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COASTAL BAYS BLUE CRAB FISHERY MANAGEMENT PLAN (SEPTEMBER 2001)

Cover Sheet

The document referenced above is proposed for incorporation by reference. The proposal to incorporate the document will appear in the Maryland Register issue of May 3, 2002. A Notice of Final Action will appear in a subsequent issue of the Maryland Register, and will give the date on which the revisions in the document referenced above will become effective. You will be notified when Final Action occurs.

Coastal Bays Blue Crab Fishery Management Plan

Prepared by:
Maryland Department of Natural Resources
Coastal Bays Fishery Advisory Committee

September 2001

MARYLAND COASTAL BAYS

POLICY COMMITTEE

ENDORSEMENT STATEMENT

BLUE CRAB FISHERY MANAGEMENT PLAN FOR MARYLAND'S COASTAL BAYS

We, the undersigned, endorse the 2001 Blue Crab Fishery Management Plan for Maryland's Coastal Bays. We agree to accept the 2001 Blue Crab Fishery Management Plan for Maryland's Coastal Bays as a guide to conserving the blue crab resource of the coastal bays, protecting its ecological and socio-economic value, and optimizing the long-term use of the resource. We further agree to support implementation, by the dates set forth in the Plan, the management actions recommended to assess the impact of *Hematodinium* (disease), conduct a comprehensive stock assessment, control crabbing effort and harvest rates, improve the quality of recreational crabbing, protect blue crab habitat, and implement effective enforcement.

We recognize that the 2001 Blue Crab Fishery Management Plan for Maryland's Coastal Bays is based on the science as we know it today, and not an endpoint. We recognize the need to commit long-term, stable, financial support and human resources to the task of managing the blue crab resource of the coastal bays and addressing important research needs. In addition, we ask the Maryland Department of Natural Resources to periodically review and update the Plan and report on progress made in achieving the Plan's management recommendations.

For Maryland Department of Natural Resources

Chuck Fox, Secretary

For Worcester County

John Bloxom, President

Jeanne Lynch, Commissioner

For Town of Ocean City	James Mathias, Mayor
For Ocean City Council	Rick Meehan, President
For U.S. Environmental Protection Agency	Richard Kampf
For Maryland Department of Agriculture	Royden Powell
For Maryland Department of the Environment	Jane Nishida, Secretary
For Maryland Department of Planning	Rich Hall
For Assateague Island National Seashore	Mike Hill, Superintendent
For MCBP Scientific Technical Committee	Rick Kutz
For Local Citizens	Jack Burbage
Carolyn Cummins	Edward Lee
	Louise Gulyas, Commissioner

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Brett Brinkley, Natural Resources Police
Nancy Butowski, Fisheries Service
Jim Casey, Fisheries Service
Steve Doctor, Fisheries Service
Dean Simpkins, Natural Resource Police
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EXECUTIVE SUMMARY

In July 1999, a Comprehensive and Conservation Management Plan was adopted for Maryland's coastal bays. This Plan distinguished Maryland's coastal bays as a separate, unique ecosystem from the Chesapeake Bay, and included a recommendation that the Maryland Department of Natural Resources (DNR) address fishery issues specific to Maryland's coastal bays. Fishery issues were divided into three categories: finfish, shellfish and blue crabs. This document specifically addresses the issues related to blue crabs, and sets forth management strategies for improving blue crab management in the coastal bays.

The status of the coastal bays blue crab stock is difficult to assess because of uncertainties in the population's stock recruitment relationship. Fishery dependent and independent data indicate relatively stable populations which fluctuate annually, and without any discernable long-term trends. Localized declines may not be apparent in the data and is of concern, especially in regards to the declining satisfaction among recreational crabbers.

The goal of the Blue Crab Fishery Management Plan (FMP) for Maryland's Coastal Bays is to manage blue crabs in a manner which conserves the coastal bay stock, protects its ecological and socio-economic values, and optimizes the long-term use of the resource. To achieve this goal, the following objectives have been defined: 1) Improve our understanding of how disease (*Hematodinium*) contributes to the mortality and population abundance of blue crabs; 2) Improve our understanding of blue crab biology and stocks; 3) Maintain an economically stable and sustainable commercial blue crab fishery; 4) Improve the recreational crabbing experience; 5) Protect, maintain and enhance blue crab habitat; and 6) Improve the enforcement of crabbing restrictions.

A series of management strategies have been developed to address the objectives of this FMP. Some of the more significant actions include: assessing the impacts of disease (*Hematodinium*) on blue crabs; improved monitoring of the blue crab stock and commercial fishery; stabilizing commercial crabbing effort; protecting important blue crab habitats; obtaining recreational catch and effort estimates; maximizing the reproductive potential of female crabs; and reducing bycatch mortality of crabs, as well as air breathing animals.

The development of this FMP is based on the science as we know it today. This FMP is not an endpoint but establishes a management framework for protecting the blue crab resource. It provides a format by which the Department can adjust management recommendations as new information on Maryland's coastal bays blue crab resource becomes available.

SECTION 1. GOAL AND OBJECTIVES

The goal of the Maryland Coastal Bays Blue Crab Fishery Management Plan is to manage blue crabs in Maryland's coastal bays in a manner which conserves the coastal bay stock, protects its ecological and socio-economic value, and optimizes the long-term use of the resource.

To achieve this goal, the following objectives must be met:

1) Improve our understanding of how disease (*Hematodinium*) contributes to the mortality and population abundance of blue crabs;

2) Improve our understanding of blue crab biology and stocks;

3) Maintain an economically stable and sustainable commercial blue crab fishery;

4) Improve the recreational crabbing experience;

5) Protect, maintain and enhance blue crab habitat; and

6) Improve the enforcement of crabbing restrictions.

SECTION 2. BIOLOGICAL BACKGROUND

Introduction

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 also an economically important resource throughout its range. For example, the commercial blue crab fishery in Maryland and Virginia has the highest value of any state commercial fishery. Reported dockside value has ranged from $53.3 million to $66.5 million between 1995 and 1999. In addition, there is a recreational fishery which contributes an unknown, but believed to be, significant quantity to the economy of the region. The blue crab is an important natural resource requiring sound management to protect its long-term health and economic benefits.

Maryland's Atlantic coastal bays comprise a separate, unique ecosystem from the Chesapeake Bay. The coastal bays watershed is much smaller than the Chesapeake Bay watershed, covering an area approximately 525 km^2. The coastal bays support an important blue crab fishery that is similar but distinct from the Chesapeake Bay. Fishery independent data from the coastal bays indicate year-to-year variation but no trends in blue crab abundance. The commercial harvest of blue crabs has also fluctuated without trend. Causes of population fluctuations are poorly understood. Between 20-60% of the variance in the Virginia commercial dredge fishery can be explained by a spawning stock-recruitment model developed from a 20-year database (Lipcius and Van Engel, 1990). Understanding processes associated with postlarval and early juvenile stages are necessary for the development of population models applicable to the blue crab and its fisheries. In particular, processes affecting transport (i.e. dominant wind patterns during there recruitment season and runoff), settlement, metamorphosis (physiological state, behavior, nursery habitat availability and salinity effects) and post-settlement survival (mortality from 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 is similar to that of other marine species with complex life cycles and open populations. Larvae (zoeae) are released by mature females in high salinity water, typically near the mouth of bays, sounds and estuaries (Van Engel, 1958). The larvae are transported to the continental shelf where development continues through 7 or 8 zoeal (larval) stages and usually takes between 30 and 45 days (reviewed in Millikin and Williams, 1984; McConaugha et al., 1983; McConaugha, 1988). Larvae require salinities in excess of at least 30 parts-per-thousand (ppt) for optimal development (Costlow 1967) and are poorly adapted to undergo development in salinities less than 26 ppt. During development, larvae feed on zooplankton and plant material (Truitt, 1939).

Larvae metamorphose (transform) into a postlarva or magalopa stage which occurs on the nearshore shelf (Epifanio et al., 1984). The duration of the postlarval stage is plastic and may have important consequences for settlement and recruitment to juvenile populations (Sulkin and Van Heukelem, 1986). Postlarvae exhibit transitional behavior, morphology and physiology between the larval and early juvenile stages, and return to estuarine waters from offshore areas (Cronin and Forward, 1982; Sulking and Van Heukelem, 1986; McConaugha, 1988; Lipcius et al., 1990; Metcalf

and Lipcius, 1992). A retention mechanism has been postulated for blue crabs which involves the along-shore southerly flow of water carrying early zoeae stages away from their origin. A circular pattern is created with the mid-shelf and wind generated flow of surface water to the north which later-stage larvae and postlarvae are returned to estuarine areas. For the Chesapeake Bay, the dispersal and recruiting phases of the blue crab are thought to be retained near the mouth and subsequently re-enter the estuary. Within the bay, postlarvae utilize nocturnal, tidal-flood currents to reach shallow, estuarine nursery habitats (Meredith, 1982; Mense and Wenner, 1989; Olmi, 1993). The nursery habitats are predominantly seagrass beds where the postlarvae metamorphose to the first juvenile instar stage (Orth and van Montfrans, 1987).

Larval transport into and out of the Maryland coastal bays may not function in the same manner as transport into larger estuaries. The Maryland coastal bays are connected to the Atlantic Ocean by an inlet at Ocean City and an inlet at the southern end of Chincoteague Bay in Virginia. Since the mouth of the Ocean City inlet is only 200 yards wide, there may be some natural restrictions to returning larvae. All female crabs may not leave the coastal bays to spawn. The coastal bays are predominantly polyhaline (>25 ppt salinity) with a mean bottom salinity of 31 ppt. Average salinity in Chincoteague Bay is about 2 ppt greater than the three other coastal bay areas (EPA, 1995) and can reach as high as 35 ppt in the summer due to slow water exchange rates and evaporation (Linder et al., 1996). Considering the salinity data, some spawning and larval development may occur within the coastal bays. Larvae have been found in the coastal bays but the extent of annual survival is unknown.

Epifanio et al. (1984) suggests there is a mixing of blue crab larvae from a variety of sources along the continental shelf. It is believed that the wind and tide ultimately distribute the larvae back to the estuaries. Consequently, settlement of postlarvae does not necessarily occur in the "parent" estuary. In addition, postlarval settlement does not occur uniformly in time, but as a series of pulses associated with wind events. For a wind event to be effective, it must occur when postlarvae are close enough to the estuary to allow transport into the estuarine habitat. This random process of events can provide an explanation of inter-annual variability in blue crab populations (Epifanio, 1995). This process has further implications for blue crab populations. The various estuaries of the Mid-Atlantic Bight are most likely subpopulations of one open population (Roughgarden et al., 1988) or metapopulation (Grosberg and Levitan, 1992). Results from a genetic study indicate there is gene flow between all blue crab populations from New York to Texas (McMillen-Jackson et al., 1994). Management strategies regarding the blue crab fishery in the coastal bays need to consider the role of larval transport, survival and recruitment, and how it contributes to the variability in commercial/recreational harvests. In addition, because there is a strong impact on future harvest by offshore larval processes, the offshore habitat should also be considered.

Settlement and Recruitment

As postlarvae enter estuaries, they progress through well-defined morphological and physiological changes which influence their behavior patterns and prepare for postlarval settlement. Planktonic individuals collected along an offshore (coastal ocean) to onshore (York River mouth) transect exhibited progressively more advanced molt stages, indicating a direct relationship of advanced physiological state with ingress into the estuary. Individuals from natural settlement habitats were in late premolt and approaching metamorphosis to the first juvenile instar (Lipcius et al., 1990; Metcalf and Lipcius, 1992).

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, generally follows a neap-spring tidal cycle, with brief periods of high abundance following spring tides by several days. This suggests that entry into estuaries is facilitated by increased tidal excursion. Superimposed on this fortnightly pattern are peaks of abundance related to wind events that transport postlarvae towards the coast and into estuaries via non-tidal volume exchange (Goodrich et al., 1989). Once within an estuary, postlarvae migrate vertically in response to light and tide, utilizing nocturnal flood tides to augment their transport up the estuary to shallow-water settlement sites (Olmi, 1993).

Postlarval settlement patterns are relatively unknown in the coastal bays. Settlement of blue crab postlarvae 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 moons (Orth and van Montfrans, 1987; van Montfrans et al., 1990). The same fluctuating pattern of settlement has been observed annually, with substantial variation in timing and magnitude. Episodic settlement peaks account for more than half the annual total. Artificial settlement substrates may provide a measure of postlarval abundance and could serve as an indicator of blue crab harvest.

Early Juvenile Stages

In the coastal bays, juveniles often inhabit mats of bryozoans, bottom detritus and seagrass beds. As the juveniles increase in size, they move into shallow, muddy, marsh-lined tidal guts generally 18 inches to 4 feet (0.4 to 1.2 m) in depth. These areas generally contain the largest abundance of juvenile crabs and are also utilized as overwintering habitat for crabs < 1 inch (25 mm).

Adults and Reproduction

In estuaries with distinct salinity regions, large male crabs generally occupy the upper reaches of tributaries while females generally migrate towards higher salinity (Hines et al., 1987). In the coastal bays where differences in salinity are small to nonexistent, adults appear to segregate in relationship to the Ocean City Inlet. A higher percentage of mature female crabs dominate Sinepuxent Bay, Isle of Wight and the St. Martin's River, areas that are slightly higher in salinity and closer to the Ocean City Inlet. Male crabs are found at higher percentages in Newport and Chincoteague Bays, areas that are farther from the Ocean City Inlet (S. Doctor, MDNR, personal communication).

Most mating occurs from May through October. Males carry and protect the females during molting and mating takes place while the females is in the soft-shell stage of the pubertal molt. Pubertal-molt female crabs initiate their final molt at approximately 100 mm in the coastal bays, smaller than in the Chesapeake Bay (115 mm) (Knotts, 1989). After this final interval of growth, the average size of adult females is 134 mm in the coastal bays and 155 mm in the Chesapeake (Knotts, 1989; Hines et al. 1987). The pairs separate and after the shell hardens, females migrate to staging areas in Sinepuxent and Isle of Wight Bays, 2.5 to 4.5 miles (4.0 to 7.0 km) from the Ocean City Inlet. Early arrivals will spawn prior to winter while latecomers spawn the following spring after winter hibernation.

Females carry their egg mass on their underside, beneath their aprons, and open to the water to expose an orange, round, sponge-like mass. Depending on crab size, the "sponge" may contain from 750,000 to 8,000,000 eggs (Prager et al., 19990). Blue crabs are serial spawners and can spawn up

to three times in a season (McConaugha et al., 1983; Jones et al., 1990). Crab larvae are hatched and released from the egg mass to enter a planktonic existence where they are subject to a host of environmental pressures such as wind-driven circulation patterns, tidal currents, temperature, salinity and extensive predation. Postlarve generally reinvade estuarine areas, metamorphose to juveniles, and disperse throughout low salinity shallow waters (Hines et al, 1987). 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 number of crabs recruiting to the coastal bays in any given year, relies partly on the size of the spawning stock. The spawning stock includes all mature females that survive natural and fishing mortality. The spawning stock is not limited to female crabs with an egg mass. Any juvenile female crabs larger than 80-100 mm (3.2-3.9 inches) has a high potential to reproduce if not removed by the fishery. The reproductive success of female blue crabs may also be limited by the availability of males (Hines et al., 2000). When regulating harvest and effort, consideration should be given to the proportion of female/male harvested.

Predator - Prey Relationships

Blue crabs serve as both predator and prey in the benthic and planktonic food webs of estuaries and bays. Movement through the water column by postlarvae make them a food source for plankton feeders such as menhaden, as well as other finfish that forage in the water column (Olmi, 1993). Settled postlarve and young juveniles become prey for numerous predators including summer flounder, American eel, drum, spot, croaker, striped bass, weakfish, some sharks and cownose rays. Juvenile crabs are also prey for large blue crabs and other species of crabs such as the lady crab, *Ovalipes ocellatus*, and the lesser blue crabs, *Callinectes similis*. The endangered Kemp's Ridley sea turtle, *Lepidochelys kempii*, prefer large blue crabs. Although the number of Kemp's Ridley is quite low, they have been reported in the Chesapeake region. Two other sea turtles, the Green turtle, *Chelonia mydas,* and the loggerhead turtle, *Caretta caretta*, can also be found in the Chesapeake region and are known to feed on crabs. Recent questions have been raised about the resurgence of striped bass and their effects on the blue crab resource. Goshorn and Casey (1993) and Mosca et al. (1995) examined the relationship between striped bass abundance and blue crab landings in Chesapeake Bay and found no significant relationship. Food habits of large striped bass (>450 mm) were examined in the Chesapeake Bay in 1997 and 1998. Results indicated that large striped bass infrequently ingest blue crabs and contributed little to the overall weight of stomach contents (Austin and Walter, 1999). Another study, however, conducted in the lower Chesapeake Bay had different results. Three fish species (striped bass, red drum and croaker) were sampled in lower bay seagrass beds. These species consumed substantial numbers of large blue crabs (van Montfrans et al., 2000). Striped bass food habits may change with age/size of the fish. Regional differences in food preferences and/or availability may also occur.

Blue crab prey include bivalves, crustaceans, fish, annelids, plants and detritus (Darnell, 1958; Tagatz, 1986; Alexander, 1986). Although the blue crab is an opportunistic predator (Laughlin, 1982; Mansour, 1992), it prefers soft-shelled clams (i.e. *Macoma* spp. and *Mya arenaria*). Blue crab feeding habits may control some bivalve populations (Lipcius and Hines, 1986; Egleston, 1990; Mansour and Lipcius, 1993; Eggleston et al., 1992). In intertidal marsh habitats, blue crabs prefer the marsh periwinkle but killifish are also an important food item (Van Heukelem, 1991). Blue crabs readily cannibalize smaller blue crabs (Mansour, 1992; Mansour and Lipcius, 1993). Recent research

on feeding habits of blue crabs indicate that when their preferred food item becomes depleted, cannibalism on juvenile crabs increases in intensity (Mansour, 1992). 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). The incidence of cannibalism in blue crabs has been measured in several areas and ranged from 25% (York and Rappahannock Rivers, 1988-1989) to as high as 90% (Rhode River, A.H. Hines, Smithsonian Environmental Research Center, 1990). Cannibalism may play an important role in the coastal bays since blue crabs are found in high densities (S. Doctor, MDNR, personal communication).

Disease

Adult and juvenile crabs from the coastal bays of the Delmarva region have been found to be infected with an unusual parasitic dinoflagellate, *Hematodinium perezi*. This dinoflagellate lives in the hemolymph of blue crabs, where it rapidly proliferates and kills its host. Beginning in 1992, Maryland watermen from the coastal bays reported dead crabs in their baited crab pots. Studies conducted since 1992 have found a seasonal pattern of disease prevalence in the coastal bays. Up to 90% of juvenile crabs have infections during the early winter but heavy mortalities in adults are reported by watermen during the summer months. Prevalence of infected crabs appears to vary with location. Infections are found more often in shallow coastal bays than in deeper, larger estuaries (Messick & Shields, in prep). Other factors, such as host size, influence the prevalence of disease infections. Experiments have shown a decrease in infection intensity at lower temperatures (Messick et al., 1999). The apparent 0% prevalence from later winter through spring in the coastal bays is probably related to low water temperatures (Messick 1994). Blue crabs presumed uninfected (there was no detectable disease in their hemolymph) have developed infections when held in warmer temperatures for 2 weeks (Messick et al. 1999).

The impact of *Hematodinium* on the blue crab resource in the coastal bays in unknown. Mortality rates during epizootic events are difficult to estimate because dead crabs sink (Shields 2000). In non-epizootic years, disease prevalence has varied between 20 to 50% on the Delmarva peninsula. Under laboratory conditions, disease-induced mortality occurred after approximately 30 days. The laboratory studies indicate that disease is a significant threat to blue crab fisheries occurring in high salinity estuaries (Shields 200). How disease contributes to mortality in the coastal bays is an important management consideration.

Habitat Requirements

Habitat within the Maryland coastal bays is biologically diverse. Over 11,000 acres of salt marsh have been estimated for the coastal bays (Christoffers 1990). For the Delmarva peninsula, submerged aquatic vegetation (SAV) has increased from 2,129 hectares in 1986 to 7,200 hectares in 1999. There was a 17% increase in the total hectares of SAV from 1998 (6,155 hectares) to 1999 (7,200 hectares) (VIMS website). Although seagrass beds are a good overwintering habitat for juvenile crabs, shallow, muddy marsh-lined tidal guts also provide excellent winter habitat for crabs (<1 inch). In the coastal bays, large numbers of small crabs have been found in marshy, tidal guts. In areas where seagrass, marsh channel and oyster habitats coexist within an area, juvenile blue crab densities have been greatest in the seagrass, followed by the marsh channel habitat. Given the presence of

seagrass and/or marsh channels, oyster habitats are minimally used (Frazer et al., 200).

In general, the habitat requirements for blue crabs are quite varied. Crabs utilize a wide range of salinities and a wide range of bottom habitat types including oyster bars, sand bottoms, salt marshes, and seagrass beds (Engel and Thayer 1998). On a regional basis, vegetated habitat areas and commercial harvests of blue crabs have been significantly correlated (Orth and van Montfrans, 1990). For example, vegetated habitats were most important for juvenile crabs in the lower Chesapeake Bay (Heck and Thoman, 1981; Penry, 1982; Heck and Wilson, 1987; Wilson et al., 987; Orth and van Montfrans, 1987; Montane et al., 1993). The availability and functional ecology of vegetated habitats 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 constraints of invading postlarvae and provide developing juveniles with significant protection from predators during initial growth (Pile, 1993) and provide molting refugia for subadults (Ryer et al., 1990). Growth rates of juvenile crabs in seagrass beds are higher than in adjacent unvegetated areas (Perkins, 1993). Grass beds also serve as overwintering habitat for juvenile crabs. Where seagrass beds are sparse, juvenile and mature males bury in unvegetated creek and river channels, as well as deeper areas in the mainstem of bays (Hines et al., 1987). Macroalgae also serve as important habitat for juvenile crabs in the coastal bays. Habitat use by young juveniles in not static. As juveniles grow larger than about 25 mm in carapace width, they migrate out of grass beds and disperse throughout other shallow-water habitats. Juvenile crabs also use oyster bars as habitat. Juvenile distribution can be altered by physical disturbances such as tropical storms. 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. Tidal gut areas are especially important in the coastal bays.

The following habitat parameters are summarized from the document, "Habitat Requirements for Chesapeake Bay Living Resources" (Funderburk et al. 1991) for blue crabs.

Dissolved Oxygen

Blue crabs avoid areas with low dissolved oxygen (DO) and are known to leave the water to escape hypoxic (low oxygen) water (often referred to as a "crab jubilee"). Studies have found about 50% mortality associated with crabs held in waters with < 2ppm oxygen at depths below 7 m (Carpenter and Cargo, 1957). Hypoxic water has been shown to effect the recruitment and migratory success of postlarval (megalopae) blue crabs by altering behavior associated with shoreward transport and settlement processes (Tankersley and Ziegler 2000). Besides affecting blue crab physiology, anoxic waters (no oxygen) may also reduce the benthic food supply and limit blue crab distribution. Maintaining a DO greater than 3mgL at 25-28°C should provide an adequate area to support blue crabs.

Salinity

Blue crabs can inhabit freshwater (0 ppt) to hypersaline water (>36 ppt) but are most often found in brackish or waters of intermediate salinity. Egg and larval development require salinities of greater than 20 ppt with optimum salinity around 30 ppt.

Turbidity

The effects of turbidity on blue crabs is unknown. Turbid water might interfere with swimming

ability of the early larval stages. Increase turbidity can have serious consequences on the survival of seagrass beds. Seagrasses are dependent on adequate transmitted light for survival. Because seagrass is used as a nursery area for young crabs and a refuge for molting crabs, its loss could have long-term effects on blue crab populations (Engel and Thayer, 1998).

Temperature

Blue crabs exhibit a wide range of temperature preferences. Temperature tolerance limits have been examined in the laboratory. Juvenile and adult female tolerance limits were similar. The upper temperature limit of crabs acclimated at 30°C and 24 ppt was 39°C and the lower limit was 4.6-4.9°C. For crabs acclimated at a lower salinity, 6.8 ppt and 30°C, had an upper limit of 37°C and a lower limit of 5.3-6.0°C. In general, blue crabs are less tolerant of low temperatures at low salinities. Thus, their behavior has survival value. During cold weather and in low salinity areas, blue crabs migrate to deeper water.

Contaminants

Juvenile blue crabs have been used in a variety of toxicity tests. The U.S. Environmental Protection Agency (EPA) has compiled the results (Mayer 1987, Addendum I). Generally, the larval stages are more sensitive to toxic materials than the juvenile or adult stages. The sublethal effect of toxic substances on the larval stage is a lengthening of the developmental period. Juveniles and adults can be exposed to toxic substances by burying in the sediment, by runoff from urban, suburban, and agricultural areas, and by eating contaminated food, especially bivalves (Van Heukelem, 1991).

Marine Protected Areas

Preventing the overexploitation of a fishery resource is a major issue for management consideration. Although advancements have been made in fishery science, there is uncertainty associated with stock assessment analyses. Uncertainty also arises from the complex nature of the aquatic environment and from incomplete biological information. Besides uncertainty associated with the environment and estimates of fish populations, there are additional biases associated with fishing mortality. They include under reported harvest, bycatch, and incidental mortality (Lauck et al., 1998). Given these restraints, the ability to detect overfishing and predict the collapse of a stock is limited. In spite of these limitations, management strategies need to be developed whether the information is complete or not. It is now an acceptable practice to allow for uncertainty and inaccuracies in projected sustainable catch levels (Lauck et al. 1998).

The use of marine protected areas (MPAs) to protect fish populations and marine/estuarine ecosystems has been suggested as a viable management tool and a possible means to address uncertainty in fishery science. Marine protected areas are also referred to as reserves or sanctuaries. Designating closed areas to fishing is not a new concept. What makes an MPA different from a fishing closure, which is usually species-and/or gear-specific, would be the length of time an area is closed and the complete elimination of all fishing activity. Protected areas have the potential to affect a variety of functions, depending on the species. They could be used to restrict access to sensitive habitats such as the use of marine zoning in the Florida Keys (Causey, 1999). They could be used to protect spawning/nursery grounds or preserve biodiversity by protecting aquatic ecosystems from the effects of fishing (Nowlis and Roberts, 1998). In areas where there is high exploitation, MPAs allow populations

to increase in size and density. As adults grow larger and older, their contributions to reproduction becomes greater. If the larger adults move out of the protected areas, they become available to harvest and increase fishing yield. If spawning takes place within the MPA, larvae may also move out of the protected area and enhance recruitment. Data from the Merritt Island National Wildlife Refuge documented an increase in abundance and the availability of larger fish compared with an area outside the refuge. Tagging results from his protected area also documented emigration from the protected area to unprotected areas (Johnson et al., 1999). Although the positive effects of MPAs have been highlighted, MPAs have limitations and their use alone cannot guarantee protection of a particular fish/shellfish populations. The use of MPA's is limited by processes that are unique to aquatic systems such as hydrographic circulation patterns, episodic events (El Nino), and large-scale patterns of population replenishment and anomalous climatic effects (Allison et al., 1998).

Determining the size and area of a MPA depends on the life history and habitat requirements of the species under consideration. Computer modeling of MPAs suggest that heavily-fished populations benefit from MPAs and may help to reduce large yearly population fluctuations (Lauck et al., 1998). Computer models also suggest that MPAs should be large, 40-80% of the populations range, to gain full benefits. Before establishing MPAs, there should be a clear goal. Since the effectiveness of MPAs has only been documented in a few cases, a monitoring program should be established to determine whether or not MPAs are achieving their desired objectives.

Establishing a MPA in the coastal bays to benefit blue crabs could be a viable management tool. After mating, female blue crabs congregate in specific staging areas to overwinter. In the spring, they are particularly vulnerable to harvest. A MPA in one of these areas could contribute to enhancing the blue crab population and support ecological functions in several ways. A MPA would protect spawning females in the spring from harvest. It would also have the potential to protect important blue crab habitats (i.e. shallow water and shoreline habitats, SAVs) and contribute to stabilizing commercial and recreational effort.

Multispecies Interactions

The northern diamondback terrapin *(malaclemys terrapin)* is a resident species in Maryland's coastal bays. It is classified as a brackish water species that inhabits shallow estuarine bays, lagoons, creeks and marshes, especially *Spartina* grass (Carr, 1952). Terrapins generally prefer creeks and marsh edges rather than open waters of sounds or bays but will utilize open water as they swim from area to area. Terrapins can withstand a wide range of salinity but are never found in freshwater ponds, streams or rivers. Terrapins are active from April through October and usually hibernate from November through March. Terrapins are top predators in the aquatic food chain and feed on a variety of bivalves, gastropods, fish and crustaceans. There is some evidence to suggest that females have a more varied diet than males and that food preferences can vary depending on their locality from year to year (Wood ,1995). The status of terrapins in Maryland's coastal bays is unknown and there is a limited amount of information on terrapin distribution. In the Delaware Bay, terrapins are relatively common along the shoreline but their overall distribution is patchy (Wood, 1995).

One of the major sources of mortality for terrapin populations is drowning in crab pots (Roosenburg et al., 1996; Seigel and Gibbons, 1995). Several aspects of their life history contribute to their vulnerability in crab pots. Terrapins are air-breathing reptiles and crab pots do not allow access to air. Terrapins are most active during the entire blue crab fishing season (April through November).

The habitat of terrapins overlaps with blue crabs. Crab pots are placed in areas where terrapins are present and terrapins are attracted to the types of bait typically used in crab pots such as razor clams, menhaden, and other fish species. Terrapins are probably more vulnerable to being caught in crab pots in the coastal bays then in the Maryland portion of the Chesapeake Bay. In the Chesapeake Bay, the use of crab pots is restricted to the Bay's mainstem. Commercial crab pots can be fished anywhere in the coastal bays including the tributaries. The recreational use of crab pots by landowner is of particular concern for terrapins. Landowners are allowed to use two crab pots from their pier or waterfront property. Many recreational crab pots are therefore, placed in shallow rivers and creeks inhabited by terrapins (Roosenburg et al., 1996).

Crab pots contribute to terrapin mortality at two levels, a constant background mortality from crab pots used on a regular basis and occasional large kills from abandoned crab pots (Roosenburg et al., 1996). A single, abandoned crab pot has killed as many as 29 and 49 terrapins, in North Carolina (Bishop, 1983) and Chesapeake Bay (Roosenburg, 1991), respectively. The extent of the large kills by abandoned pots is unknown. Annual mortality due to crab pots has been estimated between 15% and 78% for the Patuxent River terrapin population (Roosenburg et al., 1996). Male terrapins are smaller than females and are vulnerable to being caught in crab pots throughout their lives. Female terrapins are vulnerable to being caught in crab pots up to age 8 and then become too large to be caught (Roosenburg et al., 1996). Crab pot induced mortality may contribute to differential survivorship and skew sex ratios. The use of a terrapin excluder or bycatch reduction device in crab pots has been effective at preventing the capture of terrapins and reducing mortality. Beginning in April 1999, a crab pot set in Maryland waters from private piers and waterfront property must have a bycatch reduction device (BRD) attached to each entrance. The BRD may be constructed of metal wire or plastic and should be rectangular (1 3/4" by 4 3/4"). The size of the BRD has been shown to successfully exclude terrapins from crab pots without affecting the crab catch. New Jersey and Delaware also require terrapin excluder devices in crab pots. Virginia does not require any terrapin BRD.

Research and Monitoring

The Maryland Department of Natural Resources Fisheries Service has conducted trawl and seine surveys in the coastal bays since 1972. The primary function of these surveys is to sample the annual relative abundance of juvenile and adult marine species. The annual coastal bays trawl survey samples the relative abundance of blue crabs. The survey has 20 sites (Appendix 1) which are sampled by a 16 foot balloon otter trawl, each month from April through October. Data from the trawl survey are analyzed for trends in abundance and size. The most recent data (2000) indicates that blue crab abundance in the coastal bays has increased from 1998 but is not as high as it was from 1993 through 1996 (Figure 1). Catch per unit effort (CPUE) also increased in recent years (1999 and 2000) is higher than its been since 1994 (Figure 2).

Figure 1. Annual abundance of blue crabs in the Maryland coastal bays (1972-2000).

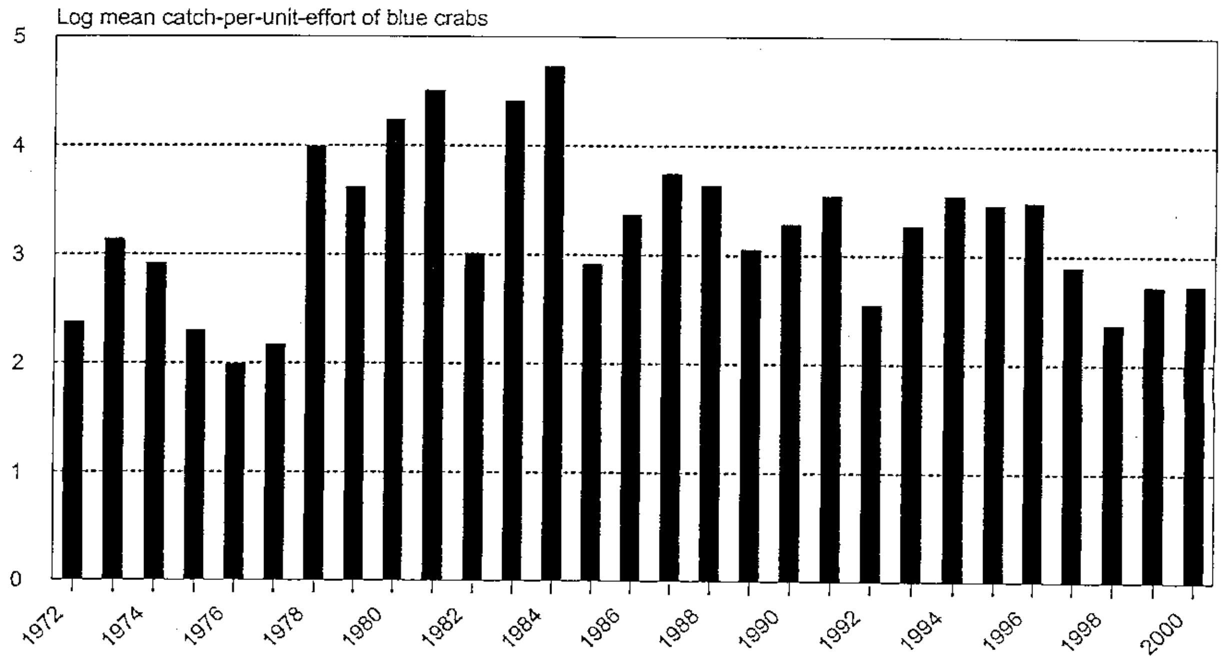
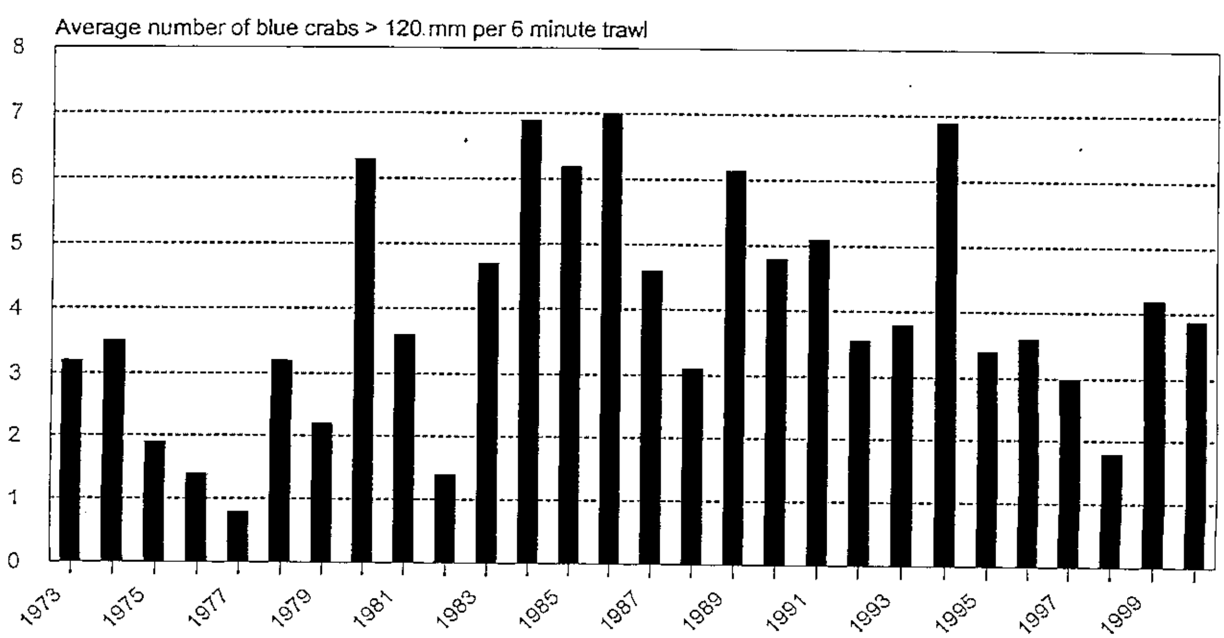


Figure 2. Catch-per-unit-effort of blue crabs (>120 mm (4.72 in.)) per 6 minute trawl in the Maryland coastal bays (1973-2000).



The mean size of blue crabs in the coastal bays is smaller than the mean size of crabs in the

Chesapeake Bay (Table 1). In the coastal bays, 95% of the blue crabs are less than the minimum legal size of 127 mm, while in the Chesapeake Bay, 79% of the crabs are below the minimum size. The difference is size can be attributed to high salinities in the costal bays. Generally, crabs from higher salinity areas reach maturity at a smaller size than those from lower salinity areas **(Reference).**

Table 1. Mean size of blue crabs from the Maryland coastal bays trawl survey and the Chesapeake Bay summer trawl survey.

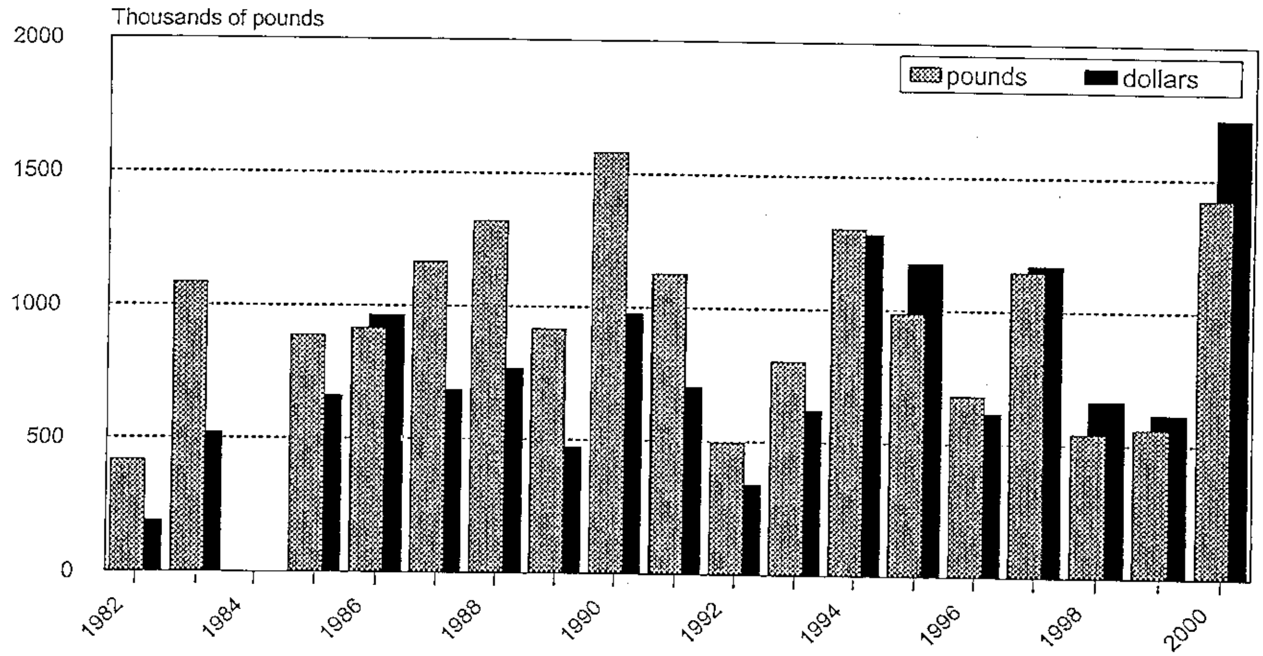
Size Category	Coastal Bays	Chesapeake Bay
All sizes and sex	58.8 mm	87.4 mm
Males >126mm	137.8 mm	146.7 mm
Mature Females	134.0 mm	151.0 mm

The density of all sizes of crabs appears to be higher in the coastal bays than in the Chesapeake Bay. The mean catch per tow of all size crabs from the coastal bays from 1989 through 1999, was 49 crabs per tow. The mean catch per tow for all size crabs from the Chesapeake Bay blue crab summer trawl survey for the same time period was 22 crabs per two. A high density of crabs in the coastal bays could be due to a variety of factors. The coastal bays habitat is a preferred depth for blue crabs throughout the whole of the coastal bays and the smaller size of the crabs probably allow for greater densities.

Status of the Coastal Bays Blue Crab Stocks

Over the past 10 years (1991-2000), annual reported commercial landings have varied from 0.5 million to 1.5 million pounds. This is similar to the 1980's when landings varied to 0.4 to 1.5 million pounds (Figure 3). Commercial coastal bay landings of hard crabs and soft/peelers has been highly variable without trend over the past 26 years. In 2000, landings increased substantially from an average of 550,000 pounds in 1998 and 1999 to 1.4 million pounds (Figure 3). Commercial landings alone do not provide an adequate description of blue crab abundance. Maryland DNR requires all commercial watermen to report their harvest, gear usage, and area fished on a monthly basis. Although there is mandatory reporting, not all commercially licensed individuals report their landings. Reporting compliance is between 73% and 79% for TFL license holders and between 90% to 93% for LCC license holders. The accuracy of the landings/harvest data has been questioned but is the best available information to date.

Figure 3. Commercial blue crab harvest and dockside value in the Maryland coastal bays (1982-2000).



The annual fishing intensity on hard crabs and soft/peeler crabs is variable. A substantial part of this variation is driven not only by natural population fluctuations but also by weather conditions, the timing and intensity of the peeler run versus that of the Chesapeake's peeler run, the outlook for the overall Chesapeake crab fishery, and the outlook for dockside prices paid by dealers. Even with this variability, there is no discernible increasing trend in the rate of commercial fishing on either the hard crab or soft/peeler fishery.

Since 1973, the fishery independent coastal bay trawl project has sampled in excess of 236,000 crabs. The annual surveys indicate the number of crabs has been highly variable but within historical values for small (<2.4 in.), medium (2.4 in. - 4.7 in.), and large (>4.7 in.) crabs. Reproduction, as measured by the relative abundance of small crabs in the trawl survey, is variable but within the historical range of values. The conclusion from the fishery independent data is that the crab stock throughout the coastal bays is relatively stable and fluctuates without any discernible long-term trends.

The impact of the recreational fishery on the blue crab stock in the coastal bays is unknown. Anecdotal evidence indicates there is a declining satisfaction among recreational crabbers, however, the fishery-independent population trends do not indicate a problem.

Description of the Coastal Bays Blue Crab Fisheries

Commercial Fishery

Commercial crabbing in the coastal bays has existed at varying intensities since the late 19th century. Over the past 10 years, at least seven different types of crab gear have been used with varying degrees of success (Table 2). During this period, crabs pots were the major gear type and accounted for approximately 98% of the harvest. Over the past seven years (1994-2000), an average of 226

commercial watermen were licensed annually in Worcester County (Table 3). Over the same period, an average of 172 licensed commercial watermen crabbed the coastal bays with an average of 70% (111 licensees) being Worcester County residents. Worcester County resident watermen do not crab strictly in the coastal bays. Approximately 26% of Worcester County residents also crab in the Chesapeake at some time during the year.

Approximately 63% of coastal bays commercial crabbers have a LCC license. Although the number of LCC license holders dominates the commercial fishery, they only land 11 to 26% of the total harvest. The LCC license permits the use of 50 pots, unlimited trotline, dip nets, collapsible traps and scrapes. The LCC licensee reports an average use of 13 to 19 pots. (Table 4). Pot use by LCC licensees also varies by month with the largest number of licensees crabbing during the summer months (June-August) (Figure 4). Those watermen with the TFL and CB3 licenses are permitted all types of legal gear. There is a 300 pot limit per boat permitted in the coastal bays. These crabbers fish the largest number of pots, averaging 200 per licensee (1994-1999) (Table 5). Although this group represents only 37% of the crabbers, they land 74% to 89% of the total commercial crab harvest. Over the past six years, the average number of pots used per licensee has varied without trend. In the last few years there has even been a slight decline in number of licensees.

The price paid for crabs is a result of market conditions, interstate imports and the economy. In 2000, the average price paid for peeler/soft crabs was $5.15/pound. Over the last 10 years, prices for this category have varied from a low of $1.54 to a high of $6.38. For hard crabs in 2000, the average price paid per pound was $0.96 for No. 2's and $1.73 for No. 1's. The total value of the blue crab harvest from the coastal bays has varied between $340,000 (1992) and $1.7 million (2000) over the past 10 years (Figure 4).

Commercial crabbers are primarily attracted to the coastal bays for its spring peeler run. Since 1995 Worcester County resident crabbers have outnumbered non-county crabbers in both the spring peeler run and the year-long hard crab fishery. Consequently, fishing intensity, pot use and landings have varied without any discernible long-term trends.

Figure 4. Average number of pots reported by LCC licensees in the Maryland coastal bays by month (1995-1999).

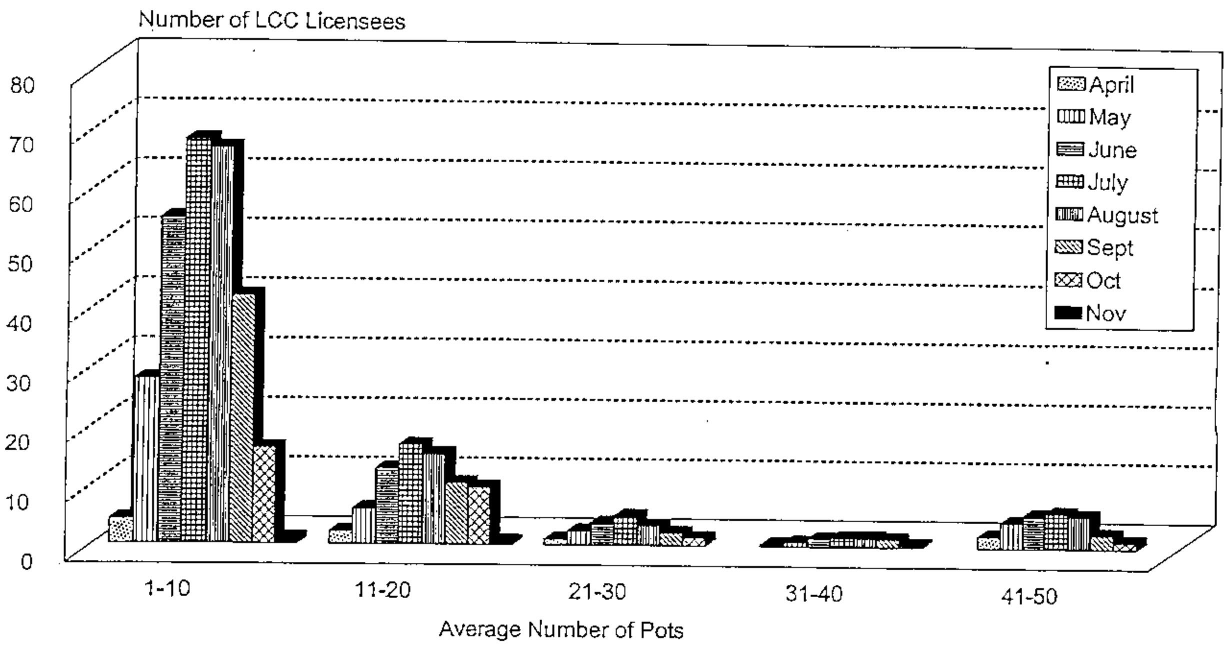


Table 2. Summary of coastal bays blue crab landings (lbs) by gear type (1990-2000).

Year	Crab Pot	Trotline	Collapsible Trap	Crab Scrape	Crab Bank Trap	Dip Net	Net Rings	Unknown
1990	1,600,000	5,058	419	—	—	—	—	—
1991	1,100,000	2,371	1,607	—	—	—	—	—
1992	500,000	—	209	—	—	—	—	—
1993	800,000	—	—	—	—	—	—	—
1994	1,200,000	13,325	65	1,891	603	—	—	794
1995	1,000,000	8,852	13	—	—	36	—	3,552
1996	700,000	2,906	13,459	—	72	31	—	2,041
1997	1,100,000	77,161	—	—	—	16	77	5
1998	5,975,000	5,975	341	—	—	—	—	—
1999	1,441,000	1,441	—	—	—	—	—	—
2000	1,419,991	1,380	—	—	—	—	22	885

Table 3. Licensed crabbers in Worcester County and the coastal bays, 1994-2000.

Year	Number of Worcester County Licensed Crabbers (a)	Total Number of Licensee's Crabbing in Coastal Bays (b)	Number of Resident Worcester County Crabbers (c)	Total Number of Crabbers Working Only in Coastal Bays (d)
1994	168	193	77	145
1995	256	195	124	162
1996	249	162	115	144
1997	236	181	116	153
1998	225	159	114	149
1999	224	159	115	151
2000	222	158	114	145

(a) Not all Worcester County licensed crabbers work only or seasonally in the coastal bays. Part of the county fronts on the lower Pocomoke River and many work exclusively or seasonally in the Chesapeake Bay and its tidal tributaries.
(b) This is the total number of licensed Maryland crabbers who work at least part of the time in the coastal bays. Many are out-of-county crabbers who come over for the spring peeler run then return to the Chesapeake Bay.
(c) This is the number of resident Worcester County licensed crabbers who indicate that they work only in the coastal bays. Again, this may be seasonal and/or part time work.
(d) This is the total number of licensed Maryland commercial crabbers, both county and non-county Maryland residents who indicate that they crab only in the coastal bays. This category also includes the totals from column (c). Again, this may be seasonal and/or part time work.

Table 4. Number of commercial crabbers with the LCC and TFL license and average number of reported pots used per LCC and TFL licensee in Maryland's coastal bays, 1994-2000.

Year	LCC License Holders		TFL License Holders	
	# of Licenses	Average # of Pots Used Per Licensee	# of Licenses	Average # of Pots Used Per Licensee
1994	122	13	65	219
1995	131	14	57	216
1996	114	14	46	194
1997	112	17	53	209
1998	111	19	43	167
1999	92	15	35	192
2000	106	11	43	195

Recreational Fishery

The recreational fishery for blue crabs in the coastal bays has not been documented. There is a need for accurate annual recreational estimates of crabbing in the coastal bays. It is generally believed to be not as large as the recreational blue crab fishery in the Chesapeake Bay which is approximately 25% of the commercial harvest. In the Chesapeake Bay, recreational landings have been estimated between 11 and 40 million pounds annually. Recreational crabbers in the coastal bays believe there has been a decrease in crab abundance based on what they use to catch. Waterfront property owners are no longer catching large number of crabs. Current data limitations make it difficult to discern if the decrease in satisfaction is due to a decrease in crab abundance or another unknown reason.

Recreational crabbing in the coastal bays is primarily a small boat fishery. Much of the recreational effort is centered in the two northernmost coastal bays, the Isle of Wight and Assawoman. The small boat fishery primarily uses collapsible traps but some illegal use of crab pots occurs. Crab pots are considered as commercial gear in Maryland but not in Virginia which may cause some confusion. Another source of confusion comes from waterfront landowners who are allowed to use two crab pots from their property. The Natural Resources Polic have confiscated as many as 50 pots during the summer months. Tributaries like Turville Creek, Mancklin Creek and the St. Martin's River are popular locations for the small boat fishery.

Crabbing from shore in the coastal bays is limited because the region does not have the numerous natural, shoreside and public access sites found in Chesapeake Bay. Most shoreside sites in the coastal bays are privately owned. The few, well-used public access sites near Ocean City are bulkheads, bridges and piers. Most of these sites are not optimum for crabbing because of strong currents, shallow waters and boating activity. These areas are better for fishing than crabbing. Only three small public sites are regularly used for crabbing, the public ramp bulkhead at south Point, the Assateague State Park pier, and the public pier in Northside Park, Ocean City. Other public sites found in the coastal bays are isolated and generally unknown except by the local residents. Throughout the coastal bays, there are approximately seven other land sites (in addition to the three already mentioned) with public access, that are used to varying degrees for fishing and/or crabbing: St. Martin's Neck Road causeway, north of the Isle of Wight; south shore, the Isle of Wight; fishing/crabbing pier at Sandy Point, Assateague State Park; bulkhead, South Point public boat ramp; public pier, village of Public Landing; and, bulkhead, Taylor's Landing public boat ramp. Shoreside crabbing takes place along the bulkheads and private piers in developments and along the southern side of the Isle of Wight. In these instances, handlines are the gear of choice with some use of collapsible traps.

SECTION 3. MANAGEMENT STRATEGY

OBJECTIVE 1: Improve our understanding of how *Hematodinium* contributes to the mortality and population abundance of blue crabs.

<u>Problem 1.1: Research and Monitoring</u> - Adult and juvenile crabs from the coastal bays have been found to be infected with a parasitic dinoflagellate, *Hematodinium perezi*. Up to 90% of juvenile crabs have infections during the early winter and high mortalities in adults are reported by watermen during the summer months. How the disease contributes to mortality and impacts the blue crab population is an important management issue.

Action 1.4.1: DNR and MCBP will identify potential funding sources to support the following research and monitoring activities:

a) Assess the impact of *Hematodinium* in the coastal bay's blue crab population (i.e. identify what intensity of *Hematodinium* infection causes mortality, and identify other factors, environmental and/or biological, that may influence blue crab mortality from *Hematodinium*).
b) Identify factors which influence *Hematodinium* proliferation, elucidating different life stages, determining the full life cycle of the parasite, and eventual production of a more specific diagnostic tool either by immunoassay or molecular assay techniques.
c) Examine how crabs become infected with *Hematodinium*.

Implementation (a-c): 2001

Action 1.4.2: DNR will define the criteria under which a Marine Protected Area can be effective in assessing the impacts of *Hematodinium* on blue crabs.

Implementation: Initiate in 2001

OBJECTIVE 2: Improve our understanding of blue crab biology and stocks.

<u>Problem 2.1: Stock Status</u> - Fishery dependent and independent data indicate relatively stable crab populations which fluctuate annually without any discernable long-term trends. Localized declines may not be apparent in this data and is of concern given the declining satisfaction among recreational crabbers. Factors influencing crab abundance are not well understood and more information is needed to facilitate future management efforts.

Action 2.1.1: Adopt an overfishing threshold consistent with Chesapeake Bay that preserves a minimum of 10 percent of the blue crab's spawning potential (F_{10} percent), and a fishing target that preserves 20 percent of an unfished stock. (F_{20} percent).

Implementation: 2001

Action 2.1.2: DNR will work towards implementing the necessary research and monitoring programs to determine the appropriate fishing mortality rates that will achieve the established fishing target of F_{20} percent. (Chesapeake Bay mortality rates (fishing and natural) are not necessarily transferable to Maryland's coastal bays.)

Implementation: Continue current fishery independent and dependent surveys, and implement additional research and monitoring, as necessary, based upon available funding.

Action 2.1.3: DNR will work towards allocating funds specific to the Department's coastal bays blue crab monitoring program and data analysis.

Implementation: Initiate in 2001

Action 2.1.4: DNR and MCBP will encourage research that examines the stock - recruitment relationship of blue crabs in the coastal bays, level of localized reproduction and entrapment of larvae, and effects of environmental parameters which influence fluctuations in crab abundance (i.e. including this action in the FMP will identify these research needs as a high priority which will better enable DNR, MCBP, Universities and others to obtain support for funding these research projects).

Implementation: 2001

Action 2.1.5: DNR will examine the utility of developing a public outreach indicator(s) of blue crab abundance which can be used to inform the community on the annual status of blue crab stocks in the coastal bays.

Implementation: 2001

Problem 2.2: Commercial Catch and Effort Data - Maryland modified the blue crab commercial reporting system in 1994 by implementing mandatory monthly reporting. Despite this effort, many fishermen still do not provide monthly reports (i.e. 25 percent and 10 percent of TFL and LCC license holders, respectively) and their harvest has to be estimated. The effects of this reporting change and accuracy of the current reporting system are unknown. Further, the harvest of crabs by individuals who begin the crabbing season (i.e. April and May) in the coastal bays prior to returning to Chesapeake Bay for the remaining season is not accurately monitored. Commercial crabbers are currently required to identify the body of water for which the majority of their monthly harvest was taken. Individuals who crab commercially in both the coastal bays and Chesapeake Bay during one month (i.e. May) may be reporting the entire months harvest as Chesapeake Bay. Implementing a new reporting system may affect the utility of long-term landings data but is necessary to address management issues in the coastal bays.

Action 2.2.1: DNR will establish, implement and evaluate a commercial reporting monitoring program to obtain accurate catch and effort data from anyone crabbing commercially in Worcester County consistent with recommendations of the Atlantic Coast Cooperative Statistics Program.

a) Evaluate the effectiveness of the "pilot" daily logbook reporting system implemented in 2000 for commercial crab harvesters and dealers in Worcester County.

Implementation: 2001

b) Consider using the Chesapeake Bay's commercial crab reporting system, but make it specific to the coastal bays, including more detailed information on location of harvest and effort data.

Implementation: 2001

Action 2.2.2: DNR will improve the enforcement of mandatory monthly reporting.

Implementation: 2001

Problem 2.3: Recreational Catch and Effort Data - There is no information on the harvest, effort, and economic impact of recreational crabbing in the coastal bays.

Action 2.3.1: DNR will design and implement a recreational crabbing survey in the coastal bays consistent with the pilot recreational crabbing survey in Chesapeake Bay.

Implementation: 2001 - Dependent on funding.

Action 2.3.2: DNR will identify potential funding mechanisms to fund and complement monitoring efforts outlined in Strategies 2.3.1 and 2.1.1.

Implementation: 2001

Problem 2.4: Invasive, Non-Indigenous Species - The coastal bays support eight species of walking crabs and three species of swimming crabs, one of latter sharing the same genus as the blue crab. Two of the former, the green crab (*Carcinus macnas*) and Japanese shore crab (*Hemigrapsus sanguineaus*) are exotic (non-native) species which have recently arrived in the coastal bays. The green crab first appeared in the Ocean City inlet and has since expanded its range north and south in the coastal bays. Green crabs prey upon bivalves and other crab species. In Maine, the green crab has been blamed for the collapse of the soft-shell clam industry (ASMFC 1999). Although both non-indigenous crab species in the coastal bays are known to feed on other crabs and generally the same forage, their effect on the native blue crab population is speculative at this time.

Action 2.4.1: DNR will continue to monitor the abundance and impact of green crabs and other invasive, non-indigenous crab species.

Implementation: Ongoing, but limited due to funding.

Action 2.4.2: DNR will evaluate the following management strategies related to green crabs:

a) DNR will prohibit the possession and sale of imported green crabs, and promote the harvest and sale of locally harvested green crabs.

b) DNR will prohibit the importation and sale of green crabs.

Implementation: 2001

Action 2.4.3: DNR will continue to work with Maryland's Non-Indigenous Species Task Force to examine invasive species issues, and develop an Aquatic Nuisance Species Plan to become eligible for Federal funding.

Implementation: Ongoing

Action 2.4.4: MCBP will develop an outreach program (i.e. brochures) to educate the coastal bays community on the impacts of exotic species.

Implementation: 2001

Problem 2.5: Functional Role of Blue Crabs in the Natural Ecological Community - The natural ecological functions of blue crabs in the coastal bays needs to be determined and considered in the blue crab fishery management plan. Outside of the information on the predator-prey relationships of blue crabs, little information is available to determine the natural ecological function of blue crabs in the coastal bays.

Action 2.5.1: DNR will examine methods/studies to better understand the natural ecological functions of blue crabs in the coastal bays, including the establishment of a Marine Protected Area in the coastal bays.

Implementation: Dependent on funding.

OBJECTIVE 3: Maintain an economically stable and sustainable commercial blue crab fishery.

Problem 3.1: Commercial Crabbing Effort - The available data indicate that commercial crabbing effort in the coastal bays is within an acceptable level. Given the current difficulties in accurately assessing the coastal bays' crab stock, limited understanding on the factors which influence population fluctuations, and concerns about the accuracy of commercial effort data, it would be prudent to prevent effort from increasing until an accurate stock assessment is available.

Action 3.1.1: DNR will improve the accuracy of effort data in the coastal bays' commercial blue crab fishery by implementing actions related to Problem 2.2 - Commercial Reporting.

Implementation: Initiate in 2000

Action 3.1.2: DNR will continue to manage the coastal bays commercial blue crab fishery through the use of time limits, seasons, gear restrictions, catch limits, size limits, limited entry, and other management strategies as necessary, to prevent further increases in fishing effort.

a) **Gear Restrictions** - Prohibit the taking of blue crabs in the coastal bays by scrape and dredge to prevent these fisheries from developing, and lessen the gear impacts on blue crab habitat;

b) **Time Restrictions** - Establish similar time restrictions to those in the Chesapeake Bay to prevent a shift in crabbing effort from the Chesapeake Bay to the coastal bays during years when crab abundance is low in the Chesapeake Bay.

1) For 2001 - Prohibit the taking of crabs for commercial purposes between 2:00 p.m. and 5:30 a.m.

Implementation: 2001

<u>Problem 3.2: Harvest of Female Crabs</u> - The harvest of sponge crabs and females at other life history stages may result in a loss of reproductive capacity. It is difficult to assess whether or not the protection of females will result in an increase in abundance of blue crabs in the coastal bays without understanding if there is a stock-recruitment relationship, and the impacts of Hematodinium. If research (Action 2.1.3) indicates localized reproduction and entrapment within the coastal bays is significant, it may be prudent to establish short-term management measures aimed at protecting female crabs, and monitor the effects of these measures on the coastal bays' blue crab population to determine if they should be continued on a long-term basis.

Action 3.2.1: DNR will continue to prohibit the harvest of sponge crabs, and limit the taking of female crabs in the coastal bays through the use of time limits, seasons, area closures, gear restrictions, catch limits, and size limits, as necessary.

a) **Area Closures** - DNR will delineate areas where female blue crabs are concentrated (Action 5.2.1(a)), and determine the appropriate time periods for which commercial crabbing and hydraulic clam dredging should be allowed within these areas. The following areas have been identified as potential closure areas (Figure 6) but need to be delineated further:

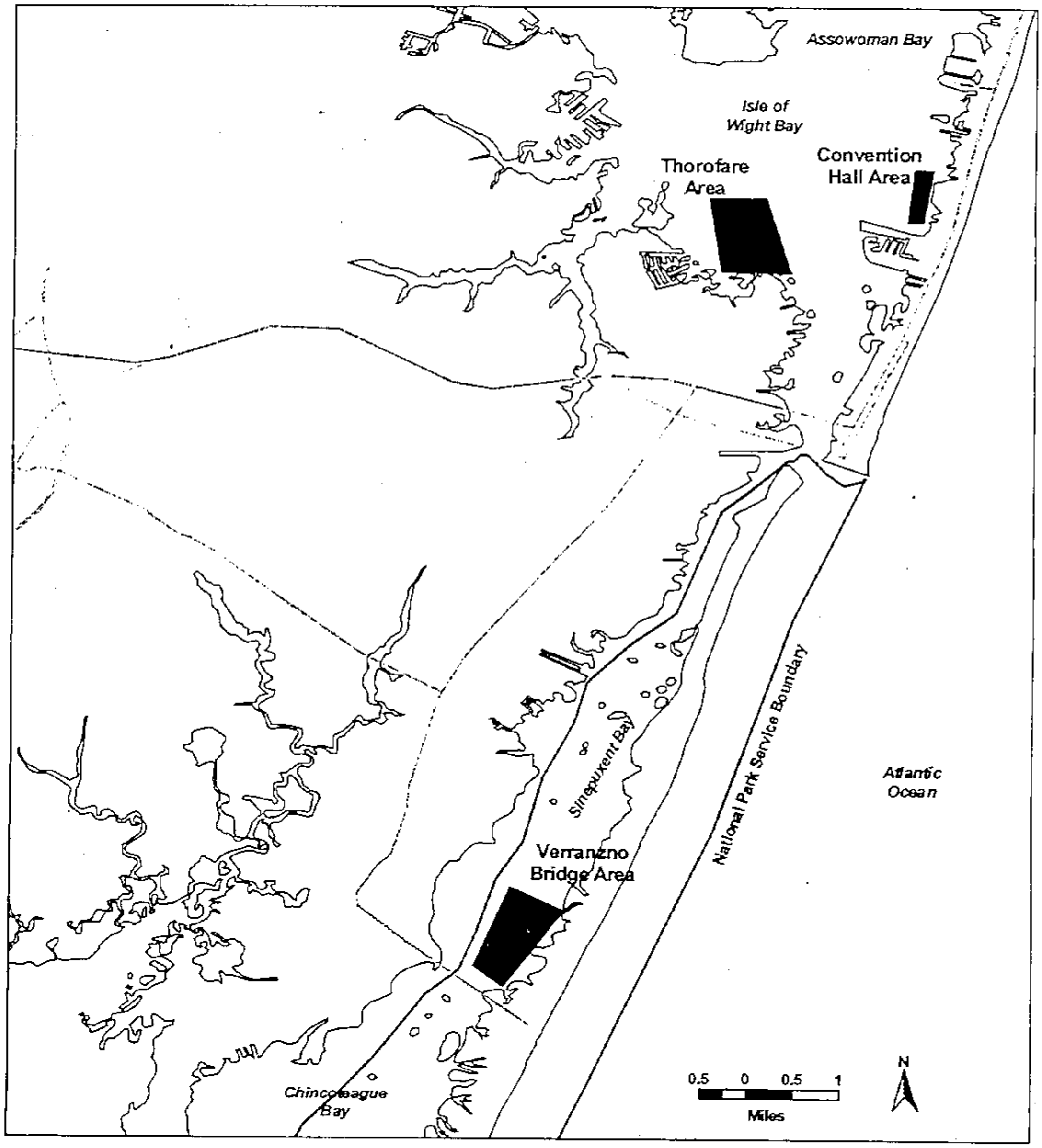
1) The Convention Hall site, bayside of Ocean City roughly between 36th and 50th Street; and

2) The Thorofare site, in southern Isle of Wight Bay;

3) The Bridge site, just north of the Verrazano Bridge on the barrier island side.

Implementation: Delineate areas in 2001, and implement area closures, if necessary, in 2002.

Figure 6. Potential Protection Areas for Female Blue Crabs



b) **Catch and Size Limits** - Determine if the current catch and size limits for female crabs are appropriate.

Implementation: Dependent on funding (potential University research project).

Action 3.2.2: DNR will investigate the economic impact of prohibiting the possession and sale of sponge crabs within the state.

Implementation: 2001

Problem 3.3: Wasteful Harvest Practices - Harvesting undersized crabs does not maximize economic value of the resource. Cull rings allow the escapement of small, legal-size peelers and mature females during certain seasons. Cull rings that allow sublegal crabs to escape are required in Maryland, however, current legislation allows cull rings to be obstructed when fishing for peelers. Lost or abandoned crab pots are attractive refuge sites that trap, and eventually result in significant mortality of crabs and finfish, as well as air breathing animals, such as terrapins, that inhabit tributaries and near-shore waters. Crab pots often become lost when boat propellers cut buoy lines and during storms. Abandoned pots can also be navigational hazards for boats.

Action 3.3.1 DNR will require unobstructed cull rings in crab pots from June 1 through April 30, and will adjust cull ring requirements based upon further research (peeler pot cull ring study being planned on Chesapeake Bay).

Implementation: 2002

Action 3.3.2: DNR will determine if measures are necessary to reduce the bycatch mortality of crabs in the hydraulic clam dredge fishery (i.e Action 3.2.1(a) - prohibition of hydraulic clam dredging in areas where female crabs are concentrated).

Implementation: 2002

Action 3.3.3: DNR will continue to require terrapin excluders in crab pots set for noncommercial purposes, encourage watermen to install terrapin excluders in commercial crab pots, and investigate the feasibility (i.e. effects on catch; economic impact) of requiring terrapin excluders in all crab pots set in the coastal bays.

Implementation: Evaluate in 2001; implement in 2002, if appropriate.

Action 3.3.4: MCBP will coordinate an annual/seasonal volunteer effort to locate and remove derelict pots.

Implementation: 2001

OBJECTIVE 4: Improve the recreational crabbing experience.

Problem 4.1: Satisfaction of Recreational Crabbers - There is anecdotal evidence that suggests a declining satisfaction among recreational crabbers. The implementation of this FMP should result in an improved blue crab stock in the coastal bays, and ultimately improve recreational crabbing. The more specific actions under Objective 4 should further enhance the recreational crabbing experience.

Action 4.1.1: DNR and MCBP will obtain information on satisfaction levels of recreational crabbers in the coastal bays to evaluate the effectiveness of management measures.

Implementation: Obtain baseline data from the 2000 water-use assessment study.

Action 4.1.2: DNR will examine the effects of habitat quality on the success rates of recreational crabbing in the coastal bays.

Implementation: Initiate in 2000.

Action 4.1.3: DNR and MCBP will develop and distribute the following information pertaining to the recreational crab fishery in the coastal bays:

a) Recreational crabbing brochure summarizing crabbing restrictions;
b) Recreational crabbing sign for access points (i.e. boat ramps and fishing/crabbing piers);
c) Maps of land-based public access and boat based crabbing locations, list of boat ramps and marinas with rental boats, and recreational crabbing tips.

Implementation: (a-c) Ongoing - dependent on funding.

Action 4.1.4: DNR, MCBP, Town of Ocean City and Worcester County will work towards increasing the number of land-accessible areas for recreational crabbing.

Implementation: Ongoing

OBJECTIVE 5: Protect, maintain and enhance blue crab habitat.

Problem 5.1: Submerged Aquatic Vegetation (SAV) - SAV is an important habitat component for blue crabs, as well as hard clams which is an important food source for blue crabs, and has been increasing in the coastal bays over the last few years. Activities which contribute to the destruction of SAV (i.e. shoreline development that reduces shallow water habitat, heavy boat traffic, crab scraping, and clam dredging) should be minimized.

Action 5.1.1: DNR will alleviate the impact of hydraulic clam dredging and prop scarring to SAV in the coastal bays by:

a) Prohibit hydraulic clam dredging in SAV;
b) Annually documenting the areas and extent of impact;
c) Researching seagrass recovery time;
d) Investigating the use of buoys to mark beds, SAV setbacks, depth restrictions, GPS equipment to identify boundaries, and education as tools to protect beds from damage; and
e) Implementing and enforcing necessary regulations to protect SAV from hydraulic clam dredging.

Implementation (a-e): Ongoing

Action 5.1.2: By implementing Action 2.1.2, DNR will prohibit the taking of blue crabs in the coastal bays by scrape and dredge to prevent these fisheries from developing and impacting SAV.

Implementation: 2001

Action 5.1.3: DNR and MCBP will continue to identify SAV species needing protection and activities needing restrictions.

Implementation: Ongoing

Action 5.1.4: MCBP will expand surveys/citizens monitoring to groundtruth SAV species composition and determine accuracy of photo interpretive maps.

Implementation: Ongoing

Action 5.1.5: DNR and Natural Resources Conservation Service (NRCS) will develop habitat requirements for the growth of seagrasses in the coastal bays by:

a) DNR will develop water quality requirements for seagrassess;
b) DNR will identify areas that meet water quality requirements for restoration purposes;
c) NRCS will compile data relating coastal bay soil types to bottom communities and identify other variables having effects on seagrass establishment and maintenance; and

Implementation (a-c): 2000

d) NRCS will complete soil mapping effort for entire coastal bays

Implementation: 2000

<u>Problem 5.2: Overwintering Habitat</u> - After mating, female blue crabs migrate to staging areas in the coastal bays. Early arriving females will spawn prior to winter, while latecomers will spawn the following spring after winter hibernation. During this time, females are vulnerable to harvest by nature of their dense distribution in specific areas. Protecting the areas where females overwinter may be beneficial to the spawning stock. Overwintering habitats of juvenile and male blue crabs also need protection.

Action 5.2.1: DNR will identify and protect blue crab overwintering areas in the coastal bays by:

a) Delineating and mapping overwintering areas; and

b) Prohibiting hydraulic clam dredging in important overwintering areas year-round, unless data indicates that these areas can be opened on a seasonal basis (see Action 3.2.1(a)).

c) DNR will define the criteria under which a Marine Protected Area can be effective in protecting blue crab overwintering areas.

Implementation: (a) 2000 and 2001; (b) 2002; (c) 2003

Problem 5.3: Shallow Water and Shoreline Habitats - Fishery independent sampling results indicate that small crabs utilize shallow water areas especially in marshy, tidal guts and grassbeds (SAV). These areas provide protection from predation and are essential for growth and feeding.

Action 5.3.1: DNR will support actions in the CCMP, specifically "Challenge 1.9 of the Fish and Wildlife Section" to protect and enhance shallow water and shoreline habitats important to blue crabs. DNR and Worcester County are the lead agencies for the majority of these actions. Refer to the CCMP for more specific information on these actions.

Implementation: Ongoing

Problem 5.4: Dissolved Oxygen - Blue crabs avoid areas with low dissolved oxygen (DO) and are known to leave the water to escape hypoxic (low oxygen) water (often referred to as a "crab jubilee"). Studies have found about 50% mortality associated with crabs held in waters with < 2ppm oxygen at depths below 7 m (Carpenter and Cargo, 1957). Hypoxic water has been shown to effect the recruitment and migratory success of postlarval (megalopae) blue crabs by altering behavior associated with shoreward transport and settlement processes (Tankersley and Ziegler 2000). Besides affecting blue crab physiology, anoxic waters (no oxygen) may also reduce the benthic food supply and limit blue crab distribution. Maintaining a DO greater than $3 mgL^{-1}$ at 25-28°C should provide an adequate area to support blue crabs.

Action 5.4.1: DNR will support actions in the CCMP, specifically in the "Water Quality Section" and "Fish and Wildlife Section" to minimize the impacts of unsuitable dissolved oxygen levels to blue crabs in the coastal bays. Maryland's Coastal Bays Program, Town of Ocean City, and Worcester County are the lead agencies for the majority of these actions. Refer to the CCMP for more specific information on these actions.

Implementation: Ongoing

Action 5.4.2: DNR will identify areas which have unsuitable levels of dissolved oxygen (i.e. < 3 mg/L) for blue crabs.

Implementation: Ongoing

Problem 5.5: Nutrient, Sediment, and Chemical Inputs - Refer to pages 10 and 11 for a description of the effects of nutrient, sediment and chemical inputs on blue crabs.

Action 5.5.1: DNR will support actions in the "Water Quality" section of the CCMP to control nutrient, sediment and chemical inputs which will protect and enhance blue crab habitats. Worcester County and Maryland's Coastal Bays Program are the lead agencies for the majority of these actions. Refer to the CCMP for more specific information on these actions.

Implementation: Ongoing

OBJECTIVE 6: Improve enforcement of crabbing restrictions.

Problem 6.1: Enforcement of Conservation Measures - There is a lack of enforcement personnel to address many of the natural resources and conservation laws in the coastal bays.

Action 6.1.1: DNR will consider increasing the number of enforcement personnel in the coastal bays, specifically during the crabbing season.

Implementation: Ongoing

Action 6.1.2: DNR will consider expanding the Natural Resource Police reserve officer program.

Implementation: Ongoing

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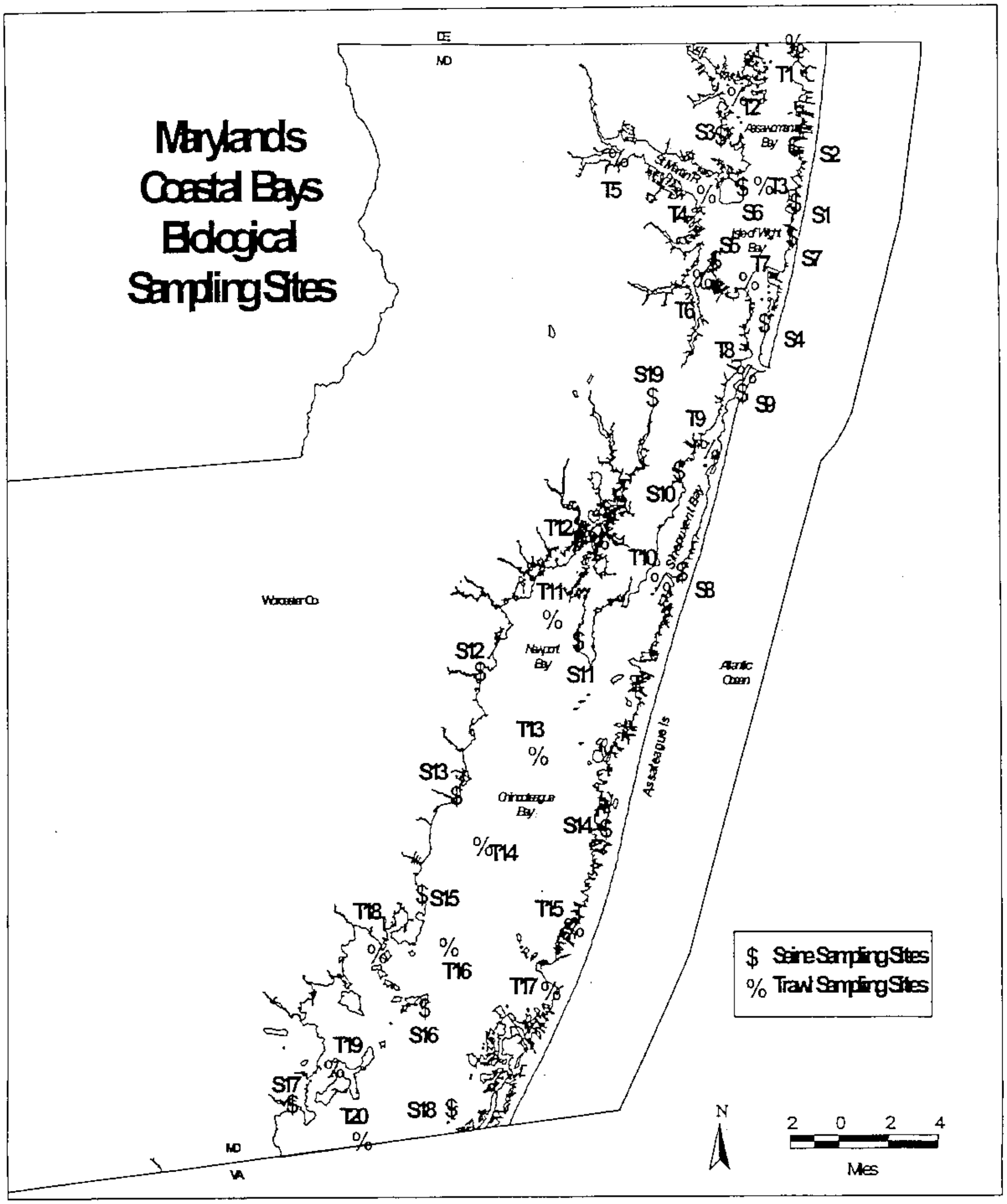
APPENDIX 1. LOCATION OF TRAWL AND SEINE SAMPLING SITES IN MARYLAND'S COASTAL BAYS.



APPENDIX 2. CHEMICAL TOXICITY TO BLUE CRABS[a]

Chemical	Temperature (°C)	Salinity (ppt)	Duration (hours)	Flow[b]	Test	Concentration
aldrin[1]	28	21	48	FT	EC_{50}	23ugLl^{-1}
antimycin A[2]	25	29	48	FT	EC_{50}	>100ugLl^{-1c}
azinphos-Methyl[1]	27	27	48	FT	EC_{50}	320ugLl^{-1c}
carbaryl[1]	30	28	48	FT	EC_{50}	320ugLl^{-1c}
chlordane[1]	29	23	48	FT	EC_{50}	260ugLl^{-1c}
chlodecone (Kepone)[1]	19	20	96	FT	LC_{50}	>210ugLl^{-1d}
chlorpyrifos[1]	17	20	48	FT	EC_{50}	5.2ugLl^{-1c}
2,4-D Proplene GI Butyl Ether Ester[3]	24	29	48	S	EC_{50}	2,800ugLl^{-1c}
dieldrin[1]	18	26	48	FT	EC_{50}	240ugLl^{-1c}
endosulfan[1]	30	24	48	FT	EC_{50}	19ugLl^{-1c}
endrin[1]	11	16	48	FT	EC_{50}	15ugLl^{-1c}
fenthion[1]	28	25	48	FT	EC_{50}	2.3ugLl^{-1c}
heptachlor[1]	17	27	48	FT	EC_{50}	68ugLl^{-1c}
malathion[1]	30	25	48	FT	EC_{50}	>1,000ugLl^{-1c}
methoxy-chlor[1]	31	24	48	FT	EC_{50}	320ugLl^{-1c}
mirex[1]	31	24	48	FT	EC_{50}	>2,000ugLl^{-1c}
naled[1]	28	25	48	FT	EC_{50}	220ugLl^{-1c}
ozone[1]	25	7.4	96	S	LC_{50}	0.26ugLl^{-1d}
toxaphene[1]	19	27	48	FT	EC_{50}	180ugLl^{-1c}

[a] Source: Mayer 1987.
[1] insecticide; [2] piscicide; [3] herbicide; [4] water sterilant
[b] FT = Flow Through; S = Static; [c] Nominal Concentration; [d] Measured concentration

APPENDIX 3: DESCRIPTION OF COMMERCIAL LICENSE CATEGORIES

There are several types of Maryland commercial crabbing licenses. Among coastal bay crabbers, the most common licenses are the Limited Crab Catcher (LCC) and the Tidal Fish License (TFL). These licenses permit the following crab gears:

1. The LCC license permits the use of up to 50 crab pots, unlimited yardage of trotline as well as the use of dip nets, traps, pounds and scrapes.

2. The TFL license permits the use of all gear legal for the purpose of taking finfish and shellfish. This includes up to 300 pots.

Other commercial crabbing licenses available include:

3. CB3: only permits the use of up to 300 crab pots

4. CB3/CB6: only permits the use of up to 600 pots. Not applicable to the coastal bays.*

5. CB3/CB9: only permits the use of up to 900 pots. Not applicable to the coastal bays.*

6. TFL/CB6: similar to #2 above but also permits up to 600 pots. Not applicable to the coastal bays.*

7. TFL/CB9: similar to #2 above but also permits up to 900 pots. Not applicable to the coastal bays.*

* NOTE: By regulation, vessels operating in Maryland's coastal bays are permitted a maximum of 300 pots/vessel.