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Chesapeake Bay

Blue Crab Management Plan

Chesapeake Bay Program

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Agreement Commitment Report

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SECTION 1. BACKGROUND

General Information

The blue crab, *Callinectes sapidus*, is a dominant epibenthic predator in estuaries, lagoons and coastal habitats of the Western Atlantic, Caribbean and Gulf of Mexico (Williams, 1984). It is economically important throughout its range and has supported the largest single-species crab fishery worldwide over the past decade (FAO, 1990). The blue crab harvest from Chesapeake Bay alone accounted for over 50 % of the national total during the past two decades (Orth and van Montfrans, 1990), and it consistently outranks harvests from other shellfish species in Chesapeake Bay by weight and total dollar value. The recreational fishery, which is estimated at about 25 % of the total commercial and recreational catch in Chesapeake Bay, also contributes greatly to the economy of the region. Thus, the blue crab is an important natural resource requiring sound management to protect its long-term health, ecological and economic benefits.

Recently, substantial increases in fishing pressure, a corresponding decrease in catch per unit effort (Fig. 1), and concurrent declines in other major exploitable fishery species (e.g., oysters and various finfish) have raised concerns over the potential for a major decline in the blue crab stock and emphasize the need for fishery management based on a sound ecological foundation. This is particularly important given the substantial interannual fluctuations in stock abundance (Fig. 2) which places the species at risk of overexploitation.

Causes of population fluctuations are poorly understood. A spawning stock-recruitment model developed from a 20-year data base can only account for 20-60 % of the variance in the Virginia commercial dredge fishery (Lipcius and Van Engel, 1990). Development of population models applicable to the blue crab and its fisheries requires an understanding of processes associated with postlarval and early juvenile stages. In particular, processes affecting transport (i.e., dominant wind patterns during the recruitment season and runoff), settlement, metamorphosis (physiological state, behavior, nursery habitat availability and salinity effects) and post-settlement survival (mortality via fishery harvest and natural predation including cannibalism) that influence juvenile survival appear critical to understanding blue crab population fluctuations.

Life History

Larval and Postlarval Phases

The life history of the blue crab (Fig. 3) is similar to that of other marine species with complex life cycles and open populations. In Chesapeake Bay, larvae (zoeae) are released by mature females in high salinity water near the mouth of the Bay (Van Engel, 1958). Zoeae are transported to the continental shelf where development proceeds for about 30-45 days through 7 or 8 developmental stages (reviewed in Millikin and Williams, 1984; McConaugha et al., 1983; McConaugha, 1988). Larvae feed on zooplankton and plant material (Truitt, 1939) High salinities in excess of 30 parts-per-thousand (ppt) are required for optimal development (Costlow, 1967) and larvae are poorly adapted physiologically to undergo proper development at salinities much below 26 ppt., emphasizing the need for an oceanic environment for larval development.

Metamorphosis to the postlarva (megalopa) stage occurs on the nearshore Atlantic shelf (Epifanio et al., 1984). A retention mechanism has been postulated for blue crabs involving the along-shore southerly flow of water entraining early zoeal stages, coupled with a mid-shelf countercurrent and wind-generated flow of surface water to the north in which later-stage larvae and postlarvae return near the Bay mouth.

Settlement and Recruitment

In many marine species, larval or postlarval abundance and settlement set the limits within which population size is determined, since these individuals represent the survivors of early life-history phases (Fritz et al., 1990). Blue crab postlarval abundance, though highly variable (Fig. 3), generally follows a neap-spring tidal cycle, with brief periods of high abundance following spring tides by several days. This suggests that entry into the Chesapeake Bay is facilitated by increased tidal excursion. Superimposed on this fortnightly pattern are peaks of abundance related to wind events that transport megalopae towards the coast and into Chesapeake Bay via non-tidal volume exchange (Goodrich et al., 1990). Once within Chesapeake Bay, megalopae migrate vertically in response to light and tide, utilizing nocturnal flood tides to augment their transport up the estuary to shallow estuarine nursery habitas (Olmi, 1993).

Settlement of blue crab postlarve has been assessed in Chesapeake Bay using artificial settlement substrates, and occurs primarily between July and mid-November each year. Settlement is characterized by episodic pulses during periods surrounding full and new moon (Orth and van Montfrans, 1987; van Montfrans et al., 1990; Fig. 3). The same fluctuating pattern of settlement has been observed annually, with substantial variation in timing and magnitude. The potential exists that episodic settlement peaks, which account for more than half the annual total, may be the major determinants of adult population size, similar to that observed for tropical reef fishes (Doherty, 1987) and the Western Australian rock lobster (Caputi and Brown, 1986). Artificial settlement substrates may provide a measure of postlarval settlement which reflects both planktonic abundance and natural settlement which may serve as an indicator of future harvests in the fishery.

Early Juvenile Stages

Late premolt postlarvae settle in the lower estuary and utilize submerged seagrass beds as nursery areas until approximately the fifth juvenile instar (Orth and van Montfrans, 1987; Pile, 1993). Large juveniles migrate out of grass beds and are found in greatest abundance at upriver stations in lower bay tributaries and begin appearing in the upper-Bay Maryland waters. This evidence suggests the importance of lower salinity areas for larger juvenile crabs which ultimately grow and segregate by habitat with large males generally occupying the upper reaches of tributaries and females migrating towards higher salinity (Hines et al., 1987).

Adults and Reproduction

Blue crabs mature at approximately 12 to 18 months of age (Van Engel, 1958) with an expected average lifetime of two to three years under heavy fishing pressure. The male:female sex ratio of the blue crab varies with salinity. Males are usually more abundant in lower salinities than females, and most mating occurs from May through October in lower- and mid-Bay habitats where salinity preferences overlap. Female crabs initiate their final molt at approximately 115 mm (Knotts, 1989) and males "cradle" the females beneath them during stages of molting. Mating takes place while the female is in the soft-shell stage of her final molt. After this final interval of growth, the average size of adult females is 155 mm (Knotts, 1989; Hines et al., 1987). The pairs separate and, after the shell hardens, females migrate to higher salinities of the lower Bay. Early arrivals will spawn prior to the coming winter while latecomers spawn the following spring after winter hibernation. Males and juveniles remain in lower salinities of the upper Bay and tributaries throughout winter and hibernate in the sediment.

Females carry their egg mass beneath their aprons and open to the water to expose an orange, round sponge containing 750,000 to 8,000,000 eggs, depending on crab size (Prager et al., 1990). Blue crabs are serial spawners and spawn from May to September up to three times in a season, with a minor peak in June and a major peak July and August (McConaugha et al., 1983; Jones et al., 1990).

Predator-prey Relationships

Blue crabs serve as both predator and prey in the benthic and planktonic food webs of Chesapeake Bay. Movement through the water column by postlarvae (Olmi, 1993) make them a food source for plankton feeders such as menhaden, as well as other finfish that forage in the water column. Settled postlarvae and young juveniles become prey for numerous predators including eel, drum, spot, croaker, striped bass, trout, catfish, some sharks and cownose rays. Endangered Atlantic Ridley sea turtles migrate to the Bay every summer for their preferred food, blue crab. Recent concern has been raised over the recovery efforts of the striped bass population where the resurgence of such a predator may deplete the blue crab resource. Goshorn and Casey (1993) and Mosca et al. (in prep.) examined the relationship between striped bass abundance and blue crab landings in Chesapeake Bay and found no significant relationship. Instances where blue crabs are plentiful in the stomachs of striped bass are likely the result of opportunistic feeding (Booth and Gary, 1993).

Prey of the blue crab include bivalves, crustaceans, fish, annelids, plants and detritus (Darnell, 1958; Tagatz, 1986; Alexander, 1986). Although the blue crab is an opportunistic predator that feeds on commonly occurring benthic prey (Laughlin, 1982; Mansour, 1992), recent research on feeding habits of blue crabs indicates that soft-shelled bivalves (e.g., Macoma spp. and Mya arenaria) are preferred food. When these resources become depleted, cannibalism on juvenile crabs increases in intensity (Mansour, 1992). The incidence of cannibalism in blue crabs from the York and Rappahannock Rivers averaged about 25-30 % over a two year period (1988-1989). Blue crabs may control some bivalve populations (Lipcius and Hines, 1986; Eggleston, 1990; Mansour and Lipcius, 1993; Eggleston et al., 1993), and cannibalism may serve as a self-regulating control on crab populations, particularly during periods of high crab abundance or low alternative prey abundance (Mansour and Lipcius, 1993).

Habitat Requirements

Regionally, vegetated habitat area and commercial harvests of the blue crab are significantly correlated (Orth and van Montfrans, 1990). Lower Chesapeake Bay vegetated habitats are most important for juvenile crabs on a bay-wide basis (Heck and Thoman, 1981; Penry, 1982; Heck and Thoman, 1984; Heck and Wilson, 1987; Wilson et al., 1987; Orth and van Montfrans, 1987; Montane et al., 1993), and thus their availability and functional ecology in concert with recruitment processes may influence blue crab population size. Beds of submerged vegetation such as eel grass (*Zostera marina*) and Widgeon grass (*Ruppia maritima*) fall within the salinity range of invading postlarvae and provide developing juveniles with protection from predators during initial growth (Pile, 1993) and sub-adults with molting refugia (Ryer et al., 1990). In addition, juvenile crabs grow more rapidly in seagrass beds than in adjacent unvegetated areas (Perkins, 1993). As juveniles grow larger than about 25 mm in carapace width they migrate out of grass beds and disperse throughout other shallow-water habitats. Tidal guts of small creeks and rivers in and around salt marshes provide additional shallow-water habitats for juvenile and male crabs to feed and take refuge during molting.

Grass beds also serve as the preferred overwintering habitat for juvenile crabs in the lower bay. Where seagrass beds are sparse in northern parts of Chesapeake Bay, juveniles and mature males bury in unvegetated creek and river channels, as well as the bay mainstem (Hines et al., 1987).

Calculations of the total areal coverage of seagrass and unvegetated habitats < 2 m in depth combined with estimates of juvenile abundance for the York and Rappahannock Rivers demonstrate the relative importance of vegetated habitats to young juvenile blue crabs. Total areal coverage of unvegetated bottom is approximately an order of magnitude greater than seagrass beds (Fig. 4). In contrast, juvenile blue crab densities are nearly an order of magnitude greater in seagrass (Fig. 4). Despite the significantly higher coverage of unvegetated bottom, there are more juvenile blue crabs in lower bay seagrass beds (an estimated 14 billion crabs) than in unvegetated habitats (approximately 11 billion, Fig. 4), indicating the importance of seagrass beds to newly settled and young juvenile blue crabs.

Chesapeake Bay Blue Crab Fisheries

Management of the baywide blue crab stock across geographic regions and state boundaries is a dynamic and complicated process. Principal commercial fishery techniques for hard crabs include trotlines, crab pots and dredges, whereas scrapes and peeler pots are mainly used for the capture of peeler crabs (i.e., crabs about to molt or shed their exoskeleton) to be used in the soft-shell and bait industries. Trotlines are utilized in Maryland where commercial crab pots are prohibited in tributaries, but are not commonly used in Virginia. The crab pot is the most widely used gear throughout Chesapeake Bay.

Blue crabs are currently the most valuable commercial fishery, as well as a highly valued recreational species in Chesapeake Bay. The blue crab supports the largest crab fishery worldwide in terms of landings (FAO, 1991). An eleven year average (1982-1992) indicates annual commercial landings in Maryland of 45.4 million pounds (MDNR data). The reported 1993 commercial harvest of over 57 million pounds in Maryland was worth approximately 35 million dollars at dockside. In 1993, there were 6,740 commercial crab licenses in Maryland (MDNR data). The largest proportion of commercial catch is landed by crabbers licensed to fish more than 50 crab pots (34% in 1992), followed by tidal fish license holders (31% in 1992) and unlimited crab catcher licensees (23% in 1992). These three license types represent crabbers who previously have not been limited in the amounts of gear they can fish. In 1992, limited crab catcher licensees (up to 50 pots, trotlines, etc.) landed only 12% of the total commercial catch. Licensed noncommercial crabbers in 1993 (15,378) were more than double the number of licensed commercial crabbers, with 54% of all license types combined issued as noncommercial residents. Harvest by noncommercial crabbers for 1993 was more than 6 million pounds, almost 10% of the total combined harvest (commercial and noncommercial).

The preliminary estimate of commercial landings in Virginia in 1993 is 50.6 million pounds (VMRC data, mandatory reporting initiated in 1993, 1993 landings not comparible to landings from previous years). In 1993, Virginia had 4,568 licensed commercial crabbers. Issuance of crab licenses in Virginia has not stabilized, and sales of licenses for crab potting and dredging have continued to increase over recent years. Crab dredging is limited to a the lower portion of the Bay mouth (prohibited in tributaries) and license breached 300 in 1989, with a high of 315 in 1993. Licensing structure for crab potters changed in 1993, but from 1980 to 1992, the number of crab pot licenses increased steadily from 1,738 to 2,614.

In 1990, 500,000 recreational crabbers in Maryland made 2.5 million trips, harvesting 11 million pounds of crabs (Stagg, et al., 1992). The 1990 recreational survey interviewed both licensed and unlicensed crabbers in Maryland, and their catch was estimated to be 19% of the total combined harvest (commercial and recreational) for 1990. In 1993, 15,378 licenses were issued in Maryland for recreational crabbing, composing 11% of total reported landings for that year. Although there are no quantitative estimates of the recreational fishery for Virginia, annual reporting by all licensed recreational fishermen is required as of 1993. Improvements in data reporting should reveal the impact of the recreational catch on the blue crab stock.

Abundance, Catch Per Unit Effort and Exploitation

Catch statistics for the Virginia commercial dredge fishery show a significant decline in winter harvests from 1956 to 1992 (Fig. 2), and this decline is also reflected in the fishery independent trawl survey conducted by VIMS/W&M which shows a decline in adult female abundance for the same time period (Fig. 1). The increase in commercial landings in Maryland after 1981 coincides with a change in the reporting system, however, it is believed that the increase in landings was real and a result of an increased crab population. Maryland DNR summer trawl survey data, which has been collected annually since 1977, indicates that blue crab abundance was relatively high in 1977, low from 1978-1980, and has been relatively high through 1986. Since then (1987-1993), considerable fluctuation has been observed. Virginia Institute of Marine Science (VIMS) trawl survey data from 1972-1988 indicates major interannual fluctuations in blue crab abundance, often asynchronous with abundance patterns of crabs in Maryland. Lipcius and Van Engel (1990) note that population abundance remains high or low for two or more years before significant fluctuation is observed, and suggest some internal feedback mechanism within the population. However, this has not been the case in recent years. Winter dredge survey data from MD DNR, University of Maryland, and VIMS show fluctuations between single years with high population estimates in 1991 and 1993 and a very low estimate in 1992 (Volstad et al., 1994). This recent and rapid fluctuation may be cause for concern and should be investigated to understand the cause(s). Catch and effort data for Maryland commercial trotlines and crab pots indicates a trend of increasing effort with concurrent declines in catch and CPUE, and suggests fishing pressure is becoming a significant factor affecting blue crab abundance in the Chesapeake Bay.

The population of blue crab in Chesapeake Bay was estimated by Volstad et al. (1993) to be 653.3 million crabs, of which 366.7 million were 50 mm or greater. While these estimates are thought to be conservative when compared to total Baywide landings, they are the only estimates currently available. Little is known about the growth of crabs in the wild, and it is uncertain if crabs in the winter, less than 50 mm, will enter the fishery until the following year (Casey, pers. comm., Montane et al., 1993). Assuming that they do, the exploitation rate of crabs 50 mm and greater in 1992 was 50% (Volstad et al., 1994). This figure does not include harvest of soft and peeler crabs or harvest by recreational fishermen which would increase the exploitation rate. Recent analysis show that indices of abundance, such as those generated by the VIMS/W&M trawl survey, are useful in projecting commercial landings (Fig. 5).

Problems and Concerns

Fishing Pressure

The blue crab fishery is diverse and targets juvenile and adult segments of the population. Peeler crabs are harvested throughout spring and summer and are consumed as soft crabs or sold as bait. With the exception of a small percentage of larger males, most crabs caught by this segment of the fishery are harvested prior to reaching maturity and are therefore removed before reproducing. Economically, however, the peeler crab fishery constitutes the highest rate of economic return per pound of harvest and therefore maximizes financial gain from the resource. The impact of this fishery on the blue crab population is difficult to assess due to inadequate mandatory reporting regulations in the past.

The hard crab fishery represents the largest component on a bay-wide basis both in terms of total dollar value and landings. Larger crabs are harvested in their hard shell condition throughout the bay in the pot (Virginia and Maryland) and trot line (Maryland) fishery. The pot fishery targets both males and females; males represent an increasing proportion of the harvest in the upper bay and tributaries whereas females are more common with increasing proximity to higher salinity water associated with the lower tributaries and bay mouth. The Maryland trotline fishery targets primarily larger males in low salinity tributaries of the upper bay. Egg-bearing females represent a large proportion of the harvest in the lower bay during the spring in Virginia waters, but make up a very small percentage of the population in Maryland and are illegal to harvest. Another segment of the fishery, the winter dredge fishery, occurs exclusively in Virginia and targets hard crabs that hibernate and overwinter in deeper water of the bay mainstem. This component is estimated to consist of between 85% and 98% mature, inseminated female crabs (Van Engle, 1962; Schaffner and Diaz, 1988) waiting to spawn the following spring. Because there exists a relationship between the number of spawners and the number of young (stock-recruit relationship) in this species (Lipcius and Van Engel, 1990), conservation of the blue crab at any stage of the fishery should enhance subsequent harvests and maintain adequate population levels (Holmes, 1994).

Although the potential size of blue crab stocks are initially controlled by entry and settlement of blue crab postlarvae (i.e., the survivors of the larval phase *sensu,* Fritz et al., 1990) in nursery habitats , subsequent natural mortality and fishery harvest are likely the major factors affecting the size of the reproductive population. There has been growing concern in recent years that declines in other important Chesapeake Bay fishery stocks (in particular, oysters) have increased fishing pressure on the blue crab. During years of relatively high levels of abundance, fishing effort is rewarded with exceptional harvest. Because blue crab abundance fluctuates annually the potential exists that excessive fishing pressure on the resource during periods of low population levels could seriously affect the future of the resource as has occurred in many other exploited species (Holmes, 1994).

Wasteful Harvesting Practices

Fostering the survival of juvenile crabs benefits future recruitment to the brood stock. Small crabs contain less meat, and harvesting small crabs as soft shells before they recruit to the hard crab fishery and the larger soft shell fishery may not maximize yeild from the resource. The preference for larger crabs shipped into Maryland from out-of-state demonstrates a market demand for larger softshell crabs (Uphoff et al., 1993). Size limits for the soft and peeler fishery in Maryland are 3" and 3.5" respectively. Virginia has no size limit, and the Potomac River Fisheries Commission has a 3" limit on peelers. Increased size limits for soft and peeler crabs would reduce juvenile mortality in the fishery (Rothschild et al., 1992) and make Chesapeake Bay's product more competitive in the market (Uphoff et al., 1993).

Blue crabs are notorious cannibalistic predators, and sub-legal crabs retained in crab pots with larger crabs have high mortality rates (Eldridge et al., 1979). Cull rings worked in the mesh of a crab pot create a circular opening that allows undersized crabs to escape. In a study by Raynie and Casey (1992), the use of cull rings 2.25" in diameter in crab pots in the Chesapeake Bay were tested for practical use in the crab fishery. The number of legal crabs caught in pots was the same with or without cull rings. However, pots with three cull rings retained 89% less sublegal crabs, and pots with only one cull ring retained 83% less sublegal crabs than pots without cull rings. Thus, cull rings are an effective measure in reducing the capture of sublegal crabs in crab pots with no negative effect on the fishery, although, commercial watermen have expressed concern for the potential loss of small peeler crabs and mature females that are legal to harvest. Virginia is currently investigating the loss of small, mature female from cull rings. (Summarize findings here?) Self culling crab pots also save time culling crabs by hand and reduce injury to sublegal crabs during handling. Some watermen have developed their own techniques and began to use cull rings voluntarily. However, cull ring use in Maryland and Virginia is now mandatory and widespread participation and standardized methods will further reduce sublegal crab catch and subsequent mortality.

Crab pots lost to storms or left abandoned at the end of the fishing season are attractive refuge sites for blue crabs. Crabs and fish trapped inside abandoned pots die and act as an attractant for other animals that feed on the carcasses (Guillory, 1993). This process of self-baiting is cited as a cause for concern in many other pot fisheries including lobster, king crab, snow crab and black cod. As a cannibalistic species, blue crabs are attracted by the weak and dead of their own species impounded in abandoned traps (Guillory, 1993).

A study of abandoned pots in Chincoteague Bay found 88% of crabs retained were sublegal (Casey and Daugherty, 1989). A similar study by Casey and Wesche (1981) in Sinepuxent Bay from July through December examined 40 un-baited pots on a weekly basis. A total of 1,033 crabs were impounded, and crabs were tagged and returned to their respective pots.

The results found 33% of the impounded crabs were unable to escape and subsequently died. Although abandoned pots during winter months in Chincoteague Bay caught less crabs, mortality increased to 100% due to decreased water temperature and crabs' inability to hibernate. A study in Louisiana found 55% mortality of impounded crabs (Guillory, 1993).

When interviewed, watermen in Chesapeake Bay cited estimates of a 10 to 30 percent rate of pot loss annually (Casey, 1990). Management of the lobster fishery has called for action regarding ghost pots in New England (American Lobster Fishery Management Plan) by developing biodegradable escape panels. Casey (1990, 1992) studied materials for their degradibility in Chesapeake Bay. Escape panels made of jute decayed within two months. This may not be accepted by watermen who would have to replace them frequently throughout a season. Cotton twine was unreliable and decay rates were varied. Materials that degraded in six to nine months also proved impractical, and fouling tended to clog escape vents as panels degraded. Other options are non-galvanized wire mesh over a portion of the pot or burning off galvanizing with a torch in a section chosen for escape. Variability of pots and the degradation of escape vent materials under different environmental conditions needs to be examined more thoroughly before a recommendation can be made.

Habitat

Habitat protection is necessary to preserve both juvenile and adult crabs.
Drastic declines in submerged aquatic vegetation (SAV) in the 1970's induced research to determine the cause. Shoreline development, channel dredging, heavy boat traffic, crab scraping and clam dredging have all been identified as causes of local destruction (Hurley, 1991). Crab scrapes are toothless dredges that are dragged through grass beds to collect soft and peeler crabs that take refuge there. Heavy crab scrapes hauled with power winders may cause significant damage to habitats that are important nursery grounds for young crabs and other species. Submerged grasses sliced at the base offers no refuge until the grass is able to recover. Areas of high frequency scraping may be scarified the same way high frequency propellor contact scars grass beds, often resulting in permanent removal of the habitat (Fonesca et al., 1992). Larger boats are being utilized more by crab scrapers, and the crab scrape fishery is expanding as more watermen drop out of the oyster fishery and outfit their boats and power rigging for the crab fishery. Virginia prohibits mechanized hauling of crab scrapes which must be pulled in by hand, and, consequently, limits the weight of scrapes that can be hauled.

Shallow water habitats are necessary for blue crab survival, particularly during development after megalopea settle and metamorphose into tiny crabs. Shallow waters of creeks and marsh guts are areas of high productivity and provide an abundance of food for young crabs. Beds of submerged aquatic vegetation that grow in shallow water offer refuge from predators. Shoreline structures such as bulkheads, revetment and breakwaters alter habitat and reduce the area of shallow water available. Dredging for marinas and boat navigation also reduce shallow water habitat. Population on Bay's coastline, projected growth...number of coastline permits issued last year...

Sediment, from shoreline erosion and land erosion, and nutrient influx have been identified as the main causes for Baywide declines. Land vegetation lowers the impact energy of rain, and soil runoff is greatly increased in deforested areas (Schlesinger, 1991) such as agricultural lands, developing areas and road construction. Sediments suspended in the water reduce the amount of light that reaches SAVs. These sediments also settle out on leaves and stems, further blocking photosynthesis.

Nitrogen and phosphorus from agricultural and urban landscape fertilizers find their way to the Bay in runoff after rains or as dissolved ions percolated through the soil. Loss of wetlands and forests to development and agriculture allows eroded soil and nutrients that were once trapped and utilized by terrestrial and wetland plants to enter water bodies directly. Automobiles and power plants that burn fossil fuel emit nitrogen oxide to the atmosphere that is then deposited to bodies of water either as acid rain or dry particulates (Schlesinger, 1991). High levels of nitrogen and phosphorous in waters and tributaries feed algae that coat leaves and stems of SAVs and create favorable conditions for explosive algae blooms. Phytoplankton in the water column are so abundant during such blooms that they block sunlight to bottom dwelling grass beds. Phytoplankton deeper in the water column are blocked out by those crowded at the surface, and subsequently die, fall to the bottom, and decompose. Massive decomposition uses up oxygen at an accelerated rate and inhibits SAV respiratation.

During the months of May to September, deeper waters of the mid-Bay mainstem from Baltimore to the mouth of the Potomac River become anoxic. Oxygen is depleted and those areas are inaccessable to blue crabs and benthic food organisms are killed. Cross-current winds and low pressure storms push anoxic water into shallow areas, causing further destruction to the benthos.

The anoxic portion of the Bay has been steadily increasing in size and duration over recent history. First documentations of oxygen depletion were mainly hypoxic areas, or areas of reduced oxygen content, which over recent years have worsened to anoxic conditions (Officer et al., 1984). Historically, the affected area was limited to a narrow strip of the deep channeled area of the Bay but it now covers a much wider area with fringes of hypoxia stretching across almost the width of the Bay and down to the Bay mouth during some years (Officer et al., 1984).

Heavy loads of nutrients and organic matter into the Bay are believed to be the cause for the historical increase of anoxia throughout the Bay. In May, when waters begin to warm, accumulated organics from the previous summer and fall beneath the halocline begin to decompose and anoxic conditions continue in deep waters through September (Officer et al., 1984; Taft et al., 1980). As winter approaches, decomposition slows to a halt and oxygen supplies are replenished with the diminished halocline until the following spring.

The depletion of filter feeders in the Bay, particularly oysters, may have had some added effect. Oysters overwinter, unlike other phytoplankton feeders, and spring warming stimulate feeding early in the season. Today a large portion of the spring phytoplankton bloom goes ungrazed (Newell, 1988), adding to organic accumulations later in the season and potentially further contributing to anoxia. Oyster repletion efforts in the Bay are underway with a revised management plan with progressive new strategies. Disease and parasites will effect the recovery rate and it will be many years before any recovery occurs.

Of final concern for the health of the blue crab is water quality. Blue crabs that overwinter in sediments are externally exposed to accumulations of toxins, and their preference for benthic bottom feeders, such as filter feeding bivalves, make them likely candidates for internal contamination as well. Blue crabs examined in the two most polluted tributaries of the Chesapeake Bay, the Elizabeth River (Norfolk, VA) and Patapsco River's Baltimore Harbor (MD), found blue crab to be highly tolerant of toxic environments (ref.). Very little contaminants were found in their muscle tissue, however, toxins were accumulated in the hepatopancreas. Blue crabs' migratory nature and short life history may make them less sucsceptible to accumulations of toxins. Blue crab larvae, on the other hand, may be highly sensitive to water quality, and sublethal doses of toxins have been found to slow larval development (Epifanio, 1984). Van Heukelem (1991) summarized literature on contaminants to blue crabs including petroleum hydrocarbons, polynuclear aromatic hydrocarbons, polychlorinated biphenyls, kepone, mirex, malathion, halogenated compounds, chlorine and chlorine produced oxidants, and heavy metals including cadmium, chromium and mercury. No literature was found for arsenic, copper, lead, mercury, nickel or zinc.

Conclusion

The following section will address concerns identified in the previous section and will describe accomplishments thus far and specific actions to be taken in coming years by each jurisdiction. These actions are based on the best biological and ecological data available, as well as historical examinations of crab abundance from commercial landings and fishery independent surveys. Biological and ecological studies identify environmental requirements for blue crab survival, such as habitat and water quality, and compromises needed in the fishery and by people living all around the Bay and the watershed. Continued monitoring of abundance, habitat and fishing pressure allow scientists and managers to identify trends and take action before the damage is irreparable. Early action is important, as the people of Chesapeake Bay have already seen with other species that are now struggling to recover.

(1)

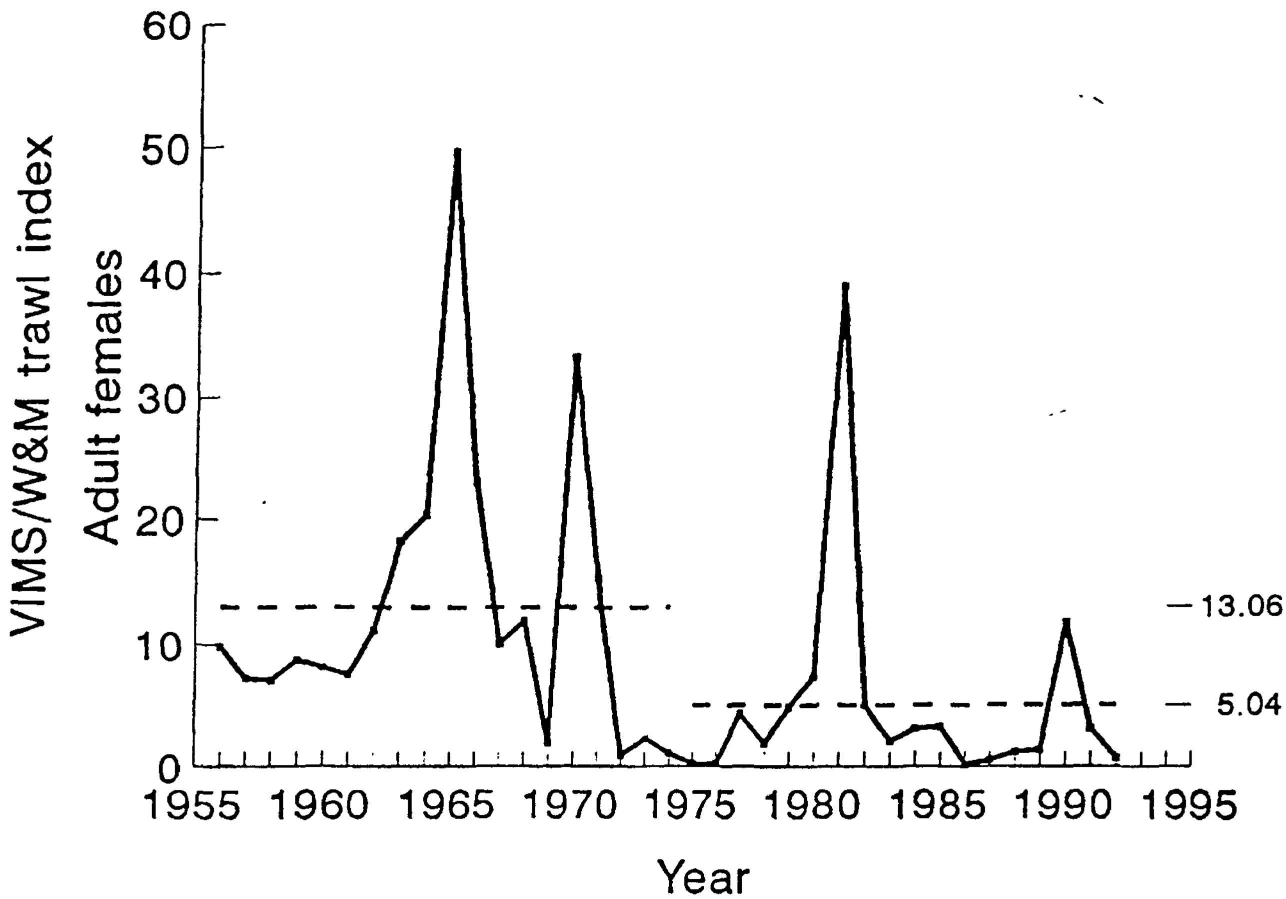


Figure x. (1) Adult female crab abundance from VIMS/W&M trawl survey by year for 1956-1992. Note the relatively low level of abundance during the past decade. Dotted lines indicate means for each period shown.

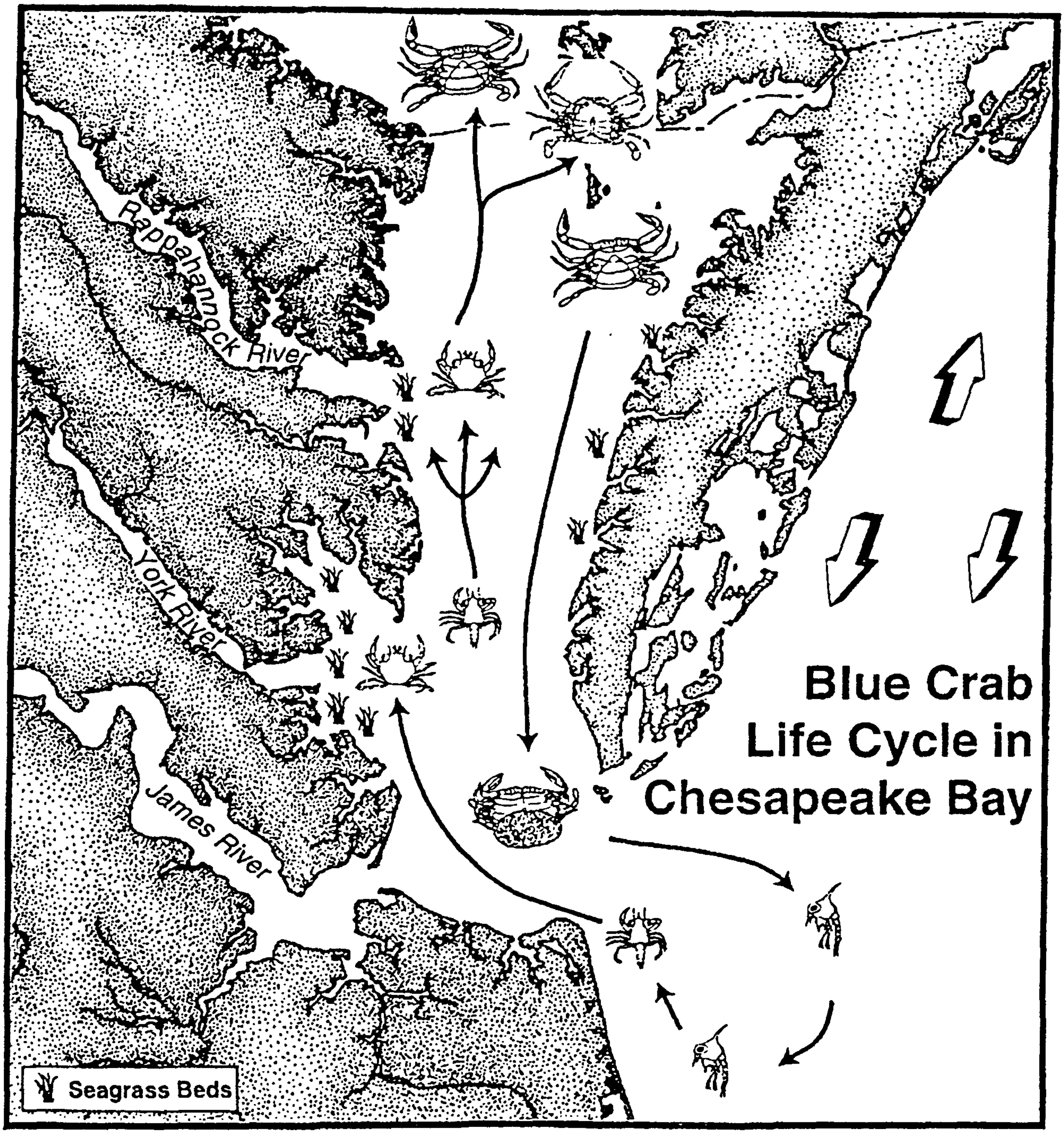


Figure 3. Life history of the blue crab in Chesapeake Bay. Large open arrows indicate dominant summer water flow.

(2)

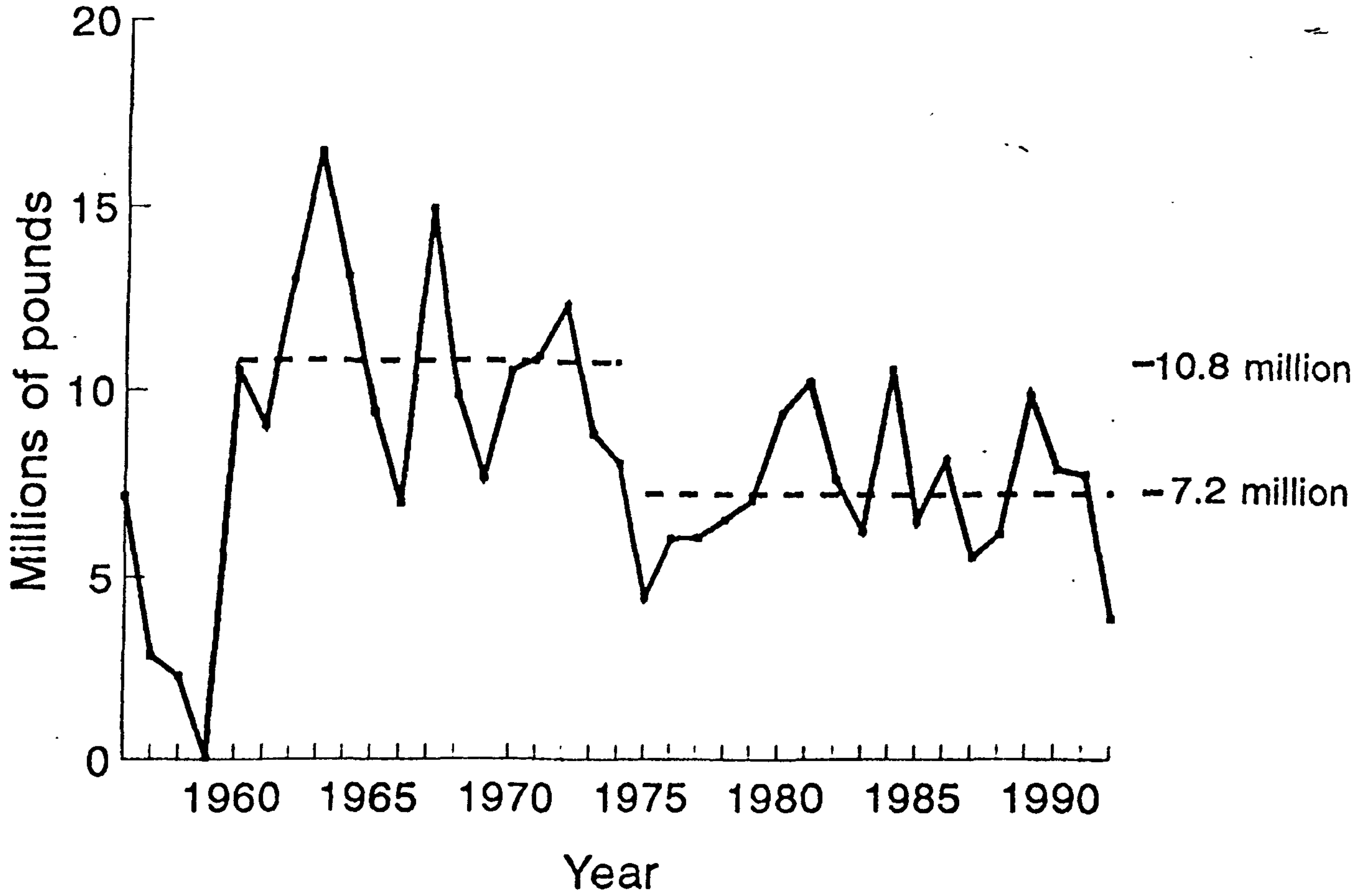


Figure x. (2) Landings from Virginia commercial dredge fishery, 1956-1992 (VMRC data). Dashed lines represent means for the periods indicated.

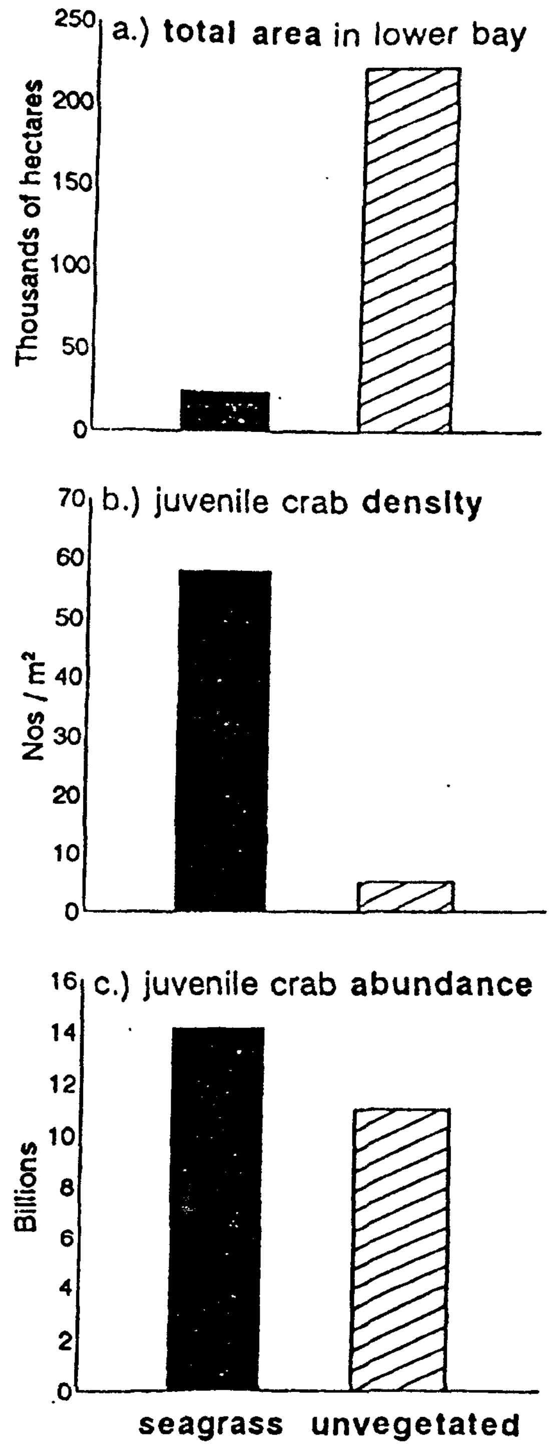


Figure (4). Estimates of the total number of blue crabs in the Lower Chesapeake Bay. Figure a denotes the total area of submersed bottom in the lower bay which is less than 2 m in depth. Figure *b* represents the mean density of juvenile crabs in vegetated and unvegetated areas of the lower bay. Figure *c* shows the resulting estimate of juvenile crab abundance in vegetated and unvegetated lower bay habitats occurring in less than 2 m water depth.

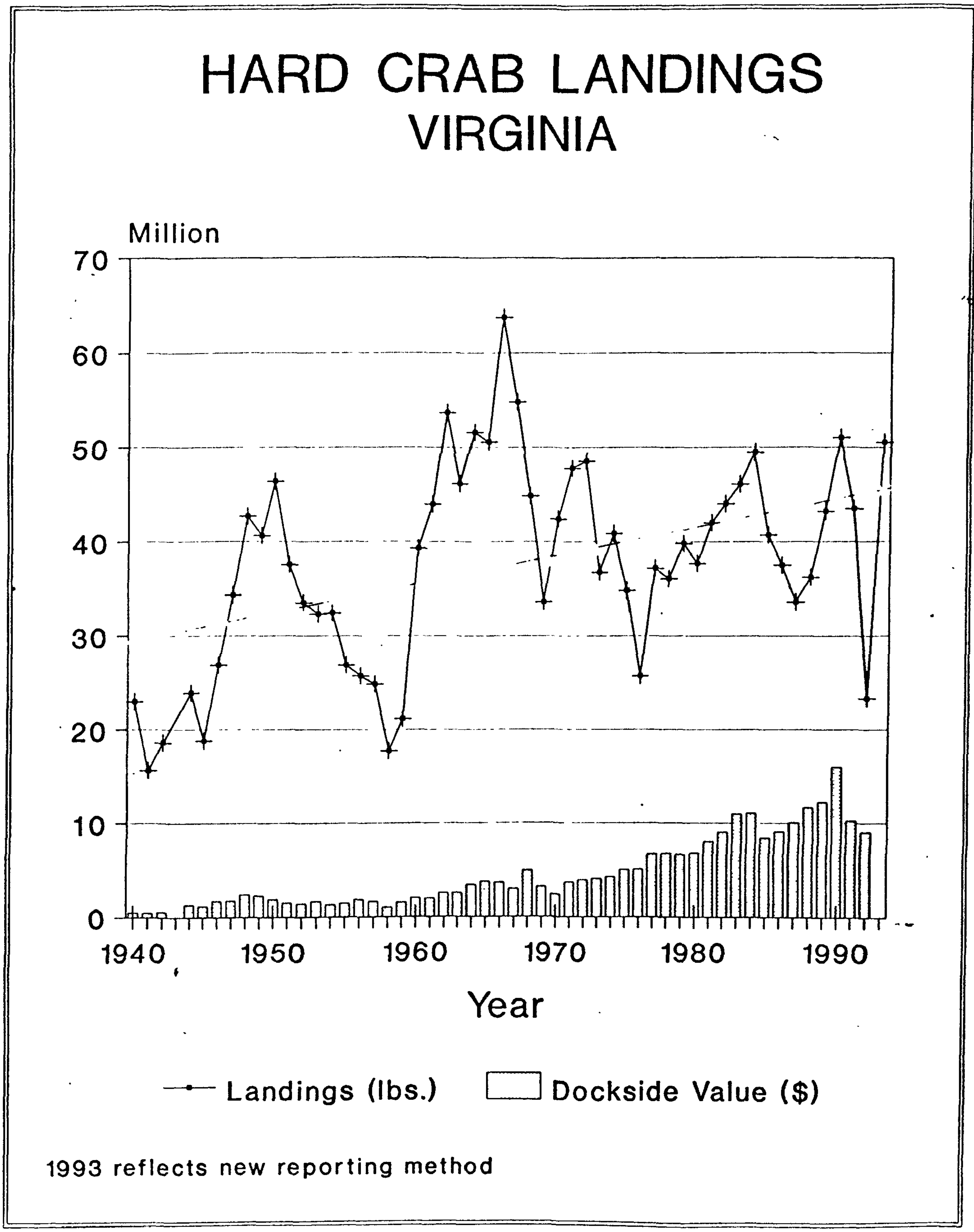
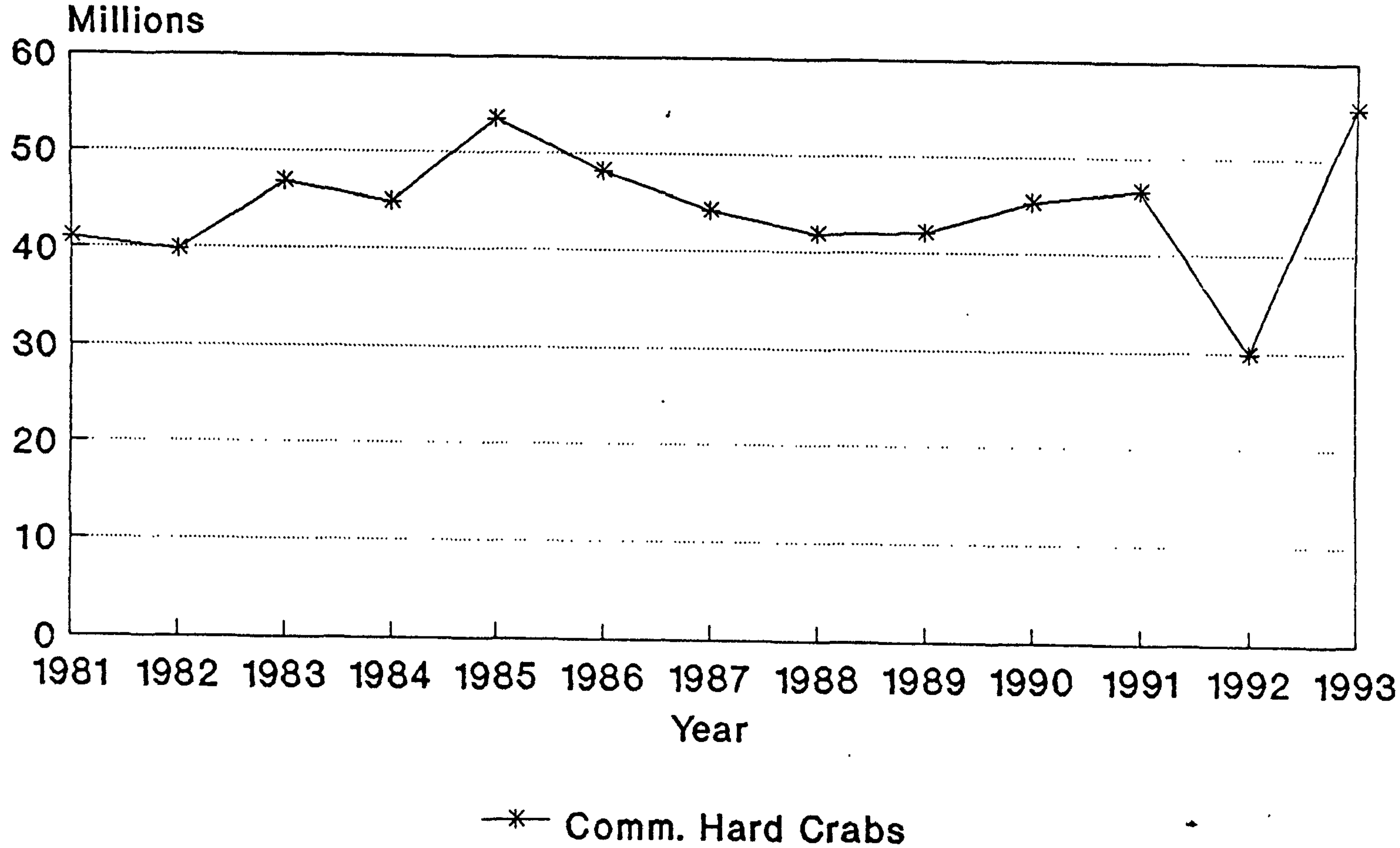

HARD CRAB LANDINGS
VIRGINIA
Million
70
60
50
40
30
20
10
0
1940
1950
1960
1970
1980
1990
Year
Landings (lbs.)
Dockside Value ($)
1993 reflects new reporting method

Figure 6

MARYLAND HARD CRAB LANDINGS
1981 - 1993



1981 to 1989 data does not include
December landings

Fig. 8

Will improve this graph to match
VA hard landings graph

(8)

MARYLAND CATCH PER UNIT EFFORT
FROM MONTHLY SURVEYS

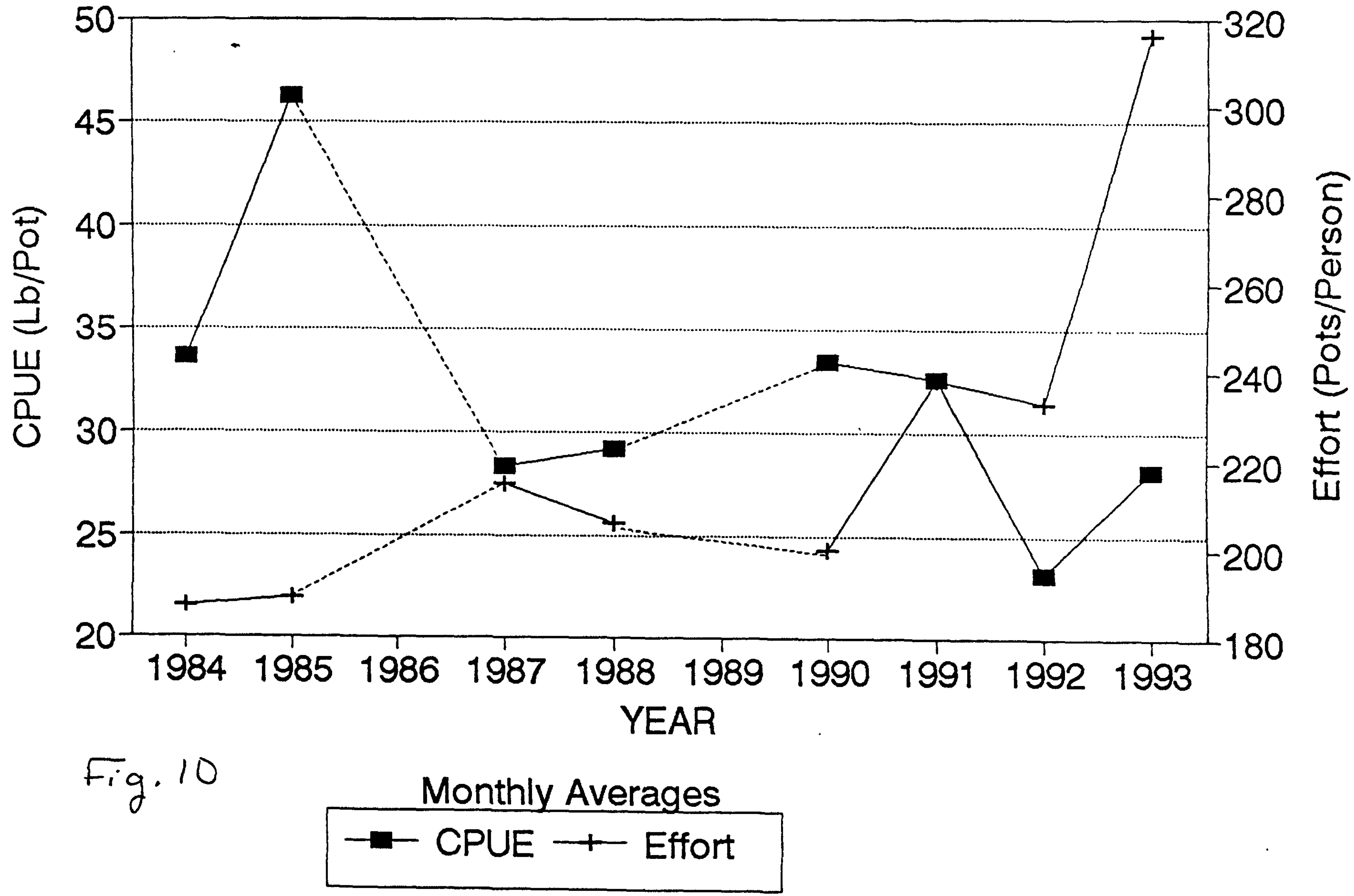
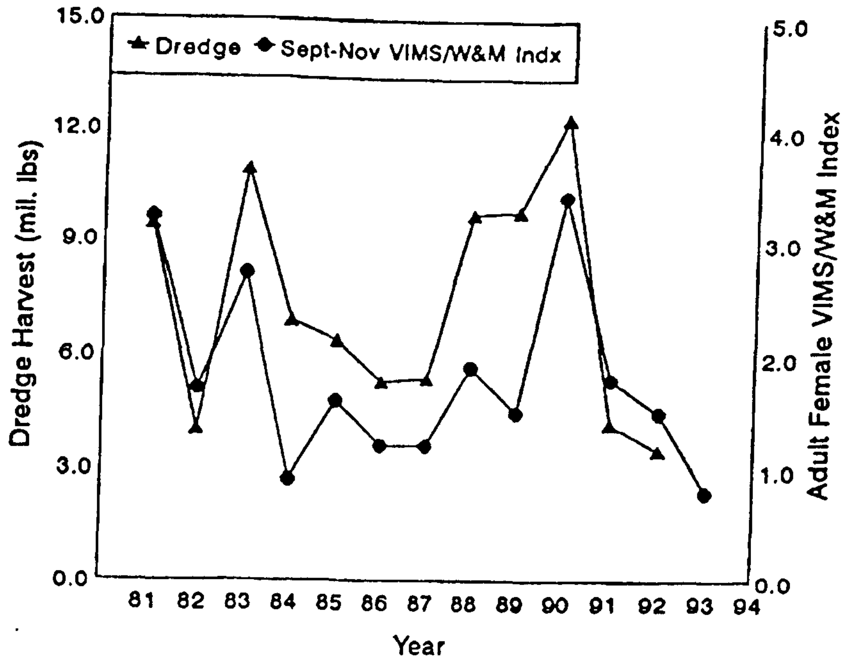
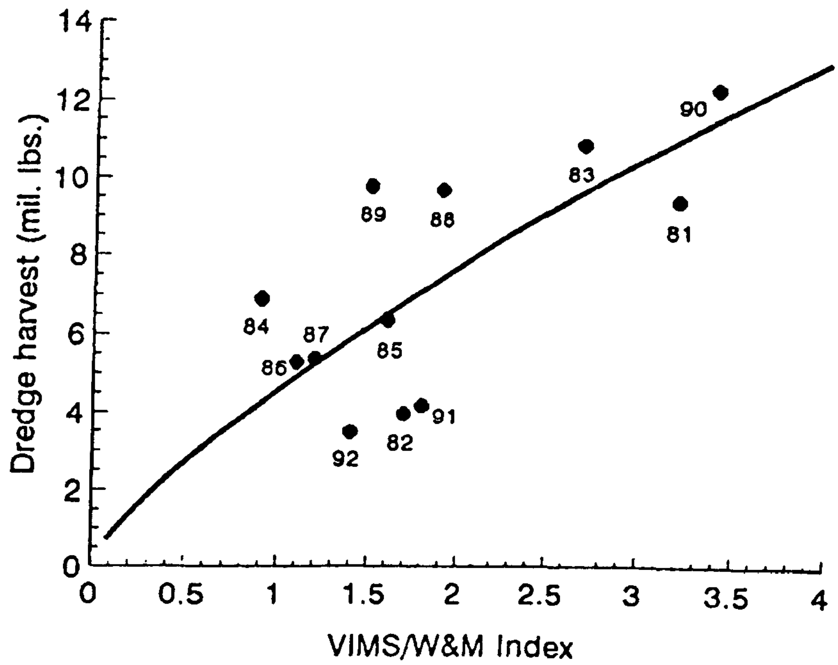


Fig. 10

10

(5)





(5) Figure x. Indices of stock abundance for 1981-1993. Shown are the commercial dredge harvest and the adult female index from the VIMS/W&M trawl survey. The lower plot is the resulting regression of dredge harvest on VIMS/W&M adult female index, with years indicated.

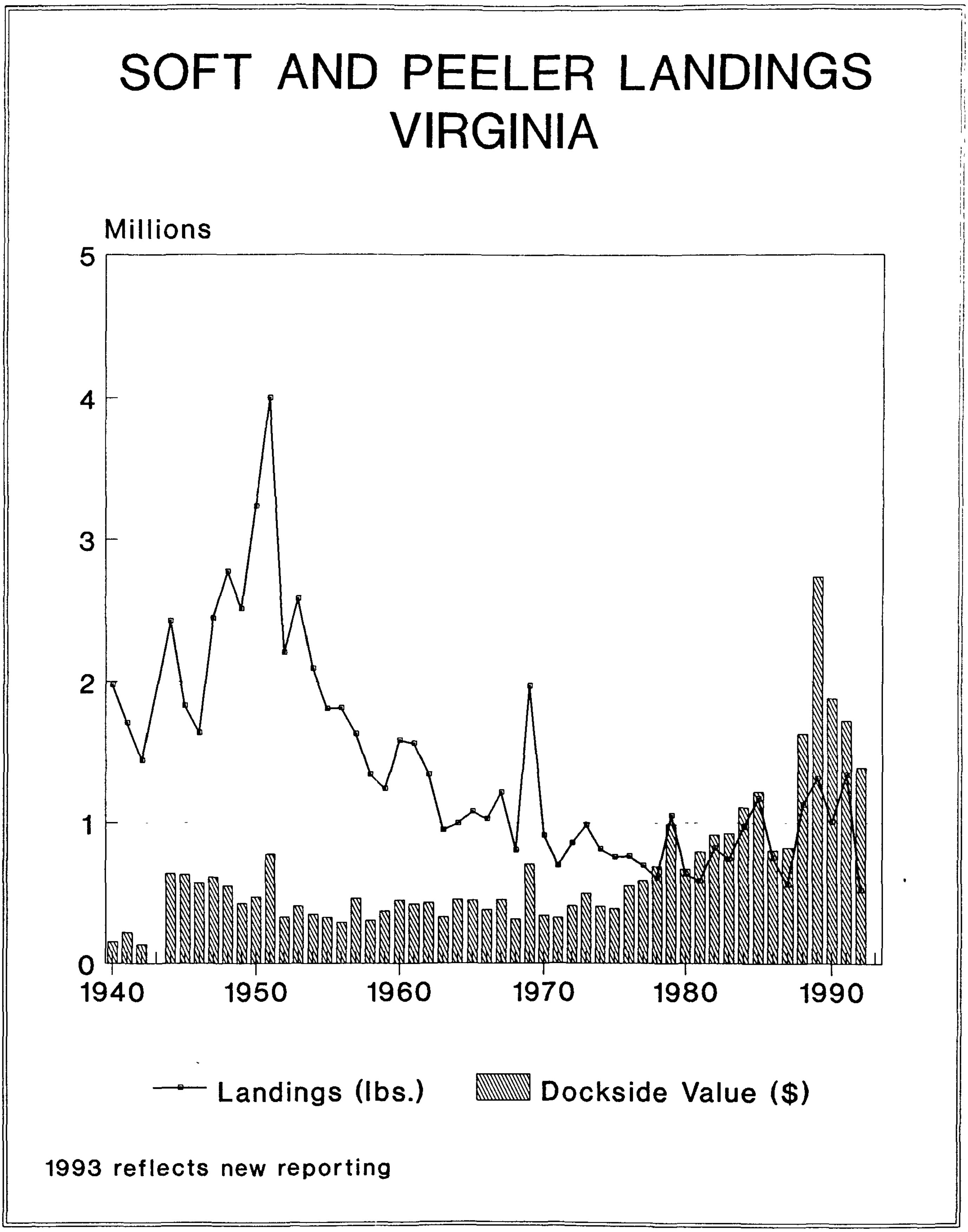

SOFT AND PEELER LANDINGS
VIRGINIA
Millions
5
4
3
2
1
0
1940
1950
1960
1970
1980
1990
Landings (lbs.)
Dockside Value ($)
1993 reflects new reporting

Fig. 7

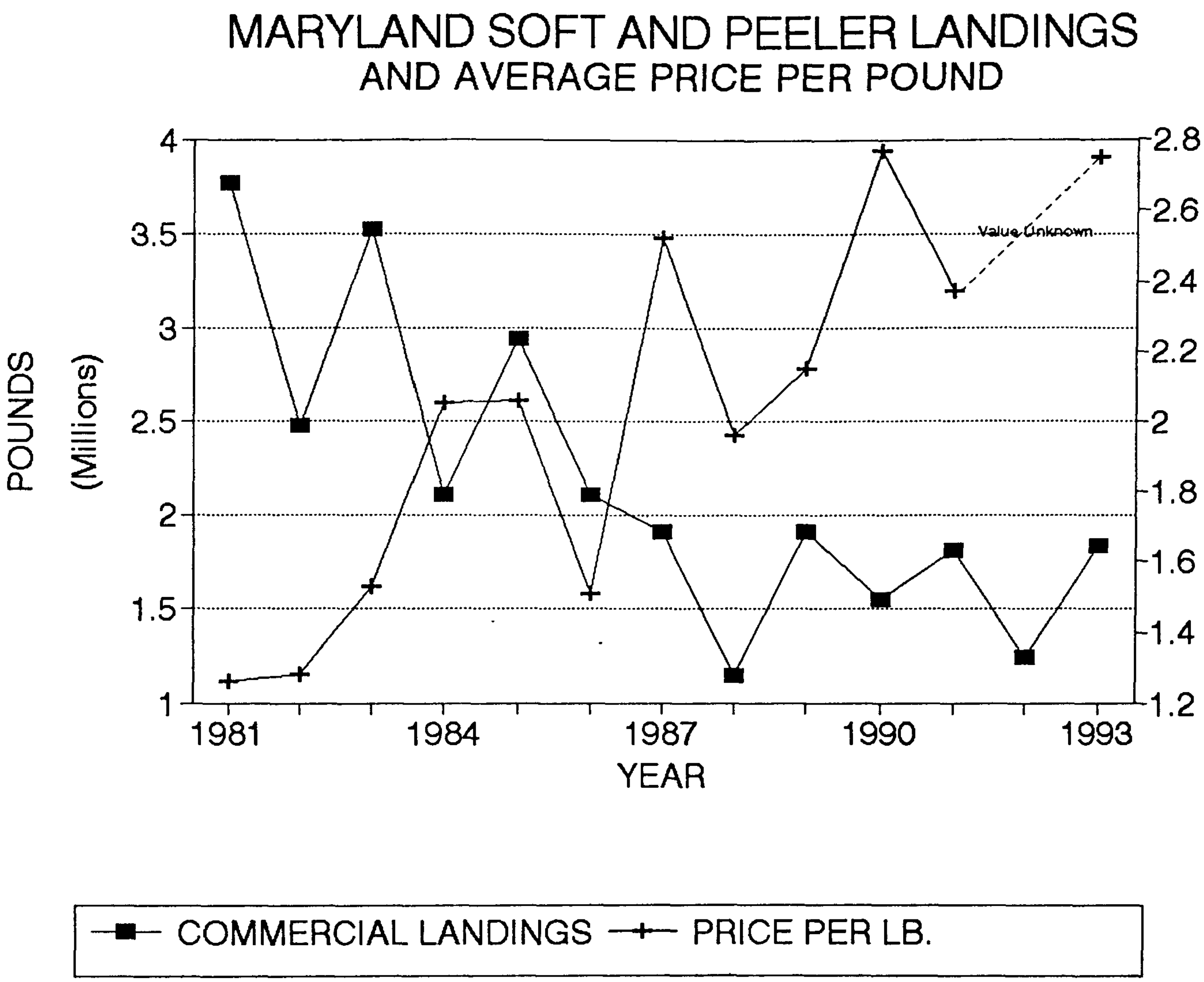


Fig. 9

QPRO A: SFT PEEL

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SECTION 2. BLUE CRAB MANAGEMENT IN CHESAPEAKE BAY

Background

In 1989, the first Chesapeake Bay Blue Crab Fishery Management Plan (BCFMP) was developed under the auspices of the Chesapeake Bay Agreement and encompassed the jurisdictions of Maryland, Virginia, Potomac River Fisheries Commission, District of Columbia and Pennsylvania. The Background Section of the 1989 BCFMP included crab biology, fishery and economic datas, status of the resource, habitat, laws and regulations, management approaches, and data and information needs. The Management Section addressed problems and presented management solutions. Five "Problem Areas" were identified: 1. Increased Fishing Effort, 2. Wasteful Harvesting Practices, 3. Lack of Stock Assessment Information, 4. Regulatory Issues, 5. Habitat Degradation.

In the four full years since the adoption of the original plan, much has changed. More extensive data that provides increased understanding have become available. Beginning in 1990, the Annual Progress Reports chronicle each year's activities for all adopted Fishery Management Plans. Significant regulatory changes as a result of the 1989 Plan have occurred and social, economic, and fisheries conditions have changed. The 1994 Plan retains some of the original goals of the 1989 Plan, such as the action to contain the commercial harvest, and also outlines a new direction based on current information and current social, economic, and fisheries conditions.

The year 1992 produced one of the lowest crab harvests on record and generated great public concern. By the fall of 1992, after extensive public discussion, both states introduced regulations to curtail the increasing fishing pressure from commercial and recreational crabbers. Despite the low harvests and public outcry that something must be done, the Maryland proposals were withdrawn due to lack of public support. Virginia was able to pass some legislation and regulatory measures in 1992 which took effect in 1993. To address the continuing concerns over harvest rates and increased effort, Maryland established the Blue Crab Advisory Board in November of 1992, similar to Virginia's Blue Crab Advisory Committee formed in 1987. After six months of deliberations, the Maryland Board's discussions produced the basis for the Maryland Crab Action Plan.

During this same time period the Living Resources Subcommittee (LRSC) established an independent body to review all Chesapeake Bay Fishery Management Plans. The Fisheries Management Plan Re-Assessment Task Force (FMP RAT) evaluated the 37 prescribed actions of the BCFMP and produced its findings in 1993. The Task Force judged that there was measurable progress on twenty-eight of the 37 actions, 13 of the 28 actions were delayed beyond the scheduled date, four actions were considered partially or minimally implemented and five have not been implemented. Action items identified by the FMP RAT Force which were not fully implemented include:

Action 1.1.1 Contain the commercial harvest at present levels;

Action 1.2 Establish Bay-wide regulations concerning harvests and size limits;

Action 11.3.2 Resolve conflicts between user groups;

Action 2.3.C Investigate extent of mortality on mature female crabs used as bait in the eel fishery;

Action 3.2 Collect Bay-wide recreational catch and effort data and evaluate impact of recreational harvest.

The FMP RAT Force review was thorough but many of the actions listed as delayed or partially implemented or not implemented have now been accomplished by regulation and legislation effective in 1994. The FMP RAT Force also produced recommendations for improving the effectiveness of the Fishery Management Plans, one of which is to conduct a substantive review at three to four year intervals to update, amend or revise the Plan.

One year after 1992 produced the worst crab harvest in years, the 1993 commercial catch in Maryland was the largest on record. Increased effort and/or participation in the Maryland fishery could account for some of the increased landings. Commercial hard crab landings for 1993 in Virginia were double the 1992 landings. Virginia implemented mandatory reporting by all commercial harvesters in 1993 and the large increase in landings for that year may be, in part, an artifact of the new reporting system. Anecdotal observations from the industry indicate 1993 was not an exceptional year for the fishery, and may even be on scale with 1992 landings.

One of the management strategies shared by Maryland and Virginia is to limit fishing effort. Implementing a combination of effort control management strategies, i.e. gear, time, and license reductions or stabilization may be effective at containing harvest. Maryland's Crab Action Plan (CAP) and respective legislation and regulations in Virginia responded to the strategy of effort stabilization with commercial and recreational restrictions. Many of the measures proposed in Maryland's CAP and adopted as regulations or legislation in 1994, and as Virginia law and regulations in 1992 and 1993, meet, and even exceed, the expectations of some problem areas in the 1989 BCFMP. The following section outlines recent management measures that resulted from commitments in the 1989 Plan.

Management Measures, 1992 - 1994

Virginia Regulations and Legislation, 1992 - 1994:

The 1992 session of the General Assembly passed a law which requires that all commercial fishermen obtain a registration license and a two-year delay process is in effect for new entrants. VMRC was given authority to limit entry and establish a maximum number of license holders and to require catch reports. A mandatory reporting program was established which requires that all commercial fishermen report their catch.

In 1992, the VMRC established a regulation describing the procedures for the registration of commercial fishermen and the manner and forms of mandatory harvest reports. Another regulation described the procedures that must be followed to cull harvested crabs to the legal limits.

The 1993 session of the General Assembly passed a law which authorized VMRC to establish recreational licenses. In other action, the commercial license structure was revamped. New licenses were established including a license for shedding crabs on a commercial scale and a peeler pot license.

In June 1993, VMRC established licenses for the recreational and personal use of crab pots, crab traps, and ordinary crab trot lines. This regulation limits the amount of gear and the catch, and sets gear identification and reporting requirements. The Commission also passed regulation which requires at least one unobstructed cull ring (2-5/16 inch diameter) in all hard crab pots as of January 1, 1994.

In November 1993, VMRC reduced the crab dredge daily catch limit from 25 to 20 barrels. Conditions to which the Commission would consider granting exceptions to the two year delay for a commercial registration license were added. The Commission also adopted regulation limiting entry in the crab dredge fishery. The sale of crab dredge licenses is limited to those persons who held licenses and were actively engaged in the fishery as of March 31, 1994, and caps the number of participants at 225.

In 1994, the General Assembly authorized the VMRC to promulgate regulations limiting the size of dredges.

Maryland 1994 Regulations and Legislation:

Maryland's Limited Entry Bill, recommended by the Maryland CAP and passed as legislation in April, 1994, limits new entries into the commercial fishery. Maryland has had a delayed entry program for five years, requiring that a person wait two years upon application before they will recieve a license to fish. Any person whose name was on the two year waiting list in Maryland prior to April 1, 1994, will receive a license two years after the date of application. The Limited Entry Bill gives the Department of Natural Resources authority to establish a prescribed number of people to participate in any given fishery. Once the two year waiting list is exhausted, no new licenses will be issued for that fishery until the number of licenses drops below the prescribed number. As licenses are lost voluntarily, by revocation or by death, the fishery will be capped at a maximum number of participants, and fishing effort will be limited.

Prior to 1994, there was no limit on the number of crab pots a commercial fishermen could fish in Maryland. Each licensee is now limited to no more than 300 pots, with an additional allottment of 300 pots per crew member not to exceed 900 pots per boat.

Times when commercial and recreational crabbers can set and fish their gear were defined in regulation in 1994 (see Appendix). Time limits were defined as such to limit effort in the number of man hours spent fishing, and were staggered in such a way as to minimize conflicts among user groups.

The noncommercial crab license was eliminated through legislation. Maryland currently has no licensing system for recreational crabbers, which now includes crabbers who were previously licensed as noncommercial crabbers. Unlicensed recreational crabbers were limited to 5 crab traps and/or rings per person while the licensed noncommercial crabber was allowed up to 50 traps and/or rings. All recreational crabbers are now limited to 10 traps and/or rings per person, not to exceed 25 traps and/or rings per boat. Trotline, which was limited to 500 feet for recreational crabbers and unlimited for noncommercial crabbers, is now limited for all recreational crabbers to 1000 feet per person, not to exceed 2000 feet per boat.

Cull rings which enable undersized crabs to escape have been used on a voluntary basis for several years. Current Maryland regulations require one cull ring 2 5/16 inches in diameter in all crab pots with mesh size greater than 1 1/2 inches or less than 2 inches. The cull ring may be obstructed at any time of year for the purpose of catching peelers.

The maximum number of crab pots which can be set from private property in Maryland is two. Some counties prior to 1994 were allowed four. The proposal that pots be set or constructed so trapped air-breathing animals could survive until released was rejected. All Maryland recreational crabbers are now limited to no more than one bushel per person and no more than 2 bushels per boat.

Current Management Strategy

Populations of blue crabs in the Bay fluctuate from year to year. Reproduction is influenced by environmental conditions such as temperature, weather events, offshore winds and currents. There is evidence that a relationship between levels of spawning stock and levels of reproduction exists when the spawning stock is fished below a certain threshold. Methods for forecasting annual abundance of the blue crab resource in the Chesapeake Bay are still being refined and a conservative approach to its exploitation is necessary.

The harvest of a fluctuating resource such as blue crab can be subject to a "ratchet effect." During relatively stable periods of high abundance as in the last decade, harvest rates and effort stabilize at a level which is excessive when abundance is average or below average. When the population is less abundant, the previously "normal" level of exploitation may result in overharvest and a potential for collapse of the population.

Managers from both jurisdictions are careful not to assume recent regulations will be completely effective in limiting effort and harvest of the fishery. These new restrictions and their effectiveness at stabilizing fishing effort must be evaluated. If these actions prove successful in limiting fishing effort on the blue crab stock in Chesapeake Bay, this management plan will have succeeded in the objective of being a "problem preventing" tool rather than solely a "problem solving" plan which many of the earlier management plans have been. If these actions prove successful, effort will stabilize, catch per unit effort will increase, landings will stabilize within some range over time and spawning stock will remain at a level adequate for stock replenishment.

Future management considerations could include daily individual harvest quotas, as are required in the commercial striped bass fishery in Maryland, as an effective alternative if current strategies prove inadequate. However, daily quotas are difficult to formulate and fishermen may be unable to respond to market demands. There is some concern that a quota system may actually induce more effort as those who did not normally land as much would feel compelled to fish up to the quota. As more data becomes available, a quota system could be investigated as a method of preventing overharvest in addition to or possibly instead of current regulations that restrict effort.

The 1994 BCFMP is better adapted to the realities of fisheries management on an interjurisdictional basis and is evolving to a "problem prevention/stock maintenance" strategy. Future management decisions will depend on the effectiveness of current regulations. Over the course of the next several years intensive research and monitoring will be necessary to evaluate whether the Bay states have insured the long term survival of the blue crab resource or whether new solutions must be sought to preserve the resource. The Blue Crab Bay-wide planning effort has been a model cooperative program to date.

Goal Statement and Objectives

<u>The goal of the 1994 Blue Crab Fishery Management Plan is to manage blue crabs in Chesapeake Bay in a manner which conserves the Baywide stock, protects its ecological value, and optimizes the long-term use of the resource.</u>

In order to achieve the Goal, the following objectives must be met:

1. Maintain the spawning stock at a size which minimizes low reproductive potential (from harvest) as a cause of poor spawning success.

2. Maintain a clear distinction between conservation goals and allocation issues.

3. Minimize conflicts among user groups and between jurisdictions by coordinating

management efforts throughout Chesapeake Bay.

4. Promote a program of education and publicity to help the public understand the causes and nature of problems in the blue crab stock, its habitats and its fisheries and the rationale for management efforts to solve these problems.

5. Promote a baywide regulatory process which provides adequate resource protection, optimizes the commercial harvest, provides sufficient opportunity for recreational crabbers, and considers the needs of other user groups.

6. Promote harvesting practices which minimize waste of the resource.

7. Determine and achieve environmental quality and habitat protection necessary for the maximum growth, reproduction and survival of blue crabs.

8. Identify and promote research to improve the understanding of blue crab biology and population dynamics.

9. Promote studies to collect necessary economic, social, and fisheries data to effectively monitor and manage the blue crab fishery.

Problems, Issues, and Solutions for 1994 - 1999

1. Increased Fishing Effort

Problem 1.1: Fishing Effort
The total amount of gear used and the number of participants in the crab fishery has increased over time. Research indicates there is a significant stock/recruitment relationship in the Chesapeake Bay blue crab population. The number of young produced (recruited) is influenced by the number of adult spawners and by environmental factors. Good recruitment requires sufficient spawning stock and favorable environmental conditions.

Strategy: In order to protect the reproductive potential of the blue crab stock, limits have been placed on fishing effort and on the number of participants. The new laws and regulations adopted in 1994 in Maryland and 1993 in Virginia to contain commercial and recreational fishing effort and protect stocks must be evaluated to determine their effectiveness. Both states will continue to monitor commercial catch, proceed with efforts to estimate effort by the recreational fishery, analyze the combined fisheries, determine safe levels of harvest, and, in Maryland, determine the maximum number of commercial harvesters.

Actions:

1.1.1 Maryland, Virginia and Potomac River Fisheries Commission have modified reporting methods to acquire more accurate and detailed data. Maryland and Virginia's mandatory reporting system collects data on areas fished, gear types and amounts, hours fished, amounts harvested and biological data. This data will be analyzed to determine actual harvest, biological composition of catch, and the effectiveness of current regulations for maintaining safe levels of harvest.

Implementation: 1994

1.1.2 Reliable and standardized crab landings are critical to evaluating the performance of the revised regulations and laws in Maryland and Virginia. New reporting methods will be compared with previous methods to standardize catch data in the two periods.

Implementation: Maryland, 1994
Virginia, Indeterminate

1.1.3 Maryland will determine a maximum number of commercial crabbing licenses and licenses with crew allocations as required under new Limited Entry law (Sect. 4-210). Based on recommendations of the Tidal Fisheries Advisory Board, the Chesapeake Bay Program and any other appropriate management body. The Department shall consider the number of people historically participating in the fishery, annual harvest, mortality, total biomass, size, number, incidental catch, target species, and any other factors which are necessary and appropriate.

Implementation: 1994

1.1.4 The impact of the 1993-1994 regulations and law in Maryland and Virginia will be evaluated. Evaluating the new limits on crabbing effort will take several years.

A. It will take several years before limited entry reduces the number of licenses through attrition.

B. Evaluation of the effects of limited entry will require several years of information from licensing data and the catch reporting system.

C. The effects of stabilized fishing effort on stocks will be difficult to evaluate and must be done through fishery independent studies.

D. Sport crabbing surveys in Maryland must be conducted consistently to evaluate the effects of time and gear restrictions. It will take several years for Virginia to accumulate a data base.

If the performance of the new requirements is determined to be insufficient, new regulations defining harvest seasons, additional gear restrictions, catch limits, and/or size limits will be considered to stabilize harvest and effort at levels which protect the reproductive potential of the blue crab stock.

Implementation: Indeterminate

1.1.5 Maryland will continue to develop a method of recording recreational catch and Virginia will continue to collect recreational data. Both states will monitor this data to determine if further restrictions on the recreational fishery are necessary.

Implementation: Indeterminate

2. Wasteful Harvesting Practices

Problem 2.1: Economic Yield
Harvesting small crabs or crabs of poor quality does not maximize economic value of the resource. The economic yield of crabs is not always optimized if buckrams (recently shed crabs whose shell is no longer soft, but is still in the process of hardening), which yield small amounts of meat, and late winter dredge crabs, which can yield poor quality meat, are brought to market. Other marginal harvesting practices include taking egg-bearing females which decreases reproductive potential and green crabs (any peeler crab without red or pink coloration in the swim fin).

Strategy: Optimum use of the blue crab resource will be promoted by eliminating and/or minimizing wasteful harvest practices, and by informing the consumer of poor quality or poor value crabs and discourage their purchase.

Actions:

2.1.1 Maryland and Virginia will continue to promote the release of buckrams through brochures and/or newsletters which identify buckrams and demonstrate the potential weight gain through time.

Implementation: Ongoing

2.1.2 Since buckrams weigh considerably less than hard crabs, i.e. 25 lbs./bushel as compared to 36-40 lbs./bushel for hard crabs, Maryland will investigate publicizing optimal bushel weight ranges for the various types of crabs and establishing minimum weight limits for each.

Implementation:

2.1.3 Maryland and Virginia will educate the consumer about wasteful harvesting practices and their effects on the resource so they may be better informed when purchasing crabs.

Implementation:

Problem 2.2: Cull Apparatus
Small crabs retained in hard crab pots suffer high mortality rates due to predation by larger crabs. Cull rings, which allow small crabs to escape, have been instituted in all jurisdictions; however, regulations allow cull rings in hard crab pots to be obstructed when fishing for peelers in Maryland and during times of economic hardship in Virginia. Cull rings may allow the escape of small, legal size peelers and mature females during certain seasons.

Strategy: The biological benefits and economic impact of cull rings in crab pots will be investigated to determine specific seasons when cull rings may be obstructed with minimal impact on the resource and the greatest economic benefit. Cull rings may also be considered as an alternative to size limits on soft and peeler crabs which are easily damaged during handling.

Actions:

2.2.1 Maryland will define seasons for peeler fishing with hard crab pots (pots with mesh size 1.5 inches or greater) for which cull rings may be obstructed to minimize the impact on the resource and maximize economic benefits. Outside of the defined season, the unobstructed cull ring requirement will be enforced.

Implementation:

2.2.2 Virginia will consider the mandatory use of cull rings throughout the hard crab pot season.

Implementation:

2.2.3 Virginia has already initiated studies to determine the economic impact of the cull ring requirement and will continue research to determine the significance of allowing obstructed cull rings for short periods of time.

Implementation: Ongoing

2.2.4 Virginia is investigating the use of cull rings in peeler pots to allow small crabs to escape and will consider mandatory cull rings in peeler pots and peeler pounds. Maryland?

Implementation: 1994

Problem 2.3: Female Harvest Rates
The practice of harvesting sponge crabs and females at other life history stages results in a loss of reproductive potential.

Strategy: Landings and fishery independent data will be reviewed to determine if actions limiting female harvest are needed. Biological and economic data will be reviewed to assess the effects of importing sponge crabs into Maryland.

Actions:

2.3.1 Maryland will investigate the interstate trade of blue crabs for the purpose of quantifying the number of sponge crabs and other types of crabs (which may not be legally harvested in Maryland) coming into the state.

Implementation:

2.3.2 Maryland will investigate the effects of prohibiting the import of sponge crabs, or crabs from which the egg packet has been removed, into Maryland, and consider regulations if the action is deemed biologically necessary.

Implementation:

2.3.3 Virginia will consider the expansion (time and/or area) of the spawning sanctuary.

Implementation:

2.3.4 Maryland will evaluate the use of female crabs as eel bait in eel pots.

Implementation:

2.3.5 Virginia and Maryland will continue to collect data on female size at maturity, migration, distribution and harvest by sex to study the effect of female harvest on crab population dynamics. This data can be used to determine management measures that protect the reproductive potential of blue crabs.

Implementation:

Problem 2.4: Abandoned Pots

Lost and abandoned crab pots are attractive refuge sites and often trap and eventually kill significant numbers of crabs and finfish. Weak and dead crabs attract other crabs into abandoned pots, and are self-baiting. Abandoned pots also trap and drown air breathing animals such as terrapins that inhabit tributaries. Biodegradable materials and escape panels have been the subject of preliminary investigation in Maryland. Abandoned pots are also navigational hazards for boats. The abandonment of pots is illegal in Maryland, and is prohibited during the month of January in Virginia. Enforcement is difficult and fines are not significant enough to discourage deliberate abandonment. Pots are also lost when boat propellors cut buoy lines, during storms, and by sabotage. Pots partially crushed by clam dredging may also be a significant source of abandoned pots.

Strategy: Causes of abandoned pots will be investigated, the deliberate abandonment of crab pots will be discouraged, and escape mechanisms in pots will continue to be researched.

Actions:

2.4.1 Virginia and Maryland will continue to address regulation of abandoned crab pots, including significant fines that may discourage deliberate abandonment.

Implementation:

2.4.2 Virginia and Maryland will continue to investigate materials for biodegradable escape panels and latches in crab pots and escape mechanisms for air breathing animals.

Implementation:

2.4.3 Maryland and Virginia will investigate the feasibility of establishing used pot disposal sites in Bay counties and other incentives which would encourage proper disposal of damaged or spent crab pots.

Implementation:

2.4.4 Maryland and Virginia will educate commercial crabbers about the problems of abandoned crab pots and educate property owners about the effects of pots left unattended.

Implementation:

2.4.5 Maryland and Virginia will investigate placement of identification on crab pots so that lost pots may be returned and purposeful abandonment will be discouraged.

Implementation:

2.4.6 The problem of clam dredge rigs destroying pots will be investigated.

Implementation:

Problem 2.5: Shedding Mortality
The mortality rate of green crabs (a peeler crab without red or pink coloration in the swim fin) held in shedding floats is high compared to peelers that are close to molting. Mortality rates in shedding floats and poorly operated shedding systems may be high. Virginia allows one shedding tank or float for personal use without a license.

Strategy: Information will be provide to shedders to minimize mortality in shedding operations.

Actions:

2.5.1 Maryland and Virginia will continue to provide technical information to shedding operations that promote reduction of peeler mortalities associated with holding practices.

Implementation: Ongoing

2.5.2 Virginia established a commercial shedding license, effective January 1, 1994, and will monitor data reports.

Implementation:

2.5.3 Maryland will reintroduce the shedders license requirement for the purpose of identifying shedders and in order to provide technical assistance.

Implementation:

2.5.4 Virginia will continue to educate watermen on problems related to green crab mortality.

Implementation: Ongoing

2.5.5 Maryland will investigate a joint venture with commercial watermen's associations to establish a state-of-the-art shedding facility for the purpose of research and to educate the shedding industry.

Implementation:

3. Stock Assessment Deficiencies

Problem 3.1: Commercial Reporting
Maryland introduced a new reporting system in 1994 which collects information on effort by gear type and person, time spent fishing, and biological characteristics (hard females, #1 and #2 male hard crabs, soft/peelers, culls) of the harvest. Virginia instituted a mandatory reporting system in January, 1993, to include information on harvest and effort levels and biological characteristics of the harvest. While the new Maryland and Virginia systems are comparable, they are still not fully compatible. Potomac River has mandatory reporting by all fishermen which collects data on effort, age and sex of blue crab harvest.

Strategy: New reporting methods will be used with continued fishery independent surveys to monitor trends in catch and effort, produce reliable estimates of blue crab abundance, and understand the fishery and the relationships between harvest and stock.

Actions:

3.1.1 Maryland and Virginia will monitor commercial records in order to evaluate the relationship between fishery dependent and fishery independent indications of abundance.

Implementation: Ongoing

Problem 3.2: Recreational Harvest
There is a lack of information about the blue crab recreational catch and effort and the economic impact of recreational crabbing in Chesapeake Bay. Virginia has instituted mandatory reporting for all licensed recreational crabbers. Maryland was unsuccessful in attempts to require recreational licenses during 1994.

Strategy: There will be a Baywide effort to collect recreational catch and effort data and to evaluate the economic impact of the recreational harvest.

Actions:

3.2.1 As of 1993, Virginia requires annual reporting by all licensed recreational crabbers including weight harvested, location of harvest, days fished, and amount of gear used. This data will be used to determine recreational harvest and effort.

Implementation: Underway

3.2.2 Maryland will seek a recreational crabbers license requirement in 1995. Maryland would require reporting for licensed recreational crabbers compatible with Virginia's reporting method.

Implementation: 1995

3.2.3 Maryland will continue to pursue a method of recording recreational catch as stated in Action 1.1.5, and propose a sport crabbing monitoring project to improve monitoring of the blue crab resource.

Implementation:

Problem 3.3: Research Needs
The population dynamics of the blue crab stock is not fully understood. Our understanding would be improved by obtaining additional information on natural and fishing mortality rates, the stock-recruitment relationship, and the effects of environmental variables and anthropogenic change on year class strength and availability.

Strategy: The Baywide effort to collect population data on blue crabs will continue, and current methods will be improved to assure baywide uniformity of data sets and achieve reliable and more accurate catch estimates.

Actions:

3.3.1 Maryland and Virginia will continue to refine the analysis of the winter dredge survey as a consistent annual assessment of the abundance, distribution, and mortality of the crab resource.

Implementation: Ongoing

3.3.2 Maryland and Virginia will continue to encourage research on recruitment-stock and stock-recruitment relationships and how environmental parameters affect fluctuations in crab abundance.

Implementation: Ongoing

4. Regulatory Issues

Problem 4.1: Commercial/Recreational Conflict
The blue crab fishery consists of recreational and commercial fractions which provide economic, social and recreational benefits to the community. Conflict between commercial crabbers and recreational boaters has become a serious problem in some of the more densely populated areas of Virginia and Maryland. From the recreational boater's point of view, crab pot floats are interfering with recreational boating. From the commercial waterman's perspective, recreational boaters are interfering with crab potting because they inadvertently run over and cut off crab pot floats. There is competition for trotline space in the tributaries.

Strategy: Conflicts among user groups and the general boating public can be minimized by rational application of time, area, and gear restrictions to allocate space and harvest of the resource. Coordinated interstate management is necessary to insure optimal baywide usage.

Actions:

4.1.1 Maryland and Virginia will continue to monitor conflicts between crabbers and recreational boaters and enforce existing regulations on open and closed crabbing areas and buoy-free channels.

Implementation: Ongoing

4.1.2 Maryland has staggered start and end times for recreational and commercial crabbing. The effectiveness of these time limits will be monitored.

Implementation: 1994

Problem 4.2: Interstate Trade
The interstate shipment of peelers and soft crabs may circumvent efforts to protect the Chesapeake Bay stock from illegal fishing activities. A major problem in Maryland is that undersized crabs are illegally harvested and then either marketed in state as out-of-state crabs or shipped to states which have no minimum size limits.

Strategy: Maryland and Virginia will continue to investigate the biological and economic effects of size limits on the soft crab fishery and the need to coordinate soft and peeler size limits.

Actions:

4.2.1 Maryland will consider a ban on the importation of crabs which do not meet State requirements.

Implementation:

4.2.2 Maryland and Virginia will work to achieve consistent Baywide standards for minimum sizes of all crabs harvested in Chesapeake Bay.

Implementation:

5. Public Health and Consumer Concerns

Problem 5.1: Personal Consumption
Poor quality crabs yield less meat and bring lower prices. Quality crabs are reserved for preferred customers such as restaurants and seafood markets, while the lesser quality crabs are often all that is available to the small consumer who buys whole crabs, usually by the bushel, for personal consumption.

Strategy: In order to maintain the quality of the supply of crabs available for public consumption, minimum weight standards and volume could be established for the various types of blue crabs.

Actions:

5.1.1 Maryland will evaluate the necessity of establishing a minimum bushel weight for various grades of crabs.

Implementation:

5.1.2 Maryland will define by regulation the minimum volume of a crab bushel, as well as potential substitutes, such as the waxed cardboard seafood box.

Implementation:

Problem 5.2: Foreign Import
Regulations limiting effort in the Chesapeake blue crab fishery have generated fear that foreign markets will see reduced local harvest as an opportunity to move in on the market. The present regulations are not expected to reduce harvest, but rather limit excessive growth of the fishery

and prevent any future openings in the market for foreign producers to fill. Over the past several years there has been an increase in imports of crabmeat from warmwater areas that compete with processed Chesapeake Bay crabmeat. This substitute product puts downward pressure on the price of crabmeat, and may lower profits of crabmeat processors and the price paid to watermen. The industry has made strong efforts to differentiate the Chesapeake Bay product as a higher-quality product than imported meat in order to maintain a higher price for its product. Maryland passed legislation in 1994 that requires crab meat with foreign content be labeled as such. Regulations are pending in Virginia concerning the repacking and subsequent labeling of crabmeat.

Strategy: Efforts will be made to insure that consumers are aware of the origin of the crab products they purchase.

Actions:

5.2.1 Imported crab meat shall be identified as such in Maryland as required by Section 21-339 of Annotated Code of Maryland, Health Article.

Implementation:

5.2.2 In addition to foreign crab meat, the interstate shipment of crab products shall be surveyed in Maryland.

Implementation:

6. Habitat Degradation

Problem 6.1: Anoxia
Loss of wetlands and forests to development and agriculture has reduced the percolation of rainwater. Excess nutrients entering the Bay from agricultural and urban runoff, sewage treatment plants and atmospheric deposition from the burning of fossil fuels results in algal blooms which produce anoxic conditions in the Bay. The anoxic portion of the Bay has been steadily increasing in size and duration over time and is reducing the amount of habitat available to crabs, increases intraspecies competition, compresses fishing effort and harms commercial fishing due to the high mortality of crabs retained in pots in anoxic and hypoxic areas.

Strategy: Maryland, Pennsylvania, and the District of Columbia have outlined a Tributary Strategy that will reduce the amount of nutrients from tributaries to the Bay 40% by the year 2000 to meet the Bay Program's nutrient reduction goal.

Actions:

Major goals outlined by the jurisdictions include:

Maryland:
- * Upgrade 50 waste water treatment plants to control nitrogen and phosphorus discharges.
- * Encourage farmers to implement nutrient management plans and plant cover crops.

Pennsylvania:
- * Implement nutrient control efforts in state farm lands.
- * Fence hundreds of miles of streams to keep livestock out.

District of Columbia:
- * Upgrade Blue Plains waste water plant, the greatest source of nutrients from the district.
- * Control combined sewer overflow to reduce the frequency of overloads.
- * Control additional runoff at construction sites, new development, public education, and habitat restoration.

Virginia is in the process of formulating a tributary strategy which will reaffirm the 40% nutrient reduction goal and is expected to be adopted in late 1994. Virginia also plans to continue tributary monitoring in support of tributary modeling.

Problem 6.2: Submerged Aquatic Vegetation and Intertidal Wetlands
Shoreline development that reduces shallow water habitat, channel dredging, heavy boat traffic, crab scraping and clam dredging have all been identified as sources of local destruction of submerged aquatic vegetation (SAV). Crab scraping in Virginia is restricted to hauling by hand and hard crab bycatch is illegal. In Maryland heavy scrapes with power winders are used during the early season to catch hard crabs. Nutrient influx, as discussed in problem 6.1, and sediment runoff are responsible for widespread declines throughout the Bay. The loss of SAV and intertidal wetlands has resulted in the loss of blue crab habitat, particularly during the juvenile and molting stages.

Strategy: The Bay jurisdictions will maintain a priority status on protection of SAV and intertidal wetlands.

Actions:

6.2.1 Maryland and Virginia will prepare a report on blue crab habitat and biology and identify critical habitat utilized by the species, and will emphasize preservation of blue crab habitat for permitting agencies.

Implementation:

6.2.2 Maryland will consider limits on scraping for hard crabs in the early crabbing season.

Implementation:

Problem 6.3: Water Quality

The blue crab appears to be a resilient species. Their migratory nature and short life span make them less susceptible to bioaccumulation of contaminants. Toxicology studies in Baltimore Harbor and the Elizabeth River, the two most heavily polluted areas of the Bay, found minimal accumulation of toxins in tissues of blue crabs. Once toxics are allowed to accumulate their effects are difficult to impossible to reverse, and blue crabs could be affected by the loss of benthic foods and/or toxics may accumulate beyond some threshold which exceeds the crab's level of tolerance. Blue crabs are most sensitive during their larval stages. Environmental requirements of larval and juvenile crabs are not well known, and spawning grounds and major nursery areas are not easily identified.

Strategy:

Actions:

6.3.1 Virginia will continue their long term monitoring program which samples the water column, benthos, and biological community in the bay mainstem and tributaries and continue fall line nutrient monitoring and chlorophyll analysis.

Implementation: Ongoing