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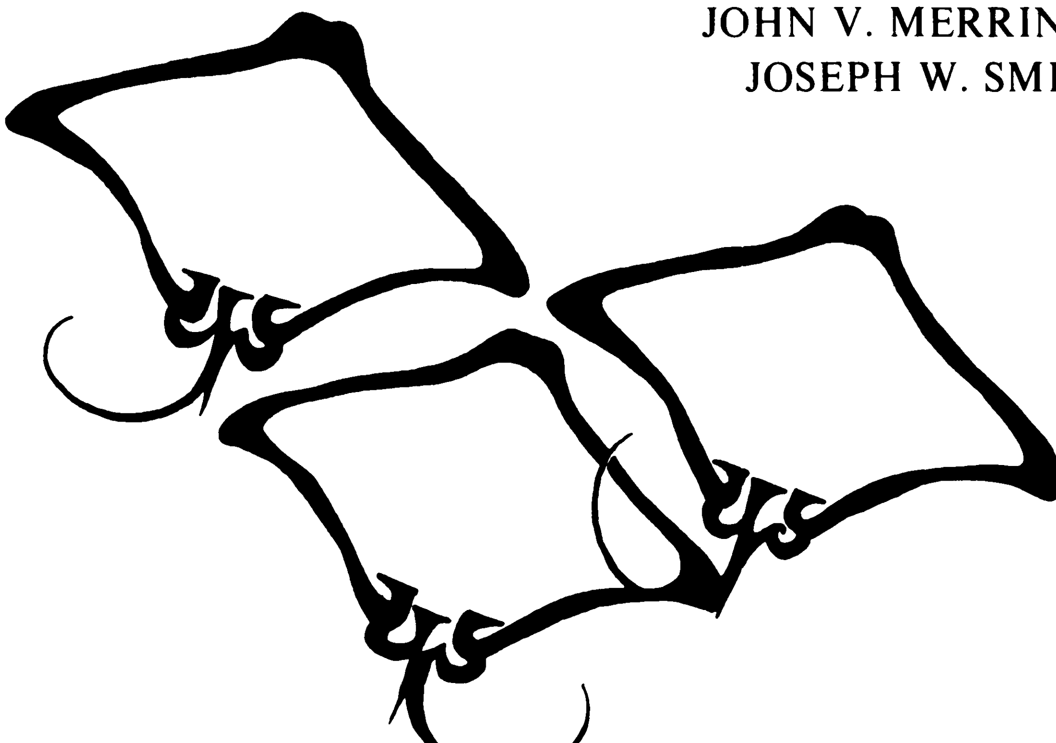
A REPORT TO THE OYSTER INDUSTRY OF VIRGINIA ON THE BIOLOGY AND MANAGEMENT OF THE COWNOSE RAY

(Rhinoptera bonasus, Mitchill)

IN LOWER CHESAPEAKE BAY

JOHN V. MERRINER
JOSEPH W. SMITH



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SPECIAL REPORT IN APPLIED MARINE SCIENCE AND OCEAN ENGINEERING NO. 216

AUGUST 1979

A REPORT TO THE OYSTER INDUSTRY OF VIRGINIA ON THE BIOLOGY AND MANAGEMENT OF THE COWNOSE RAY *(Rhinoptera bonasus,* Mitchill) IN LOWER CHESAPEAKE BAY

JOHN V. MERRINER AND JOSEPH W. SMITH

SPECIAL REPORT IN APPLIED MARINE SCIENCE AND
OCEAN ENGINEERING NO. 216, AUGUST, 1979

VIRGINIA INSTITUTE OF MARINE SCIENCE
AND
SCHOOL OF MARINE SCIENCE
COLLEGE OF WILLIAM AND MARY
GLOUCESTER POINT, VA 23062

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TABLE OF CONTENTS

INTRODUCTION

In recent years (1972-1977) several Rappahannock River oyster growers reported substantial losses to seed and harvestable beds due to cownose ray predation. In spring 1975, eight major Virginia oyster growers solicited aid in the form of control measures to reduce ray predation. VIMS Advisory Service contacts indicated that the problem was a recurrent one in many areas and the ray population appeared to be increasing in the past decade.

Concurrently, feeding cownose rays were observed to have a detrimental impact on eelgrass (*Zostera marina*) beds (Orth 1975). The destruction of eelgrass habitat by rays is often considerable, resulting in reduced biological productivity of shoal areas, reduced sediment stability and localized erosion (Orth 1975 and 1976).

Several previous authors have reported accounts of cownose ray predation on commercially important shellfish stocks. As early as 1815, Mitchill (1815) noted that cownose rays "are detested by the people who live near the shores, by reason of the damage they do the clams [*Mya arenaria*]". Smith (1907) reported that cownose rays prefer razor clams and oysters, while Wallace et al. (1965) listed the cownose as a serious summertime predator of soft clams (*Mya arenaria*) stocks in Chesapeake Bay. Recently, Otwell and Crow (1977) recorded the destruction of valuable bay scallop (*Aequipecten irradians*) beds by cownose rays in North Carolina.

Accounts of commercial shellfish predations by other species of rays also exist. The Javanese cownose ray (*Rhinoptera javanica*) has been cited in the destruction of valuable pearl oyster beds in the Indian Ocean (Shipley and Hornell 1906). Coles (1910) pointed out the voracity with which the spotted eagle ray (*Aetobatis narinari*) attacks planted clam beds. The bat ray (*Myliobatis californica*) has menaced the California oyster industry (Walford 1935; Barrett 1963).

The purpose of this report is to: (1) suggest reasons for the recently observed cownose ray predation on Rappahannock River oyster beds and the apparent increased abundance of the ray, and (2) recommend short- and long-term methods to control and/or manage cownose ray predation on commercially important shellfish beds.

Cownose Ray Life History

The following is a brief summary of cownose ray (*Rhinoptera bonasus*) life history in the lower Chesapeake Bay as compiled by Smith (in preparation).

Massive schools of up to several thousand *Rhinoptera bonasus* arrive near the Cape Lookout, N.C. area in early to mid-April when nearshore water temperatures have risen to 15-16°C. The spring migrants school by size, adults versus juveniles. Schools enter Chesapeake Bay by early May via the Virginia-North Carolina coastline and bayside Eastern Shore. Initial movement in the Bay appears to be north and westward. A gradual upriver penetration occurs on the western shore of the Bay throughout May. By early June, schools have reached Claybank on the York River, Towles Point on the Rappahannock River and the mouth of the Yeocomico River on the Potomac River. By this time the massive schools of rays sighted in the spring have fragmented into schools of no greater than several hundred individuals. The furthest upriver penetration noted during this investigation was Claybank on the York, Bowler's Wharf on the Rappahannock and Kingcopsico Point on the Potomac. Decreased freshwater runoff during the summer months may allow further upriver penetration.

Adult males average 89 cm (35 inches) in disc width and weigh 11.8 kg (26 lbs.). They mature at 80-84 cm (32-33 inches) wide. The largest male collected during the study measured 98 cm (39 inches) wide and 16.2 kg (36 lbs.).

Adult females are somewhat larger, averaging 96 cm (38 inches) wide and 15.5 kg (34 lbs.) They are mature at about 90 cm (35 inches) across the disc. The largest female taken measured 107 cm (42 inches) wide and 22.8 kg (50 lbs.).

The young are born from late June through early July and measure about 40 cm (15 inches) wide at birth. One full term embryo per gravid female appears to be the rule in _R. bonasus_. The gestation of another brood of young begins by early August. Gravid females depart the Bay in the fall with relatively large embryos.

Size segregation continues throughout the summer months, with adult cownose rays schooling by sex. By early August, adult males appear to vacate the river systems of the western shore of the Bay. Gravid females continue to occupy these areas for the remainder of the summer.

Adult males appear to leave the Bay first, followed by the adult females in late September to early October. The exit route appears to be the high salinity waters of bayside Eastern Shore. The smaller _R. bonasus_ seem to tolerate cooler autumnal water temperatures and remain in the Bay through October. The fall migration to the south is not as closely associated with the coastline as was the spring movement.

Analysis of stomach contents indicate the soft clam, _Mya arenaria_, is the preferred food item of _R. bonasus_ in the river systems. The cownose diet in these areas also includes _Macoma spp._, _Tagelus plebeius_, _Crassostrea virginica_, _Mercenaria mercenaria_, _Modiolus demissus_ and _Mulinia lateralis_. Rays collected along the Eastern Shore consumed _Mytilus edulis_ and _Ensis directus_. Specimens taken near Cape Lookout in April fed on bay scallops, _Aequipecten irradians_ (W. S. Otwell, personal communication).

Feeding schools exhibit a shoalward or nearshore movement with the rising tide and retreat during the second half of the ebb tide. Infaunal shellfish are mined by rapid movements of the pectoral fins and protrusion and suction of the mouth parts. While feeding in shallow water the rays' angular tips of the pectoral fins may break the surface of the water, often resulting in shark scares.

Evidence Suggesting an Increase in the Cownose Ray Population

Elasmobranch populations are particularly susceptible to the effects of an intense fishery. Generally, they have a slow growth rate and low fecundity, hence recruitment cannot keep pace with a high rate of exploitation (Holden 1974). Historically, initial exploitation is followed by a rapid decline in catch rate or total collapse of the fishery (Holden 1974). Outstanding examples include fisheries for the soupfin shark, *Galeorhinus zyopterus*, along the West Coast of the U.S. (Ripley 1946), the Australian school shark, *Galeorhinus australis*, (Olsen 1954), the Pacific Northwest stocks of spiny dogfish, *Squalus acanthias* (Alverson and Stansby 1963), the basking shark, *Cetorhinus maximus* (Parker and Stott 1965) and the Scottish-Norwegian stocks of *S. acanthias* (Holden 1968).

Elasmobranch life histories are not conducive to a rapid build-up of the stock once fishing pressure is decreased. However, a gradual increase in abundance of *S. acanthias* has been reported following the cessation of an intense fishery in the Pacific Northwest during the 1940's (Alverson and Stansby 1963). *R. bonasus* fits the mold of the typical elasmobranch stocks. It is a slow grower with low fecundity (Smith, in prep.).

Traditionally, rays have had little or no commercial value in Chesapeake Bay. They are generally considered nuisances and culled from the catch; hence, landings data are not available. Scant citations in the literature suggest *R. bonasus* was not as abundant in the Bay during the first half of the century as during the past two decades. Hildebrand and Schroeder (1928) considered it a "very rare" visitor to the Bay. Bayliff (1951) reported his specimen a record for the upper Bay (Solomons, Md.), although locals considered it common. Joseph (1961), citing pound net catches of 330 and 600 specimens, indicated that cownose rays were present in the lower Bay "in unusual numbers" during the spring and summer of 1960. Local fishermen polled at the time could not "recall such concentrations in the past." Schwartz (1965) noted that huge flotillas of R. bonasus annually invade the upper Bay, while Musick (1972) recently listed the cownose as abundant to common in the upper and lower Bay during the summer.

During this investigation all licensed pound net and haul seine fishermen in Virginia were polled via a postcard questionnaire and requested to comment (among other requests) on the abundance of R. bonasus in their catches over the past 10 years. A moderate return rate was obtained (21%). A total of 54% (n = 15) of the respondents reported R. bonasus numbers were increasing, 7% (n = 2) noted a decrease in abundance, while 39% (n = 11) reported their catches remained steady. Our observations of commercial catches during this study suggest that R. bonasus is presently the most abundant elasmobranch which occurs throughout the Bay during the summer months.

The population estimates above are highly subjective. Nevertheless, it is hypothesized that the recent apparent abundance of R. bonasus may be due to the decline in numbers of commercial haul seine and pound net fishing rigs in Chesapeake Bay and vicinity over the past 50 years.

While in the Bay, R. bonasus are found in compact schools of several to several hundred rays. Feeding schools invade shoal waters at high tide. Due to this shallow water distribution, they are particularly vulnerable to the principal fishing gears used in the Bay, i.e. haul seines and pound nets. The former are fished in waters not exceeding 8 feet (2.4 m) at near low water (Code of Virginia 1974). Pound nets are generally constructed such that the head (fish retaining section) is situated in deep water or near the edge of a channel, while the hedging extends towards shallow water and/or perpendicular to the shoreline (Reid 1955). Fishes deflected by the hedging are funneled into the head. Fishermen generally cull rays overboard with pitchforks or other sharp implements. Death or gross infection surely ensues. Haul seiners often leave the rays to expire on the beach.

Pound nets were introduced into Chesapeake Bay in 1870. By 1880, 162 rigs were in operation in Virginia (Reid 1955). Virginia pound net numbers peaked at 2,262 in 1930, while high number for the Bay was 2,970 during the previous year (Figure 1). Total number of nets remained above 2,000 until 1948 when a precipitous decline began. A scant 574 nets were licensed in 1974. Likewise, the total number of haul seines in the Bay peaked during the late 1940's at about 600 and has since dropped to 164 in 1974 (Figure 2).

It seems reasonable to suggest that the decline in numbers of commercial fishing rigs in Chesapeake Bay and vicinity over the past 50 years has reduced the mortality of the *R. bonasus* stock due to fishing. There has been a concurrent oceanic warming trend over the last 30 years which could have resulted in migration of a greater proportion of the cownose ray population northward into the Chesapeake Bay. Consequently, a gradual build-up of the population is proposed.

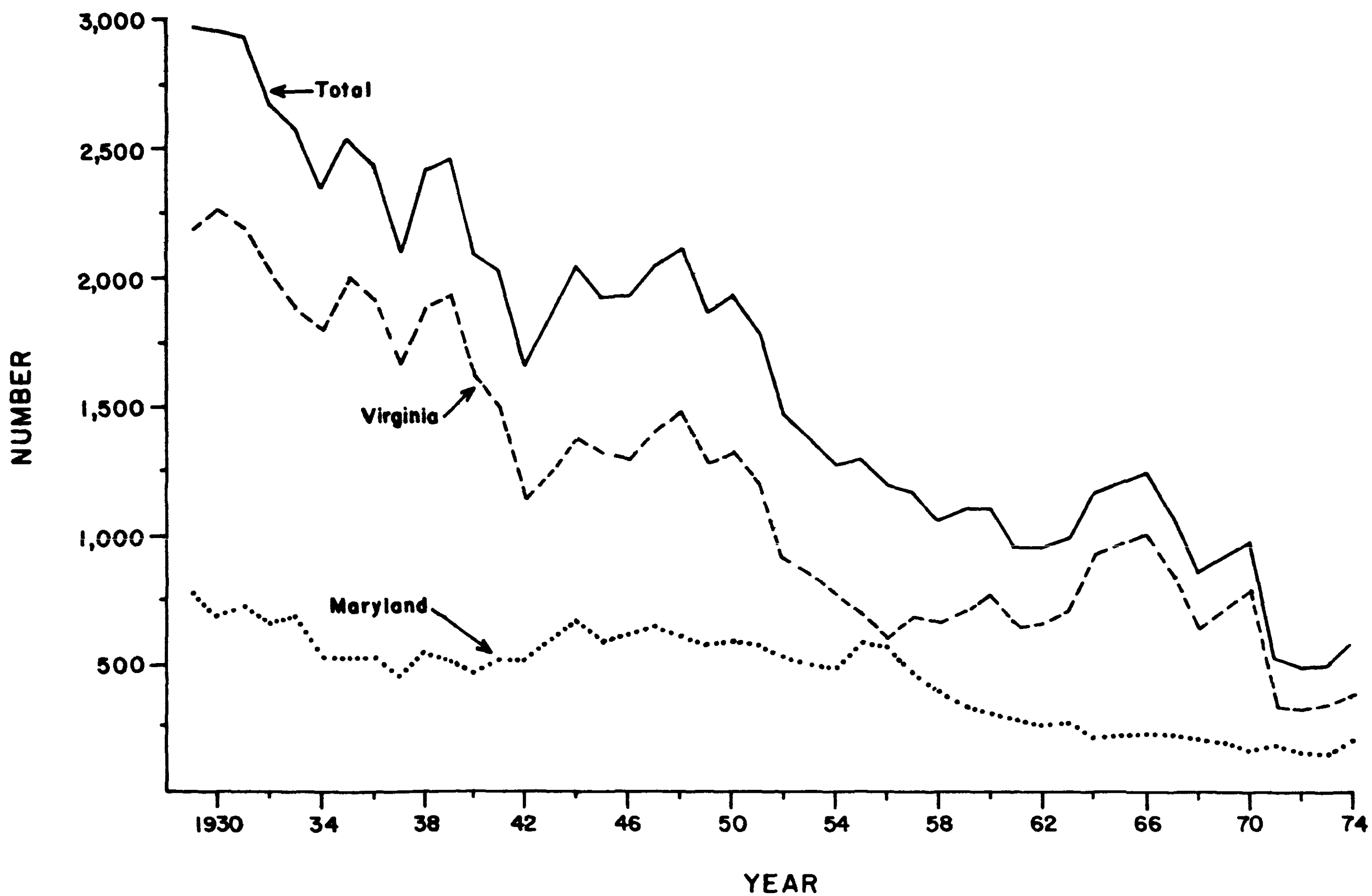


Figure 1. Number of licensed pound nets in Virginia and Maryland, 1929-1974 (From: U. S. Fisheries Statistics).

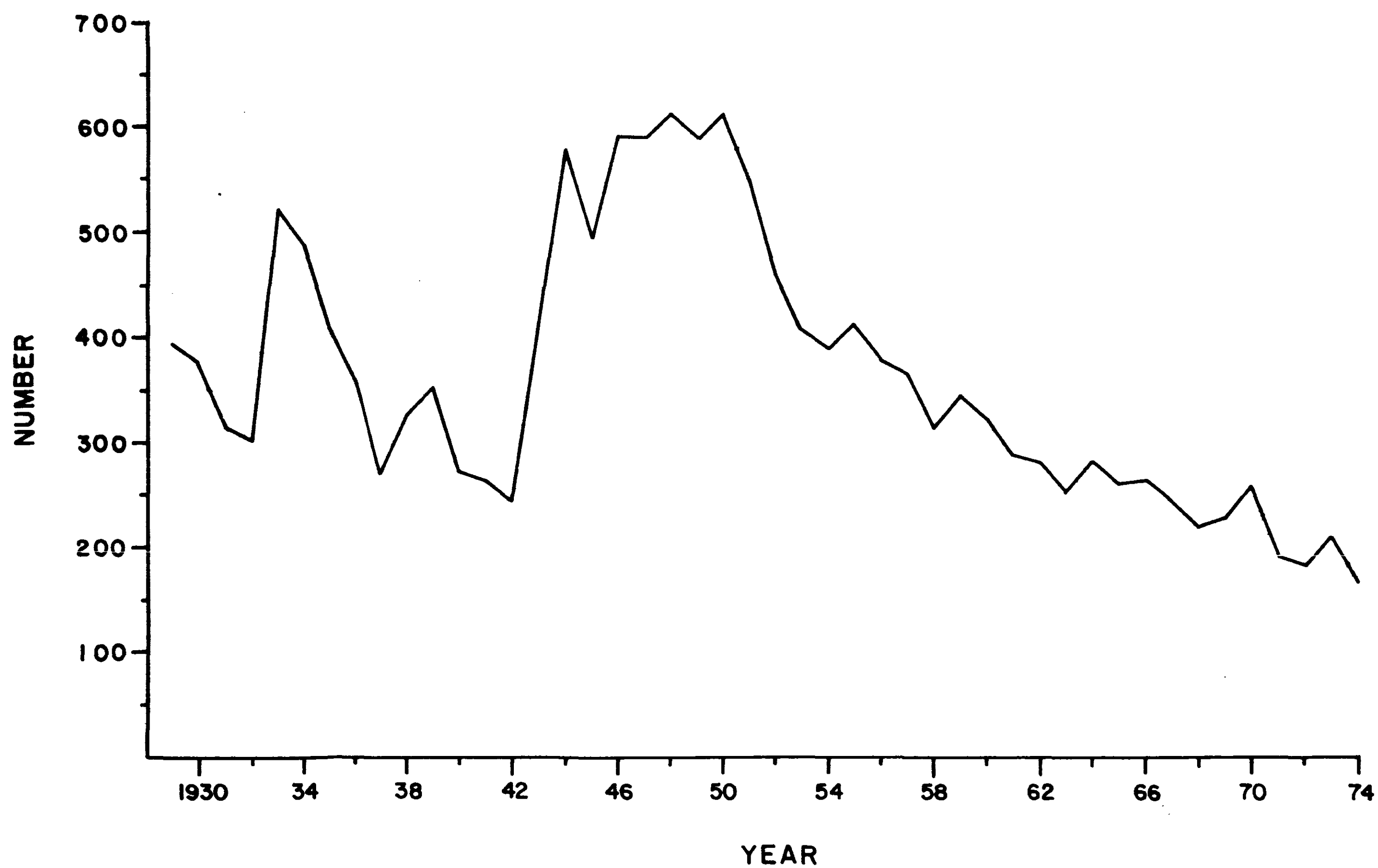


Figure 2. Total number of licensed haul seines in Virginia and Maryland, 1929-1974 (From: U. S. Fisheries Statistics).

Reasons for the Recently Observed Predation on Rappahannock River Oysters

Results of our investigation indicate that the soft clam, *Mya arenaria*, is the preferred food of *R. bonasus* in the river systems of Chesapeake Bay. Other investigators have also noted the ray's preference for *Mya* (Mitchill 1815; Bigelow and Schroeder 1953; Wallace et al. 1965; Orth 1975).

The soft clam fishery in Chesapeake Bay is a recent development. Since its inception in 1953, Maryland landings have been the mainstay of the total harvest, although Virginia landings were significant in 1965 and 1966 (Figure 3). During the late 1960's, commercial quantities of *Mya* were identified in the upper and lower Rappahannock, but their distribution was discontinuous (Haven 1970). Following the passage of Tropical Storm Agnes in June 1972, however, it was estimated that 90% of the Bay's *Mya* stocks perished due to the combined stress of low salinities (freshwater runoff) and high water temperatures (Haven et al. 1976). The report indicates soft-shell clams were destroyed in the Rappahannock River, but survived in the York River and in Chesapeake Bay between these two rivers, and also on the eastern shore of Maryland. Presumably, *Tagelus*, *Macoma spp.*, and *Mulinia* populations were also affected by Agnes.

The scant commercial *Mya* landings in 1973-1976 (Figure 3) reflect the impact of Tropical Storm Agnes. A recurrent mid-summer, low dissolved oxygen problem in Maryland also depressed landings (U.S. Fishery Statistics 1970). It is suspected that in the past 2-3 years (1975-1978), *Mya* have again become abundant in the Rappahannock River (Rappahannock River oyster growers and D. Haven, personal communications).

Concurrent with the demise of the Bay's *Mya* stocks has been the decline of Virginia's oyster industry. Haven et al. (1978) recently

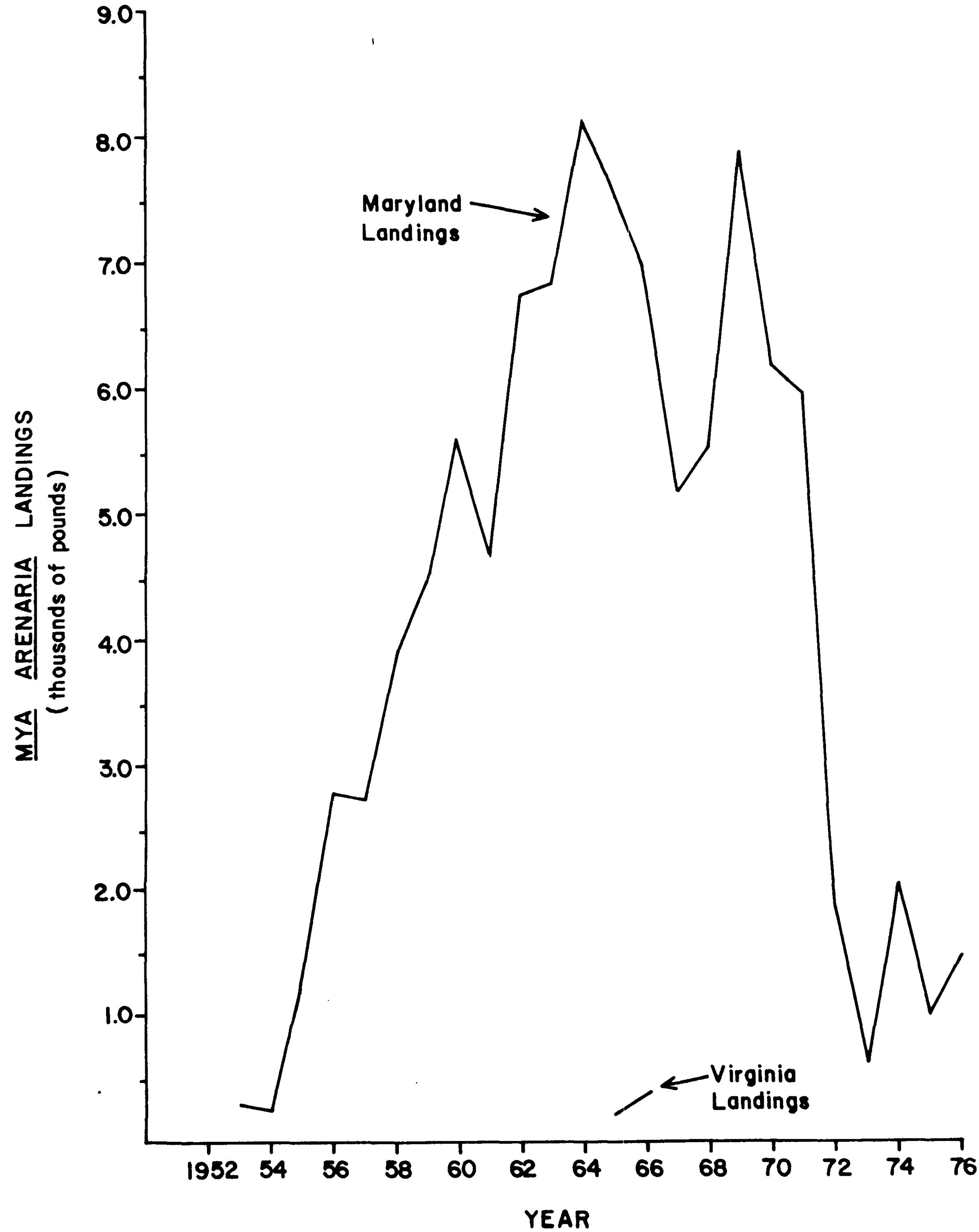


Figure 3. Maryland and Virginia *Mya arenaria* landings, 1953-1976 (1976 landings Jan.-Nov.) (From: U. S. Fisheries Statistics).

completed a long-term review of this fishery. After a harvest of 3.5 million bushels in 1954, a precipitous decline in production occurred, and in 1975 only about 0.9 million bushels were landed. One of the principal agents responsible for the decline has been the oyster pathogen, Minchinia nelsoni (MSX), which became apparent in Chesapeake Bay about 1959. The disease killed most of the oysters in the high salinity waters of the Bay. Its effects, however, decrease where mean salinities fall below 15 o/oo and it is virtually absent in salinities below 12 o/oo. Predators such as the oyster drills, Urosalpinx cinerea and Eupleura caudata, and the fungus, Dermocystidium marinum have also abetted the decline. Similar to MSX, however, the effects of these organisms are only felt where mean salinities are above 12-15 o/oo. The present policy of Rappahannock River oyster growers is to plant only in low salinity waters where those pathogens and predators noted above are not viable (D. Haven, personal communication).

Together with the apparent increase in R. bonasus numbers, it is suggested that the recently observed cownose ray predation on private oyster beds in the Rappahannock River may be attributed to:

(1) the destruction of Mya stocks in the Rappahannock due to Tropical Storm Agnes in 1972.

(2) the catastrophic decline of oyster production in Chesapeake Bay over the past 25 years.

Thus, depletion of the ray's preferred food item, Mya, may have resulted in increased predation on an already impacted stock of oysters in the Rappahannock River.

METHODS OF CONTROL

The elimination or reduction of certain predators from an area may be a desirable management practice when their numbers or predations have a negative impact on more desirable species (Rounsefell and Everhart, 1953 and Alverson and Stansby, 1963). Reducing cownose ray predation on Chesapeake Bay stocks of commercially important shellfish may be accomplished by: (1) physical or mechanical barriers placed on or about shellfish beds to exclude rays or (2) reduction of the cownose ray stock.

Generally, the shellfish industry's solution to ray predation has come in the form of mechanical barriers. Fences have been used in the Philippines (Villadolid and Villaluz 1938), California (Barrett 1963), and Eastern Shore, Va. (Kraeuter and Castagna 1977 and in prep.; D. Haven, personal communication). French shellfish growers implant arrays of pointed stakes on the oyster bottom where tidal ranges prohibit the use of fencing (D. Haven, personal communication). California oysters are planted in shallow, protected waters where defense against the bat ray, *Myliobatis californica*, is possible (Barrett 1963).

The bat ray has also been the target of special exterminating parties of sportfishermen (Walford 1935). During the past two decades, one West Coast oyster grower (Coast Oyster Co., Eureka, California) has fished directly for this ray with commercial fishing gears (see below).

Along similar lines, extensive gear destruction and depredation on more commercially valuable species were attributed to increasing populations of spiny dogfish, *Squalus acanthias*, along the Pacific Northwest and Northeast coasts of the U.S. (Alverson and Stansby 1963; Commonwealth of Massachusetts 1964). In each case, development of a commercial fishery for dogfish was recommended as the most practical solution.

Physical and Mechanical Deterrents to Ray Predation

Penning Experiment I

Introduction. Interviews with several oyster growers suggested that shell bed depth was a possible controlling factor in attracting rays to given oyster beds. Grounds with light beds (3 inches or less in thickness) were reported to be more severely and frequently damaged than grounds with heavy shell bases (about 12 inches thick).

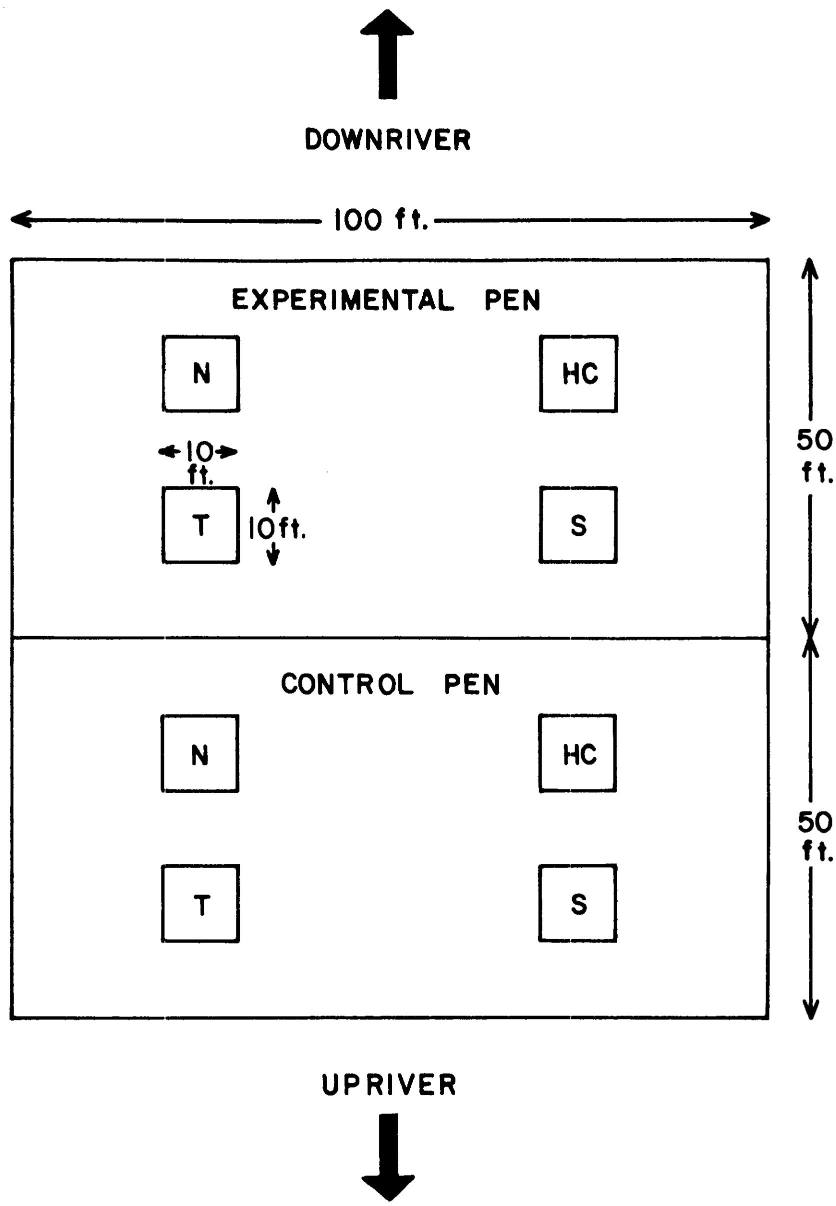
The purposes of the penning experiment were to determine: 1) if live rays could be maintained under controlled conditions, 2) if rays would feed and exhibit a more or less "natural or normal" behavior pattern while confined in an enclosure, and (3) if cultch depth is a possible controlling factor in ray predation on oyster beds.

Materials and Methods. Two juxtaposed pens, each 30.4 m x 15.2 m (100 ft. x 50 ft.) were erected in the York River along the northwest shore of Gloucester Point. The pens were constructed of galvanized wire fencing 1.5 m (5 feet) high and metal fence posts (2 m tall) placed about 3 m apart. Mean low water depth in the pens was about 0.6 m (2 feet). Four feeding sub-plots, 3 m x 3 m (10 ft. x 10 ft.), were established within each pen (Figure 4):

1) 3 bushels of oysters planted on natural bottom
2) 3 bushels of oysters planted on a 3 inch shell base
3) 3 bushels of oysters planted on a 6 inch shell base
4) 100 hard clams planted in the natural bottom.

Oysters were market-sized singles (3-4 inches long). Hard clams were "chowder" sized.

Eleven live cownose rays were placed in the experimental pen. The other pen was maintained as a control to measure natural mortality



TREATMENTS:

N = Oysters Planted on Natural Bottom

T = Oysters Planted on a 3-inch Shell Bed

S = Oysters Planted on a 6-inch Shell Bed

HC = Hard Clams Planted on Natural Bottom

Figure 4. Cownose ray pen, 1976.

of the planted shellfish. The rays were collected on August 24 (n = 5) and 25 (n = 6), 1976 by a 91.4 m (300 ft.) monofilament gill net in the York River. After removal from the net, the rays were placed in a large plastic basin (1.2 m x 1 m x 1 m) with river waters and transported via boat to the pens. All rays were adult females averaging 96 cm in disc width and 15 kg in weight.

Results. The rays were observed daily. They exhibited a tight schooling behavior almost immediately after being placed in the pen. Within a week evidence of direct feeding by the rays upon the planted shellfish was found. The experiment was terminated after 21 days of ray captivity.

In the experimental pen, the rays totally destroyed the sub-plots of oysters and clams on natural bottom and the hard clams. The oysters planted on a 3-inch and 6-inch bed of cultch were damaged but a few live oysters remained. Mortalities in the control pen were very low. The bottom of the control pen remained flat and undisturbed, whereas the bottom of the experimental pen had shallow excavations over the entire area.

Penning Experiment II

Introduction. Project contacts with the oyster industry in 1976 suggested that plastic milk jugs containing marbles tethered to the surface above an oyster bed and barbed wire strung across oyster bottom might effectively deter ray predation. As noted above, arrays of pointed stakes and stake fences have also been reported successful in protecting shellfish beds from feeding rays. Since we found that captive rays fed "naturally" in the summer of 1976, we could test various physical deterrents to ray predation by penning experiment in 1977.

Materials and Methods. A 45.7 m x 15.2 m (150 ft. x 50 ft.) pen was constructed using the same materials and site as noted above. Ten 3 m x 3 m (10 ft. x 10 ft.) subplots containing 3 bushels of market-size single oysters were established within the pen (Figure 5). Four devices were tested for their efficacy in deterring feeding rays:

1) 2.5 cm x 5.1 cm x 2.4 m (1 inch x 2 inch x 8 feet) wooden stakes placed .3 m (1 ft.) apart around the perimeter of the plot.

2) An array of 2.5 cm x 2.5 cm x 1 m (1 inch x 1 inch x 3 ft.) pointed wooden stakes placed .6 m (2 ft.) apart about the plot and protruding .5 m (1.5 ft.) above the horizon of the plot.

3) 8 lengths of barbed wire strung across a plot anchored on both sides by a 3 m (10 ft.) steel pipe. The wire was allowed to remain semi-coiled.

4) 9 plastic 1 gallon milk jugs, each containing several glass marbles, were tethered by 2 m (6 ft.) lengths of twine and anchored to the bottom by bricks 1 m (3 ft.) apart.

Each treatment was randomly assigned to two plots (Figure 5). Two plots received no treatments and served as controls. Live rays were acquired as noted above.

Results. Construction of the pens was completed by June. A violent thunderstorm swept through the area on June 9, 1977 and broke, displaced or dislodged many of the wooden stakes. The milk jugs were torn from their moorings. Barbed wire and pointed stakes were unaffected. Approximately 75% of the oysters were silted over or washed away. Repairs were made, but we encountered difficulty in collecting more live rays.

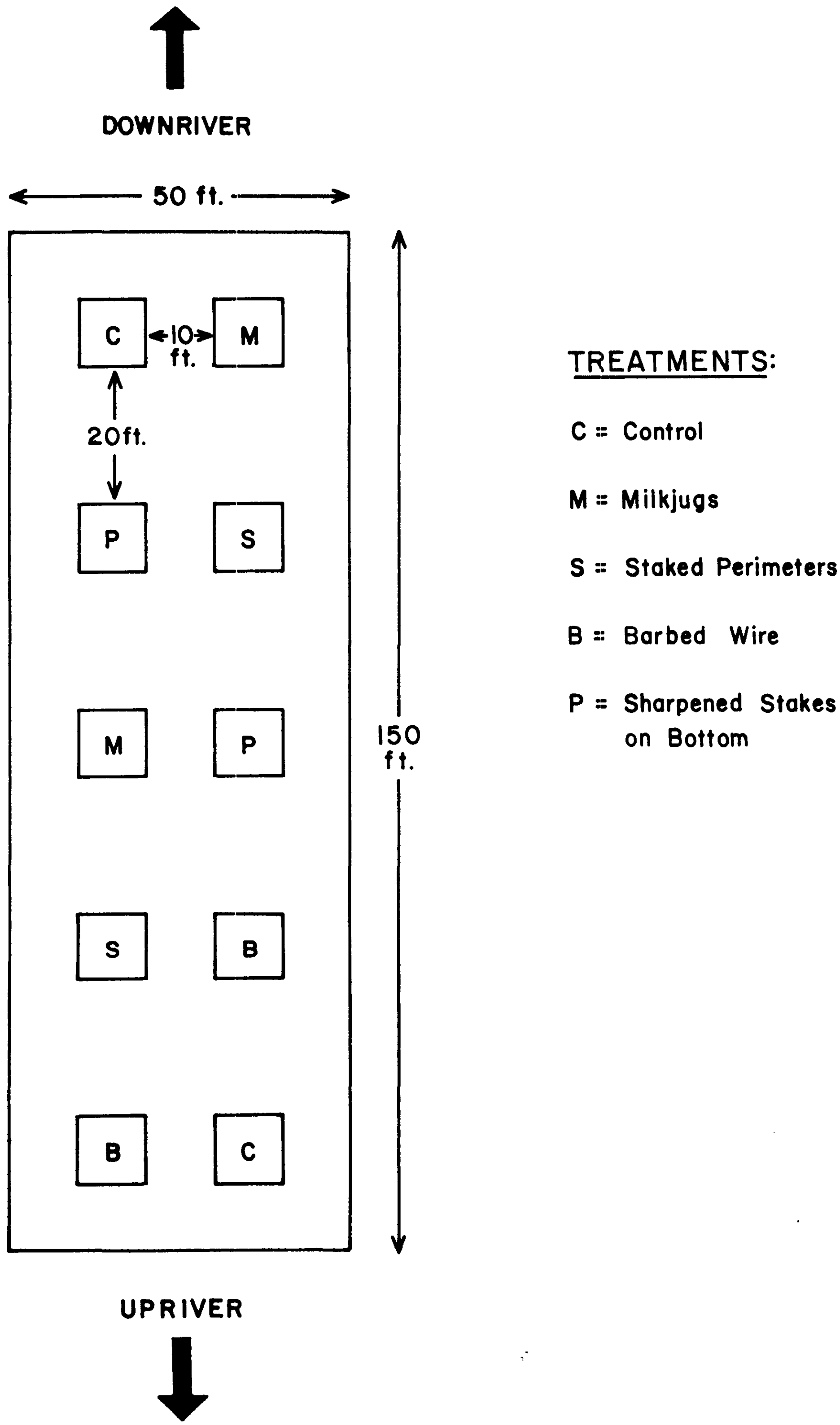


Figure 5. Cownose ray pen, 1977.

A total of 6 adult female cownose rays (disc width ca. 95-97 cm) were released into the pen on August 2 (n = 3) and 3 (n = 3), 1977. As in the previous year's experiment, they almost immediately assumed a tight schooling formation. During high tide, the rays swam over the barbed wire and pointed stake plots. At low water the rays remained close to the perimeter of the pen.

On August 8 several potholes were noted on the natural bottom of the pen. Several oyster shell fragments were found on the control plots August 22.

One dead ray was found in the pen on August 22. By August 29, the remaining five rays had succumbed. Deaths may have been due to the high surface water temperatures recorded at Gloucester Point during the study period (range 26.4 - 29.0°C; $\bar{x}$ = 27.7; n = 31 days).

Oysters were harvested from the plots by hand on September 2. Mortalities were high, about 50-60%, probably due to siltation and high water temperatures. Only a few ray-damaged valves were found on the test plots. Approximately 35 oyster shell fragments and/or hinges were discovered on the two control plots.

Conclusions. Increased cultch depth is not effective in deterring cownose ray predation on single, market-size oysters. Possibly, the minimal ray predation noted by growers on beds of thick cultch was due to the inability of *R. bonanus* to effectively mine "clumps" of oysters as opposed to singles.

The results of the second penning experiment are difficult to interpret. High oyster mortalities incurred were probably due to high water temperatures and siltation. The rays also perished after about three weeks of captivity. Obviously, favorable environmental conditions were not present during the test period and it is questionable as to whether the rays exhibited "normal" feeding behavior.

The fortuitous storm that swept through the study area demonstrated the fragility of milk jugs and wooden stake fences as mechanical barriers to ray predation. Barbed wire and pointed stakes may be effective on a small scale. However, these devices would surely hamper present harvesting methods. They may also serve to increase the siltation rate, thus smothering the oysters (D. Haven, personal communication). In conclusion, the widespread application of any mechanical device to protect Chesapeake Bay oyster beds, some of which cover several thousand acres and are located in up to 7.6 m (25 ft.) of water (Haven et al., 1978), would be impractical and expensive.

West Coast Stake Fencing

As noted above, the California oyster industry has experienced extensive predation by the bat ray, Myliobatis californica. The following information was acquired (by JVM) during interviews with F. M. Douglas, an oyster grower in Humbolt Bay, California and Walter Dahlstrom of the California Fish and Game Department.

The oyster problems associated with ray damage in California is unlike that on the East Coast. California oysters are grown on inter-tidal beds. In most cases stake fences are used around the oyster bars, although growers in Drakes Estero have gone to rack culture to avoid ray predation. Cut stakes (2.5 cm x 5.1 cm x 3.1 m = 1 inch x 2 inch x 10 ft.), formerly of redwood but presently eucalyptus, or young trees (ca. 2.5 to 7.6 cm = 1 to 3 inches in diameter) such as alder are driven 0.5-.6 m (18-24 inches) into the bottom and are spaced 0.3 m (12 inches) apart around the oyster bar. These last from 3-5 years.

The purpose of the fencing is twofold: (1) to keep rays out, and (2) the rays that do find their way around the end of the fencing at high tide are caught in small fish traps as the tide receeds. Mr. Douglas' fences are placed along the edges of the oyster bar close to a drop-off. A fish trap is placed at the lower end of the bar. On some of the bars, the channel side of fencing is omitted if there is another natural low spot draining the bed. The fence then acts as a lead for the fish traps.

Douglas also employs a seine during the last of the ebb tide which is set across a channel adjacent to an oyster bar. The rays concentrate in the deeper channels as the tide falls; they are simply allowed to wash into the net.

Douglas claims fence maintenance costs approximately $3,000/year (1977 estimate). He pays $0.27/stake and approximately $200 in labor for placement of 1,500 to 2,000 stakes. Estimated total cost of the placement of a single stake on the bar is $0.37.

Catch records of bat rays by the Coast Oyster Co. in Humbolt Bay were provided by Mr. Douglas (Table 1). From 1956 through 1961 only fencing and fish traps were used. Douglas claims that no juveniles or young-of-the-year were caught during this period and the average weight per fish (Table 1) substantiates this observation. It is assumed that the smaller rays passed through the 0.3 m (12 inch) space between stakes.

From 1962 through 1965 Douglas experimented with trawls and seines in the channels, while the fences and traps remained operational. From 1966 to the present he has used both seines and fencing with traps. Approximately 75% of the rays are caught in the seine and 25% in the traps. Average weight per ray has decreased since the mid-1960's (Table 1), demonstrating the efficiency of the seine in catching young-of-the-year and juvenile rays.

Although total effort per year is highly variable, total numbers and weight of rays landed per year since 1971 suggests that the combined effect of traps and seines has been to significantly reduce the number of bat rays frequenting Humbolt Bay in recent years.

Table 1. Catches of west coast bay rays, *Myliobatis californica*, by the Coast Oyster Co., Eureka, California (1956-1976).

Year	Total Number of rays caught	Total Weight	Average weight/ray
1956	1,297		
1957	517		
1958	1,810		
1959	1,830	80,673	44
1960	242	7,815	32
1961	1,512	98,810	65
1962	184	8,190	44
1963	2	100	50
1964	527	28,435	54
1965	174	1,355	8
1966	76	2,440	32
1967	1,611	7,586	5
1968	1,573	9,140	6
1969	1,577	17,206	11
1970	2,972	50,769	17
1971	482	11,526	24
1972	395	11,199	28
1973	367	3,985	11
1974	656	3,403	5
1975	423	2,753	6
1976	382	9,440	25

Recent Use of Fencing in Chesapeake Bay

In August 1976 Mr. Roy Davis of Back River, Poquoson, Va., reported the loss of 1.8 million "little neck" clams (hard clam, *Mercenaria mercenaria*) planted on 1/2 acre to cownose ray predation. Within five days from the planting date all but about 70,000 clams had been destroyed which almost certainly was caused by cownose rays. Project personnel (R. K. Dias and R. J. Orth) assessed the damage, and estimated a total loss of about $100,000 to this single planter.

In early spring 1977 Mr. Davis placed fencing around approximately 2 acres of a shallow subtidal bed on which he had placed 4.5 million small hard clams. The fence was made of netting with 0.3 m (12 inch) meshes, (similar to pound net hedging). Leads were attached to the bottom line. Stakes were placed every 6.1 m (20 ft.) to support the netting.

Davis estimated a cost of $300-$400 for the netting, $1.40/stake (50 stakes) and $300-$400 for labor. Total cost of the fence was estimated at under $1,000.

Davis sighted cownose rays in the Back River during May and throughout the summer months. He reported no cownose ray damage to his beds during this period. However, he incurred considerable ray damage in late September. He had removed the fencing in preparation for harvest and under the assumption that the rays had left the Bay.

Reducing Cownose Ray Numbers

Development of a Ray Fishery: A reduction of cownose ray numbers would probably decrease predation on commerically important shellfish. Thus, the development of a fishery for rays seems highly desirable.

In the absence of a high domestic market demand for ray or skate there have been no directed fisheries for batoids in the U. S. Recently, Otwell and Lanier (1978) completed a study of the utilization of skates and rays in North Carolina. The clearnose skate (*Raja eglanteria*) and the cownose ray were the target species of the project. They reported that present "market trends in Europe are conducive for increased importation of skate and ray" and concluded that "foreign market trends, product characteristics of domestic skate, and fishermen/processors interests indicate potential for development of a skate and ray fishery in North Carolina." The report recommended that "a proper, cautious promotion directed toward researched markets should find market potential for the cownose ray."

Aerial and shore-based observations indicate a nearshore distribution for cownose ray schools. Feeding schools invade intertidal and shallow-subtidal areas during high tide analogous to the West Coast bat ray habits. Once food is discovered, cownose rays are not easily persuaded to leave an area except by falling tide. Otwell and Lanier (1978) and Merriner and Smith (in prep.) have demonstrated the feasibility of harvesting schools of cownose rays with existing commercial fishing gears and haul seines. Haul seine fishermen have also demonstrated a willingness to fish for rays if the price per pound is competitive with that of other market fish in the area (croaker, spot, trout, bluefish) (Otwell and Lanier 1978; Merriner and Smith in prep.). Thus, development of a fishery for cownose rays appears to be the most practical and promising method for a longterm reduction of cownose ray predation on commercially important shellfish beds.

As an interim measure, oyster lease holders could collectively sponsor or support one or more "ray haul seine rigs" within the areas subject to greatest damage. This operation would be an exact analog to Mr. Douglas' operations in Humbolt Bay California. Utilization of the rays may take several forms: food, scrap, strip bait for recreational anglers, crab pot bait, base to extend oily fish mix as chum, curios (spine, jaws, teeth), pharmaceuticals or extractible chemicals, etc.

Sportfishing for Rays: A reduction in cownose ray numbers might also be achieved by stimulating interest in directed recreational fishing for rays. This idea is not unprecedented. Walford (1935) noted that the West Coast bat ray is often the target of special extermination parties of sportfishermen. Significant numbers of bat rays are often taken during shark fishing derbies in San Francisco Bay (Herald and Ripley 1951; Herald and Dempster 1952; Herald 1953). During this project, we have aquainted sportfishermen with the species of rays which enter the Chesapeake Bay and pointed out their edibility via two Advisory Service publications (Smith and Merriner 1977 and 1978) and several local newspaper columns.

The initiation of a cownose ray derby or rodeo may serve to reduce cownose ray numbers in localized areas, such as the middle and lower Rappahannock River. Sufficiently large prizes would probably be needed to stimulate interest and attract anglers away from weakfish, blues, or striped bass. Prize categories might inlude largest male and female cownose ray, most rays landed, best pair of anglers, along with various line test categories. Since a reduction of the ray stock is the desired result, the event should occur from mid-May through mid-June before ray parturition.

The state of Texas has recently moved to add four rays to the State Fish Records Program (Marine Fisheries Review, 1977). As an addition or complement to proposed ray derbies, we suggest that the Virginia Saltwater Fishing Tournament consider offering citations for cownose rays caught on rod and reel. Cownose ray minimum citation weight should be 40 lbs. A similar recommendation should be made for the North Carolina citation program (Mr. Joel Arrington, Coordinator).

Recommendations

1) Fences composed of large mesh netting material represent the best short-term method of protecting commercial oyster bottom or other

planted bottom from cownose ray predation. The use of fences at present is limited to intertidal or shallow subtidal beds. For this reason, fences appear ideally suited for protecting hard clam beds. Placement of netting around the larger leased oyster beds would be expensive and could be construed as a navigational impediment or unwarrented extension of rights to the bottom. Recreational boaters and sailors would likely object to this practice. Action/ resolution by VMRC would be advisable.

2) Commercial fishermen and processors of Virginia are urged to develop a fishery for cownose rays. Recent skate and ray utilization studies indicate a willingness on the part of foreign markets to import a quality ray wing product from the U. S. We encourage the food technology branches of VPI-SU and industry to pursue these options. The early work at NCSU should be followed by packaging and promotional studies.

3) The history of fisheries for elasmobranch fishes has been one of rapid exploitation followed by near total collapse of the fishery. Most recently several "sharkers" along the Florida coast have reported a collapse in catch/effort as they expanded their fishery (Otwell, FSU, personal communication). This decline is due to the low fecundity and slow growth rate of these fishes. If a sustained fishery is desired, quotas will have to be set to prevent overfishing. This will necessitate an accurate estimate of the size of the cownose ray population and a projection of sustainable yield. Pending knowledge of mortality and population size, we suggest that a directed fishery for cownose rays in the Bay should begin only after July 15. This would allow for parturition in mid-June and early July thus insuring at least partial recruitment. We suggest no closed season for cownose rays in the Rappahannock River.

4) We encourage the development of a cownose ray derby for sportfishermen in the Rappahannock River. Multiple derbies could be arranged in conjunction with local festivals or National holidays. While it is not likely to generate the interest of Assateague pony roundups, it would attain national PR by its novelty and would spread the word of "Rappahannock oysters".

5) It is recommended that the Virginia Saltwater Fishing Tournament add the cownose ray (minimum weight > 40 lbs.) to its list of citable fishes.

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