

MARINE FISHERIES OF DELAWARE^{1,2}

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ABSTRACT

Delaware is almost in the geographical center of the Middle Atlantic Bight. The fisheries harvest endemic species, more or less restricted to the area, boreal species that migrate south in winter, and warmwater species that come north in summer. About 85 species have been recorded in commercial and recreational fisheries. Some have produced substantial catches, and the total commercial catch reached a peak in 1953 at nearly 167,000 metric tons. Production of commercial fisheries has since dropped to a low of only 305 metric tons in 1968, a drop of 99.8%, and has remained not much higher than that level ever since. Most of this decline was caused by the decline of the dominant menhaden fishery to zero in 1967, but drops in food finfishes and food shellfishes have been substantial also. The history has been one of boom or bust since the beginning, but superimposed upon this has been a gradual decline in almost all species. Several fisheries, notably purse seine, otter trawl, clam dredge, haul seine, and pound net, have ceased altogether.

The recreational fisheries have been growing in numbers of fishermen and in catches. Comparing food finfishes only, because industrial fisheries have no counterpart in the recreational fishery, and shellfishes have never been compared adequately, the recreational fisheries may now be taking three times as much as the commercial.

The boom and bust characteristic of the commercial fisheries has been caused by the widely fluctuating and uncertain nature of the major species, menhaden, blue crab, weakfish, croaker, and spot. Others, like surf clam, oyster, alewives, horseshoe crab, sturgeon, shad, and hard clam, have declined from overfishing, adverse changes in the inshore environment, or both. Some, like blue crab and weakfish, are fairly abundant at present, and weakfish is taken mostly by recreational fishermen. Others, like menhaden, have succumbed to heavy fishing of younger fish farther south. Menhaden vessels are now refrigerated, and can stay out longer and travel farther, which reduces the number of plants needed. Menhaden are still taken in Delaware Bay, but landed elsewhere.

The oceanographic regime is highly variable and not conducive to regular movements of northern or southern species into the area. These fisheries probably would be highly variable even if other changes had not also intervened. Maintaining them at fairly high levels will require cooperation from other states, cooperation which has not been forthcoming up to now. The State-Federal Fishery Management Board may help to improve interstate cooperation. The shellfisheries are more likely to survive, but to do so they will require enlightened management. The popular food fishes are likely to continue to decline as commercial species and become largely recreational. Some attention to the balance between commercial and recreational fisheries probably should be given soon.

The marine fisheries of the State of Delaware in many respects characterize the marine fisheries of the Middle Atlantic Bight region (New York to Virginia) as a whole. Delaware Bay is in the geographical center (lat. 39° N) of the section of coast from Cape Cod, Mass. (lat. 42° N), to Cape Hatteras, N.C. (lat. 36° N), and its marine fisheries have relied on three general classes of marine resource: 1) endemic species, more or less restricted to the region, or at least restricted in their migrations, such as surf clam, *Spisula solid-*

issima, and American oyster, *Crassostrea virginica*; 2) boreal species that migrate seasonally into the region in winter, such as Atlantic cod, *Gadus morhua*, or silver hake, *Merluccius bilinearis*; and 3) temperate water species that migrate north in summer, like Atlantic croaker, *Micropogonias undulatus*, or weakfish, *Cynoscion regalis*. Delaware is far enough south so that it does not usually get large quantities of boreal species, but it does on occasion have large numbers of southern species in the area.

June and Reintjes (1957), with respect to the fisheries of New Jersey, Delaware, and Maryland, noted that this area more or less marks the center of geographical distribution of migratory fish stocks which range between Cape Cod and Cape Hatteras. They pointed out that it is the southern

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limit of such species as the Atlantic cod; haddock, *Melanogrammus aeglefinus*; American lobster, *Homarus americanus*; and others which come down from the north, and the northern edge of the range of black drum, *Pogonias cromis*; red drum, *Sciaenops ocellatus*; spot, *Leiostomus xanthurus*; and other southern species. They also noted that it is one of the most productive coastal regions in North America, which in 1953 produced over 662 million lb (300,300 t (metric tons)) of fishes and shellfishes, with an estimated value of \$11.5 million to fishermen, and was capable of producing a great deal more. We could not reproduce these figures exactly from the 1953 statistics, but they were not far off. Total fishes were about 815 million lb (369,700 t), worth \$12.7 million to fishermen, and the total commercial catch for the three States, including shellfishes, was about 891 million lb (404,200 t) worth about \$31 million. By 1977 this had dropped to a commercial catch of 150 million lb (68,040 t) of fishes, 93 million lb (42,200 t) of shellfishes, for a total of only 243 million lb (110,200 t) worth about \$70.5 million to fishermen. To this should be added 149 million lb (67,600 t) of fishes and 24.7 million lb (11,200 t) of shellfishes caught by recreational fishermen in 1974. These figures are not comparable with the recreational catch in 1953, which was presumably for the outer coast only, and did not include shellfishes. Nevertheless, it is fairly obvious that the recreational catch was larger in 1974. In 1947 dollars the two values were almost identical, \$38.7 and \$38.9 million. This is not consistent with the view that these fisheries were underexploited in 1953.

Reintjes and Roithmayer (1960) extended these studies for another 4 yr (1954-57 inclusive) and concluded that the region supports large populations of resident species and seasonal concentrations of migratory fishes. They concluded that production of fishes and shellfishes in the area appeared to be the highest per unit area in the Western Hemisphere, and that the fisheries generally were underexploited and underutilized. Using Rounsefell and Everhart's (1953) criteria, they found that of resident benthic species, such as summer flounder, *Paralichthys dentatus*; black sea bass, *Centropristis striata*; butterfish, *Peprius triacanthus*; and scup, *Stenotomus chrysops*; only black sea bass appeared to be exploited at the maximum. Sedentary benthic species included surf clam and sea scallop, *Placopecten magellanicus*, and these and ocean quahog, *Arctica island-*

ica, and others were not overtaxed at that time. Migratory coastal species, like Atlantic menhaden, *Brevoortia tyrannus*; croaker; Atlantic cod; silver hake; weakfish; spot; red hake, *Urophycis chuss*; and bluefish, *Pomatomus saltatrix*, fluctuated widely and created greater instability in the fisheries than any other component of the total resource. Finally, migratory pelagic species like tuna, *Thunnus* sp.; sharks, Class Chondrichthyes; round herring, *Etrumeus teres*; sand lance, *Ammodytes* sp.; squids, *Loligo* sp. and *Illex* sp.; and others, were all abundant but in 1957 unexploited.

Perlmutter (1959) on the other hand, considering the fisheries of a wider area, from New York to Virginia inclusive, concluded that of the five major species other than menhaden and alewives—namely croaker, weakfish, scup, summer flounder, and black sea bass—only black sea bass appeared not to have declined in abundance. Thus, the picture is not entirely clear, and previous authors have not agreed. It must be pointed out, however, that those authors were not looking at precisely the same set of fisheries.

Eight fish and shellfish species have produced commercial landings >1,000 t (2,204,000 lb) in Delaware at some time in the recorded history of commercial fisheries in the State (Table 1). Another 10 species have at one time or another yielded commercial landings between about 1,000 and 100 t (2.2 million and 220,000 lb). Altogether, in recorded history from 1880 to 1978 inclusive (Pileggi and Thompson 1978), about 85 aquatic species or groups of species have been recorded in commercial or recreational marine fishery landings in Delaware. All species or groups of species are listed in Tables 1 and 2. Major species are discussed later in descending order of maximum annual landed weight.

The commercial fisheries of Delaware have been substantial in their time, peaking at nearly 167,000 t (370 million lb) in 1953 (Figure 1), but falling off after 1962 to a low of only 305 t (673,000 lb) by 1968. This was once the fourth largest State along the Atlantic coast in total landings. By far the most important species in terms of weight was menhaden, which reached a peak of 164,000 t (>360 million lb) in 1953 (Figure 2). Setting aside menhaden, which in most years made up the bulk of the catch, and the horseshoe crab, *Limulus polyphemus*, total food finfishes emerge as declining steadily since landings were first recorded (Figure 3), beginning in 1887 with a total of nearly

TABLE 1.—Maximum domestic commercial landings by species in the State of Delaware since 1880 and year of maximum landings. Species arranged in decreasing order of maximum landings. Weights in metric tons.

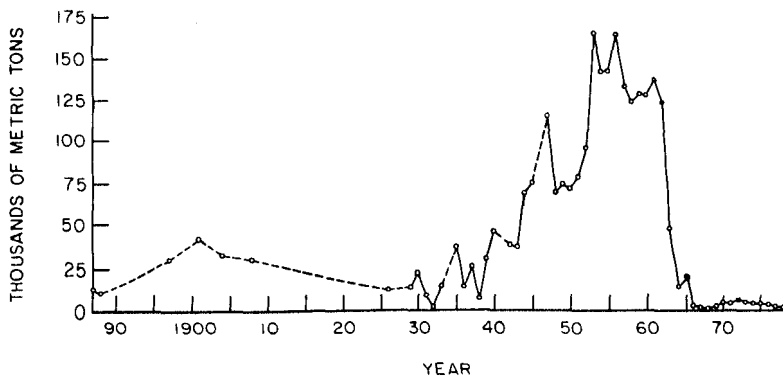
| Species | Maximum landings and year | Secondary peak and year | Species | Maximum landings and year | Secondary peak and year |
|---|---------------------------|-------------------------|--|---------------------------|-------------------------|
| Atlantic menhaden, <i>Brevoortia tyrannus</i> | 163,679 (1953) | | American lobster, <i>Homarus americanus</i> | 18 (1887, 1888) | 14 (1971) |
| Surf clam, <i>Spisula solidissima</i> | 3,962 (1970) | | Suckers, family Catostomidae | 16 (1897) | |
| Blue crab, <i>Callinectes sapidus</i> | 2,233 (1957) | | Northern kingfish, <i>Menticirrhus saxatilis</i> | 15 (1956) | |
| American oyster, <i>Crassostrea virginica</i> | 1,969 (1954) | | Atlantic mackerel, <i>Scomber scombrus</i> | 14 (1967) | |
| Weakfish, <i>Cynoscion regalis</i> | 1,457 (1889) | | Terrapin, <i>Malaclemys</i> sp. | 14 (1880) | |
| Alewife, <i>Alosa pseudoharengus</i> , <i>A. aestivalis</i> | 1,449 (1930) | | Red crab, <i>Geryon quinqueedens</i> | 12 (1977) | |
| Horseshoe crab, <i>Limulus polyphemus</i> | 1,352 (1908) | 907 (1976) | Mussel, <i>Mytilus edulis</i> | 10 (1932) | |
| Atlantic sturgeon, <i>Acipenser oxyrinchus</i> | 1,281 (1887) | | Squids, <i>Loligo opalescens</i> , <i>Illex illecebrosus</i> | 10 (1952) | |
| American shad, <i>Alosa sapidissima</i> | 735 (1897) | | Atlantic herring, <i>Clupea harengus</i> | 9 (1948) | |
| Atlantic croaker, <i>Micropogonias undulatus</i> | 510 (1930) | 303 (1955) | King mackerel, <i>Scomberomorus cavalla</i> | 8 (1951) | |
| Hard clam, <i>Mercenaria mercenaria</i> | 414 (1951) | | Unclassified flounders | 5 (1977) | |
| Spot, <i>Leiostomus xanthurus</i> | 294 (1880) | 103 (1955) | American plaice, <i>Hippoglossoides</i> <i>platessoides</i> | 4 (1947) | |
| Striped bass, <i>Morone saxatilis</i> | 266 (1973) | | Northern puffer, <i>Spherooides maculatus</i> | 3 (1963) | |
| Mullet, <i>Mugil cephalus</i> | 264 (1931) | | Unclassified sharks | 3 (1955) | |
| American eel, <i>Anguilla rostrata</i> | 198 (1887) | | Sheepshead, <i>Archosargus probatocephalus</i> | 3 (1880) | |
| Conchs, <i>Busycyon</i> spp. | 189 (1976) | | Minnnows, family Cyprinidae | 2 (1957) | |
| White perch, <i>Morone americana</i> | 181 (1897) | | Silver perch, <i>Bairdiella chrysoura</i> | 2 (1939) | |
| Common carp, <i>Cyprinus carpio</i> | 98 (1904) | | Grayfish, <i>Squalus acanthias</i> , <i>Mustelus</i> <i>canis</i> | 2 (1975) | |
| Summer flounder, <i>Paralichthys dentatus</i> | 95 (1958) | | Red drum, <i>Sciaenops ocellatus</i> | 1 (1926) | |
| Red hake, <i>Urophycis chuss</i> | 92 (1947) | | Yellowtail flounder, <i>Limanda ferruginea</i> | 1 (1930) | |
| Silver hake, <i>Merluccius bilinearis</i> | 92 (1947) | | Hickory shad, <i>Alosa mediocris</i> | 1 (1948) | |
| Black sea bass, <i>Centropristis striata</i> | 82 (1975) | | Black bass, <i>Micropterus</i> spp. | 1 (1908) | |
| Scup, <i>Stenotomus chrysops</i> | 71 (1949) | | Gizzard shad, <i>Dorosoma cepedianum</i> | 1 (1932) | |
| Catfish and bullheads, family Ictaluridae | 68 (1908) | | Frogs, <i>Rana</i> spp. | 1 (1908, 1926) | |
| Yellow perch, <i>Perca flavescens</i> | 68 (1880) | 22 (1930) | Unclassified food fishes | 1 (1977) | |
| Black drum, <i>Pogonias cromis</i> | 62 (1880) | 14 (1956) | White hake, <i>Urophycis tenuis</i> | (1) (1976) | |
| Snapper turtle, <i>Chelydra serpentina</i> , <i>Macrochelys temminckii</i> | 60 (1955) | | Shrimp, <i>Palaemonetes vulgaris</i> or <i>Crangon septemspinosus</i> | (1) (1887, 1888) | |
| Atlantic cod, <i>Gadus morhua</i> | 59 (1944) | | Soft clam, <i>Mya arenaria</i> | (1) (1887, 1888) | |
| Tautog, <i>Tautoga onitis</i> | 34 (1930) | | Sunfish, family Centrarchidae | (1) (1901) | |
| Bluefish, <i>Pomatomus saltatrix</i> | 32 (1931) | 29 (1949) | Atlantic bonito, <i>Sarda sarda</i> | (1) (1935, 1953) | |
| Butterfish, <i>Pepilus triacanthus</i> | 31 (1949) | | Conger eel, <i>Conger oceanicus</i> | (1) (1935) | |
| Unclassified industrial fishes | 27 (1958) | | | | |
| Winter flounder, <i>Pseudopleuronectes</i> <i>americanus</i> | 23 (1966) | | | | |
| Jonah crab, <i>Cancer borealis</i> | 20 (1977) | | | | |
| Pike or pickerel, <i>Esox</i> spp. | 19 (1897) | | | | |

¹ One-half t or less.

TABLE 2.—Species reported as caught by recreational fishermen in Delaware waters and not included in Table 1.

| Species | Species | Species | Species |
|--------------------------------------|--|--|--|
| Skates, family Rajidae | Dolphin, <i>Coryphaena</i> sp. | Yellowfin tuna, <i>T. albacares</i> | Wahoo, <i>Acanthocybium solanderi</i> |
| Stingray, <i>Dasyatis</i> sp. | Pigfish, <i>Orthopristis chrysoptera</i> | Albacore, <i>T. alalunga</i> | White marlin, <i>Tetrapturus albidus</i> |
| Lizardfish, <i>Synodus</i> sp. | Tunas, <i>Thunnus</i> spp. | Little tunny, <i>Euthynnus alletteratus</i> | Searobins, <i>Prionotus</i> spp. |
| Oyster toadfish, <i>Opsanus tau</i> | Bluefin tuna, <i>T. thynnus</i> | Spanish mackerel, <i>Scomberomorus maculatus</i> | Spiny boxfish?, <i>Lactophrys</i> sp.? |
| Goosefish, <i>Lophius americanus</i> | Blackfin tuna, <i>T. atlanticus</i> | | |
| Amberjack, <i>Seriola</i> sp. | | | |

FIGURE 1.—Total commercial landings, all species, in Delaware, 1887-1978. When years were missing, points were joined by broken lines.



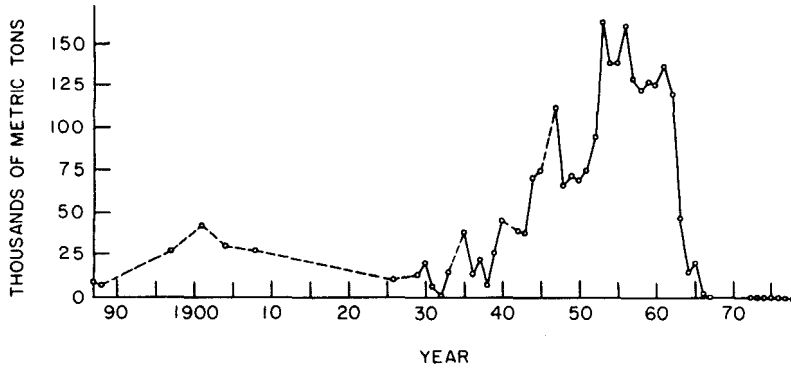


FIGURE 2.—Total landings of industrial fishes and shellfishes in Delaware, 1887-1978.

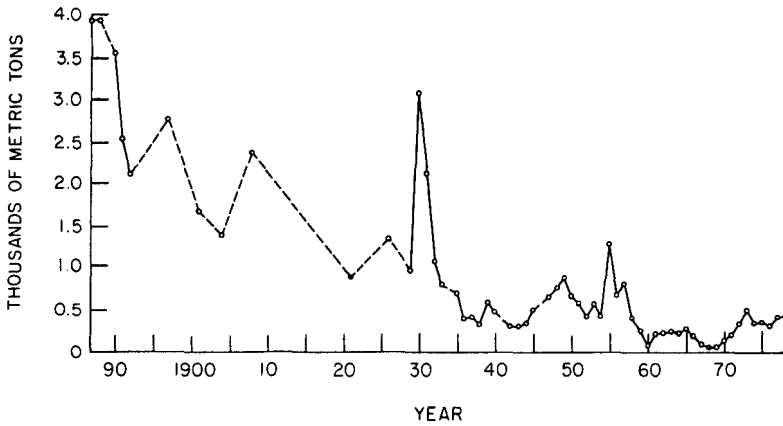


FIGURE 3.—Total commercial landings of food finfishes in Delaware, 1887-1978.

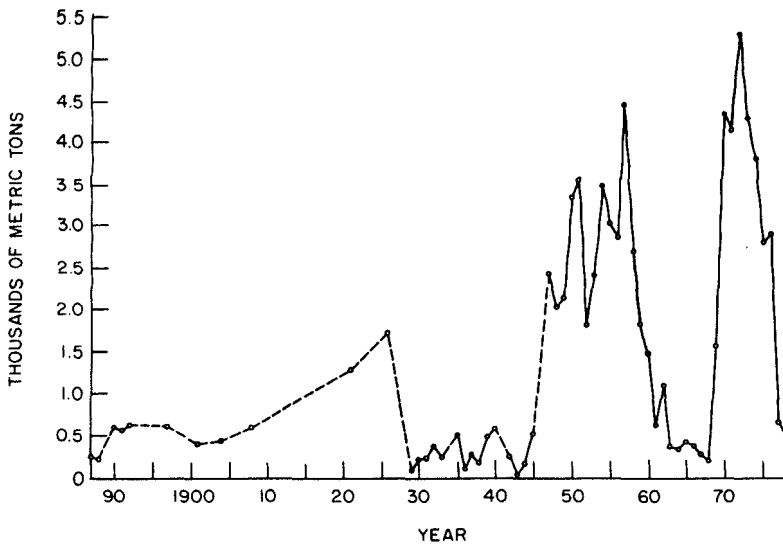


FIGURE 4.—Total commercial landings of food shellfishes in Delaware, 1887-1978.

4,000 t (9 million lb), falling by 1969 to a low of 65 t (143,000 lb), then rising to 418 t (921,000 lb) by 1977. This was a decline from peak to valley of about 98.4%. Species that contributed mainly to this drop were Atlantic sturgeon, *Acipenser oxyrinchus*; American shad, *Alosa sapidissima*; alewife, *A. pseudoharengus* and *A. aestivalis*; and white perch, *Morone americana*, all anadromous species. Later croaker, weakfish, spot, and striped bass, *Morone saxatilis*, also dropped substantially, all species with a close coastal or anadromous life history. The drop was not all caused by a reduction in abundance of these species, since effort in most fisheries was dropping too.

The shellfishes had quite a different history (Figure 4), peaking in 1926 at about 1,800 t (nearly 4 million lb), in 1957 at 4,500 t (nearly 10 million lb), and in 1972 at 5,400 t (nearly 12 million lb). This was interspersed with lows of <54 t (120,000 lb) in 1943, 232 t (512,000 lb) in 1968, and 685 t (1,511,000 lb) in 1977, drops of 94.3, 94.8, and 87.2%, respectively. These represent three periods in the history of the shellfisheries of Delaware, oyster peaking in 1926, blue crab, *Callinectes sapidus*, in 1957, and surf clam rising briefly in the early 1970's.

The history of Delaware's commercial fisheries has been one of boom and bust since the beginning. The causes have been the wide fluctuations in availability, referred to already, associated with species at the limits of their geographic ranges, plus overexploitation and degraded habitat. The menhaden industry harvested its last fish with purse seines in 1966, the food finfish industry has declined fairly steadily, and the shellfish industry has had at least three major ups and downs in the last 50 yr. Several fisheries have ceased completely. What are the prospects for the future of Delaware's fisheries?

INDUSTRIAL FISHERIES

Industrial fisheries have consisted mostly of menhaden, with lesser amounts of horseshoe crab from time to time. The industrial fisheries were relatively small until 1944, when they rose above 100 million lb for the first time. They remained fairly large until 1963, and quickly collapsed after that. The last purse seine catch landed in Delaware was in 1966. Menhaden are still caught in Delaware waters but are landed elsewhere. Prior to the mid-1940's the fishery was not well developed, probably because the Pacific sardine,

Sardinops sagax, industry on the west coast was more efficient and was able to supply most of the markets. After 1945, the decline of the Pacific sardine industry and the growth of the broiler industry in the east opened up new markets, and the menhaden industry on the east coast prospered, especially after 1952. By 1963, declining recruitment, probably associated with heavy fishing farther south, affected the supply of fish to northern waters, and the last plant in Delaware closed at the end of the 1966 season.

A small reduction plant operated on horseshoe crab for a few years from 1930 to 1944. A small number was taken after 1966, probably for bait. The greatest landings recorded were about 500,000 lb in 1935. The decrease was largely caused by a reduction in demand, although horseshoe crab now may be less abundant than before (Daiber⁴). This conclusion, however, is largely intuitive.

FOOD FINFISHES

Landings of food finfishes in Delaware have been declining since the first record in 1887. There have been temporary increases, such as in 1930-31 and 1955, but for the most part it has been steadily downward (Figure 3). The anadromous species were the first to be affected. Sturgeon was first, dropping from a high of nearly 1,300 t (3 million lb) in 1887 to only 15 t (34,000 lb) by 1908. This was reflected also in the price, which was less than a cent a pound, on the average, in 1887, but had risen to over 20¢/lb by 1908. Shad was not far behind, dropping from about 800 t (1.4 million lb) in 1890 to 18 t (39,000 lb) in 1931, while the price rose from <4¢ to about 18¢/lb. Alewife catches reached their peak later, at about 1,450 t (3.2 million lb) in 1930. By 1938 they had dropped to 21 t (47,000 lb), and never exceeded 60 t (150,000 lb) after that. White perch, another anadromous species, produced the greatest landings in 1897 at about 180 t (297,000 lb), and by 1940 was down to 7 t (16,000 lb).

Coastal fishes were equally temporary. Weakfish was the most important species, with total landings of about 1,500 t in 1889 (3,212,000 lb), later fluctuating several times, and finally dropping to a low of only 2 t (5,000 lb) in 1968.

⁴Franklin C. Daiber, Professor of Marine Biology and Biological Sciences, College of Marine Studies, University of Delaware, Newark, DE 19711, pers. commun. December 1979.

Croaker produced 500 t (>1 million lb) in 1930 and was down to nothing in 1961 for over a decade. Spot produced almost 300 t (649,000 lb) in 1880 and was highly variable after that, dropping to nothing in 1961 for over a decade, then showing up again in 1975. Spot is salted down for personal use by local fishermen, and some parts of the catch are not reported. Striped bass was never a large commercial producer in Delaware, and in fact reached its peak in 1973 at about 265 t (586,000 lb).

FOOD SHELLFISHES

Landings of shellfishes, minus seed oysters, which appear later as market oysters, and horse-shoe crabs, which are used to make meal or as bait, have an interesting history. The principal species are only four: American oyster, blue crab, surf clam, and hard clam, *Mercenaria mercenaria*. The total take of these species has been highly variable, fluctuating from almost nothing to nearly 5,500 t (12 million lb), with different species making up most of the landings at each peak. Almost the entire peak in 1926 was made up of American oyster (Figure 4), 1,554 t (3,426,000 lb). In 1951 and 1957 the major species was blue crab, with American oyster second. Blue crab landings peaked in 1951 and 1957 at 2,260 t (nearly 5 million lb). The peak in 1972 was caused mostly by landings of 3,879 t (8,551,000 lb) of surf clam.

American oyster was relatively high in the early days, dropped to a low of only 22 t (48,000 lb) in 1943, peaked again from 1947 to 1958 with a maximum of 1,968 t (4,340,000 lb) in 1954, reached an all-time low of 15 t (33,000 lb) in 1961, and since has come back partially, reaching a high of 230 t (509,000 lb) in 1972. Blue crab dropped to a low in 1968, and since have risen to 1,655 t (3,650,000 lb) in 1976. Surf clam did not appear in landings until 1956, rose to a peak of 773 t (1,705,000 lb) in 1959, dropped to nothing in 1963, showed up again in 1969, peaked in 1970 at 3,962 t (8,734,000 lb), and dropped again to nothing in 1976. Hard clam built up to a peak of 414 t (912,000 lb) in 1951 and dropped to a low of 15 t (34,000 lb) in 1975. The only one of the four that appears to be reasonably healthy at the present time is the blue crab, but judging from past fluctuations blue crab can not be depended upon to maintain a healthy fishery, even if adequate management measures were in effect. Blue crab is

near the northern limit of its range in Delaware, and probably can be expected to fluctuate widely for that reason.

RECREATIONAL FISHERIES

The recreational fisheries of Delaware, like marine recreational fisheries almost everywhere, are not well known. It can safely be assumed that they are growing, if the national surveys are a criterion, for catches have risen from 80,741 t (178 million lb) of food finfishes in 1960 to 121,564 t (about 268 million lb) in 1974. The rate of rise may have been greater than this, for in 1965 the estimated catch dropped to 58,060 t (128 million lb). These catches, however, are for the area from New York to Cape Hatteras, except for 1974, which did not include any part of the North Carolina coast. Only in 1974 was an estimate made of the Delaware catch, at about 2,903 t (6.4 million lb) of food finfishes, plus 1,814 t (about 4.0 million lb) of shellfishes. This consisted of 1,723 t (about 3.8 million lb) of weakfish, 227 t (about 500,000 lb) of bluefish, 84 t (185,000 lb) of sharks, 69 t (153,000 lb) of summer flounder, 227 t (500,000 lb) of other fishes; 998 t (2.2 million lb) of hard clam, 816 t (1.8 million lb) of soft clam, *Mya arenaria*, and a small amount of other shellfishes. If these figures are at all realistic, the food finfish catch of recreational fishermen in Delaware is substantially higher than the commercial catch.

This is confirmed by figures contained in sport-fishing surveys conducted in 1953, 1954, and 1955. Using average weights of fishes from the 1970 saltwater angling survey (Deuel 1973), it was estimated that recreational fishermen caught 1,814 t (nearly 4 million lb) of fishes in 1955, which compared with 1,225 t (about 2.7 million lb) of the same species in the commercial catch. Estimates of recreational catches covered a period of only about 3 mo, whereas the commercial catch covered the entire year. Consequently, it is probably a conservative estimate that recreational fishermen took at least twice as much as commercial fishermen.

Later estimates made the discrepancy even greater, and this is not surprising, for the numbers of anglers were increasing also (Deuel 1973). Miller (1978) estimated that the recreational catch in 1977 was about 5.8 million fishes, plus considerable quantities of blue crab and hard clam. By weight, this would be perhaps 3,402 t (7.5 million lb), which was three times as great as the

commercial catch, and possibly more. This report also gave estimated landings by recreational fishermen for other years, 2.4 million fishes in 1968 and 1.9 million in 1973. Using the same average annual weights these amounted to roughly 1,542 t (3.4 million lb) and 1,225 t (2.7 million lb), respectively. This was 21 times and 2.3 times the commercial catch of finfishes, respectively. These are probably not very accurate, but it is clear that sportfishermen in Delaware caught more fishes than commercial fishermen.

THE OCEANOGRAPHIC REGIME

Parr (1933) found that through alternate development and breakdown of temperature barriers at Cape Cod-Nantucket Shoals and Cape Hatteras, the shallow water belt along the Middle Atlantic coast is in open-temperature continuity with the waters north of Cape Cod in winter and with waters south of Cape Hatteras in summer, being barred in opposite directions during these seasons. Temperatures in the Cape Cod region develop slowly in winter, early spring, and late fall, but show violent fluctuations in summer. In the Cape Hatteras region the opposite succession of conditions prevails, with relatively smooth temperature changes in summer, but with violent fluctuations in winter, early spring, and late fall. Winter invasions of fishes from the north are quantitatively poor and not very penetrating, but visitors from south of Cape Hatteras are usually complete. In the Delaware Bay region these changes are at a maximum, and Delaware Bay has the greatest difference between maximum and minimum temperature whether at the 5 per-

centile (Figure 5) or the 95 percentile (Figure 6) level. This means that the temperature regime is less variable to the north and south of Delaware, and presumably the effect on migrations is less. The data from which Figures 5 and 6 were taken are from Waters (1967). This shows for a period of over 100 yr the 5 percentile and 95 percentile isotherms of surface water temperatures along the Atlantic coast of North America. The temperature rises rapidly in spring and falls almost as rapidly in fall, and also varies considerably from time to time. For example, the 70° F isotherm penetrates only to Virginia in cool years (Figure 5), but rises as far north as Cape Cod in warm years (Figure 6) in summer. Similarly, in winter the 42° F isotherm comes as far south as Cape Hatteras in cold years, whereas in warm years it barely reaches Cape Cod.

This means that Delaware is in a region of rather highly variable water temperature, which will influence how far north southern species will come in summer, and how far south boreal species will come in winter. This is obviously not a favorable oceanographic regime for highly predictable fisheries, even if their numbers did not fluctuate greatly from time to time.

FISHES AND SHELLFISHES

Menhaden

Although it undoubtedly was abundant in the Delaware area, menhaden did not support a major commercial fishery in the early days. Along many parts of the coast it was originally used mainly as fertilizer, applied directly to agricultural land.

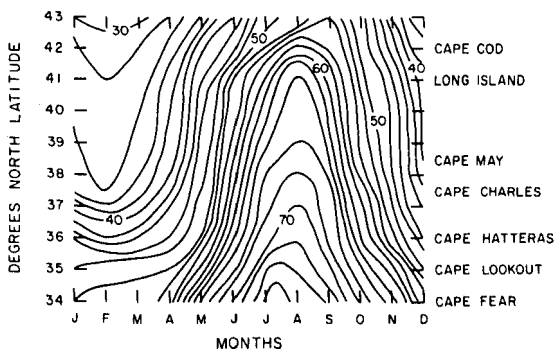


FIGURE 5.—Surface temperatures along the Middle Atlantic coast, 5 percentiles, by months and degrees latitude.

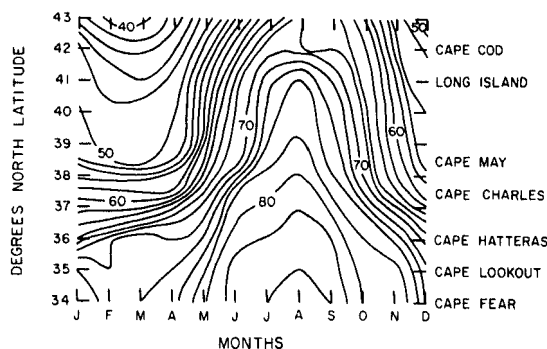


FIGURE 6.—Surface temperatures along the Middle Atlantic coast, 95 percentiles, by months and degrees latitude.

Most, if not all, of this harvest probably was not recorded in commercial landings. In 1880 (Collins 1887), 10 t (23,000 lb) of the total reported catch of 237 t (522,999 lb) landed in Delaware were used as human food. Modern usage of the resource is as raw material for production of oil, meal, and soluble proteins. Menhaden now is used only indirectly as a commercial food product, by incorporating meal and solubles in diets for poultry and livestock. The oil is used in a variety of products from paint to cosmetics.

By 1887 and 1888 a menhaden industry had developed in Delaware. Two factories were in operation at Lewes, employing 88 men ashore. Fishing vessels were powered by steam; 5 vessels and 107 fishermen operated in 1887, 4 vessels and 84 fishermen in 1888. Most of the catch at that time was made in gill nets but haul seines took about 27% of the total catch. The catch produced 878,206 l (232,000 gal) of oil and 3,000 tons of scrap (fish meal) in 1887; 582,455 l (153,870 gal) and 1,800 tons in 1888.

The method of recording landings and industrial production of menhaden used in the 1880's produced some inconsistent figures. It is obvious that landings of 100 t (220,399 lb) reported for Delaware in 1887 could not produce 878,206 l (232,300 gal) of oil and 3,000 tons of scrap. The discrepancy was caused by the method of allocating raw materials and processed products. The fishing vessels were registered in Connecticut and their catch was reported in their State of origin. The plants at Lewes, Del., were also built and owned by Connecticut interests, but their production was credited to Delaware, the State in which they were located.

Menhaden landings in Delaware can be estimated by using figures on menhaden production

for the State. These are given, for the most part, in numbers of fish rather than in weight, a peculiar method of accounting for the greatest weight of fish landed, especially as we know that they were not counted. Menhaden were weighed by filling a bucket which held half a ton. In 1901 weight was given in numbers of fish, but it was also said that 1.67 fish weighed 1 lb, which was equivalent to 3,000 fish/ton. This conversion factor was used to calculate weight of fish in 1904 and earlier. In 1908 and thereafter, total landings for Delaware were given in pounds.

This peculiar way of handling menhaden could be quite misleading. For example, in Chesapeake Bay, the average weight of menhaden in the purse seine catch was about 3 or 4 fish to the pound, and probably is more now. In North Carolina it must be even greater. These are averages, and they will vary considerably from spring to fall, and with relative numbers of the different ages of fish. Thus, it is much more logical to quote menhaden landings by weight, since that is the way they are measured. A menhaden catch in Chesapeake Bay will contain considerably greater numbers of fish than one of the same weight in Delaware or farther north.

Menhaden landings in Delaware were fairly large in the early 1900's but fell to a low point in 1932 (Figure 7). This low point was partly caused by the depression, which reduced demand and prices, but also by the great overproduction of whale oil in 1931, which saturated world markets. The Pacific sardine fishery was also beginning about 1915, and the menhaden fishery did not develop fully until the late 1940's, when the Pacific sardine fishery began to collapse. The rise of the broiler industry, especially in the Delmarva Peninsula, also created favorable market condi-

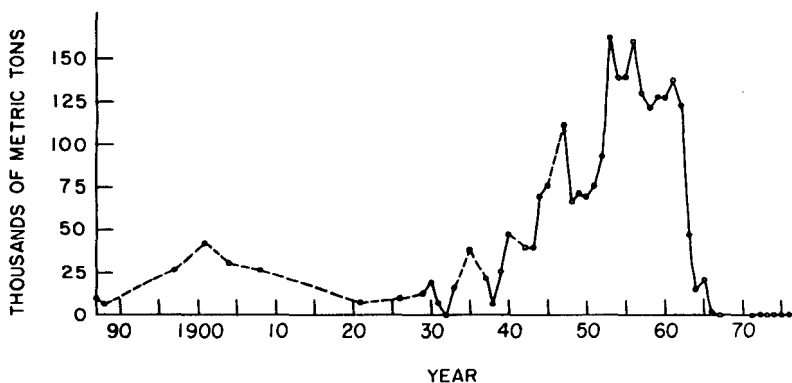


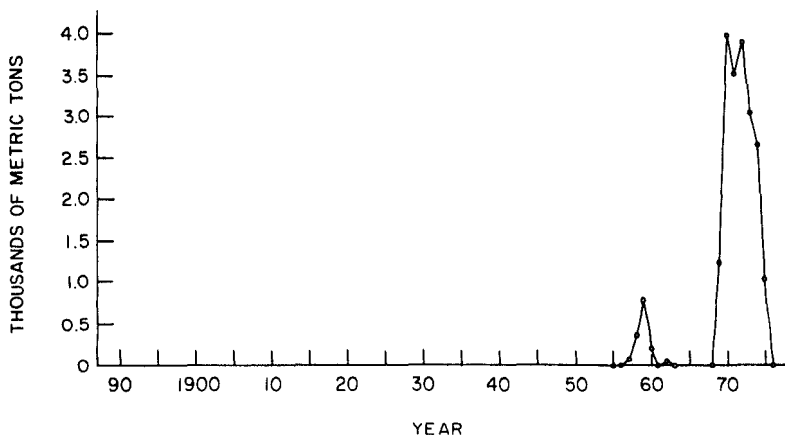
FIGURE 7.—Commercial landings of Atlantic menhaden in Delaware, 1887-1977.

tions. Catches were at a peak from 1953 to 1962, averaging 136,828 t (301,649,000 lb), after which they sharply declined, and the purse seine fishery, which was the dominant gear used until then, ended after the 1966 season. During this period Delaware was the most important State along the Atlantic coast in 1952 in menhaden landings, second in importance from 1953 to 1958, and second again in 1960 and 1961.

Surf Clam

Next to menhaden, surf clam produced the greatest weight of landings in Delaware, 3,962 t (8.7 million lb) in 1970. This was weight of meats only, equivalent to 28,123 t (about 62 million lb), live weight. This was not only the most recent fishery in Delaware, having produced the first small catch in 1956 (Figure 8), but also was relatively short lived. The fishery developed quickly but dropped to nothing by 1963, redeveloped in 1969, and produced its last catch in 1975. Figures on landings, however, do not tell the whole story. According to Daiber (footnote 4), a processing plant has been situated at Lewes for approximately 20 yr. At first, dredge boats landed directly at the plant, then as they fished farther away they landed the catch at other ports and surf clams were trucked to Lewes. More recently, vessels became larger, and when they worked near the mouth of Delaware Bay they landed at the docks of the former menhaden plants and surf clams were trucked the short distance to the processing plant. The vessels are now landing in New Jersey, and surf clams are trucked in, for the plant is still operating.

FIGURE 8.—Commercial landings of surf clam in Delaware, 1956-1975.



The fishery in the vicinity of Delaware was merely a phase of the fishery as a whole, which began off Long Island, N.Y., during the Second World War, and gradually shifted down the coast as ground after ground was overexploited. The peak was reached in 1974, off Virginia, and catches declined substantially after that. The Mid-Atlantic Council is now trying to manage the resource, along with ocean quahog.

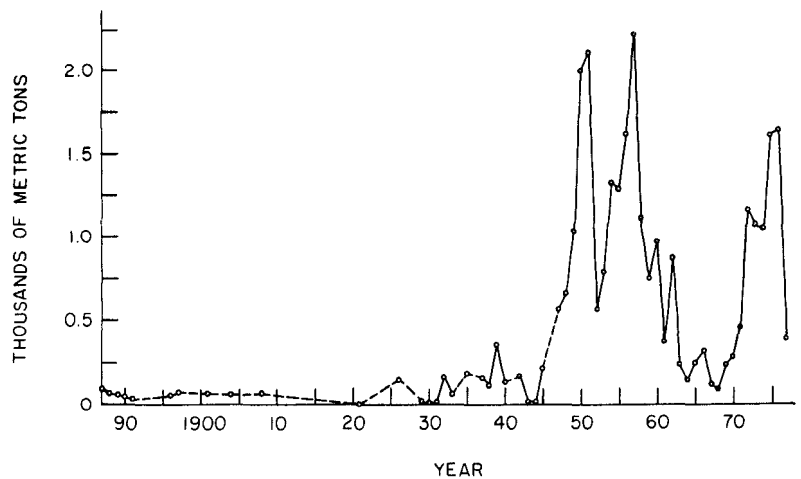
Blue Crab

A small fishery for blue crab has existed in Delaware waters since the early days. Landings were not very large until after the Second World War, then shot up to 2,000 t (>4 million lb) in 1950 and 1951 (Figure 9). They dropped sharply in 1952, then rose gradually to nearly 2,265 t (5 million lb) in 1957, then dropped off to about 90 t (200,000 lb) by 1968. Subsequently, they have risen again and in 1975 and 1976 were 1,590 t (>3.5 million lb). The decline in 1977 probably was caused by an extremely cold winter.

Blue crab is abundant north to Chesapeake Bay, where it supports a major fishery. From Delaware north it appears spasmodically, sometime existing in great abundance, sometimes almost disappearing. It extends north to Cape Cod, and occasionally appears in the Gulf of Maine. The great variations in availability from Delaware Bay north are probably explained on the basis of environmental fluctuations, the major element of which is probably winter temperature. This is characteristic of a species near the northern limits of its range.

During the 1960's, however, it has been suggested that the intensive use of DDT in control of

FIGURE 9.—Commercial landings of blue crab in Delaware, 1887-1977.



mosquitoes on coastal marshlands may have been a factor. It is suggestive in that blue crab has returned in great abundance to Delaware, New Jersey, New York, and even farther north. On the other hand, its abundance is obviously affected adversely by cold winters, such as the winter of 1976-77, which killed many of the blue crabs in New York waters. It is expected that blue crab will continue to be highly variable in abundance from Delaware north. At present, however, it is the most important fishery in the area.

Blue crab is an important predator of hard clam wherever it is abundant. In areas where extensive hard clam fisheries exist, or where the potential for hard clam production is high, it might be well to encourage fisheries for blue crab, and to place no limits on the catch, because there is an established and valuable fishery for hard clam, and the two may not be able to coexist in abundance.

American Oyster

The American oyster industry in Delaware was rather small for most of its history, taking most of its harvest from naturally producing grounds in the State. Prior to 1929 its history is not clear because landings were available for only 14 of the 49 yr. It appears that it peaked somewhere between 1912 and 1926 (Figure 10), then dropped off to low levels until after the Second World War. For about 12 yr, from 1947 to 1958, it fluctuated from about 900 to 1,800 t (2 to 4 million lb), then dropped abruptly, and since then has been <225 t (500,000 lb) except for 1 yr. Poor management, followed by disease, were the principal causes, according to Daiber (footnote 4).

Price (1978) has noted that in the late 1800's, Delaware Bay as a whole (New Jersey and Delaware) produced about 10,423 t (23 million lb)

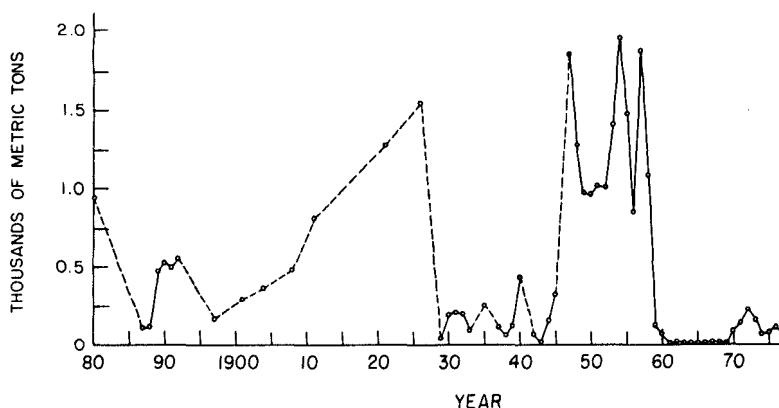


FIGURE 10.—Commercial landings of American oyster in Delaware, 1880-1977.

of American oysters, and had substantial shad, sturgeon, and other fisheries. A variety of factors, including improper management of shellfish beds (harvesting without replenishing equal quantities of shell stock), development of the watershed with attendant siltation, heavy industrialization of the Delaware River, industrial effluents and oil spills, mosquito control by ditching wetlands and spraying, and closure of harvesting areas caused by sewage contamination, caused American oyster production to decline to 4,082 t (9 million lb) by 1954. By 1960 the American oyster industry suffered a catastrophic collapse caused by the pathogen MSX (*Minchinia nelsoni*). In Delaware, the value of American oyster landings declined from almost \$3 million to <\$40,000 from 1954 to 1961. The fishery has not been re-established to date (Maurer et al. 1971).

Gunter (1975) claimed that American oyster production in Delaware Bay as a whole (Delaware and New Jersey) has declined in two vast steps, from about 6,500 t (14,247,000 lb) from 1880 to 1931, to 3,600 t (7,951,000 lb) from 1932 to 1957, to 390 t (859,000 lb) from 1959 to 1970. He pointed out that the two declines each occurred 3 yr after diversions of Delaware River water to New York City in 1929 and 1953. He did not offer other data to substantiate cause and effect.

Weakfish

There is little question that weakfish was the "money" fish of the Delaware fishery. It has fluctuated widely in abundance from time to time, but has held up well, and may now be as abundant or more so, than it ever was. Although the record of commercial landings from 1880 to 1977 is in general downward (Figure 11), this is a popular sport fish, and recreational catches in recent years, if they are at all accurate, suggest that the

catch remains at over 1,360 t (3 million lb). The resource obviously fluctuates widely in abundance for environmental reasons, of which more will be said later. It was relatively abundant in the 1950's and very low in abundance in the 1960's. The decline of the commercial fishery was probably a combination of these natural fluctuations and an increasing catch by the recreational fishery. The estimated catch by sport fishermen in 1974 was 1,724 t (about 3.8 million lb). Assuming a much smaller recreational catch in the 1880's, this compares favorably or even exceeds earlier catches. Some also have suggested that the decline in abundance of weakfish after the Second World War may have been caused by widespread use of DDT on salt marshes (Joseph 1972).

The gradual decline in the take of weakfish by commercial fishermen probably contributed to the virtual collapse of the commercial fisheries generally in Delaware. Sturgeon, shad, and croaker, the other major contributors to the in-shore fishery, had already been reduced in abundance much earlier, and with weakfish virtually gone, there was little else to attract commercial fishermen. This probably was hastened by recreational fishermen, who discovered an old law some time in the 1960's that prohibited trawling in Delaware Bay and applied pressure to have it observed. New Jersey fishermen have not been allowed to trawl in the Bay for many years.

Alewives

Except for a brief period in the early 1930's, alewives were a relatively small and declining resource in Delaware (Figure 12). Catches declined fairly steadily, until by the 1960's they were almost zero. The brief increase in alewife landings in the early 1930's may have been caused by the

FIGURE 11.—Commercial landings of weakfish in Delaware, 1880-1977.

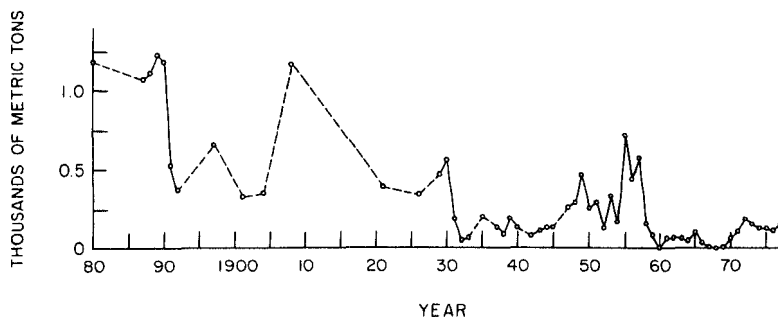
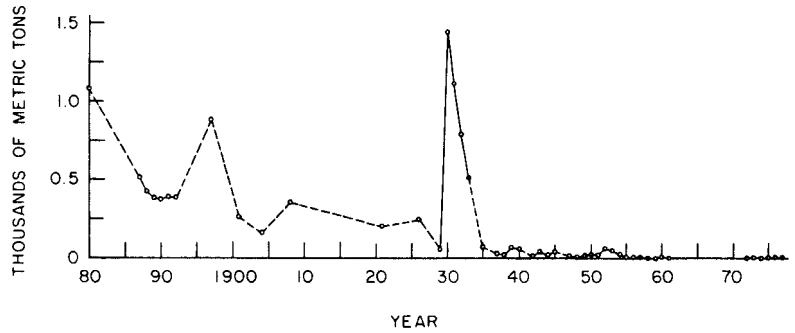


FIGURE 12.—Commercial landings of alewife in Delaware, 1880-1977.



depression, which created markets for a few years for cheap fish.

Establishment of water powered mills on all the tidal creeks, with their associated dams, may have contributed to the decline in landings, preventing spawning above the dams.

Sturgeon

Sturgeon was still fairly abundant in Delaware in the 1880's (Figure 13), producing 1,300 t (nearly 3 million lb). By the 1900's, however, they had declined to a low level, and yielded 45 t (<100,000 lb) annually thereafter. It is a tribute to the viability of the sturgeon that it has continued to produce small catches, despite its vulnerability. Fishermen in the early days may have contributed de-

liberately to the decline of the sturgeon stocks, by destroying them because they damaged nets. The great demand and high prices for caviar also undoubtedly had an effect.

Shad

Shad declined in landings much as sturgeon did in the early days, producing relatively small catches after about 1908 (Figure 14). In Delaware it produced somewhat increased catches in the mid-1940's, early 1950's, and early 1960's, but not as great during the days of the Second World War as in New Jersey, New York, and Connecticut. Like all anadromous species, shad was particularly vulnerable to adverse changes in the environment of rivers, but changing human tastes,

FIGURE 13.—Commercial landings of Atlantic sturgeon in Delaware, 1880-1932.

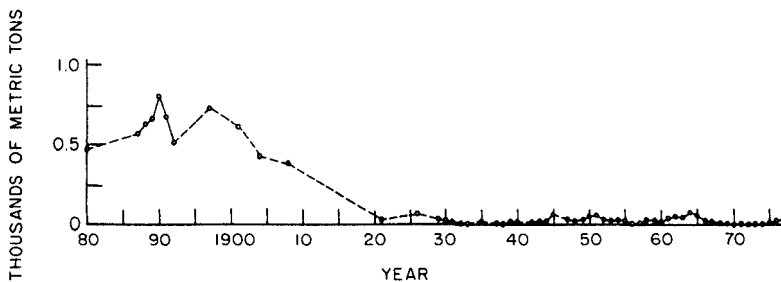
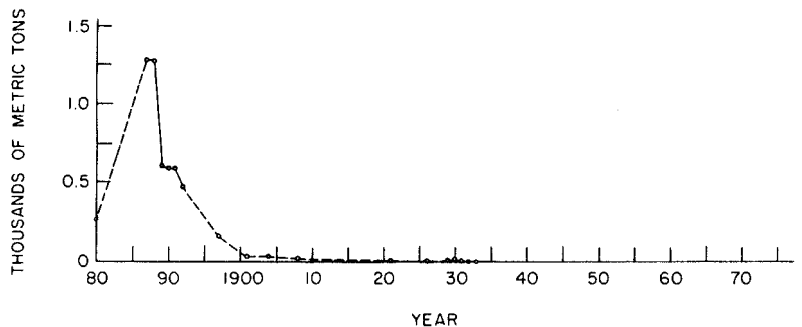


FIGURE 14.—Commercial landings of American shad in Delaware, 1880-1977.

highly seasonal demand, and the growing ease of trucking or flying shad from the south, where runs are much earlier, probably also played a part, as they did in New York (Medeiros 1974). Recreational fishing for shad in the Delaware River is growing (Grucela 1978) in landings and effort. The Delaware River stock is in good condition as compared with other rivers in the area.

Croaker

Croaker appeared later than weakfish in Delaware (Figure 15), reaching its peak in 1930 with about 500 t (slightly over 1 million lb). Thereafter it fell off irregularly, producing no catches after 1960 until 1975. Croaker, like weakfish, is a southern fish, and comes north of Chesapeake Bay only when conditions are particularly favorable, or when populations are high. Thus its abundance is likely to remain quite variable. The complete absence of croaker as a commercial resource during the 1960's and early 1970's may also have been caused by extensive use of DDT in estuaries, enhanced also by the stresses of living at the northern extreme of its range. Recovery in the mid-1970's may have been a delayed response to

banning the use of this compound for mosquito control.

Hard Clam

Hard clam did not figure prominently in the catch in Delaware until after the Second World War (Figure 16) when stabilization of Indian River Inlet raised the salinity in the bay behind, and improved the environment for hard clam. It did not remain high for very long, however, and fell irregularly but steadily after 1951, when the maximum catch was about 414 t (912,000 lb) to 17 t (38,000 lb) in 1977, a drop of nearly 96%. It is probable that the decline was caused by a combination of overharvesting and pollution, which closed certain areas to clamming. Recreational clamming also is popular in Delaware (Miller 1978).

Spot

Spot is reported to have produced 295 t (650,000 lb) in Delaware in 1880, but was not reported again in catches until 1904 (Figure 17). This species is often caught by fishermen for their own

FIGURE 15.—Commercial landings of Atlantic croaker in Delaware, 1880-1977.

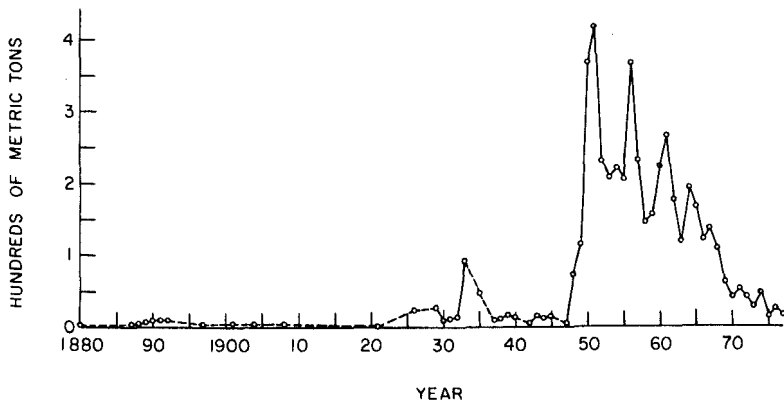
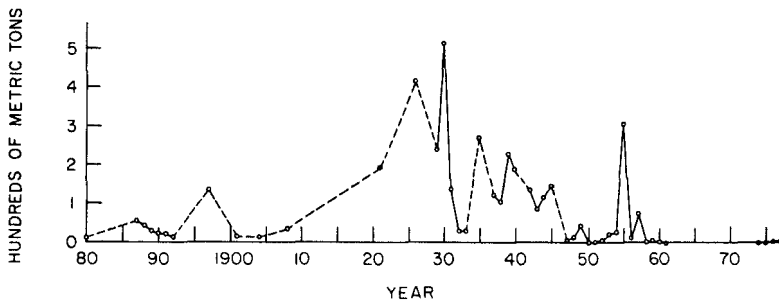
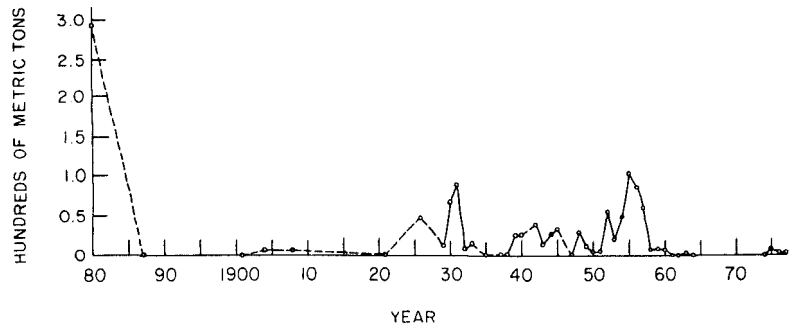


FIGURE 16.—Commercial landings of hard clam in Delaware, 1880-1977.

FIGURE 17.—Commercial landings of spot in Delaware, 1880-1977.



use, and is salted down for winter consumption. Such fish are not normally recorded in the catch. Existing records show that it reached a peak in 1931 and again in 1955, then fell off to nothing after 1963 until 1975. It is possible that spot also was affected by DDT in that period. Spot is an inshore species and, like croaker and other species, is near the northern limit of its range, thus is subjected sometimes to great stress when winter temperatures are low.

Striped Bass

Striped bass catches parallel those along other sections of the coast, declining to a low in the 1930's, then building up to a peak in the early 1970's, with rather wide fluctuations in between (Figure 18). There is little doubt that abundance has increased since the 1930's, but it is too early to say whether the recent decline is large enough to be of concern or simply reflects another temporary low in abundance. Striped bass probably once spawned in the Delaware River from Marcus Hook to below Wilmington where the river waters are normally between 1 and 5‰ in salinity. These waters are presently heavily polluted.

Regulation of the striped bass fishery has become a social-political matter, as the resource has grown in popularity as a sport fish. Recently, the Congress has allocated considerable sums for striped bass biological research, probably too late to do much good. If past history repeats itself, the resource will recover before the research produces much new knowledge. The State-Federal Fishery Management Board is putting together a coordinated coastwise research and management program, which may be of benefit if the states can get together on a uniform management program in the face of conflicting pressures. We will have to wait and see whether the past 50 yr have produced any accumulated wisdom that can be applied effectively.

Mullet

Mullet, *Mugil cephalus*, produced maximum landings in 1931 and fell off to low levels thereafter (Figure 19). Mullet may not have caught on as a popular fish in Delaware, and its brief upswing in the early 1930's may have been in response to the depression. There must be additional causes, however, for mullet has not been recorded in commercial catches since the early 1960's.

FIGURE 18.—Commercial landings of striped bass in Delaware, 1880-1977.

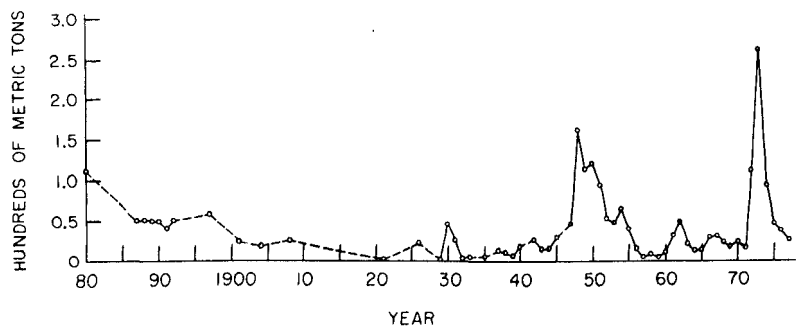
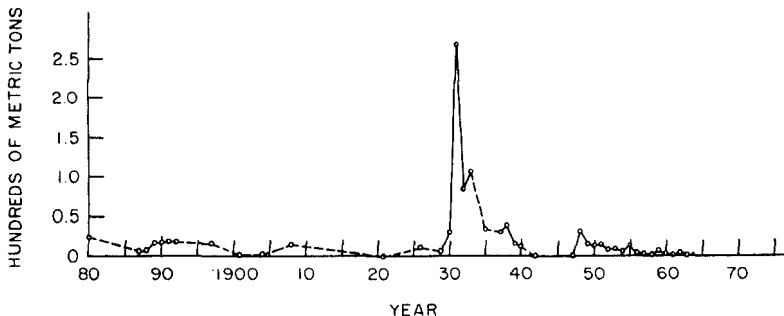


FIGURE 19.—Commercial landings of mullet in Delaware, 1880-1962.



American Eel

American eel, *Anguilla rostrata*, fell off to an all-time low in commercial landings in the 1940's, and since has built up slowly (Figure 20). Although it may have been affected by deterioration of the rivers, it does not spawn there, thus would not be affected as seriously as sturgeon, shad, or alewife. It is probably underexploited, and the recent modest size in landings in the last 30 yr may have been caused by increased markets in Europe and elsewhere.

White Perch

White perch has fallen off rather steadily since the 1880's, with major short rises in production in 1930, late 1940's, and 1958 (Figure 21). These fluctuations were probably caused by temporary upsurges in abundance caused by unusually good year classes. The decline in weakfish production generally has to be related to the decline in commercial fishing. There is no indication that the resource is in poor condition.

FIGURE 20.—Commercial landings of American eel in Delaware, 1880-1977.

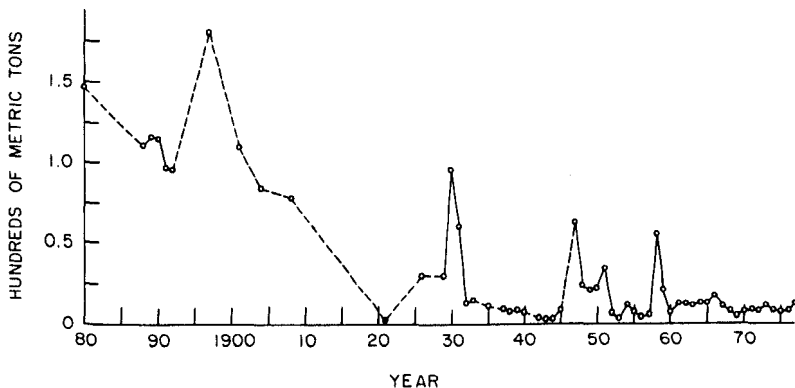
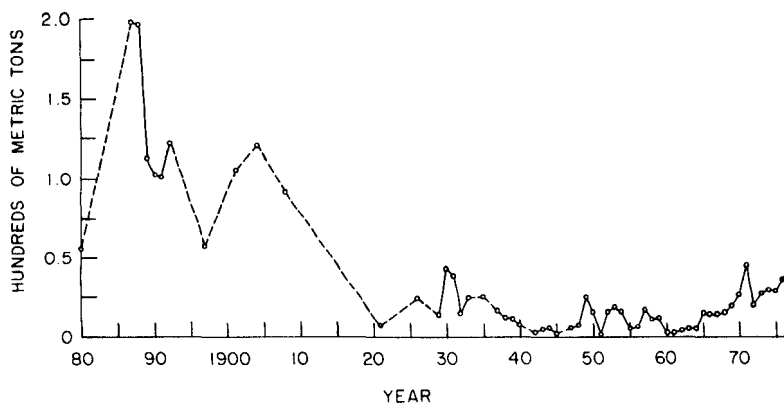


FIGURE 21.—Commercial landings of white perch in Delaware, 1880-1977.

FISHING GEARS

The principal gears used in Delaware were purse seines, gill nets, haul seines, pots, lines, and otter trawls. Except for otter trawls, these were mostly inshore gears, and took sturgeon, shad, alewife, weakfish, croaker, striped bass, and other anadromous or coastal species.

Purse Seines

Purse seines landed by far the greatest amounts of fishes in Delaware. The peak (Figure 22) was reached in 1953 at 165,000 t (somewhat over 360 million lb), the third largest of any state on the Atlantic coast, exceeded only by Virginia and New Jersey. Delaware led the states in menhaden landings in 1944-47, 1949, and 1952 and was second in 1950 and 1958. The fishery peaked temporarily in the 1940's, as did many fisheries toward the end of the war, but major landings were from 1953 to 1962, the decade of prosperity. The fishery collapsed soon after, and the last landings with purse seines were in 1966. Prior to the Second World War, the purse seine fishery was relatively small.

The purse seine fishery was directed at menhaden, and no other fishes were credited to this gear, although very small numbers of other species may have been taken occasionally. The collapse of this fishery was caused primarily by a

reduction in abundance following the 1962 fishing year. The purse seine fishery in Virginia had been increasing in intensity during this period, and by 1963 relatively few fish survived the Virginia and North Carolina fisheries to migrate farther north. The effect was felt at all points north of Chesapeake Bay. Probably the only way of preserving the purse seine fisheries to the north, except on those rare occasions when large year classes or reduction in effort allowed some fish to migrate farther north, would have been to prohibit fishing south of Delaware or to place a minimum size on fishing to the south. Either alternative would be virtually impossible because southern fishermen would be certain to oppose it. The effect of such a law, if it could have been passed before a large industry developed in Chesapeake Bay and southward, would have been interesting to observe. It is possible, although of course not certain, that the decline might not have been as great.

Gill Nets

Four kinds of gill nets have been used in Delaware: drift, stake, anchor, and runaround. Drift gill nets were further broken down at times into shad, sturgeon, and other. For practical purposes, these can be broken down into fixed nets, drift nets, and runaround nets. Generally speaking, drift nets were set in slower waters farther downstream and took large quantities of weakfish and

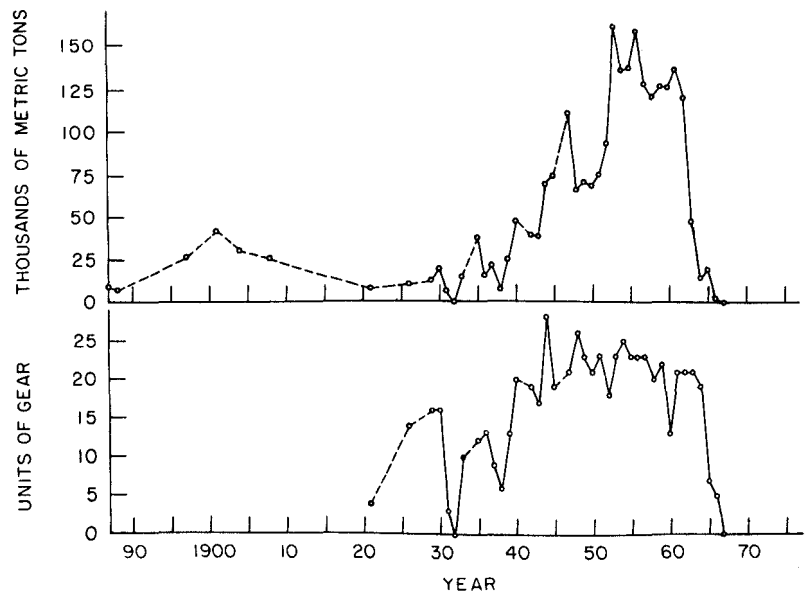


FIGURE 22.—Commercial landings by purse seines in Delaware, 1887-1966, and numbers of units of gear licensed.

croaker, among other fishes. Fixed nets were set for the most part farther upstream and took anadromous and freshwater species. Runaround nets also took mostly marine species, mullet when it was plentiful, but also weakfish, croaker, spot, and other fishes.

Landings from gill nets have declined rather steadily since the 1880's (Figure 23). The numbers of gill nets fell rather sharply to a low in the early 1940's, but have risen slowly since then. In general, numbers of gill nets have paralleled the catch, but whether they have remained about the same size is not known. Recent catches have been somewhat better than usual, as species like weakfish, striped bass, and certain others have shown up in increasing numbers off the coast.

In the beginning the greatest catch was sturgeon, making up >50% of the catch in 1887 and 1888. Sturgeon lost importance as time went on, dropping to seventh in importance by 1926, and was not a major species thereafter. American shad soon became first, but also dropped off fairly early, regaining first place in the mid-1930's, and holding this position almost every year until about 1951. Shad then dropped off again, regained first

place in 1958, and was first until 1965 except for 1 yr. Since then it has fallen off to fourth or fifth place. Alewives ranked third in the early days, then slowly fell off, although in 1932 they ranked first. They are now relatively minor, and in several years in the late 1930's and early 1940's, and from 1958 to 1972, were caught in only 2 yr. Croaker became first in 1926 and retained that rank in most years until after 1945. Weakfish has fluctuated, but in general has increased in abundance, ranking second or third in most years since 1929, although it fell off in the early 1950's and again in the 1960's. In the 1970's it has ranked first most of the time. Striped bass has increased until recently, ranking first or second in 1958, and, except for a period of 5 yr in the late 1950's, has remained first or second until recently.

Other species have been prominent in landings occasionally, but have not remained among the primary species for long. Among these is mullet, first to third from 1931 to 1940, but absent from catches in most years since then. White perch ranked third to fifth until 1904, and did not regain this rank until 1960. Spot was second to fourth from 1939 to 1948, and again from 1952 to 1960,

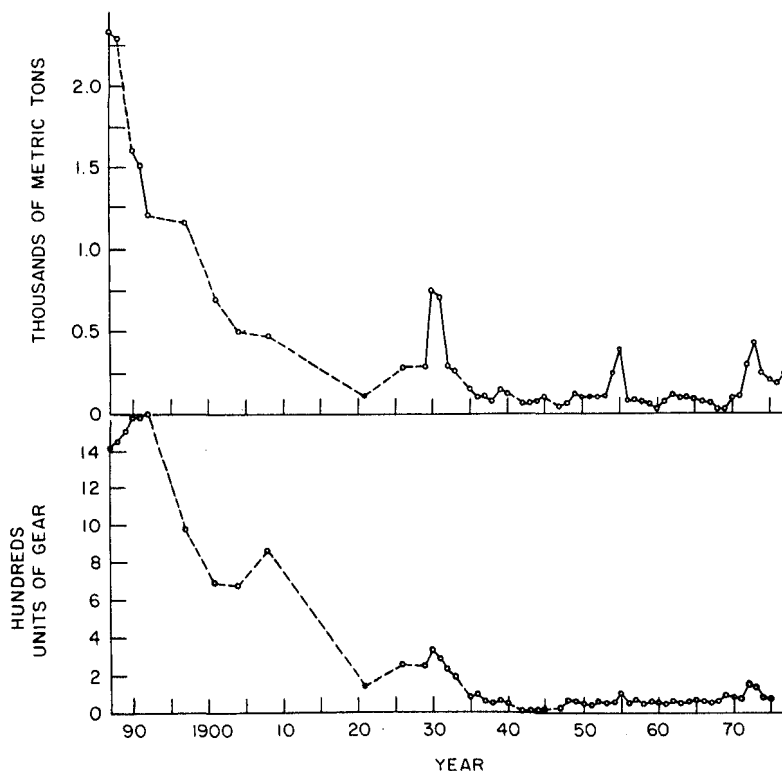


FIGURE 23.—Commercial landings by gill nets in Delaware, 1887-1977, and numbers of units of gear licensed.

even ranking first in 1956 and 1957. During the whole period gill net catches dropped from 22,700 t (>5 million lb) in 1887 to 45 t (<100,000 lb) in 1960, 1968, and 1969, then rose to 450 t (almost 1 million lb) in 1973. For most of the period, shad, weakfish, striped bass, and croaker, all relatively high-priced fishes, kept the fishery going, although until very recently, with decreasing numbers of fishes. It is difficult to escape the fact that the declining supply of weakfish was the primary reason for the decline of the gill net fisheries (Figure 11).

Haul Seines

Haul seines were a fairly important gear in the early days, reaching peak landings of 2,000 t (>4.4 million lb) in 1930 (Figure 24), but slowly and somewhat irregularly declining in production until the last net ceased operating in 1971 after landing <0.5 t (only 1,000 lb) of fishes. Weakfish again was the most important species most of the time, being exceeded by alewives in 1897, and in 1930 to 1933 inclusive. It is clear that weakfish was the mainstay of the haul seine fishery, and when it was gone the fishery did not survive for long. Haul-seining, however, has always been a

part-time operation in spring according to Daiber (footnote 4).

Croaker also was important for a time, especially in 1926, 1929, and 1930, 1935 to 1942, 1945, 1955, and 1957. Shad was important from 1887 to 1904, white perch from 1887 to 1908. Striped bass was important in the 1880's and 1890's, showed up again from 1942 to 1951; common carp, *Cyprinus carpio*, was fairly important in 1897 to 1930, again in 1935 and 1950, 1951, and 1957; spot was important in 1926 and 1942; and mullet in 1948.

Pots

Pots were used for various species in Delaware, primarily for American eel, lobster, and blue crab. Later, considerable quantities of sea bass and conch, *Busycon* sp., were taken. Most of the catch, however, was blue crab, which peaked in 1957 and in 1975 (Figure 25). Obviously this fluctuation in blue crab abundance was real, dropping from 1,450 t (about 3.2 million lb) in 1957 to 110 t (<250,000 lb) in 1968, then climbing rather rapidly to 1,632 t (nearly 3.6 million lb) by 1975. This is the largest fishery in Delaware at present, but it is unlikely, in view of the variable nature of the resource, to remain high for long. Being near

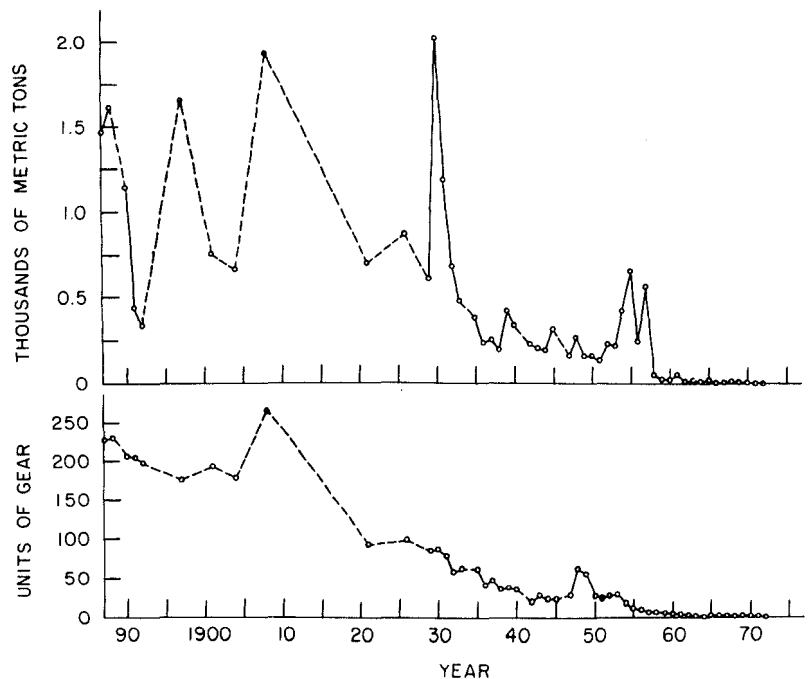


FIGURE 24.—Commercial landings by haul seines in Delaware, 1887-1971, and numbers of units of gear licensed.

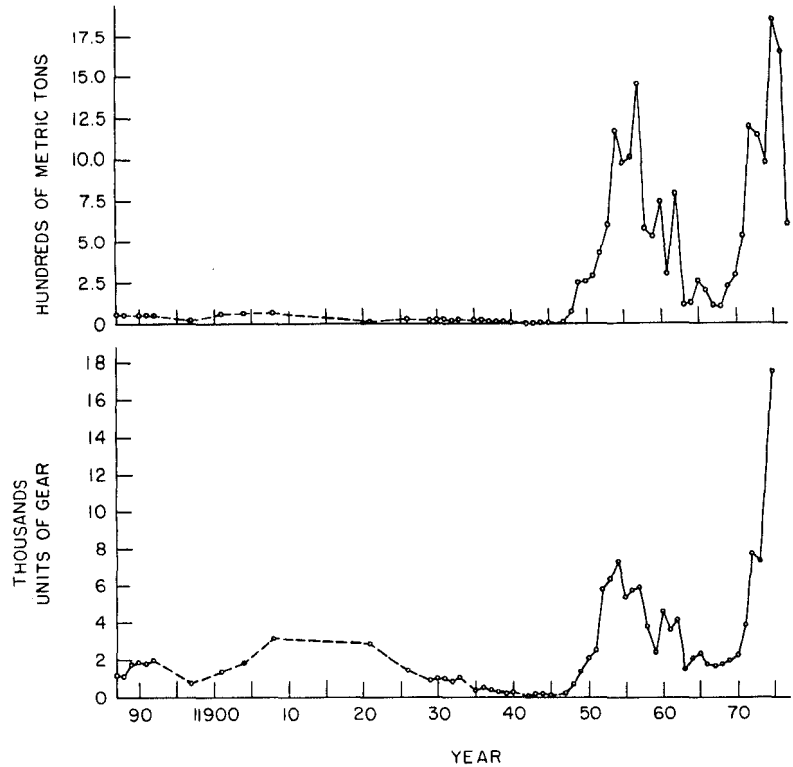


FIGURE 25.—Commercial landings by pots in Delaware, 1887-1977, and numbers of units of gear licensed.

the northern limit of its usual range, the blue crab is likely to be variable in abundance in Delaware.

Lines

Various kinds of line also were fished in Delaware from time to time. In addition to handlines, trawl lines, trotlines with baits, and longlines with hooks have been fished from time to time. From 1887 to 1926 inclusive, the kinds of line were not specified. In all years but one, however, weakfish was the largest catch. In 1926 crab made up about 85% of the catch, probably on trotlines with baits. From 1929 on, weakfish was an important, but variable component of the catch; tautog, *Tautoga onitis*, was important for a few years in the early 1930's; and croaker was an important, but variable component of the catch from 1930 to 1944. Striped bass was important from 1943 to 1945 and rose to first or second in rank in the 1970's. Trawl lines and later trotlines with hooks took almost exclusively cod, the first from 1929 to 1944, the second from 1960 to 1971. Trotlines with baits took blue crab in 1929, 1935, 1939 to 1951, and 1955 to 1960. Handlines were the only ones that have

persisted, and their catches were almost entirely weakfish and striped bass in the 1970's (Figure 26). Once again, weakfish appears to have been the mainstay of the handline fishery.

Otter Trawl

The otter trawl fishery was relatively short lived in Delaware. It began in 1935, did not make catches again until 1940, reached its peak in 1948, and was over at the end of the 1966 season (Figure 27). It was an inshore fishery for the most part, taking mostly weakfish, summer flounder, scup, white perch, croaker, red hake, spot, butterfish, silver hake, striped bass, and squids. Over half the accumulated catch was weakfish, which substantiates the importance of this species to the fisheries of Delaware. The other main species, in the sense that they supported the fishery to the end, were summer flounder, butterfish, and striped bass. In the 1960's, recreational fishermen found an old law that prohibited trawling in Delaware Bay and put on pressure to enforce it. As already mentioned, this, with the decline in weakfish, was the final blow to the trawl fishery.

FIGURE 26.—Commercial landings by lines in Delaware, 1887-1977, and numbers of units of gear licensed.

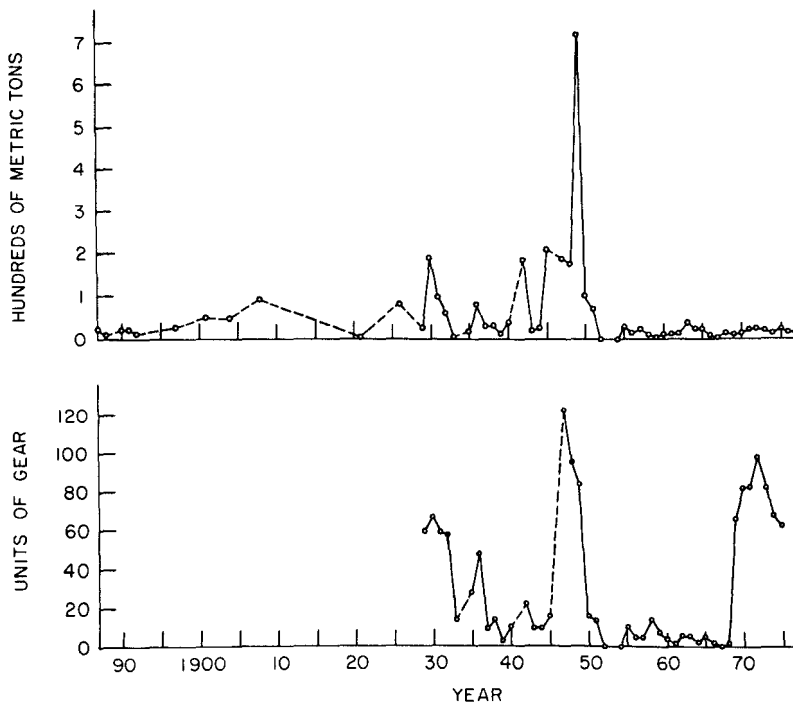
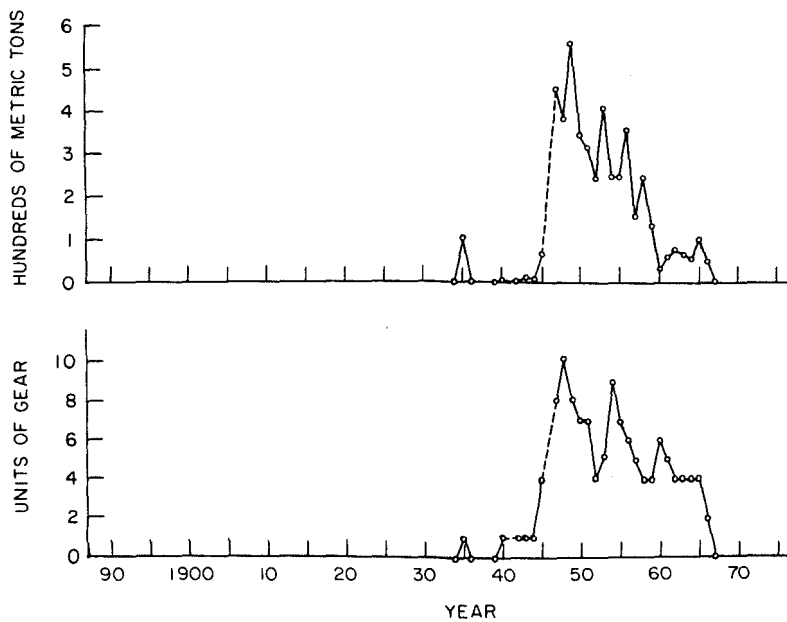


FIGURE 27.—Commercial landings by otter trawls in Delaware, 1935-66, and numbers of units of gear licensed.



Pound Net

Pound nets were not as important in Delaware as they were along most of the coast. They were used in Delaware mostly to catch horseshoe crab for manufacture into meal (Figure 28). Only 13.5% of the catch was fishes, and these were mostly alewife, white perch, carp, and catfish or bullheads (Family Ictaluridae). When horseshoe crab was no longer taken, pound nets quickly ceased

operation. The last net was fished in 1938. In 1956 and 1957 pound nets were set again, but the catch was insignificant.

Oyster Dredges

Dredges were the main gear used to harvest oysters in Delaware, and they apparently took fair numbers prior to 1929 (Figure 29). There followed about a 15-yr period in which the catch was very

FIGURE 28.—Commercial landings by pound nets in Delaware, 1887-1957, and numbers of units of gear licensed.

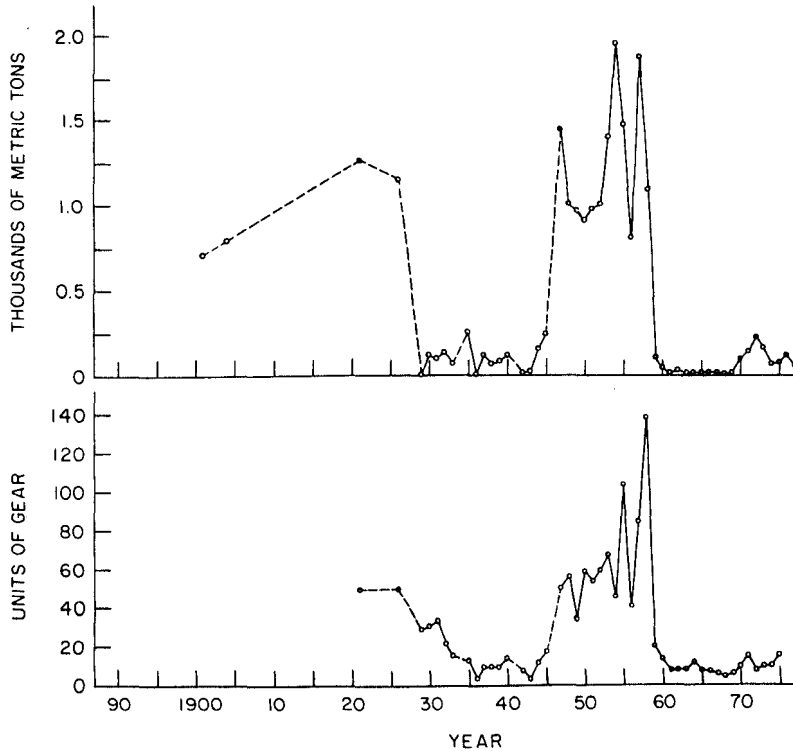
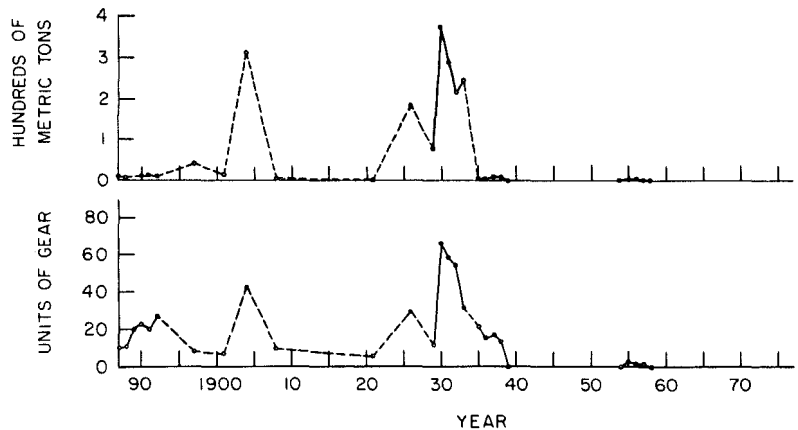


FIGURE 29.—Commercial landings by oyster dredges in Delaware, 1901-77, and numbers of units of gear licensed.

low, followed by the decade 1947 to 1958 when the industry was at its peak. After 1958 the industry almost collapsed, and it has not recovered. The harvest of oyster by tongs was much smaller, but somewhat similar through 1947. After 1947 there was no resurgence.

Maurer et al. (1971) made a survey of the oyster industry in Delaware Bay in 1968 and 1969. They found that Delaware Bay beds were badly depleted, but certain rivers in the vicinity showed potential as seed areas. One planted bed showed promise, suggesting that with proper management Delaware Bay could be rehabilitated and again produce oysters. The incidence of *Minchinia nelsoni* probably always was lower in the rivers than in the bay, and incidence on Delaware Bay beds was not as high as in the mid-1960's.

The hoped for increase had not occurred up to 1978, suggesting that no one was willing to take the risks, or had tried and failed. The present poor condition of oyster beds in Delaware Bay is caused by *M. nelsoni*, aggravated by general degradation of the environment. It is possible, but not certain, that with proper care the grounds could be restored to production.

Clam Dredges

Dredges were used to harvest hard clam and surf clam in Delaware. The first hard clam taken

by dredge was recorded in 1901, but substantial numbers were not taken until 1929, when 360 t (nearly 800,000 lb) were caught (Figure 30). Catches dropped to much lower levels in 1931 and 1932, and remained fairly low until after the Second World War. This probably was at least partly caused by stabilization of Indian River Inlet, which raised the salinity in the Delaware Bay, and proved favorable for hard clam. Landings have been quite variable since, and the last hard clam listed as taken by this gear was in 1969.

Another short-lived fishery was dredging for surf clam, which began in 1956 and produced moderate catches until 1962, then ceased. Landings again were reported in 1969, peaked at 3,800 t (>8 million lb) in 1970, remained fairly high until 1974, but ceased in 1976. The fluctuations largely reflected where the boats were operating, as discussed earlier in the surf clam section.

Crab Dredges

Blue crab was first recorded as caught by dredges in Delaware in 1932. Catches were relatively small until the 1950's, when 1,700 t (>3.5 million lb) were recorded in 1950 and 1951 (Figure 31). Catches then dropped sharply, peaked again in 1957 at 770 t (about 1.7 million lb), and dropped to a very low level from 1964 to 1973, after which they picked up again but at a lower level.

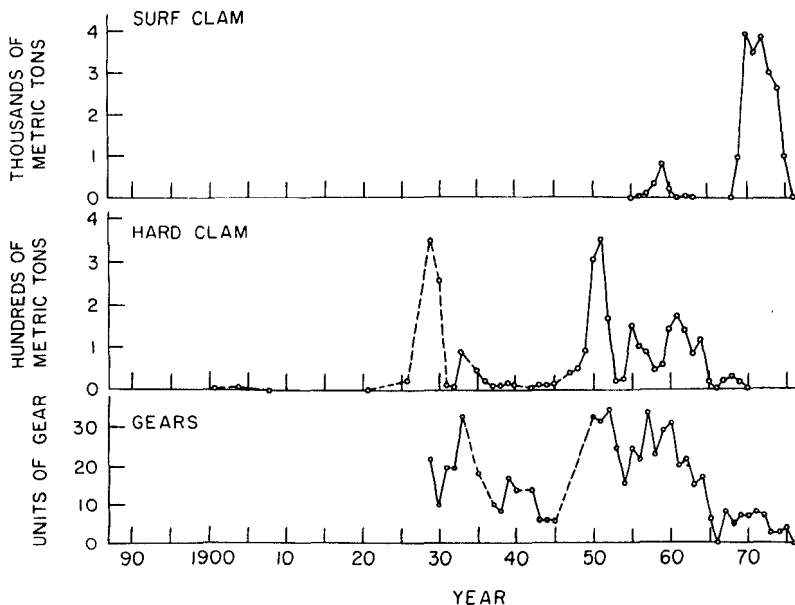


FIGURE 30.—Commercial landings by hard clam dredges in Delaware, 1901-69, and by surf clam dredges 1956-75, and numbers of units of gear licensed.

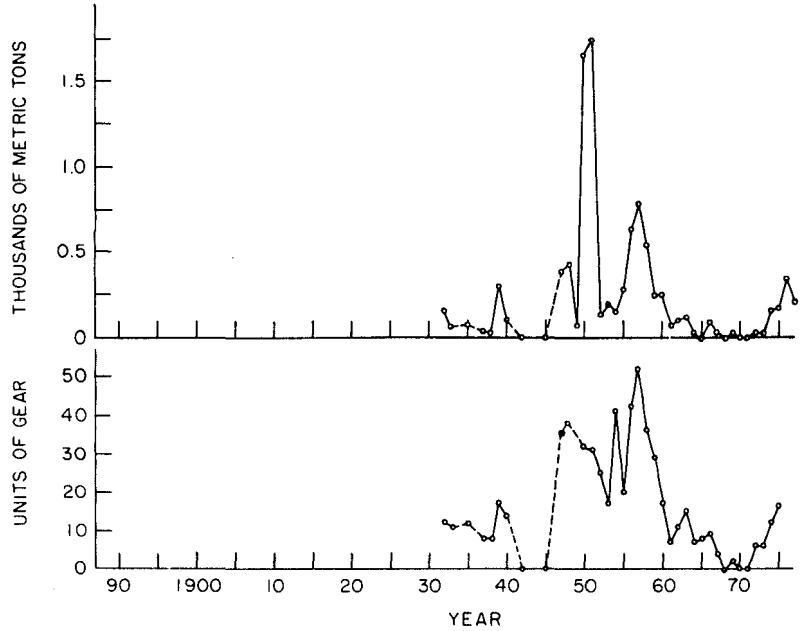


FIGURE 31.—Commercial landings by crab dredges in Delaware, 1932-77, and numbers of units of gear licensed.

Blue crab is highly variable in abundance in Delaware, and can not be expected to support a steady fishery.

Fyke Nets

Fyke nets were much more important in Delaware in the early days, reaching a low point in 1947, and fluctuating, more or less according to the abundance of fishes later (Figure 32). A low point in landings was reached in the 1940's,

followed by peaks in 1955, 1964, and 1977, each at lower levels. Species composition of the catch has varied—catfish; white perch; American eel; sea bass; striped bass; alewife; flounders; yellow perch, *Perca flavescens*; and turtles making up most of the catch at various times.

Rakes

Most of the catch by rakes has been hard clam. Catches were insignificant in 1929 and 1930, and

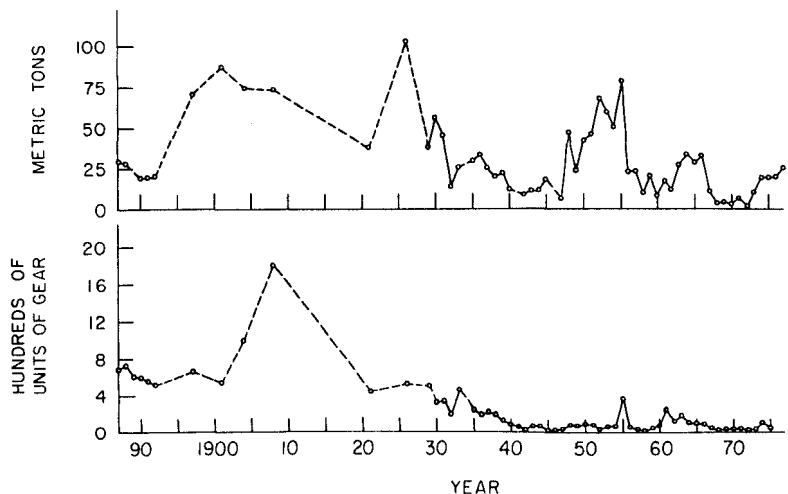


FIGURE 32.—Commercial landings by fyke nets in Delaware, 1887-1977, and numbers of units of gear licensed.

harvesting did not begin again until 1948 (Figure 33). Catches rose to a peak in 1953 at 215 t (about 474,000 lb), fell off to almost nothing by 1955, followed by an all-time high in 1956 of >300 t (683,000 lb). Subsequently, they have fallen off to 9 t (<20,000 lb) by 1977.

CONCLUSIONS

This history of the Delaware fisheries illustrates clearly the transient nature of marine resources generally in the Middle Atlantic Bight region, especially when effective controls on fishing are lacking. All of the major species in the region, with the possible exception of surf clam, are freshwater, anadromous, or coastal migratory species, and all have shown major fluctuations in abundance or availability. All are much less abundant in the region than formerly, and in nearly every case this can be attributed to overfishing. This, and the great variability in the supply of many of the major species, has led to a decline in the commercial fisheries, and a gradual takeover by recreational fishermen. Several major fisheries, e.g., purse seine, surf clam dredge, haul seine, otter trawl, and pound net fisheries, have ceased altogether.

Degradation of the coastal environment also has taken a toll, although this cannot be documented clearly. However, it is fairly clear that dams and pollution of coastal streams have affected spawning of anadromous species, and these have suffered most. Mitigation of pollution and clearing of obstructions from waterways should improve the situation.

The future is uncertain. Many of the species cannot be helped very much unless cooperation with other states is improved. This is underway through the State-Federal Fishery Management Board, but it is too early yet to tell how much this will improve the situation. Menhaden is unlikely to come back unless effective steps can be taken to increase mesh size or otherwise reduce the catch of small fishes in Virginia and North Carolina. Even if that unlikely alternative is accomplished, it probably would be difficult or impossible to reestablish a reduction plant because environmental laws in Delaware would prevent it. Weakfish was the principal mainstay of the food fish industries in Delaware, and its present value to recreational fishermen in the State makes it unlikely that a commercial fishery will start again. The other species are even less likely to support major commercial fisheries.

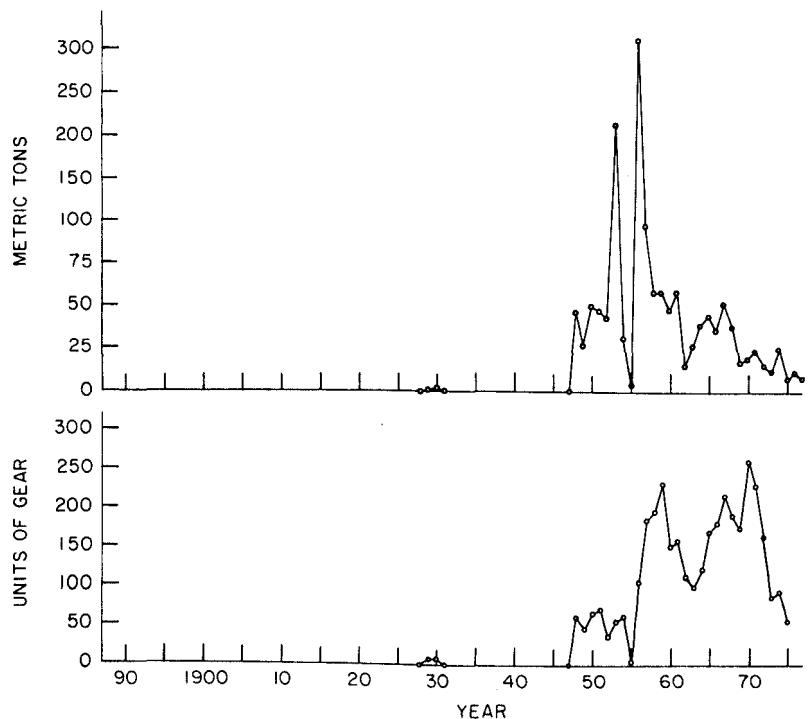


FIGURE 33.—Commercial landings by rakes in Delaware, 1929-77, and numbers of units of gear licensed.

The remaining species are shellfishes, mainly surf clam, blue crab, American oyster, and hard clam. The future of the surf clam resource will depend upon how successful the Mid-Atlantic Council can be in developing adequate enforcement measures, and on the ability of the states to develop parallel management plans. Blue crab will probably continue to be highly variable in production, but should be able to support a fairly prosperous fishery at times. Oysters might be able to come back from their present reduced level if adequate attention is paid to modern methods of culture. Hard clam probably can support a modest fishery if the environment of the coastal bays can be preserved and enhanced.

As a whole, it appears that the commercial fisheries of Delaware will remain small, and that they will be largely shellfisheries. Recreational fishing probably will continue to take increasing numbers of the total catch of finfishes. Whether the recreational fisheries can be managed to maintain the yield will depend upon how the states can cope with this problem.

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