.6		3,184.6
Landings (discard <52 cm)			2,145.0		3,095.1

Table 7. — Length frequency distribution (%) of haddock.

Length interval (cm)	Cod ends and covers					Cod ends only			
	Overall average	107 mm	138 mm	*Joseph & Lucia II*	*Joseph & Lucia III*	107 mm covered	107 mm uncovered	138 mm covered	138 mm uncovered
28-30	0.1	0.2		0.1		0.2			
31-33	0.2	0.4	0.1	0.1	0.3	0.0		0.1	
34-36	0.3	0.6	0.2	0.5	0.1	0.4	0.1	0.0	
37-39	1.2	1.5	1.1	1.6	0.9	0.9	0.9	0.2	
40-42	4.7	5.6	4.2	5.0	4.3	5.3	3.5	2.5	0.6
43-45	5.7	5.9	5.6	6.2	5.2	6.0	6.2	3.9	1.2
46-48	4.5	4.1	4.7	4.5	4.5	4.1	5.9	4.4	2.8
49-51	12.7	13.5	12.2	13.9	11.5	13.6	12.9	12.1	10.7
52-54	26.2	27.2	25.6	24.4	27.7	27.7	26.2	26.7	28.8
55-57	28.2	25.4	29.7	28.4	28.0	25.8	26.9	31.9	34.3
58-60	12.8	11.1	13.7	11.7	13.7	11.3	13.1	14.9	15.8
61-63	2.3	2.6	2.1	2.1	2.4	2.6	2.5	2.3	4.0
64-66	0.6	0.6	0.6	0.5	0.6	0.6	0.9	0.7	0.8
67-69	0.3	0.4	0.3	0.4	0.3	0.4	0.2	0.3	0.1
70-72	0.3	0.7		0.3	0.3	0.8	0.3		0.3
73-75	0.0	0.0		0.0		0.0	0.2		0.3
76-78	0.1	0.4		0.3		0.4	0.1		0.3
79-81									0.0
82-84									0.1
Totals	1,547	540	1,007	761	786	531	1,372	915	1,544

Table 8. — Haddock length frequency distributions and percent retained for 107 mm cod end covered tows — both vessels.

Length interval (cm)	Numbers caught		Percent retained
	107 mm	107 mm plus covers	
28-30	1	1	100.0
31-33	0	2	0.0
34-36	2	3	66.6
37-39	5	8	62.5
40-42	28	30	93.3
43-45	32	32	100.0
46-48	22	22	100.0
49-51	72	73	98.6
52-54	147	147	100.0
55-57	137	137	100.0
58-60	60	60	100.0
61-63	14	14	100.0
64-66	3	3	100.0
67-69	2	2	100.0
70-72	4	4	100.0
73-75	0	0	100.0
76-78	2	2	100.0
Totals	531	540	

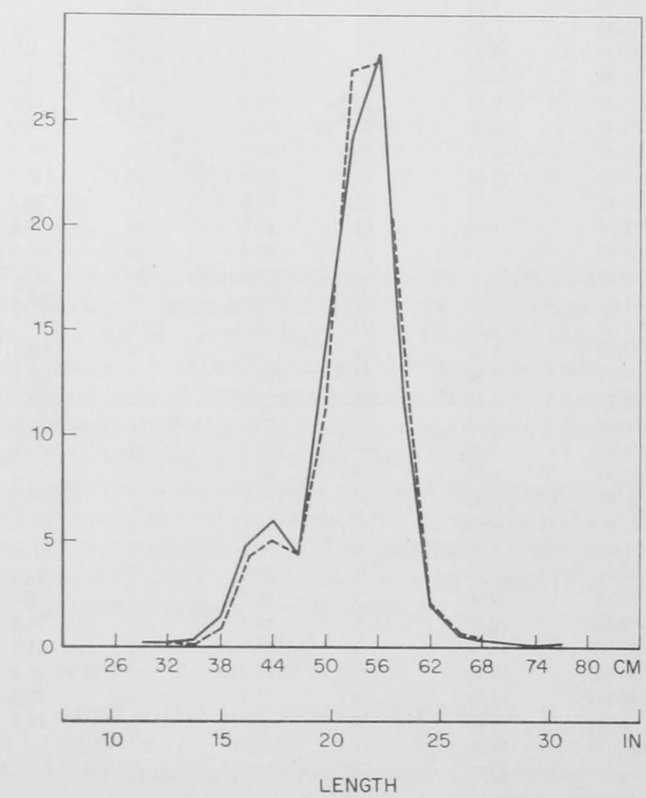

Figure 5. — Vessel comparisons — haddock. Cod ends + covers: solid line = *Joseph & Lucia II*; dash line = *Joseph & Lucia III*.

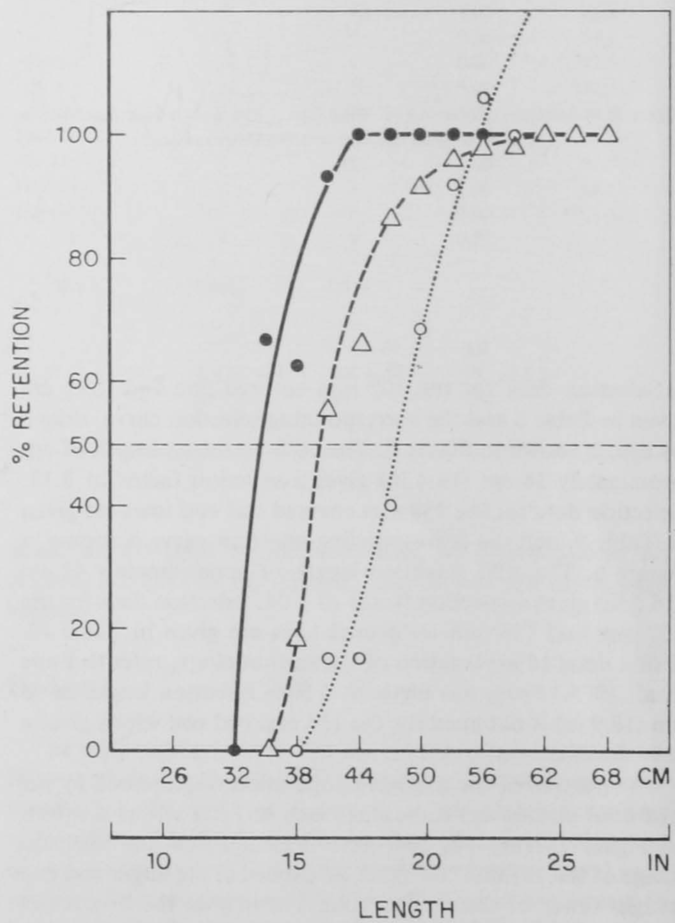

Figure 6. — Selection curves — haddock. Solid circles = 107 mm covered; open circles = 138 mm uncovered; open triangles = 138 mm covered.

Table 9 — Haddock length frequency distributions and percent retained for 138 mm cod end covered tow — both vessels.

Length interval (cm)	Numbers caught 138 mm	138 mm plus covers	Percent retained
31-33	1	1	100.0
34-36	0	2	0.0
37-39	2	11	18.2
40-42	23	42	54.8
43-45	36	56	64.3
46-48	40	47	85.1
49-51	111	123	90.2
52-54	244	258	94.6
55-57	292	299	97.7
58-60	136	138	98.6
61-63	21	21	100.0
64-66	6	6	100.0
67-69	3	3	100.0
Totals	915	1,007	

Table 10. — Haddock length frequency distributions and percent retained for the 138 mm uncovered cod end compared with the 107 mm uncovered cod end both vessels.

Length interval (cm)	Numbers caught (A) 107 mm	(B) 138 mm	$\frac{B}{A}$		$\frac{B}{1.37 A} \times 100$
34-36	1	0	0.00		0.0
37-39	13	0	0.00		0.0
40-42	48	10	0.21		15.2
43-45	85	18	0.21		15.5
46-48	81	44	0.54		39.7
49-51	177	165	0.93		68.0
52-54	360	445	1.24		90.2
55-57	369	529	1.43		104.6
58-60	180	244	1.35	Avg. 1.38	98.9
61-63	34	61	1.79		131.0
64-66	12	13	1.08		79.1
67-69	3	2	0.67		48.7
70-72	4	4	1.00		73.0
73-75	3	4	1.34		97.3
76-78	2	4	2.00		36.4
79-81	0	0	—		—
82-84	0	1	—		—
Totals	1,372	1,544			

$\sum_{52}^{81} A = 967$ $\sum_{52}^{81} B = 1,303$ $\frac{B}{A} = 1.35$

Table 11. — Weights of haddock by 3 cm groups.

Length interval (cm)	Kg/fish	Small uncovered No.	Kg	Small covered No.	Kg	Large uncovered No.	Kg	Large covered No.	Kg
10-12	0.013								
13-15	0.027								
16-18	0.048								
19-21	0.08								
22-24	0.12								
25-27	0.18								
28-30	0.25			1	0.3				
31-33	0.34			0	0			1	0.3
34-36	0.44	1	0.4	2	0.9			0	0
37-39	0.57	13	7.4	5	2.9			2	1.1
40-42	0.72	48	34.6	28	20.2	10	7.2	23	16.6
43-45	0.90	85	76.5	32	28.8	18	16.2	36	32.4
46-48	1.10	81	89.1	22	24.2	44	48.4	40	44.0
49-51	1.32	177	233.6	72	95.0	165	217.8	111	146.5
52-54	1.58	360	568.8	147	232.3	445	703.1	244	385.5
55-57	1.88	369	693.7	137	257.6	529	994.5	292	549.0
58-60	2.20	180	396.0	60	132.0	244	536.8	136	299.2
61-63	2.56	34	87.0	14	35.8	61	156.2	21	53.8
64-66	2.96	12	35.5	3	8.9	13	38.5	6	17.8
67-69	3.40	3	10.2	2	6.8	2	6.8	3	10.2
70-72	3.88	4	15.5	4	15.5	4	15.5		
73-75	4.41	3	13.2	0	0	4	17.6		
76-78	4.98	2	10.0	2	10.0	4	19.9		
79-81	5.60					0	0		
82-84	6.27					1	6.3		
85-87	6.99								
88-90	7.77								
Totals		1,372	2,271.5	531	871.2	1,544	2,784.8	915	1,556.4
Total weight			2,271.5		871.2		2,784.8		1,556.4
Landings (discard <52)			1,829.9		698.9		2,495.2		1,315.5
% discards			19.4		19.8		10.4		15.5

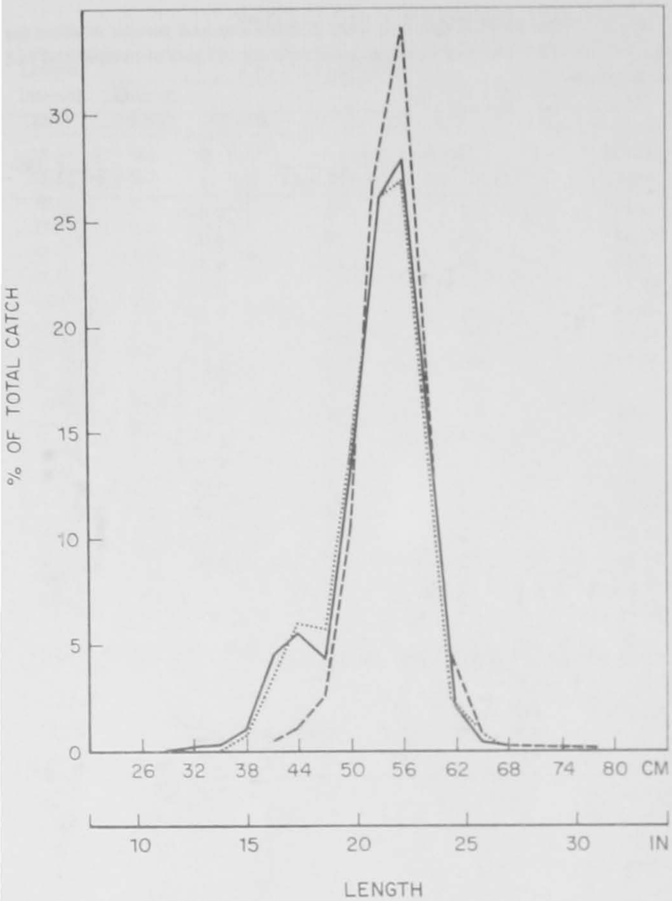

Figure 7. — Catch distributions — haddock. Solid line = cod ends + covers; dash line = 138 mm cod ends; dot line = 107 mm cod ends.

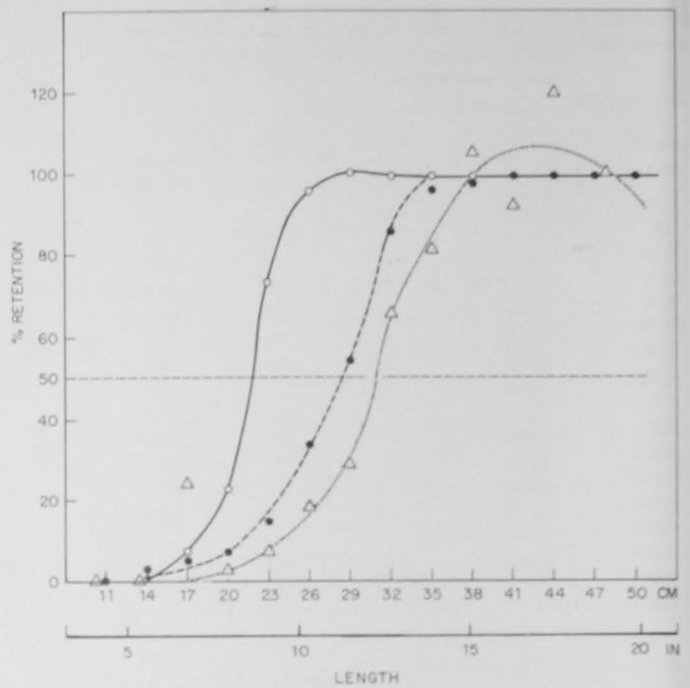

Figure 8. — Selection curves — yellowtail flounder. Solid circles = 133 mm covered; open circles = 102 mm covered; open triangles = 133 mm uncovered.

Yellowtail Flounder

These results are based on catch data from Experiments One, Two, and Four. The selection factors determined during this series of experiments (Table 12) show the alternate tow selection factors are in close agreement with those found by Lux (1968). Assuming the real selectivity lies between the two methods used, 2.25 is a fair choice for the selection factor. The selection curves determined from the combined data (Fig. 8, Tables 13 to 15) indicate the 25-75% selection ranges found throughout the experiment varied from 3 to 6 cm. Again, as with the Atlantic cod data, the selection factors for the small covered mesh are lower than those determined for the larger mesh.

It should be noted that a comparison of the two large-mesh selection curves determined by the two methods used is not strictly valid. This is due to the fact that the uncovered selection curve was derived by comparing the large-mesh uncovered cod ends with the small-mesh uncovered cod ends and the covered selection curve was derived by comparing the large-mesh covered cod ends with the 50 mm covers. In the first case the retention percentages will be affected by the selectivity of the small-mesh cod ends, this occurring where the selection process overlaps (in this case about 17 to 27 cm). The degree of inaccuracy introduced was checked by adjusting the large-

Table 12. — Yellowtail flounder selection factor summary.

Experiment	Total no. of fish	Selection factor Small mesh	Large mesh	Alternate tow
One	3,581	2.07	2.16	2.37
Two	8,881	2.08	2.09	2.30
Four	321	—	—	—
Combined[1]	12,783	2.16	2.18	2.29

[1]Combined also contains data from Experiment Four.

Table 13. — Yellowtail flounder length frequency distributions and percent retained for the small-mesh (102 mm overall average) covered tows — six vessels.

Length interval (cm)	Numbers caught 102 mm	102 mm plus covers	Percent retained
10-12	0	2	0.0
13-15	0	36	0.0
16-18	14	185	7.6
19-21	78	335	23.3
22-24	242	333	72.7
25-27	274	286	95.8
28-30	216	216	100.0
31-33	491	496	99.0
34-36	715	720	99.3
37-39	523	524	99.8
40-42	282	284	99.3
43-45	182	182	100.0
46-48	52	52	100.0
49-51	9	9	100.0
52-54	4	4	100.0
55-57	2	2	100.0
Totals	3,084	3,666	

Table 14. — Yellowtail flounder length frequency distributions and percent retained for the large-mesh (133 mm overall average) covered tows — six vessels.

Length interval (cm)	Numbers caught 133 mm	133 mm plus covers	Percent retained
10-12	0	0	0.0
13-15	1	25	4.0
16-18	13	221	5.9
19-21	26	460	5.7
22-24	62	460	13.5
25-27	109	316	34.5
28-30	132	243	54.3
31-33	335	392	85.5
34-36	532	550	96.7
37-39	319	323	98.8
40-42	199	199	100.0
43-45	118	118	100.0
46-48	46	46	100.0
49-51	9	9	100.0
52-54	0	0	—
Totals	1,901	3,362	

Table 15. — Yellowtail flounder length frequency distributions and percent retained from uncovered cod end tows — six vessels.

Length interval (cm)	Numbers caught (A) 102 mm	(B) 133 mm	B/A	% retained by 133 mm B/0.82A × 100
10-12	0	0	0.00	0.0
13-15	0	1	0.00	0.0
16-18	15	3	0.20	24.4
19-21	118	2	0.02	2.1
22-24	460	27	0.06	7.2
25-27	430	68	0.16	19.3
28-30	395	94	0.24	29.0
31-33	567	301	0.53	64.7
34-36	833	551	0.66	81.0
37-39	513	444	0.87	105.5
40-42	295	223	0.76 (Avg. 0.82)	92.2
43-45	146	144	0.99	120.3
46-48	46	38	0.83	100.7
49-51	20	11	0.55	67.1
52-54	2	2	1.00	121.6
55-57	2	0	0.00	—
Totals	3,842	1,909		

mesh uncovered retention percentages with the small-mesh covered retention percentages and was found to be small. Continuing in the same vein, if all four types of tows (small and large, covered and uncovered) were compared with the same base (covered cod ends plus covers) and adjusted on a numbers-per-tow basis, a comparison could be made between the two mesh sizes that might indicate some degree of relative efficiency. A larger number of tows than performed during this series of experiments is required to do this with any degree of confidence.

An analysis of combined landings and discards (Table 16) indicates a smaller catch with the larger mesh. From observations made during the experiments, it was noted that the majority of fish 30 cm (11.8 in) and smaller were discarded. This is a lower cull point than in the past. Hennemuth and Lux

Table 16. — Yellowtail flounder landings and discards.

Length interval (cm)	Kg/fish	Small uncovered No.	Small uncovered Kg	Large uncovered No.	Large uncovered Kg
10-12		0	0.0	0	0.0
13-15	0.02	0	0.0	1	0.02
16-18	0.04	15	0.6	3	0.1
19-21	0.07	118	8.3	2	0.1
22-24	0.09	460	41.4	27	2.4
25-27	0.13	430	55.9	68	8.8
28-30	0.22	395	86.9	94	20.7
31-33	0.31	567	175.8	301	93.3
34-36	0.41	833	341.5	551	225.9
37-39	0.59	513	302.7	444	262.0
40-42	0.68	295	200.6	223	151.6
43-45	0.86	146	125.6	144	123.8
46-48	1.04	46	47.8	38	39.5
49-51	1.17	20	23.4	11	12.9
52-54	1.44	2	2.9	2	2.9
55-57	1.67	2	3.3	0	0.0
58-60	2.14				
Totals		3,842	1,416.7	1,909	944.0
Landings (discard ≤30 cm)			1,223.6		911.9
Discards		1,418	193.1	195	32.14
% discards		36.9	13.6	10.2	3.4

% reduction in discards between mesh sizes: 75% by weight.

(1970) reported a cull midpoint for yellowtail by the commerical fleet of 34 cm (13.5 in). Using 30 cm as the cull point, the data from this series of experiments indicates a 36.9% discard rate (by number of fish) for a 4-in mesh. A 5.5-in mesh reduces this discard by 75% when compared on a weight basis.

Pollock

These results are based on a catch of 1,118 pollock made during Experiment Three. (It should be noted that at night in the same area catches of 14,000 lb of pollock in 2 to 3 h tows were common.) Both vessels fished the same basic population distribution (Fig. 9). The covered-tow method could not be

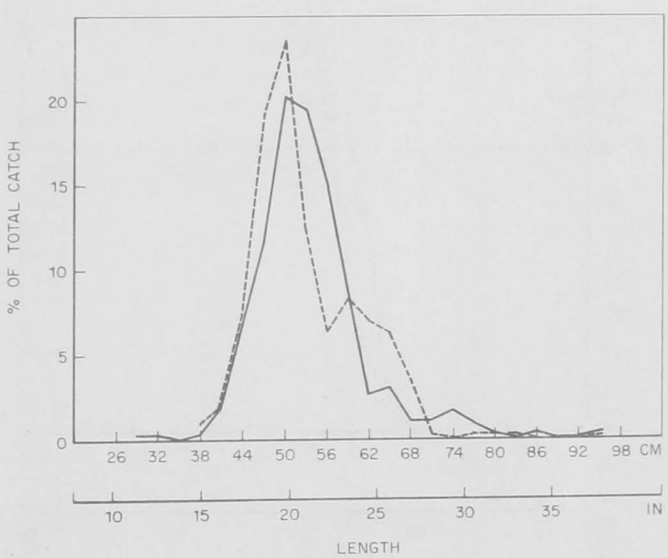

Figure 9. — Vessel comparisons — pollock. Cod ends + covers: solid line = *Joseph & Lucia II*; dash rule = *Joseph & Lucia III*.

used to determine the selection of the small cod end due to lack of small fish. Selection data for the 138 mm covered cod end tows are given in Table 17 and Figure 10. The 50% retention length of about 45 cm (17.7 in) gives a selection factor of 3.26. Selection data for the 107 mm and 138 mm uncovered tows are given in Table 18 and Fig. 10. A 50% retention length of 46 cm (18.1 in) is obtained for the 138 mm cod end which gives a selection factor of 3.33. It is interesting to note that the same large covered tows showed a definite masking effect in regard to haddock during this experiment but it did not show up for pollock. The larger cod end caught fewer small fish (Fig. 11).

Table 17. — Pollock length frequency distributions and percent retained for 138 mm cod end covered tows — both vessels.

Length interval (cm)	Numbers caught: 138 mm	Numbers caught: 138 mm plus covers	Percent retained
37-39	0	2	0.0
40-42	1	11	9.1
43-45	17	37	45.9
46-48	48	87	55.2
49-51	78	115	67.8
52-54	64	83	77.1
55-57	42	50	84.0
58-60	47	48	97.9
61-63	24	24	100.0
64-66	28	28	100.0
67-69	15	15	100.0
70-72	2	2	100.0
73-75	2	2	100.0
76-78	0	0	100.0
79-81	1	1	100.0
82-84	0	0	100.0
85-87	1	1	100.0
Totals	370	506	

Table 18. — Pollock length frequency distributions and percent retained for the 138 mm uncovered cod end compared with the 107 mm uncovered cod end — both vessels.

Length interval (cm)	Numbers caught: (A) 107 mm	Numbers caught: (B) 138 mm	B/A		B/2.9A × 100
37-39	1	0	0.00		0.0
40-42	5	1	0.20		6.9
43-45	13	7	0.54		18.6
46-48	23	34	1.48	Avg. 2.94	51.0
49-51	40	91	2.28		78.4
52-54	21	78	3.71		128.1
55-57	21	78	3.71		128.1
58-60	15	38	2.53		87.4
61-63	4	24	6.00		206.9
64-66	5	15	3.00		103.4
67-69	4	5	1.25		43.1
70-72	2	5	2.50		86.2
73-75	2	1	0.50		17.2
76-78	1	4	4.00		137.9
79-81	1	3	3.00		103.4
82-84	1	3	3.00		103.4
85-87	1	0	—		
88-90	2	0	—		
91-93	0	3	—		
94-96	0	0	—		
97-99	0	0	—		
100-102	2	0	—		
Totals	164	390			
	120	102			
	$\Sigma A = 122$	$\Sigma B = 348$	$\frac{B}{A} = 2.85$		
	49	49			

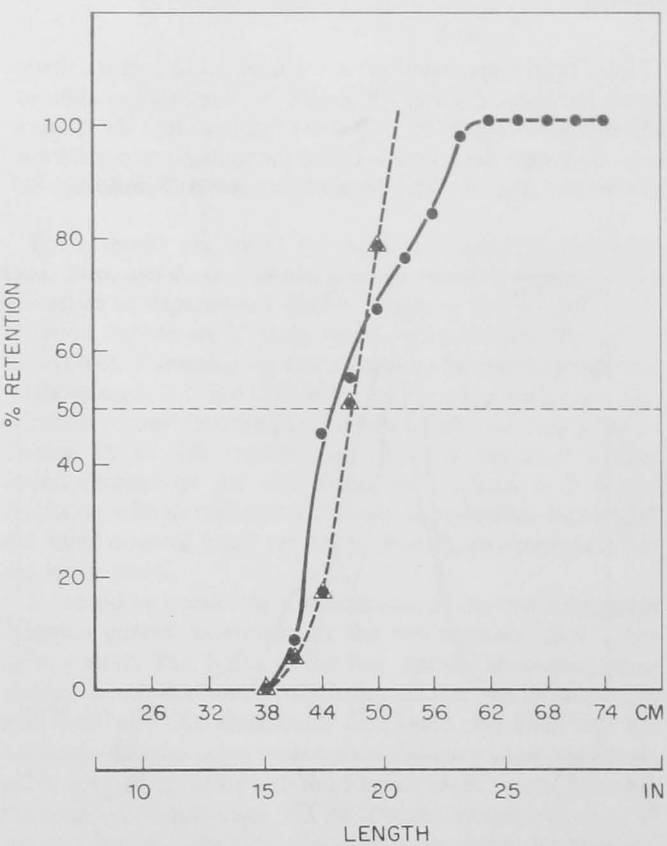

Figure 10. — Selection curves — pollock. Solid circles = 138 mm covered; solid circles in triangles = 138 mm uncovered.

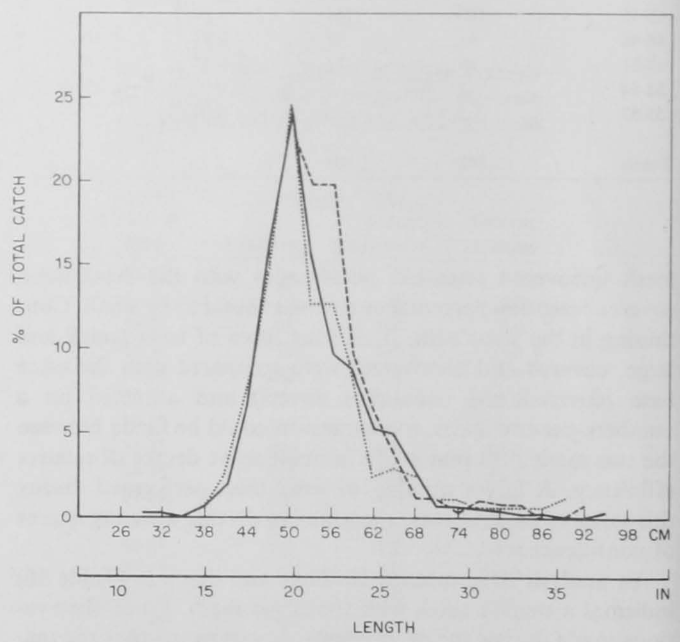

Figure 11. — Catch distributions — pollock. Solid line = cod ends + covers; dash line = 138 mm cod ends; dot line = 107 mm cod ends.

Winter Flounder

The results in this section are based on data from Experiments One, Two, and Four, representing a total catch of 4,152 winter flounder. There were insufficient data to calculate the selection factors from the uncovered tows in Experiment One and from both covered and uncovered tows in Experiment Four. However, with all data combined, fairly good results were obtained (Tables 19 to 21, Fig. 12). There again is an increase in selection factor with the larger mesh. An overall selection factor of 2.2 for winter flounder seems a reasonable choice based on this data. The 25-75% selection range was in most cases about 5 cm.

From the uncovered-tow data (Table 22) there seems to be an increase in efficiency for the larger mesh starting at about

Table 19. — Winter flounder selection factor summary.

Experiment	Total no. of fish	Selection factor: Small mesh	Selection factor: Large mesh	Selection factor: Alternate tow
One	725	2.07	2.23	—
Two	2,398	2.02	2.05	2.21
Four	1,029	—	—	—
Combined	4,152	2.04	2.07	2.27

Table 20. — Winter flounder length frequency distributions and percent retained for the small-mesh (103 mm overall average) covered tows — six vessels.

Length interval (cm)	Numbers caught: 103 mm	Numbers caught: 103 mm plus covers	Percent retained
10-12	0	0	0.0
13-15	1	9	11.1
16-18	3	11	27.3
19-21	10	30	33.3
22-24	96	109	88.1
25-27	161	170	94.7
28-30	204	209	97.6
31-33	161	164	98.2
34-36	83	84	98.8
37-39	68	68	100.0
40-42	70	70	100.0
43-45	46	46	100.0
46-48	24	24	100.0
49-51	15	15	100.0
52-54	2	2	100.0
55-57	2	2	100.0
58-60	1	1	100.0
Totals	947	1,014	

Table 21. — Winter flounder length frequency distributions and percent retained for large-mesh (133 mm overall average) covered tows — six vessels.

Length interval (cm)	Numbers caught: 133 mm	Numbers caught: 133 mm plus covers	Percent retained
10-12	0	0	0.0
13-15	0	6	0.0
16-18	1	45	2.2
19-21	9	107	8.4
22-24	17	120	14.2
25-27	58	158	36.7
28-30	145	241	60.2
31-33	127	155	81.9
34-36	86	92	93.5
37-39	54	56	96.4
40-42	58	59	98.3
43-45	51	51	100.0
46-48	19	19	100.0
49-51	16	16	100.0
52-54	11	11	100.0
55-57	6	6	100.0
58-60	3	3	100.0
61-63	1	1	100.0
Totals	662	1,146	

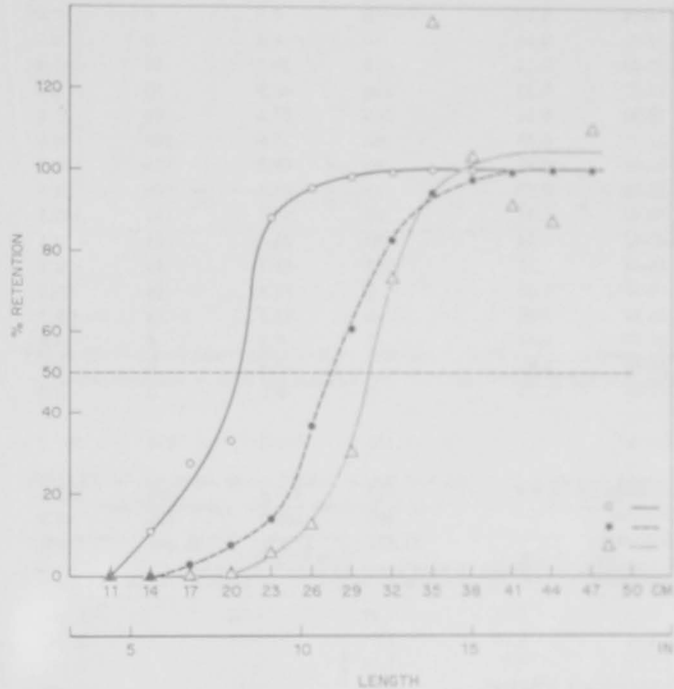

Figure 12. — Selection curves — winter flounder. Solid circles = 133 mm covered; open circles = 103 mm covered; open triangles = 133 mm uncovered.

Table 22. — Winter flounder length frequency distributions and percent retained from uncovered cod end tows — six vessels.

Length interval (cm)	Numbers caught: (A) 103 mm	Numbers caught: (B) 133 mm	$\frac{B}{A}$		% retained by 133 mm $\frac{B}{1.2A} \times 100$
10-12	0	0	0.00		0.0
13-15	0	0	0.00		0.0
16-18	0	0	0.00		0.0
19-21	16	0	0.00		0.0
22-24	115	10	0.08		7.2
25-27	204	30	0.15		12.3
28-30	265	99	0.37		31.1
31-33	168	148	0.88		73.4
34-36	90	185	2.06		171.3
37-39	85	106	1.25		103.9
40-42	103	113	1.10	Avg.	91.4
43-45	62	65	1.05	1.2	87.4
46-48	32	43	1.34		110.1
49-51	8	16	2.00		166.7
52-54	6	13	2.17		180.6
55-57	3	6	2.00		166.7
58-60	1	0	0.00		0.0
Totals	1,158	834			

the 34 to 36 cm fish length interval. Choosing a discard (cull) point of 30 cm, it can be seen that the large mesh landed more fish by numbers and weight (Table 23). The large mesh using the 30 cm cull point, decreased discards by 73% by weight.

Table 23. — Winter flounder landings.

Length interval (cm)	Kg/fish	Small uncovered No.	Small uncovered Kg	Large uncovered No.	Large uncovered Kg
10-12	0.05	0	0.0	0	0.0
13-15	0.07	0	0.0	0	0.0
16-18	0.09	0	0.0	0	0.0
19-21	0.11	16	1.8	0	0.0
22-24	0.18	115	20.7	10	1.8
25-27	0.23	204	46.9	30	6.9
28-30	0.36	265	95.4	99	35.6
31-33	0.45	168	75.6	148	66.6
34-36	0.55	90	49.5	185	101.8
37-39	0.77	85	65.5	106	81.6
40-42	0.91	103	93.7	113	102.8
43-45	1.14	62	70.7	65	74.1
46-48	1.36	32	43.5	43	58.5
49-51	1.68	8	13.4	16	26.9
52-54	2.05	6	12.3	13	26.7
55-57	2.43	3	7.3	6	14.6
58-60	2.93	1	2.9	0	0.0
61-63	3.42	0	0.0	0	0.0
Totals		1,158	599.2	834	597.9
Landings (discard ≤30 cm)		558	434.4	695	553.6
Discards		600	165.0	139	44.3
% discards		51.8%	27.5%	16.6%	7.4%

% reduction in discards between mesh sizes: 73% by weight.

American Plaice

The results in this section represent the data from 32 tows made during Experiment Two. The total catch consisted of 3,798 American plaice. A visual inspection of Figure 13 shows the length-frequency distribution between the two vessels to be about the same. Some masking was evident in the large covered cod ends, but with the large number of small fish caught, this was probably unavoidable.

Selection data for the 99 mm covered cod end tows are given in Table 24 and the corresponding selection curve is shown in Figure 14. The 50% retention length of approximately 23.3 cm (9.2 in) gives a selection factor of 2.35. The 25-75% selection range is approximately 3.6 cm (1.4 in). Selection data for the 131 mm covered cod end tows are given in Table 25 and Figure 14. The 50% retention length of approximately 29.5 cm (11.6 in) gives a selection factor of 2.25. The 25-75% selection range is approximately 6 cm (2.4 in). Selection data for the 99 mm and 131 mm uncovered tows are given

Table 24. — American plaice length frequency distributions and percent retained for 99 mm cod end covered tows — *Linda B* and *Metacomet*.

Length interval (cm)	Numbers caught 99 mm	Numbers caught 99 mm plus covers	Percent retained
10-12	1	10	10.0
13-15	12	114	10.5
16-18	22	254	8.7
19-21	26	206	12.6
22-24	58	152	38.2
25-27	87	101	86.1
28-30	67	67	100.0
31-33	36	37	97.3
34-36	24	24	100.0
37-39	20	20	100.0
40-42	16	16	100.0
43-45	12	12	100.0
46-48	16	16	100.0
49-51	11	12	91.7
52-54	6	6	100.0
55-57	3	3	100.0
58-60	1	1	100.0
Totals	418	1,051	

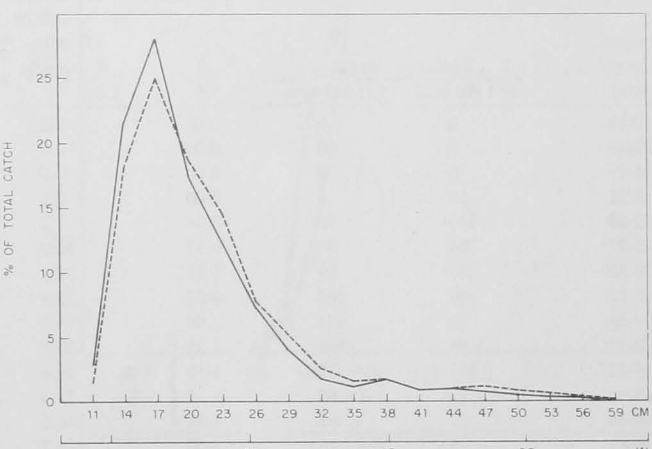

Figure 13. — Vessel comparisons — American plaice. Cod ends + covers: solid line = *Metacomet;* dash line = *Linda B.*

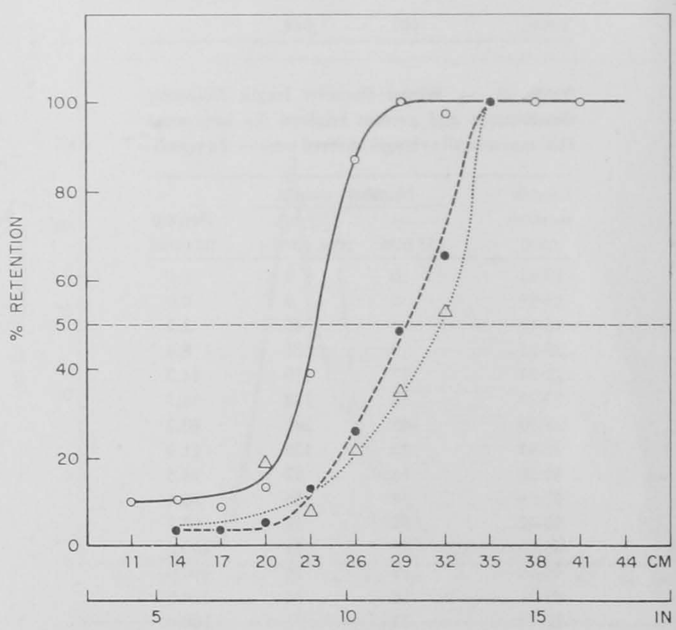

Figure 14. — Selection curves — American plaice. Solid circles = 131 mm covered; open circles = 99 mm covered; open triangles = 131 mm uncovered.

in Table 26 and Figure 14. There was near equal retention above the 100% retention point, thus the distributions were considered equivalent. From this method, a 50% retention length of 31.6 cm (12.4 in) is obtained for the 131 mm cod end which gives a selection factor of 2.41. The 25-75% selection range is approximately 7 cm (2.8 in). From this data a choice of 2.3 for the American plaice selection factor seems reasonable and is in agreement with past studies (Holden 1971). The catch distribution of the two cod end sizes compared with the overall available population (Fig. 15) along with

Table 25. — American plaice length frequency distributions and percent retained for 131 mm cod end covered tows — *Linda B* and *Metacomet*.

Length interval (cm)	Numbers caught: 131 mm	Numbers caught: 131 mm plus covers	Percent retained
10-12	0	27	0.0
13-15	16	487	3.3
16-18	16	563	2.8
19-21	18	349	5.2
22-24	32	263	12.2
25-27	34	134	25.4
28-30	36	75	48.0
31-33	20	31	64.5
34-36	19	19	100.0
37-39	29	29	100.0
40-42	12	12	100.0
43-45	19	19	100.0
46-48	14	14	100.0
49-51	9	9	100.0
52-54	8	8	100.0
55-57	4	4	100.0
58-60	2	2	100.0
Totals	288	2,045	

Table 26. — American plaice length frequency distributions and percent retained for the 131 mm uncovered cod end compared with the 99 mm uncovered cod end — *Linda B* and *Metacomet*.

Length interval (cm)	Numbers caught: (*A*) 99 mm	Numbers caught: (*B*) 131 mm	$\frac{B}{A} \times 100$ = % retained by 131 mm
10-12	0	0	0.0
13-15	4	1	25.0
16-18	11	1	9.1
19-21	26	4	16.7
22-24	74	6	8.1
25-27	109	24	22.0
28-30	79	28	35.4
31-33	44	23	52.3
34-36	35	40	114.3
37-39	25	19	76.0
40-42	12	15	125.0
43-45	27	17	63.0
46-48	15	17	113.3
49-51	10	9	90.0
52-54	9	9	100.0
55-57	2	4	200.0
58-60	1	0	—
61-63	1	0	—
64-66	0	1	—
Totals	484	218	
	$\sum_{34}^{66} A = 137$	$\sum_{34}^{66} B = 131$	

catch data (Table 27) do not indicate anything in regard to efficiency but show discards can be reduced by 50% using the larger mesh.

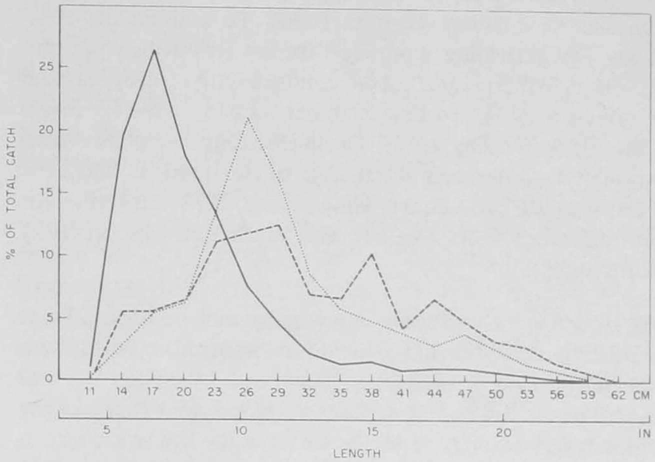

Figure 15. — Catch distribution — American plaice. Solid line = total cod ends + covers; dash line = total 131 mm cod ends; dot line = total 99 mm cod ends.

Table 27. — American plaice landed weight and discard summary — *Linda B* and *Metacomet*, with an assumed discard at 30 cm (11.8 in).

	Small cod ends: Weight (kg)	Small cod ends: % discards	Large cod ends: Weight (kg)	Large cod ends: % discards
Day 1	28.4	29.4	32.7	15.6
Day 2	149.4	25.1	44.2	15.6
Day 3	12.0	41.2	7.5	20.2
Day 4	34.8	30.0	133.7	11.4
Overall discard average:		31.4		15.7

Reduction in discards: 50.0%

Catch, summary by numbers of fish

	Small uncovered	Large uncovered
No. discarded	- 303	- 64
No. landed	- 181	- 154
Total	- 484	- 218
% discard	- 62.6	- 29.4

MANAGEMENT IMPLICATIONS

Discards

In New England the term "discard" can mean anything in the catch that is thrown back overboard. This can include desirable species too small to market, unmarketable species, and bottom trash such as rocks and shell. A marketable fish can become discard by management decisions such as quotas or size limits. The captain also makes the economic decision of retaining certain species and sizes based on price and markets available. Probably ever since commercial fishing with nets began, fishermen have been discarding fish too small to market and hook-and-line fisherman have been complaining about it. In England in 1558 these complaints caused Queen Elizabeth I to issue a royal decree setting a minimum mesh size of 2.5 in (Jensen 1972).

In New England the complaints reached a crescendo soon after the introduction of the otter trawl — an introduction made by Captain Collins, Chairman of the U.S. Fish Commission, in 1903. By 1912 the first American steam trawler, *Spray*, and five sister ships, *Foam, Ripple, Crest, Surf,* and *Swell,* were routinely fishing Georges Bank. To address the complaints, David Belding, a biologist for the Massachusetts Commission on Fisheries and Game, conducted an investigation on the effects of otter trawling by making a trip on the FV *Foam* in that year (Belding 1916). During Belding's trip the vessel discarded as undersized about 25% of the haddock and 14% of the Atlantic cod caught. He assumed 100% mortality for these discarded fish. The cod end mesh size was probably smaller than 3 in.

Belding's work was soon followed by that of Alexander et al. (1915) as described in the introduction of this report. From data collected on 61 trips, they found that by weight "... 40 per cent of the cod and 38 per cent of the haddock taken by the otter trawlers from June to December were fish too small to market. From January to May but 3 per cent of the cod and 11 per cent of the haddock were unmarketable on account of their size." By numbers, for haddock, this amounted to 77 and 40%, respectively (Herrington 1935). Their observers reported practically all of these discarded fish as dead when thrown over the side. The cod end mesh size was about 2.5 in.

Herrington's work in the 1930-31 period, when small haddock were unusually abundant, indicated discards of undersized fish two to three times larger than marketable haddock (Herrington 1932). He went on to say that the commercial captains were concerned enough about this to make an agreement among themselves to avoid grounds where small fish predominated. However, the small fish were everywhere, making the agreement ineffective. In that 1-yr period, 1930-31, about 63 million baby haddock were destroyed, "...about equal to the number of haddock in a commercial catch of 200,000,000 pounds" (Herrington 1936). Again, this destruction varied by season, area fished, and yearly.

Premetz (1953) reported that for the 1947-51 period annual discards of undersized haddock were over 4.5 million lb, representing over 6% of the catch. The greatest part of the destruction occurred from June to November. His data further show that the overlap in culling between discards and fish retained for market ranged from 11 to 19 in (0.5 to 2.3 lb) and was usually a function of the size of the catches. The majority of the culling occurred between 13 and 15 in (33 and 38 cm).

From fishermen's reports, the discard of 1975 year-class haddock during 1977 was very high. It may have been of the same order of magnitude as that reported for the 1930-31 period mentioned above. Even though there was a mesh-size regulation in effect, reports indicate that many fishermen geared down, either using a smaller mesh or liner, to catch the abundant small haddock that are sold as "scrod."

Haddock and Atlantic cod are not the only fish discarded. Lux (1968) reported yellowtail flounder discards of 50% of the catch by weight. This was using mesh sizes of about 114 mm and a cull point of about 35 cm. The survival of discarded yellowtail was estimated by Lux to be about 25% The average discards and landings for 1963-66 averaged about 11,000 and 33,000 t, respectively (Hennemuth and Lux 1970).

A summary of the results, in regard to discards, of the catches made during the series of experiments reported in the previous sections of this paper is contained in Table 28. For Atlantic cod, haddock, and winter flounder, there was a reduction of discards and an increase in landings by the larger mesh. For yellowtail flounder there was a reduction of discards and of landings. In reviewing this data, the question arises that if this overall increase in catch and decrease in discards is in fact true, why have not the fishermen optimized their operation by going to a larger mesh (5 in or greater)? Several hypotheses are offered.

1) Evolutionary development (gear). The otter trawl has only been fished in New England for 75 yr. During this period there has been an increase in mesh size and many "highliner" captains do use mesh sizes over 5 in. Evolutionary development is a long process and just may not be complete in regard to optimizing mesh size.

2) Economics. The catch of smaller species of fish, i.e., whiting, may offset the loss of catch of larger groundfish caused by reduced trawl efficiency. The inshore fleet may be a good example of this.

3) Natural cycle variations. Every so often a good year class of Atlantic cod or haddock comes along. The fishermen will fish these schools when only a small portion of the fish have reached market size and thus will use a mesh size that would retain 100% of the scrod, roughly a 4-in mesh. Anyone using a larger mesh will most likely catch fewer marketable fish.

Table 28. — Discard summary for New England mesh experiments using only uncovered cod-end data.

Species	Discard size (mm)	105 mm cod ends % discard No.	105 mm cod ends % discard Kg	135 mm cod ends % discard No.	135 mm cod ends % discard Kg	Large mesh % discard reduction	Large mesh landings % change
Atlantic cod	≤42	28.3	6.9	3.2	0.6	93	+35
	≤52	47.3	15.5	11.6	3.4	78	+44
Haddock	≤42	4.5	1.9	0.6	0.3	84	+25
	≤52	29.5	19.4	15.3	10.4	46	+36
Yellowtail	≤30	36.9	13.6	10.2	3.4	75	−25
flounder	≤36	73.3	50.1	54.8	37.2	26	−16
Winter	≤30	51.8	27.5	16.6	7.4	73	+37
flounder	≤36	74.1	48.4	56.6	35.6	26	+25

4) Observation. It is harder to see catch-efficiency improvements when compared with seeing marketable fish escaping through the meshes when the net is at the surface.

Application of Mesh Management

Deciding to use mesh size regulation as a management tool is only the first step on a long road towards successful application. The second, and probably the most important, step is to determine what goals are to be attained by mesh size regulation. The most obvious role mesh size can play is in the reduction of discards of undersized fish. The problem here is to define what an undersized fish is. To a fisherman it may be any fish too small to market profitably, or legally, if there is a minimum size regulation enforced. To a scientist or manager it may be any fish smaller than some optimized size based on yield or yield per recruit.

Generally, discards of undersized fish decrease with increasing mesh size. At a certain point, under steady state conditions, a mesh size that would maximize the yield from the fishery, in weight, will be reached. The key variables that affect this point are fishing mortality, natural mortality, and growth rate. A mesh size can be chosen to attain this goal. Mesh size can also be chosen to protect a certain portion of the spawning stock, i.e., allow the fish to reach a size to spawn at least once or twice before recruiting to the fishery. The size mesh needed to accomplish this usually lies between that necessary to reduce discards of fish too small to market and that needed to maximize the yield of the fishery by weight. There may also be an economically optimum mesh size, one that would provide a supply of certain size fish that would maximize the return to the fishermen or stabilize prices.

Mesh size may even be used to limit effort over the short term. Increasing the mesh size by an increment that would offset any catch increases due to improved efficiency would cause a decrease in catch per unit effort. However, a new steady state condition will eventually be reached where CPUE may be greater than before or the fishery would be beyond the optimum point of harvesting. Assume that a mesh size is chosen that is a compromise between reducing discards of unmarketable fish and optimizing the overall yield (weight landed) of the fishery and in so doing protects the first spawners. Assume also, for now, that it is a single species fishery that is being discussed. The next step is implementation of the mesh regulation and, correspondingly, the enforcement of it.

It has been argued that if fishermen are fully informed and believe in the benefits that would accrue to the fishery there would be no implementation problems. However, the benefits accrue to the fishery, not necessarily to an individual fisherman. It is easier for a fisherman to see marketable fish escaping his large mesh cod end than to see gradual long-term increases in catch for the industry. Better prospects in the fishery may encourage more entries and an individual's share might not change at all. Whatever the reason, there is an incentive for fishermen to look at short-term losses rather than long-term gains. This incentive is highest when recruitment is strong.

The simplest way to avoid the regulation is to fish an undersized cod end and hope not to get caught. If the fisherman does get caught, the penalty, if any, is usually insignificant compared with the gains made by cheating. If a fisherman wants to decrease his chances of getting caught, he can fish a small mesh liner inside the regulation cod end. This allows him to remove it before entering port or upon the arrival of a Coast Guard vessel. There is also the technical loop-hole. For example, if the regulation does not specify the length of the cod end required, the fishermen could attach an extra short cod end of regulation mesh to an extension piece of smaller mesh size. A way to avoid this may be in using more general definitions such as defining cod end as the "terminal portion of a trawl in which the catch is normally retained." There can also be the honest mistake of a fisherman using a nonregulation mesh because he was sold the wrong size.

In a single species fishery the above problems should be relatively easy to solve. To counter the incentive to cheat, a greater disincentive must be present. Fishermen in New England suggest vessel "tie-ups" for those that violate the regulations. Some fishermen believe repeated violations should lead to suspension and even loss of license to fish. To aid in clear-cut identification of violators, the regulations must be black and white; no gray areas. One rule, for example, could be that a vessel may only have one mesh size onboard even to the point of requiring all parts of the trawl be at least the same mesh as the cod end.

To eliminate problems of what constitutes a legal cod end, a certification program may be in order. Such a program existed in New England during the 1950's on a voluntary basis. Fisheries enforcement agents were contacted by a dealer when a shipment of new cod ends arrived. The agents would go to the dealer and certify the cod ends by measuring and comparing with a set of standards that took into account material type and shrinkage rates. Upon passing, the cod end had four numbered brass tags squeezed onto it and then soldered. The cod end was then considered certified legal unless major (10%) repairs were undertaken. The system worked fairly well until the number of variations in twine type and quality became excessive and many failed to meet government specifications. At this point cod end manufacturers guaranteed their cod ends to the fishermen as legal size or they would stand the consequences. Eventually the voluntary certification program was phased out. Today, however, there seems to be a need for a certification program, quite possibly with a less rigorous set of criteria. Too many cod ends are being sold as legal size when they are not even close, even before shrinkage.

Another solution that is commonly advanced is the use of minimum size limits. A minimum size limit serves two main purposes. First it encourages fishermen to use the regulation mesh and, secondly, it discourages fishermen from fishing on populations of predominantly small fish. The problem with size limits is how to set them in relation to the 50% retention point of the regulation mesh. If the size limit is set lower than the 50% point, the fishermen have incentive to cheat as legal size fish are escaping the regulation mesh. If the size limit is set too high in relation to the 50% point there would be high discard rates nullifying the benefits of the regulation mesh. Setting the minimum size limit to correspond with the 50% retention point is a poor compromise at best. What may be a better approach to the problem is to set the size limit on a proportional basis closely corresponding with the selection curve of the regulation mesh, e.g., no more than 20% of the cod and/or haddock landings of a trip can be scrod (by weight). This sort of system would require better accountability at wharfside. One way to do this is to require all boxes of fish to be labeled (vessel, trip number, market category, and serial number) and listed by serial number on the weighouts.

There are other problems that surface when the application of mesh regulations is discussed in New England. One common objection some fishermen voice is that dogfish (*Squalus acanthias* and *Mustelus canis*) will gill in the large cod end meshes creating time-consuming labor requirements for their removal. Comparing a 5-in or greater mesh vs. a 4-in or smaller mesh, this may be a valid concern. However, the difference between using a 5⅛-in and a 5¾-in mesh, in regards to dogfish gilling, may be insignificant. One way to look at it is that there are fewer meshes in the larger cod end thus less gilled fish to remove.

Another concern of fishermen is the effect of a bar breaking in a cod end mesh. In a 3-in cod end a bar breaks leaving a 6-in hole; a failure that can be tolerated. Unfortunately, the days of using a 3-in mesh are gone. The difference between a bar failure between a 5⅛ and a 5¾- in cod end is a hole 10¼ in vs. one of 11½ in; both probably will give the same losses. One other common complaint is that the large cod end just will not be strong enough to handle large catches. So far there is no evidence that this complaint is valid but if it does turn out to be a problem there should be an easy technical solution available.

It should be kept in mind that the application of large mesh cod ends may have certain advantages to the fishermen, other than catch related, that outweigh the above disadvantages. The larger mesh should have a "cleaner" catch requiring easier landing and handling on deck. The cost of webbing, which is sold by weight, should be less, and it should be easier to mend. The larger mesh should also offer less towing resistance which may save on fuel costs.

Unfortunately, in New England, the relatively simple case of a single species groundfishery does not exist. However, New England is fortunate in that one mesh size probably can be chosen to accommodate management requirements for many key species—Atlantic cod, haddock, pollock, yellowtail flounder, winter flounder, and American plaice. Two important commercial species that require a smaller mesh are redfish and silver hake.

From a mesh based viewpoint there are two basic systems of management for New England's mixed bottom trawl fishery; one that allows a vessel to go to sea with more than one mesh size aboard and the other that does not. Present fishing strategies of most inshore and offshore vessels make it desirable to carry two mesh sizes to sea. The main reason is that it gives the captain flexibility in making his trip profitable. However, most fishermen and enforcement personnel agree that it is difficult, if even possible, to enforce a mesh size regulation with two mesh sizes aboard. No matter how technically sophisticated a dual mesh regulation can be made, the psychological barrier, i.e., the temptation to cheat, that exists when a fisherman knows the "other fellow" has a small mesh onboard and could be using it to outfish him, is insurmountable.

The solution seems to be in the one mesh only form of regulation. There are areas and seasons where this probably can work well without too many changes in fishing strategies. In some areas there may have to be major changes in traditional practices but these changes will not necessarily be detrimental to the fishermen. In other areas, mostly inshore, small mesh even for the larger groundfish may be the only way possible to fish. The main applications problem in determining a workable management scheme with mesh size regulation as a primary tool is effective enforcement.

Another point that must be kept in mind is that if a fishery has several different gears involved, the regulations must be balanced so that the fish become vulnerable to them at about the same age. There may be economic factors, due to differences in operating costs, that would create the need to adjust a balance based strictly on age of first capture.

Summation

The most recent groundfish management proposals in the northeast have included mesh size regulations as one of the main management tools. This basically entails increasing the size of the cod-end mesh to allow greater escapement of the smaller fish. Besides increasing the mean size of the fish caught, there are many direct and indirect effects on the fishing industry, resource management, and the ecosystem itself.

An example of direct economic impact is that in most cases larger fish bring a better price to the fishermen. When small flounders are worth only $0.10/lb, large flounders are bringing about $0.80 to the fishermen. This, in large part, is due to the fact that larger fish allow for more efficient processing. In many aspects larger fish are also of better quality, e.g., large whiting have improved texture and firmness. Larger whiting can also be processed as fillets worth a lot more than the smaller fish that mostly have to go into reduction. The above discussion points out that a change in mesh size can impact the processing sector of the fishing industry and the availability of certain processed products.

Larger mesh has direct impacts on the fishermen. The catch usually comes up cleaner, less by-catch of trash and unmarketable species. Compared with a smaller mesh that catch is usually greater by weight but fewer in number because it is composed of larger fish. This would then create less work on deck sorting, cutting, and gutting. The by-catch control aspect here is a double-edged sword. Some of the smaller species, whiting and redfish for example, are marketable and this catch would be reduced by a larger mesh. In the same manner less work on deck could lead to reduced crewing which has both positive and negative economic consequences.

Going to a larger mesh will allow more fish to grow to a larger size. This has the direct benefit of increasing the overall yields of the resource. It also puts more age groups and greater numbers of fish into the spawning pool, thus increasing the spawning potential and possible future year class strengths. What is not known is how more larger fish in the sea may impact the overall ecological balance. Larger mesh may increase resource stability, and correspondingly, reduce market cycles. This could lead to increased price stability and thus improved capability for financial planning for both fishermen and processor. However, a better financial climate may increase investment into fishing operations and in fact bring an increase in effort that could lead to overfishing. To carry this train of thought further, a larger industry, during a natural downturn in the fish populations, may be strong enough politically to bring on protectionist (predator, not the prey) regulations. These regulations, such as mortgage guarantees, fuel subsidies, lost gear replacement, etc., have the tendency to keep marginal operators in the fishery longer, thus adding to the overfishing pressure. The professional fisherman plays the cycles for maximum profit and thus has something to lose in a more controlled market.

Fisheries management itself is directly affected. The delayed recruitment brought about by the larger mesh would allow another survey data point on population size to be analyzed. This should improve estimates of projected landings which in itself could have many ramifications.

Any management regime based on some aspect of gear control (mesh size) can have significant long-term effects. Larger mesh saves energy by creating less drag. This in turn would allow fishermen to use larger nets which may be a lot more effective, thus increasing CPUE. If the mesh regulation tends to be restrictive, as would be the case if it effectively limited effort, fishermen would tend to shift to other gears. If this shift is to gill nets, for example, this can lead to increased gear conflict situations and product quality problems. Very little is known about the destructive fishing aspects of other gears and these impacts can be significant. This would increase the need for gear research to answer management questions.

ACKNOWLEDGEMENT

When the idea of managing the New England groundfishery by mesh size regulation in lieu of catch quotas was proposed in 1977, very few people actively supported it. I would like to acknowledge those members of the New England Fishery Management Council who promoted this study, the captains and crews of the eight fishing vessels that volunteered to conduct the work, and the state and federal scientists and managers that participated at sea and ashore. In all, over 100 people devoted significant time and effort because they believed there had to be a better way to manage the groundfishery. The industry today owes a debt of gratitude to these individuals. I hope this report does justice to their efforts.

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APPENDIX A

VESSEL SPECIFICATIONS

Item	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Type vessel	Stern (net drum) trawler	
Call sign	KXS 387	WYP 9523
Length	16.8 meters (55 feet)	18.9 meters (62 feet)
Gross tons	36 tons	54 tons
Draft	2 meters(6.5 feet)	2.7 meters (9 feet)
Speed	9 knots	9 knots
Engine and Drive	GM V671 Diesel 3:1 reduction	Detroit SV71N Diesel 4.5:1 reduction
Horsepower	170 SHP	240 SHP @ 1800 rpm

Item	LINDA B	METACOMET
Type vessel	Eastern rig side trawler	
Home port	Gloucester, Massachusetts	
Call sign	WC 8799	WF 2782
Length	17.4 m (57 ft)	16.8 m (55 ft)
Gross tons	32 tons	33 tons
Draft	2.3 m (7.5 ft)	1.9 m (6.2 ft)
Speed	10 knots	9 knots
Engine and Drive	Detroit Diesel 8V71N 3:1 reduction	Detroit Diesel 8V71N 4.5:1 reduction
Horsepower	240 SHP @ 1800 rpm	240 SHP @ 1800 rpm

APPENDIX A

VESSEL SPECIFICATIONS (cont'd)

Item	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Type vessel	Eastern rig side trawler	
Home port	Gloucester, Massachusetts	
Call sign	WU 8451	WY 3319
Length	26.8 m (88 ft)	29.3 (96 ft)
Gross tons	179 tons	192 tons
Draft	4.3 m (14 ft)	4.3 m (14 ft)
Speed	11 knots	11 knots
Engine and Drive	Fairbanks Morse 8 cylinder OP; 4:1 reduction	Fairbanks Morse
Horsepower	680 SHP @ 1300 rpm	900 SHP

Item	VALKYRIE	PATTON
Type vessel	Stern drum trawler	
Home port	New Bedford, Massachusetts	
Call sign	WX 8041	WYP 2632
Length	29.9 m (98 ft)	23.7 m (77.6 ft)
Gross tons	198 tons	155 tons
Draft	3.7 m (12 ft)	3.4 m (11.3 ft)
Speed	10.5 knots	10.5 knots
Engine and Drive	CAT. 398 3.5:1 reduction	CAT. 850 3:1 reduction
Horsepower	1000	765

APPENDIX B

GEAR SPECIFICATIONS

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Trawl	133 mm average mesh size throughout. #54 braided nylon twine.	
Cod ends	Type 1 - 106 mm average mesh size; 80 meshes around by 50 deep; #102 braided nylon twine, machine made. Type 2 - 139 mm average mesh size; 80 meshes around by 35 deep; #102 braided nylon twine, hand made.	
Cover (when used)	50 mm mesh size; #72 twisted nylon; 225 meshes around by 133 meshes deep, machine made.	
Headrope	15.8 meters total of 19 mm polypro	
Footrope (sweeps)	9.5 mm chain in wing section and 12.7 mm chain in bosom; strung with 10 cm diameter rubber "cookies" over 60% of its length.	11 mm chain strung with 10 cm diameter "cookies;" about 30 per meter of length. Groundrope of 19 mm poly connected to sweep by 7.6 cm scallop rings and shackles about every 40 cm.
Floats	7-8" diameter aluminum spheres	9-8" diameter aluminum spheres; 2 along each wing and 5 along center
Chafing gear	Mat of polyethylene strands covering aft half (and underside only) of cod end and cover.	
Doors	Rectangular shaped of wood construction 2.13 meters long by 1.11 meters wide weighing 270 kg. Bracket triangular shaped in two parts of iron bar located 1/3 back from forward end.	Oval shaped steel 2.13 meters long by 1.11 meters wide weighing 382.5 kg. Solid bracket in two parts located 1/4 and 1/2 back from forward end.

APPENDIX B

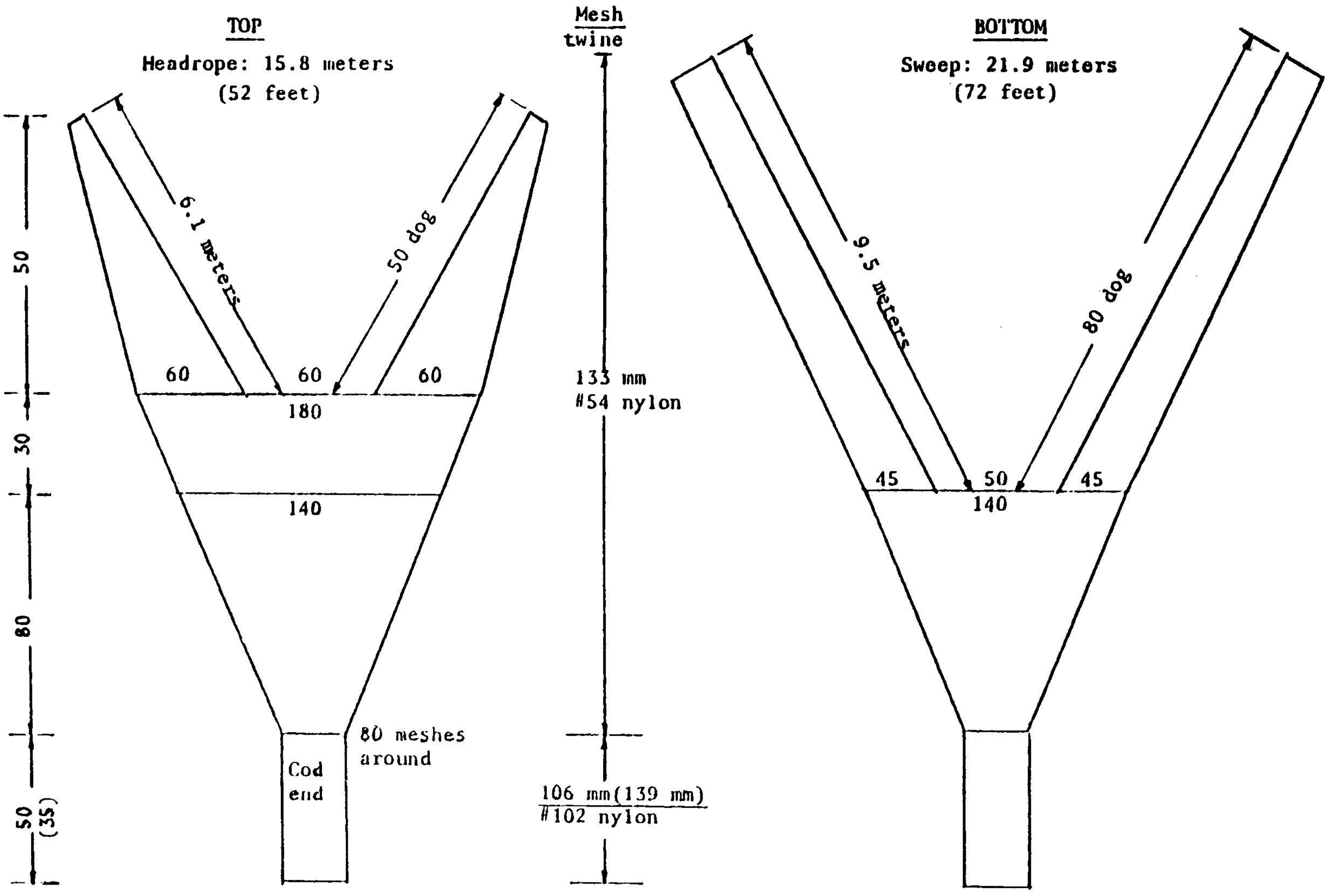
GEAR SPECIFICATIONS (cont'd)

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Backstraps	Two 2.13 meter lengths of 9.5 mm chain	
Bridle wires (legs)	13.7 meters long 9.5 mm chain on bottom and 9.5 mm wire on top.	9.1 meters long 9.5 mm chain on bottom and 12.7 mm wire (6x19) on top.
Trawl wire	14.3 mm 6x19 wire	15.8 mm 6x19 wire
Ground cables	36.5 meters 15.8 mm 6x19 wire	55 meters of 15.8 mm 6x19 wire
Miscellaneous	No quarter ropes, bull rope, lazy line or tickler chains used.	

Gear	LINDA B	METACOMET
Trawl (forward parts)	114 mm average mesh size with 108-mm mesh extension. 30-thread polypropylene.	108-mm average mesh size. 36-thread polypropylene.
Cod ends	Type 1: 99-mm average mesh size; 80 meshes around by 50 deep; #102 braided nylon twine, machine made. Type 2: 131-mm average mesh size; 80 meshes around by 35 deep; @102 braided nylon twine, handmade.	
Cover (when used)	50-mm average mesh size; 225 meshes around by 133 deep; #72 twisted nylon twine, machine made.	
Headrope	23.2 m (76 ft) of 1-inch polypropylene.	21.0 m (69 ft) of 7/8-inch nylon.
Footrope (sweeps)	5/16-inch chain hung in small bights.	3/8-inch chain hung in small bights.

TRAWL DIAGRAM

FRANCIS ELIZABETH and CHRISTOPHER ANDREW



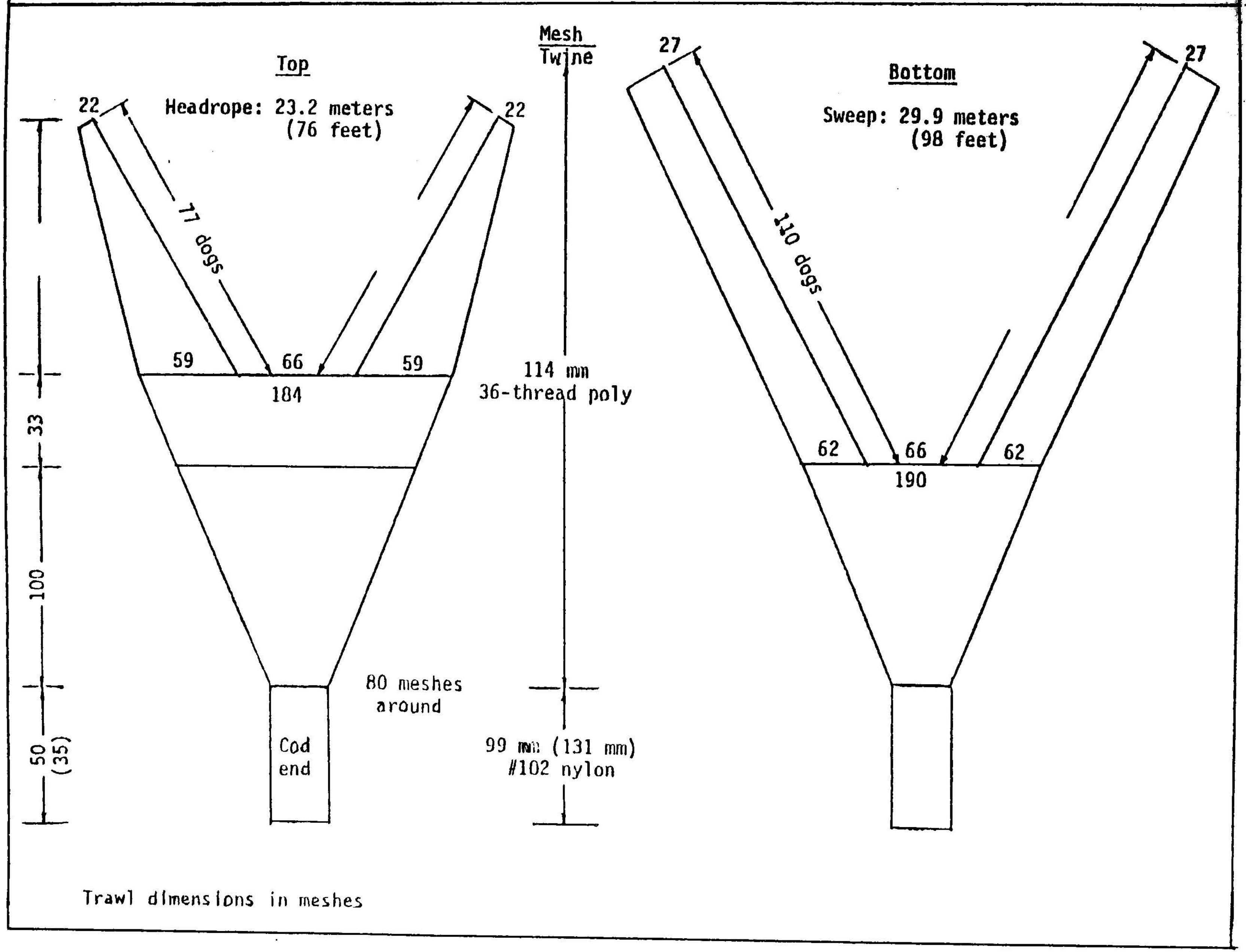
Trawl dimensions in meshes

APPENDIX B

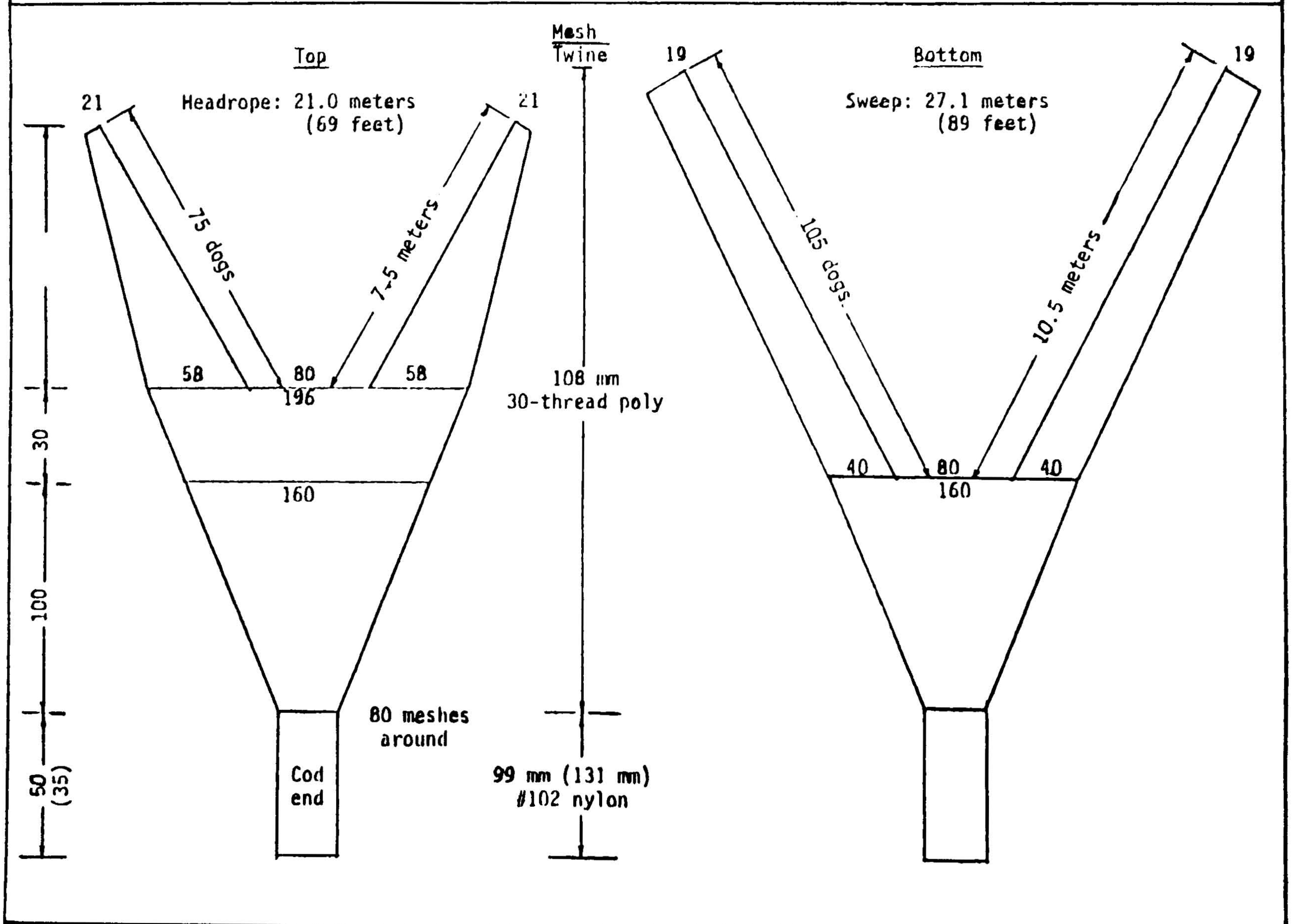
GEAR SPECIFICATIONS (cont'd)

Gear	LINDA B	METACOMET
Floats	8 plastic floats(8-inch).	9 plastic floats(8-inch).
Chafing gear	Mat of polyethylene strands covering aft half (and underside only) of cod end and cover.	
Doors	Rectangular-shaped of wood and steel construction, 2 m (6.5 ft) long by 1.1 m (3.6 ft) wide, weighing 270 kg (600 lb). Bracket triangular-shaped of steel bar.	Rectangular shaped of wood and steel construction, 2 m (6.5 ft) long by 1.1 m (3.6 ft) wide, weighing 337 kg (750 lb). Bracket triangular-shaped of steel bar, located 0.48 m (1.6 ft) from forward end.
Backstraps	Two 2-m (6.5 ft) lengths of 9.5-mm (3/8-inch) chain.	
Bridle wires (legs)	18.3 m (60 ft) of 12.7-mm (1/2-inch) 6x19 wire.	
Trawl wire	14.3-mm (9/16-inch)6x19 wire.	12.7-mm (1/2-inch) 6x19 wire.
Ground cables	27.4 m (90 ft) of 14.3-mm (9/16-inch) 6x19 wire.	36.6 m (120 ft) of 12.7-mm (1/2-inch) 6x19 wire.
Miscellaneous	No quarter ropes, bull rope, or tickler chains used during test (bull rope normally used). Lazy-line 36.6-m (120-ft) loop and 18.3-m (60-ft) lead. 36.6-m (120-ft) loop and 18.3 m (60-ft) lead.	

Trawl Diagram, F/V LINDA B.



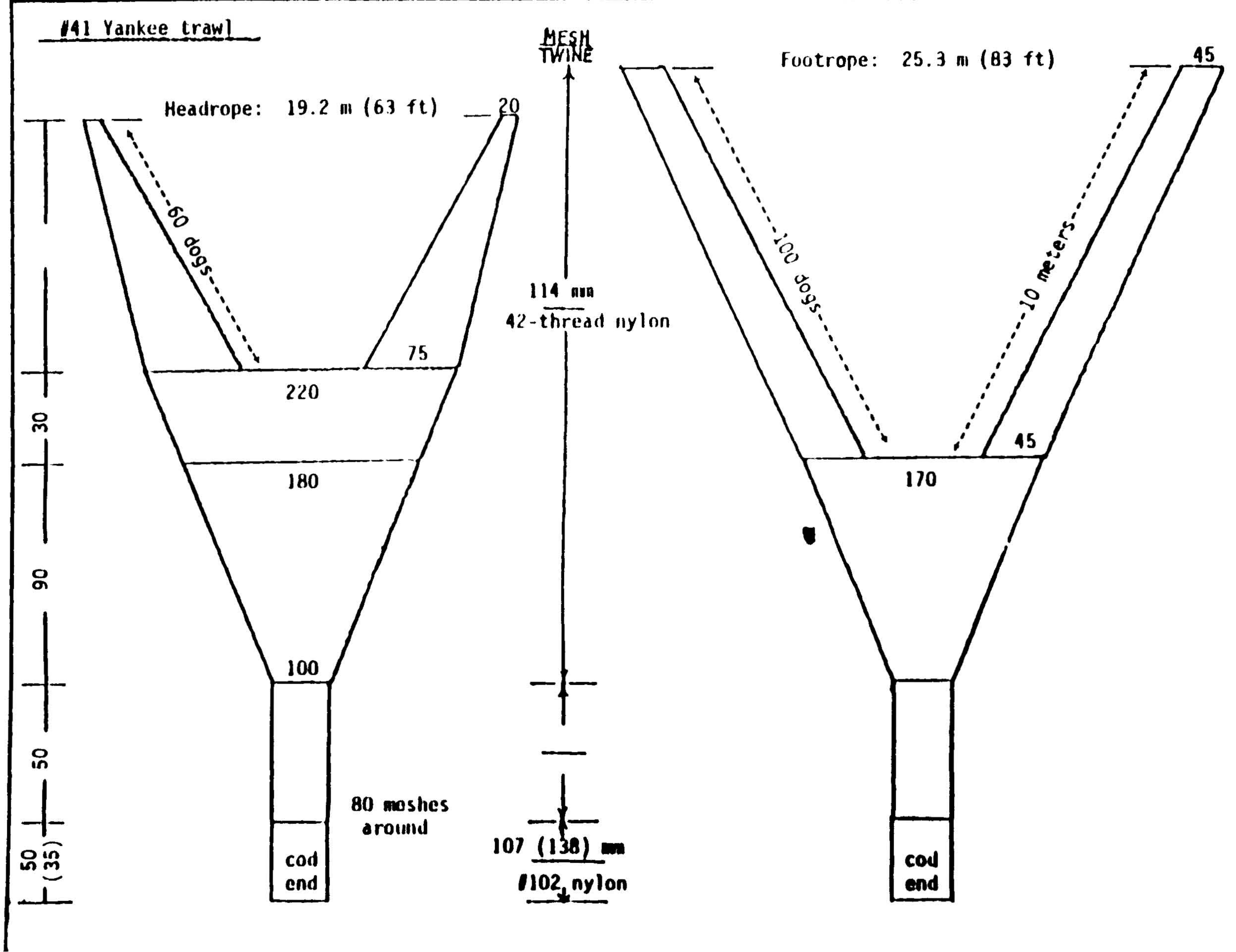
Trawl Diagram, F/V METACOMET



GEAR SPECIFICATIONS (cont'd)

	JOSEPH & LUCIA II AND III (Vessels had nearly identical trawls)
Trawl (forward parts)	- 114 mm (4.5 inches) average mesh size; mostly #42 thread nylon twine.
Cod ends	- Type 1: 107 mm average mesh size; 80 meshes around x 50 deep; #102 braided nylon twine; machine-made. - Type 2: 138 mm average mesh size; 80 meshes around x 35 deep; #102 braided nylon twine; handmade.
Cover (when used)	- 50 mm average mesh size; 225 meshes around x 133 deep; #72 twisted nylon twine; machine-made.
Headrope	- 19.2 m (63 ft) of 1.5-inch nylon.
Footrope (sweeps)	- 25.3 m (83 ft) of 5/8-inch chain; belly has 18-inch rollers with 2 spacers between each; wings have 14-inch and 18-inch bobbins with 3 spacers between each.
Floats	- 22 on belly and 8 on each wing (8-inch aluminum).
Chafing gear	- Mat of polyethylene strands covering aft half (and underside only) of cod end and cover.
Doors	- Rectangular-shaped of wood and steel construction; 2.7 m (9 ft) long x 1.4 m (4.5 ft) wide; weighing 818 kg (1,800 lb). Bracket triangular-shaped of steel bar.
Backstraps	- Two 2.7-m (9-ft) lengths of 5/8-inch chain.
Bridle wires(legs)	- 18.3 m (60 ft) of 7/8-inch 6x19 wire.
Trawl wire	- 7/8-inch 6x19 wire.
Ground cables	- 18.3 m (60 ft) of 7/8-inch 6x19 wire.
Miscellaneous	- Trawl equipped with quarter ropes, bullrope, lazy-line, and splitting straps.

Trawl diagram
JOSEPH & LUCIA II AND III

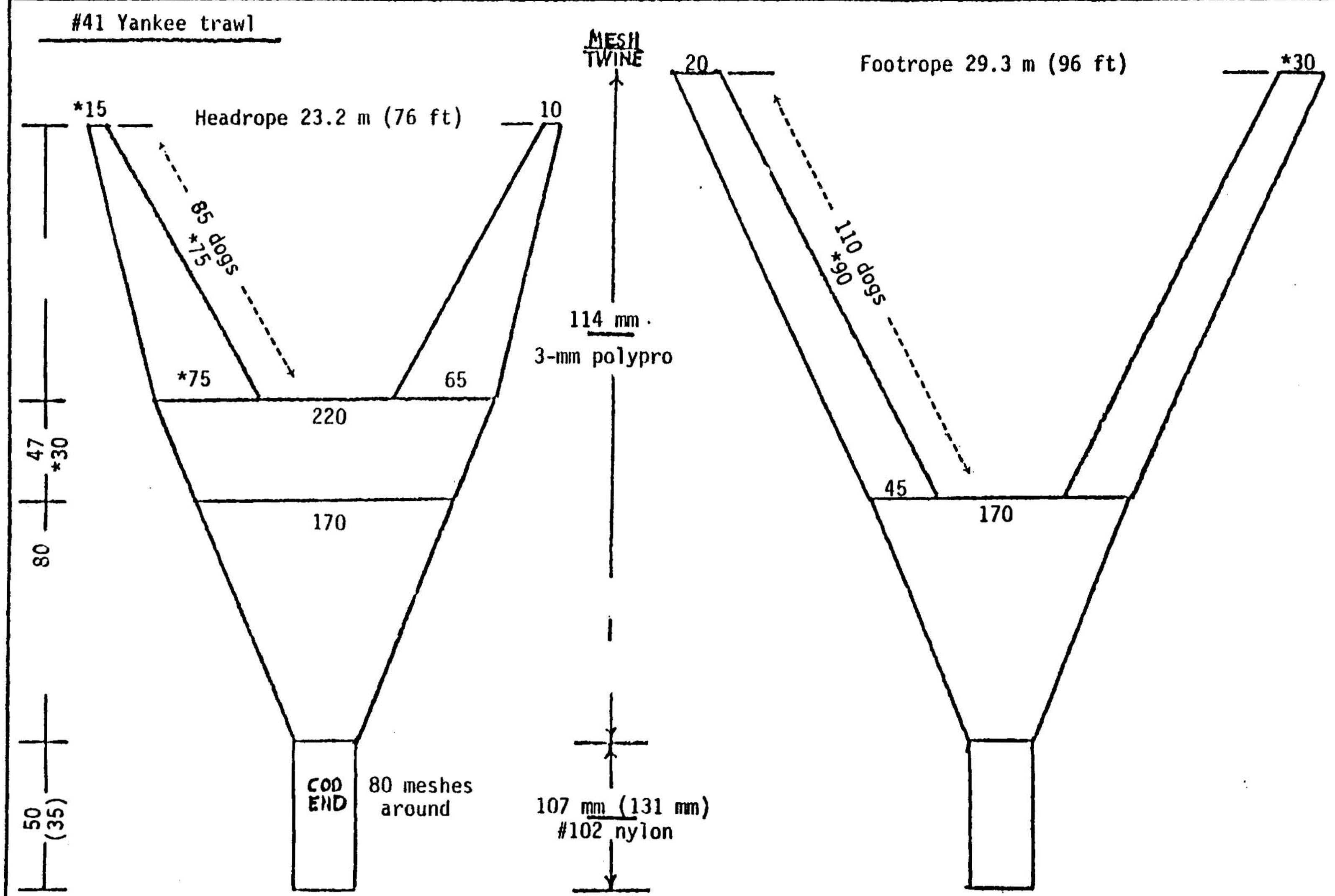


APPENDIX B

GEAR SPECIFICATIONS (cont'd)

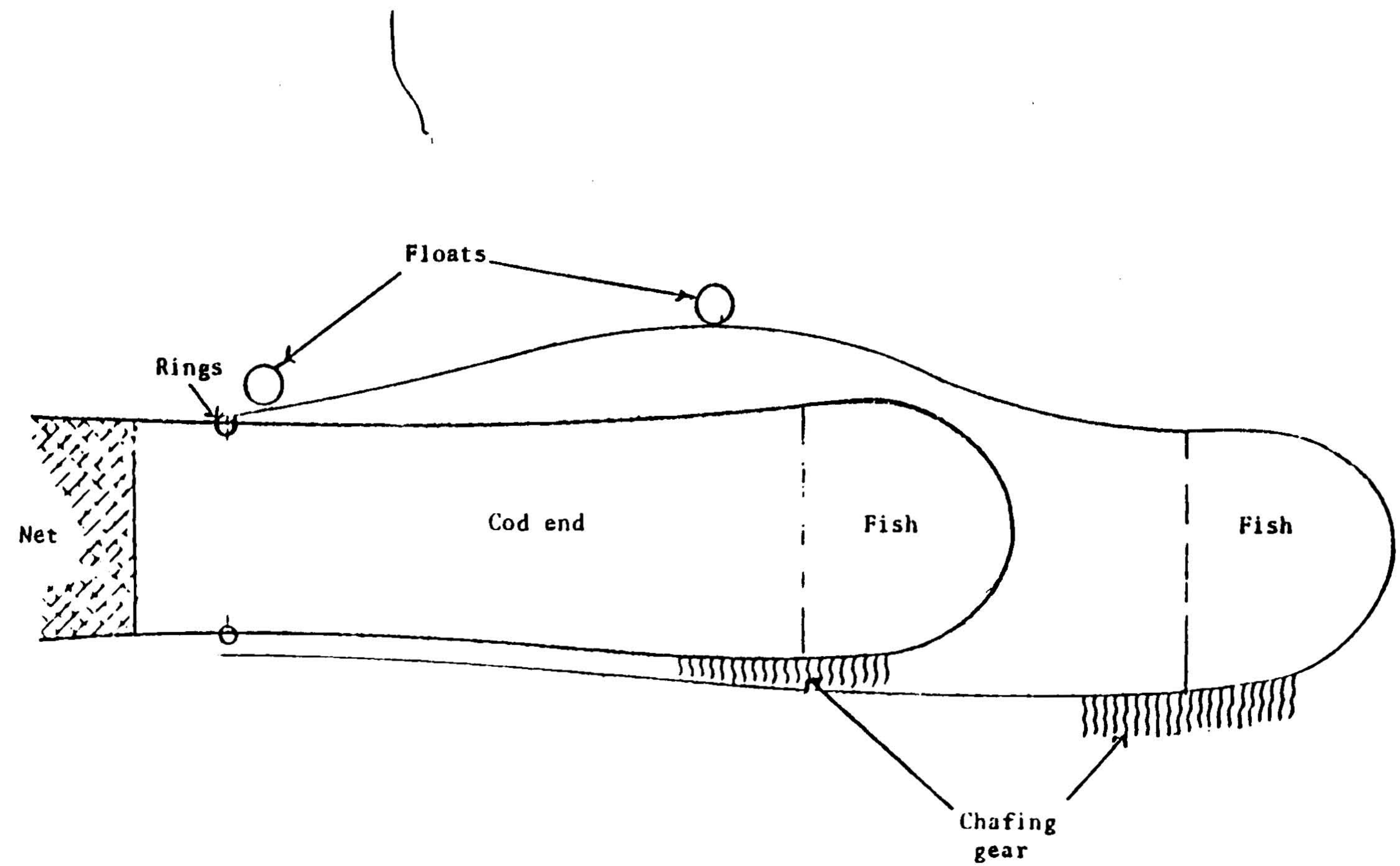
	VALKYRIE	PATTON
Trawl	- 114 mm (4.5 inches) average mesh size; 3-mm polypropylene twine.	
Cod ends	- Type 1: 107 mm average mesh size; 80 meshes around x 50 deep; #102 braided nylon twine; machine-made.	
	- Type 2: 131 mm average mesh size; 80 meshes around x 35 deep; #102 braided nylon twine; handmade.	
Cover (when used)	- 45 mm average mesh size; 270 meshes around x 150 deep; polypropylene.	
Headrope	- 23.2 m (76 ft) of 1-inch combination rope.	
Footrope (sweeps)	- 29.3 m (96 ft) of 5/8-inch chain with heavy rollers and bobbins wing-to-wing.	
Floats	- 45 (8-inch aluminum).	24 on wings, 14 on belly (galvanized).
Chafing gear	- Mat of polyethylene strands covering aft half (and underside only) of cod end and cover.	
Doors	- Slotted semi-oval steel doors (made in Portugal).	
	3.1 m (10 ft) long x 2.1 m (7 ft) wide; 650 kg.	2.7 m (8.8 ft) long x 1.4 m (4.7 ft) wide; 500 kg.
Backstraps	- Two 2.4-m (8-ft) lengths of 5/8-inch chain.	
Bridle wires (legs)	- 9.1 m (30 ft). Top of 5/8-inch wire; bottom of 7/8-inch wire.	Top 9.1 m (30 ft) of 1/2-inch wire; bottom 9.4 m (31 ft) of 3/4-inch wire.
Trawl warp	- 1-inch wire.	7/8-inch wire.
Ground cables	- 5.2 m (17 ft) of 7/8-inch wire.	4.3 m (14 ft) of 3/4-inch wire.

Trawl Diagram
VALKYRIE and PATTON*



*PATTON (where different)

COVER RIGGING



APPENDIX C

MESH MEASUREMENT STATISTICS

Trawl Stations

JOSEPH & LUCIA III

A. Small Cod End

	1	2	5	6	9	11	Overall
$\bar{x}$ =	105.80	109.83	109.70	109.03	111.97	111.47	109.6
S_x =	3.30	3.01	3.25	4.25	3.48	3.40	3.45
$S_{\bar{x}}$ =	0.60	0.55	0.59	0.78	0.64	0.62	0.63

Trawl Stations

JOSEPH & LUCIA II

B. Large Cod End

	3	4	7	8	9	11	Overall
$\bar{x}$ =	140.90	137.77	134.20	135.63	133.40	133.50	135.9
S_x =	5.27	3.37	4.08	3.96	3.23	3.09	3.84
$S_{\bar{x}}$ =	0.96	0.62	0.74	0.72	0.59	0.56	0.70

Trawl Stations

JOSEPH & LUCIA III

B. Large Cod End

	3	4	7	8	10	12	Overall
$\bar{x}$ =	140.97	141.73	138.90	138.50	143.30	141.83	140.8
S_x =	3.96	3.75	5.59	4.12	4.56	4.33	4.39
$S_{\bar{x}}$ =	0.72	0.68	1.02	0.75	0.83	0.79	0.80

Trawl Stations

VALKYRIE

A. Small Cod End

	1	2	7	8	9	10	15	16	Overall
$\bar{x}$ =	107.4	108.8	112.5	106.3	105.3	111.1	107.4	107.3	108.3
S_x =	3.67	3.38	5.95	3.27	3.71	3.66	4.12	5.25	4.13
$S_{\bar{x}}$ =	0.67	0.62	1.09	0.60	0.68	0.67	0.75	0.96	0.76

PATTON

A. Small Cod End

	1	2	7	8	9	10	15	16	Overall
$\bar{x}$ =	105.8	105.4	105.6	105.1	106.7	106.1	106.7	106.6	106.0
S_x =	3.57	4.09	3.61	3.54	2.71	3.14	3.81	3.64	3.51
$S_{\bar{x}}$ =	0.65	0.75	0.66	0.65	0.49	0.57	0.70	0.67	0.64

Trawl Stations

VALKYRIE

B. Large Cod End

	3	4	5	6	11	12	13	14	Overall
$\bar{x}$ =	127.2	125.2	128.0	126.1	128.5	128.3	127.9	127.7	127.4
S_x =	4.11	3.46	4.78	4.46	8.05	5.26	5.34	6.77	5.28
$S_{\bar{x}}$ =	0.75	0.63	0.87	0.81	1.47	0.96	0.97	1.24	0.96

PATTON

B. Large Cod End

	3	4	5	6	11	12	13	14	Overall
$\bar{x}$ =	132.7	133.9	137.4	132.8	135.2	134.0	136.2	134.8	134.6
S_x =	5.92	5.97	6.00	4.16	7.76	5.34	7.65	4.42	5.90
$S_{\bar{x}}$ =	1.08	1.09	1.10	0.76	1.42	0.98	1.40	0.81	1.08

APPENDIX C
MESH MEASUREMENT STATISTICS

	Trawl Stations									
	5	6	9	12	Overall	7	8	10	11	Overall
CHRISTOPHER ANDREW	A. Small Cod End					B. Large Cod End				
$\bar{x}$ =	140.00	107.50	103.92	104.33	104.90	140.00	143.40	140.00	138.00	140.35
S_x =	3.20	3.28	2.55	2.97	2.98	4.23	4.45	4.14	3.61	4.11
$S_{\bar{x}}$ =					0.272					0.375
FRANCES ELIZABETH	A. Small Cod End					B. Large Cod End				
$\bar{x}$ =	109.23	106.37	106.53	104.97	106.80	141.00	138.23	133.83	134.33	136.80
S_x =	3.99	4.07	2.64	4.47	3.79	3.70	4.66	3.90	5.20	4.37
$S_{\bar{x}}$ =					0.346					0.398

	Trawl Stations								
	1	2	7	8	9	10	15	16	Overall
LINDA B	A. Small Cod End								
$\bar{x}$ =	98.23	98.67	100.13	99.73	98.87	98.87	100.10	99.50	99.26
S_x =	4.10	2.38	2.61	2.59	2.24	2.70	2.37	2.93	2.74
$S_{\bar{x}}$ =	0.75	0.44	0.48	0.47	0.41	0.49	0.43	0.54	0.177
METACOMET	A. Small Cod End								
$\bar{x}$ =	101.60	96.60	98.40	97.90	97.70	98.70	98.80	98.50	98.53
S_x =	4.00	3.50	4.10	3.10	2.90	3.60	3.60	3.40	3.53
$S_{\bar{x}}$ =	0.70	0.60	0.80	0.60	0.50	0.70	0.70	0.60	0.228

	Trawl Stations								
	3	4	5	6	11	12	13	14	Overall
LINDA B	B. Large Cod End								
$\bar{x}$ =	127.60	127.27	128.57	129.23	130.43	128.83	128.53	129.17	128.70
S_x =	3.87	3.37	3.45	3.26	3.92	3.02	3.5164	2.48	3.36
$S_{\bar{x}}$ =	0.71	0.62	0.63	0.59	0.72	0.55	0.64	0.45	0.217
METACOMET	B. Large Cod End								
$\bar{x}$ =	133.30	135.30	134.80	134.30	133.90	132.90	132.90	134.40	133.98
S_x =	3.20	5.60	3.70	4.10	3.50	4.90	3.30	5.10	4.18
$S_{\bar{x}}$ =	0.60	1.00	0.70	0.08	0.60	0.90	0.60	0.90	0.270

	Trawl Stations						
	1	2	5	6	10	12	Overall
JOSEPH & LUCIA II	A. Small Cod End						
$\bar{x}$ =	102.30	101.50	104.17	103.70	106.57	103.97	103.7
S_x =	3.16	3.69	3.77	4.45	3.52	3.75	3.72
$S_{\bar{x}}$ =	0.58	0.67	0.69	0.81	0.64	0.63	0.67

$\bar{x}$ = average (mean) size of meshes (mm). Sample size at each station was 30 meshes.
S_x = standard deviation indicating variation in mesh sizes. Two times S_x, added to and subtracted from $\bar{x}$, gives the size limits between which 95% of the meshes fall.
$S_{\bar{x}}$ = standard error which is a measure of the preciseness of the mean. Two times $S_{\bar{x}}$, added to and subtracted from $\bar{x}$, gives the 95% confidence limits of $\bar{x}$ shown in this table.

APPENDIX D

TOW DATA

Tow data (all tows 1 hr from set to haulback).

A. 12 December 1977. 10 kilometers east of Scituate, Massachusetts. Bottom type: sand and mud.

Tow 1

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Large mesh uncovered	
Wire out:	128 meters	137 meters
Course:	170°	155°
Start time:	1110	1056
Avg. depth:	45 meters	45 meters
Weather:	Overcast; wind NNW at 15 knots; seas 1-2 meters; temp. -6°C	

Tow 2

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Large mesh covered	
Wire out:	128 meters	137 meters
Course:	170°	165°
Start time:	1305	1255
Avg. depth:	45 meters	45 meters
Weather:	Overcast; wind NW at 10 knots; seas 1-1.5 meters; temp. -6°C.	

Tow 3

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Small mesh covered	
Wire out:	128 meters	137 meters
Course:	170°	170°
Start time:	1510	1434
Avg. depth:	41 meters	41 meters
Weather:	Overcast; wind NW at 10 knots; seas 1-1.5 meters; temp. -6°C	

Tow 4

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	----------	Small mesh uncovered
Wire out:	----------	137 meters
Course:	----------	330°
Start time:	----------	1615
Avg. depth:	----------	41 meters
Weather:	Overcast; wind NW at 10 knots; seas 1-1.5 meters; temp. -6°C	

B. 13 December 1977. 11 kilometers ENE of Scituate, Massachusetts. Bottom type: Mud.

Tow 5

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Small mesh uncovered	
Wire out:	137 meters	137 meters
Course:	000°	350°
Start time:	0805	0750
Avg. depth:	50 meters	47 meters
Weather:	Overcast; wind north at 10 knots; seas 1 meter; temp. -6°C.	

Tow 6

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Small mesh covered	
Wire out:	137 meters	137 meters
Course:	160°	125°
Start time:	0955	0929
Avg. depth:	50 meters	50 meters
Weather:	Overcast; wind NNE at 15 knots; seas 1 meter; temp. -3°C.	

Tow 7

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Large mesh uncovered	
Wire out:	137 meters	137 meters
Course:	350°	350°
Start time:	1140	1130
Avg. depth:	51 meters	51 meters
Weather:	Overcast; wind NE at 15 knots; seas 1 meter; temp. 0°C.	

Tow 8

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Cod end:	Large mesh covered	
Wire out:	137 meters	137 meters
Course:	170°	170°
Start time:	1320	1307
Avg. depth:	51 meters	51 meters
Weather:	Overcast; wind NE at 15 knots; seas 1 meter; temp. 0°C.	

APPENDIX D

TOW DATA (cont'd)

Tow data (all tows 1 hr from set to haulback).

A. 22 March 1978. Between Long Beach and Eastern Point, Gloucester, Massachusetts. Bottom type: sand and mud.

	LINDA B	METACOMET		LINDA B	METACOMET
Tow 1			**Tow 3**		
Cod end:	Small mesh uncovered		Cod end:	Large mesh uncovered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)	Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	East	East	Course:	West	West
Start time:	0640	0640	Start time:	1015	1015
Avg. depth:	24 fms (43.9 m)	24 fms (43.9 m)	Avg. depth:	27 fms (49.3 m)	27 fms (49.3 m)
Weather:	Wind WSW at 20 knots; seas 4 ft; overcast.		Weather:	Wind West at 30 knots; seas 4 ft; cloudy.	
Tow 2			**Tow 4**		
Cod end:	Small mesh covered		Cod end:	Large mesh covered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)	Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	East	East	Course:	West	West
Start time:	0830	0826	Start time:	1150	1200
Avg. depth:	25 fms (45.7 m)	25 fms (45.7 m)	Avg. depth:	25 fms (45.7 m)	25 fms (45.7 m)
Weather:	Wind West at 25 knots; seas 4 ft; partly cloudy.		Weather:	Wind WNW at 30 knots; seas 4 ft; partly cloudy.	

B. 23 March 1978. East of Thatcher's Island, Gloucester, Massachusetts. Bottom type: sand and mud.

	LINDA B	METACOMET		LINDA B	METACOMET
Tow 5			**Tow 7**		
Cod end:	Large mesh covered		Cod end:	Small mesh covered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)	Wire out:	100 fms (182.9 m)	125 fms (228.5 m)
Course:	East	East	Course:	North	North
Start time:	0600	0615	Start time:	0915	0945
Avg. depth:	28 fms (51.2 m)	28 fms (51.2 m)	Avg. depth:	40 fms (73.1 m)	35 fms (64.0 m)
Weather:	Wind SSE at 15 knots; seas 3 ft; overcast.		Weather:	Wind SSE at 10 knots; seas 2 ft; partly cloudy.	
Tow 6			**Tow 8**		
Cod end:	Large mesh uncovered		Cod end:	Small mesh uncovered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)	Wire out:	100 fms (182.9 m)	125 fms (228.5 m)
Course:	North	North	Course:	SW	SW
Start time:	0730	0755	Start time:	1050	1050
Avg. depth:	30 fms (54.8 m)	30 fms (54.8 m)	Avg. depth:	40 fms (73.1 m)	40 fms (73.1 m)
Weather:	Wind SSE at 15 knots; seas 3 ft; partly cloudy.		Weather:	Wind South at 5 knots; seas 1 ft; partly cloudy.	

APPENDIX D

TOW DATA (cont'd)

Tow data (all tows 1 hr from set to haulback).

C. 25 March 1978. Off Long Beach, Gloucester, Massachusetts. Bottom type: sand and mud.

	LINDA B	METACOMET
Tow 9		
Cod end:	Small mesh covered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	NE	NE
Start time:	0630	0630
Avg. depth:	22 fms (40.2 m)	22 fms (40.2 m)
Weather:	Wind NE at 10 knots; seas 1 ft; clear.	
Tow 10		
Cod end:	Small mesh uncovered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	SE	SE
Start time:	0755	0810
Avg. depth:	21 fms (38.5 m)	21 fms (38.4 m)
Weather:	Wind NE at 10 knots; seas 1 ft; clear.	

	LINDA B	METACOMET
Tow 11		
Cod end:	Large mesh covered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	SW	SW
Start time:	0945	0950
Avg. depth:	24 fms (43.9 m)	24 fms (43.9 m)
Weather:	Wind North at 10 knots; seas 1 ft; clear.	
Tow 12		
Cod end:	Large mesh uncovered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	NE	NE
Start time:	1115	1130
Avg. depth:	21 fms (38.4 m)	21 fms (38.4 m)
Weather:	Wind North at 5 knots; seas calm; clear.	

D. 28 March 1978. Vicinity of Thatchers Island, Gloucester, Massachusetts. Bottom type: sand and mud.

	LINDA B	METACOMET
Tow 13		
Cod end:	Large mesh uncovered	
Wire out:	100 fms (182.9 m)	125 fms (228.5 m)
Course:	North	North
Start time:	0600	0610
Avg. depth:	32 fms (58.5 m)	38 fms (69.5 m)
Weather:	Wind WSW at 15 knots; seas 3 ft; partly cloudy.	
Tow 14		
Cod end:	Large mesh covered	
Wire out:	100 fms (182.9 m)	125 fms (228.5 m)
Course:	SW	SW
Start time:	0730	0730
Avg. depth:	37 fms (67.6 m)	44 fms (80.4 m)
Weather:	Wind WSW at 15 knots; seas 3 ft; partly cloudy.	

	LINDA B	METACOMET
Tow 15		
Cod end:	Small mesh uncovered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	SW	SW
Start time:	1100	1030
Avg. depth:	24 fms (43.9 m)	24 fms (43.9 m)
Weather:	Wind WSW at 20 knots; seas 4 ft; partly cloudy.	
Tow 16		
Cod end:	Small mesh covered	
Wire out:	100 fms (182.9 m)	100 fms (182.9 m)
Course:	West	West
Start time:	1100	1030
Avg. depth:	24 fms (43.9 m)	24 fms (43.9 m)
Weather:	Wind WSW at 20 knots; seas 4 ft; partly cloudy.	

Tow data (all tows 1 hr from set to haulback). Bottom type: mud and rock.

A. 13 August 1978.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 1		
Cod end:	Small mesh covered.	
Wire out:	225 fms	225 fms
Course:	NNW	320
Start time:	0540	0542
Avg. depth:	92 fms	85 fms
Weather:	Wind calm; 68°; overcast.	Seas 1 ft; fog.
Tow 2		
Cod end:	Small mesh uncovered.	
Wire out:	225 fms	225 fms
Course:	SW	270
Start time:	0718	0728
Avg. depth:	93 fms	90 fms
Weather:	Wind calm; 68°; overcast.	Seas 1 ft; fog.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 3		
Cod end:	Large mesh covered.	
Wire out:	225 fms	200 fms
Course:	W	200
Start time:	1303	1300
Avg. depth:	74 fms	70 fms
Weather:	Wind calm; overcast.	Fog.
Tow 4		
Cod end:	Large mesh uncovered.	
Wire out:	225 fms	200 fms
Course:	E	110
Start time:	1445	1453
Avg. depth:	74 fms	70 fms
Weather:	Wind calm; overcast.	Seas 1 ft; fog.

B. 14 August 1978.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 5		
Cod end:	Small mesh uncovered.	
Wire out:	225 fms	200 fms
Course:	E	260
Start time:	0810	0758
Avg. depth:	81 fms	72 fms
Weather:	Wind calm; overcast.	Seas 3 ft.
Tow 6		
Cod end:	Small mesh covered.	
Wire out:	225 fms	200 fms
Course:	W	270
Start time:	0953	950
Avg. depth:	81 fms	78 fms
Weather:	Wind calm; overcast.	Seas 3 ft; fog.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 7		
Cod end:	Large mesh uncovered.	
Wire out:	225 fms	200 fms
Course:	E	120
Start time:	1158	1145
Avg. depth:	81 fms	78 fms
Weather:	Wind calm; overcast.	Seas 2 ft; fog.
Tow 8		
Cod end:	Large mesh covered.	
Wire out:	225 fms	200 fms
Course:	W	270
Start time:	1345	1350
Avg. depth:	83 fms	79 fms
Weather:	Wind calm, overcast.	Seas 2 ft; fog.

C. 15 August 1978.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 9		
Cod end:	Large mesh uncovered.	Small mesh uncovered.
Wire out:	225 fms	200 fms
Course:	N	335
Start time:	0830	0835
Avg. depth:	85 fms	84 fms
Weather:	Wind calm; overcast,	fog. Seas 2-3 ft.
Tow 10		
Cod end:	Small mesh uncovered.	Large mesh uncovered.
Wire out:	225 fms	200 fms
Course:	S	040
Start time:	1015	1015
Avg. depth:	84 fms	82 fms
Weather:	Wind calm; overcast.	Seas 1-2 ft; fog.

	JOSEPH & LUCIA II	JOSEPH & LUCIA III
Tow 11		
Cod end:	Large mesh uncovered.	Small mesh uncovered.
Wire out:	225 fms	200 fms
Course:	S	180
Start time:	1155	1155
Avg. depth:	84 fms	82 fms
Weather:	Wind calm; overcast.	Seas 1-2 ft, fog.
Tow 12		
Cod end:	Small mesh uncovered.	Large mesh uncovered.
Wire out:	225 fms	200 fms
Course:	N	350
Start time:	1340	1350
Avg. depth:	85 fms	82 fms
Weather:	Wind calm; overcast.	Seas calm; fog.

APPENDIX D

TOW DATA (cont'd)

Tow data. Bottom type: sand.

A. 8 October 1978.

	VALKYRIE	PATTON
Tow 1		
Cod end:	Small mesh uncovered.	
Wire out:	60 fms	60 fms
Course:	S	175°
Start time:	0745	0740
Avg. depth:	22 fms	25 fms
Weather:	50°; clear. Seas 2-3 ft.	
Tow 2		
Cod end:	Small mesh covered.	
Wire out:	150 fms	150 fms
Course:	S	140°-360°
Start time:	0935	0940
Avg. depth:	52 fms	56 fms
Weather:	51°; clear. Seas 2-3 ft.	

	VALKYRIE	PATTON
Tow 3		
Cod end:	Large mesh uncovered.	
Wire out:	130 fms	120 fms
Course:	N	345°
Start time:	1130	1125
Avg. depth:	45 fms	40 fms
Weather:	59°; clear. Seas 3-4 ft.	
Tow 4		
Cod end:	Large mesh covered.	
Wire out:	150 fms	150 fms
Course:	N	340°
Start time:	1405	1407
Avg. depth:	52 fms	56 fms
Weather:	60°; partly cloudy. Seas 1-4 ft.	

B. 9 October 1978.

	VALKYRIE	PATTON
Tow 5		
Cod end:	Large mesh covered.	
Wire out:	60 fms	55 fms
Course:	N	345°
Start time:	0730	0730
Avg. depth:	20 fms	20 fms
Weather:	52°; partly cloudy. Seas 3-5 ft.	
Tow 6		
Cod end:	Large mesh uncovered.	
Wire out:	60 fms	55 fms
Course:	N	360°
Start time:	0855	0855
Avg. depth:	18 fms	18 fms
Weather:	50°; partly cloudy. Seas 3-6 ft.	

	VALKYRIE	PATTON
Tow 7		
Cod end:	Small mesh covered.	
Wire out:	60 fms	55 fms
Course:	E	120°
Start time:	1050	1055
Avg. depth:	29 fms	31 fms
Weather:	46°; partly cloudy. Seas 3-6 ft.	
Tow 8		
Cod end:	Small mesh uncovered.	
Wire out:	100 fms	120 fms
Course:	W	260°
Start time:	1230	1230
Avg. depth:	40 fms	41 fms
Weather:	52°; partly cloudy. Seas 3-6 ft.	

APPENDIX D

TOW DATA (cont'd)

Tow data. Bottom type: sand.

C. 10 October 1978.

Tow 9

	VALKYRIE	PATTON
Cod end:	Small mesh covered.	
Wire out:	70 fms	80 fms
Course:	N	010°
Start time:	0715	0715
Avg. depth:	26 fms	23 fms
Weather:	58°; clear. Seas 2-5 ft.	

Tow 10

	VALKYRIE	PATTON
Cod end:	Small mesh uncovered.	
Wire out:	70 fms	70 fms
Course:	S	170°
Start time:	0905	0905
Avg. depth:	25 fms	25 fms
Weather:	60°; clear. Seas 3-6 ft.	

Tow 11

	VALKYRIE	PATTON
Cod end:	Large mesh covered.	
Wire out:	120 fms	120 fms
Course:	N	340°
Start time:	1055	1100
Avg. depth:	43 fms	44 fms
Weather:	60°; clear. Seas 3-7 ft.	

Tow 12

	VALKYRIE	PATTON
Cod end:	Large mesh uncovered.	
Wire out:	110 fms	120 fms
Course:	W	270°
Start time:	1230	1235
Avg. depth:	38 fms	37 fms
Weather:	62°; clear. Seas 3-7 ft.	

D. 11 October 1978.

Tow 13

	VALKYRIE	PATTON
Cod end:	Large mesh uncovered.	
Wire out:	90 fms	90 fms
Course:	N	180°
Start time:	0735	0735
Avg. depth:	30 fms	31 fms
Weather:	60°; partly cloudy. Seas 2-3 ft.	

Tow 14

	VALKYRIE	PATTON
Cod end:	Large mesh covered.	
Wire out:	90 fms	90 fms
Course:	N	360°
Start time:	0905	0910
Avg. depth:	35 fms	30 fms
Weather:	71°; clear. Seas 2-3 ft.	

Tow 15

	VALKYRIE	PATTON
Cod end:	Small mesh uncovered.	
Wire out:	90 fms	90 fms
Course:	N	350°
Start time:	1045	1240
Avg. depth:	30 fms	30 fms
Weather:	70°; partly cloudy. Seas 2-3 ft.	

Tow 16

	VALKYRIE	PATTON
Cod end:	Small mesh covered.	
Wire out:	90 fms	90 fms
Course:	N	360°
Start time:	1215	1415
Avg. depth:	30 fms	31 fms
Weather:	70°; clear. Seas 1-2 ft.	

APPENDIX E

Catch Weight Data (in kilograms)

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Tow 1 139 Cod end	Yellowtail - 45.8 Flounders - 13.4 Cod (1) - 11.0 Whiting - 5.0 Ocean pout - 15.4 Other - 18.4 Total 109.0	Yellowtail - 157.0 Flounders - 14.0 Cod - 27.0 Ocean pout - 33.4 Other - 19.0 Total - 250.4
Tow 2 139 Cod end	Yellowtail -101.0 Flounders - 15.4 Cod (2) - 6.0 Whiting - 8.4 Ocean pout - 73.5 Other - 25.5 Total 229.8	Yellowtail - 121.0 Flounders - 26.0 Cod - 9.5 Ocean pout - 107.0 Other - 24.0 Total - 287.5
Tow 2 Cover	Loose knot no weights taken	Yellowtail - 53.5 Flounders - 11.0 Cod - 11.0 Ocean pout - 183.0 Other - 20.0 Total - 278.5
Tow 3 106 Cod end	No good (net caught something heavy; caused door to capsize)	Yellowtail - 39.0 Flounders - 24.6 Cod - 16.0 Ocean pout - 126.5 Other - 57.0 Total - 263.1
Tow 3 Cover	No good	Yellowtail - 6.0 Ocean pout - 32.5 Other - 11.0 Total - 49.5

APPENDIX E

Catch Weight Data (in kilograms) (cont'd)

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Tow 4 106 Cod end	Did not tow (darkness)	Yellowtail - 83.5 Flounders - 36.5 Cod - 62.5 Ocean pout - 68.5 Other - 37.5 Total - 288.5
Tow 5 106 Cod end	Yellowtail - 47.0 Flounders - 16.0 Cod - 34.0 Whiting - 5.5 Ocean pout - 11.0 Haddock - 4.5 Other - 50.0 Total - 168.0	Yellowtail - 126.5 Flounders - 30.5 Cod - 27.5 Whiting - 9.5 Ocean pout - 29.0 Haddock - 3.0 Pollock(1) - 7.0 Other - 27.0 Total - 260.0
Tow 6 106 Cod end	Yellowtail - 14.5 Flounders - 15.0 Cod - 39.0 Ocean pout - 13.5 Other - 36.0 Total - 118.0	Yellowtail - 74.5 Flounders - 37.5 Cod - 46.0 Whiting - 18.0 Ocean pout - 39.0 Other - 42.5 Total - 257.5
Tow 6 Cover	Flounders - 8.5 Cod - 5.5 Whiting - 4.5 Ocean pout - 18.5 Total - 37.0	Yellowtail - 2.5 Flounders - 19.0 Cod, haddock, and pollock- 4.5 Whiting - 22.0 Ocean pout - 49.0 Other - 44.0 Total - 141.0
Tow 7 139 Cod end	Yellowtail - 33.5 Flounders - 15.0 Cod - 55.0 Other - 49.0 Total - 152.5	Yellowtail - 64.0 Flounders - 32.0 Cod - 47.0 Whiting - 7.5 Pollock(1) - 11.5 Other - 18.5 Total - 180.5

APPENDIX E

Catch Weight Data (in kilograms) (cont'd)

	FRANCES ELIZABETH		CHRISTOPHER ANDREW	
Tow 8 139 Cod end	Yellowtail	14.5	Yellowtail	33.0
	Flounders	12.0	Flounders	17.0
	Cod	18.5	Cod	24.5
	Other	12.5	Pollock(1)	3.5
			Whiting	4.5
			Ocean pout	14.0
			Other	14.5
	Total	57.5	Total	111.0
Tow 8 Cover	Yellowtail	4.5	Yellowtail	12.0
	Flounders	13.0	Flounders	10.0
	Cod	6.5	Cod	14.5
	Whiting	25.5	Whiting	19.5
	Hakes	51.0	Hakes	33.0
	Haddock	18.5	Haddock	3.0
	Ocean pout	18.5	Ocean pout	30.0
	Total	137.5	Total	122.0
Tow 9 106 Cod end	Yellowtail	72.5	Yellowtail	138.0
	Flounders	26.5	Flounders	16.0
	Cod	37.0	Cod	46.5
	Ocean pout	87.5	Ocean pout	128.5
	Other	45.0	Other	16.5
	Total	268.5	Total	345.5
Tow 10 139 Cod end	Yellowtail	47.0	Yellowtail	59.5
	Flounders	27.5	Flounders	22.5
	Cod	26.5	Cod	14.0
	Ocean pout	30.5	Ocean pout	32.0
	Other	32.0	Other	23.5
	Total	163.5	Total	151.5
Tow 10 Cover	Yellowtail	28.5	Yellowtail	54.0
	Flounders	12.5	Flounders	17.0
	Cod	28.5	Cod	25.5
	Ocean pout	42.0	Whiting	2.5
	Other	13.5	Ocean pout	36.5
			Other	10.0
	Total	125.0	Total	145.5

Catch Weight Data (in kilograms) (cont'd)

	FRANCES ELIZABETH	CHRISTOPHER ANDREW
Tow 11 139 Cod end	Yellowtail - 35.5 Flounders - 23.5 Cod - 22.5 Ocean pout - 63.0 Other - 21.5 Total - 166.0	Yellowtail - 32.0 Flounders - 18.0 Cod - 33.0 Ocean pout - 98.5 Other - 22.5 Total - 204.5
Tow 12 106 Cod end	Yellowtail - 55.5 Flounders - 15.5 Cod - 53.0 Ocean pout - 54.0 Other - 42.0 Total - 220.0	Yellowtail - 36.0 Flounders - 7.5 Cod - 38.0 Ocean pout - 20.5 Other - 18.0 Total - 120.0
Tow 12 Cover	Yellowtail - 19.5 Flounders - 1.0 Cod - 6.5 Ocean pout - 18.5 Other - 5.5 Total - 51.0	Yellowtail - 26.0 Flounders - 3.5 Cod - 7.0 Ocean pout - 14.0 Other - 7.5 Total - 58.0

APPENDIX E

Catch Weight Data (cont'd)

		LINDA B		METACOMET	
		kg	lb	kg	lb
Tow 1 Small cod end	Cod -	6.1	13.4	18.2	40.0
	Yellowtail -	138.9	305.6	127.1	279.6
	Blackback -	37.4	82.3	24.6	56.3
	Dabs -	12.4	27.3	10.6	23.3
	Ocean pout -	40.0	88.0	117.4	258.3
	Other -	55.0	121.0		
	Total -	289.8	637.6	297.9	657.5
Tow 2 Small Cod end	Cod -	16.1	35.4	1.3	2.9
	Yellowtail -	92.4	203.3	80.4	176.9
	Blackback -	31.5	69.3	25.5	56.1
	Dabs -	8.8	19.4	9.3	20.5
	Ocean pout -	80.0	176.0	59.1	130.0
	Other -	48.0	105.6		
	Total -	276.8	609.0	175.6	386.3
Tow 3 Cover	Cod -	0.6	1.3	0.7	1.5
	Yellowtail -	0.6	1.3	0.8	1.8
	Blackback -	0.3	0.7	0.4	0.9
	Dabs -	0.2	0.4	1.6	3.5
	Ocean pout -	8.0	17.6	4.0	8.8
	Other -	0.6	1.3		
	Total -	10.3	22.6	7.5	16.5
Tow 3 Large cod end	Cod -	14.0	30.8	1.6	3.5
	Yellowtail -	101.5	223.3	68.1	149.8
	Blackback -	18.0	39.6	14.3	31.5
	Dabs -	7.6	16.7	2.5	5.5
	Ocean pout -	80.0	176.0	38.9	85.6
	Other -	23.0	50.6		
	Total -	244.1	537.0	125.4	275.9
Tow 4 Large cod end	Cod -	20.8	45.8	2.0	4.4
	Yellowtail -	94.3	207.5	85.1	187.2
	Blackjack -	25.2	55.4	35.3	77.7
	Dabs -	8.8	19.4	18.7	41.1
	Ocean pout -	44.0	96.8	34.3	75.5
	Other -	20.0	44.0		
	Total -	213.1	468.9	175.4	385.9

Catch Weight Data (cont'd)

		LINDA B kg	LINDA B lb	METACOMET kg	METACOMET lb
Tow 4 Cover	Cod -	0.9	2.0	4.8	10.6
	Yellowtail -	4.0	8.8	10.6	23.3
	Blackback -	3.9	8.6	20.9	46.0
	Dabs -	3.5	7.7	13.1	28.8
	Ocean pout -	30.0	66.0	100.0	220.0
	Other -	5.0	11.0		
	Total -	47.3	104.1	149.4	328.7
Tow 5 Large cod end	Cod -	3.0	6.6	3.4	7.5
	Yellowtail -	53.0	116.6	38.5	84.7
	Blackback -	11.5	25.3	5.2	11.4
	Dabs -	13.4	29.5	4.7	10.3
	Ocean pout -	55.0	121.0	16.0	33.2
	Other -	45.0	99.0		
	Total -	180.9	398.0	67.8	147.1
Tow 5 Cover	Cod -	1.2	2.6	1.5	3.3
	Yellowtail -	9.3	20.5	15.3	33.7
	Blackback -	4.2	9.2	10.1	22.2
	Dabs -	24.0	52.8	14.7	32.3
	Ocean pout -	10.0	22.0	30.0	66.0
	Other -	2.5	5.5		
	Total -	51.2	112.6	71.6	157.5
Tow 6 Large cod end	Cod -	76.6	168.5	38.5	84.7
	Yellowtail -	60.1	132.2	41.2	90.6
	Blackback -	21.7	47.7	17.5	38.5
	Dabs -	18.5	40.7	13.8	30.4
	Ocean pout -	67.5	148.5	53.4	117.5
	Other -	35.0	77.0		
	Total -	279.4	614.6	164.4	361.7
Tow 7 Small cod end	Cod -	711.3	1364.9	221.1	486.4
	Yellowtail -	238.2	524.0	153.4	337.5
	Blackback -	40.1	88.2	26.4	58.1
	Dabs -	58.6	128.9	37.4	82.3
	Ocean pout -	50.0	110.0	55.5	122.1
	Other -	100.0	220.0		
	Total -	1198.2	2436.0	493.8	1086.4
Tow 7 Cover	Cod -	55.5	122.1	37.2	81.8
	Yellowtail -	1.5	3.3	3.3	7.3
	Blackback -	0.8	1.8	0.5	1.1
	Dabs -	12.6	27.7	10.9	24.0
	Ocean pout -	7.0	15.4	13.5	29.7
	Other -	5.0	11.0		
	Total -	82.4	181.3	65.4	143.9

APPENDIX E

Catch weight data (cont'd)

			LINDA B		METACOMET	
			kg	lb	kg	lb
Tow 12	Cod		2.6	5.7	4.7	10.3
Large cod end	Yellowtail	-	110.9	244.0	227.7	500.9
	Blackback	-	17.8	39.2	24.2	53.2
	Dabs	-	1.9	4.2	0.3	0.7
	Ocean pout	-	7.5	16.5	25.5	56.1
	Other	-	21.0	46.2		
	Total	-	161.7	355.8	282.4	621.2
Tow 13	Cod	-	48.0	105.6	38.9	85.6
Large cod end	Yellowtail	-	103.6	227.9	52.7	115.9
	Blackback	-	14.5	31.9	12.0	26.4
	Dabs	-	50.7	111.5	26.0	57.2
	Ocean pout	-	35.0	77.0	48.0	105.6
	Other	-	65.5	144.1		
	Total	-	317.3	698.0	177.6	390.7
Tow 14	Cod	-	24.7	54.3	17.0	37.4
Large cod end	Yellowtail	-	75.7	166.5	59.0	129.8
	Blackback	-	12.1	26.6	6.5	14.3
	Dabs	-	54.0	118.8	18.6	40.9
	Ocean pout	-	8.5	18.7	72.5	159.3
	Other	-	63.0	138.6		
	Total	-	238.0	523.5	173.6	381.7
Tow 14	Cod	-	21.3	46.9	30.6	67.3
Cover	Yellowtail	-	6.4	14.1	14.7	32.3
	Blackback	-	3.4	7.5	2.6	5.7
	Dabs	-	26.0	57.2	16.1	35.4
	Ocean pout	-	24.5	53.9	31.0	68.2
	Other	-	20.5	45.1		
	Total	-	102.1	224.7	95.0	208.9
Tow 15	Cod	-	21.6	47.5	14.6	32.1
Small cod end	Yellowtail	-	111.4	245.1	70.1	154.2
	Blackback	-	26.1	57.4	31.4	69.1
	Dabs	-	8.9	19.6	20.8	45.8
	Ocean pout	-	31.5	69.3	74.0	162.8
	Other	-	49.5	108.9		
	Total	-	249.0	547.8	210.9	464.0

APPENDIX E

Catch weight data (cont'd)

		LINDA B kg	LINDA B lb	METACOMET kg	METACOMET lb
Tow 8 Small cod end	Cod -	195.1	429.2	157.9	303.4
	Yellowtail -	117.6	258.7	89.2	196.2
	Blackback -	36.7	80.7	23.4	51.5
	Dabs -	59.5	130.9	42.5	93.5
	Ocean pout -	18.0	39.6	50.0	110.0
	Other -	54.0	118.8		
	Total -	480.9	1057.9	363.0	754.6
Tow 9 Small cod end	Cod -	9.1	20.0	5.3	11.7
	Yellowtail -	164.5	361.9	133.5	293.7
	Blackback -	39.3	86.5	44.5	97.9
	Dabs -	1.0	2.2	6.1	13.4
	Ocean pout -	12.5	27.5	56.0	123.2
	Other -	43.0	94.6		
	Total -	269.4	592.7	245.4	539.9
Tow 9 Cover	Cod -	0	0	2.0	4.4
	Yellowtail -	0	0	1.5	3.3
	Blackback -	0	0	3.4	7.5
	Dabs -	0	0	3.0	6.6
	Ocean pout -	0	0	3.0	6.6
	Other -				
	Total -	0	0	12.9	28.4
Tow 10 Small cod end	Cod -	6.3	13.9	20.6	45.3
	Yellowtail -	176.3	387.9	155.9	343.0
	Blackback -	53.7	118.1	34.8	76.6
	Dabs -	9.3	20.5	1.6	3.5
	Ocean pout -	88.5	194.7	45.0	99.0
	Other -	40.0	88.0		
	Total -	374.1	823.1	257.9	567.4
Tow 11 Large cod end	Cod -	13.3	29.3	13.5	29.7
	Yellowtail -	192.3	423.1	81.2	178.6
	Blackback -	38.2	84.0	24.7	54.3
	Dabs -	4.0	8.8	4.0	8.8
	Ocean pout -	26.5	58.3	37.0	81.4
	Other -	16.5	36.3		
	Total -	290.8	639.8	160.4	352.8
Tow 11 Cover	Cod -	9.1	20.0	31.4	69.1
	Yellowtail -	11.0	24.2	10.4	22.9
	Blackback -	15.1	33.2	9.9	21.8
	Dabs -	9.7	21.3	10.1	22.2
	Ocean pout -	20.5	45.1	42.0	92.4
	Other -	13.5	29.7		
	Total -	78.9	173.5	103.8	228.4

APPENDIX E

Catch weight data (cont'd)

			LINDA B		METACOMET	
			kg	lb	kg	lb
Tow 16	Cod	-	19.9	43.8	18.0	39.6
Small cod end	Yellowtail	-	134.9	296.8	85.7	188.5
	Blackback	-	27.3	60.1	13.3	29.3
	Dabs	-	11.0	24.2	5.9	13.0
	Ocean pout	-	16.5	36.3	35.0	77.0
	Other	-	36.0	79.2		
	Total	-	245.6	540.4	157.9	347.4
Tow 16	Cod	-	3.6	7.9	0.7	1.5
Cover	Yellowtail	-	1.1	2.4	1.4	3.1
	Blackback	-	0.9	2.0	1.1	2.4
	Dabs	-	7.5	16.5	4.8	10.6
	Ocean pout	-	8.5	18.7	4.5	9.9
	Other	-	5.5	12.1		
	Total	-	27.1	59.6	12.5	27.5

APPENDIX E

Catch weight data (cont'd)

		JOSEPH & LUCIA II kg	JOSEPH & LUCIA II lb	JOSEPH & LUCIA III kg	JOSEPH & LUCIA III lb
Tow 1 Small cod end	Haddock -	33.4	73.5	36.7	80.7
	Pollock -	32.8	72.2	26.6	58.5
	Cod -	102.7	225.9	168.2	370.0
	Redfish -	3.7	8.1	4.4	9.7
	Whiting -	1.9	4.2	0.5	1.1
	Dabs -	32.8	72.2	13.7	30.1
	Ling -	12.5	27.5	17.0	37.4
	Total -	219.8	483.6	267.1	587.5
Tow 1 Cover	Haddock -	0.3	0.7		
	Pollock -	0.6	1.3		
	Cod -			1.7	3.7
	Whiting -	0.2	0.4		
	Dabs -	0.4	0.9	0.4	0.9
	Ling -	5.8	12.8		
	Total -	7.3	16.1	2.1	4.6
Tow 2 Small cod end	Haddock -	71.2	156.6	84.7	186.3
	Pollock -	8.1	17.8	46.6	102.5
	Cod -	12.7	27.9	48.6	106.9
	Redfish -	2.4	5.3	7.1	15.6
	Whiting -	2.3	5.1	0.9	2.0
	Dabs -	21.5	47.3	29.3	64.5
	Ling -	17.1	37.6	26.1	57.4
	Total -	135.3	297.6	243.3	535.2
Tow 3 Large cod end	Haddock -	424.0	932.8	494.2	1,087.2
	Pollock -	262.7	577.9	364.3	801.5
	Cod -	93.0	204.6	44.8	98.6
	Redfish -	10.4	22.9	6.0	13.2
	Whiting -	4.0	8.8	2.3	5.1
	Dabs -	2.9	6.4	0.3	0.7
	Ling -	0.8	1.8		
	Total -	797.8	1,755.2	911.9	2,006.3
Tow 3 Cover	Haddock -	31.1	68.4	47.7	104.9
	Pollock -	39.2	86.2	127.1	279.6
	Cod -	1.2	2.6	1.0	2.4
	Redfish -	21.9	48.2	35.6	78.3
	Whiting -	4.1	9.0		
	Dabs -			2.1	4.6
	Ling -	1.2	2.6	0.5	1.1
	Total -	98.7	217.0	214.0	470.9

APPENDIX E

Catch weight data (cont'd)

		JOSEPH & LUCIA II kg	JOSEPH & LUCIA II lb	JOSEPH & LUCIA III kg	JOSEPH & LUCIA III lb
Tow 4 Large cod end	Haddock -	246.7	542.7	371.3	816.9
	Pollock -	237.7	522.9	372.9	820.4
	Cod -	52.8	116.2	179.4	394.7
	Redfish -	7.3	16.1		
	Whiting -			0.7	1.5
	Dabs -	3.4	7.5	1.9	4.2
	Total -	547.9	1,205.4	926.2	2,037.7
Tow 5 Small cod end	Haddock -	170.0	374.0	222.3	489.1
	Pollock -	74.8	164.6	139.3	306.5
	Cod -	54.4	119.7	35.0	77.0
	Redfish -	95.6	210.3	22.4	49.3
	Whiting -	3.0	6.6		
	Dabs -			13.8	30.4
	Total -	397.8	875.2	432.8	952.3
Tow 6 Small cod end	Haddock -	411.7	905.7	389.4	856.7
	Pollock -	30.5	67.1	38.1	83.8
	Cod -	210.3	462.7	119.4	262.7
	Redfish -	3.9	8.6	7.5	16.5
	Whiting -	9.0	19.8	12.6	27.7
	Dabs -	6.1	13.4	8.7	19.1
	Ling -	0.8	1.8	1.0	2.2
	Total -	672.3	1,479.1	576.7	1,268.7
Tow 6 Cover	Haddock -	2.2	4.8	2.9	6.4
	Pollock -	0.4	0.9	2.6	5.7
	Redfish -	2.5	5.5	14.8	32.6
	Whiting -	9.1	20.0	11.3	24.9
	Dabs -	0.4	0.9	1.4	3.1
	Ling -	2.1	4.6	0.8	1.8
	Total -	16.7	36.7	33.8	74.5
Tow 7 Large cod end	Haddock -	296.8	653.0	353.0	776.6
	Pollock -	77.8	171.2	53.0	116.6
	Cod -	158.5	348.7	48.6	106.9
	Redfish -			1.3	2.9
	Whiting -	2.6	5.7	1.4	3.1
	Dabs -	10.1	22.2	2.8	6.2
	Ling -	2.8	6.2		
	Total -	548.6	1,207.0	460.1	1,012.3

APPENDIX E

weight data (cont'd)

		JOSEPH & LUCIA II		JOSEPH & LUCIA III	
		kg	lb	kg	lb
ow 8	Haddock -	317.6	698.7	319.2	702.2
arge cod end	Pollock -	42.3	93.1	42.1	92.6
	Cod -	128.7	283.1	134.3	295.5
	Redfish -	6.2	13.6	13.1	28.8
	Whiting -	4.4	9.7	5.0	11.0
	Dabs -	3.4	7.5	5.0	11.0
	Ling -	2.4	5.3	1.6	3.5
	Total -	505.0	1,111.0	520.3	1,144.6
ow 8	Haddock -	11.1	24.4	11.0	24.2
over	Pollock -	11.2	24.6	1.7	3.7
	Cod -	1.4	3.1	2.3	5.1
	Redfish -	1.4	3.1	1.3	2.9
	Whiting -	3.1	6.8	2.2	4.8
	Dabs -	0.5	1.1	0.2	0.4
	Total -	28.7	63.1	18.7	41.1
		Large cod end		Small cod end	
ow 9	Haddock -	581.2	1,278.6	569.8	1,253.6
	Pollock -	2.3	5.1	4.8	10.6
	Cod -	183.9	404.6	92.6	203.7
	Redfish -	2.9	6.4	13.2	29.0
	Whiting -	3.1	6.8	5.9	13.0
	Dabs -	5.7	12.5		
	Ling -			2.4	5.3
	Total -	779.1	1,714.0	688.7	1,515.2
		Small cod end		Large cod end	
ow 10	Haddock -	575.0	1,265.0	527.2	1,159.8
	Pollock -	67.0	147.4	30.8	67.8
	Cod -	68.9	151.6	128.6	282.9
	Redfish -	8.8	19.4		
	Whiting -	20.3	44.7	3.3	7.3
	Dabs -	1.9	4.2	5.7	12.5
	Ling -	2.0	4.4	2.0	4.4
	Total -	743.9	1,636.7	697.6	1,534.7

APPENDIX E

Catch weight data (cont'd)

		JOSEPH & LUCIA II		JOSEPH & LUCIA III	
		kg	lb	kg	lb
		Large cod end		Small cod end	
Tow 11	Haddock -	181.2	398.6	85.5	188.1
	Pollock -	6.2	13.6		
	Cod -	140.2	308.4	72.7	159.9
	Redfish -	26.4	58.1	75.1	165.2
	Whiting -	0.5	1.1		
	Dabs -	0.7	1.5	1.5	3.3
	Total -	355.2	781.3	234.8	516.5
		Small cod end		Large cod end	
Tow 12	Haddock -	493.1	1,084.8	212.0	466.4
	Pollock -	4.5	9.9	4.7	10.3
	Cod -	119.8	263.6	75.6	166.3
	Redfish -	19.2	42.2	1.5	3.3
	Whiting -	6.1	13.4	0.3	0.7
	Dabs -	3.2	7.0	1.4	3.1
	Ling -	10.9	24.0	3.2	7.0
	Total -	656.8	1,444.9	298.7	657.1

APPENDIX E

Catch weight data (cont'd)

		VALKYRIE		PATTON	
		kg	lb	kg	lb
Tow 1 Small cod end	Cod -	16.2	35.6	68.9	151.6
	Yellowtail -	11.5	25.3	8.6	18.9
	Winter flounder -	6.1	13.4		
	Spiny dogfish -	8.3	18.3		
	Total -	42.1	92.6	77.5	170.5
Tow 2 Small cod end	Haddock -	35.6	78.3	27.6	60.7
	Cod -	74.5	163.9	40.9	90.0
	Yellowtail -	6.0	13.2	4.3	9.5
	American plaice -	17.4	38.3	9.0	19.8
	Winter flounder -			0.9	2.0
	Whiting (silver hake) -	9.4	20.7		
	Spiny dogfish -	9.1	20.0		
	Total -	152.0	334.4	82.7	182.0
Tow 2 Cover	Haddock -	9.6	21.1	4.0	8.8
	Cod -	2.3	5.1	14.5	31.9
	Yellowtail -			0.6	1.3
	American plaice -	3.6	7.9	0.8	1.8
	Whiting (silver hake) -	21.6	47.5		
	Spiny dogfish -	3.2	7.0		
	Total -	40.3	88.6	19.9	43.8
Tow 3 Large cod end	Haddock -	14.2	31.2	10.3*	22.7
	Cod -	32.8	72.2	9.1	20.0
	Yellowtail -	3.0	6.6		
	American plaice -	5.0	11.0	*	
	Winter flounder -	1.1	2.4		
	Whiting (silver hake) -	1.2	2.6		
	Spiny dogfish -	2.2	4.8		
	Total -	59.5	130.8	19.4	42.7
Tow 4 Large cod end	Haddock -	28.1	61.8	50.3	110.7
	Cod -	53.0	116.6	73.0	160.6
	Yellowtail -	1.1	2.4		
	American plaice -	5.2	11.4		
	Whiting (silver hake) -	2.7	5.9		
	Total -	90.1	198.1	123.3	271.3

*Cod end torn up.

Catch weight data (cont'd)

		VALKYRIE		PATTON	
		kg	lb	kg	lb
Tow 4 Cover	Haddock -	6.5	14.3	16.2	35.6
	Cod -	5.9	13.0	18.8	41.4
	American plaice -	3.1	6.8		
	Whiting (silver hake) -	2.9	6.4		
	Spiny dogfish -	2.8	6.2		
	Total -	21.2	46.7	35.0	77.0
Tow 5 Large cod end	Cod -	478.5	1,052.7	1.0	2.2
	Yellowtail -	5.3	11.7	6.7	14.7
	Winter flounder -	10.5	23.1		
	Spiny dogfish -	16.0	35.2		
	Total -	510.3	1,122.7	7.7	16.9
Tow 5 Cover	Yellowtail -	3.0	6.6		
	Winter flounder -	4.4	9.7		
	Whiting (silver hake) -	0.3	0.7		
	Spiny dogfish -	13.7	30.1		
	Total -	21.4	47.1		
Tow 6 Large cod end	Cod -	24.4	53.7	63.1	138.8
	Yellowtail -	2.5	5.5	1.3	2.9
	Winter flounder -	73.5	161.7	41.8	92.0
	Spiny dogfish -	107.7	236.9		
	Total -	208.1	457.8	106.2	233.7
Tow 7 Small cod end	Cod -	1,443.6	3,175.9	*	
	Yellowtail -	7.9	17.4	1.4	3.1
	Winter flounder -	9.9	21.8	0.9	2.0
	Spiny dogfish -	4.1	9.0		
	Total -	1,465.5	3,224.1	2.3	5.1
Tow 7 Cover	Yellowtail -	0.1	0.2		
	Spiny dogfish -	0.8	1.8		
	Total -	0.9	2.0		

*Trawl apparently wasn't fishing.

APPENDIX E

ch weight data (cont'd)

			VALKYRIE		PATTON	
			kg	lb	kg	lb
w 8	Haddock	-	1.6	3.5	0.4	0.9
all cod end	Cod	-	40.8	89.8	15.5	34.1
	Yellowtail	-	5.4	11.9	7.5	16.5
	Winter flounder	-	11.9	26.2	8.5	18.7
	Spiny dogfish	-	0.6	1.3		
	Total	-	60.3	132.7	31.9	70.2
w 9	Cod	-	79.1	174.0	26.7	58.7
all cod end	Yellowtail	-	10.7	23.5	7.3	16.1
	Winter flounder	-	11.7	25.7	2.2	4.8
	Spiny dogfish	-	308.4	678.5		
	Total	-	409.9	901.7	36.2	79.6
w 9	Cod	-	2.6	5.7		
ver	Yellowtail	-	0.1	0.2		
	Spiny dogfish	-	72.3	159.1		
	Total	-	75.0	165.0		
w 10	Cod	-	499.8	1,099.6	422.5	929.5
all cod end	Yellowtail	-	16.2	35.6	7.0	15.4
	Winter flounder	-	12.1	26.6	6.7	14.7
	Spiny dogfish	-	27.8	61.2		
	Total	-	555.9	1,223.0	436.2	959.6
w 11	Haddock	-	18.4	40.5	3.8	8.4
rge cod end	Cod	-	178.4	392.5	274.2	603.2
	Yellowtail	-	1.8	4.0	3.9	8.6
	Winter flounder	-	49.1	108.0	35.8	78.8
	Whiting(silver hake)	-	0.4	0.9		
	Total	-	248.1	545.9	317.7	699.0
w 11	Haddock	-	14.1	31.0	13.7	30.1
ver	Cod	-	4.2	9.2	19.4	42.7
	Yellowtail	-	0.4	0.9	0.7	1.5
	Winter flounder	-	0.6	1.3	0.9	2.0
	Spiny dogfish	-	0.6	1.3		
	Total	-	19.9	43.7	34.7	76.3

APPENDIX E

Catch weight data (cont'd)

			VALKYRIE		PATTON	
			kg	lb	kg	lb
Tow 12 Large cod end	Haddock	-	3.9	8.6	7.3	16.1
	Cod	-	599.5	1,318.9	730.8	1,607.8
	Yellowtail	-	5.3	11.7	4.7	10.3
	Winter flounder	-	60.0	132.0	67.7	148.9
	Spiny dogfish	-	3.7	8.1		
	Total	-	672.4	1,479.3	810.5	1,783.1
Tow 13 Large cod end	Haddock	-	1.9	4.2		
	Cod	-	256.4	564.1	173.3	381.3
	Yellowtail	-	6.6	14.5	2.7	5.9
	Winter flounder	-	87.9	193.4	66.8	147.0
	Total	-	352.8	776.2	242.8	534.2
Tow 14 Large cod end	Cod	-	807.6	1,776.7	12.8*	28.2
	Yellowtail	-	8.2	18.0		
	Winter flounder	-	110.0	242.0	1.9	4.2
	Spiny dogfish	-			5.5	12.1
	Total	-	925.8	2,036.7	20.2	44.5
Tow 14 Cover	Cod	-	**		2.1	4.6
	Total	-			2.1	4.6
Tow 15 Small cod end	Cod	-	285.6	628.3	125.3	275.7
	Yellowtail	-	3.2	7.0	2.9	6.4
	Winter flounder	-	112.0	246.4	73.8	162.4
	Total	-	400.8	881.7	202.0	444.5
Tow 16 Small cod end	Cod	-	572.8	1,260.2	137.8	303.2
	Yellowtail	-	6.2	13.6	3.3	7.3
	Winter flounder	-	96.2	211.6	60.0	132.0
	Total	-	675.2	1,485.4	201.1	442.5
Tow 16 Cover	Haddock	-	0.1	0.2		
	Cod	-	2.8	6.2	1.5	3.3
	Yellowtail	-	0.1	0.1	0.1	0.2
	Whiting(silver hake)	-	0.1	0.2		
	Total	-	3.1	6.7	1.6	3.5

*Large tear in belly.
**Cover torn up.

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