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Final Report

Catch, effort and biology of American lobster, *Homarus americanus*, in the offshore lobster trap fishery of the lower Middle Atlantic Bight.

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ABSTRACT

From June 1974 through October 1976, fourteen cruises were made on commercial lobster trapping vessels off the mid-Atlantic coast. Catch per effort data were collected from 2308 traps, carapace size frequency distributions were formed and analyzed from measurements of over 3300 lobsters and information on quality was obtained from 5487 lobsters. Total catch per trap-haul (CTH) ranged from 0.64 lobsters in January 1976 to 4.5 lobsters in July 1976. Saleable (≥81mm) CTH ranged from 0.46 lobsters in January 1976 to 3.25 lobsters in October 1974. Lobsters examined in and just north of Washington Canyon were found to have the smallest mean carapace length (CL) and catches from those areas contained the greatest percentage of sublegal (<81 mm CL) lobsters. Incidence of cull, damaged and dead lobsters increased throughout the sampling period from 3.8% in 1974 to 5.2% in 1976. Molting occurs from spring through fall and is probably at its peak in July, August and September. The larval nematode, *Ascarophis* sp., an offshore lobster stock discriminator, infested 17.9% of the 218 lobsters examined for parasites.

Examination of logbook data furnished by a Virginia offshore lobster operation shows that best catches occurred in the canyon areas rather than between canyons. Best catches in Norfolk Canyon in 1975 occurred in May, June, July and were slightly less in October and November.

A tagging study of 1000 lobsters was initiated in May 1977. Results from one area, between Norfolk and Washington canyons, reveal a total instantaneous mortality rate (Z) = 4.76672 and a fishing mortality rate (F) = 1.432223. Movements of tagged lobsters were generally confined to $<$10 miles and toward inshore. Initial size-final size regression equations were calculated based on returns of 11 males and 16 females that molted before recapture.

Introduction

In June 1974, a contract (#03-4-043-353) between the National Marine Fisheries Service (NMFS) and the Virginia Institute of Marine Science was developed for the purpose of studying the American lobster, *Homarus americanus* H. Milne-Edwards, fishery and lobster stocks on and at the edge of the continental shelf off the middle Atlantic coast, Lobster Management Area Four (Fig. 1).

The study was part of the State-Federal Fisheries Management Program on the American lobster. The objectives of this study were to obtain catch and effort data from the fishery and to describe some of the biological characteristics of the stocks, as a basis for the development and implementation of management practices to ensure a viable fishery.

This paper is concerned with:

1) a description of the commercial lobster fishery and its landings statistics;

2) catch and effort data and their differences between study areas and over time, based upon logbook records and shipboard samples;

3) size composition of the stocks by sex, study area and over time;

4) variation in the quality of the catch by study area and over time;

5) incidence of intestinal parasites of American lobsters off the Mid-Atlantic Coast;

6) summarization of tag returns, tag loss, and information on movements and molting of lobsters tagged and released off the Virginia coast.

Description of Fishery

The commercial fishery for American lobster off the mid-Atlantic coast from New Jersey to North Carolina, Lobster Management Area Four, includes an inshore and offshore trap fishery, a lobster otter-trawl fishery, and incidental landings taken in fish otter trawls, fish pots, and scallop dredges. The inshore trap fishery, within seven miles of the coast, is confined to New Jersey and Delaware, the southern limit of an inshore lobster fishery which extends along the New England coast and to Quebec and the Maritime Provinces of Canada (Wilder 1954). The offshore lobster trap fishery extends along the continental shelf and slope, 40 to 80 miles (64-129 km) offshore at depths of 40-180 fathoms (73-329 m), from Wilmington Canyon to off Oregon Inlet, North Carolina (Fig. 1). This area is the southern extreme of an offshore trap fishery which extends north to 50 to 100 miles (80-161 km) off the coast of Nova Scotia (DeWolf 1975). Trapping for lobsters off New Jersey also occurs in an intermediate, along-shore zone located up to 25 miles (40 km) offshore.

Combined inshore and offshore lobster landings for all gear in the five states of Lobster Management Area Four were less than six percent of the weight and dollar value of the total American lobster catch, for the seven year period 1969-1975 (Table 1) (Wheeland 1972, 1973, 1975; Thompson 1974; Pileggi and Thompson 1976, 1979; Wise and Thompson 1977).

Important changes in gear use occurred over the seven year period, primarily in New Jersey and Virginia. Prior to 1971, the majority of offshore lobsters were caught by otter trawl. In 1971, the lobster trap became the predominant gear (Schroeder 1959; Skud and Perkins 1969). Lobster trawler landings and the number of vessels decreased to one-third by 1975 in New Jersey, from 974,000 pounds and 47 vessels in 1969 to 294,000 pounds and 17 vessels in 1975 (Fig. 2). Relatively few lobster trawlers and small landings occurred in Virginia in 1969; only one vessel trawled for lobsters after 1971.

Lobster traps in New Jersey increased in number from over 12,000 in 1969 to 42,000 in 1972 and have steadily decreased to about 35,000 since then (Fig. 2). There is no relationship between the number of traps and pounds of lobsters landed. Landings and the number of traps in Virginia have fluctuated widely since traps were introduced in 1971. Inshore and offshore trap catches and numbers of traps were not separately reported in the five state area until 1973.

Landings in lobster traps in Delaware and Maryland, and incidental landings of lobsters by fish trawlers and fish traps in Area Four have been relatively insignificant. Statistics are not available as to the proportion of the New Jersey catch which comes from Lobster Management Area Three or from inshore, or the catch of lobsters from Area Four which might be landed in states outside the Area.

Several large companies were involved in the offshore trap fishery in the area from 1971 to 1975. They fished throughout the year with 80-95 ft steel-hulled vessels using 800-2000 traps per vessel. The crews usually consisted of six men, but sometimes more when two, 12-hour shifts per day for hauling traps were scheduled. The lobstering trips lasted from 4-7 days, including one to two days steaming to and from the fishing grounds.

The typical southern offshore lobster trap operation was that of the independent fisherman. These fishermen trapped from spring through fall using 45-90 ft steel-hulled or wooden-hulled vessels, three to five man crews and worked 200-1500 traps. They usually made 1-3 day trips which included 8-20 hours steaming time. The soak time for gear was generally 5-8 days. Adverse weather conditions and low catches usually precluded lobstering by the independents in winter.

At least eleven different lobster trap types were observed being used throughout the study. Type 1 pots were rectangular wire, 119 x 56 x 35.5 cm (L x W x H), with 2.5 cm bar mesh and a funnel ring diameter of 16 cm. Type 2 pots were wooden and shaped as a truncated prism, 101 x 66 (top width) x 80(bottom width) x 50.5 cm, with a funnel ring diameter of 18.2 cm; the mean lath spacing was 3.14 cm (s.d. = 0.455 cm). Type 3 pots were wooden, rectangular, 111.5 x 60 x 36.5 cm, with a funnel ring diameter of 17.0 cm; the mean lath spacing was 2.02 cm (s.d. = .286 cm). Type 4 pots were wooden framed with cotton string netting, 3.5 cm bar mesh, on sides and top and were shaped as a truncated prism; the pot dimensions were 91.5 x 58.5 (top width) x 67.2 (bottom width) x 44 cm; no measurement on funnel ring diameter was made. Type 5 pots were wooden, rectangular, with string, 3.5 cm bar mesh netting on ends and sides; pot dimensions were 90.5 x 68 x 45 cm, with a funnel ring diameter of 16.0 cm; mean lath spacing on the top was 2.75 cm (s.d. = .428 cm). Type 6 pots were wooden halfcylinders (no dimensions were recorded). Type 7 traps were rectangular wire, 123 x 46 x 31 cm, with 2.5 cm bar mesh and an escape vent 10 x 5 cm in one end. Type 8 traps were vinyl-coated wire 122 x 61 x 46 cm, with 2.5 cm bar mesh and an escape vent 7.6 x 4.4 cm in one end. Type 9 traps were vinyl-coated wire 152 x 61 x 46 cm, with 4.8 cm bar mesh and an escape vent 7.6 x 4.8 cm in one end. Type 10 traps were rectangular wire 118 x 27 x 30 cm with 2.5 cm bar mesh and an escape vent 7.6 x 4.4 cm. Type 11 traps were wooden, rectangular, 123 x 61 x 36 cm, with mean lath spacing 3.01 cm (s.d. = 0.543 cm). The Type 2, wooden "bear" traps were predominant throughout the study. An increase in numbers of Types 1, 7 and 10 wire traps, was noted in 1976.

Each trawl string generally contained from 20-50 traps spaced 12.8-18.3 m apart and attached with polypropylene line to a main line. The main trawl line had International Orange buoys on either end, with masts with either flags or radar reflectors sometimes attached.

Bait for the lobster traps was of various types: clupeids (sea herring, menhaden, blue-back herring), fish racks or skeletons, canned cat food and artificial lobster bait were used. Some fishermen preferred to throw the bait, loose, in the traps while others used bait bags attached to the top-center inside the trap.

Concrete blocks or bricks were usually placed in bottom corners of traps as weights to help the traps settle on the ocean bottom in an upright position and to prevent drifting of the gear.

The vessels usually had either Loran-A or Loran-C navigational equipment and depth-finders. Fishermen normally keep personal log records which include the loran bearings of set gear. With this record of gear location, they are able to return to their gear and, also, inform the Coast Guard or the National Marine Fisheries Service (NMFS) of the location of lost gear.

Once the vessel was in position near one of the trawl string buoys, a grapple or boat hook was used to bring the buoy aboard. The main trawl line was brought in by an hydraulic hauler located amidships on the starboard side of the vessel. The vessel captain normally operated the hauler and was assisted by the mate in lifting each trap aboard. The trap was positioned on a platform or on the starboard rail and the contents removed by one of the deckhands. Another deckhand culled, banded, and/or pegged the lobsters and placed the saleable lobster catch in sea water holding tanks or on ice. Incidental catches of rock crabs, jonah crabs and red crabs sometimes occurred. These crabs were either culled overboard or were kept if sale for them had been arranged. Necessary repairs were then made to the traps, which were then baited and stacked on the aft deck or on the rail in preparation for the next set.

Positioning of traps on the ocean bottom has been somewhat of a controversy in the southern offshore area. Several fishermen prefer to set their gear along the depth contours as New England offshore lobstermen generally do (McCauley 1972). Most of the fishermen in Area Four contend that better catches are made when gear is set across the depth contours of the continental slope; thus, their gear is normally set perpendicular to the gear

of the others. At least one gear conflict incident in the area has occurred probably because of this different manner of setting the traps. Major gear loss or entanglement in the area has also been ascribed to foreign and domestic trawlers and longliners.

Lobsters from the area are shipped to markets in Richmond, VA, Washington, DC, Baltimore, MD, Philadelphia, PA, and New York. Some lobsters are sold locally in the ports where landed.

State regulations concerning the American lobster in Area Four are shown in Table 2.

Methods and Materials

The general area of the study, Lobster Management Area Four (Fig. 1), lies off the coasts of New Jersey, Delaware, Maryland, Virginia and North Carolina. Seven more specific study sites offshore, between Ocean City, Maryland and Oregon Inlet, North Carolina, embracing the 100 fathom (183 m) curve, were established based on National Marine Fisheries Service statistical areas and units, the latter being one degree latitude by one degree longitude (Fig. 3 and Table 3).

From August 1974 through October 1976, 14 cruises on commercial lobster trapping vessels to the various study sites were made by personnel of the Virginia Institute of Marine Science. Date, study area, number of traps randomly sampled for catch and effort and number of lobsters randomly sampled for size, sex and quality composition of the catch on each cruise are shown in Table 4. Lobsters used for intestinal parasite analysis were taken on these cruises and were also taken on several research vessel cruises in Management Area Four. Details not included in this report may be found in earlier quarterly and annual reports (Van Engel et al 1974-1979).

The sampling procedure differed somewhat for the period August 1974 through January 1976 from the procedure used since April 1976. In the earlier period size composition data were obtained from a number of traps in a trawl string and information on number and quality of the catch was obtained from all the traps in the next trawl string. This alternation of procedures explains the disparity in number of traps and lobsters examined for size composition and quality information in the earlier sampling period.

The following is a description of the random selection technique used since April 1976. It was learned from the lobsterman prior to the cruise the approximate range of numbers of traps per trawl string and number of trawl strings. One record sheet per trawl string was made up with trap numbers 1-100 (maximum number of traps per trawl string approached but did not exceed 100). The first trap on each trawl was excluded since a biased catch might occur in that trap due to lack of competition of traps on both sides. The last trap on a trawl string was sometimes sampled. We were unable to determine a priori the last trap on any given trawl string because at times actual numbers of traps per trawl string did not tally with the captain's log. Allowing for a spacer of three traps between sampled traps, we selected twenty numbers at random, using a calculator which generated random numbers. The three-trap spacer was necessary to avoid adjacent traps being chosen which could lead to a large accumulation of lobsters to be examined, causing undue confusion. As trawl strings were hauled aboard the vessel, the traps to be sampled were determined by referring to the random selection sheet assigned to that trawl.

Quality composition data for the later period, since April 1976, were obtained in a manner different from that practiced earlier. Prior to April 1976 quality data were obtained by communicating with and observing the crew as they handled the catch of the trawl string designated for sampling catch number and quality.

Differences between our definition (classification) of soft and papershell lobsters and that of the crew became apparent. The crew deemed a lobster soft or papershell only if it were too soft to be saleable. Since April 1976, while handling a lobster to measure the carapace length, we classified a lobster as soft if it were limp and very soft when the carapace was compressed. The lobster was designated a papershell if the carapace were somewhat pliable when we used a slight amount of hand pressure on the lateral surfaces of the carapace and chelipeds, following the technique of Thomas (1973).

Many papershells, by our definition and examination, were not discarded by the crew; hence, a new category, saleable papershells was created in April 1976.

Statistical tests for mean differences and association (chi-square) followed procedures of Elliott (1971), Sokal and Rohlf (1969) and Snedecor and Cochran (1967).

CATCH AND EFFORT

Several sources of information were used in determining estimates of catch, effort and differences in catch per trap-haul among study areas and time periods.

Ships' logs of offshore operations were not required by any of the states in Management Area Four and were seldom voluntarily offered by the fishermen for our review. Logs covering the Virginia-based fishery from Baltimore Canyon to off Oregon Inlet, NC, from May 1974 through December 1975, were provided to us by the NMFS. These logs contained records of the geographic location, depth, number of traps on each trawl string hauled and the pounds of lobsters in each trawl string on each trip.

The number of trap hauls varied geographically and seasonally (Tables 5, 6). In 1974, most trap hauls were made in Washington Canyon, study area V; between Norfolk Canyon and Oregon Inlet, study area II; and off Oregon Inlet, study area I. In 1975, effort was concentrated in Norfolk Canyon and between Norfolk and Washington canyons, study areas III and IV. Seasonally, most trap hauls were made from May through September in 1974, and January, June through September and in November 1975.

These are underestimates of effort. Catch reported in ships' logs for 1974 was only 76% of the catch reported by NMFS for the year (Table 7); it is assumed that the remaining 24% of the catch occurred from January through April, for which no logs were available. If catch were directly proportional to effort throughout the year, which is not likely, we estimate that the total trap hauls in 1974 was near 80,000. Similarly, catch reported in ships' logs in 1975 was only 78.9% of that reported by NMFS. From this information, we estimate total effort in 1975 was near 31,000 trap hauls.

Our estimates of catch per unit of effort (c/f) (Tables 5, 6, 8) were derived from two sources: 1) detailed observations by us at sea of the total catch in numbers of lobsters from several trawl strings and 2) from the ships' logs in which were recorded the dates on which trawls were set and hauled, the number of traps in each trawl string and the total catch (in pounds) of saleable lobsters in each trawl.

Collection of c/f data at sea by specific study area for each season was not consistent enough to warrant c/f comparisons by area on a seasonal basis using analysis of variance. Information on c/f and set-over-days (SOD) for each cruise, 1974-1976, is shown in Table 8. The total catch per trap-haul (CTH) ranged from 0.64 (January 1976) to 4.5 (July 1976). The saleable CTH ranged from 0.46 (January 1976) to 3.25 (October 1974).

Catch per trap haul was generally above the average in summer and fall and below the average in winter and spring. Estimates of catch per trap-haul-set-over-day (CTHSOD) for each cruise are also shown in Table 8. The total CTHSOD ranged from 0.03 (February-March 1975) to 0.88 (July 1976). Saleable CTHSOD ranged from 0.03 (February-March 1975) to 0.55 (July 1976). The mean number of SOD was greater in winter and spring due to bad weather and mechanical problems and CTHSOD was also less than average in winter and spring.

Logbook information from May 1974 through December 1975 was limited in scope in that some areas were not fished every month, that within areas there were substantial variations in depth at which lobster traps were set, and that little information was available on catches with very short (1-2) SOD, and very long (>14) SOD. Sufficient data were not available to warrant two-way analysis of variance by depth and area, by depth and month, or by area and month.

CTH data in pounds of lobsters with 1-14 SOD were transformed, where x=log 10 (CTH + 1), and a one-way analysis of variance, was performed by area for each month from May 1974 through December 1974 (Sokal and Rohlf 1969). Information obtained where SOD was >14 was not used as this long SOD is not typical of the fishery. In most months, where differences existed, July, August, November, December, CTH was greater in canyon areas III and/or V than between canyons. Evidently there is some preference for canyon habitat as exhibited by higher CTH and probably greater density of lobsters in the canyons than on the shelf and slope adjacent to the canyons.

Two-tailed t-tests at the 5% level of significance (Snedecor and Cochran 1967) were performed on CTH for area III for each month May through November 1974 against its counterpart in 1975 and for the entire year 1974 against 1975. Catches in May and June 1975 were unexplainably greater than those in May and June 1974. CTH in August 1974 was greater than that in August 1975 for no apparent reason. There were no significant differences in catch in each remaining month in 1974 with those in 1975. Also, when the annual data for area III, May through December 1974 were compared with data from January through November 1975 no difference in CTH was found. Stability in CTH suggests that the lobster stocks, at least, in Norfolk Canyon were not heavily exploited from 1974 to 1975.

One-way analysis of variance using transformed CTH was also performed to test differences in CTH by month, January through November 1975, for Area III (Sokal and Rohlf 1969). Best CTH's in area III (Norfolk Canyon) were found to occur in May, June and July. A slight decrease in CTH occurred in August and September. CTH increased in October and November but not quite up to the May through July level. Lowest CTH occurred from January through April.

Availability and possibly feeding activity of lobsters is probably greater in late spring and summer months, explaining the higher CTH in May through July. Peak molting activity occurs in August and September with a lesser amount of molting occurring in April (Harris, personal observation and communication with area lobstermen), similar to the peak time when molting occurs in lobsters along the coast of Maine (Krouse 1973). Decreased mobility and inhibited feeding activity after molting probably lower the catching effectiveness of the lobster trap for saleable lobsters and along with the lack of market for soft-shelled lobsters a reduced CTH occurs in August and September. The increase in CTH in October is due to recruitment of another molt group of lobsters to legal size, increase in feeding activity and a higher percentage of marketable lobsters as the new shells harden. The three previous reasons, plus another, possibly transition from adverse winter conditions on the continental shelf and slope to the proper blend of several physical parameters, such as, light intensity, temperature, and current, that increase availability of lobsters to the fishery may be responsible for the large increase in CTH from the lowest level in April to the highest in May.

Figure 4 shows the relationship between lobster CTH (in pounds) and SOD by area and by month using logbook data from May 1974 through December 1975. Because there were few catch data from areas IV, VI and VII, we were prompted to combine area IV with area III and combine areas VI and VII for graphical purposes. SOD >14 are not shown. Trend lines were drawn by eye using three criteria, 1) that the line begin at the origin (0,0), 2) that emphasis be placed on data points having large sample sizes (points representing less than 5% of the traps hauled for that month are shown as circles), 3) that the trend line be a smooth curve.

Generally, there seems to be little difference in catch trend lines among areas for any given month in 1974 or 1975 (Figure 4). Seasonal variations in the CTH for different SOD are evident. Smallest CTH occurred in winter and early spring (May 1974 and January through April 1975). Set-over-day with optimum CTH varied considerably, usually between four to thirteen days.

Further interpretations of the trend lines are limited by the contraints cited above. Conceivably they may be used by lobster fishermen in planning the frequency with which traps should be fished, with additional constraints imposed by the size of vessel, number of crew, costs of fuel, number of traps, distance from landing site to fishing site, and such social limitations as the number of days leave between trips.

Size Composition

Differences in mean carapace lengths of lobsters collected at sea by random sampling of the catch were examined separately for males and females by area for each year 1974-1976 by one-way analyses of variance (Sokal and Rohlf 1969). Measurements were those of short carapace length (CL), from the base of the eye socket to the posterior border of the carapace, measured parallel to the mid-line.

Within each year, data were usually obtained from only one company and the type of trap, or the proportion of different types, did not change. Comparisons between years were not possible because of changes in gear types from one company to another. A significant difference in mean carapace length was shown to occur in lobsters caught by different gear types.

Differences were found in mean CL for each year for both sexes. Scheffe's multiple comparison test (Sokal and Rohlf 1969) was performed to see where differences in mean CL lay. The mean CL of male lobsters was smaller in area V than in area II in 1974; smaller in area VI than in areas III and IV in 1975; and smaller in area V than in areas III and IV in 1976 (Table 9). For females, the mean CL was smaller in areas V and I than in area III in 1974; smaller in area VI than in areas III and VII in 1975; and smaller in area V than in area VI and in area VI than in areas III and IV in 1976 (Table 10).

From 1974 through 1976 lobsters in and just north of Washington Canyon (areas V and VI) were generally found to have the smallest mean CL. Although not reflected in logbook records from one company in Virginia or NMFS landing records, we believe that fishing effort has been more constant and intense in and just north of Washington Canyon (Table 7). This greater fishing effort over a number of years could have led to decreased mean size of the lobsters in that area.

Quality Composition

Included in the commercial catch of lobsters are categories that are not saleable, such as damaged, dead and softshelled lobsters; and those that are illegal to keep, such as ovigerous lobsters (also known as "eggers") and shorts (those less than minimum legal size). Presumably, the percentage composition of lobsters of different quality changes seasonally, according to growth and reproductive cycles, and with the intensity of the fishery. For the later case, as fishing effort increases, the number of legal-sized lobsters would decrease and opportunity to become damaged would increase. Not all damaged lobsters are discarded: live lobsters with one or both claws missing are sold as "culls".

Catch quality of 5,487 lobsters was obtained on 14 cruises on commercial lobster vessels in Management Area Four from August 1974 through October 1976 (Tables 11-13). Lack of information in certain categories is due to differences in sampling technique used throughout the study and described in the Methods and Materials section.

It is apparent from our sampling from August 1975 through October 1976 that most molting occurred in summer and early fall. Higher percentages of the catch were softshell or papershell in August 1975 (5.0%), July 1976 (6.9%), and October 1976 (10.5%), (Table 12) than at other times. Skud and Perkins (1969) concluded that July and perhaps August were peak months of molting in Veatch Canyon. Krouse (1973) stated that the peak of molting occurred in September in 1969 and August in 1969 and 1970 in inshore Maine lobsters.

Eggers (ovigerous females) were caught in almost every month in which cruises were made; no cruises were made in June or December in the 3-year study. This evidence indicates that regulations affecting the return of eggers to the water must be annual.

The percentage of cull, damaged, and dead lobsters (3.8% in 1974, 4.4% in 1975 and 5.2% in 1976) has increased slightly through the sampling period (Table 13). Statistical significance of differences in percentages was not tested. Undoubtedly, as fishing pressure continues, more lobsters, especially sublegals, are caught in traps, possibly injured (e.g. claw broken off) when being handled, discarded overboard, and then caught again after they have molted without time for regeneration of a new claw.

Number and percent of short (sublegal) lobsters in samples taken at sea are shown in Table 14. Areas V and VI had the highest percentage of sublegal lobsters taken from the four areas sampled. As stated before, this is probably due to more constant and intense fishing pressure in and north of Washington Canyon which has led to a decrease in mean size of lobsters there, resulting in these areas having the smallest size lobsters of the areas sampled.

Incidence of Parasites in Lobsters

The larval nematode Ascarophis sp., an intestinal parasite, was found by Uzmann (1967) to be an offshore lobster population discriminator among lobsters collected from Hudson, Block, Veatch and Corsair canyons. In the absence of other information on movements of lobsters in Area Four and to test the possibility that the lobsters were infested with discriminating parasites, we examined 218 lobsters collected from that area from August 1975 through March 1977.

Thirty-nine lobsters were infested (Table 15). The rate of infestation, 17.9%, was similar by chi-square analysis (Elliott 1971) to the 25% rate found in over 3000 lobsters by Uzmann (1967).

Lobsters examined for parasites ranged from 49-179 mm CL. None of the 11 lobsters $\geq$ 112 mm CL contained parasites. Because of the relatively small number of large lobsters sampled, results do not necessarily suggest that these nematodes are size specific.

One-hundred ninety-seven of the lobsters examined were caught on commercial and research vessel cruises in Norfolk and Washington canyons and on the continental shelf and slope between and adjacent to those canyons (Areas III, IV, V; Fig. 1) at depths of 73-402 m. Infestation with Ascarophis sp. occurred in 36 (18.3%) of these 197 lobsters.

The remaining 21 lobsters examined were caught on research vessel cruises off the coasts of Delaware and New Jersey at depths of 57-95 m. Three (14.3%) of these 21 lobsters were infested with Ascarophis sp.

Chi-square analyses (Elliott 1971) showed no differences in rate of infestation between lobsters sampled from Areas III, IV, V and those taken off the coasts of Delaware and New Jersey.

Nematodes were found in 13 (14.3%) of 91 male lobsters and in 26 (20.5%) of 127 female lobsters sampled in all areas (Table 15). No difference between rates of infestation with these nematodes by sex was found using chi-square analyses (Elliott 1971). This agrees with information on lack of sex specificity of these parasites in lobsters as shown by Uzmann (1967) in more northern areas.

Only one (0.5%) lobster (86 mm CL female) was infested with acanthocephalan cysts, Corynosoma sp., a coastal lobster stock discriminator, according to Uzmann (1970). This lobster was caught in Norfolk Canyon in August 1975. Mixing of offshore and onshore stocks is apparently rare, but may occur in the summer during an inshore migration as Uzmann (1970) contends.

Mortality Estimates

Concern exists as to what amount of fishing pressure lobster stocks can endure without declining yields and what yield will support a viable fishery. Estimates of growth and mortality are necessary for yield assessment: these can be made from recoveries of tagged lobsters. In addition, inshore-offshore or north-south movements of lobsters might be detected and estimates made of the interdependence or independence of the offshore lobster stocks within the various canyons, and between the canyons and inshore.

In May 1977, 1000 lobsters were obtained from commercial lobster vessels on three regular pot fishing cruises, tagged with sphyrion and cinch tags and released in three lobster potting areas: Norfolk Canyon, between Norfolk and Washington canyons, and Washington Canyon (Fig. 1). The sphyrion tag was inserted at the epimeral line, between the carapace and the first abdominal segment, to the left or right of the intestine. The cinch tag was placed around one claw, usually the left claw if present and of normal size. The sphyrion tag should be retained by the lobster after a molt while the cinch tag would not be retained. The two types of tags were applied to each lobster since 1) recognition of double-tagged lobsters by fishermen is more likely than for single-tagged lobsters; 2) mortality estimates may be more accurate in a study using two types of tags on each lobster; 3) cinch tags should aid in evaluating sphyrion tag loss.

To stay within budgetary limits, and since it was not necessary to purchase lobsters for tagging that were <81 mm carapace length (CL) or ovigerous females, lobsters were selected for size to obtain approximately 50% < 81 mm CL and only a few > 110 mm CL. No selection was made for either sex, other than that all ovigerous females that were caught were tagged and released.

The number of tagged lobsters released at each site and number and percent recaptured by December 31, 1977 and December 31, 1978 are shown in Table 16.

This section summarizes tag returns and losses from the area between Norfolk and Washington canyons for the first six months (through November 2, 1977), movements through December 31, 1977, and molting through December 31, 1978.

Because of our concern over which formulae to use in estimating mortality rates (F and Z), we used several approaches to their solution. Total instantaneous mortality rate, Z, may be overestimated, since besides fishing (F) and natural mortality (M) it includes losses caused by other factors such as emigration and loss of tags. For convenience, all mortality other than that due to fishing is designated by the letter X.

Estimates of Z (4.76672) and F (1.43223) were obtained from the regression of tag returns on time interval (Table 17). Details of the analyses and discussion of the results are given in Harris and Van Engel (1978) and Van Engel and Harris (1979).

As stated in our earlier reports, the estimates of Z are affected by the time intervals selected for grouping returns and by losses of tagged lobsters from sources other than fishing. Returns from double-tagging were analyzed to obtain an estimate of the bias in Z. Total instantaneous mortality, Z, was found to be overestimated if only one tag were attached to each lobster, while fishing mortality, F, was insignificantly altered.

Linear and exponential regressions of the ratios of single tag retentions to retention of both tags ($_1N_A/_2N$, $_1N_B/_2N$) on 45-day time intervals were calculated, after counting lobsters that had molted and lost a cinch tag as not having lost the tag (Van Engel and Harris 1979).

There is a large range between the estimates of probabilities of loss of either of the tags, as shown in Table 18. Analyses using exponential regression should give more accurate estimates of tag loss, since their coefficients of determination, r^2, are larger than those found by linear regression methods. Extrapolation using the linear and exponential equations to 365 days, beyond the limits of the data, produces annual estimates which are too high: conceivably those reported by Russell (1978) using Krouse's (1977) data are also too high for the same reason.

Estimates derived by using all tag losses as observed (VIMS-1) were larger than estimates which were derived by ignoring the fact that the cinch tag was lost when the lobster molted (VIMS-2).

We wish to repeat statements from an earlier report (Van Engel and Harris 1979).

"There is no certainty that Gulland's (1963) method provides a better estimate of loss, nor that the method can be applied without modification to crustacean data. It is apparent to us that the factors responsible for loss of a cinch tag are not the same as those responsible for loss of a sphyrion tag. Molting is an event which causes the loss of a cinch tag: the attachment of the sphyrion tag is planned to assure (almost always) the retention of the tag through a molt. The probability of a cinch tag loss is about double that of a sphyrion tag loss in 180 days (Table18, VIMS-1)."

"We have serious doubts that the cinch tag 'qualifies' as a second tag in double-tagging experiments, since the cinch tag is placed in an 'abnormal' position where it is more likely to be lost than the sphyrion tag and for entirely different reasons. Also, molting and the loss of a cinch tag reduces the effective time over which a double-tagging experiment can be conducted. Two sphyrion tags placed so that they may be retained through a molt would be better choices in a double-tagging experiment than a sphyrion-cinch combination. However, considerations such as time needed to apply an extra sphyrion tag, tag-induced mortality from the use of two sphyrion tags, and alternate locations on the lobster for the re-application of an improperly applied sphyrion tag should be examined before conducting a dual sphyrion tagging program."

"Within the array of probabilities of tag losses (Table 18), none appears to offer a better solution to the question of the value of double-tagging than the previous statement that Z could be overestimated in a single-tagging study. Conceivably, a larger number of tag releases with the concomitant larger number of returns may have provided more accurate estimates of mortality rates and the evaluation of sphyrion tag loss."

Since no new information on movements of tagged lobsters or on growth has been obtained since our last two reports (Harris and Van Engel 1978; Van Engel and Harris 1979), these subjects will be reviewed briefly.

Movements

Most of the recaptured lobsters were caught $<$ 10 miles and inshore of their points of release. Notable exceptions were three ovigerous females released in Washington Canyon (Table 16) that were recaptured at depths 60 m deeper than the depth of their release points. They had released their eggs before capture in late August to early September 1977.

Growth

Between May 1977 and December 31, 1978, thirty lobsters were recovered that had molted prior to recapture.

A scatter diagram of the relationship between final size and initial size reveals that larger than average increments occurred in two female and one male lobsters (Fig. 5). The magnitude of the increments suggests that each of these three lobsters underwent two molts before recapture. The growth rates of the remaining 11 males and 16 females are described by the following equations:

Males: Final Size = 2.60209 + 1.14034 Initial Size
$r = 0.95458$ $r^2 = 0.91122$

Females: Final Size = 5.66011 + 1.09014 Initial Size
$r = 0.98747$ $r^2 = 0.97510$

The regression equations given in our last report (Van Engel and Harris 1979) related percent increment to initial size.

DISCUSSION AND RECOMMENDATIONS

Approximately all of the American lobsters landed in the coastal states from southern New Jersey south to North Carolina are caught 64-129km (40-80 mi) off the coast by lobster traps. Since 1971, offshore lobster trap fishermen have concentrated their effort along the continental shelf and slope at water depths of 73-329 m from Wilmington Canyon to waters off Oregon Inlet, N.C.

Total annual lobster landings in these states ranged from one million to 2.2 million pounds from 1971-1975.

A small offshore lobster trap operation is probably best suited economically for this area. Two large corporations with several large vessels, several thousand traps and large land base facilities have ceased operations and left the area. On the other hand, small offshore lobster trap operations have continued. In these small operations only one vessel is operated, a maximum of approximately 1000-1500 traps are fished, a reliable crew is obtained and limited land base facilities are used.

Variations in fishing intensity throughout Management Area Four have probably lead to differences in lobster size frequency distributions and catch quality composition within the area. Of the areas sampled, the more northern section (i.e., Washington Canyon) had smaller sized lobsters and a larger percentage of sub-legal lobsters (<81 mm CL) than the more southern section (i.e., Norfolk Canyon).

Size frequency data and catch and effort data are essential for an appraisal of the trends in the fishery and estimating the effects of fishing on the offshore lobster resource in the area.

It is recommended that the lobster resource of the area be managed on a regional basis. Daily catch and effort records should be required of all fishermen who trap lobsters in the area and the size of lobsters in the catch should continue to be monitored. Revision of future management plans or those under consideration could be made more effectively if these data were collected on a regular basis.

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Table 1.

Catch, value and percent of US landings of American lobsters in Management Area Four, by state, 1969-1975, and seven-year average. 000 omitted.

		1969	1970	1971	1972
US					
	lbs.	33,787	34,152	33,688	32,244
	value	28,998	33,464	35,594	39,512
NJ					
	lbs.	1,434	1,836	1,323	1,308
	% of US	4.2	5.4	3.9	4.1
	value	1,212	1,739	1,459	1,828
	% of US	4.2	5.2	4.1	4.6
DE					
	lbs.	0	0	30	22
	% of US	0	0	0.1	0.1
	value	0	0	41	36
	% of US	0	0	0.1	0.1
MD					
	lbs.	27	22	28	21
	% of US	0.1	0.1	0.1	0.1
	value	21	20	28	26
	% of US	0.1	0.1	0.1	0.1
VA					
	lbs.	181	229	234	884
	% of US	0.5	0.7	0.7	2.7
	value	123	149	200	1,028
	% of US	0.4	0.4	0.6	2.6
NC					
	lbs.	19	5	< 1	0
	% of US	0.1	< 0.1	< 0.1	0
	value	14	5	< 1	0
	% of US	< 0.1	< 0.1	< 0.1	0
TOTAL					
	lbs.	1,661	2,092	1,615	2,235
	% of US	4.9	6.1	4.8	6.9
	value	1,370	1,913	1,728	2,918
	% of US	4.7	5.7	4.9	7.4

Table 1, cont'd.

		1973	1974	1975	1969-1975 Average
US					
	lbs.	28,991	28,543	30,200	31,658
	value	41,586	43,294	51,412	39,123
NJ					
	lbs.	1,363	1,119	851	1,319
	% of US	4.7	3.9	2.8	4.2
	value	2,234	1,916	1,555	1,706
	% of US	5.4	4.4	3.0	4.4
DE					
	lbs.	30	26	27	19
	% of US	0.1	0.1	0.1	0.1
	value	51	55	49	33
	% of US	0.1	0.1	0.1	0.1
MD					
	lbs.	24	37	59	31
	% of US	0.1	0.1	0.2	0.1
	value	33	65	106	43
	% of US	0.1	0.1	0.2	0.1
VA					
	lbs.	199	274	91	299
	% of US	0.7	1.0	0.3	0.9
	value	285	503	164	350
	% of US	0.7	1.2	0.3	0.9
NC					
	lbs.	2	0	0	4
	% of US	< 0.1	0	0	<0.1
	value	2	0	0	3
	% of US	< 0.1	0	0	<0.1
TOTAL					
	lbs.	1,618	1,456	1,028	1,672
	% of US	5.6	5.1	3.4	5.3
	value	2,605	2,539	1,874	2,135
	% of US	6.3	5.9	3.6	5.5

Table 2 Lobster regulations by state, 1977*

	ME	NH	MA	RI	CT	NY	NJ (Area Four)	DE (Area Four)	MD (Area Four)	VA (Area Four)	NC (Area Four)
1. License requirements											
no license required							X		X		X
required to fish lobster	X	X	X	X	X	X		X		X	
required to land lobster	X	X	X	X	X	X				X	
required to deal in lobster	X	X	X	X	X						
2. Legal provisions for aquaculture enterprises	X	X	X	X	X	X	X				
3. Fishermen classification:											
none							X		X	X	X
commercial	X	X	X	X	X	X		X			
non-commercial		X	X	X	X	X		X			
4. Catch/effort reporting											
not required							X		X	X	X
required annually	X	X	X		X	X		X			
requires daily record				X	X						
5. Gear regulations											
none							X		X		
by license class:		X	X	X	X	X				X	
quantity allowed		X	X			X		X		X	
type allowed	X	X	X			X		X			
owner identification required	X	X	X	X	X	X		X			
escapement opening in catching device specified	X		X					X			X
6. Fishing activity regulations											
none											
by license class or method:			X	X		X		X			
number of licenses			X								
catch quotas						X		X			
area	X	X	X			X					
season	X		X					X			
day or time of day	X	X	X	X	X			X			
landing of lobster meat regulated	X	X	X	X	X	X		X		X	X
landing of lobster parts regulated	X	X	X	X	X	X		X			X
landing of gravid female lobsters prohibited	X	X	X	X	X	X	X	X	X	X	X
landing of v-notched female lobsters prohibited	X										
landing of lobsters regulated by size (carapace length)	X	X	X	X	X	X	X	X	X	X	X
5 inches maximum allowed	X										
3 1/16 inches minimim all'd				X							
3 1/8 inches minimum all'd		X					X				
3 3/16 inches minimum all'd	X		X		X	X		X	X	X	X

*Northeast Marine Fisheries Board, 1978, Table 19.

Table 3. Subdivision of continental shelf and slope, offshore lobster fishery study sites, Lobster Management Area Four.

Study Area	NMFS Area	Degrees Lat.	Degrees Long.	Units	Geography
I	636	35	74	11-13 21-23	Oregon Inlet
II	632	36	74	23-26 31,32	South of Norfolk Canyon between Canyon and Inlet
III*	626	37	74	26,36	Norfolk Canyon
IV*	626	37	74	35,45	Between Norfolk and Washington canyons
V*	626	37	74	34,44	Washington Canyon
VI	626	37	74	42,43 53,61,62	Between Washington and Baltimore canyons
VII	622	38	73	15,16,26	Baltimore Canyon

* tagged American lobster release areas.

Table 4. Commercial lobstering trips in Lobster Management Area Four, August 1974 through October 1976, in which Virginia Institute of Marine Science personnel participated.

		c/f			
Date	Study Area	Traps Examined	Saleable Lobsters	Lobsters Measured	Lobsters examined for quality
Aug., 1974		574	1154		1298
Sep., 1974		323	672		756
Oct., 1974		230	748		906
Nov., 1974		106	246		256
1974	I,II,III,V	1233	2820	602	3216
Jan., 1975		34	43		53
Feb., 1975		27	22		24
Mar., 1975		145	162		190
May, 1975		82	48		63
Aug., 1975		313	648		762
Oct., 1975		47	52		52
1975	III,IV,V,VI,VII	648	975	1448	1144
Jan., 1976		92	42		22
Apr., 1976		124	174		250
July, 1976		128	358		579
Oct., 1976		83	170		276
1976	III,IV,V,VI	427	744	1258	1127
Totals		2308	4539	3308	5487

Table 5. Number of traps hauled, average set-over-days (SOD), catch per trap haul (CTH) and catch per trap haul-set-over-day (CTHSOD) for a Virginia commercial offshore lobster operation, 1974. Area I, off Oregon Inlet; Area II, between Norfolk Canyon and Oregon Inlet; Area III & IV, Norfolk Canyon and between Norfolk and Washington canyons; Area V, Washington Canyon; Area VI & VII, between Washington and Baltimore canyons and in Baltimore Canyon. (see text for detailed description of areas). Data shown applies only to SOD ≤ 14.

Area	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
I									1974
No. traps	1908	4364	3215	1895	1653	748	258	0	14041
Mean SOD	5.96	4.24	5.12	7.07	6.04	7.21	6.78		5.53
Mean CTH (lbs)	2.04	2.39	2.58	4.64	2.95	3.40	1.24		2.79
Mean CTHSOD	0.34	0.56	0.50	0.66	0.49	0.47	0.18		0.50
II									
No. traps	3359	2743	2345	2682	2094	1145	526	898	15792
Mean SOD	4.28	5.11	6.32	6.07	6.30	7.20	4.18	7.26	5.69
Mean CTH (lbs)	2.29	2.97	3.91	3.21	3.81	4.97	4.17	1.14	3.20
Mean CTHSOD	0.54	0.58	0.62	0.53	0.61	0.69	1.00	0.16	0.56
III, IV									
No. traps	1965	403	825	1469	1312	1620	1531	1130	10255
Mean SOD	4.43	7.17	6.08	5.17	6.32	7.00	6.68	8.17	6.12
Mean CTH (lbs)	2.02	3.13	4.39	4.74	3.21	4.65	4.39	2.75	3.64
Mean CTHSOD	0.45	0.44	0.72	0.92	0.51	0.66	0.66	0.34	0.60
V									
No. traps	2937	1712	3572	2649	1909	1833	856	771	16239
Mean SOD	4.43	7.52	5.48	5.07	7.75	6.85	9.66	7.58	6.14
Mean CTH (lbs)	2.07	2.79	5.92	5.33	3.54	4.99	3.60	2.45	4.12
Mean CTHSOD	0.47	0.37	1.08	1.05	0.46	0.73	0.37	0.32	0.67
VI, VII									
No. traps	523	105	197	237	167	105	132	30	1496
Mean SOD	5.36	13.25	10.43	6.44	13.60	9.00	11.50	8.00	8.20
Mean CTH (lbs)	2.31	1.71	3.68	3.44	2.13	6.43	3.41	1.67	2.98
Mean CTHSOD	0.43	0.13	0.35	0.53	0.16	0.71	0.30	0.21	0.36
Totals									
No. traps	10692	9327	10154	8932	7135	5451	3303	2829	57823
Total catch (lbs)	22841	24794	42957	39300	24180	25589	12766	6070	198410

Table 6. Number of traps hauled, average set-over days (SOD), catch per trap haul (CTH), and catch per trap haul-set-over-day (CTHSOD) for a Virginia commercial offshore lobster operation, 1975. Area I, off Oregon Inlet; Area II, between Norfolk Canyon and Oregon Inlet; Area III & IV, Norfolk Canyon and between Norfolk and Washington canyons; Area V, Washington Canyon; Area VI & VII, between Washington and Baltimore canyons and Baltimore Canyon (see text for detailed description of areas). Data shown applies only to SOD ≤ 14.

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
I													1975
No. traps	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean SOD													
Mean CTH(lbs)													
Mean CTHSOD													
II													
No. traps	304	0	0	0	133	181	130	0	0	0	0	0	748
Mean SOD	7.42				5.00	5.50	5.57						6.20
Mean CTH(lbs)	1.10				1.88	3.04	3.23						2.08
Mean CTHSOD	0.15				0.38	0.55	0.58						0.34
III, IV													
No. traps	1167	696	417	407	559	2022	1589	3562	2510	431	2501	25	15886
Mean SOD	7.21	8.52	9.40	4.69	4.32	4.84	7.02	5.82	7.77	6.86	8.37	13.00	6.77
Mean CTH(lbs)	1.12	1.08	1.31	1.43	6.37	4.62	5.56	3.43	2.95	4.52	3.86	2.00	3.54
Mean CTHSOD	0.16	0.13	0.14	0.30	1.47	0.95	0.79	0.59	0.38	0.66	0.46	0.15	0.52
V													
No. traps	614	360	474	0	18	0	0	0	0	0	0	0	1466
Mean SOD	8.90	9.83	8.63		2.00								8.90
Mean CTH(lbs)	0.76	0.97	1.18		0.0								0.94
Mean CTHSOD	0.09	0.10	0.15		0.0								0.11

Table 6, cont'd.

Area	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
VI, VII													1975
No. traps	845	261	300	605	321	0	0	0	0	0	0	0	2332
Mean SOD	6.83	12.33	8.07	8.09	9.15								8.25
Mean CTH (lbs)	1.54	1.15	1.00	0.75	0.0								1.01
Mean CTHSOD	0.23	0.09	0.12	0.09	0.0								0.12
Totals													
No. traps	2930	1317	1191	1012	1031	2203	1719	3562	2510	431	2501	25	20432
Catch (lbs)	3409	1401	1406	1036	3811	9892	9255	12218	7405	1948	9654	50	61526

Table 7. Trap hauls and catch of lobsters, obtained from ships' logs, for study areas I-VII, 1974 and 1975. Data are for all SOD*. Lobster trap catch for Virginia, from Wise and Thompson (1977) and Pileggi and Thompson (1979).

	1974		1975	
	Trap Hauls	Catch, pounds	Trap Hauls	Catch, pounds
Study Area				
I	14,265	40,288	- 0 -	- 0 -
II	16,296	52,905	917	1,790
III, IV	11,260	40,080	18,749	64,718
V	17,154	69,570	1,770	1,860
VI, VIII	1,722	5,258	2,738	2,850
Totals	60,697	208,101	24,174	71,218
NMFS		273,600		90,300
Log catch as % of NMFS Total		76		78.9

*The data in tables 5 and 6 were derived from hauls with SOD $\leq$14

Table 8. Weighted averages of the catch, in numbers, of American lobsters per trap-haul (TH) and trap-haul-set-over-day (THSOD), all areas combined 1974-1976.

Collection	Date	Number of traps	Mean SOD	Total Catch TH	Total Catch THSOD	Saleable Catch TH	Saleable Catch THSOD
L74-01	Aug 2 - 9 1974	574	6.7	2.26	0.34	2.01	0.30
L74-02	Sept 3 - 7 1974	323	6.6	2.34	0.35	2.08	0.31
L74-03	Oct 16-20 1974	230	6.8	3.94	0.58	3.25	0.48
L74-04	Nov 11-14 1974	106	No Data	2.42	No Data	2.32	No Data
L75-01	Jan 14-15 1975	34	7.0	1.56	0.22	1.26	0.18
L75-02	Feb 27-Mar 2, 1975	27	32.0	0.89	0.03	0.81	0.03
L75-03	Mar 29-Apr 2, 1975	145	7.2	1.31	0.18	1.12	0.16
L75-04	May 2 - 6 1975	82	No Data	0.77	No Data	0.59	No Data
L75-05	Aug 18-24 1975	313	5.4	2.43	0.45	2.07	0.38
L75-06	Oct 13, 1975	47	7.0	1.1	0.16	0.85	0.12
L76-01	Jan 6 - 7 1976	92	9.75	0.64	0.07	0.46	0.05
L76-02	Apr 6 - 9 1976	124	16.4	2.0	0.12	1.4	0.09
L76-03	July 11-13 1976	128	5.1	4.5	0.88	2.8	0.55
L76-04	Oct 19-21, 23-26, 1976	83	11.25	3.3	0.30	2.05	0.18

Table 9. Differences in mean short carapace length (CL) of male American lobsters by study area for each year 1974-1976, determined by Scheffe's multiple comparison test.

1974

Area	Sample Size	Mean C.L. (mm)
V	84	98.18
I	47	100.02
III	96	104.85
II	85	107.09

1975

Area	Sample Size	Mean C.L. (mm)
VI	55	89.51
VII	73	96.49
V	7	99.29
III	519	100.46
IV	62	110.55

1976

Area	Sample Size	Mean C.L. (mm)
V	510	90.72
VI	35	93.66
III	35	99.97
IV	7	108.43

Table 10. Differences in mean short carapace length (CL) of female American lobsters by study area for each year 1974-1976, determined by Scheffe's multiple comparison test.

1974

Area	Sample Size	Mean C.L. (mm)
V	63	96.16
I	56	97.13
II	94	99.78
III	77	106.13

1975

Area	Sample Size	Mean C.L. (mm)
VI	62	85.82
IV	18	92.22
V	23	93.04
II	528	96.07
VII	101	101.53

1976

Area	Sample Size	Mean C.L. (mm)
V	569	88.57
VI	50	96.24
III	46	109.02
IV	5	127.00

Table 11. Quality composition of offshore lobster commercial trap catch, by cruise, Lobster Management Area Four, August 1974-May 1975.

Trip	Date		Saleable Good	Saleable Cull	Discards Damaged	Discards Dead	Discards Eggers	Discards Short	Total
L74-01	Aug 2-9 1974	Total	1091	51	17	0	15	124	1298
		%	84.0	3.9	1.3	0	1.2	9.6	
L74-02	Sep 3-7 1974	Total	654	17	3	1	32	49	756
		%	86.5	2.2	0.4	0.1	4.2	6.5	
L74-03	Oct 16-20 1974	Total	722	14	11	1	107	51	906
		%	79.6	1.5	1.2	0.1	11.8	5.6	
L74-04	Nov 11-14 1974	Total	237	6	0	0	9	4	256
		%	92.5	2.3	0	0	3.5	1.5	
L75-01	Jan 14-15 1975	Total	40	3	0	0	4	6	53
		%	75.5	5.7	0	0	7.5	11.3	
L75-02	Feb 27-Mar 2 1975	Total	19	2	1	0	0	2	24
		%	79.2	8.3	4.2	0	0	8.3	
L75-03	Mar 29-Apr 2 1975	Total	157	5	1	0	10	17	190
		%	82.6	2.6	0.5	0	5.3	8.9	
L75-04	May 2-6 1975	Total	47	1	1	0	10	4	63
		%	74.6	1.5	1.5	0	15.9	6.3	
	Total		2967	99	34	2	187	257	3546
	%		83.7	2.8	0.96	0.05	5.3	7.2	

Table 12. Quality composition of offshore lobster commercial trap catch, by cruise, Lobster Management Area Four, August 1975-October 1976.

Cruise and Date	Area		Saleable: Good	Saleable: Paper	Saleable: Cull	Discards: Damaged	Discards: Soft	Discards: Dead	Discards: Eggers	Discards: Short	Total
L75-05											
Aug 18-24		Total	618	-	33	2	38	0	3	68	762
1975	III	%	81.1		4.3	0.3	5.0	0	0.4	8.9	
L75-06											
Oct 13		Total	39	-	1	0	1	0	0	11	52
1975	VI	%	75.0		1.9	0	1.9	0	0	21.2	
L76-01											
Jan 7		Total	13	-	1	0	0	0	5	3	22
1976	IV	%	59.1		4.6	0	0	0	22.7	13.6	
L76-02	III	Total	39	-	3	1	1	2	5	6	57
Apr 6-9		%	68.4		5.2	1.8	1.8	3.5	8.8	10.5	
1976	V	Total	123	-	11	0	0	3	10	46	193
		%	63.7		5.7	0	0	1.6	5.2	23.8	
L76-03											
July 10-14		Total	305	40	17	1	0	1	11	204	579
1976	V	%	52.7	6.9	2.9	0.2	0	0.2	1.9	35.2	
L76-04,											
L76-05											
Oct 19-21		Total	125	29	16	0	0	3	13	90	276
Oct 23-26		%	45.3	10.5	5.8	0	0	1.1	4.7	32.6	
1976	V										
Total	III-VI		1262	69	82	4	40	9	47	428	1941
%			65.0	3.6	4.2	0.2	2.0	0.5	2.4	22.1	

Table 13. Injured lobsters (culls, damaged and dead) caught in calendar years 1974, 1975 and 1976.

Calendar year	Total catch	Number injured	Percentage injured
1974	3216	121	3.8
1975	1144	50	4.4
1976	1127	59	5.2

Table 14. Number and percent of sublegal, <81 mm CL lobsters in commercial catch since August 1975. Area III, Norfolk Canyon; Area IV, between Norfolk and Washington canyons; Area V, Washington Canyon; Area VI, between Washington and Baltimore canyons.

Date		Area III		Area IV		Area V		Area VI	
		Shorts	Total Catch	Shorts	Total Catch	Shorts	Total Catch	Shorts	Total Catch
1975									
Aug	No.	68	762						
	%	8.9							
Oct	No.							11	52
	%							21.2	
1976									
Jan	No.			3	22				
	%			13.6					
Apr	No.	6	57			46	193		
	%	10.5				23.8			
July	No.					204	579		
	%					35.2			
Oct	No.					90	276		
	%					32.6			
Total	No.	74	819	3	22	340	1048	11	52
	%	9.0		13.6		32.4		21.2	

Table 15. Incidence of lobsters infested with nematodes (Ascarophis sp.), by area, August 1975-March 1977.

Date	Area	No. Lobsters sampled (No. Lobsters infested)			Incidence of Infestation %		
		M	F	Sexes Combined	M	F	Sexes Combined
Aug. Sept. 1975	III	26(1)	*37(6)	63(7)	3.8	16.2	11.1
Dec. 1975	III	18(3)	18(2)	36(5)	16.7	11.1	13.9
Jan. 1976	III	3(1)	16(5)	19(6)	33.3	31.3	31.6
Jan. 1976	IV	11(1)	13(1)	24(2)	9.1	7.7	8.3
Apr. 1976	III	6(3)	9(2)	15(5)	50.0	22.2	33.3
Apr. 1976	V	4(2)	16(4)	20(6)	50.0	25.0	30.0
July 1976	V	7(1)	5(2)	12(3)	14.3	40.0	25.0
Oct. 1976	V	3(0)	5(2)	8(2)	0.0	40.0	25.0
Subtotal		78(12)	119(24)	197(36)	15.4	20.2	18.3
Nov. 1976	Off DE and NJ	11(1)	6(2)	17(3)	9.1	33.3	17.6
Mar. 1977	Off DE and NJ	2(0)	2(0)	4(0)	0.0	0.0	0.0
Total		91(13)	127(26)	218(39)	14.3	20.5	17.9

*One female 86 mm, contained 33 acanthocephalan cysts (Corynosoma sp.). This was the only lobster examined that contained this discriminator of coastal lobster stocks.

Table 16. Release and recapture data, American lobster, offshore Maryland and Virginia.

Release location	Release Date	Number tagged and released	Number (and percent) recaptured By Dec. 31, 1977	By Dec. 31, 1978
Norfolk Canyon	May 4, 1977	107	27(25.2)	33(30.8)
Washington Canyon	May 12, 1977	329	9(2.7)	14(4.3)
Between Norfolk and Washington Canyons	May 24, 25, 1977	564	229(40.6)	269(47.7)
		1000	265(26.5)	316(31.6)

Table 17. Estimate of instantaneous fishing mortality rate, F, for American lobster, offshore Virginia, based on grouping data in 45 day intervals.

Days out since release (mean days)	Interval, r	Number of tags, n
0 - 15 (7.5)	-	94
16 - 60 (37.5)	0	66
61 - 105 (82.5)	1	38
106 - 150 (127.5)	2	14
151 - 195 (172.5)	3	13

Z = 4.76672 annual rate
R = 1.43223 annual rate

Table 18. Probabilities of sphyrion and cinch tag losses, calculated by different methods for Virginia and Maine. VIMS-1 includes all tag losses as observed. VIMS-2 considers cinch tags not lost on lobsters that molted. American lobster, *Homarus americanus*.

	VIMS-1		VIMS-2		Kennebunkport, Maine Russell (1978) with data from Krouse (1977)
	Linear	Exponential	Linear	Exponential	Linear
For 180 days					
1. Probability of sphyrion tag loss, ${}_{A}P_{t}$	0.25856	0.31068	0.19990	0.28080	—
2. Probability of cinch tag loss, ${}_{B}P_{t}$	0.42586	0.63554	0.10260	0.13941	—
For 365 days					
3. Probability of sphyrion tag loss, ${}_{A}P_{t}$	0.43519	0.92730	0.34835	0.81687	0.400
4. Probability of cinch tag loss, ${}_{B}P_{t}$	0.61866	0.99811	0.19032	0.72016	0.449

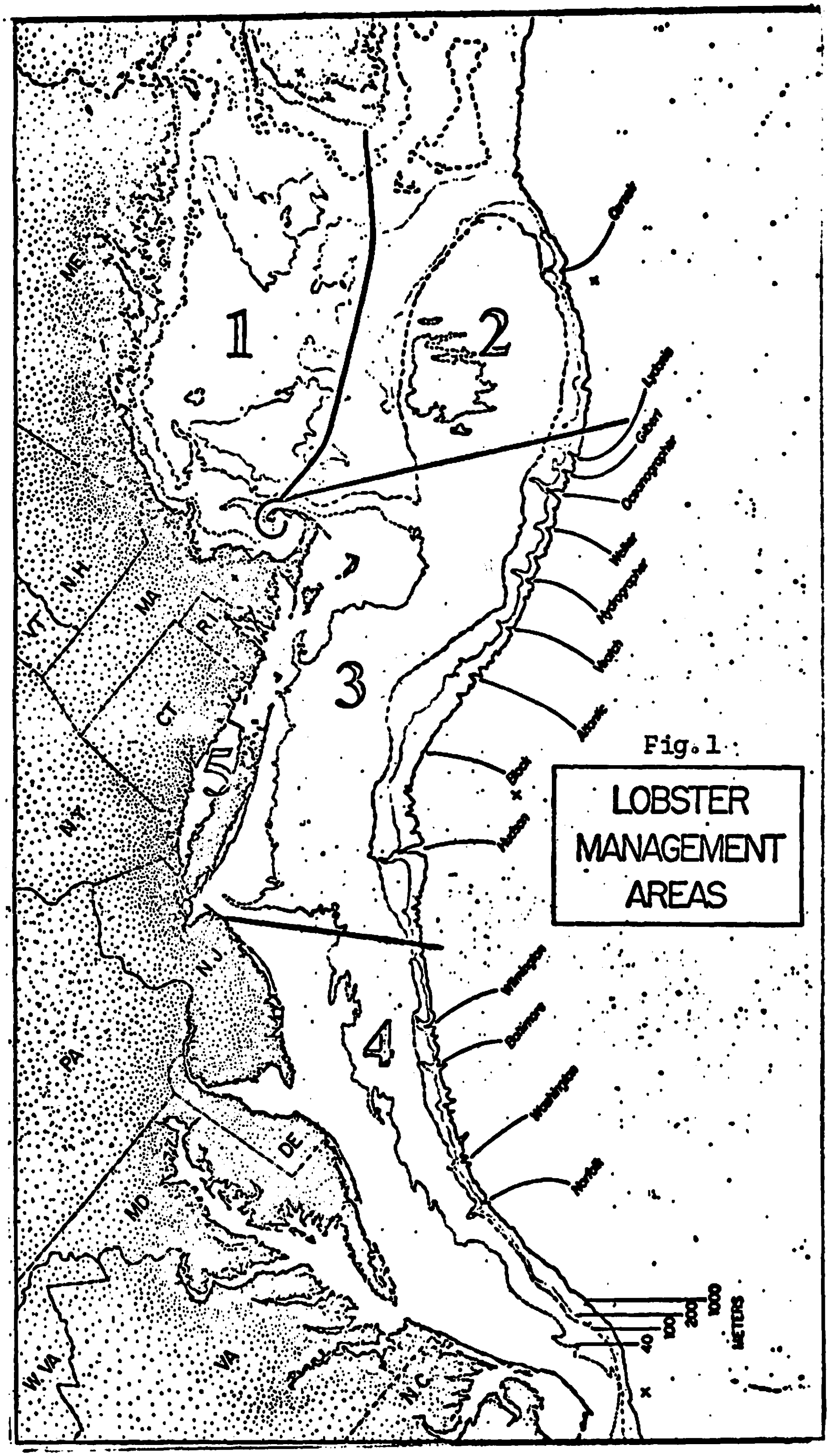
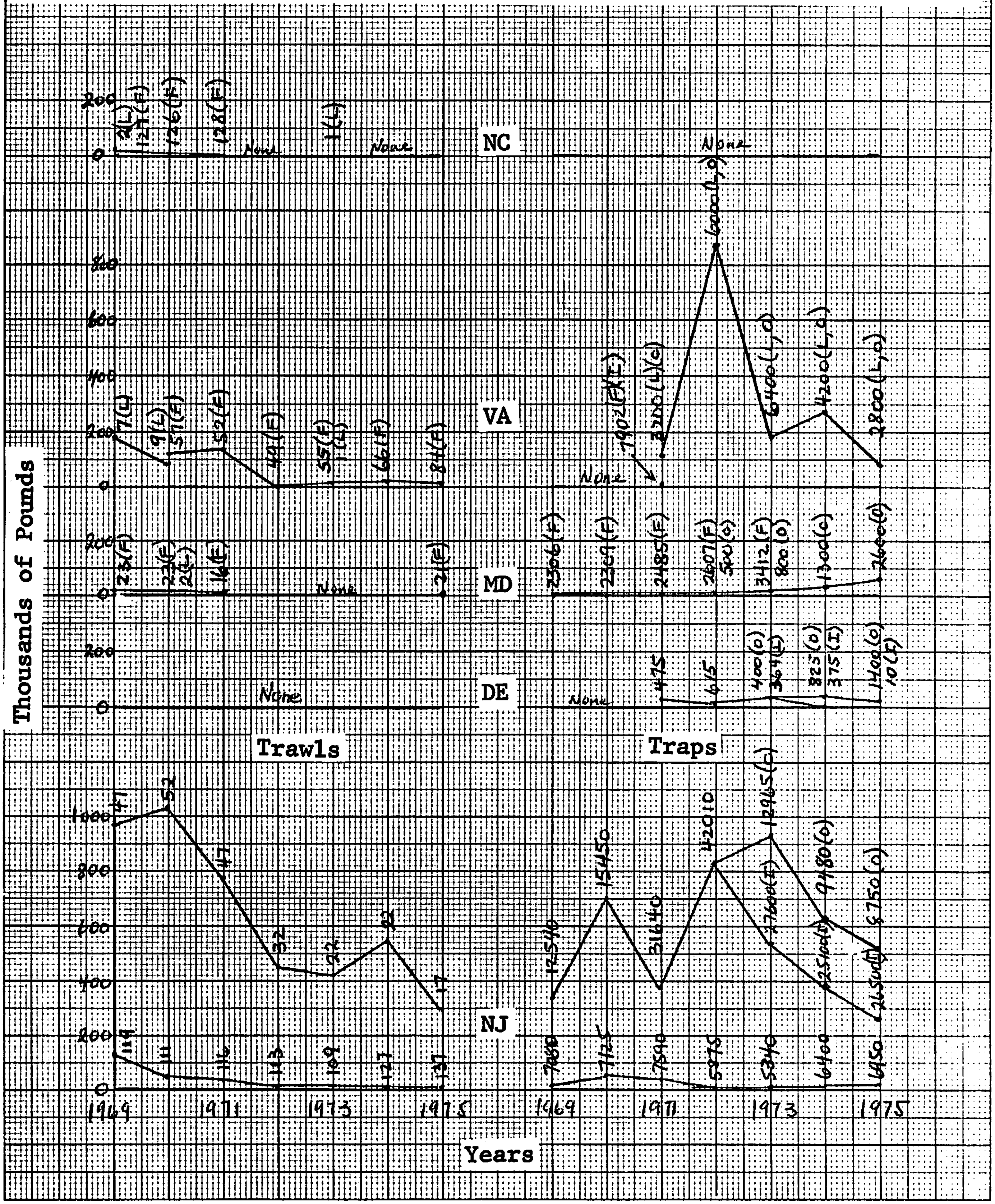


Fig. 1

LOBSTER MANAGEMENT AREAS

Figure 2. American lobster landings, in thousands of pounds, by trawls and traps, for each state in Lobster Management Area Four. Number of units of gear, type and location are indicated; F=Fishing, L=Lobstering, I=Inshore, O=Offshore.



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Calendar year	Total catch	Number injured	Percentage injured
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Date		Area III		Area IV		Area V		Area VI	
		Shorts	Total Catch	Shorts	Total Catch	Shorts	Total Catch	Shorts	Total Catch
1975									
Aug	No.	68	762						
	%	8.9							
Oct	No.							11	52
	%							21.2	
1976									
Jan	No.			3	22				
	%			13.6					
Apr	No.	6	57			46	193		
	%	10.5				23.8			
July	No.					204	579		
	%					35.2			
Oct	No.					90	276		
	%					32.6			
Total	No.	74	819	3	22	340	1048	11	52
	%	9.0		13.6		32.4		21.2	

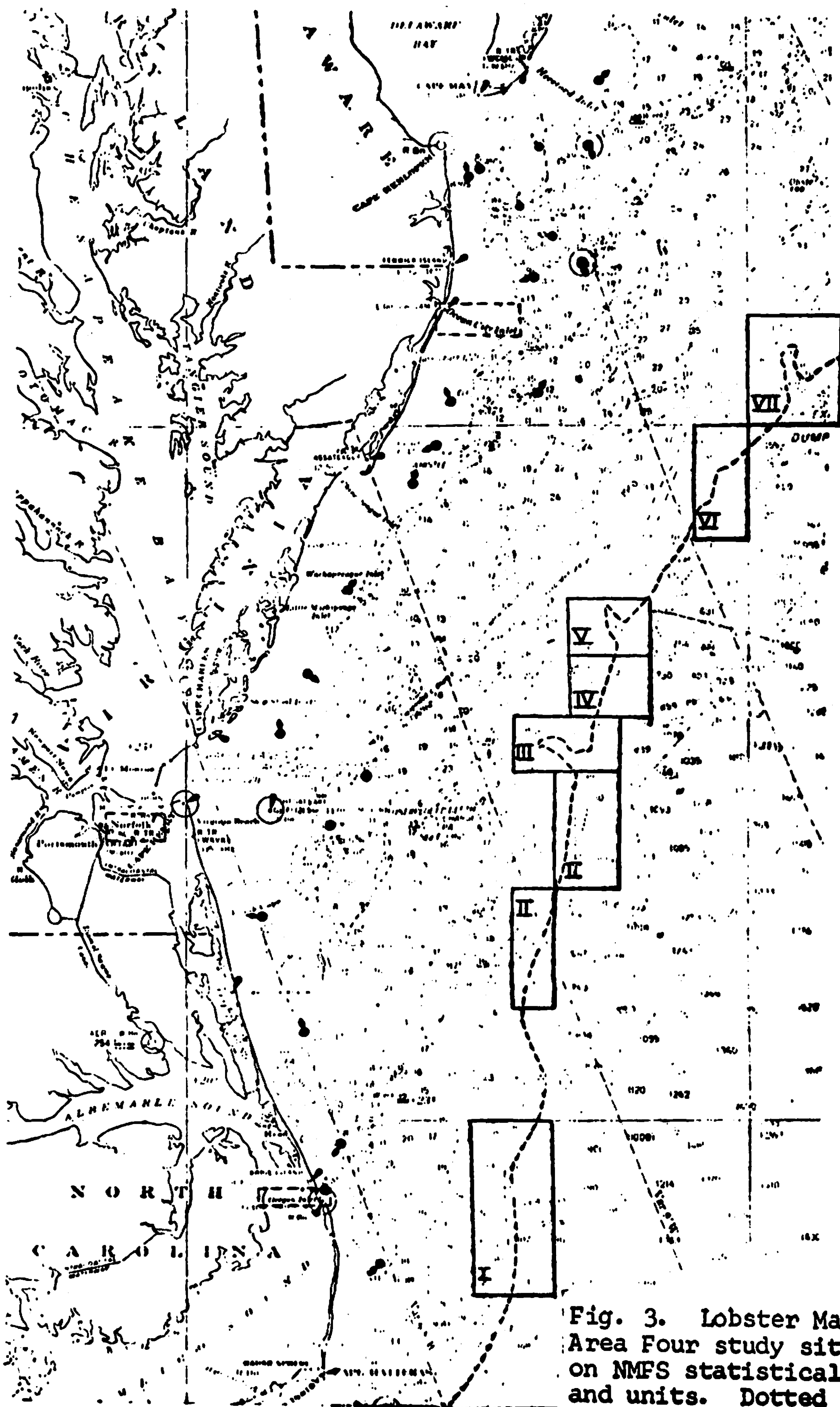


Fig. 3. Lobster Management Area Four study sites, based on NMFS statistical areas and units. Dotted line is 100 fathom curve.

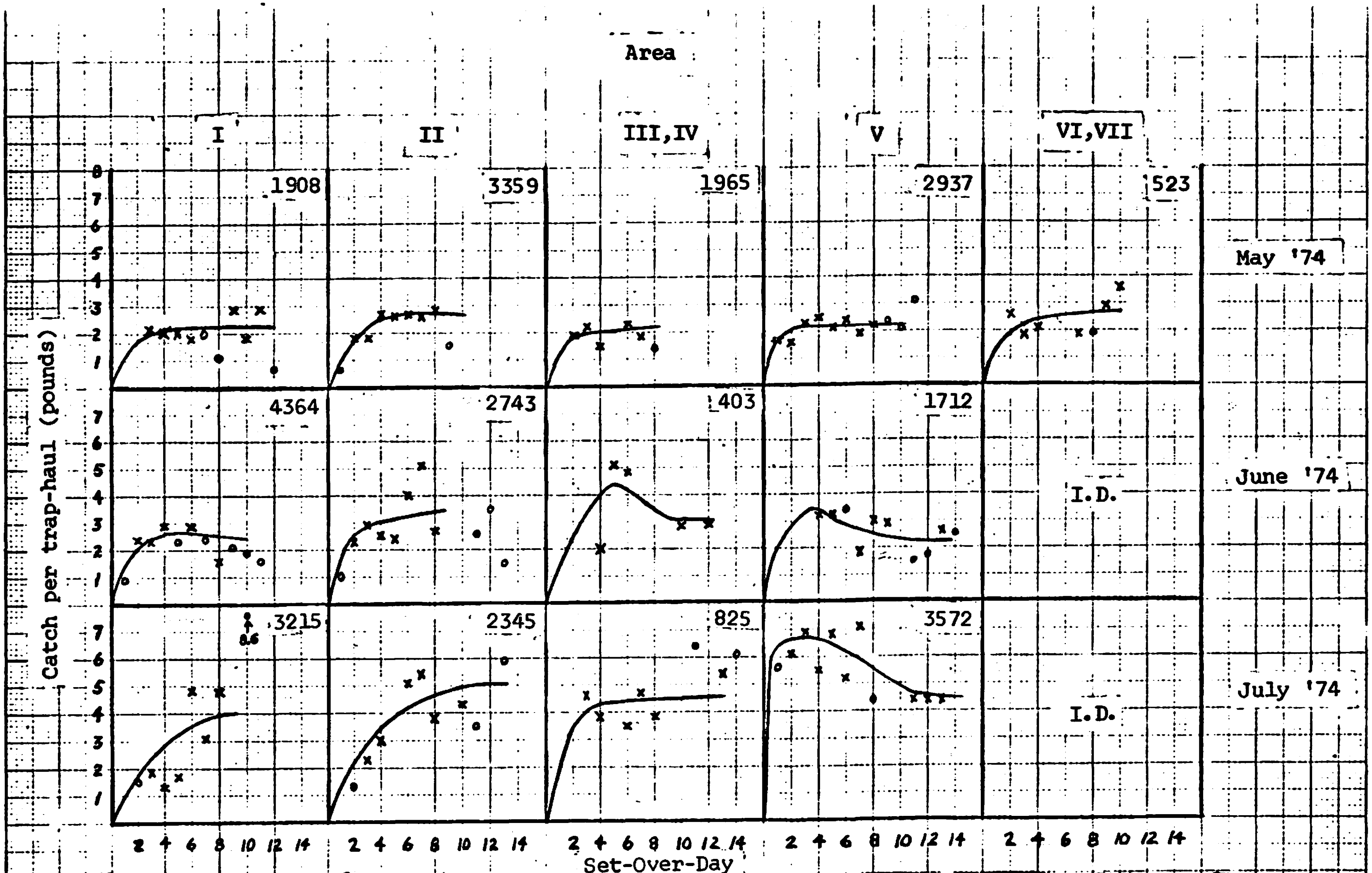
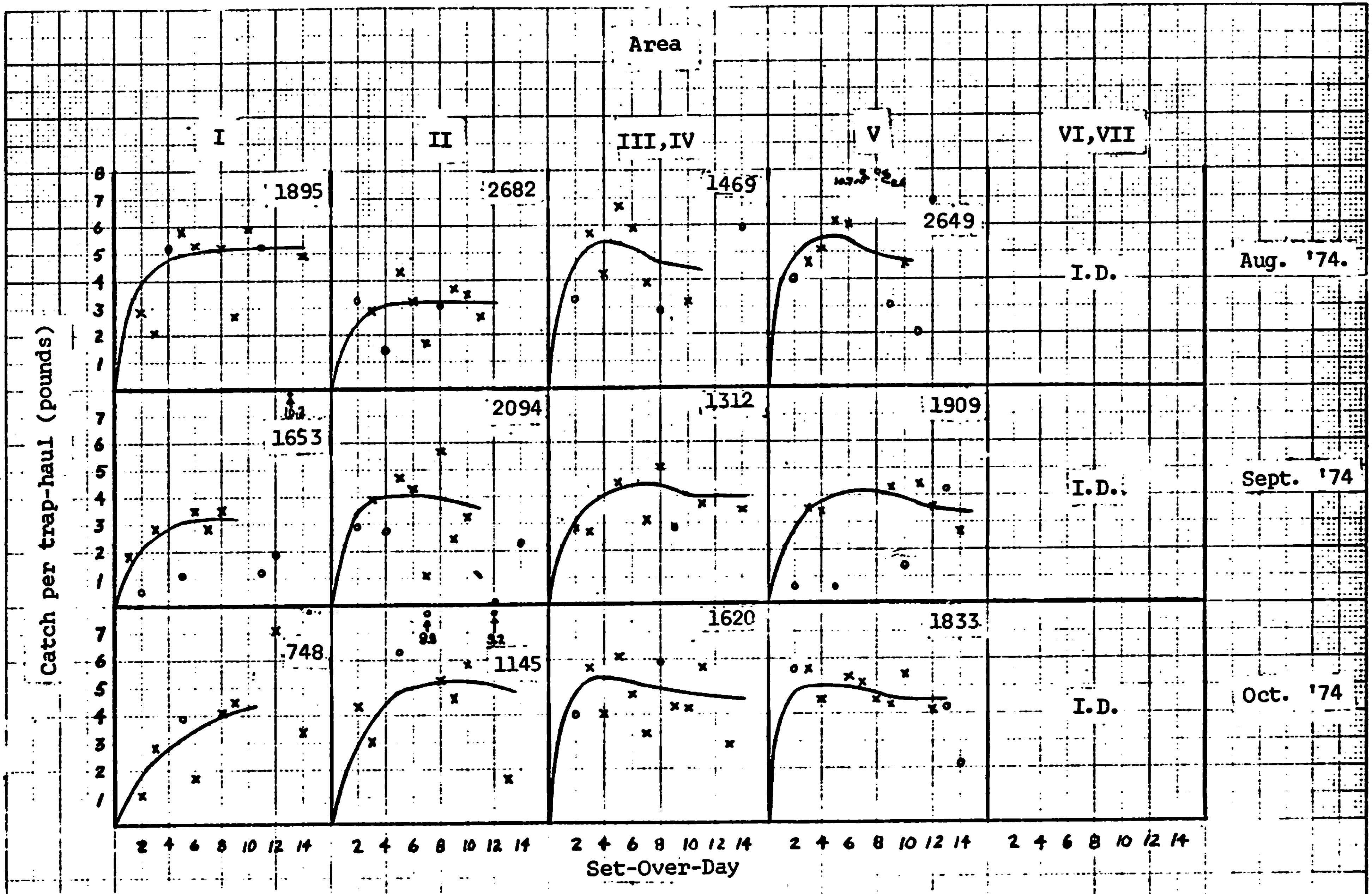


Fig. 4 . The relationship between lobster catch per trap-haul (pounds) and set-over-days, by area and by month, May 1974-December 1975. Number of traps hauled is shown in top right corner of each graph. I.D. denotes insufficient data and N.D. denotes no data. Areas I - VII are described in text.



Area
I
II
III,IV
V
VI,VII
1895
2682
1469
2649
I.D.
Aug. '74.
1653
2094
1312
1909
I.D.
Sept. '74
748
1145
1620
1833
I.D.
Oct. '74
Catch per trap-haul (pounds)
Set-Over-Day

Fig. 4, cont'd.

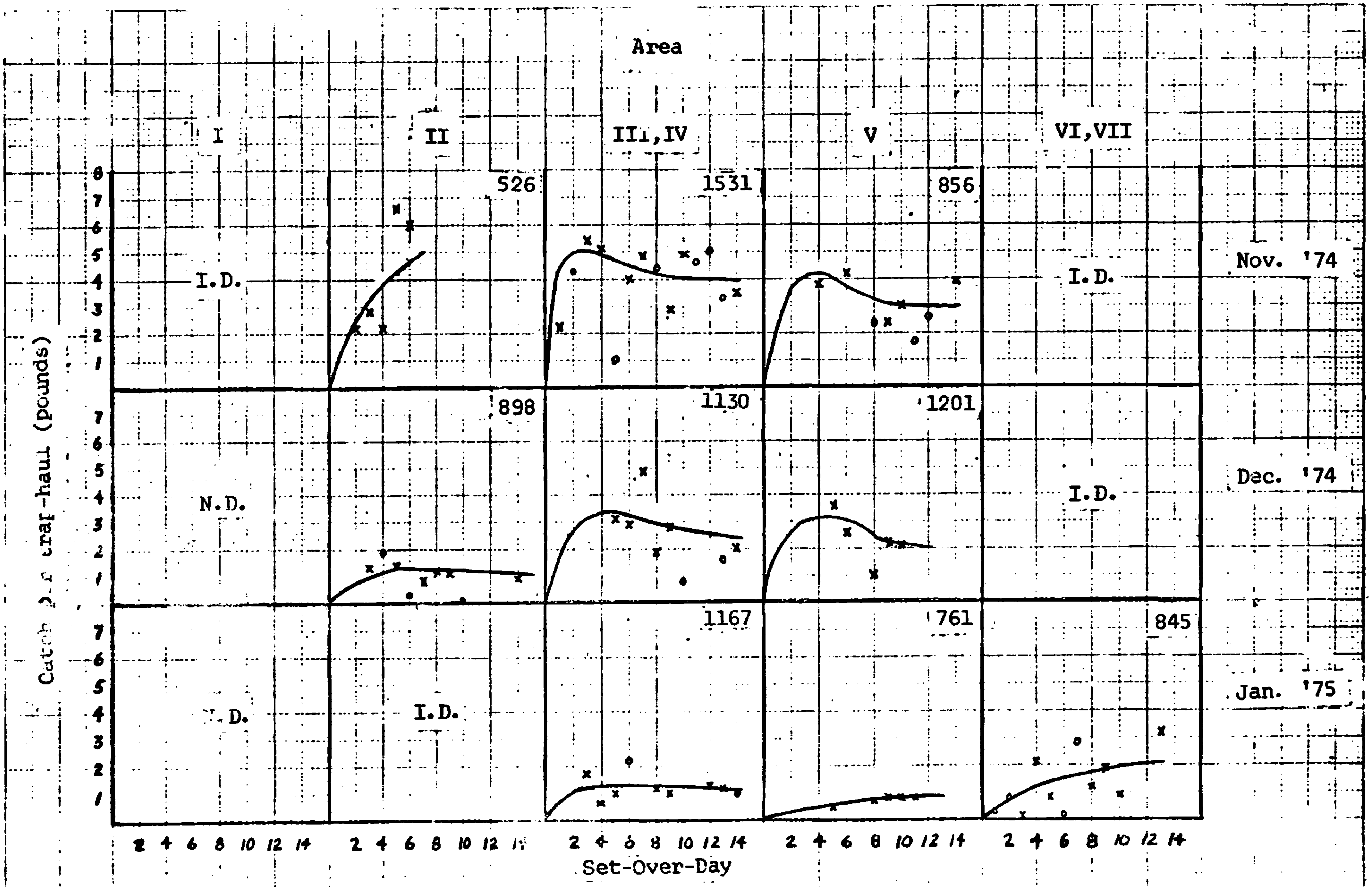
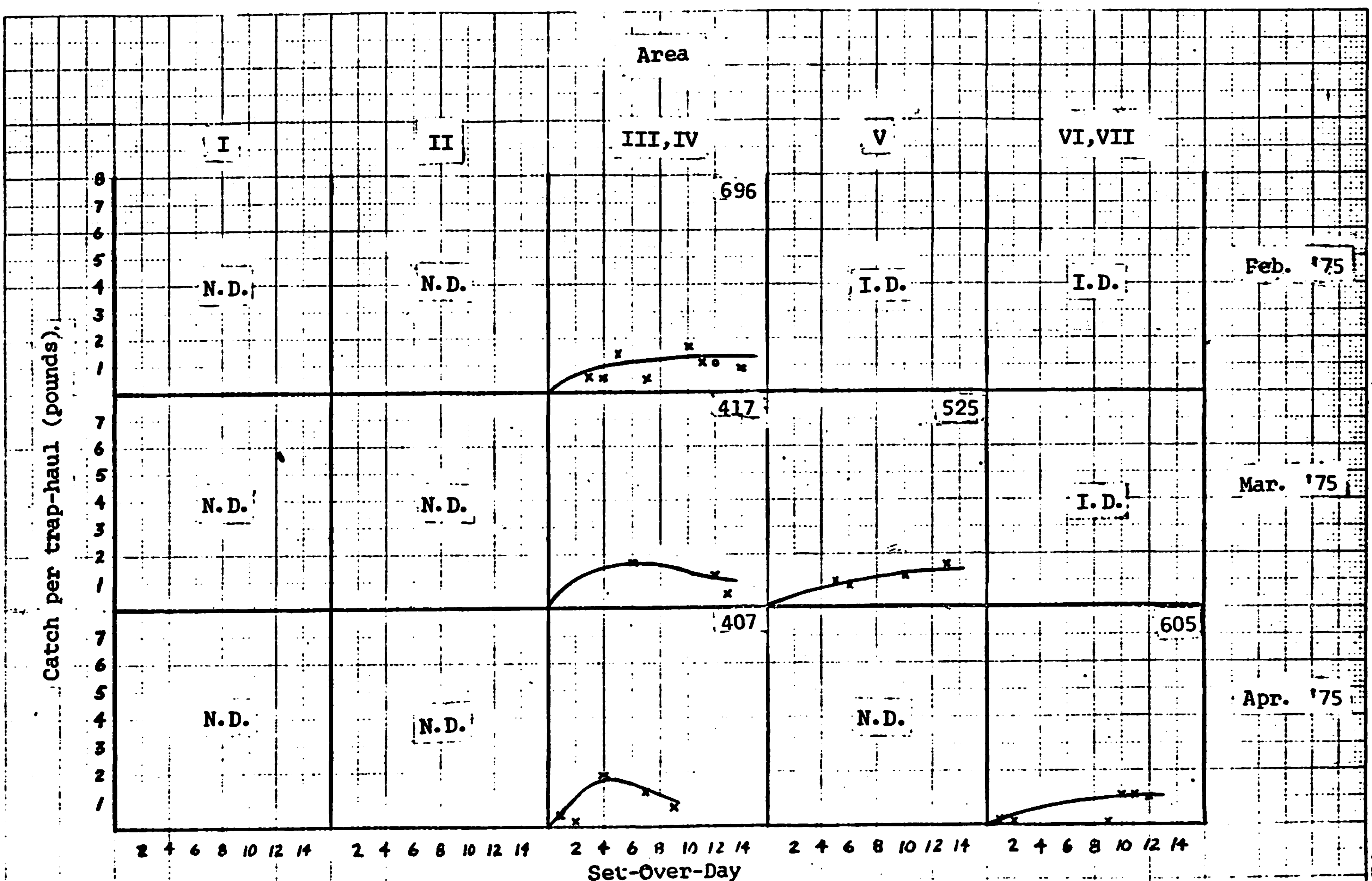

Area
I
II
III, IV
V
VI, VII
Catch per trap-haul (pounds)
526
1531
856
I.D.
I.D.
Nov. '74
N.D.
898
1130
1201
I.D.
Dec. '74
N.D.
I.D.
1167
761
845
Jan. '75
Set-Over-Day

Fig. 4, cont'd.



Area
I
II
III,IV
V
VI,VII
Catch per trap-haul (pounds)
N.D.
I.D.
696
417
525
407
605
Feb. '75
Mar. '75
Apr. '75
2 4 6 8 10 12 14
Set-Over-Day

Fig. 4 , cont'd.

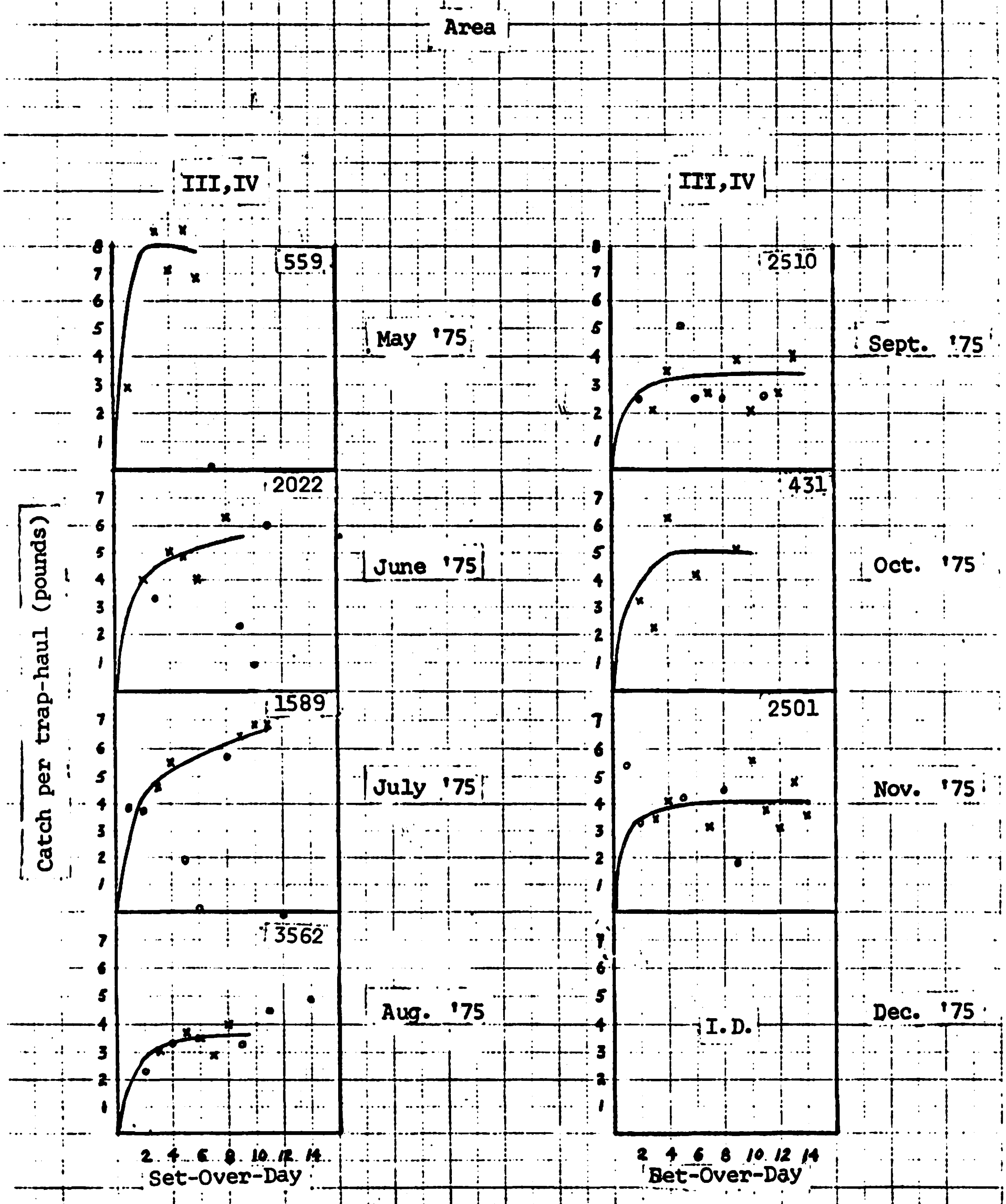

Area
III,IV
III,IV
559
May '75
2510
Sept. '75
2022
June '75
431
Oct. '75
1589
July '75
2501
Nov. '75
3562
Aug. '75
I.D.
Dec. '75
Catch per trap-haul (pounds)
2 4 6 8 10 12 14
Set-Over-Day
2 4 6 8 10 12 14
Set-Over-Day

Fig. 4, cont'd.

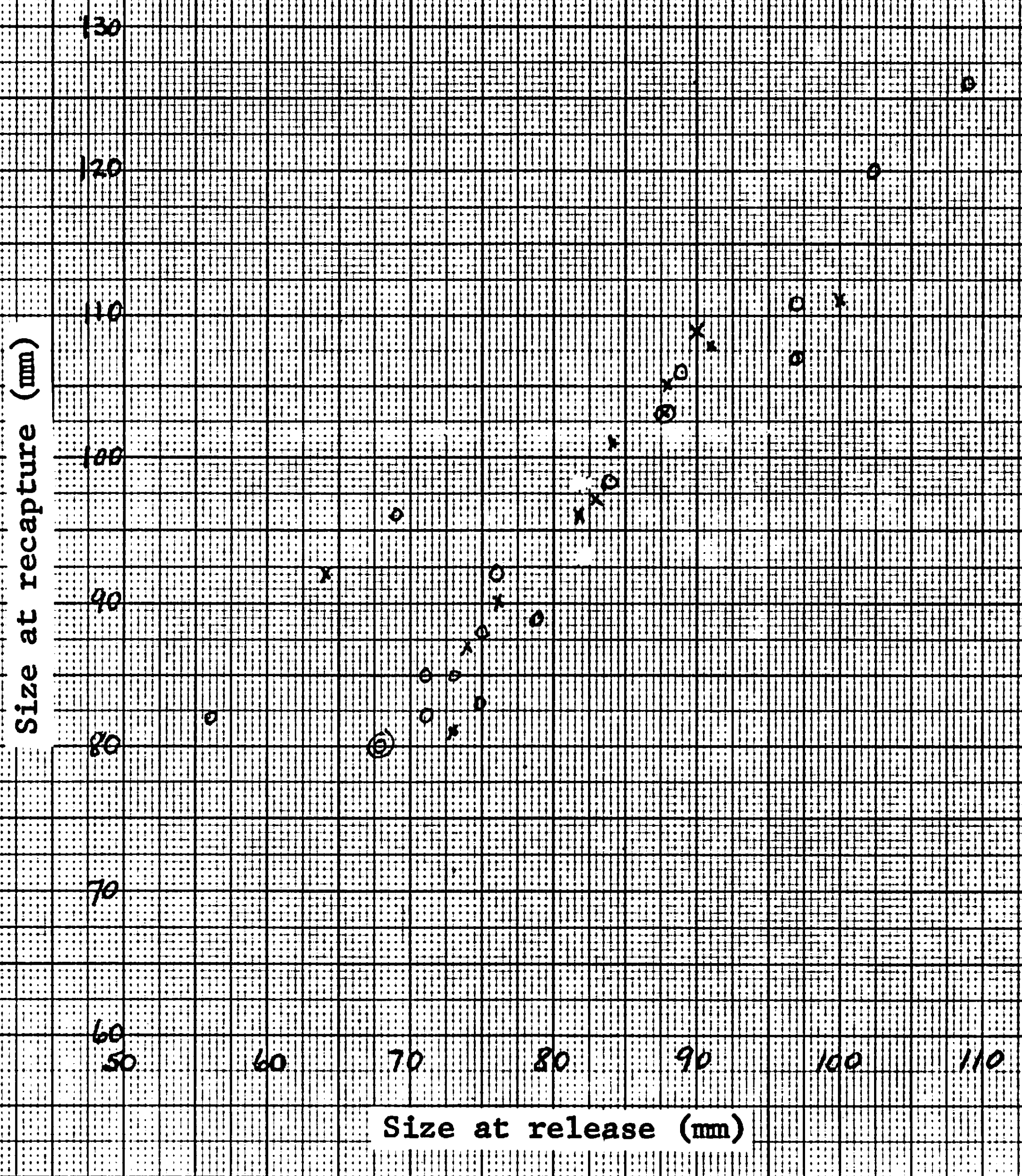


Figure 5. Relationship between the size at recapture and size at release of American lobsters, recaptured between May 1977 and December 31, 1978, Lobster Management Area Four. Males (x), Females (o).