THE MENHADEN FISHERY OF THE GULF OF MEXICO UNITED STATES:

A Regional Management Plan

1988 Revision

edited by

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3.0 SUMMARY

The menhaden fishery is one of the Unites States' oldest and most valuable fisheries and is the largest in volume of landings. Gulf menhaden landings were first recorded in 1880 (Lyles 1965) when less than 1,000 pounds were landed in west Florida. With considerable annual fluctuations, gulf landings increased to the 1984 record of 2.2 billion pounds. This amounted to 76% of U.S. menhaden landings and 29% of total U.S. landings of fish and shellfish. Landings at Gulf of Mexico ports have exceeded 1 billion pounds since 1971.

The first regional management plan (Christmas and Etzold 1977) was adopted and implemented by the Gulf State-Federal Fishery Management Board (GS-FFMB) in 1977. Results of ongoing review and evaluation of research and management achievements warranted a revised management plan. A contract for development of the proposed revision was issued to Gulf States Marine Fisheries Commission (GSMFC) by the Southeast Regional Office, National Marine Fisheries Service (SERO, NMFS) on October 1, 1982. On the basis of information acquired in carrying out eight procedures specified in the contract, revision included deletion of material no longer applicable, incorporation of the results of research completed since 1976, updating of serial data and changes in procedures and priorities. The revision was issued in September 1983.

Plans for developing the second revision were initiated by the Menhaden Advisory Committee (MAC) and approved by the Gulf States Marine Fisheries Commission (GSMFC) in March 1987. An Ad Hoc Subcommitttee for plan development was appointed. Plan revision was subsequently carried out with support from funds made available to the GSMFC under the Interjurisdictional Fishery Act of 1986 (IJF). The biological basis for the current plan and its predecessors has undergone scientific peer review by relevant Federal and state scientists.

Gulf menhaden support an important renewable territorial sea and internal waters fishery. The resource, with highest density in the north central gulf, is distributed along the coasts of all of the Gulf States. Menhaden and other pelagic plankton feeding species serve as important foods for the major predatory fishes of commercial and recreational importance. Gulf menhaden feed near the bottom of the food chain and are efficient converters of available energy. They occur in coastal and estuarine waters at an abundance level which is adequate to support the food needs of the predatory fish populations and the large Gulf Coast commercial fishery.

The gulf menhaden (Brevoortia patronus) is the principal species landed in the Gulf States and ranges from the Yucatan Peninsula in Mexico to Tampa Bay, Florida. This species supports a shallow-water nearshore fishery when it occurs in dense schools in waters along the Gulf Coast. Research vessels have taken some adults up to 25 miles offshore and in waters where the depth exceeded 50 fathoms (91 m), but information on its offshore range is limited.

Extensive coastwise migrations by Gulf of Mexico menhaden are not known to occur. There is evidence that older fish move toward the Mississippi River delta and that there is considerable long-shore transport of larvae.

The existence of more than one stock of gulf menhaden has not been demonstrated. Consequently, gulf menhaden is believed to comprise a single stock or population of fish and that stock comprises the Management Unit (MU). There is some evidence that it could be split into more than one MU. Management strategy provides for that possibility.

In general, gulf menhaden life history is typical of the life cycle followed by most estuarine dependent species in the gulf. Various life history stages occupy different habitats where they are exposed to a wide range of environmental conditions. Fluctuation in these environmental conditions affect gulf menhaden year class strength.

Information on growth rates, natural mortality, spawner-recruit relationships and fishing mortality were combined into a population-predictor model. Maximum Sustainable Yield (MSY) estimated by the biological model is 803,300 metric tons (MT) with an annual range of yields from approximately 700,000 MT to 825,000 MT. The gulf menhaden population appears to be healthy, highly productive and capable of supporting average annual harvests in excess of 800,000 MT although considerable variation is expected. The domestic annual harvest capacity is sufficient to take the allowable harvest.

Menhaden habitat is subject to numerous deleterious activities. The MAC will monitor proposed projects that may negatively impact menhaden populations and recommend appropriate action.

Numerous Federal laws, policies and regulations may directly or indirectly influence the management of menhaden. State laws, regulations and policies applicable to the Gulf of Mexico menhaden fishery include many statutory and regulatory constraints promulgated under a variety of state enabling legislation and administration structures. State management systems show similarities and differences among states.

Wet reduction of menhaden yields three products: fish meal, fish oil and condensed fish solubles. The efficiency of the reduction processes removes all solids and solubles. As a result plant effluents satisfy all current standards. Menhaden meal is a valuable ingredient for animal feeds. It contains a minimum of 60% protein with a well-balanced amino acid profile. The poultry industry is heavily dependent on fish meal as an ingredient to improve feed efficiency to produce maximum growth rates. Depending on price and availability of fish meal, broiler rations may contain up to 8% fish meal. The second most valuable market for fish meal is in swine feeds. Swine have requirements for the fish meal amino acids and the high available energy levels. Aquaculture demonstrates ever increasing demands for menhaden meal. Formulated feeds for catfish, trout, salmon, and shrimp require up to 40% fish meal to produce efficient growth.

Menhaden oil has been used in edible products for many years in Europe. The oil is refined, deodorized and hydrogenated to blend with other fats for cooking oils and margarine. The Food and Drug Administration is currently reviewing studies to allow use in the United States.

Menhaden oil also has valuable technical uses in this country. Menhaden oil is easily emulsified with water which makes it a valuable component of marine lubricants and greases.

Solubles are used as an ingredient in the poultry industry to complement or replace fish meal in the feed formula. Its value as a feed ingredient for swine is enhanced by the glycine levels. A large market for menhaden solubles exists in the mid-west where solubles are dried on a carrier such a soybean meal or mill feeds and sold as a dry product to formulators of swine feeds. Another use of fish solubles is in liquid feeds. They are compounded with molasses and fortified with soluble nutrients and used as a liquid feed supplement for cattle.

In the last five years there has been a dramatic increase in the direct use of menhaden for bait, especially for crabs and crayfish. Current research indicates that several additional uses will be developed.

The management system and institutional structure are shown in Figures 7.1 and 7.2. The GS-FFMB is charged with developing regional management plans for fishery resources that move between or are broadly distributed among the territorial waters and areas seaward and for recommending suitable policies and strategies to each member state.

Approval of recommendations by the MAC requires a two-thirds majority vote of those present and voting. There should be a minimum of two meetings of the MAC each year as deemed necessary by two or more members or at the direction of the GS-FFMB.

The basic structure of the management system is the GS-FFMB which develops and recommends suitable policies and strategies for regional management actions. The GS-FFMB establishes appropriate procedures and policies necessary to design, implement and evaluate all regional management activities.

The advantages of the GS-FFMB are that all members have knowledge of and interest in fishery management problems. State administrators regularly advise their state decision makers on fishery management problems as well as make recommendations to their legislators. Some decisions can be made by the state agencies; others may require approval of one or more of the state legislatures. Also, they are members of the GSMFC and, therefore, can coordinate the activities of the GS-FFMB and GSMFC. The NMFS Regional Director and Region IV Director of the U.S. Fish and Wildlife Service are voting members and provide representation of Federal interests.

Goal

A gulf menhaden management strategy that will allow an annual maximum harvest which protects the stock from overfishing on a continuing basis.

Objectives

a. To determine, maintain and improve the biologically sustainable yield of Gulf of Mexico menhaden stock based on best available scientific data.

b. To monitor and improve established estimates of maximum sustainable yield (MSY) and optimum yield (OY) for the Gulf of Mexico menhaden stock.

c. To update and evaluate current data base available for management.

Review of the gulf menhaden fishery is conducted by the MAC in consort with GS-FFMB and GSMFC. The NMFS annually reviews the fishery with the MAC. Monitoring of the gulf menhaden fishery is conducted by GSMFC, the NMFS and the Gulf States in cooperation with the menhaden industry.

Management of the gulf menhaden resource will require long-term continuation of several on-going research programs and special projects of shorter duration. Continuing collection and timely analyses of the Captain's Daily Fishing Report will provide a new source of information about the fishing process and gulf menhaden resource. Biological, economic and sociological research areas needed to support the gulf menhaden program have been identified and assigned to priorities.

4.0 INTRODUCTION

4.1 Contractural Requirements

This revision was funded under P.L. 99-659, Interjurisdictional Fisheries Act, to the Gulf States Marine Fisheries Commission (GSMFC) to revise, publish and distribute the Regional Management Plan for the menhaden fishery of the Gulf of Mexico. (See Section 19.1 in the appendix for historical plan implementation information.)

4.2 Task Force Members

W. Borden Wallace, Chairman	Wallace Menhaden Products, Inc.
Richard Condrey	Louisiana State University
John Merriner	National Marine Fisheries Service
Larry B. Simpson	Gulf States Marine Fisheries Commission
J.Y. Christmas	Consultant, Gulf States Marine Fisheries Commission
David J. Etzold	Consultant, Gulf States Marine Fisheries Commission

Credit for writing the contents of this plan has not been assigned to individuals. Each member of the task force contributed in the area of his expertise and in discussions that resulted in changes of draft material. Thus, any assignment of authorship must include all members of the task force and the planning staff. Interjurisdictional Fisheries Management Program Coordinator was Mr. Stephen Meyers.

GSMFC made all necessary arrangements for task force workshops and funded travel for state agency representatives.

5.0 DESCRIPTION OF STOCK(S) COMPRISING THE MANAGEMENT UNIT (MU)

5.1 Biological Description and Geographic Distribution

5.1.1 Data Bank

There is considerable information on the biology of menhaden. Most of the material published through 1973 is conveniently referenced in six bibliographies. Gunter and Christmas (1960) published a review of the literature on menhaden with special reference to the Gulf of Mexico. Annotated bibliographies on the biological aspects of American menhadens have been compiled by Reintjes, Christmas and Collins (1960), Reintjes (1964a), Reintjes and Keney (1975), and Dudley (1988). A computerized menhaden bibliography, developed at the request of the Menhaden Advisory Committee (MAC) (Fontenot, Condrey and Ford 1980) includes over 1200 references. The literature on larval and juvenile menhaden from oceanic and estuarine studies has been reviewed by Condrey et al. (1982).

Data bases maintained by National Marine Fisheries Service (NMFS) as part of their menhaden research program include biostatistical data on age and size since 1964, landings data from the menhaden purse seine fishery since 1946, and captain's daily fishing reports since 1979. Additional special data files include juvenile abundance and tagging studies. All are utilized in stock assessments (Nelson and Ahrenholz 1986 and Vaughan 1987).

5.1.2 Description and Distribution of Menhaden in the Gulf of Mexico

The menhaden genus (*Brevoortia*) belongs to the herring family (Clupeidae), and menhaden are similar in appearance to the alewife and shad. Three species occur in the Gulf of Mexico: gulf menhaden (*B. patronus*), finescale menhaden (*B. gunteri*) and yellowfin menhaden (*B. smithi*).

Menhaden are distinguished from other Clupeidae by a large head, absence of teeth in juveniles and adults, pectinated scales, location of the dorsal fin over the interval between the pelvic and anal fins and a compressed body with bony scutes. Other features include numerous long gill rakers, a unique muscular pyloric stomach or gizzard and a conspicuous scapular spot.

Gulf menhaden are characterized by large scales (36 to 50 oblique rows crossing the midline of the body), a series of smaller spots on the body behind the scapular spot and prominent radiating striations on the upper part of the opercle. Yellowfin and finescale menhaden have smaller scales (58-76 rows) according to Hildebrand (1948) and do not have the smaller spots and strong opercular striations.

The gulf menhaden ranges from the Yucatan Peninsula in Mexico to Tampa Bay, Florida. The finescale menhaden occurs from Mississippi Sound southwestward to the Gulf of Campeche in Mexico. The yellowfin menhaden ranges from Chandeleur Sound, Louisiana, southeastward to the Caloosahatchee River, Florida (and presumably around the Florida peninsula), to Cape Lookout, North Carolina (Hildebrand 1948; Suttkus 1956 and 1958; Christmas and Gunter 1960; Gunter and Christmas 1960; Reintjes and June 1961; Reintjes 1964b and 1969; Turner 1969 and 1971). The yellowfin menhaden was reported from Grand Bahama Island. This is the first authenticated record of a North American species from beyond the Continental Shelf (Levi 1973).

Gulf menhaden is the principal species landed in the Gulf States. Incidental catches of yellowfin menhaden and finescale menhaden are landed also.

In general, gulf menhaden life history is typical of the cycle followed by most estuarine dependent species in the gulf. Spawning occurs offshore. The young move into estuarine nursery areas where they spend the early part of their lives. Maturing adults move back offshore to spawn. Various life history stages occupy different habitats where they are exposed to a wide range of environmental conditions. A conceptual life history model is shown in Figure 5.1. There may be extensive alongshore transport of menhaden larvae in western Louisiana waters as well as across shelf transport (Shaw et al. 1985).

Schooling is apparently an inborn behavioral characteristic beginning at the late larval stage and continuing throughout the remainder of life. Their occurrence in dense schools, generally by species of fairly uniform size, is an outstanding characteristic that facilitates mass production methods of harvesting menhaden (Reintjes and June 1961).

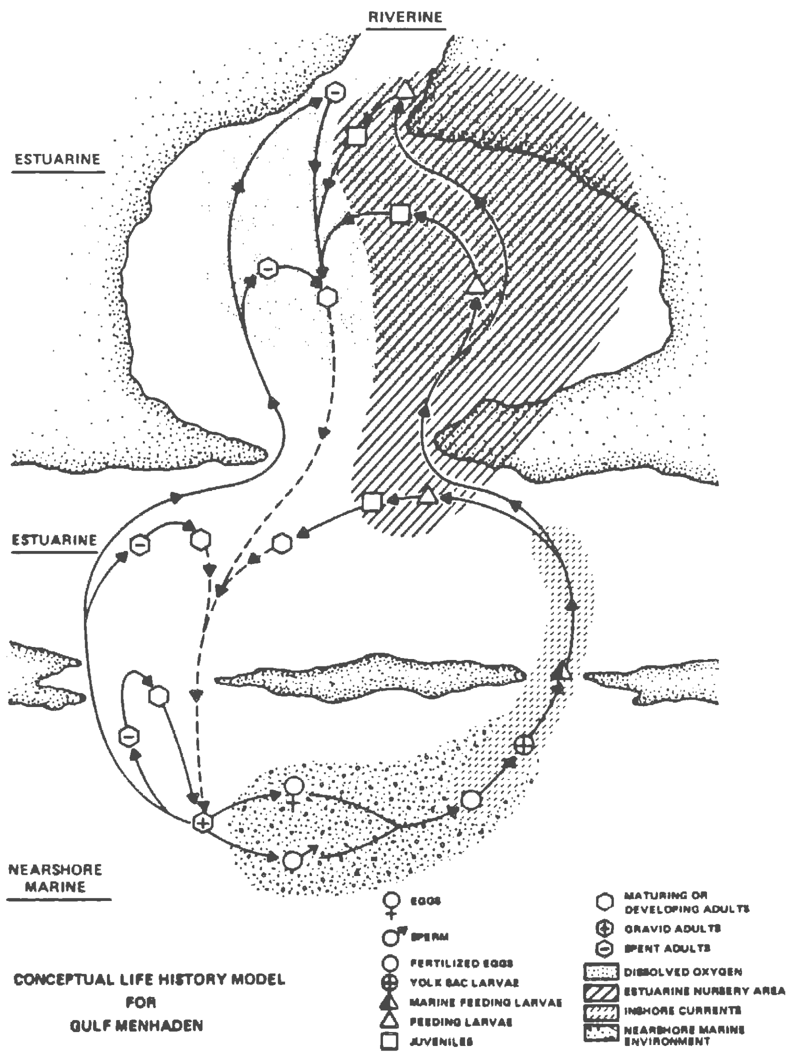


Figure 5.1 Conceptual life history model for gulf menhaden. Dissolved oxygen indicates areas of potential depletion. (Developed by J.Y. Christmas, J.T. McBee, R.S. Waller and F.C. Sutter, III; Gulf Coast Research Laboratory).

Menhaden occur in schools from southern Florida to Mexico (Reintjes and June 1961). Extensive coast-wise migrations by Gulf of Mexico menhaden are not known to occur. There is evidence that older fish move toward the Mississippi River delta. The gulf menhaden is a shallow-water fish, but information on its offshore range is limited. Adults have been collected 20 to 25 miles offshore by bottom trawls, by surface nets fished over 20-fathom depths and by mid-water trawls where total depths ranged from 40 to 55 fathoms (Christmas and Gunter 1960).

The seasonal appearance of large schools of menhaden in the nearshore gulf waters from about April to November dictates the menhaden fishery season. Schools leave the nearshore fishery during fall and apparently move offshore. Efforts to locate schools of adult menhaden during the winter have been generally unsuccessful; however, Roithmayr and Waller (1963) reported winter concentrations of gulf menhaden in the northern gulf between 4 and 48 fathoms. They concluded that at least some fish do not move far offshore but winter on the inner and middle continental shelf area just off the Mississippi River Delta. Turner (1969) collected adult menhaden within the 10-fathom contour off the Florida coast but did not collect any in gill nets fished in 10 to 32 fathoms of water, thus indicating that menhaden in that area do not move far offshore. Additional evidence indicating the bulk of menhaden winter near summer fishing grounds in the gulf include: (1) no menhaden having been taken beyond the edge of the continental shelf; and (2) the onset of the fishing season takes place within a few days along the Gulf Coast, indicating the local concentrations not having traveled any great distance (Roithmayr and Waller 1963).

5.1.3 The Management Unit

5.1.3.1 Stock(s)

The existence of more than one genetic stock of gulf menhaden has not been demonstrated. Meristic studies (Christmas, unpublished) showed no significant differences in populations east and west of the Mississippi Delta. Consequently, gulf menhaden is believed to comprise a single stock or population of fish. The task force accepts the one stock hypothesis at this time. That stock comprises the Management Unit (MU).

The returns from mark-recapture experiments indicate that: (1) fish recaptured during the year of release showed very little movement between fishing grounds east of the Mississippi River Delta and west of the Delta; (2) little mixing of fish from east and west of the Delta occurred during winter; and (3) movement of tagged adult fish appears to be essentially inshore-offshore with no extensive east-west and west-east migration (U.S. Department of Commerce 1972; Kroger and Pristas 1975). These studies indicate that gulf menhaden may be split into two potential management units in the northern gulf by the Mississippi River Delta. If the delta and fresh-water barrier effectively separate fish into two stocks, the 300-500 year period of the barrier's existence may not be long enough for detectable genetic differences to develop. Furthermore, one gene pool may be maintained by larval transport from one spawning area to another while geographically separate adult "stocks" require that more than one MU be utilized. Management strategy must provide for this possibility.

5.1.4 Spawning

5.1.4.1 Spawning Season

Data presented by numerous researchers over the last three decades corroborate a spawning season extending from about September to April with a peak between December and

February (Shaw, Cowan and Tillman 1985). Spawning periods and areas have been substantiated by collections of eggs, larvae, juveniles, adults with ripe gonads and by the examination of ovarian components. Larval and juvenile menhaden under about 40 mm total length (TL) have been collected in gulf estuaries from early September to late July as the following accounts indicate:

a. Eastern Gulf: Springer and Woodburn (1960) sampled Cross Bayou Canal, Tampa Bay, Florida for 15 consecutive months and collected 1024 gulf menhaden with standard lengths (SL) of 33 mm or less during four months: February (1), March (568), April (378) and May (72). They found small yellowfin menhaden (average 23.3 mm TL) most abundant during May concluding that this species probably spawns during spring, later than gulf menhaden which was most abundant in March (average 23.5 mm TL).

Tagatz and Wilkens (1973) sampled Pensacola Bay, East Bay and East Bay River in northwest Florida monthly from November 1968 through May 1970. They found that menhaden (10 to 32 mm TL) entered the bay from December to April. The presence of fish as large as 26 mm TL in early December and as small as 17 mm TL in late April indicated that spawning occurred at least from late October to late March. Tagatz and Wilkens (1973) sampled Pensacola Bay and collected menhaden larvae smaller than had been previously reported from any other gulf estuary except Mobile Bay (Swingle 1971). Menhaden larvae may enter estuaries along the northeastern gulf at an earlier age and/or smaller size than in other areas of the gulf.

Swingle (1971) sampled Alabama estuaries monthly from February 1968 through March 1969. He collected larval and juvenile menhaden (8-40 mm TL) in plankton nets during October and from December through April.

Christmas and Waller (1973) sampled Mississippi estuaries monthly from April 1968 through March 1969. Menhaden were collected by seines and their sizes recorded in 5 mm TL increments. Immigration of gulf menhaden began in December and young as small as 22 mm TL were collected in June and July.

Waller and Sutter (1982) reporting seven years of monitoring in Mississippi Sound, found that young menhaden, 15 mm or less TL, entered the study area during November or December through May of each year.

Turner (1969) collected menhaden eggs in a study of Mississippi Sound and adjacent offshore waters in December 1966 and January 1967. He also collected 18 mm FL larvae in mid-December which suggests that spawning of menhaden occurs in the Mississippi Sound area at least as early as November. Menhaden eggs were collected monthly from December through March. Larvae, 11 to 14 mm fork length (FL), were collected as early as December and as late as April. He concluded that spawning occurs principally nearshore (within the 10-fathom curve) from December through March and reaches a peak in January and February. He also collected adult gulf menhaden and yellowfin menhaden in northern Florida and both species and their hybrids in southern Florida; examination of gonads substantiated a December through March spawning period.

Combs (1969) used ovarian components as a spawning index for gulf menhaden and established that spawning occurs in the northern gulf, east of the Mississippi Delta from late October to February or early March. He postulated that gulf menhaden exhibits intermittent total spawning in the gulf. Turner (1971) reported the collection of a finescale menhaden (maturity stage III, ripening female) on 29 October 1966 at Pascagoula Beach, Mississippi.

Suttkus (1956) studied the early life history and biology of the gulf menhaden in Lake Pontchartrain, Louisiana. Larvae 20 to 30 mm TL moved into the lake from December through March, and he presumed that spawning began during October in the open waters of the gulf and ended in February. Fecundity and reproduction studies of gulf menhaden by Suttkus and Sundararaj (1961) corroborated these spawning dates for Louisiana waters.

b. Western Gulf: Perret, et al. (1971) conducted an intensive sampling program in Louisiana estuaries from April 1968 through March 1969. They collected larval menhaden (20 to 30 mm TL) monthly from September through May. The occurrence of larvae in collections as early as September was probably not indicative of a major spawning effort.

Baldauf (1954) collected menhaden smaller than 23 mm SL from the Nueces River in Texas, monthly from November 1952 through April 1953. Hoese (1965) collected larval menhaden from estuaries near Port Aransas, Texas from November through May and suggested a spawning period from October through March for that area. Simmons (1957) reported that menhaden spawned in Laguna Madre of Texas during February 1956; 15-mm specimens were collected during March, April and May.

Arnold, Wheeler and Baxter (1960) made collections in East Lagoon near Galveston, Texas from November 1953 through May 1958. They collected menhaden larvae monthly from November through April for each year that samples were taken except in November 1954. They concluded that spawning probably occurs offshore from late October through April with a peak in January.

Additional data on the seasonal occurrence and abundance of larval and juvenile menhaden in Texas estuaries and further corroboration of a winter-spring spawning season are given by Gunter (1945) and Reid (1955a; 1955b; 1956; 1957).

5.1.4.2 Spawning Area

Data indicate that gulf menhaden spawn offshore though actual spawning has not been observed nor have sites been delineated. Turner (1969) presented indirect evidence of spawning areas in the eastern gulf from collections of menhaden eggs and larvae. Most of the eggs were collected within the five fathom curve which suggested that spawning takes place near shore in Florida waters. Combs (1969) did not delineate the geographical areas of gulf menhaden spawning, but he provided evidence that spawning occurs only in high-salinity waters.

Fore (1970) inferred spawning areas of gulf menhaden from the distribution of eggs indicating that spawning occurs mainly over the continental shelf between Sabine Pass, Texas, and Alabama. Greatest concentrations were found in waters between the 4 and 40 fathom contours off Texas and Louisiana and near the Mississippi Delta.

From examination of an extensive number of existing plankton samples and literature reviews, Christmas and Waller (1975) concluded that menhaden spawn along the entire United States Gulf Coast from near shore to as far as 60 miles offshore.

Shaw et al. (1985) collected eggs over water depths of 11-128 m, 35-152 km (22-94 miles) offshore in western Louisiana. Highest egg densities were taken between the 10 and 23 m isobaths and at temperatures and salinities of 17° to 20°C and 32 to 36 ppt. Larvae were taken inshore of the 37 m isobath (121 km or 75 mi offshore) with highest densities between 13-24 m and 29-36 ppt.

Turner (1969) collected menhaden eggs, larvae, and ripe and spent adults in the eastern gulf off the coast of northern Florida (from Panama City to Cedar Key) and Southern Florida (from Tampa to Cape Sable).

Hettler (1968) reported the collection of ripe female yellowfin menhaden ten miles north of Naples, Florida in three fathoms and one mile south of Sanibel Island in two fathoms of water in March 1966. He also collected ripe yellowfin males, ripe male gulf menhaden and hybrid males in the same area.

Christmas and Waller (1975) examined plankton samples collected off southwest Florida (Cedar Key to Cape Sable) and found eggs from December until March with a February peak. In egg collections from the Mississippi Delta to Cedar Key, peak spawning was reflected by the December and February samples.

Menhaden eggs collected in 1963 revealed that the spawning season in the northern and western Gulf of Mexico extended from mid-October through March with a peak in December (Fore 1970).

Plankton samples collected from the western gulf (Mississippi Delta to Brownsville, Texas) contained menhaden eggs from October through March, with spawning peaks during March in the southern portion of this region and in December in the northern portion (Christmas and Waller, 1975).

5.1.4.3 Fecundity

The number of eggs spawned by a mature female usually increase with the size of the fish. Suttkus and Sundararaj (1961) examined ovaries of female gulf menhaden in Age Groups I, II and III and reported the mean number of eggs per fish per age group to be 21,960; 68,655 and 122,062 respectively.

Lewis and Roithmayr (1981) examined spawning age and egg numbers per cohort to determine the reproductive potential of gulf menhaden. Spawning occurred in the winter reaching a peak in December and January, a conclusion generally reached by Suttkus and Sundararaj (1961) and supported by egg and larval distribution studies of Christmas and Waller (1975). Lewis and Roithmayr also concluded that spawning occurs for the first time at age 1 as the fish approach their (arbitrary) second birthday. This has significance for the fishery since previous studies by Ahrenholz (1981) have shown that age 1 fish are not fully recruited into the fishery; some age 1 fish have an opportunity to spawn before being subjected to heavy fishing pressure. Vaughan (1987) estimated that total fecundity for the entire stock of spawners in the 1964-1984 data set varied from 10.3 trillion eggs to 143.3 trillion eggs with an average fecundity of approximately 12,000 eggs per mature female. Fecundity increased with length (and age), but since numbers of older fish constitute only a small fraction of the overall spawning population, late age 1 or early age 2 fish contributed the bulk of stock fecundity. The model assumes a single intermittent spawn (Combs 1969) per spawning season.

5.1.5 Eggs and Larvae

It is presumed that gulf menhaden eggs remain near the surface until hatching and that the larvae are planktonic. Hettler (1968; 1970) artificially fertilized batches of eggs from yellowfin menhaden with sperm from finescale, gulf and a naturally occurring hybrid menhaden. He reported that fertilized menhaden eggs float in sea water, but dead or unfertilized eggs sink. Reintjes (1961) reported that menhaden eggs were taken in oblique tows from 70 meters to the surface along the south Atlantic coast.

Descriptions of finescale menhaden eggs and larvae are lacking. It is assumed that eggs and larvae of the three species found in the gulf are very similar or indistinguishable. Houde and Fore (1973) reported that fertilized gulf menhaden eggs are spherical, 1.0 to 1.3 mm in diameter, non-adhesive, buoyant in sea water and float in loose aggregations near the surface. Eggs of yellowfin menhaden artificially fertilized with sperm of yellowfin, gulf and hybrid menhaden, ranged from about 1.05 to 1.30 mm (Hettler 1968; Reintjes 1962). Hettler (1984) described and compared the eggs and larvae of gulf and Atlantic and yellowfin menhaden.

Kuntz and Radcliffe (1917) gave an account of hatching and early larval development of Atlantic menhaden. They reported that fertilized eggs hatched within 48 hours. Hettler (1968) reported a hatching time (time for one-half of each batch of fertilized eggs to hatch) of 38 to 39 hours for eggs of yellowfin menhaden fertilized with sperm of gulf menhaden and held at 19.5° to 21.5°C. Hettler (1970) observed that yellowfin menhaden eggs began hatching 48 hours after artificial fertilization with yellowfin menhaden sperm.

5.1.6 Age and Growth

5.1.6.1 Growth of Larvae

Hettler (1968) reported that larvae produced from yellowfin menhaden (female) x gulf menhaden (male) reached a length of 3.6 mm TL, 3.9 mm TL, 4.2 mm TL, 4.5 mm TL and 4.3 mm TL in 6, 26, 58, 82 and 130 hours following hatching, respectively. The yolk sac was completely absorbed after 80 hours but most of the larvae did not start feeding, and consequently they shrunk. Larvae of yellowfin menhaden artificially fertilized and reared in the laboratory were 7.6 mm TL long when 11 days old and 11.9 mm TL long 27 days after hatching (Hettler, 1970). Larvae and young gulf menhaden ranging in length from 18.9 to 58.4 mm TL (age unknown) were described by Suttkus (1956).

The sequence of scale formation and scalation patterns were described by Chapoton (1967) from a series of young gulf menhaden collected along the Texas coast. Scales commenced to develop in fishes as small as 21 mm FL and were complete in some individuals at 25 mm; all fish 27 mm and larger were fully scaled.

Dunham (1975) reared gulf menhaden in experimental ponds stocked with juveniles and determined that the first annulus was formed in March or April.

5.1.6.2 Post-Transformation Age and Growth

Age and growth information on gulf menhaden has been developed from samples taken by NMFS in a port sampling program initiated in 1964 at gulf menhaden processing plants. Random samples were taken from the vessels before or during the unloading process. Details of the sampling methodology are given by Nicholson (1978). Age-structure of the landings is determined by reading annual marks, or annuli, on the scales of gulf menhaden and is then extrapolated to an estimated total number of gulf menhaden landed by plant, by week, and by age-class. Details of the aging technique were reported by Nicholson and Schaaf (1978). Information on number-at-age is necessary to determine estimates and patterns of recruitment, natural and fishing mortality, rates of growth, yield-per-recruit, and a biologically-derived estimate of maximum sustainable yield (MSY).

Vaughan (1987) summarized gulf menhaden data collected in the 1964-1985 NMFS port-sampling programs for age and growth information to determine population age-structure and growth rates of gulf menhaden. The results indicate that gulf menhaden seldom exceed four years of age. The bulk of the fishery is composed of age 1 and age 2 fish, with a limited number of age 3 and even fewer age 4 fish being taken. Relatively few age 0 fish (i.e. fish less than 1 year of age) are taken. Estimated numbers at age were calculated with the average numbers in the population at an arbitrary birth date of January 1 being: 23,016 million at age 1; 4,458 million at age 2; 321.5 million at age 3; and 20.2 million at age 4. The natural longevity of gulf menhaden is unknown, but the high natural and fishing mortality rates experienced by the stock would make the number of age 5 and older fish exceedingly small.

Growth rate information calculated by Vaughan (1987) indicates rapid growth, although the ultimate size reached is less than that of Atlantic menhaden because of the shorter life span. The equation used was $\log_e W = 3.205 \log_e L - 11.878$. Based on an analysis of approximately 270,000 individual gulf menhaden, mean size during mid-summer (peak of the fishing season) was found to be approximately 151 mm at age 1, 183 mm at age 2, 203 mm at age 3, and 217 mm at age 4. For each age group, there was no major variation in mean length over the study period, indicating similar growth rates from year to year.

5.1.7 Natural Mortality

The NMFS conducted a large-scale marking experiment on adult gulf menhaden in the late 1960's and early 1970's. Adults were tagged with internal ferromagnetic tags which were later retrieved by magnets positioned along the processing line in all gulf menhaden reduction plants. Ahrenholz (1981) analyzed those tag returns to provide an estimate of natural mortality (M) for gulf menhaden. His estimate of natural mortality rate was approximately 1.1 (67% per year), indicating a rapid loss due to disease, predation and other factors independent of the directed purse-seine fishery. Since the analysis was carried out on tags retained from menhaden processing plants, the estimate of natural mortality is based on tag losses from all other factors, including natural causes and deaths resulting from discards from other fisheries in which gulf menhaden are incidentally captured. Adjustments for tagging mortality and tag shedding were made from estimates contained in Kroger and Dryfoos (1972).

Major assumptions involved in the analysis of the tag returns and subsequent use of the natural mortality rate in determinations of the status of the gulf menhaden stock by Ahrenholz (1981), Nelson and Ahrenholz (1986), and Vaughan (1987) are that older fish tagged in the study generally stayed within the range of the purse-seine fishery (i.e., were available to be captured) and that the natural mortality rate of gulf menhaden has not changed significantly since the study was conducted. The significance of a high natural mortality rate is that population size declines rapidly in the absence (and presence) of fishing and that maximum biomass of a particular year class is reached at an early age.

5.1.8 Spawner-Recruit Relationship

Spawning at age and fecundity data developed by Lewis and Roithmayr (1981) have been combined by Vaughan (1987). Estimates of number of recruits and number of spawners by age from the 1964-1985 data set were used to develop a spawner-recruit relationship for gulf menhaden. Results of a Ricker-type spawner-recruit model indicate maximum "average" recruitment of 29.9 billion individuals at age 1 is reached at a spawning stock size of approximately 8.6 billion individuals. The data indicate a slight decrease in recruitment at higher spawning stock sizes (due to poorer survival) and a slow decline in average recruitment at lower spawning stock sizes. The range in the number of estimated recruits into the fishery varied from 8.3 billion individuals in 1966 to 41.8 billion individuals in 1982. To account for differences in age-structure of spawners in different years (Nelson and Ahrenholz 1986), the spawner-recruit model was also run using number of eggs produced by the spawning stock and biomass of the spawning stock and resultant recruitment. Results of those runs indicate maximum "average" recruitment at an egg production level of approximately 39 trillion and a maximum "average" recruitment biomass of 570,000 metric tons at age 1 from a spawning stock of approximately 329,000 metric tons.

The five-fold variation in recruitment levels calculated for the 1964-1982 year classes is not exceptional for similar species around the world (NOAA 1976). Although the recruitment fluctuation is not extreme, it is sufficient to cause major changes in yearly biomass, resulting in major impacts on the gulf menhaden purse-seine fishery. Major assumptions associated with the application of the spawner-recruit data are that the model used is appropriate for gulf menhaden and that the range and average recruitment calculated for the study period is representative of long-term recruitment levels from gulf menhaden instead of being an unusually high or low recruitment level in a long-term cycle.

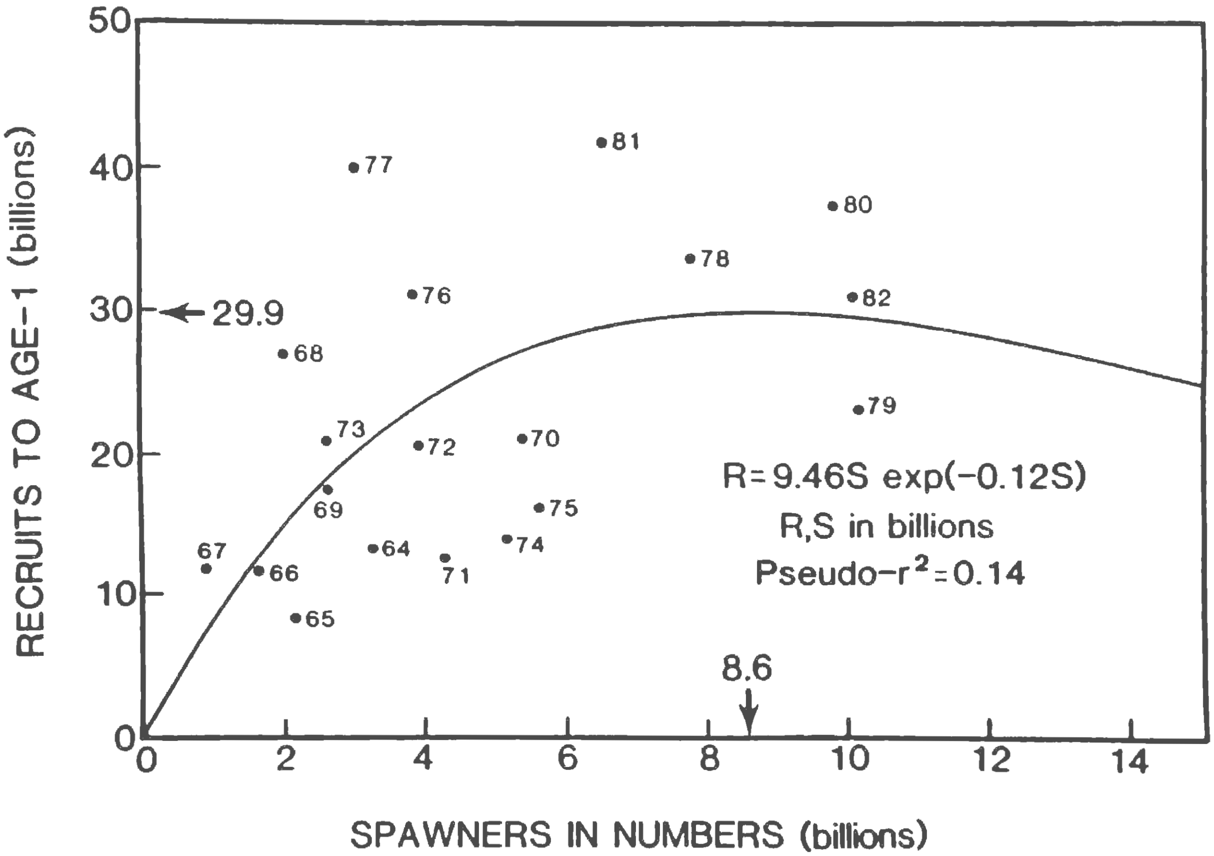
The proportion of age 2 spawners to the spawning stock has been fairly consistent, ranging between 82% and 98% in numbers and between 69% and 97% in egg production (Vaughan 1987). As illustrated in Figure 5.2 for the Ricker curve based on spawners in numbers and recruits to age 1, considerable scatter remains due to environmental conditions and measurement error. The relationship, however, is statistically significant so that future recruitment does depend to some extent upon the size of the spawning stock which produced them. Spawning stock biomass per recruit (SSB/R) and percent maximum spawning potential (%MSP) were calculated for gulf menhaden for fishing years 1964-1982. SSB/R increased from an average of 8.4 (1964-1970) to 13.1 (1976-1982), while %MSP increased from an average of 29.5 (1964-1970) to 49.0% (1976-1982). As with the noted decline in effective fishing effort (Vaughan 1987), increases in SSB/R and %MSP since the mid-1970s result from a more rapid increase in recruitment and population size than in landings.

5.1.9 Migration and Recruitment

5.1.9.1 Larval Transport

Whether the movement of larvae from their hatching area to estuaries represents passive drifting, active swimming or a combination of the two is not known. However, it is well documented that larvae (about 12.5 to 25 mm in length) enter gulf estuaries where they transform into juveniles and reside for several months before returning to the gulf (Arnold, Wheeler and Baxter 1960; Christmas and Waller 1973; Copeland 1965; Gunter and Christmas 1960; Hoese 1965; Perret, et al. 1971; Springer and Woodburn 1960; Suttkus 1956; Swingle 1971; Tagatz and Wilkens 1973; and Turner, Johnson and Gordy 1974). Shaw et al. (1985b) developed a qualitative transport model for western Louisiana which indicated west-northwest longshore advection within the coastal boundary layer was the major mechanism transporting larvae to the estuaries rather than cross-shelf transport from immediately offshore. Reintjes (1970) surmised that larvae of gulf menhaden are 3 to 5 weeks old when they enter estuaries. Recent larval otolith and water current data have revised this estimate to be more like 40-70 days in western Louisiana (Deegan 1985, Shaw et al. 1988). They then move from the higher-salinity waters of the lower estuary to the lower-salinity waters in the upper estuary and tributaries. It is assumed that planktonic larvae require favorable currents to make their way into estuaries. Ekman transport

Figure 5.2. Numbers of gulf menhaden recruits to age 1 (R) plotted against numbers of spawners (age 2+) (S) for year classes, 1964-1982. Curve represents the fitted Ricker function.



studies in the northern Gulf of Mexico have shown net northerly movement of surface waters (Cushing 1977). Favorable tidal currents for gulf menhaden larvae are assumed. In any event, periods of optimum conditions may vary from year to year (Christmas, et al. 1982).

5.1.9.2 Migration

Although there is evidence indicating that some young-of-the-year menhaden overwinter in estuaries (Turner and Johnson 1973, Deegan 1985 and others), the overwhelming majority migrate offshore. Migration apparently occurs throughout the summer and fall. Springer and Woodburn (1960) reported that migration from the estuaries in the Tampa Bay, Florida area took place during June and July and Tagatz and Wilkens (1973) found that most juveniles had moved out of estuaries in the Pensacola Bay, Florida, area by August.

Suttkus (1956) reported that migration of age 0 menhaden from Lake Pontchartrain, Louisiana appeared to occur in August or September. Copeland (1965) found that the greatest migration of advanced juveniles from estuaries at Port Aransas, Texas, occurred from November through May.

5.1.9.3 Recruitment and Movement, Tagging Program

The NMFS conducted a juvenile tagging program in Gulf Coast estuaries from the late 1960's through 1985. Juveniles were tagged internally with ferromagnetic tags and recovered with electromagnets in menhaden processing plants. Ahrenholz (1981) analyzed the returns to determine patterns of recruitment from nursery areas into the fishery, subsequent exploitation after entering the fishery, and migratory patterns. He concluded that fish first entered the fishery primarily in the general geographic area in which they were tagged (i.e., age 1 fish generally moved offshore during the summer and entered the fishery). Age 1 fish in the eastern and western edges of the traditional fishing grounds are not heavily exploited, while age 1 fish within the traditional fishing area are more fully exploited. Age 2 and older fish showed a tendency to move towards the center of the fishing grounds, becoming fully vulnerable to the fishery, and being exploited at levels equal to those of fish tagged in estuaries onshore of traditional grounds. There was little evidence of migration around the Mississippi River Delta. Fish that were tagged east of the river were mostly taken east of the river. A similar situation was found for fish tagged west of the river, and the limited number of crossover tags recovered from plants may have been a result of captures by vessels fishing on one side of the river and landing on the other side. Based on the proportion of tag recaptures of each age, migration of age 1, 2, 3 and 4 fish to areas not fished by the menhaden fleet appears unlikely.

5.1.10 Food and Feeding Habits

Metamorphosis of larvae into juveniles is accompanied by a change in feeding habits from a selectively feeding carnivorous diet to a filtering omnivorous diet and by development of a highly specialized gill raker-alimentary tract complex. As young menhaden develop, the maxillary and dentary teeth become non-functional and disappear; gill rakers increase in length, number and complexity; pharyngeal pockets appear; the alimentary tract folds forward, a muscularized stomach (gizzard) and many pyloric cecae develop and the intestine forms several coils (June and Carlson, 1971).

Peck (1894) concluded that menhaden are indiscriminate feeders and take in materials in the same proportions as they occur in ambient water. Adults are capable of filtering 23 to 27 liters of water per minute.

Darnell (1958, 1961) examined the feeding mechanism and stomach contents of gulf menhaden in Lake Pontchartrain. He concluded that they feed strictly by filtration and that suspended bacteria and material other than living plankton are important components of the food of menhaden in turbid estuaries.

Friedland (1985) studied structures of the branchial basket associated with filter feeding in Atlantic menhaden and suggested that food is captured primarily by mechanical sieving.

Guillory (1986) found a high correlation (in Louisiana west of the delta) between salinity and oil yield and concluded that "oil yield may then be linked to the role of salinity as an index of the introduction of nutrient rich freshwater."

5.2 Abundance and Biological Conditions

5.2.1 Fishing Mortality

The estimated number-at-age of gulf menhaden landed by the fishery from 1964-1985, and natural mortality rate calculated by Ahrenholz (1981) were combined in a virtual population (cohort) analysis by Vaughan (1987) to determine the rate of mortality attributable to the purse-seine fishery. The analysis provided back-calculated estimates of fishing mortality by age and by 6-month intervals for 1964-1983. The analysis also provided estimates of population size by age at the beginning of each 6-month interval and back to an age of 0.5 years, when limited numbers of fish at that age are first taken by the fishery. The results of that analysis indicate that age 1 fish are only partially recruited into the fishery, with older fish fully exploited. Over the period from 1964-1983, the fishery took an average of 27% of the age 1 fish and about 55% of the older fish each year.

Assumptions involved in the analysis are that all fish are available to the fishery sometime during their life cycle and that the estimate of natural mortality employed is realistic. Natural and fishing mortality do not operate independently of each other and must be combined to provide estimates of total mortality on the gulf menhaden stock. When the two rates are combined, annual total mortality estimates are 81%, 93% and 94% on age 1, 2, and 3 fish, respectively.

5.2.2 Population Size

Population size estimates derived from the cohort analysis ranged from a low of approximately 7.5 billion individuals at the start of the fishing season in 1966 to a high of approximately 39 billion individuals in 1982. The bulk of the population, considering only fish of age 1 and older, was composed of age 1 fish with overall population size predicated on the size of the incoming year class (Figure 5.3).

5.2.3 Yield-Per-Recruit

A yield-per-recruit model of gulf menhaden used by Vaughan (1987) indicates a yield per recruit (yield per individual fish recruited but not necessarily harvested) of 12.2 grams (Figure 5.4). This estimate, extrapolated to the average of 58 billion recruits at an age of 0.5 years (the age of first capture) provides an estimate of approximately 707,600 metric tons. This differs some from average landings of 811,600 metric tons during the period in which data were gathered for the yield-per-recruit model. The model was run on average conditions of fishing mortality imposed by the fishery from 1964-1983 with various multiples of that mortality by age of fish by three-month periods. The model was also run annually for the period 1964-1983. Yield-per-recruit estimates were obtained for the high and low of 16.34 and 14.29 grams, respectively.

The model predicts a maximum stock biomass at an age of 1.5 years indicating that substantial effort has to be applied at an early age to maximize yield by the fishery. Increasing fishing mortality would theoretically increase yield-per-recruit slightly, but would probably reduce overall yield by impacting the spawning stock size and reducing the number of subsequent recruits. Delaying the age of entry into the fishery would result in a substantial decrease in yield-per-recruit because of the high natural mortality rate.

The model combines information on growth rate and natural mortality, and on fishing mortality rates calculated from a cohort analysis. It assumes that the natural mortality rate is realistic and representative of the entire 1964-1977 data base. The model does not take into account the impact of fishing mortality on the spawning stock and recruitment. This is addressed in Section 5.4.2.1, biological models.

5.3 Ecological Relationships

5.3.1 Role of Estuaries

The dependency of menhaden on estuaries is apparent, although the relationship is somewhat obscure. Reintjes and Pacheco (1966) discussed the relationship and stated that the association of menhaden with estuaries for the greater part of the first year of life appears to be a consistent, if not necessary, aspect of the life cycle. Reintjes (1970) reviewed the role of estuaries in the life cycle of gulf menhaden and stated that the menhaden industry is dependent upon (1) spawning success, survival in the open gulf and movement into the passes; and (2) capacity and suitability of the estuaries for growth and survival. Reintjes (1970) further stated that:

> Menhaden, in turn, are an important component in an estuary. After they transform from the slender, transparent larvae to juveniles they become filter feeders. They swim about in schools, usually with their mouths gaping open, to filter the small planktonic animals and plants from the water. They have a complex gill apparatus that forms a basketlike sieve that removes all but the smaller particles from the water. As the bulk of the organisms eat algae or the remains of higher plants, menhaden are principally herbivores. Menhaden are one of the few fishes (mullet is another) that live by grazing on the plants in the estuaries. They are at one of the lowest trophic levels near the bottom of the food chain and provide food, in turn, for nearly all the carnivores that are large enough to eat them. This then forms both sides of the coin: The role of estuaries in the life cycle of menhaden and the role of menhaden in the ecology of estuaries.

Estuaries serve as nursery areas for menhaden for about six months or more of the first year of life and may be essential for the larvae to metamorphose (June and Chamberlin, 1959). Combs (1969) found that gonadogenesis occurs only in menhaden larvae that arrived in a euryhaline littoral habitat. This indicates that gonadogenesis is initiated in gulf menhaden only after the recently hatched fish have entered estuarine waters.

5.3.2 Factors Affecting Survival

Reintjes and Pacheco (1966) discussed some physical, chemical and biological factors affecting young menhadens and pointed out the scarcity of data on this subject. Young menhadens have been collected in gulf estuaries at temperatures ranging from 5° to 34.9°C and in salinities from $0.0°/_{oo}$ to $67°/_{oo}$ (Christmas and Waller 1973; Perret, et al. 1971; Simmons 1957; Swingle 1971). Reintjes and Pacheco (1966) cited references indicating that larval menhaden may suffer mass mortalities when water temperature falls below 3°C for several days or chills rapidly to 4.5°C. Mass mortalities of menhaden, apparently due to high salinity ($80°/_{oo}$ or greater), have been reported by Simmons (1957).

Mass mortalities attributed to low concentrations of dissolved oxygen have occurred in Alabama estuaries (Crance 1971) and in other areas. Other factors that probably affect menhaden in estuaries include currents, toxic pollutants, predators and parasites and diseases.

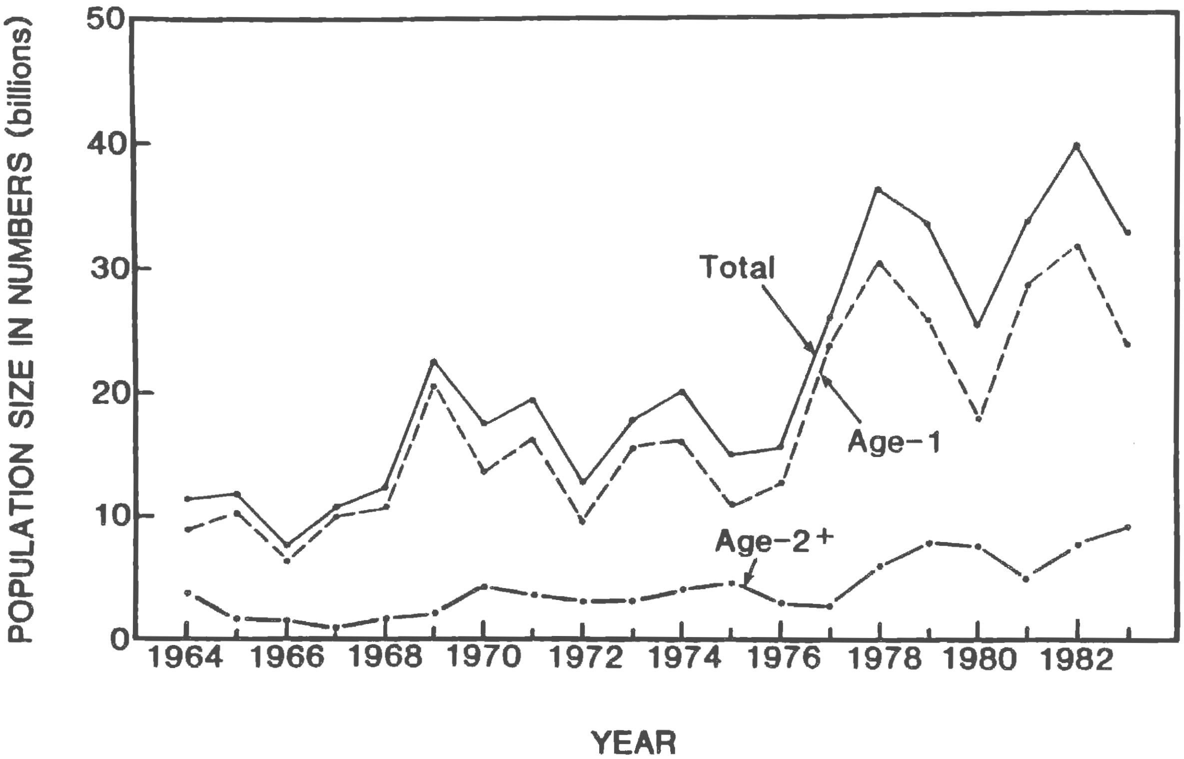


Figure 5.3. Population number of gulf menhaden April 1, 1964-1983, estimated from virtual population analysis on 1960-1982 year classes (Vaughan 1987).

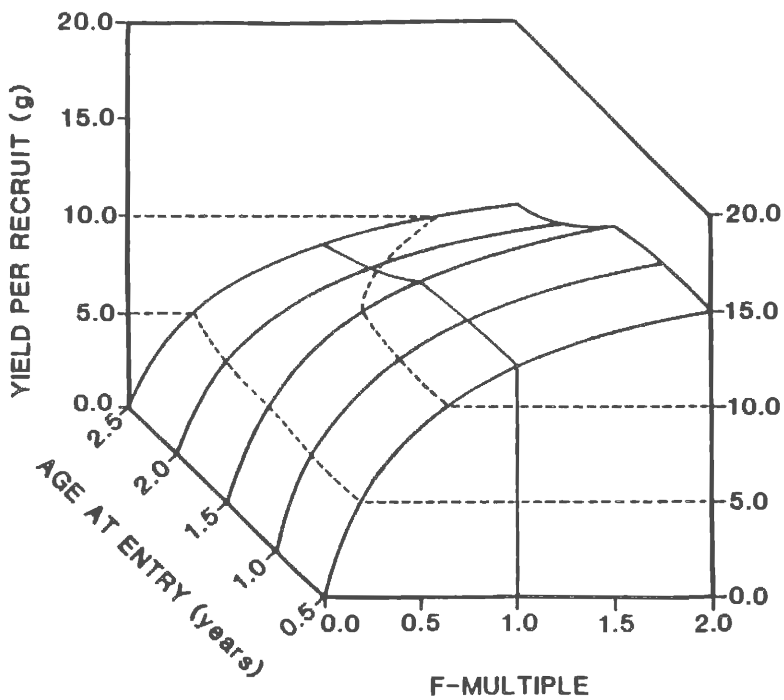


Figure 5.4. Yield-per-recruit of gulf menhaden under average conditions of growth and with multiples of average fishing mortality by three month interval (F-multiple=1.0) for the 1978-1985 fishing years (Vaughan 1987).

5.3.3 Predator-Prey Relations

Gulf menhaden play dual roles as both prey and predator. Many species of piscivorous fish and birds eat them (Gunter 1945, Overstreet and Heard 1978, and Thompson 1983). They ingest large numbers of the planktonic larvae of other species. The effects of predation in estuarine and marine communities in the Gulf of Mexico have not been quantified. Dunham (1975) noted that juvenile menhaden are readily preyed upon and listed ten predator species, including spotted seatrout. Those reports concerned age 0 menhaden that had not been recruited to the commercial fishery population. The role of adult gulf menhaden as a forage species in gulf waters is not well known.

Conclusions reached in consideration of predator-prey relations of Atlantic menhaden in the Fishery Management Plan for Atlantic Menhaden (Atlantic Menhaden Management Board 1981) also apply to gulf menhaden:

> The full ecological value of the menhaden resource in addition to its important use in the production of fish meal, oil and solubles may be realized only when its contribution as a food item for other valuable finfish species is considered.
>
> McHugh (1967) took issue with socio-political pressure brought to bear in recent years on the commercial fishing constituencies by recreational fishing interests. The pressure has usually been based on the assumption that commercial fishing gear over-exploits the food supply of sport fishes or actually kills large numbers of sport species. McHugh could find no scientific evidence to support the allegations. He countered the argument of recreational fishermen by suggesting that menhaden may consume large quantities of other valuable nekton species. Further, he raised the question of relationships between menhaden and abundance of shrimp, blue crabs and other resources. The inference is that although menhaden serve as prey for commercial and recreationally sought species, they may in turn prey on early planktonic life stages of other valuable species.

5.3.4 Environmental Impact on Recruitment

It is generally believed that environmental conditions have a large impact on gulf menhaden year class strength. Quantification of those relationships has been studied in recent years, although additional research is needed throughout its range.

The critical period for gulf menhaden, as for most marine fishes, is during the early life history stages, especially the egg and larval stages. In fisheries literature the "critical period" has been defined as the "phase during which the strength of a year class is determined" (Gulland 1965). The egg and larval stages are considered crucial because natural mortalities are highest then and because these stages are most susceptible to the external environment. Stone (1976), Christmas, et al. (1982), and Guillory, Geaghan and Roussel (1982) either examined or discussed the relationship between environmental conditions in the critical early life history stages of gulf menhaden recruitment.

Stone (1976) examined the combined effects of fishery effort and various environmental factors (air and water temperature, tide, rainfall, and wind speed and direction) to total gulf landings of menhaden. Stone made the following conclusions: (a) fishing effort accounts for approximately 70% of the variation in harvest; (b) environmental variables significantly related to menhaden harvest are minimum air temperatures and wind direction, with minimum air temperatures and wind direction interacting with minimum air temperature; and (c) the critical time periods for the above variables are still not identified.

Guillory et al. (1984) examined the correlation between several environmental factors measured during the egg, larval and early juvenile abundance, as measured by catch-per-effort (CPE) in the fishery the following year. CPE was defined as number of age 1 fish landed in Louisiana reduction plants per vessel-ton-week of boats landing in Louisiana. Significant correlation coefficients between 1963-77 environmental factors and 1964-78 CPE were: -0.81 for January water temperature; -0.73 for incidence of January southeast wind; +0.68 for March salinity; -0.66 for January tide level; -0.62 for February Mississippi River discharge; and -0.54 for March wind speed. This approach assumes that effort directed towards age-1 fish is proportional to total effort and that the true abundance of a particular aged fish is indicated by their catch and CPE.

Christmas, et al. (1982), in their Habitat Suitability Index (HSI) models for gulf menhaden, identified optimum temperature and salinity conditions for the egg and larval stages:

	Salinity (°/oo)	Temperature (°C)
eggs/yolk-sac larvae (marine)	25-36*	14-22*
feeding larvae (marine)	15-30*	15-25*
feeding larvae/juveniles (estuarine)	5-13*	5-20*

* lowest mean monthly winter value

5.4 Maximum Sustainable Yield (MSY)

5.4.1 Definition and Estimate

Ricker (1975) defines MSY as, "The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions (for species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others)." For gulf menhaden, MSY is an estimate of the potential long-term average of annually fluctuating yields under the range of environmental conditions and recruitment levels occurring during 1964-1985. Using the best scientific information available, Vaughan (1987) estimated the annual MSY at 803,300 metric tons with a "normal" annual range of yields of approximately 700,000 to 825,000 metric tons.

5.4.2 Summary of Information Used to Specify MSY

5.4.2.1 Biological Model

Information on growth rate, natural mortality, the spawner-recruit relationship, and fishing mortality for the 1964-1985 period were combined into a population-predictor model by Vaughan (1987) (Figure 5.5). The average fishing mortality, by age, imposed by the fishery for the 1964-1985 time period was used in the model, along with higher and lower multiples of that mortality, to determine population biomass and yield at various levels of fishing mortality. This allowed an estimation of the impact of fishing mortality on the stock and on yield under "average" biological conditions. The model was also used to calculate MSY for the gulf menhaden fishery. Assuming that 1964-1985 conditions are representative of the biology of gulf menhaden, the model predicted a MSY of approximately 803,300 metric tons at 100% of the average fishing mortality applied during that period (Table 5.1). At the average fishing mortality imposed by the fishery during that period, the model predicts a long-term sustainable average yield of 803,300 metric tons (same as MSY). The model also identifies the level of fishing at which a gradual decline to eventual extinction takes place at approximately 110% greater than the average mortality imposed from 1964-1985. Beyond that point, the rate of extinction increases with increased fishing mortality. Results of low and high fishing mortality levels show steep slopes on the ascending and descending limbs of the sustainable yield curve predicted by the model (Figure 5.5). Considerable fluctuation in yield will result from fluctuations in recruitment, but the long-term MSY estimate appears to be realistic, provided that the assumed spawner-recruit relationship is valid, and that the basic pattern of recruitment remains unchanged.

The impact of fishing mortality on the stock is also reflected in estimates of population biomass generated by the model. These estimates show an average pre-exploitation population biomass of approximately 2.6 million metric tons, followed by an accelerating decline as increased fishing mortality takes progressively larger fractions of the population and disproportionately larger fractions of older and heavier fish (Table 5.1).

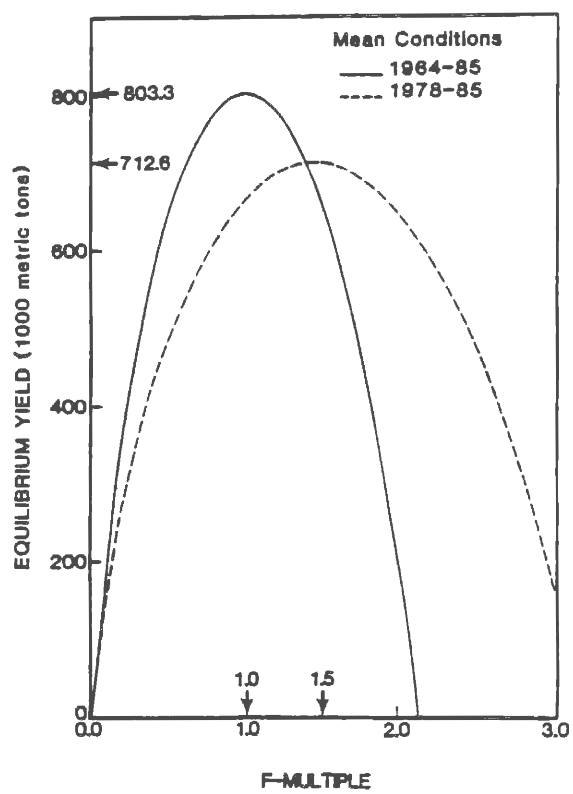


Figure 5.5. Sustainable yield predicted by a deterministic population simulation model of the gulf menhaden fishery at multiples of the average fishing mortality (F-Multiple=1.0) for the 1964-1985 fishing years (solid line) and 1978-1985 fishing years (dashed line) (Vaughan 1987).

Table 5.1. Sustainable yield and population biomass estimated from a gulf menhaden population-predictor model at 1964-1985 average fishing mortality imposed by the fishery, and at multiples of that mortality (Vaughan, personal communication).

Fishing Mortality (% of 1964-1985 Average)	Sustainable Yield (Metric Tons)	Population Biomass (Metric Tons)	Years to Stabilization
0	0	2,596,800	7
20	365,969	2,394,100	6
40	580,216	2,221,100	5
60	710,583	2,056,800	5
80	780,847	1,890,700	6
100 (MSY/average)	803,268	1,709,200	1[1]
120	780,715	1,504,900	10
140	713,519	1,271,700	13
160	597,171	997,300	23
180	428,240	677,200	34
200	196,166	295,800	110
220	0	0	450+[2]
240	0	0	50+[2]

[1] starting age structure based on average age-specific F
[2] to extinction

Estimates of a realistic range of yields around which the fishery may operate were obtained by running the population predictor model at levels of high and low recruitment. Results indicate a "normal" range of yields of approximately 700,000 to 825,000 metric tons around the long-term average yield of 803,300 metric tons predicted at the average fishing mortality. These extremes are near the actual ranges in yield observed in the fishery during the period for which data were collected (317,300 to 982,800 metric tons) and provide estimates of yield ranges expected in future years.

5.4.2.2 Fishing Effort

The unit of effort currently used for description and analysis of the gulf menhaden purse-seine fishery is vessel-ton-week (VTW). Seasonal fishing effort by vessel is obtained by multiplying number of weeks during which a vessel was active (landed fish on at least one day in the week) by the vessel's net registered tonnage (nominal effort). This unit of effort is preferred over the vessel-week unit (VW) used for the Atlantic menhaden purse-seine fishery because, on the average, larger vessels on the gulf tend to have larger catches (Schaaf, et al. 1975). Hence, since the VTW unit accounts for some of the differences in efficiency within the gulf purse-seine fleet, it possesses stronger analytical and predictive characteristics (Figure 5.6) than the VW unit. Approximately 85 percent of the variation in catch is explained by VTW, which is 9 to 17 percent more than that explained by VW (Ahrenholz personal communication). However, the net registered tonnage does not accurately reflect the harvest capability of individual vessels.

Fishing effort historically has served two fundamental purposes in analyses of the gulf menhaden population. First, a unit of effort helps to explain differences in catch efficiency between vessels within a season. As described in the paragraph above, VTW serves this purpose, but is limited. An improved estimate of nominal effort should be developed. Second, a unit of effort, either directly (nominal) or indirectly (effective), is used to reflect proportional changes in the instantaneous fishing mortality rate. Nelson and Ahrenholz (1986) have shown how nominal VTW can be adjusted to effective VTW, but this adjustment requires a priori knowledge of population size and so is not useful for predicting fishing mortality from vessel activity. This dependence of nominal fishing effort on population size violates an important assumption of surplus production models that use CPUE (catch-per-unit-effort) to reflect changes in stock abundance. Hence, using CPUE as a warning signal for stock decline is not sufficiently sensitive for the gulf menhaden fishery. A possible solution to this problem may be the incorporation of time dependent variables such as search time suggested by Condrey (1982) to develop a relationship between a measure of nominal effort and fishing mortality.

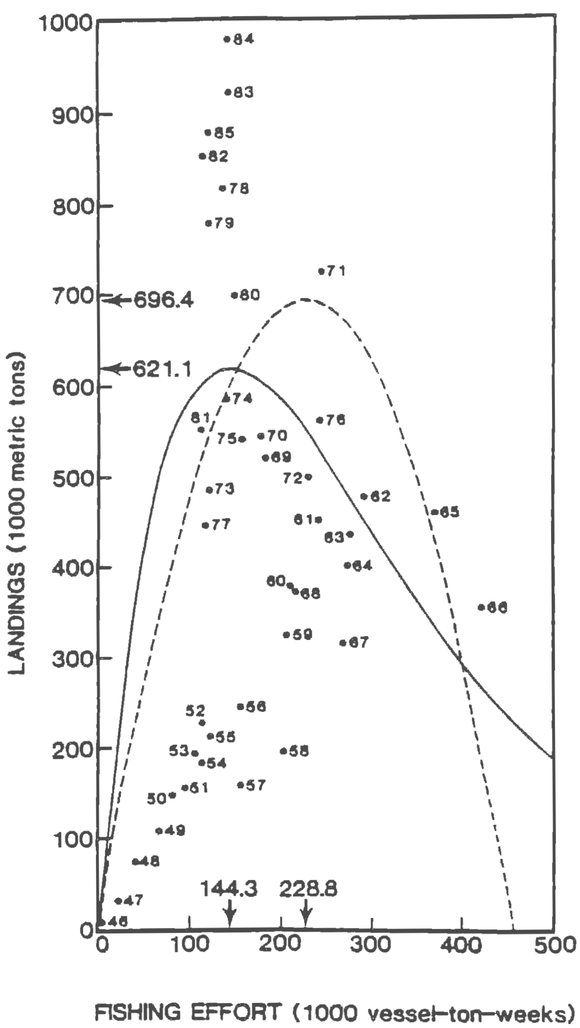


Figure 5.6. Parabolic (dashed line) and PRODFIT (solid line) surplus production function models fitted to catch and effort data for the gulf menhaden fishery from 1946-1985, with 1964-1983 data being estimates of effective effort, based on adjustments from calculated catchability coefficients for those years (Vaughan 1987).

5.4.2.3 Catch-Effort Model

From Vaughan (1987):

Surplus production models are typically used to obtain estimates of maximum sustainable yield from yield and fishing effort data (Vaughan et al. 1984). When using these models, yield is assumed to be proportional to population abundance and fishing effort proportional to fishing mortality. Theoretically, plotting catch against effort should give a dome-shaped curve, which is not the case for gulf menhaden data, although the points might lie along the ascending limb of such a curve (Figure 10 [Figure 5.7]). When relating fishing effort (E) to the instantaneous fishing mortality rate (F), the catchability coefficient (q) is assumed to be constant; i.e.,

$$F = q\ E, \tag{4}$$

where the unit of fishing effort, E, is defined as vessel-ton-weeks for gulf menhaden. As noted in Nelson and Ahrenholz (1986), the above unit of fishing effort, referred to as nominal effort, is not a reliable measure of fishing mortality. A unit of fishing effort that is a reliable measure of fishing mortality is referred to as effective effort. The difficulty in directly obtaining a reliable unit of fishing effort results from the schooling nature of clupeid fishes, which are more susceptible to fishing effort than non-schooling species [see discussion of "dynamic aggregation process" in Clark and Mangel (1979)]. The concern here is that severe stock depletion could occur before it was indicated by an analysis of yield and CPUE data.

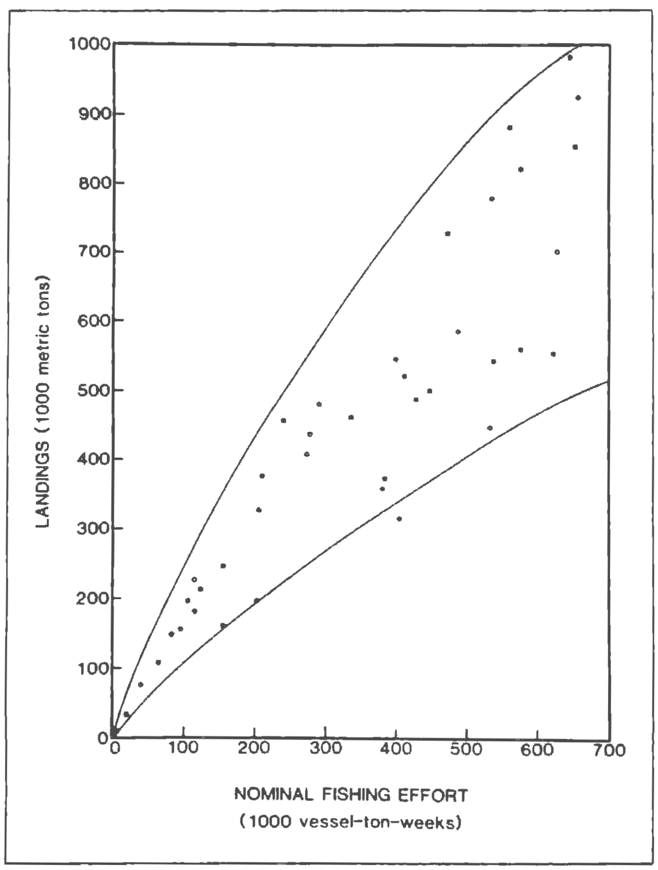


Figure 5.7 (Figure 10 from Vaughan 1987). Gulf menhaden landings plotted against nominal fishing effort for the 1946-85 fishing years. Solid curves represent range in landings depending on fishing effort.

To demonstrate that the population catchability coefficient, q, for gulf menhaden is not constant but dependent upon the population size, it was estimated by solving Eq. (4) for q (=F/E) for each fishing year from 1964 through 1983 (Figure 11 [Figure 5.8]) and compared with the population size for the same fishing year (Figure 12 [Figure 5.9]). To calculate the population (all ages combined) instantaneous fishing mortality rate (F), it was first necessary to compute the population exploitation rate (u) by comparing numbers caught in a fishing year (for all ages 1-4) with the population size (for all ages 1-4) on 4 April for that year (Table 11). The population F is then calculated iteratively from the equation:

$$F = u\ (F + M)/1 - \exp(-(F + M)),$$

where u and M (=1.1/year) are known. Estimates of q range between 6.9×10^{-7}/year-vessel-ton-week in 1965 and 1966 when the population sizes were 11.8 and 7.5 billion, respectively (Table 11 [Table 5.2]). As noted in Nelson and Ahrenholz (1986), there is a pronounced inverse relationship between the catchability coefficient and population size (Figure 12 [Figure 5.9]). Furthermore, the historical trend that they noted continues to be evident with the addition of seven more years of data; i.e., there appears to be a functional curve. With generally increasing population size since 1964, the catchability coefficient has declined to a level in 1982 that is one-sixth that of 1965-66.

To adjust nominal fishing effort to account for variations in q, I used the 1964 value of $q(q_a)$; i.e.,

$$E' = E\ q/q_a,$$

where E' is a unit of "effective" fishing effort (Figure 13 [Figure 5.10]). Note that while nominal effort has increased rapidly, effective fishing effort has declined since 1966.

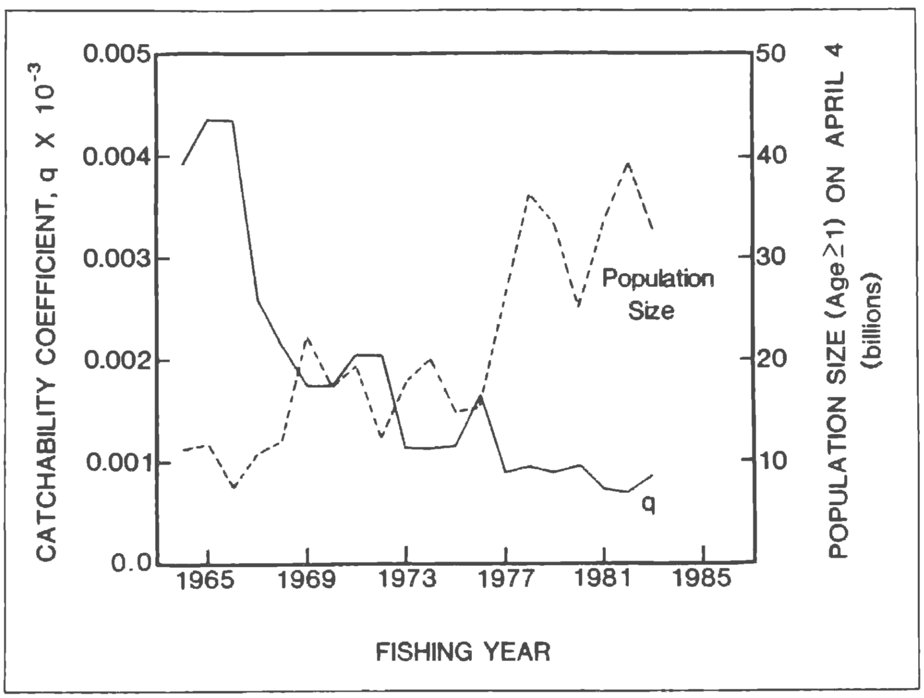


Figure 5.8 (Figure 11 from Vaughan 1987). Catchability coefficient (q) and population size (age-1 and older) for gulf menhaden plotted against fishing year, 1964-83.

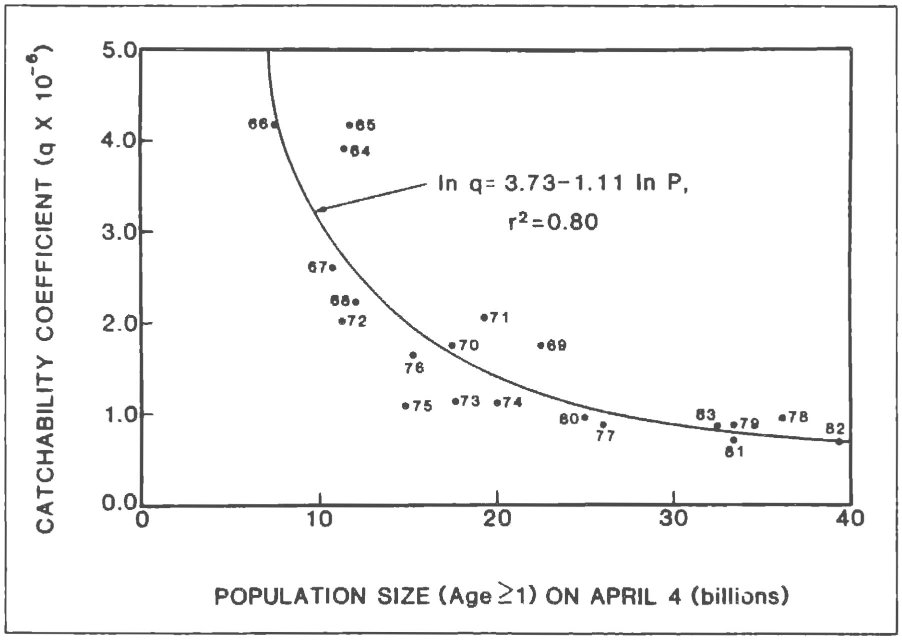


Figure 5.9 (Figure 12 from Vaughan 1987). Catchability coefficient (q) plotted against population size (age-1 and older of gulf menhaden). Also shown is linearized regression of ln q against ln P (solid curve).

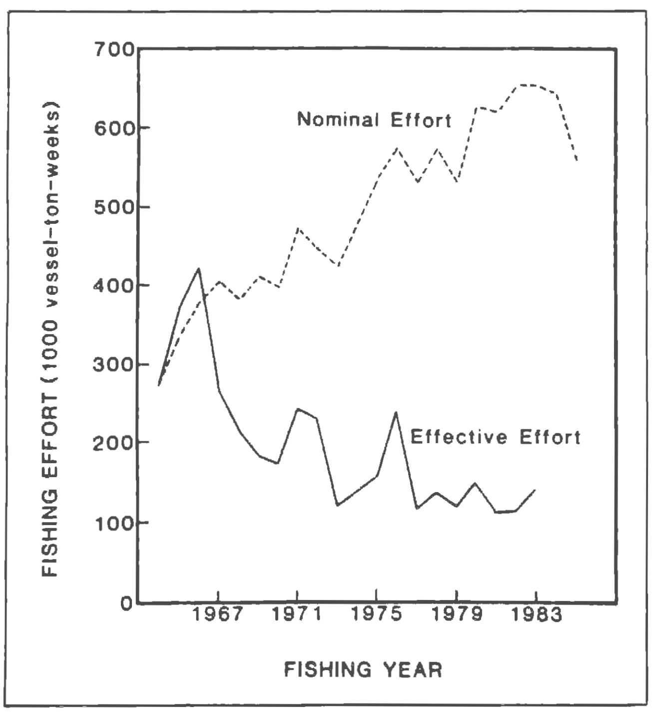


Figure 5.10 (Figure 13 from Vaughan 1987). Nominal and effective fishing effort for gulf menhaden plotted against fishing year, 1964-1985.

Table 5.2 (Table 11 from Vaughan 1987). Estimated population size (ages 1-4) on 4 April, numbers landed (ages 1-4), population exploitation rate (u), population instantaneous fishing and mortality rate (F, yr^{-1}), catchability coefficient (q, yr^{-1} $vessel\text{-}ton\text{-}weeks^{-1}$), and effective fishing effort (E', vessel-ton-weeks) for gulf menhaden by fishing year, 1964-85.

Fishing year	Population size (10^9)	Numbers landed (10^9)	Population u	F	$q(10^{-6})$	$E'(10^3)$
1964	11.32	4.95	0.437	1.071	3.92	272.9
1965	11.76	6.19	0.526	1.459	4.35	371.8
1966	7.48	4.21	0.563	1.658	4.35	422.5
1967	10.71	4.62	0.431	1.048	2.59	267.1
1968	12.07	4.51	0.374	0.850	2.22	216.7
1969	22.41	7.39	0.330	0.716	1.74	182.4
1970	17.35	5.60	0.323	0.695	1.74	177.2
1971	19.36	7.90	0.408	0.965	2.04	245.9
1972	12.44	4.87	0.392	0.910	2.03	231.9
1973	17.69	4.24	0.240	0.477	1.12	121.6
1974	20.02	5.38	0.269	0.549	1.13	140.0
1975	14.85	4.40	0.296	0.620	1.15	158.1
1976	15.27	6.17	0.404	0.951	1.65	242.4
1977	25.99	6.11	0.235	0.465	0.87	118.5
1978	36.12	9.59	0.265	0.539	0.84	137.4
1979	33.39	7.92	0.237	0.470	0.88	119.7
1980	25.01	7.15	0.286	0.593	0.95	151.2
1981	33.39	7.54	0.226	0.444	0.71	113.1
1982	39.39	9.01	0.229	0.451	0.69	114.9
1983	32.57	9.80	9.273	0.559	0.85	142.6
1984		11.12				
1985		11.15				

The computer program PRODFIT (Fox 1975), which accounts for non-equilibrium conditions, is used to estimate parameters for different surplus production models depending on the value of m in the following equation:

$$U = (A + B\ E')^{1/(m-1)},$$

where U is catch-per-unit-effort, and A, B, and m are parameters to be estimated. The generalized production model of Pella and Tomlinson (1969) is obtained when m is allowed to be estimated freely. However, when m is forced equal to 2.0, the Schaefer model (Schaefer 1954, 1957) is obtained, and when m is forced equal to 1.0, the Gompertz model (Fox 1970) is obtained. The program PRODFIT also allows the analyst to enter the number of significant age classes to be entered in the analysis (i.e., this is used in estimating parameters under non-equilibrium conditions). Those age classes contributing at least 10% to the landings in numbers served as the basis for determining the number of significant age classes for each fishing year in the analysis (1946-85).

Estimates of MSY based on 1946-85 fishing years range from 621.1 KMT when m is estimated freely (m = 0.99; Pella-Tomlinson model) to 696.4 KMT when m is forced equal to 2.0 (Schaefer model) (Figure 14 [Figure 5.6]). The scatter evident in Figure 14 illustrates why little confidence is placed in this approach to estimating MSY. More confidence is placed in population simulation models, which are discussed later.

With MSY estimates ranging between 620 and 700 KMT, one would expect that recent levels of landings could not be maintained. However, these high levels of landings are occurring with relatively low fishing mortality (i.e., 25% mean exploitation rate in the 1980's compared with 44% mean exploitation rate in the 1960's; Table 11 [Table 5.2]) and declining effective fishing effort. The decline in exploitation rate (and effective fishing effort) appears to be the result of increased population size due to recent high recruitment (Table 4 [Table 5.3]). The next section provides some insight into whether there is sufficient spawning stock numbers and recruits to sustain the stock.

Table 5.3 (Table 4 from Vaughan 1987). Estimated number of spawners (by age on 1 January and total) that produced the year class, estimated egg production from the spawning stock, and estimated numbers of recruits at age-0.5 and -1 for gulf menhaden by year classes, 1964-84.

Year class	Spawners: Numbers-at-age (10^6) 2	3	4	Total	Eggs (10^{12})	Recruits: Age-0.5	Age-1
1964	2,992.7	240.5	7.5	3,240.7	38.6	23,159.4	13,357.7
1965	1,950.7	160.5	14.7	2,125.9	24.4	14,372.3	8,261.8
1966	1,525.0	61.2	8.1	1,594.3	16.1	22,909.7	13,199.6
1967	877.0	25.1	1.2	903.3	10.3	24,081.1	13,876.7
1968	1,921.0	97.3	1.2	2,019.5	22.4	46,799.3	26,943.2
1969	2,493.3	61.1	8.5	2,562.9	31.6	30,294.4	17,462.4
1970	2,592.2	82.2	3.5	5,377.9	55.6	36,925.8	21,271.8
1971	3,801.5	422.1	6.8	4,230.4	54.4	21,713.2	12,512.1
1972	3,670.5	172.1	39.6	3,882.2	45.5	35,879.7	20,688.2
1973	2,384.1	210.9	6.0	2,601.0	32.9	36,819.9	21,210.9
1974	5,009.1	127.5	7.5	5,144.1	74.2	24,192.2	13,955.6
1975	4,765.0	821.3	6.8	5,593.1	88.1	28,400.5	16,305.9
1976	3,132.2	661.3	7.8	3,801.3	58.9	54,129.7	31,230.1
1977	2,634.6	251.5	98.7	2,984.8	39.4	69,001.8	39,810.6
1978	7,592.8	129.2	20.4	7,742.4	80.6	58,612.0	33,816.2
1979	9,195.2	933.6	14.3	10,143.1	125.2	40,114.8	23,144.2
1980	8,287.1	1,389.6	110.4	9,787.1	125.2	65,029.0	37,461.3
1981	5,442.9	847.7	208.0	6,498.6	69.2	72,429.8	41,788.4
1982	8,997.3	971.1	95.4	10,063.8	103.8	53,745.6	31,008.5
1983	10,786.1	1,043.0	45.9	11,875.0	143.3	NE	NE
1984	7,345.9	1,241.2	118.8	8,705.9	107.8	NE	NE

5.4.2.4 Population Simulation Models

From Vaughan (1987):

Estimating maximum sustainable yield, based on biological characteristics of the population, is more preferable than estimates based on yield and fishing effort (surplus production models discussed earlier in this report). Walters (1969) developed a simulation model (computer program POPSIM), which allows the inclusion of estimates of growth in weight, a spawner-recruit relationship, and natural and fishing mortality rates. ... In addition to the two estimated Ricker spawner-recruit models described in the previous section (based on recruits to age-1), a third spawner-recruit relationship was developed on the basis of the uniform probability density function for the range in observed recruitment to age-1 on 1 January during the period 1964-82 (8.3 to 41.8 billion fish) (Table 4). Fishing mortality can be different for each age class, but must be constant between seasons for which F is greater than zero. Because of between-season limitation on fishing mortality rates in the Walters (1969) model, no fishing is assumed to occur before age-1, and fishing on age 1-4 fish is assumed to occur only during the second and third quarters (April-September). These limitations are not thought to have any significant effect on the model results, since few age-0 fish have been caught since the mid-1970's and the fishing season is restricted by law to the period from mid-April to mid-October. Natural mortality (M) is assumed equal to 1.1/year (67% per year) as in previous analyses.

Numerous POPSIM runs were made for three spawner-recruit relationships (spawners in numbers, spawners as eggs, and random recruitment) and for two sets of mean conditions (1964-85 and 1978-85). For each of these six conditions (3 x 2), population simulations or projections were run for a series of F-multiples ranging from 0.2 to 3.0. The projections were for at least 50 years (e.g., a 25-year projection is shown in Figure 17 [Figure 5.11]), and produced estimates of population-size-at-age, and yield to the fishery for each year. For most runs involving either of the Ricker spawner-recruit relationships, only a few years of the simulation were required for equilibrium (sustainable) conditions to be attained. Obviously, no such equilibrium conditions are attainable from the random recruitment model. Table 14 [Table 5.4] the equilibrium conditions obtained from F-multiples ranging from 0.2 to 2.0 for the Ricker model with spawners in numbers and using 1964-85 mean conditions. F-multiples greater than 2.0 would ultimately lead to a population crash. Estimates of MSY for the 1964-85 mean conditions range from 803 KMT (F-multiple of 1.0, spawners in numbers), while estimates of MSY for the 1978-85 mean conditions range from 705 KMT (F-multiple for 1.5, spawners as eggs) to 713 KMT (F-multiple of 1.5, spawners in numbers) (Table 14).

Two features become evident after comparing the equilibirum yields between 1964-85 and 1978-85 mean conditions for the two Ricker models (spawners in numbers, Figure 18 [Figure 5.5]). First, the 1964-85 mean conditions have a higher MSY than do the 1978-85 mean conditions; secondly, the 1978-85 mean conditions appear less susceptible to population collapse than do the 1964-85 mean conditions at higher values of the F-multiple. The higher MSY estimate, obtained for the 1964-85 mean conditions compared with the 1978-85 mean conditions, is probably due to the higher mean weight of individuals landed during the full 1964-85 period compared with the recent 1978-85 period (Figure 7 [Figure 5.12]). The lower MSY estimate is obtained in spite of higher recruitment levels since 1978. The apparent decrease in susceptibility to population collapse is based on lower exploitation rates (Figure 5 [Figure 5.13]), a shift to higher F for MSY (Fig. 18), and results from the higher recruitment levels since 1978. Fifty-year mean yield can be compared

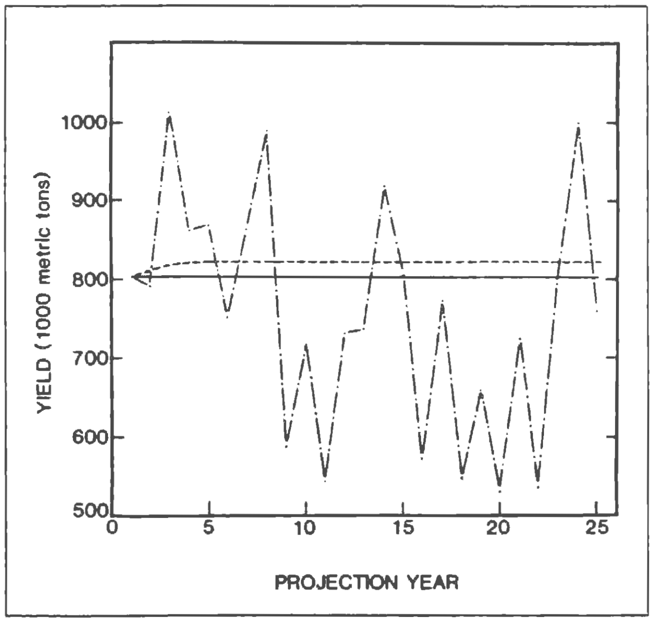


Figure 5.11 (Figure 17 from Vaughan 1987). Population projections for 25 years with F-multiple=1.0 under 1978-85 mean conditions for gulf menhaden. Three superimposed curves are for Ricker model with spawners in numbers (solid line), Ricker model with spawners as eggs (dashed line), and random recruitment model (dot-dashed line).

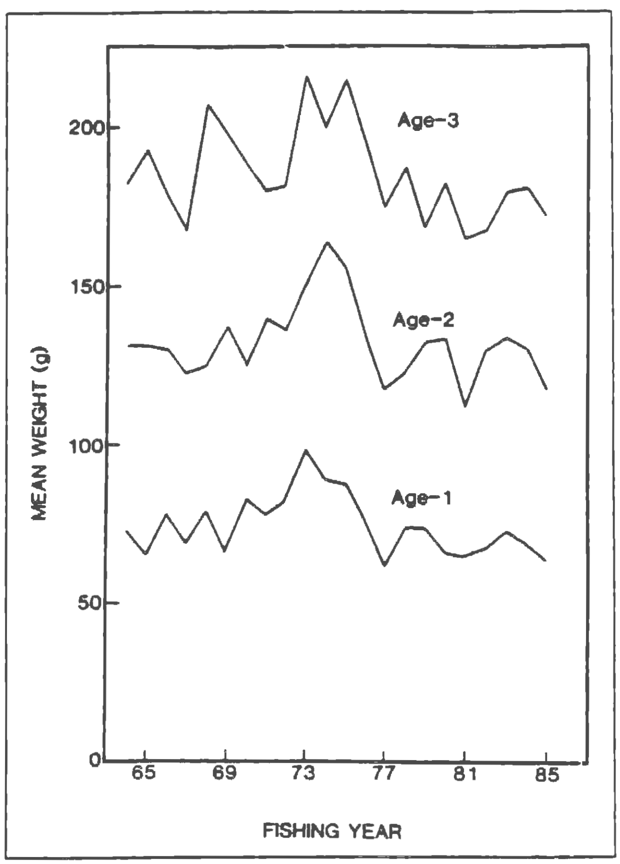


Figure 5.12 (Figure 7 from Vaughan 1987). Mean annual weight of purse-seine landed gulf menhaden, ages 1, 2, and 3, for fishing years 1964-85.

Table 5.4 (Table 14 from Vaughan 1987). Annual age-specific fishing mortality rates for gulf menhaden expressed as multiples of the average fishing mortality rate at age, actual fishing mortality rates at age used in the population simulation model, population size in biomass and numbers and sustainable yield based on Ricker spawner-recruit relationship between numbers of recruits at age-1 and spawners as numbers (ages 2-4) for 1964-85 mean conditions. Additional maximum sustainable yield (MSY) estimates obtained for 1978-85 mean conditions and for spawner-recruit curves based on spawners as eggs.

F multiple	Actual F at age 0	1	2	3	4	Population Biomass (10^3 mt)	Population No. (10^9)	Sustainable yield (10^3 mt)
0.0	0.0	0.000	0.000	0.000	0.000	2596.8	40.2	0.0
0.2	0.0	0.109	0.306	0.333	0.563	2394.1	40.1	366.0
0.4	0.0	0.217	0.613	0.667	1.126	2221.1	39.5	580.2
0.6	0.0	0.326	0.919	1.000	1.689	2056.8	38.3	710.6
0.8	0.0	0.435	1.225	1.333	2.252	1890.7	36.4	780.8
1.0	0.0	0.543	1.531	1.666	2.815	1709.2	33.9	803.3
1.2	0.0	0.652	1.838	2.000	3.378	1504.9	30.6	780.7
1.4	0.0	0.761	2.144	2.333	3.941	1271.7	26.4	713.5
1.6	0.0	0.869	2.450	2.666	4.504	997.3	21.1	597.3
1.8	0.0	0.978	2.756	3.000	5.067	677.2	14.5	428.2
2.0	0.0	1.807	3.063	3.333	5.630	295.8	6.4	196.2
			MSY for Ricker spawner-recruit relations					
			1978-85 mean conditions					
Spawners as numbers:								
1.5	0.0	0.547	1.427	1.760	7.927	1363.2	34.0	712.6
Spawners as eggs:								
1.5	0.0	0.547	1.427	1.760	7.927	1355.3	33.8	704.8
			1964-85 mean conditions					
Spawners as numbers:								
1.0	0.0	0.543	1.531	1.666	2.815	1709.2	33.9	803.3
Spawners as eggs:								
1.1	0.0	0.598	1.648	1.833	3.097	1666.2	33.5	825.1

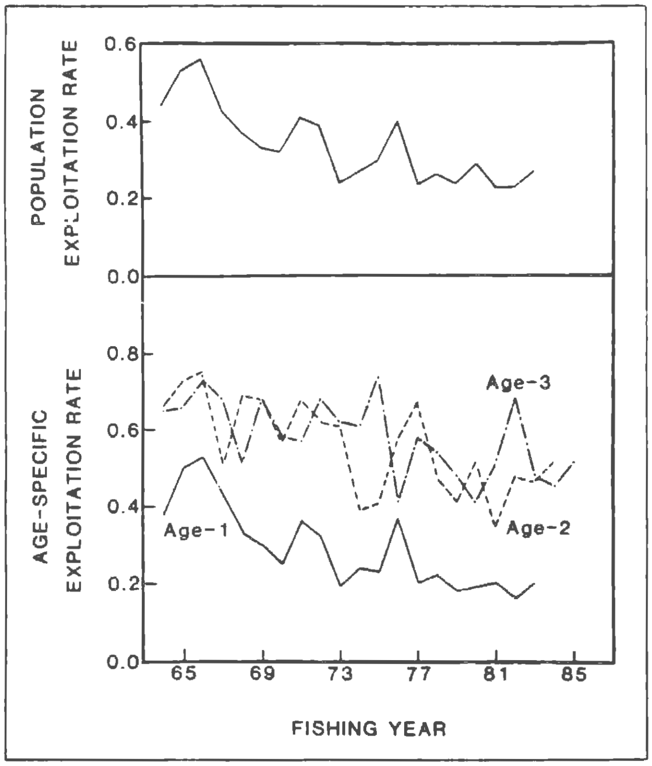


Figure 5.13 (Figure 5 from Vaughan 1987). Annual estimates for gulf menhaden of (upper) population exploitation rates and (lower) age-specific exploitation rates (ages 1 through 3).

between two of the spawner-recruit relationships (Ricker model with spawners in numbers and random recruitment) for the 1978-85 mean conditions (Figure 19 [Figure 5.14]). If recruitment is random and independent of stock size, a population crash is unlikely. However, the curve for the random recruitment models appears to be approaching an asymptotic value for 50 year mean yield as the F-multiple increases. The yearly average for the asymptotic MSY from the random recruitment model is about 750-800 KMT for 1978-85 mean conditions (Figure 19).

The MSY estimates from the population simulation approach (705-825 KMT) are generally higher than those obtained from the surplus production models (620-700 KMT). I expect that estimates of MSY from the population simulation model would be more realistic than those obtained from the surplus production models which are based solely on catch and effort data.

5.5 Status and Probable Future Conditions

From Vaughan (1987):

Management Implications

The gulf menhaden fishery is conducted within the territorial sea and offshore of five coastal states (Florida to Texas). All states voted in favor of a cooperative management plan under the Gulf States Marine Fisheries Commission (GSMFC) in 1977 (Christmas and Etzold 1977). This plan was revised and adopted in 1983 (Christmas et al. 1983). Since management authority is vested in the individual states, some regulations are area-specific on a state

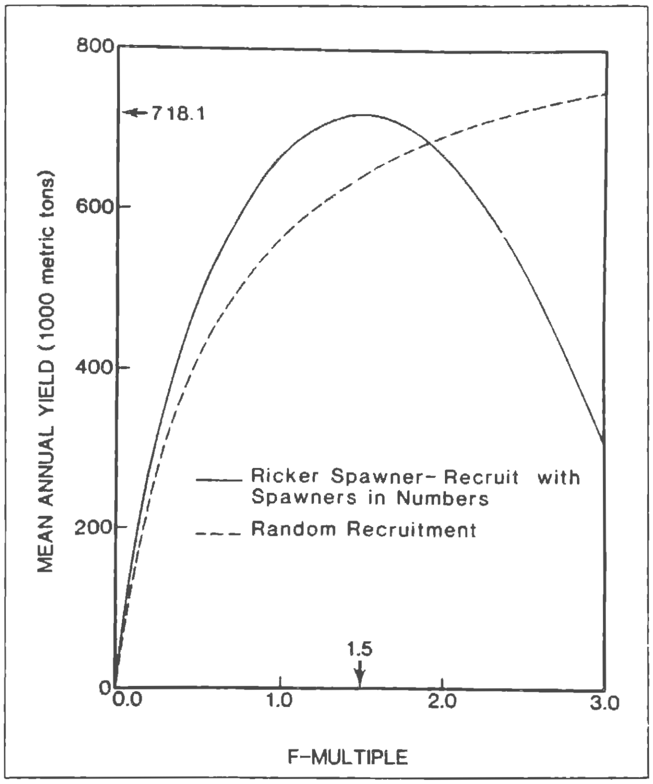


Figure 5.14 (Figure 19 from Vaughan 1987). Fifty year mean yield for 1978-85 mean conditions from gulf menhaden population simulation model. Two superimposed curves are for Ricker model with spawners in numbers (solid line) and random recruitment model (dashed line).

or county basis, but other regulations, such as length of fishing season (mid-April through mid-October), are common to all states. No state controls or limits the catch or fishing effort of vessels.

Both landings and fishing effort have increased dramatically since 1946 (Figure 2 [Figure 5.15]), with high record landings during the 1984 fishing season (982.8 KMT) and record high nominal fishing effort during the 1983 fishing season (655,800 vessel-ton-weeks). Although an earlier stock assessment revealed that levels of stock biomass were sufficient to produce historical landings (Nelson and Ahrenholz 1986), a new analysis was deemed necessary to determine if more recent high harvests are due to (a) an increase in effective fishing effort and availability of the stock, or (b) an increase in stock size due to exceptionally large year classes in recent years. Given either of the above conditions, it is unlikely that the fishery can sustain these high levels of harvest indefinitely; landings eventually will be reduced. If condition (a) is prevalent, stock damage may occur and harvests would drop below levels that would occur if condition (b) is prevalent where no stock damage is expected to occur.

Recruitment to age-1 (on 1 January) has varied between 8.3 and 41.8 billion fish (Table 4 [Table 5.3]), with many of the greater values occurring since 1977. Greater values for population size and spawners resulted. Therefore, effective fishing effort has actually declined since the 1960's (Figure 13 [Figure 5.10]). The implication is that the increased landings

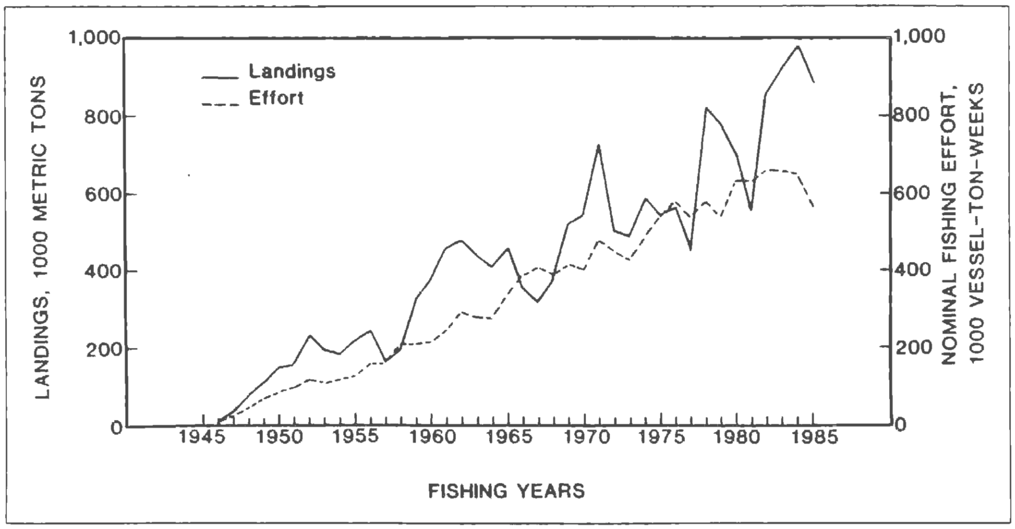


Figure 5.15 (Figure 2 from Vaughan 1987). Gulf menhaden landings and nominal fishing effort for fishing years, 1946-85.

since 1978 are the result of exceptionally good recruitment (i.e., year classes) and not the result of greater fishing effort. Increased availablity of gulf menhaden to the fishery does not seem likely, given the loss of reduction plants at the geographic extremes (Table 1 [Table 5.5]) and area and seasonal closures that have been implemented (Christmas et al. 1983).

Although recruitment has been high since the late 1970's, it depends largely upon environmental conditions that are beyond the control of management (as evidenced by the unexplained scatter in Figure 16). To the extent that recruitment does depend upon the spawning stock, the dependency rests primarily on age-2 spawners. The concern to management is that several poor environmental years leading to several poor recruitment years could put the gulf menhaden population at risk. Thus, there is need for frequent monitoring and evaluation of the gulf menhaden stock.

Estimates of MSY data range from 620 to 700 KMT based on surplus production models (landings and fishing effort data from 1946-85 fishing years), and from 705 to 825 KMT based on population simulation models (using Ricker spawner-recruit relationships based on 1964-82 year classes). The latter range of estimates for MSY is probably more indicative of the average landings that could have been removed from the gulf menhaden stock during the period from which data were obtained (1964-85 fishing years), given the limitations in adjusting the fishing effort (restricted to 1964-83 fishing years, Table 11 [Table 5.2]) used in surplus production models and the firmer biological basis for the population simulation approach. The concern is that recent landings greater than historical estimates of MSY (greater than 850 KMT since 1982, Table 2 [Table 5.6]) may be too high. However, these analyses are always retrospective and have an inherent time lag in them which prevents a direct assessment of the period since 1982.

Table 5.5 (Table 1 from Vaughan 1987). Number of gulf menhaden reduction plants by port and total, number of purse-seine vessels, and number of fish sampled for age and size for fishing years, 1964-85.

Fishing year	Ports								No. reduction plants	No. reduction vessels	No. fish sampled
	A	MP	E	D	MC	IC	C	SP			
1964	0	3	2	2	1	0	2	1	11	78	12,457
1965	0	3	2	3	1	1	2	1	13	87	15,819
1966	1	3	2	2	1	1	2	1	13	92	13,016
1967	0	3	2	2	1	1	3	1	13	85	14,519
1968	1	3	2	2	1	1	3	1	14	78	16,499
1969	1	3	2	1	1	1	3	1	13	75	15,281
1970	0	3	2	2	1	1	3	1	13	76	10,560
1971	0	3	2	2	1	1	3	1	13	85	7,859
1972	0	3	2	1	1	1	3	0	11	75	10,030
1973	0	2	2	1	1	1	3	0	10	66	8,958
1974	0	2	2	1	1	1	3	0	10	71	10,120
1975	0	3	2	1	1	1	3	0	11	78	9,529
1976	0	3	2	1	1	1	3	0	11	82	13,586
1977	0	3	2	1	1	1	3	0	11	80	14,918
1978	0	3	2	1	1	1	3	0	11	80	12,985
1979	0	3	2	1	1	1	3	0	11	78	11,620
1980	0	3	2	1	1	1	3	0	11	79	9,961
1981	0	3	2	1	1	1	3	0	11	80	10,408
1982	0	3	2	1	1	1	3	0	11	82	10,709
1983	0	3	2	1	1	1	3	0	11	81	14,840
1984	0	3	2	1	1	1	3	0	11	81	16,000
1985	0	2	1	1	0	1	2	0	7	73	13,240

A = Appalachicola, FL: Fish Meal Co. (1966, 1968-69).

MP = Moss Point, MS: Seacoast Products Co. (1964-72, 1975-84), Standard Products Co. (1964-85), Zapata Haynie, Inc. (1964-85).

E = Empire, LA: Empire Menhaden Co. (1964-85), Petrou Fisheries, Inc. (1964-84).

D = Dulac, LA: Dulac Menhaden Fisheries (1964-1968, 1970-71), Fish Meal and Oil Co. (1964-65), Zapata Haynie, Inc. (1965-85).

MC = Morgan City, LA: Seacoast Products Co. (1964-84).

IC = Intracoastal City, LA: Seacoast Products Co. (1965-84), Zapata Haynie, Inc. (1985).

C = Cameron, LA: Louisiana Menhaden Co. (1964-85), Seacoast Products Co. (1964-84), Zapata Haynie, Inc. (1967-85).

SP = Sabine Pass, TX: Texas Menhaden Co. (1964-71).

Table 5.6 (Table 2 from Vaughan 1987). Estimated landings of gulf menhaden in numbers-at-age (0-4+), total numbers landed (ages 0-4+), total landings by weight and nominal fishing effort (vessel-ton-weeks) for the fishing years, 1964-85.

Fishing year	Landings in numbers-at-age (10^9) 0	1	2	3	4+	Total	Total landings (10^3 mt)	Nominal fishing effort (1000 vtw)
1964	a	3.33	1.50	0.12	a	4.95	409.4	272.9
1965	0.04	5.03	1.08	0.08	a	6.23	463.1	335.6
1966	0.03	3.31	0.87	0.03	a	4.24	359.1	381.3
1964	0.02	4.27	0.34	0.01	0.0	4.64	317.3	404.7
1968	0.07	3.48	1.00	0.04	a	4.58	373.5	382.3
1969	0.02	6.07	1.29	0.03	0.0	7.41	523.7	411.0
1970	0.05	3.28	2.28	0.04	0.0	5.65	548.1	400.0
1971	0.02	5.76	1.96	0.18	a	7.92	728.2	472.9
1972	0.02	3.05	1.73	0.09	a	4.89	501.7	447.5
1973	0.05	3.03	1.11	0.10	a	4.29	486.1	426.2
1974	a	3.85	1.47	0.06	0.0	5.38	587.4[b]	485.5
1975	0.11	2.44	1.50	0.46	a	4.51	542.6	538.0[c]
1976	0.0	4.59	1.37	0.20	0.0	6.17	561.2	575.8
1977	0.0	4.66	1.33	0.11	a	6.11	447.1	532.7
1978	0.0	6.79	2.74	0.05	a	9.59	820.0	574.3
1979	0.0	4.70	2.88	0.34	a	7.92	777.9	533.9
1980	0.07	3.41	3.26	0.44	0.05	7.22	701.3	627.6
1981	0.0	5.75	1.42	0.33	0.03	7.54	552.6	623.0
1982	0.0	5.15	3.30	0.50	0.06	9.01	853.9	653.8
1983	0.0	4.69	3.81	0.38	0.03	8.90	923.5	655.8
1984	0.0	7.75	2.88	0.44	0.05	11.12	982.8	645.9
1985	0.0	8.13	2.72	0.28	0.02	11.15	881.1	560.6

[a] $>0.005 \times 10^9$.
[b] Typographic error found in original NMFS data set and corrected in 1984.
[c] Correction made in tonnage for one vessel since analysis of Nelson and Ahrenholz (1986).

Estimates of MSY from surplus production models continue the upward trend noted in Nelson and Ahrenholz (1986). Chapoton (1972) obtained an estimate of MSY of 430 KMT for the 1946-70 period, Schaaf (1975) obtained an estimate of 478 KMT for the 1946-72 period, and Nelson and Ahrenholz (1986) obtained estimates ranging from 540 to 640 KMT for the 1946-79 period. The primary biological concern raised by stock assessment scientists is that the nature of the descending limb can only be determined accurately if landings exceed the current MSY for several years. If the descending limb were steep, this could put the stock at risk. The Pella-Tomlinson model from catch and effective effort data has a flat descending limb (m - 0.99, Figure 14 [Figure 5.6]), while the Pella-Tomlinson model from catch and population F data has a steep slope (m = 2.78).

The gulf menhaden is shorter lived than the Atlantic menhaden (higher natural mortality), which can result in rapid year-to-year changes in fishable stock. Although increasing the number of year classes in the fishable stock is neither biologically practical nor suggested, caution is advised relative to the high F's found and the dependency of the fishery upon very few age groups. Expansion of this fishery by effort or area is not recommended.

In summary, the gulf menhaden fishery is currently fully exploited and biologically appears reasonably stable in view of the age composition, life span, and effects of environmental factors. Annual production, fishing effort, and fleet size appear reasonably balanced. Although recent short-term harvests in excess of MSY do not appear detrimental to the stock, long-term harvesting above MSY cannot be maintained given our current understanding of the resource and uncertainties in our estimates of MSY.

6.0 DESCRIPTION OF THE HABITAT OF THE STOCK(S) COMPRISING THE MANAGEMENT UNIT

6.1 Condition and Trends

Before any description of gulf menhaden habitat is undertaken, the geographic range of both the species and the commercial fishery and general biology must be reviewed. Gulf menhaden are distributed in the Gulf of Mexico from the Yucatan Peninsula in Mexico to Tampa Bay, Florida (Christmas and Etzold 1977); however, since the fishery is active only from the Florida panhandle to eastern Texas, habitat descriptions will apply primarily to this area. As an estuarine-dependent marine species, gulf menhaden occupy a wide variety of habitats during the course of their life cycle. Adult menhaden spawn along the entire United States Gulf Coast from nearshore to as far as 60 miles offshore. The larvae enter estuaries, transform into juveniles, and then penetrate into the upper, low salinity zones of the estuary. The juveniles migrate back to the gulf in late fall. After spawning, the adults move into shallower waters, remain there until late fall, and then move further offshore during the winter.

The following general descriptions of the northern gulf continental shelf, shoreline, and estuaries were summarized from Galstoff (1954), Va. Inst. Mar. Sci. (1976), and Beckert and Brashier (1981). The continental shelf in the northern gulf ranges from 8 to 117 miles in width. There are three general offshore bottom types in the northern gulf. The dominant bottom type off northwest Florida, Alabama, and eastern Mississippi is quartz sand with some shell or coral deposits. In some areas the quartz sands are mixed with alluvium from coastal rivers. The second bottom type extends approximately from a point even with Pascagoula Bay to the Texas-Louisiana border; the bottom is mainly a complex of fine grained, muddy sediments with occasional surface deposits of sand and shell. Mississippi River deposition (2 million tons of sediment per year) is the principal source of sediment. The third bottom type, offshore from Texas, is characterized by sand and finer grain sediments.

The general circulation pattern of the gulf can be summarized briefly as follows. Water from the Caribbean enters as the Yucatan Current through the Yucatan Straits. Part of the Yucatan Current penetrates toward the Mississippi River Delta and then divides into two components - one circulating clockwise in the northeast gulf called the Loop Current; the other circulating counterclockwise toward the west in the northwest gulf. During January, February, and March there is a strong westward and southwestward flow across the shallow Louisiana shelf west of the Mississippi River. Nearshore currents are driven by the impingement of regional gulf currents across the shelf, passage of tides, and local and regional wind systems; the orientation of the shoreline and bottom topography may also place constraints on speed and direction of shelf currents.

Gulf salinities beyond the continental shelf average between 36.0 and 36.5 ppt. However, salinity values in shelf regions may vary widely from the above values due to the opposing effects of river input and enhanced evaporation. Annual salinity variations may be in the 20 ppt range. In general, lowest salinities occur in the spring and highest salinities occur in the summer and fall. The mean annual surface water temperature is in the upper 60°F in the northern gulf, but may range 15°-20°F during the year.

Gulf tides are small and noticeably less developed than along the Atlantic or Pacific Coasts. The normal tidal range at most places is not more than 1-2 feet. Despite the small tidal range, tidal current velocities are occasionally high, especially near the constricted outlets that characterize many of the bays and lagoons. Tide type varies widely throughout the gulf, although the dominant tide type can be classified for different regions. Tides are diurnal (i.e., one high tide and one low tide each lunar day of 24.8 hours) from approximately St. Andrew's Bay, Florida, to western Louisiana. The tide is semi-diurnal in the Apalachicola-Apalachee Bay area of Florida, whereas in west Louisiana and Texas it is mixed.

The following is a general description of the eastern gulf, central gulf, and western gulf. The eastern gulf includes Apalachee Bay, St. Georges Sound, Apalachicola Bay, Choctawhatchee Bay, St. Andrews Bay and Pensacola Bay. In the area of Apalachee Bay, Florida, the coastline is irregular as a result of rock outcroppings, island clusters, and oyster reefs. Beaches and semi-enclosed bays are rare. Salt marshes line the shore and penetrate several miles inland in some places. Beds of turtle grass mixed with algae extend offshore to approximately the 2 meters contour. The Gulf Coast from Apalachee Bay to the Mississippi-Alabama border is characterized by high energy, wide sand beaches situated either on barrier islands located close to the mainland or on the mainland itself. Tidal marshes border the inland bays, but their development is not extensive as compared to Louisiana. Beds of mixed sea grasses and algae occur in some areas.

Coastal waters in the eastern gulf may be generally characterized as clear, nutrient-poor and highly saline. Primary production is generally low, except in the immediate vicinity of estuaries or on the outer shelf when the nutrient-rich Loop Current penetrates into the area. Pockets of high salinity ($36^{\circ}/_{oo}$) water may be found on the bottom in some areas.

The central gulf includes Alabama, Mississippi, and Louisiana. Major estuaries include Mobile Bay, Mississippi Sound, Lakes Borgne-Pontchartrain, Breton Sound complex, Mississippi Delta, Barataria Bay, Terrebonne-Timbalier Bays, Caillou Bay, Atchafalaya Bay, Vermilion Bay, Mermenteau River system, and Calcasieu Lake. The short coast of Mississippi is formed by offshore barrier islands, which are characterized by high energy sand beaches grading to salt marsh in the center. The mainland shore is comprised of salt marsh, natural beach, seawalls and artificial beaches, and brackish-freshwater marsh in the Pearl River Delta. The eastern and central Louisiana coast is dominated by sand barrier islands and associated bays and marshes. The most extensive marshes in the United States are associated with the Mississippi-Atchafalaya River deltas. The shoreline of the western one-third of Louisiana is made up of sand beaches, with extensive inland marshes.

In general, estuaries and nearshore gulf waters of Louisiana and western Mississippi are low saline, nutrient-rich, and turbid. These characteristics are due primarily to the high rainfall and high discharges of the Mississippi-Atchafalaya Rivers and other coastal rivers. A complex geography of sounds and bays protected by barrier islands and tidal marshes acts to delay mixing, resulting in extensive areas of brackish conditions. As a probable consequence of the large fluvial nutrient input, the Louisiana nearshore shelf is considered one of the most productive areas of primary production in the Gulf of Mexico.

The gulf shoreline of eastern Texas is predominantly sand beaches. The estuaries are characterized by low but extremely variable salinities, and reduced tidal action. Sedimentation is pronounced, especially around rivers. There are large expanses of salt marshes. Nutrient concentrations and general productivity are high. Major estuaries include Sabine Lake, Galveston Bay system, Brazos River, Matagorda Bay, and San Antonio Bay.

Food availability was listed by Christmas et al. (1982) as a variable in their menhaden Habitat Suitability Index (HSI) models for all life history stages except for the egg and non-feeding yolk-sac larval stages. Larval menhaden are carnivores that prey selectively upon zooplankton, whereas juvenile and adult menhaden are filter-feeders that primarily ingest phytoplankton. Phytoplankton production, and indirectly zooplankton production, is related to the nutrient concentration of inshore waters. Several environmental variables (water color, salinity, substrate) used by Christmas et al. (1982) are, in part, indexes of food availability; of course, extremes of salinity, and other factors also directly influence larval and early juvenile mortality rates. Average annual salinity is assumed to be an index of the amount of entering freshwater, with its input of nutrients. Turbidity (as defined by water color) can be an index of the amount of nutrients and organic detritus in the water column; in order of suitability for menhaden, water color regimes include brown, green, and clear.

Other factors that were key variables in the HSI models included marsh acreage and substrate. Although the effect of marsh on gulf menhaden is difficult to quantify, the estuary is as dependent on marsh for its characteristics as menhaden are dependent upon estuaries (Christmas et al. 1982). They indicated that areas characterized by extensive tidal marsh (>1000 acres) with extensive drainage provided better menhaden habitat than areas with less or little tidal marsh. The importance of marsh to estuarine productivity and its subsequent biological carrying capacity has been well documented in the literature. Cavit (1981) showed that Louisiana menhaden catches off a particular hydrological unit increased with the product of total marsh acreage and intermediate marsh acreage and with the proportion of total marsh acreage to the total water surface acreage. Substrate is an important HSI variable because estuarine and nearshore marine habitats are relatively shallow; thus, currents and wave action resuspend nutrients and organic detritus which have been incorporated into the bottom sediments. Mud was classified as the optimum substrate for the suitability index, followed by sandy mud and sandshell.

Looking at overall menhaden production and all life history stages, the following habitats can thus be defined from Christmas, et al. (1982) suitability indexes:

	Value of Indicator		
Factor	Optimum	Medium	Low
Annual salinity (nearshore/estuarine)	5-20$^\circ/_{oo}$	not applicable	not applicable
Substrate	mud	sandy mud	shell-sand
Marsh	extensive (>1000 acres)	moderate (50-1000 acres)	low (<50 acres)
Water color	brown	green	clear

Optimum nearshore and estuarine habitat can be defined as areas having extensive tidal marshes, mud substrate, brown water color, and an annual salinity of 5-20$^\circ/_{oo}$. Louisiana and Mississippi coastal waters, especially the Mississippi-Atchafalaya Deltas, probably best meet these criteria.

Christmas et al. (1982) used numerous variables (temperature, salinity, dissolved oxygen, marsh habitat, substrate, and water color) to evaluate certain Gulf Coast estuaries as nursery habitat for larval and juvenile gulf menhaden. HSI values for these estuaries are listed below:

Estuary	HSI	Estuary	HSI
Mobile Bay (Dog to Fowl River), AL	0.65	Barataria Bay, LA	1.00
Little Lagoon, AL	0.36	Timbalier Bay, LA	.88
Mobile Delta, AL	0.97	Trinity Bay, TX	0.87
Davis Bayou, MS	0.77	Upper Lagunda Madre, TX	0.30

6.2 Habitat Condition

Menhaden occupy offshore waters in the Gulf of Mexico as adults and require estuaries as nursery grounds. Tidal passes provide migration routes from gulf waters to the estuaries. Offshore areas used by adults appear to be the least affected by habitat alterations and water quality degradation. Currently, the primary threat to offshore habitat comes from oil and gas development and production, offshore dumping of dredged material, disposal of chemical wastes, and the discharge of contaminants by the river systems, such as the Mississippi River, which empty into the gulf. However, no studies are available indicating that these activities have adversely affected menhaden in their offshore habitat.

Nearshore areas as a whole appear to be in good condition, but local problem areas exist. For example, water quality may be reduced in areas affected by the plumes of major rivers. Local disturbances occur during construction related to periodic beach nourishment, dredged material disposal, and dredging. Some areas also are affected by thermal effluents and sewage outfalls.

The estuarine nursery areas appear to be the most impacted of the habitats used by menhaden. Natural and man-induced alterations of the fragile environment have altered freshwater inflow and removed much of the area that would be considered suitable habitat. The amount of remaining wetlands suitable for menhaden production in the Gulf of Mexico has not been quantified. However, it is estimated that only about 2.6 million acres of salt marsh, a wetland type preferred by menhaden, remain (Alexander et al. 1986). This represents about 30 percent of the wetlands of these types that remain in the coterminous United States. The overall rate of wetland losses similarly is not known since adequate mapping programs and baseline data are not available. However, Alexander et al. (1986) estimated that for the last 25 years coastal wetlands have been depleted at an average rate of 20,000 acres per year. This rate may be even higher in the gulf. For example, Gagliano (1984) has estimated that natural and man-induced forces in Louisiana contribute to a yearly land loss, including marsh, of more than 50 square miles. The estuaries also have been the most impacted by water quality degradation. Numerous pollution-related reports and publications exist, but there still is no complete list of chemical contaminants, their concentrations, or effects. A comprehensive inventory to assess how seriously the gulf's estuaries are polluted also is needed.

Habitats of particular concern are those which play an essential role in the life cycle of the species, but especially the estuarine nursery grounds. Other areas of specific concern are barrier islands in each state, as these structures are vital to maintain estuarine conditions needed by menhaden during their larval and juvenile stages. Passes from the gulf into estuaries are of equal importance, as the slow mixing of sea water and fresh water is generally regarded as being of prime importance in the productivity of any estuary. A rapid exchange may cause environmental stresses too great for many estuarine organisms.

We are unaware of any current relationship of habitat quality that affects the ability to harvest and market menhaden resources. However, if pollutants such as pesticides, herbicides, hydrocarbons, etc., become concentrated to levels that are dangerous to humans, the marketability of menhaden products for human consumption could be compromised.

6.3 Habitat Threats

The quantitative relationship between menhaden production and habitat has not been determined. Accordingly, the degree that habitat alterations have affected menhaden is unknown. Turner and Boesch (1987) assembled and examined the accumulating evidence of the relationship between the extent of wetland habitats and the yield of fishery species dependent on coastal bays and estuaries. They discussed evidence of stock losses following wetland losses and stock gains following wetland gains. Accordingly, a significant threat facing menhaden production is the loss of habitat. Natural wetland losses result from forces such as erosion, sea level rises, subsidence, and accretion. According to Lindall et al. (1979) the major man-induced activities that impact environmental gradients in the estuarine zone are:

1. construction and maintenance of navigation channels;
2. discharges from wastewater plants and industries;
3. dredge and fill for land use development;
4. agricultural runoff;
5. ditching, draining, or impounding wetlands;
6. oil spills;
7. thermal discharge;
8. mining, particularly for phosphate, and petroleum;
9. entrainment and impingement from electric power plants;
10. dams;
11. marinas;
12. alteration of freshwater inflows to estuaries;
13. saltwater intrusion; and
14. non-point-source discharges of contaminants.

All of the gulf's estuaries have been impacted to some degree by one or more of the above activities. These may be industrial as in Mississippi (Etzold and Christmas 1979), residential as in Florida, or petroleum related similar to that in Louisiana (Adkins and Bowman 1976). Another problem area is the reduction of freshwater inflow into estuaries because of channelization and/or pumping to redistribute desirable freshwater supplies for other users. Restricting access to nursery grounds also limits the amount of nursery area available to menhaden. Impoundment of wetlands for various reasons such as spoil and waste containment, roadways and causeways, aquaculture, mosquito control and so forth occurs to varying degrees.

Management of water levels and exchange in tidal marshes often severely restricts or denies access by juvenile menhaden to nursery grounds when water levels are controlled. Accordingly, impoundments can adversely affect menhaden production. National Marine Fisheries Service (NMFS) data reveal that in Louisiana over 591 square miles of marshes were proposed or permitted for some form of water level control from 1981 through 1987. Herke et al. (1987) examined the effects of fixed-crest weirs used for water control. They concluded that these structures would seriously limit the ability of fish to migrate in and out of coastal wetlands and thus seriously disrupt the life histories of economically important fisheries resources in the gulf.

Natural wetland losses are difficult to control since often major environmental manipulations are required, for example, rediverting Mississippi River flows over marshes that are deteriorating. Another method of control involves mitigation of wetland losses by restoration, generation, or enhancement of habitat (Lindall et al. 1979). Mitigation, however, often may not be desirable since some of the mitigation technologies are poorly understood. Wetland creation technology is an emerging science that requires more development before it can be routinely applied (Mager and Thayer 1986). Moreover, optimum habitat and environmental conditions must be determined by estuary so that the best habitat and conditions can be created when the methodologies are adequately developed.

The amount and rate of man-induced wetland losses have not been quantified but can be controlled by state and/or Federal regulatory agencies. The Environmental Protection Agency (EPA) has the responsibility to regulate wastewater discharges, and the Corps of Engineers (COE) manages a program that regulates physical wetland alterations (dredging, filling, impounding, etc.). The amount of menhaden habitat affected by EPA's program is unknown, but data on the effect of the COE's regulatory program in the Southeast is available. Tables 6.1 and 6.2 summarize five years of NMFS data on the COE's program, providing proposed alterations by state and by habitat type (Mager and Thayer 1986). For the Gulf States, almost 174,000 acres of wetland losses were proposed by more than 4,000 projects. Mager and Keppner (1987) showed that 6,354 permit applications and Federal projects between 1981 and 1986 proposed the alteration of almost 278,000 acres of wetlands in the Southeast. This provides an indication of the significance of the COE's program and the potential cumulative nature of wetland losses.

Table 6.1. Number of proposed projects and acres of habitat by state proposed for dredging, filling, draining, and impounding based on NMFS habitat conservation efforts from 1981 through 1985.[1]

State	Number of permit applications	Acreage proposed by applicants	Acreage NMFS did not object to	Acreage potentially conserved	Mitigation recommended by NMFS
LA	1,229	149,875	38,932	110,943	103,386
TX	684	16,644	3,694	12,950	4,462
MS	94	578	307	211	44
AL	206	960	280	680	47
FL	1,806	5,879	2,846	3,033	1,241
GA	194	1,106	204	902	247
SC	576	5,610	450	5,160	109
NC	547	3,119	1,673	1,446	576
PR	42	347	33	314	159
VI	7	129	81	48	134
Total	5,385	184,187	48,500	135,687	110,405

[1] modified from Mager and Thayer (1986)

Table 6.2. Acres of habitat by habitat type involved in NMFS habitat conservation efforts from 1981 through 1985.[1]

	Acreage proposed by applicants	Acreage NMFS did not object to	Acreage potentially conserved	Mitigation recommended by NMFS
Black mangrove	324	93	231	155
White mangrove	348	132	216	128
Red mangrove	662	16	646	562
Saltgrass	1,781	105	1,676	2,315
Freshwater marsh	10,357	7,119	3,238	32,796
Freshwater unvegetated	237	238	-1	31
Freshwater submerged vegetation	473	132	341	612
Hardwood swamp	3,507	1,234	2,273	2,641
Black needlerush	1,627	68	1,559	141
Other marsh	7,480	1,141	6,339	4,584
Smooth cordgrass	5,027	446	4,581	6,227
Saltmeadow cordgrass	14,538	1,211	13,327	37,904
Shoalgrass	192	13	179	80
Halophila	2	2	0	0
Widgeongrass	366	111	255	1,564
Manateegrass	20	4	16	2
Turtlegrass	85	20	65	111
Eelgrass	2	1	1	2
Algae	1,123	28	1,095	10
Clay	63	55	8	0
Mud	106,868	30,161	76,707	19,795
Miscellaneous	19,973	329	19,644	40
Oyster beds	56	31	25	10
Rock	377	12	365	64
Sand	7,301	4,520	2,781	629
Shell	101	7	94	2
Silt	1,297	1,271	26	0
Total	184,187	48,500	135,687	110,405

[1] modified by Mager and Thayer (1986)

Water quality degradation also is a threat to menhaden habitat. This results from the discharge of chemicals in industrial and chemical wastes and from non-point-source discharges such as from septic tanks and parking lots. Urban and agricultural runoff can be laden with toxic substances such as petrochemicals, pesticides, heavy metals, and herbicides. The aerial spraying of large areas for mosquito control results in the addition of pesticides that are extremely toxic to larval estuarine organisms. Thermal effluent from steam and nuclear generating facilities using "once-through" cooling can raise water temperatures making them less suitable or uninhabitable, especially during summer. The discharge of sewage also can create problems.

6.4 Habitat Information Needs

The following research needs relative to menhaden habitat are provided so that state, Federal, and private research efforts can be focused on those areas that would allow the Gulf States Marine Fisheries Commission (GSMFC) to develop measures that best manage menhaden and their habitat:

1. Identification of optimum menhaden habitat and environmental conditions;
2. The quantitative relationships between menhaden production and habitat;
3. Effects of water quality degradation on menhaden production;
4. Identification of areas of particular concern for menhaden;
5. Determination of habitat conditions that limit menhaden production;
6. Methods for restoring menhaden habitat and/or improving existing environmental conditions that adversely affect menhaden production; and
7. Determination of overall rate of wetland loss and the reasons for the wetland loss.

6.5 Habitat Conservation Programs

Federal environmental agencies such as the National Marine Fisheries Service (NMFS), the Fish and Wildlife Service (FWS), and the Environmental Protection Agency (EPA) analyze projects proposing wetland alterations for potential impacts on resources under their purview. Recommendations resulting from these analyses are submitted to the COE where they are included in a public interest review that determines whether or not a permit would be issued for a proposed alteration. NMFS data reveal that implementation of its recommendations on more than 4,000 projects in the Gulf States would have resulted in the conservation of about 128,000 acres and the restoration and generation of more than 109,000 acres of wetlands (Mager and Thayer 1986). Most of these wetlands would provide suitable menhaden habitat.

It is evident that the conservation of menhaden habitat heavily relies on whether the recommendations of agencies such as the NMFS, the FWS, the EPA and the various state fish and wildlife departments are incorporated into permitting decisions. Although granted input under Section 404 statues, the NMFS, FWS, and state regulatory and management agencies are not granted veto power in the permitting process. The NMFS, FWS, and the state fish and wildlife agencies are, however, granted commenting authority on applications for Federal agency permits pursuant to the Federal Fish and Wildlife Coordination Act. Mager (in press) surveyed 857 projects where permits had been issued by COE Districts in the Southeast to find out the degree that NMFS recommendations had been incorporated by the COE into issued permits. While treatment varied by district, NMFS recommendations were fully accepted 50 percent, partially accepted 24 percent, and rejected 26 percent of the time. In terms of habitat, 22,054 acres of wetlands were proposed for alteration by the 857 projects sampled, the NMFS accepted alterations in 9,061 acres, and the COE issued permits to alter 11,617 acres or 2,556 acres more than recommended by NMFS. This indicates that if menhaden habitat is to be conserved as much as possible, greater weight must be given to the recommendations of the NMFS and other environmental agencies in the COE public interest review. This review determines whether or not a permit to alter wetlands would be granted.

Other agencies also are involved in habitat matters that may affect menhaden. The Soil Conservation Service assists owners of coastal wetlands in developing management plans to stabilize and/or freshen coastal marshes. These plans may result in some restriction of access to nursery areas in the resulting semi-impounded marshes. NOAA's

Office of Ocean and Coastal Resource Management may aid in establishing standards for approval to designate estuarine sanctuaries. The National Park Service also may establish coastal and nearshore national parks and monuments, such as Everglades National Park. The EPA has the authority to regulate the discharge of pollutants, and the COE regulates dredging, construction, and the discharge of spoil and disposal materials in wetlands covered under their programs. Construction in offshore areas is regulated primarily by the Minerals Management Service and discharges are regulated by EPA. The COE also can regulate construction, but does not accept comments relative to fish and wildlife resources. Recommendations pertaining only to navigation and national defense issues are accepted.

Most states (Louisiana, Mississippi, Alabama, and Florida) have Federally approved Coastal Zone Management programs. Texas has completed a revised Coastal Zone Management Program, but has not submitted it for Federal approval. These programs allow for state input and/or regulation of activities within its boundaries, although this process is quite variable among states. Most, if not all, Gulf Coast States have permitting and regulatory programs which are used when reviewing various applications for approval to alter wetlands. The Louisiana Coastal Protection Task Force recommended that seven million dollars from the Coastal Environmental Protection Trust Fund be approved to combat coastal erosion in six particular areas along the Louisiana coast (Rives 1982). Louisiana Act 41, which became a law on November 23, 1981 (Rives 1982), also provides monies to long and short range programs designed to combat coastal erosion, saltwater intrusion, and subsidence.

Section 3 of the Mississippi Coastal Program (1980), includes three separate objectives for habitat protection. These are: (1) habitat degradation, which determines safe concentrations of toxicants and regulation of discharge at allowable levels; (2) habitat destruction, which includes regulation of ditching and draining, dredging and filling, dam construction, alteration of barrier islands, etc.; and (3) habitat creation, which provides for marsh creation from dredged spoils, artificial reef construction, and creation of seagrass beds.

Some habitat improvements and/or enlargements also have been initiated or noted in coastal areas. Examples are the cleaning and restoring, at least partially, of the Houston Ship Channel water quality and the dredging of a special fish pass channel between the Gulf Intracoastal Waterway in Laguna Madre and the "Graveyard" (a large water basin where fish become trapped and die during extended low water periods). It is further noted that the NMFS has recommended or accepted mitigation, as a stipulation of COE permit applications reviewed between 1981 and 1986, that would create, restore, generate, or enhance more than 109,000 acres of wetlands in gulf estuaries. Additionally, banning of some types of pesticides (e.g., DDT), regulations affecting the discharge of industrial wastes, and dumping of municipal sewage and runoff into riverine systems has afforded some protection to aquatic organisms inhabiting estuaries receiving runoff from these rivers.

Pursuant to an agreement between the Department of the Army and the National Oceanic and Atmospheric Administration, the NMFS and COE initiated a pilot study to investigate the potential for the creation of wetlands using existing authorities and funding. The Southeast Region of the NMFS has been selected as one of the two regions nationwide where the studies would be carried out. Two study sites are located in the Gulf of Mexico's Galveston Bay estuary, Texas. Marsh plants have been planted at both sites on emergent dredged material. Plans are underway to construct channels in the planted areas to create creeks and to monitor the results. This is a cooperative effort between the Galveston District COE and the NMFS Regional Office and Southeast Fisheries Center's Galveston Laboratory.

The feasibility of introducing fresh water from the Mississippi River into wetland areas experiencing saltwater intrusion has been under study since the 1950's. More recently, Etzold (1980) and others, under the umbrella of GSMFC and the American Shrimp Processors Association, have been working with the COE, the Louisiana Department of Wildlife and Fisheries, U.S. Fish and Wildlife Service and Congress to design, build, and operate three diversion structures in Louisiana. The structure at Caernarvon is currently being built and will commence operation in early 1991, flowing into Breton Sound. A second structure at Davis Pond should be completed in 1995 and will flow into Barataria Bay. The third structure is to be constructed just north of the Bonnet Carre' Spillway and will flow through Lake Pontchartrain, Lake Borgne, and the Mississippi Sound. Construction is scheduled for 1990 with full operation by 1993.

The ultimate purpose of these three diversions is to reduce marsh loss and enhance wildlife and fisheries production in the Mississippi Delta. Data gathering has begun in Breton Sound and will begin in late 1988 in Lake Pontchartrain, Lake Borgne, and the Mississippi Sound. Results of water quality, salinities, etc., will set up baseline conditions which will continue for four years after the structures begin operation.

The Cameron-Creole Watershed Project, sponsored by the Soil Conservation Service, is located adjacent to Calcasieu Lake, an important nursery for menhaden. The project will attempt to alleviate the problem of salinity intrusion and associated marsh loss. The project area (75,000 acres) will be protected from salinity intrusion by levees and a series of weirs. Phase I of the project calls for dewatering of the area to stimulate vegetative growth and later reflooding. The drawdown will take place in late winter/spring in association with dropping water levels that occur with cold fronts. During the dewatering period, gates will be open only when water levels are dropping; consequently, the normal pattern of ingress/egress of estuarine species will be curtailed. The gates will be reopened on July 15 to reflood the project area. The goal of the project is to reestablish the natural marsh vegetation gradients that occur in association with salinity gradients.

6.6 Habitat Recommendations

Recognizing that all species are dependent on the quantity and quality of their essential habitats, it is the recommendation of the GSMFC that menhaden habitats be protected, restored, and improved to increase their extent and to improve their productive capacity for the benefit of present and future generations. The objectives of the various regulatory programs that affect habitat should be to:

(1) Maintain the current quantity and productive capacity of habitats supporting important commercial and recreational fisheries, including their food base;
(2) Restore and rehabilitate the productive capacity of habitats which have already been degraded; and
(3) Create and develop productive habitats where increased fishery productivity will benefit society.

The GSMFC will support state and Federal environmental agencies in their habitat conservation efforts and may directly engage the regulatory agencies on significant actions that affect menhaden habitat. The goal is to insure that menhaden habitat losses are kept to the minimum and that efforts for appropriate mitigation strategies and applicable research are supported.

Wetlands protection depends upon a combination of Federal and state laws, and whether land is publicly or privately owned. Section 10 of the River and Harbor Act, the Fish and Wildlife Coordination Act, and Section 404 of the Clean Water Act provide for widespread input to modification of wetlands. At the Federal level, the COE and the EPA manage regulatory program that can control the amount of man-induced wetland alterations in the gulf. Almost all Gulf States have provisions for protecting the habitat, but implementation of these provisions is different in each state. Therefore, these agencies should make every effort to conserve wetlands upon which menhaden production depends. Controllable wetland losses (e.g., those affected by state and Federal regulatory programs) must be minimized by permitting authorities. Giving greater consideration to recommendations of fisheries agencies for projects involving wetland alterations, restoration of altered habitat, and generation of new menhaden habitat also should be considered.

7.0 FISHERY MANAGEMENT JURISDICTION, LAWS AND POLICIES AFFECTING THE STOCK(S) THROUGHOUT THEIR RANGE OR FISHING FOR SUCH STOCK(S)

7.1 Management Institutions

7.1.1 Jurisdiction

Menhaden are estuarine dependent species which spawn in gulf waters and move to near-shore and inshore areas in the spring. They spend their larval and juvenile periods in territorial and internal state waters, and some adults remain in those waters all year. The fishery for menhaden has been conducted predominantly within the territorial sea and internal waters of the Gulf States. Consequently management has been by individual state regulations.

In 1976 Congress passed the Magnuson Fisheries Conservation and Management Act (MFCMA) which claimed exclusive jurisdiction for 200 miles offshore but did not extend or diminish (except under preemption provisions) jurisdiction of the states. If a menhaden fishery on spawning stocks developed in the Exclusive Economic Zone (EEZ) by residents of other than the five Gulf of Mexico States and/or vessels registered in a state other than the Gulf of Mexico States, Federal regulation to prevent overfishing the spawning population might be required.

Jurisdiction of the Gulf of Mexico States extends beyond state waters to their citizens and/or vessels in the absence of a Federal Fishery Management Plan (FMP). This authority has and is expected to be effective and efficient for the Gulf States to totally manage the menhaden resource in the Gulf of Mexico.

Authority over foreign fishing is not an issue in the menhaden fishery of the Gulf of Mexico since the establishment of the EEZ which allows foreign fishermen to harvest only the surplus (Total Allowable Level of Foreign Fishery, TALFF) not harvested by domestic fishermen up to the OY. Their is no available surplus for menhaden since the domestic fisherman can and do fully utilize all of the menhaden resource. If foreign fishing was contemplated they would have to negotiate a Governing International Fishing Agreement (GIFA) in advance of fishing with the State Department thereby allowing the current FMP to prevent this from happening.

7.1.2.1 Federal Management Institutions

a. Regional Fishery Management Councils -- With the passage of MFCMA, the Federal government assumed responsibility for fishery management within the EEZ, a zone contiguous to the territorial sea and whose inner boundary is the outer boundary of each coastal state. The outer boundary of the EEZ is a line 200 miles from the (inner) baseline of the territorial sea. Management in the EEZ is to be based on plans developed by regional fishery management councils. Each council is to prepare plans with respect to each fishery requiring management within its geographical area of authority, and to amend such plans as may be implemented as federal regulation.

   Among the guidelines under which the councils must operate are standards which state that to the extent practicable, an individual stock of fish shall be managed as a unit through its range and that management measures shall, where practicable, promote efficiency and shall minimize costs and avoid unnecessary duplication (MFCMA Section 301(a)).

A fishery management plan must protect the stock from overfishing while achieving an optimum yield on a continuing basis. Other Federal guidelines require that management be cost effective.

b. National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA) -- The Secretary of Commerce, acting through NMFS, has the ultimate authority to approve or disapprove all fishery management plans prepared by regional fishery management councils pursuant to the MFCMA. NMFS has issued regulations to guide the development of fishery plans and the operation of regional fishery management councils. Where a council fails to develop a plan, or correct an unacceptable plan, the Secretary may do so. NMFS also collects data and statistics on fisheries and fishermen as an aid to fishery management and conducts management authorized by international treaties.

c. Office of Coastal Zone Management (OCZM), NOAA -- OCZM asserts authority through National Marine Sanctuaries, pursuant to Title III of the Marine Protection, Research, and Sanctuaries Act (MPRSA). Though several sites have been nominated as National Marine Sanctuaries, none have been designated in the Gulf of Mexico. The OCZM Estuarine Sanctuary program has designated Rookery Bay in Collier County, Florida, and nominated the Apalachicola River and Bay in Franklin County, Florida, as estuarine sanctuaries. Lastly, by setting standards for approving and funding state coastal zone management programs, OCZM may further influence fishery management.

d. National Park Service (NPS), Department of the Interior (DOI) -- The NPS retains the authority to manage fish primarily through the establishment of coastal and nearshore national parks and national monuments. Everglades National Park is an example of an area managed by the NPS.

e. Fish and Wildlife Service (FWS), DOI -- The ability of the FWS to affect the management of fish is based primarily on the Endangered Species Act and the Fish and Wildlife Coordination Act. Under the Fish and Wildlife Coordination Act, the FWS reviews and comments on proposals for work and activities in or affecting navigable waters that are sanctioned, permitted, assisted, or conducted by Federal agencies. The review focuses mainly on potential damage to fish and wildlife, and their habitat.

f. Environmental Protection Agency (EPA) -- EPA may provide protection to fish communities through the granting of National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants into ocean waters, and the conditioning of those permits so as to protect valuable resources.

g. Corps of Engineers (COE), Department of the Army -- COE jurisdiction over the disposal of dredged material, pursuant to both the Clean Water Act and the MPRSA, could be exercised in a manner protective of fishery resources. Proposals to dispose of materials during the construction of artificial reefs, for example, are assessed to assure that the disposed materials do not pollute or physically alter the environment.

7.1.2.2 Other Management Institutions

The Gulf State-Federal Fisheries Management Board (GS-FFMB) is charged with responsibility for developing regional management plans for the fisheries resources that move between or are broadly distributed among the territorial waters and areas seaward thereof and for recommending suitable policies and strategies to each member state (see Charter, Appendix, Section 19, 19.2).

State institutions are included in Section 7.4.

7.1.3 The Management System

The management system is based upon accomplishing goals and objectives through the operational model of the system shown in Figure 7.1:

a. The system is contingent on a regional data base that provides information for:

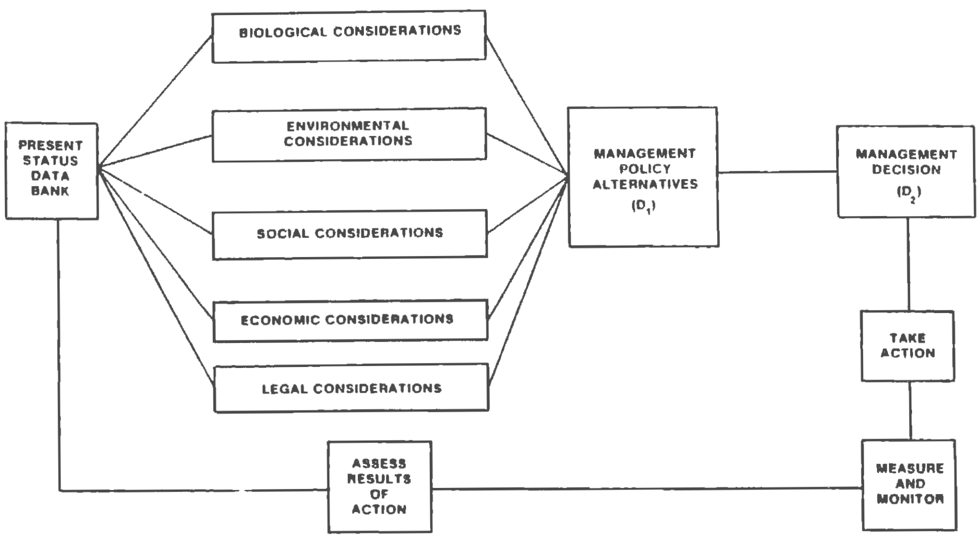
   1. Population dynamics models;

   2. Development of insight into the economic structure of the industry;

   3. Optimal vessel and fleet configuration;

   4. Determination of social attributes of the fishing community; and

   5. Determination of environmental parameters which to provide continuous information concerning the status of the resource as well as the condition of the environment which supports the menhaden resource.



EXPLANATION OF DECISIONS TO BE MADE

D_1 At this point biological, environmental, social, legal, economic and other considerations are taken into account to produce alternative actions which are used to solve the problem under examination. All forms of action should be considered, ranging from the null alternative (the "do nothing" alternative) to drastic action. Those alternatives which appear to have the best chance of solving the problem, along with each option's advantages and disadvantages should be used for decision (D_2).

The Menhaden Advisory Committee investigating the problems develops these alternative solutions.

D_2 The Gulf State-Federal Fisheries Management Board makes this decision by choosing the best alternative in accordance with previously set policies.

Figure 7.1. Operational model of the management system.

b. This information is used to:

   1. Improve harvest prediction models;

   2. Develop economic criteria to allow managers to judge the health of the fishing industry and evaluate the impact of management decisions;

   3. Formulate social and political criteria which can be used to determine (a) the potential acceptance of management decisions, and (b) the social impact of management decisions; and

   4. Suggest guidelines to advise members of the industry and public concerning the status of the menhaden resource.

c. While these tasks are being accomplished, management policies will be developed that will consider existing biological, economic, social and environmental conditions in the fishery. The next step of this process will decide on the proper techniques for implementing policies. After implementation, policies will be evaluated for their effectiveness and relevance to changing conditions.

d. The objectives of the regional management system are to:

   1. Sustain the resource and to maintain a viable fishing industry;

   2. Establish a system that can predict the future status of the resource and industry;

   3. Evaluate the biological, economic, environmental, legal and sociological effects of management policies; and

   4. Develop alternate management schemes using the best available scientific data base.

e. The system provides for regional management of the resource throughout its range leaving local options where they will serve the best interest of the states and the Nation. Another advantage includes development of a dependable predictive ability that will:

   1. Reduce economic loss to the industry from overinvestment;

   2. Increase effectiveness of management through coordination of research efforts;

   3. Enable managers to evaluate the biological, economic, environmental, legal and social effects of their decisions.

   4. Allow states to coordinate administrative research and enforcement policies;

   5. Allow managers to fully document biological and economic trends in the menhaden fishery.

   6. Provide catch and effort data in the event that the Federal government receives applications for foreign participation in the menhaden fishery.

(The Gulf Council, after examination of the data on the menhaden fishery, has decided a council management plan for menhaden is not needed. They feel the fishery is being managed adequately by the GS-FFMB and its plan at this time).

7. Assist with the establishment of a regional scientific data base that includes biological, economic, environmental and social factors that can be used as a basis for eliminating information gaps that prevent managers from significantly improving resource management.

7.1.4 Management Structure Composition

The GS-FFMB has responsibility for regional management in the system.

Recommendations of the Menhaden Advisory Committee (MAC) are approved by a two-thirds majority vote of those present and voting. There should be a minimum of two meetings of the MAC each year as deemed necessary by two or more members or at the direction of the GS-FFMB.

Basic organization of the management structure is shown in Figure 7.2.

The basic structure is the GS-FFMB which sets policy for regional management actions. The GS-FFMB establishes appropriate procedures and policies to take necessary actions to design, implement and evaluate all regional management activities.

The advantages of the GS-FFMB are that all members have knowledge of and an interest in fishery management problems, and the state administrators regularly advise their state decision makers on fishery management problems as well as make recommendations to their legislators. Some decisions can be made by the state agencies; others may require approval of one or more of the state legislatures. Also they are members of the GSMFC and, therefore, can coordinate the activities of the GS-FFMB and GSMFC. The NMFS Regional Director and Region IV Director of the U.S. Fish and Wildlife Service as voting members provide representation of Federal interests.

7.2 Treaties and Other International Agreements

There are no treaties or other international agreements that affect the harvesting of Gulf of Mexico menhaden. Since the resource is being fished at or near MSY and there is ample domestic capacity to harvest and process the available biomass (Section 5.5) no foreign fishing permits to harvest Gulf of Mexico menhaden have been submitted or would be approved by the U.S. Government at this time.

7.3. Federal Laws, Regulations and Policies

The following federal laws, policies and regulations may directly or indirectly influence the management of menhaden.

7.3.1 Magnuson Fishery Conservation and Management Act of 1976 (MFCMA): 16 U.S.C. §§1801-1882 as amended

The MFCMA mandates the preparation of fishery management plans for important resources within the 200 nm (370 km) EEZ. Each plan aims to establish and maintain the optimum yield for the subject fishery.

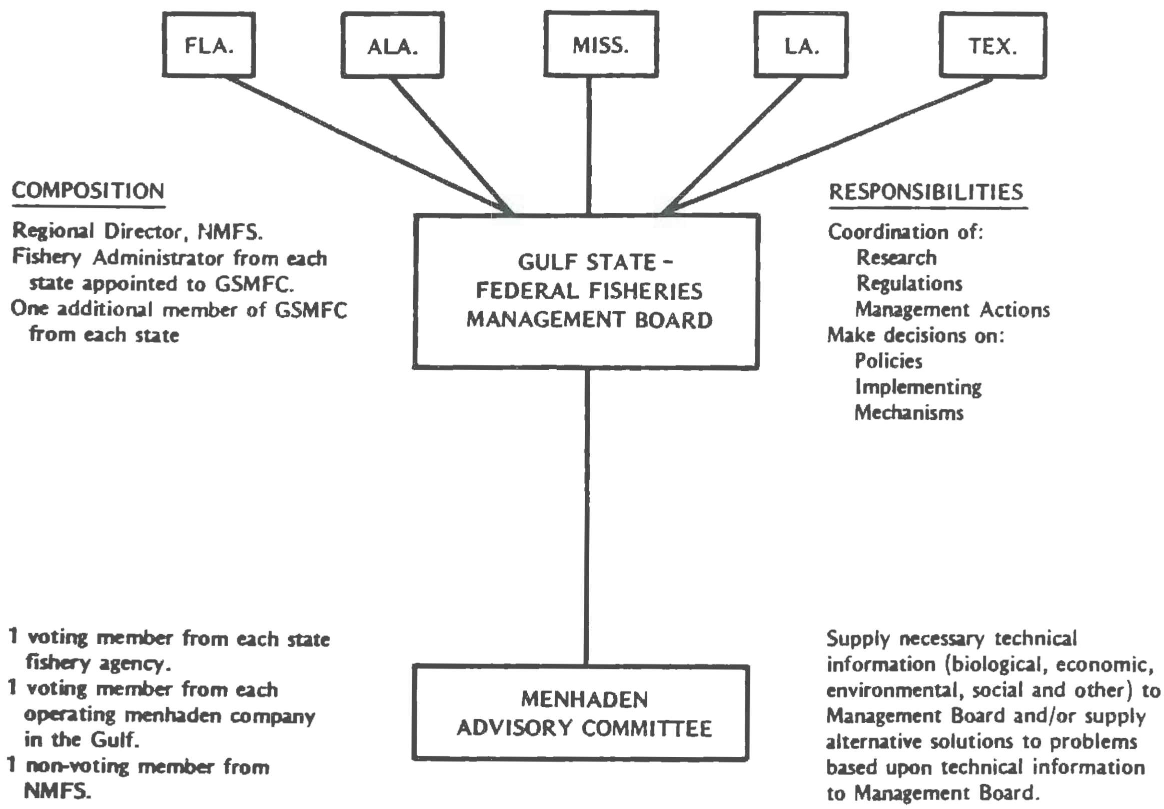


Figure 7.2. Gulf Menhaden Management Structure

7.3.2 Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Title III: 16 U.S.C. §§1431-1434

This Act provides protection of fish habitat through the establishment of marine sanctuaries.

7.3.3 Clean Water Act (CWA): 33 U.S.C. §§1251 et seq.

The CWA requires that a National Pollutant Discharge Elimination System (NPDES) permit be obtained before any pollutant is discharged from a point source into waters of the U.S., including waters of the contiguous zone and the adjoining ocean. The disposal of drilling effluents and other wastes from drilling platforms is among the activities for which a NPDES permit from EPA is required. Issuance of such a permit is based primarily on the effluent guidelines found in 40 C.F.R. §435. However, additional conditions can be imposed on permit issuance on a case-by-case basis in order to protect valuable resources in the discharge area.

7.3.4. Marine Protection, Research, and Sanctuaries Act (MPRSA), Title I: 33 U.S.C. §§1401-1444

A permit is required for transportation of materials for the purpose of ocean dumping. EPA issues all permits, with the exception of those for transportation of dredged materials issued by the COE. Criteria for issuing such permits include consideration of effects of dumping on the marine environment, ecological systems, and fisheries resources.

7.3.5 Oil Pollution Act of 1961, as amended: 33 U.S.C. §§1001-1016

The Oil Pollution Act regulates intentional discharge of oil or oily mixtures from ships registered in the U.S., and thus provides some degree of protection to fishery resources. Tankers cannot discharge oil within 50 nm (92 km) of the nearest land. Ships other than tankers must discharge as far as practicable from land. The quantity of oil which can be discharged is also regulated.

7.3.6 Coastal Zone Management Act of 1972, as amended (CZMA): 16 U.S.C. §§1451-1464

Under the CZMA, states are encouraged, with Federal funding grants, to develop coastal zone management programs which establish unified policies, criteria, and standards for dealing with land and water use issues in their coastal zone, an area which includes the state's territorial sea. Approved coastal programs are thus capable of directing activities away from areas possessing particularly sensitive resources. Guidelines for these area were published in 15 C.F.R. 921 on June 4, 1974.

7.3.7 Endangered Species Act of 1973, as amended: 16 U.S.C. §§1531-1543

The Endangered Species Act provides for the listing of plant and animal species as threatened or endangered. Once listed as a threatened or endangered species, taking (including harassment) is prohibited, and a process is established which seeks to insure that projects authorized, funded, or carried out by Federal agencies do not jeopardize the existence of these species or result in destruction or modification of habitat determined by the Secretary to be critical.

7.3.8 National Environmental Policy Act (NEPA): 42 U.S.C. §§4321-4361

NEPA requires that all Federal agencies recognize and give appropriate consideration to environmental amenities and values in the course of their decision-making. In an effort to create and maintain conditions under which man and nature can exist in productive harmony, NEPA requires that Federal agencies prepare an environmental impact statement (EIS) prior to undertaking major actions which might significantly affect the quality of the human environment. Within these statements, alternatives to the proposed action which may better safeguard environmental values are to be carefully assessed.

7.3.9 Fish and Wildlife Coordination Act: U.S.C. §§661-66c

Under the Fish and Wildlife Coordination Act, the FWS and NMFS review and comment on fish and wildlife aspects of proposals for work and activities sanctioned, permitted, assisted, or conducted by Federal agencies which take place in or affect navigable waters. The review focuses on potential damage to fish and wildlife and their habitat and may therefore serve to provide some protection to fishery resources from Federal activities, particularly in nearshore waters, since Federal agencies must give due consideration to recommendations of the two agencies.

7.3.10 Fish Restoration and Management Projects Act: 16 U.S.C. §§777-777k

Under this Act, the Department of Interior is authorized to apportion funds to state fish and game agencies for fish restoration and management projects. Funds for protection of threatened fish communities located within state waters, including marine areas, could be made available under the Act.

7.3.11 National Park Service

National Park Service under the Department of Interior may regulate fishing activities within park boundaries.

Padre Island National Seashore and the Gulf Islands National Seashore have no special fishing regulations. State regulations apply within the boundaries.

7.3.12 Lacy Act Amendment of 1981 (Public Law 97-79)

This amendment strengthens and improves enforcement of Federal fish and wildlife laws and provides Federal assistance in enforcement of state laws. The Act prohibits import, export, and interstate transport of illegally taken fish and wildlife.

7.3.13 By Act of Congress (13 U.S.C. 61)

Collection of data on the production, consumption and stocks of menhaden oil, herring oil, and other fish oils is authorized, and reporting mandatory.

7.4 State Laws, Regulations and Policies

7.4.1 Management Measures

Management measures applicable to the Gulf of Mexico menhaden fishery include numerous statutory and regulatory constraints promulgated under a variety of state enabling legislation and administrative structures. Many of those constraints have resulted from political pressure originating from long standing conflicts; however, there have been some constraints placed on the fishery through biological recommendations that have been beneficial.

The menhaden fishery has repeatedly been accused of taking large quantities of edible fish in addition to menhaden (Gunter 1962). A number of scientific studies (Christmas, Gunter and Whatley 1960; Guillory and Hutton 1982; Dunham 1972) have investigated this issue, and all reports have indicated no substantial percentage of any species other than gulf menhaden.

The Atlantic Plan's statement concerning other conflicts also applies to the gulf menhaden fishery:

> Other conflicts have been principally spatial and aesthetic, involving competition for space with recreational boaters and fishermen. Most menhaden purse seine vessels operate under a code of ethics designed to avoid conflicts. Generally, the vessels try to stay away from recreational boaters, beaches, piers, etc.; avoid areas known to be used for shellfishing, pound netting, and other commercial fishing activities; clean up spills of fish; and cooperate to the fullest extent possible with state fishery management agencies. Very few

problems have been reported in recent years; in fact, the menhaden industry by its efforts to work harmoniously with recreational fishermen and boaters, the general public and governmental agencies, has set an example for the commercial fishing industry.

As a result of recommendations made to state agencies by the GS-FFMB in implementing the Gulf Menhaden Management Plan (Christmas and Etzold 1977), the fishing season opens and closes on the same date in all of the Gulf States. Although details differ from state to state, there are regional constraints in many areas. All states impose license/fees on menhaden vessels and/or purse seines; all states have established sanctuaries where menhaden fishing is not allowed. There are limits on the permissible amount of species other than menhaden allowed in the catch, and severe penalties are provided for violation of management measures and mesh size is limited in two states. Menhaden processing plants are all subject to state pollution control standards based on Federal law and paying license/fees. All plants are required to provide landings data. A synoptic review of the state's management structures and other features pertinent to the gulf menhaden fishery is presented in Table 7.1. A more comprehensive review by states follows.

7.4.2 Florida

7.4.2.1 Administrative Organization

The agency charged with the administration, supervision, development and conservation of the natural resources is the Department of Natural Resources. Within the department, there is a marine fisheries commission delegated rulemaking authority over marine fisheries, subject to final approval by the governor and cabinet sitting as the head of the Department of Natural Resources.

7.4.2.2 Legislative Authorization

7.4.2.2.1 Source

Before 1983, regulations applicable to coastal fisheries were established by the Legislative Branch through Chapter 370, Florida Statutes (F.S.), or through over 200 Special Acts of the Legislature (called "local laws"); the Executive Branch had limited authority to promulgate rules within that statutory authority. These regulations encompassed: (a) license and licensee fee provisions; (b) enforcement; (c) seafood dealers, and; (d) general gear and season restrictions. Creation of the marine fisheries commission in 1983 substantially changed the direct responsibility of regulation. The commission was given full rulemaking authority, subject to final approval by the governor and cabinet sitting as the head of the Department of Natural Resources, in the following subject areas relating to marine life, with the exception of endangered species: (a) gear specifications; (b) prohibited gear; (c) bag limits; (d) size limits; (e) species that may not be sold; (f) protected species; (g) closed areas, except for public health purposes; (h) quality control, except for oysters, clams, mussels, and crabs; (i) seasons; and (j) special considerations relating to eggbearing females. The authority to regulating fishing gear in manmade saltwater canals was specifically not designated to the commission and was retained by the legislature. Otherwise, any conflicting authority or any division or bureau of the department, or any other agency of state government is withdrawn as of the effective date of any ruly proposed by the commission and approved by the governor and cabinet, and the inconsistent rule, or part thereof, is superseded to the extent of the inconsistency.

Table 7.1. Synoptic overview of present state management systems.

	FLORIDA	ALABAMA	MISSISSIPPI	LOUISIANA	TEXAS
Administrative Organization	Department of Natural Resources. All rules and regulations are promulgated through the Executive Director and must be approved by the Governor and cabinet.	Department of Conservation and Natural Resources, Marine Resources Division	Division Mississippi Department of Wildlife Conservation exercising its powers insofar as possible through the Bureau of Marine Resources (BMR)	Louisiana Wildlife and Fisheries Commission	Parks and Wildlife Department; Fisheries Division, Branch of Coastal Fisheries
Legislative Authorization	Chapter 370: Florida Statutes Annotated. Allows for local laws and "General Bills of Local Application."	Title 9, Code of Alabama 1975	Chapter 4; Article 1 Mississippi Code of Statutes, Annotated Some Statutes Concerning Fisheries (49.15)	Louisiana Constitution Article VI, Section 1. Some Statues Concerning Fisheries	"Uniform Wildlife Regulatory Act" (Vernon's Ann. P.C. Art. 978j-1) 3 counties are excluded.
Licenses	Purse Seine-$25	Purse Seine-$500	Menhaden Vessel-$50 Each Net-$150 Plant-$500	Commercial Fishing License-$55	Purse Seine-$2.00/100'
	Nonresident-$25	Nonresident-$1000 - $2185		Vessel License-$15	Each Vessel-$2000
	State Wholesale Dealer Resident-$450 Nonresident-$1000 Alien-$1500	No Vessel Fees		Commercial Gear License-$500/net Wholesale/ Retail License-$105	Plant-$100

Rules promulgated by the commission shall be consistent with the following standards:

(a) The paramount concern of conservation and management measures shall be the continuing health and abundance of the marine fisheries resources of this state.

(b) Conservation and management measures shall be based upon the best information available, including biological, sociological, economic, and other information deemed relevant by the Commission.

(c) Conservation and management measures shall permit reasonable means any quantities of annual harvest, consistent with maximum practicable sustainable stock abundance on a continuing basis.

(d) When possible and practicable, stocks of fish shall be managed as a biological unit.

(e) Conservation and management measures shall assure proper quality control of marine resources that enter commerce.

(f) State marine fishery management plans shall be developed to implement management of important marine fishery resources.

(g) Conservation and management decisions shall be fair and equitable to all the people of this state and carried out in such a manner that no individual, corporation, or entity acquires an excessive share of such privileges.

(h) Federal fishery management plans and fishery management plans of other states or interstate commissions should be considered when developing state marine fishery management plans. Inconsistencies should be avoided unless it is determined that it is in the best interest of the fisheries or residents of this state to be inconsistent.

7.4.2.2.2 Limited Entry

Knight and Jackson (1973) found "No precedents warranting a discussion of limited entry in the context of Florida coastal fisheries," but the 1988 Florida Legislature did not set such a precedent in the spiny lobster fishery. Section 370.14(3) requires that each trap and attendant buoy used in the spiny lobster fishery bear a number assigned by the department. This number is established by a licensing procedure. However, Chapter 88-359, Laws of Florida, provided that only spiny lobster trap licenses active in fiscal year 1987-88 may be renewed or reissued, and then only to the license holder, immediate family member or a person to whom a trap number was transferred in writing. This limitation on number of fishery participants will automatically be repealed in 1991.

7.4.2.3 Licenses

Every person, firm, or corporation which sells, offers for sale, barters, or exchanges for merchandise any saltwater products, or which harvests saltwater products with certain gear or equipment as specified by law, must have a valid saltwater products license. A resident shall pay an annual license fee of $25 for a saltwater products license issued in the name of an individual or $50 for a saltwater products licence issued to a valid boat registration number. A nonresident shall pay an annual license fee of $100 for a saltwater products license issued in the name of an individual or $200 for a saltwater products license issued to a valid boat registration number. An alien shall pay an annual license fee of $150 for a saltwater products license issued in the name of an individual or $300 for a saltwater products license issued to a valid boat registration number.

Vessel License - All vessels are licensed, and fees paid according to the following formula:

All boats less than 12 feet (length)	$2
More than 12 but less than 16 feet	$6
More than 16 but less than 26 feet	$11
More than 26 but less than 40 feet	$31
More than 40 but less than 65 feet	$51
More than 65 but less than 110 feet	$61
110 feet or more	$76
Dealer classification	$10

An additional fee of $50 is required of aliens and nonresidents (Chapter 327.25, F.S.).

Wholesale Dealer's License - All wholesale dealers, as defined in Chapter 370.07, F.S. shall pay an annual license tax according to the following schedule:

Resident wholesale county seafood dealer	$300
Resident wholesale state seafood dealer	$450
Nonresident wholesale county seafood dealer	$500
Nonresident wholesale state seafood dealer	$1000
Alien wholesale county seafood dealer	$1000
Alien wholesale state seafood dealer	$1500

7.4.2.4 Reciprocal Agreements

Authorization to enter into reciprocal agreements is contained in Fla. Stat. Ann. 370.18. The authority contained in this section is limited to matters of access to fishery resources and does not appear to extend to management in general.

7.4.2.5 Regulations

Rules promulgated under authority of Chapter 370, Florida Statutes, are contained in Chapters 16R and 16N of the Florida Administrative Code. As the Florida Marine Fisheries Commission addresses current regulations, changes are promulgated as rules under Chapter 46-27, Florida Administrative Code.

Regulations concerning menhaden have not been addressed by the marine fisheries commission. In general, they reiterate statutory provisions, or amplify them, with very little discretion being left to the department.

Several deserve recognition in this document. Chapter 370.88, F.S., provides that no food fishes except tunas shall be taken by purse seine. Chapter 370.11 forbids use of food fish "for the purpose of making oil, fertilizer or compost therefrom." In addition, eight Florida west coast counties have prohibited use of purse seines in territorial waters, and one east coast county has prohibited use of any nets in its territorial waters (see Figure 7.3).

7.4.2.6 Scientific Collecting Permits

Such permits are available from the division of marine resources upon request, and the division's approval.

7.4.2.7 <u>Penalties for Violations</u>

Section 370-021(2), Florida Statutues, specifies general penalties for violations. Unless otherwise provided by law, any person, firm, or corporation who is convicted for violating any provision of Chapter 370, any rule of the department adopted pursuant to Chapter 370, or any rule of the marine fisheries commission, shall be punished:

(a) Upon a first conviction, by imprisonment for a period of not more than 60 days or by a fine of not less than $100 nor more than $500, or by both such fine and imprisonment.

(b) On a second or subsequent conviction within 12 months, by imprisonment for not more than 6 months or by a fine of not less than $250 nor more than $1000, or by both such fine and imprisonment.

A recently-established category of "major violations" provide for additional penalties. For example, for a second or subsequent conviction within 24 months for any violation of the same law or rule involving the taking or harvesting of more than 100 pounds of any finfish, an additional penalty of $5 for each pound of illegal finfish. For any violation involving the taking, harvesting, or possession of more than 1,000 pounds of any illegal finfish, an additional penalty equivalent to the wholesale value of the illegal fish. Moreover, any permits or licences issued pursuant to Chapter 370 may be suspended or revoked for any major violation.

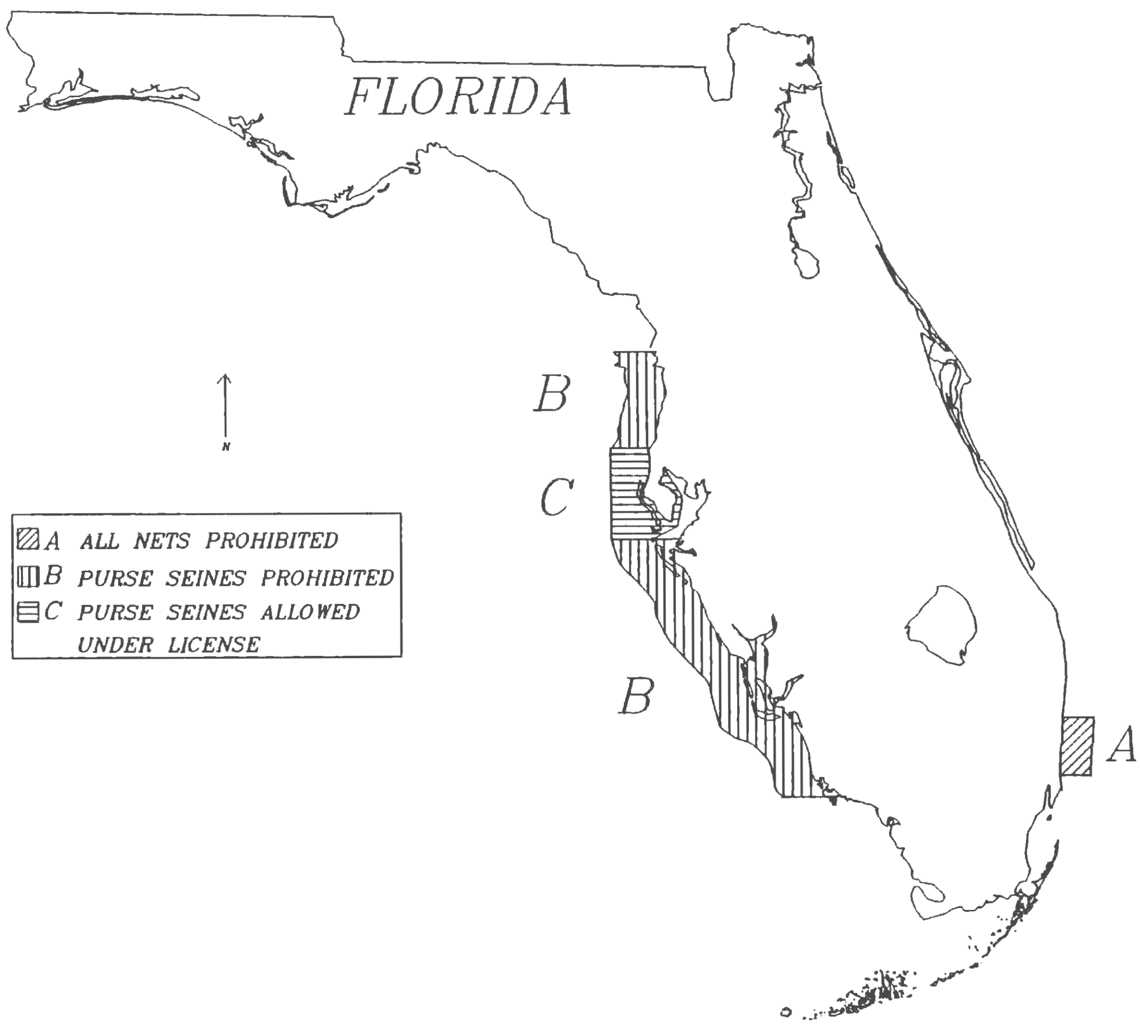


Figure 7.3. Areas closed to menhaden fishing by purse-seine in Florida.

7.4.3 ALABAMA

7.4.3.1 Administrative Organization

The Alabama Department of Conservation and Natural Resources has had authority over marine fisheries resources since 1919. The marine resources division was established as a separate division in 1951 and given jurisdiction over marine fisheries. The department has considerable flexibility in establishing regulations concerning fisheries matters as long as regulations comply with state law.

7.4.3.2 Legislative Authorization

7.4.3.2.1 Source

The department's authority over marine fisheries is contained in Title 9, 1975, Code of Alabama. Authority to establish regulations is contained in Section 9-2-4.

7.4.3.2.2 Limited Entry

"A major limitation upon the power of the department to promulgate rules is that no regulation may hamper industry or ... interfere with the operation of any industrial plant or plants or any industrial operation." Schoenbaum[1] pointed out that the Alabama Supreme Court [Sanders vs. State (302 50.2d 117, Ala. 1974)] held that commercial fishing is not an "industry" for purposes of this section. He concluded that it should be possible to implement management strategies to limit availability of licenses or permits that did not prevent new firms from access to the fishery.

7.4.3.3 Licenses (statutory)

Purse Seine	$500
Purse Seine, non-resident	$1000 - $2185 (varies under reciprocal laws)

7.4.3.4 Reciprocal Agreements

The authority to enter into reciprocal agreements with other states is contained in Sections 9-12-160 through 162. It authorizes non-residents to fish in Alabama waters on a reciprocal basis if they reside in a state where Alabama fishermen are not required to purchase non-resident fishing licenses, i.e. limited to fishing access.

7.4.3.5 Regulations

a. Season: Third Monday in April through Friday following the second Tuesday in October.

b. Mesh Size: No smaller than 3/4" bar.

c. Net Length: None set.

d. Sanctuaries: See Figure 7.4.

e. Other: Bycatch limited to 5% by number other than herrings and anchovies.

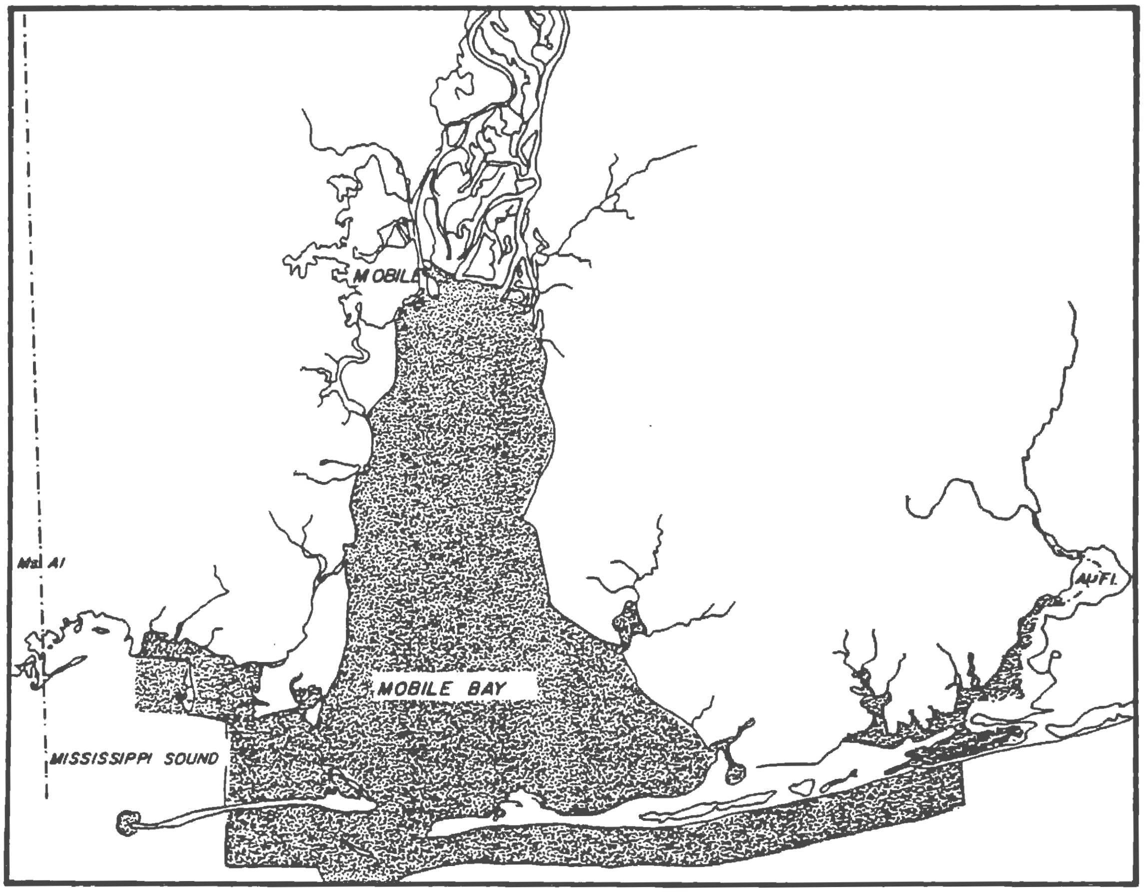


Figure 7.4. Areas closed to menhaden fishing by purse-seine in Alabama.

7.4.3.6 Penalties

Penalty for violation of regulations is $25 to $500 fine.

7.4.3.7 Scientific Collecting Permits

Scientific collecting permits are available to qualified persons through application to the marine resources division.

7.4.4 MISSISSIPPI

7.4.4.1 Administrative Organization

The Mississippi Commission on Wildlife Conservation, Department of Wildlife Conservation (MDWC) is vested with full power to manage marine fisheries in Mississippi. This power is exercised through the Bureau of Marine Resources (BMR) insofar as possible under Chapter 4 of Title 49 Mississippi Code of 1972, which created the MDWC (49-15-11). The members of the five person commission, one from each congressional district, are appointed by the governor with the advice and consent of the senate.

The MDWC has full power to manage, control, supervise and direct any matters pertaining to all "seafood" not otherwise delegated to another agency. However, the minimum fishing season, taxes and licensing for menhaden are set by legislative act.

7.4.4.2 Legislative Authorization

7.4.4.2.1 Source

Statutory provisions are set forth in Paragraphs 49-15-1 through 69, Mississippi Code.

7.4.4.3 Licenses

Licenses necessary for catching, processing and selling menhaden include:

	Resident	Nonresident
Menhaden Boat/Net	$150	N/A
Menhaden Processor	$500	N/A

7.4.4.4 Reciprocal Agreements

The commission has authority to enter into reciprocal agreements with other states and the Federal government in carrying out research and development activities and in carrying out other objectives of the commission.

7.4.4.5 Regulations

The commission has the power to promulgate regulations not set forth by a Legislative Act. All regulations or ordinances are to be published in a newspaper having general circulation in counties affected by such regulation. Current regulations include:

a. Fishing for menhaden is prohibited within one mile of the shoreline of Harrison and Hancock counties (Figure 7.5).

b. The menhaden season is set by statute to open on the third Monday of April. The closing date is now set by commission ordinance as Friday following the second Tuesday in October.

c. Each menhaden company is required to report its landings and pertinent catch data (e.g., number of sets, catch locations, etc.) to the MDWC.

d. Special Provisions. Purse seines may not be used to catch in excess of five percent by weight in any single set of the net any of the following species: spotted seatrout (speckled trout), bluefish, Spanish mackerel, king mackerel, dolphin, pompano, cobia (ling or lemonfish), and jack crevalle. It is also illegal for any vessel carrying a purse seine to have on board in excess of ten (10) percent by weight of the total catch, any of the aforementioned species. It is further illegal for any vessel carrying a purse seine to have on board any quantity of red drum (*Sciaenops ocellatus*).

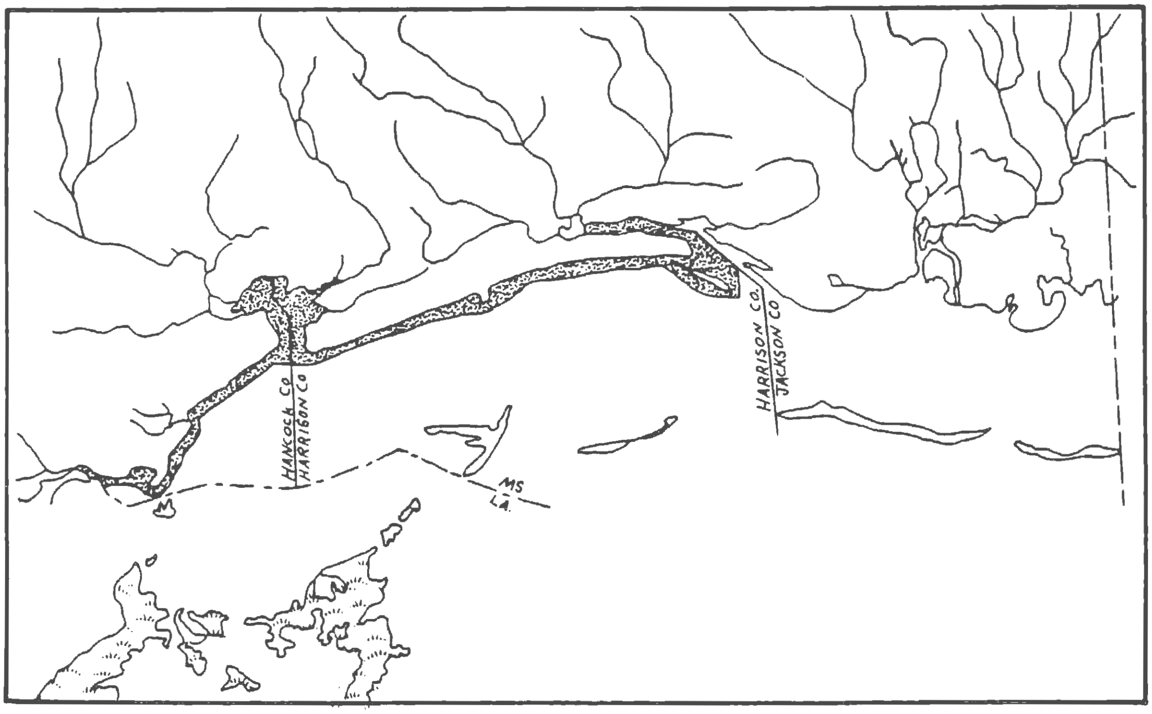


Figure 7.5. Areas closed to menhaden fishing by purse-seine in Mississippi.

7.4.4.6 Penalties

Penalties for violation are set forth in paragraph 49-15-63. On conviction of a violation the offender shall be fined not less than one hundred dollars ($100), nor more than five hundred dollars ($500), for the first offense; and not less than five hundred dollars ($500), nor more than one thousand dollars ($1000), for the second offense when such offense is committed within a period of three (3) years from the first offense; and not less than two thousand dollars ($2000) nor more than four thousand dollars ($4000), or imprisonment in the county jail for a period not exceeding thirty (30) days for any third or subsequent offense when such offense is committed within a period of three (3) years from the first offense and also upon conviction of such third or subsequent offense, it shall be the duty of the court to revoke the license of the convicted part and of the boat or vessel used in such offense, and no further license shall issue to such a person or for said boat to engage in catching or taking of any seafoods from the waters of the State of Mississippi for a period of one (1) year following such conviction. Further, upon conviction of such third or subsequent offense committed within a period of three (3) years from the first offense, it shall also be the duty of the court to order the forfeiture of any equipment or nets used in such offense. Provided, however, that equipment as used in this section shall not mean boats or vessels. Any person convicted and sentenced under this section shall not be considered for suspension or other reduction of sentence.

7.4.4.7 Scientific Collecting Permits

Scientific collecting permits are available to qualified persons by request to the Bureau of Marine Resources.

7.4.5 LOUISIANA

7.4.5.1 Administrative Organization

The Louisiana Department of Wildlife and Fisheries is the agency responsible for coastal fisheries management whereas the Louisiana Wildlife and Fisheries Commission formulates policies and regulations. The Louisiana Wildlife and Fisheries Commission is a constitutionally created seven-member body possessing authority and control over "wildlife of the state, including...oyster, fish and other aquatic life." Moreover, the constitution provides that the Commission "shall have sole authority to establish definite management programs and policies...with no administrative functions." The Secretary of the Louisiana Department of Wildlife and Fisheries is appointed by the governor with consent of the senate to serve at his pleasure. The Secretary's duties consist of serving in an administrative and executive capacity "in accordance with the policies...of the Commission." The secretary is accorded the duty of preparing and recommending wildlife regulations to be considered for adoption by the commission. Within the administrative hierarchy, the assistant secretary is responsible for the administration of "commercial fur and fishing laws of the state." Below the assistant secretary is the division chief of seafood.

7.4.5.2 Legislative Authorization

7.4.5.2.1 Source

Louisiana statutory law covers mesh size for seine and trawl and the licensing of commercial fishermen, nets and vessels for the taking of menhaden. Commission discretion and flexibility in opening the season are provided, but some aspects of the fishery are regulated by statutory authority.

Because the constitution places the policy-making authority solely with the commission and because of the requisite procedures that must be followed in formulating that policy plus the existence of a substantial amount of statutory law, the state management system probably would not be very responsive to an effective coordinated fisheries management plan.

7.4.5.2.2 Limited Entry

Louisiana law provides that "ownership of all fish...remains in the state for purpose of regulating and controlling the use and disposition within its borders." Moreover, there is judicial precedent to the effect that the taking of fish is a "privilege" subject to regulation by the state "for any...cause it deemed sufficient." Thus, having cognizance of the fact that the state, as trustee for the people, has the obligation to assure that the marine fishery resources benefit the people as a whole, the issue is whether economic regulation via limited entry constitutes a valid recognition in the public interest. If it may be assumed that legislation providing for an adequate livelihood to fishermen, improving fisheries management efforts and eliminating economically inefficient regulations involves a public interest, limited entry in Louisiana may be a viable and legally sound approach. The presumption that "the legislature must have acted only after a thorough investigation and upon a finding that the interest of the public required the legislation" lends credence to the validity of a limited entry statute.

7.4.5.3 Licenses and Taxes

Louisiana license fees include:

	Resident	Nonresident
Commercial Fishing License	$55	$105
Vessel License	$15	$65
Commercial Gear License	$500/net	$2000/net
Wholesale/Retail Dealer's License	$105	$405

Commercial licenses are due and payable on the first day of each year. Licenses are available from the department's license agents in the New Orleans or Baton Rouge offices and may be purchased at any time.

7.4.5.4 Reciprocal Agreements

The Louisiana Wildlife and Fisheries Commission has authority to enter into "reciprocal fishing license agreements" with the authorities of any other state. Further, La. R.S. 56:673 authorizes the commission to enter into reciprocal agreements with the states of Mississippi and Texas pertaining to "seasons, and all other rules and regulations pertaining to the taking or protection of any species of fish or other aquatic life" in bodies of water which form the "common boundary" between Louisiana and the reciprocating states.

7.4.5.5 Regulations

a. The season for landing and processing menhaden is from the third Monday in April to the first Friday after the second Tuesday in October.

b. "Menhaden seine" is defined as a purse seine used to take menhaden and herring-like species. Purse seine means any net or device commonly known as a purse seine using a tom-weight and/or power block to handle the net and then pursed by means of a drawstring that can be drawn to close the bottom of the net. Such nets are constructed of mesh of such size and design as not to be used primarily to entangle commercial-size fish by gills or other bony projection.

c. Sanctuaries in which menhaden fishing may be excluded can be formed under Louisiana law. At the present time, there is such a sanctuary provision in effect in an area bounded by a line extending in a southerly direction from Caminada Pass to a point three miles offshore, then northeasterly to the Barataria Pass sea buoy, then to the Four Bayou Pass sea buoy, then northerly to the eastern side of Four Bayou Pass (Figure 7.6).

d. By state law the legal fishing area is seaward of the inside-outside shrimp line except in the Chandeleur-Breton Sound area. The "menhaden fishing line" extends from the mouth of Sabine Pass along the offshore beaches to South Point on Marsh Island, southeasterly to Eugene Island Lighthouse and to the most westerly point of Point Au Fer Island. Then continuing along the beaches to Grand Bayou du Large and along the north and east shore of Caillou Bay southward to the most westerly point of Pass Wilson. Then easterly along the Isles Dernieres and the Timbalier Islands to the mouth of Bayou Lafourche. Then eastward along the shoreline and barrier islands and around the passes of the Mississippi River to Kimble Pass. Then northwesterly to Bird Island,

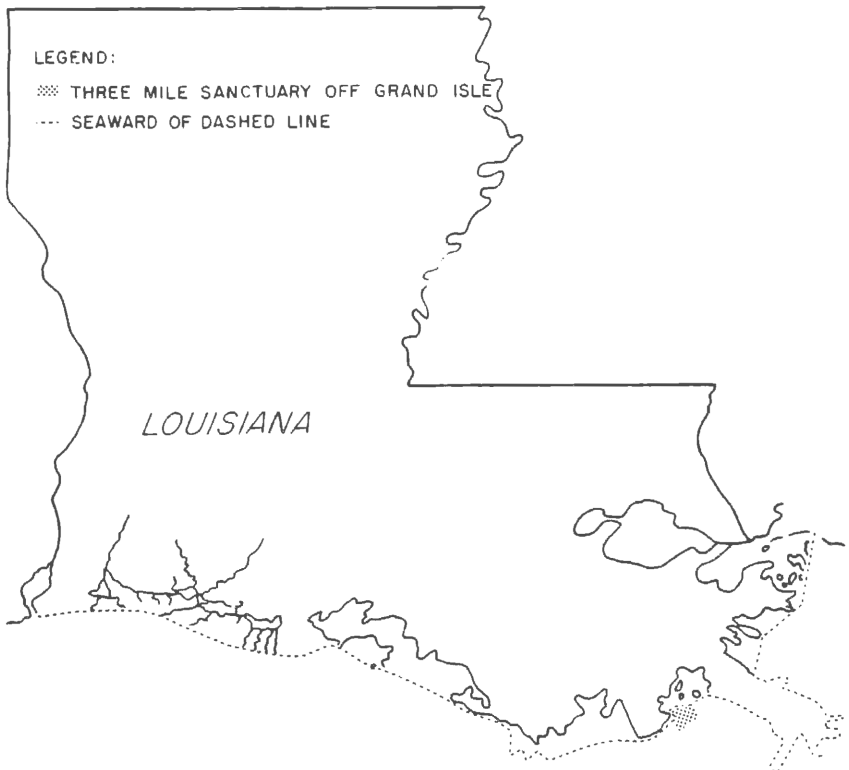


Figure 7.6. Areas closed to menhaden fishing by purse-seine in Louisiana.

westerly to Sable Island and then to California Point, and then northerly to Mozambique Point to Point Chicot to Mitchell Key to Door Point, and then due north to the Louisiana-Mississippi line.

e. Anyone fishing with a menhaden license shall not have in their possession more than five percent by volume of any species other than menhaden, herring-like species and mullet.

Resident and nonresident persons of Louisiana and foreign corporations are prohibited from seining for and catching menhaden or other species of fish not ordinarily used for human consumption in the inside and outside waters over which Louisiana has jurisdiction, to be transported to another state for the purpose of rendering and processing same, unless the state, to which the menhaden or other such species of fish are transported for the purpose of rendering and processing, permits citizens of Louisiana and Louisiana corporations the like privilege to seine for and catch and transport into Louisiana for the purpose of rendering and processing same, under the same conditions as provided by Louisiana law, menhaden and other like species of fish in the waters over which the state has jurisdiction. (RS56:339).

The constitution places regulation-making authority solely with the commission and there are many procedures that must be followed in formulating these regulations.

7.4.5.6 Penalties for Violations

Unless otherwise specified a mandatory fine of $250-$500 and/or a jail sentence of not more than 90 days are provided for first offenders and revocation of license for one year; a fine of $500-$800, 60-90 days in jail, and seizure of equipment and for one year for second offenders; and for third and subsequent offenses, a fine of $750-$1000 and 90-120 days in jail, seizure of equipment and revocation of license for one year. There are also provisions for seizures and forfeiture of vessels or equipment used illegally.

7.4.5.7 Scientific Collecting Permits

The Louisiana Department of Wildlife and Fisheries may take fish of any kind when, where, and in such manner as may be deemed necessary for scientific or educational purposes and for propagation and distribution. The department may introduce or permit to be introduced live fish or fish eggs of any kind in public or private waters of the state. No person shall introduce into the state any live fish or fish eggs, other than goldfish and aquarium fish, without a permit issued by the department. The secretary may issue permits to any persons to take fish for scientific or educational purposes or for propagation or distribution. The prohibition against the taking of fish by means of any device not specifically permitted under the legal size limits provided for during any closed season or closed zones designated by the commission does not apply to such persons if, in the opinion of the Department, the fish are necessary for scientific or educational purposes, or for propagation or distribution to other waters of the state. These permits may be revoked at any time if abused.

7.4.6 TEXAS

7.4.6.1 Administrative Organization

The lead agency for coastal fisheries management is the Texas Parks and Wildlife Department, and the policy function has been assigned to the Texas Parks and Wildlife Commission. The commission appoints an executive director who serves as the chief executive officer of the department. Within the department there exists the fish and wildlife division and within the division the branch of coastal fisheries. These are administratively functional offices.

The commission has authority to establish all rules and regulations permitted by statute concerning coastal fisheries within its jurisdiction. The director and the remainder of the department staff are concerned with the development of recommendations for regulations, and with their enforcement.

7.4.6.2 Legislative Authorization

7.4.6.2.1 Source

The basic fisheries management law in Texas is the "Wildlife Conservation Act of 1983."

7.4.6.2.2 Limited Entry

In 1949, the Texas Legislature enacted a law providing for limited licensing of commercial fishing vessels. The provision allowed discretion to the Texas Fish and Game Commission to set a quota on the number of licenses to be issued for the succeeding year, if in its opinion, it was deemed necessary to preserve the maximum sustainable yield. Anyone holding a commercial license prior to April of 1949 was entitled to a renewal, and no new licenses could be issued until all renewals were filled. The statute also provided residents priority in the issuance of any new licenses. The Supreme Court of Texas struck down the measure on the grounds that it violated the due process clause of the state constitution. It may be, had the legislature been more careful in enacting the quota scheme (eliminating, for example, the favoritism specifying the maximum size boats to be used, and providing for more than one kind of fishing license), the provision could have been upheld. Nonetheless, the decision affords a legal precedent against the use of licensing quotas or other limited entry schemes for purposes of fisheries management.

7.4.6.3 Licenses and Taxes

Licenses necessary for catching, processing and selling of menhaden include:

Menhaden fish plant	$100
Each boat	$2000
Net size	$2.00 per 100 feet

7.4.6.4 Reciprocal Agreements

At the present time, the State of Texas has no statutory authorization for any of its agencies or departments to enter into reciprocal agreements with other jurisdictions concerning access to or management of marine fisheries. Such a provision apparently did exist but that provision, which also contained a differential fee schedule for residents and nonresidents with respect to commercial fishing activities, was repealed in 1949 and the authority in a subsection of that article concerning reciprocal agreements for such license fees was also repealed since the necessity therefore was obviated under a new uniform fee schedule.

7.4.6.5 Regulations

The commission has authority to establish all rules and regulations permitted by statute concerning coastal fisheries within its jurisdiction. Current regulations include:

a. The menhaden season is set from the third Monday in April through the Friday following the second Tuesday in October.

b. Purse seines must not be a mesh size less than 1.5 inch stretched mesh, excluding the bag.

c. Menhaden may not be fished in any bay, river or pass, within 1/2 mile from shore in gulf waters or within one mile of any jetty or pass (Figure 7.7).

d. Purse seines used in taking menhaden may not be used to take any other edible aquatic product for sale, barter or exchange.

e. Catches in purse seines must not exceed 5% by volume of other edible aquatic products in possession.

7.4.6.6 <u>Penalties for Violations</u>

Fines and penalties for violations of Texas menhaden regulations: A fine of not less than $200 nor more than $1000, confinement in jail up to 180 days, or both.

7.4.6.7 <u>Scientific Collecting Permits</u>

Scientific collection permits are available to qualified persons.

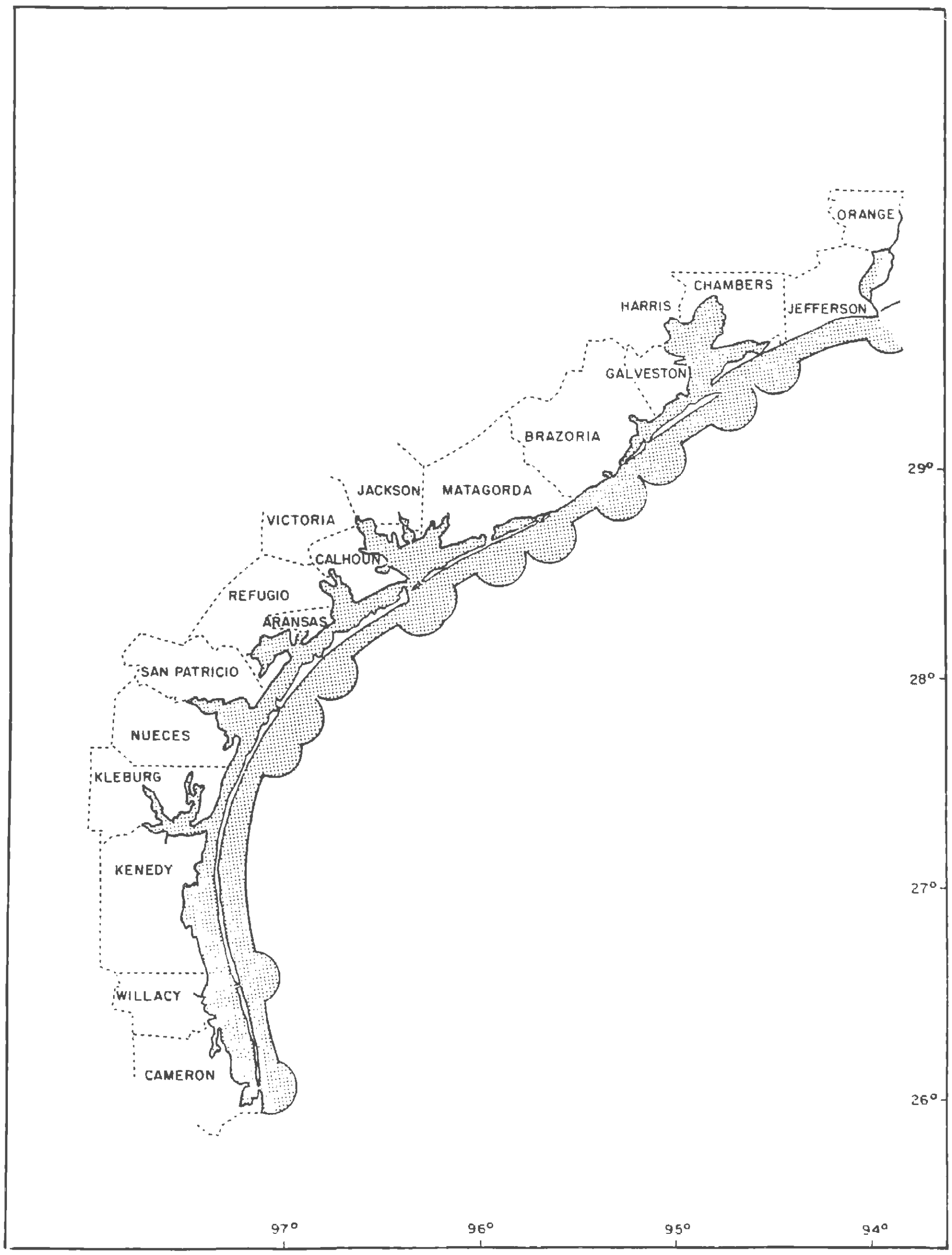


Figure 7.7. Areas closed to menhaden fishing by purse seine in Texas.

8.0 DESCRIPTION OF FISHING ACTIVITIES AFFECTING STOCK(S) IN THE MANAGEMENT UNIT

8.1 History of Exploitation

8.1.1 Past User Groups (Foreign and Domestic)

There is no record of the harvest and/or processing of gulf menhaden by foreign users. The first landings data for gulf menhaden reported in U.S. statistics occurred in 1880 (Lyles 1965). John Frye's (1978) excellent account of the history of menhaden fishing in the Gulf of Mexico begins (page 93):

> The Gulf of Mexico had no nineteenth century George Brown Goode to ask from Florida to Texas who was catching menhaden and how and with what luck. Landings were recorded first off West Florida in 1880, but of fewer than one thousand pounds. Some landings were reported in Alabama in 1902, but none there since 1931. Scientific and other writings include brief, tantalizing references to menhaden fishing in the gulf in the late nineteenth and early twentieth centuries, but information on catches and location and plants and types of fish boats is fragmentary. One plant is known to have operated in Texas from about 1900 until at least 1923, and others in the vicinity of Port St. Joe and Apalachicola, Florida, from at least 1918.
>
> By whom the early enterprises were set up is left untold, although the names of Delaware's DuPonts are part of the gulf lore. It can be guessed that early fishermen along Florida, Alabama, Mississippi, Louisiana, and Texas shores saw big schools of gulf menhaden (Brevoortia patronus) and their much less abundant cousins, fine-scale (B. gunteri) and yellow-fine (B. smithi), and caught them in haul seines or trawls, possibly when fishing for shrimp or other species. They found them edible or useful, with manuring of fields and production of scrap for fertilizer and of oil probable. A 1915 industrial chemistry manual notes menhaden oil production in Texas in 1900, with a yield of "3.51 gallons to the 1000 fish." Gulf menhaden now yield twelve to fifteen gallons per thousand fish, against two or so for Atlantic menhaden.
>
> No doubt menhaden also were found useful as bait for mackerel and tarpon, or along creeks and bayous, for crabs. Fishermen tend to find something to do with anything easily caught in volume -- except, so far, jellyfish.

His account adds some details of menhaden fishery history, especially concerning the World War I period around Port Arthur, Texas, prior to the beginning of the "recordable history" in the 1930's. He provides an interesting account, including personalities, boats and plants, as the industry developed and stabilized in the 1970's.

Chapoton (1970; 1972) reviewed the history and status of the gulf menhaden purse-seine fishery through 1970. Historically, the menhaden resource has been essentially directly used by the fish meal and oil industry.

8.1.2 Vessel and Gear Types and Quantities

Fishing equipment and methods used in the menhaden purse-seine fishery are described by Lee (1953), June (1963), Simmons and Breuer (1967), Perret (1968), Whitehurst (1973), Nicholson (1978) and Frye (1978).

From the beginning of the industry in the mid-1800's until World War II, there were very few fundamental changes in gear and techniques. However, after World War II a number of important changes took place, some of which were pioneered in the Gulf of Mexico. Some of the changes are: the use of aircraft in the late 1940's to spot menhaden schools; the switch from natural to synthetic fibers in nets making them stronger and longer lasting; hydraulic power blocks for retrieval of the net; elimination of the striker boat; refrigerated fish holds in the mid-50's; aluminum diesel-powered purse (or seine) boats in the 60's which added speed and maneuverability; hydraulic davits to speed up launching and retrieving the purse boats and pumps to transfer the catch from net to the carrier vessel. In addition, all carrier vessels since 1950 have been constructed of steel with increased carrying capacity, speed and operating range. Also, larger and more comfortable living accommodations have been included for the crew members.

Rapid development of the modern gulf menhaden industry started after World War II. Only six menhaden vessels were reported operating in the Gulf of Mexico by the Fish and Wildlife Service in 1940 (Statistical Digest No. 4); there were 81 in 1956 (Table 8.1). In the modern fleet vessels are generally owned and operated by the menhaden companies, and some vessels may be shifted from one state to another depending on the availability of fish during a season. Consequently, numbers of vessels landing fish in each state are not additive.

While the number of vessels has been relatively stable since 1954, their ability to catch fish has increased. Vessel size increased rapidly. All ten vessels reported in the gulf in 1945 were under 75 net tons; by 1973 almost 80% exceeded 200 net tons. The first spotter plane reported in 1949; in 1973 there were 31 airplanes for 65 carrier vessels. Fish pumps (6) were first reported in 1951, and all vessels were using fish pumps in 1962. Power blocks (4) were first reported in 1956 and the brail net disappeared from gulf vessels in 1966. All vessels were refrigerated by 1972.

Those and other changes reduced search and loading time, decreased the amount of manual labor and allowed vessels to range farther, stay out longer and land more fish of a better quality. Crews were reduced from an average of 25 in 1960 to about 17 in 1973 and to 14 in 1985. Efficiency of the captain and crew continued to be a factor in the volume landed.

8.1.3 Fishing Areas

Processing plants have been located around the northern gulf from Apalachicola, Florida, to Sabine Pass, Texas (Figure 8.1). Until the modern fleet developed, fishing was limited to areas near operating plants. Although there are now eight plants located from Moss Point, Mississippi, to Cameron, Louisiana, the fishing area extends from Apalachicola to Freeport, Texas.

Areal distribution of the catch for 1964 to 1969 was estimated from log books placed aboard vessels by NMFS or its predecessors (Nicholson 1978). Those data indicated that 45% of the sets were completed west of the Mississippi River delta and 44 to 93% of those were made less than 10 miles from shore. East of the delta 100% of the sets were made less than ten miles from shore. Nicholson (1978) noted that, in effect, the fishing west of the delta was "restricted to a narrower band adjacent to shore than is indicated by the data."

Table 8.1. Numbers of operating plants, airplanes, vessels[1] by size, and vessels with fish pumps, power blocks, and refrigerations, gulf menhaden fishery 1945-1987 (Nicholson 1978 and Smith et al. 1987 updated).

			No. of vessels				No. of vessels with:		
Years	No. of plants operating	No. of air planes	Under 75 net tons	76-200 net tons	Over 200 net tons	Total	Fish pumps	Power blocks	Re-friger-ation
1945	2	0	10	0	0	10	0	0	0
1946	3	0	13	1	0	14	0	0	0
1947	4	0	21	9	0	30	0	0	0
1948	5	0	27	12	0	39	0	0	0
1949	7	1	36	17	0	53	0	0	0
1950	10	3	42	23	0	65	0	0	0
1951	10	4	42	26	0	68	6	0	0
1952	10	4	41	23	0	64	7	0	0
1953	10	5	46	24	0	70	12	0	0
1954	9	7	40	32	0	72	39	0	0
1955	9	8	39	31	2	72	43	0	0
1956	10	12	38	39	4	81	63	0	2
1957	10	15	32	35	6	73	72	4	9
1958	10	15	20	48	9	77	69	7	14
1959	11	17	18	44	11	73	66	16	23
1960	10	19	12	52	11	75	71	21	29
1961	10	19	6	52	11	69	66	21	32
1962	12	23	6	54	14	74	74	43	35
1963	11	25	5	53	15	73	73	56	36
1964	11	24	5	53	18	76	76	64	40
1965	13	27	4	48	30	82	82	79	57
1966	13	29	1	42	37	80	80	80	59
1967	13	31	1	32	43	76	76	76	70
1968	12	33	2	26	41	69	69	69	65
1969	12	33	2	27	43	72	72	72	68
1970	13	34	2	26	45	73	73	73	70
1971	13	35	1	29	52	82	82	82	77
1972	11	33	0	22	53	75	75	75	75
1973	10	31	0	14	51	65	65	65	65
1974	11	55	0	14	57	71	71	71	71
1975	11	59	0	14	64	78	78	78	78
1976	11	59	0	14	68	82	82	82	82
1977	11	61	0	11	69	80	80	80	80
1978	11	62	0	11	69	80	80	80	80
1979	11	61	0	8	70	78	78	78	78
1980	11	60	0	7	72	79	79	79	79
1981	11	61	0	6	74	80	80	80	80
1982	11	63	0	7	75	82	82	82	82
1983	11	41	0	7	74	81	81	81	81
1984	11	44	0	7	74	81	81	81	81
1985	7	45	0	6	67	72	72	72	72
1986	8	42	0	5	67	72	72	72	72
1987	8	45	0	6	69	75	75	75	75

Chapoton, 1982

[1] Number of vessels that landed menhaden at least one day in each of 9 or more weeks, 1945-1973. Number of vessels that landed menhaden at least one day, 1974-1987.

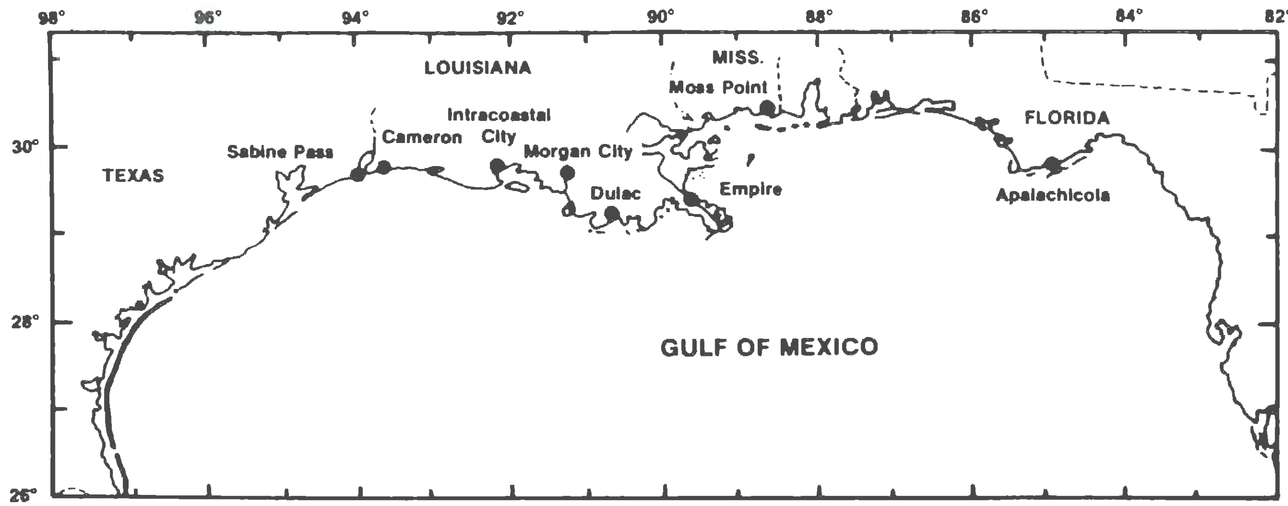


Figure 8.1. Historical location of reduction plants for the gulf menhaden fishery in the Gulf of Mexico (Nicholson 1978).

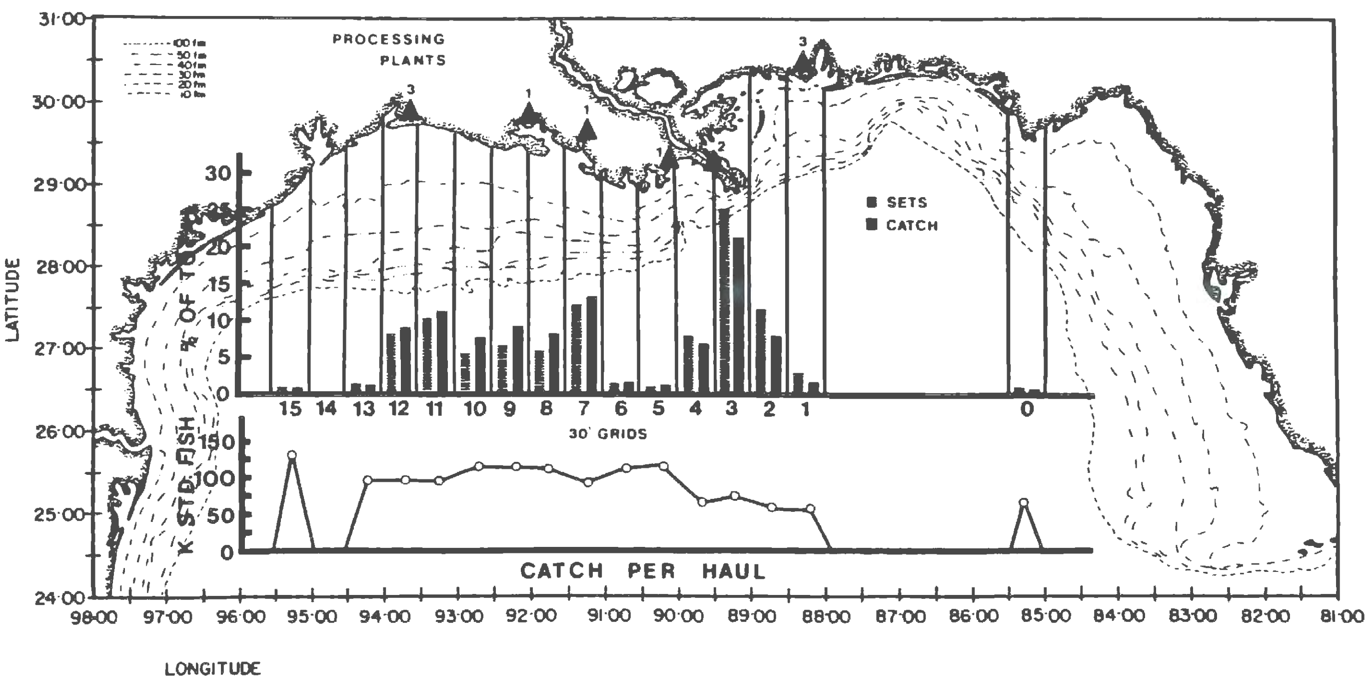


Figure 8.2. Areal distribution of catch-effort (sets) and catch-per-set in the 1978 Gulf of Mexico menhaden fishery (Christmas 1980).

Matlock and Strawn (1976) found that "*B. patronus* from Alabama weighed more, for a given length, than *B. patronus* from upper Galveston Bay." They suggested that, assuming consistent standard length-total weight relationships, the differences in length-weight relationships may be related to "environmental variations such as nutrition (food abundance, type, quality), competition, water quality, sexual maturity, genetic variation or seasonality."

The seasonal abundance and quality of the food supply as it varies with environmental factors is probably a major factor in the broad annual and areal fluctuations in landings and oil production. Joseph (1985) found that while there were few if any differences in annual or seasonal means of fatty acids of Atlantic oils, nine of the ten fatty acids in the gulf oils had significantly different ($p<0.001$) seasonal means, and four had annual means that differed significantly. The geographic means of both 18:1w9 and 22:6w3 were highly different, statistically, in the gulf oils.

In a preliminary analysis of 1978 data from the Captain's Daily Report developed by the Menhaden Advisory Committee in 1977 and voluntarily completed by the gulf menhaden industry, Christmas (1980) estimated that 28% of 1978 gulf menhaden landings were caught in areas east of the river (Figure 8.2). Reported landings at Mississippi plants comprised 16% of the 1978 landings (NMFS 1979). The bait fishery for menhaden has grown rapidly in the last five years. Landings reported for 1987 amounted to over 15 million pounds in Florida and over 10 million pounds in Louisiana.

8.2 Domestic Activities

8.2.1 User Groups

The greatest volume of the menhaden resource is directly utilized by the fish meal and oil industry. The relatively small bait fishery that existed off the west coast of Florida five years ago has expanded considerably, and current research on other uses may lead to new utilization for other products.

A much greater impact is applied on the resource by the shrimp and industrial groundfish fisheries. Haskell (1961) noted menhaden made up an average 2.2% by weight of the industrial bottomfish catch in 1959; however, Roithmayr (1965) noted few menhaden are taken by this fishery.

Juhl and Drummond (1976) estimated that in the inshore shrimp fishery of Louisiana, 1,341,515 Kg or 23.7% of the total finfish discards of the shrimp fishery is menhaden. Eymard (personal communication) estimated that menhaden by weight made up 16.0% of the inshore and 8.0% of the offshore finfish discards of the shrimp fleet in Louisiana in 1976. Guillory et al. (1985) examined gulf menhaden/shrimp ratios in trawls and wingnets. Substantial numbers of menhaden may be taken as bycatch in the inshore shrimp fishery; however, no detrimental effect has been demonstrated.

8.2.2 Vessels and Gear

The menhaden fleet operating in the Gulf of Mexico in 1984 harvested a record catch of 982.8 K metric tons. Although, as already noted, there has been no increase in numbers of vessels in the recent history of the fishery, increased size and full utilization of modern gear provided the needed harvest capacity.

8.2.2.1 Fish Spotting Aircraft

Spotter planes are usually single-engine land-based aircraft with a single high wing. They are fully equipped with electronic navigation and communication systems and are capable of flying for extended periods of time without refueling. The pilots are highly skilled and experienced in identification and general behavior of menhaden schools as well as fishing procedures and can closely estimate the quantity and size of the fish that make up the school (based on comparisons of pilots estimates with actual landings data). The planes are either owned or under contract by the fishing company and are based near the plants. The pilots are usually employed by the fishing company and are compensated by a salary plus a bonus on the amount of fish landed at the plant.

Spotter pilots make reconnaissance flights prior to the beginning of the fishing season to determine the general location, movement and size of menhaden schools. During the fishing season a spotter pilot departs about dawn and rendezvous with the fishing vessels for which he is spotting and aids in locating fishable schools. Then, by radio, he directs the carrier vessel to schools of menhaden that appear to offer the best chances of a productive catch.

The spotter pilot maintains radio contact with the carrier vessels and visual contact with the school, or schools of menhaden. When the carrier vessel arrives in the fishing area, the spotter pilot directs it to the best available school and directs the purse boats in the setting of the purse seine. One spotter aircraft usually serves several carrier vessels.

8.2.2.2 Purse Boats

Purse boats are of open construction of aluminum, approximately 36 to 40 feet long, about 10 feet wide. They are equipped with a diesel engine that propels the boat and furnishes power for the operation of the hydraulic seine block and allied fishing gear.

8.2.2.3 Purse Seine

Purse seines used by gulf menhaden fishermen are conventional in design. The size and material may vary, but usually a seine is about 1200 feet long, 10 or more fathoms deep and made of 3/4 or 7/8-inch bar-mesh synthetic twine. The curtain-type net is hung between lines containing surface floats and bottom leads and noncorrosive purse rings. The bottom of the net is closed by drawing a line through the rings along the bottom line. This is accomplished by dropping the ends of the net overboard adjacent to a heavy lead weight (tom) to which pulleys, or blocks, are attached, through which the purse line passes thereby allowing the net to be closed at or near its extended depth.

8.2.2.4 Carrier Vessels

Menhaden carrier vessels are specialized craft that transport the catch from the fishing grounds to the reduction plants. The vessels also serve as crew quarters and carry the purse seine and the two purse boats. A high bow, a low stern and a tall mast with a crow's nest are common characteristics. The fish are stored below deck in central holds that are usually refrigerated. The wheel house, crew quarters and the mess halls are usually located forward and the engine room aft. The vessels range from 140 to nearly 200 feet in length and may carry up to 600 or more tons of menhaden. The carrier fleet operating in the gulf in 1987 consisted of about 75 vessels. Statistics on 75 menhaden carrier vessels operated in the Gulf of Mexico during 1987 were as follows:

	Range	Mean
Length	140 - 195	149
Gross tons	181 - 644	387
Net tons	85 - 438	261
Horse Power	420 - 2000	1214
Age (yrs)	1 - 33	14

Menhaden vessels have a crew of about 14 men, consisting of a captain, mate, pilot, chief engineer, second engineer, cook and 8 fishermen.

During the fishing season carrier vessels leave the various plants so that they will be on the fishing grounds by daybreak. Depending on their catch, the weather and other factors, they may make several trips during the week.

The search for menhaden is conducted by three persons, the spotter plane pilot, the vessel captain and the mate. Once a "color" or "whip" is sighted, indicating that a school of appropriate size is within range, the carrier vessel crew goes into action. On orders from the captain, the purse-boat crews (fishermen), rush to stations at the davits on either side of the ship, toward the stern. The purse boats are lowered into the water, joining at the stern of the carrier. Each purse boat carries half of the purse seine as they race together toward the school of fish. Once they get close, the purse boats separate, and begin to pay out, or "set", the net as they proceed in a half circle until they meet again with the school completely surrounded by the net. The purse line, running through the bottom rings, closes the bottom of the seine to confine the menhaden, then the seine is retrieved mechanically by the power block aboard each boat, forcing the fish into a relatively small section of the net known as the "bunt."

Upon another command by the vessel captain, the carrier pilot will bring the carrier, or "mother ship," to the purse boats where they are secured to the port side along the surface float line and the fish are raised closer to the surface by a large boom aboard the carrier. The catch is then pumped into the refrigerated hold of the "mother ship" through a large flexible hose attached to a suction pump aboard the carrier. The transport water is returned to the sea. If it appears that there will be more fish in the immediate area, the purse boats are secured to the stern of the vessel, where they will be towed as she cruises.

Once the hold is full and/or the trip is completed, the vessel will return to the plant, where the fish are unloaded by pumps. The number of "sets" made by the vessel per day, depends on the availability and size of the schools. Usually schools contain from 3 to 100 metric tons of menhaden.

8.2.3 Employment

8.2.3.1 Harvesting Sector

In the 1987 fishing season 1,064 fishermen were employed on 75 menhaden vessels fishing in the Gulf of Mexico. "Fishermen" included captains, mates, pilots, engineers and fishermen. Those seasonal employment opportunities were available through the 26-week season.

8.2.3.2 Processing Sector

Eight menhaden processing plants in the gulf employed 880 people in 1987. About 41% of processing plant employment is full time.

8.2.3.3 Other

There are no estimates of the number of jobs created by the menhaden industry in service and distribution sectors.

8.2.4 Fishing and Landing Areas

Fishing and landing areas in the 1978 season are shown in Figure 8.2. Most of the fish caught are landed at processing plants near the area where the fish are caught. Fishing in the eastern and western extremes of the fishing area occurs only when large concentrations of fish are observed there. This is usually done by vessels from Moss Point, Mississippi, for the areas off Apalachicola and by vessels from Cameron, Louisiana, for the areas off Freeport, Texas.

8.2.5 Potential Alternate Resources

At present the menhaden industry does not to any great extent utilize any other species. The Atlantic thread herring *Opisthonema oglinum*, does enter the catch to some degree. Attempts to exploit this resource principally off the Florida west coast have been thwarted by restrictive legislation. Some other species, most notably round herring, have been considered as alternative resources, but harvesting of round herring, *Etrumeus teres*, with the present gear of the menhaden industry would probably be impossible.

Houde et al. (1976) estimated that there are 803,575 metric tons (MT) of potential pelagic fish stocks other than menhaden in the eastern Gulf of Mexico. A breakdown of the species and quantities of each are as follows: round herring, 378,587 MT (with an estimated 150,000 MT available to be harvested); thread herring, 240,806 MT; scale sardines, 184,182 MT; and a tentative estimate of 100,000 MT of Spanish sardines.

8.2.6 Amount of Landings/Catch

See Section 9.1.

8.2.7 U.S. Harvesting Capacity

The current fleet of approximately 75 purse-seine vessels appears to be more than adequate to harvest the recruited gulf menhaden stock during years of low to moderate stock size and capable of taking advantage of those years when a large harvestable stock is available (Nelson and Ahrenholz, 1986). That capability was demonstrated in 1982 when over 854 K metric tons of gulf menhaden were landed at existing plants. Annual production, fishing effort, and fleet size appear reasonably balanced (Vaughan 1987).

8.2.8 Extent to Which U.S. Fishing Vessels Will Harvest Optimum Yield (OY) (Domestic Annual Harvest, DAH)

The long term estimated MSY of 803,300 metric tons of gulf menhaden has a "normal" annual range of approximately 700,000 to 825,000 metric tons (Section 5.4.1). The domestic harvest taken by U.S. fishing vessels (1964-1982) has been very close to the estimated yield. Consequently, it is expected that all of the OY (DAH) will be harvested by U.S. vessels.

8.2.9 Extent to Which U.S. Fishing Vessels Propose to Deliver to Foreign Vessels

In the vertically integrated menhaden industry there is no proposal to deliver fish to foreign vessels.

8.3 Domestic Processing Capacity

8.3.1 Contracts or Agreements to Purchase U.S. Harvested Fish

In the vertically integrated menhaden industry each company contracts to purchase fish caught by its own vessels by paying agreed share costs to vessel crews.

8.3.2 Ability and Intent to Process

The ability of the eight menhaden processing plants operating in the Gulf of Mexico to process the maximum expected harvestable biomass was demonstrated in 1982. In the absence of catastrophic economic changes they expect to continue processing DAH.

8.3.3 Geographical Proximity of Harvest Areas to U.S. Processing Facilities

Processing facilities have been located in the vicinity of gulf menhaden concentrations (Figure 8.2).

8.3.4.1 Number of Plants

The number of menhaden processing plants operating in the Gulf of Mexico fishery was reduced to 11 when the last Texas plant was closed after the 1971 season. Ten plants operated in 1973 and 1974. Eleven plants were in operation through 1984, and eight are currently processing fish (Figure 8.2). Processing plants must be able to process peak catches when they occur. As a result, menhaden processing plants often operate at less than full capacity (Hu 1983). The principal recent changes in processing have been made in response to complying with regulations, especially promulgations on water quality control. All menhaden plants are mechanized so they are less labor intensive in the processing phase than some other fishery processing industries.

8.3.4.2 Processing

Whole menhaden are unloaded by pumps from the hold of the vessel and conveyed to a continuous process steam cooker. Cooking coagulates the protein and releases bound oil and water from the flesh after cooking. The mass of solids and liquids is firm enough to undergo high pressurization as it is conveyed through a continuous press. This operation squeezes oil and water containing dissolved and suspended solids from the mass leaving a damp intermediate known as press cake which is conveyed to continuous process driers. The resulting product (fish scrap) is then milled into meal which is treated with an antioxidant which allows the meal to maintain its superior protein and energy quality during storage and shipment.

The oil and water phase, or press liquor, is pumped through screens and decanters where most of the suspended solids are removed and returned to the press cake. The semiclarified liquor is then separated into the oil and water components by continuous process centrifuges. The oil undergoes a final centrifuging or settling to remove practically all water and impurities and is then ready for shipment.

The combination of water and dissolved solids, separated from the oil by centrifugation, is referred to as stickwater and is pumped to a multi-effect evaporator. At most processing plants, the stickwater is partially concentrated and a percentage is returned to the press cake. In this case all solids are returned to the meal which is then termed whole or full meal. Some stickwater is concentrated to 50% solids content and brought to a pH of 4.5 to preserve its nutritional qualities. This product is called condensed fish solubles.

Figure 8.3 illustrates the processing of 100 metric tons of raw menhaden through a modern plant. Recent advances in processing have resulted in recovery of all solids and solubles. As a result, plant effluents satisfy the current Federal and state standards. Numbers used for this figure are based on data developed from the proximate composition of gulf menhaden as published in Marine Fisheries Review Paper 1199 and supported by industry data. The numbers represent averages since proportions of water, protein, fat and ash in raw fish vary considerably from year to year and during a season. Fish from one area may differ considerably from those taken in another part of the fishing grounds. Cause of these variations is unknown.

8.3.4.3 Products

Wet reduction of menhaden yields three products, menhaden meal, menhaden oil and menhaden solubles.

a. Menhaden meal. This product is a valuable ingredient for animal feeds. It contains a minimum of 60% protein with a well-balanced amino acid profile. High levels of the essential sulfur amino acids, lysine and methionine, are present. The fat content contributes to the high metabolizable energy levels desired by feed formulators. Fish meal also contains desirable levels of important minerals such as calcium meta-phosphate, the "bone builder," and natural selenium which help maintain animals in a healthy state.

The poultry industry is heavily dependent on fish meal as a feed ingredient for maximum growth rate and to improve feed efficiency. Depending on price and availability of fish meal, poultry rations may contain up to 8% fish meal. Because of this specific use, and because the large poultry producing area is in the near gulf region, a large percentage of the gulf menhaden fish meal is committed to the poultry industry.

Another valuable market for fish meal is swine feeds. Swine have high requirements for the fish meal amino acids and the high available energy levels.

Additionally, aquaculture demonstrates ever increasing demands for menhaden fish meal. Formulated feeds for catfish, trout, salmon, and shrimp require up to 40% fish meal to produce efficient growth.

b. Menhaden Oil. Menhaden oil has been used for many years in edible products in Europe and South America. The oil is refined, hydrogenated, deodorized and then blended with other fats for use in cooking oils, shortening, and margarine.

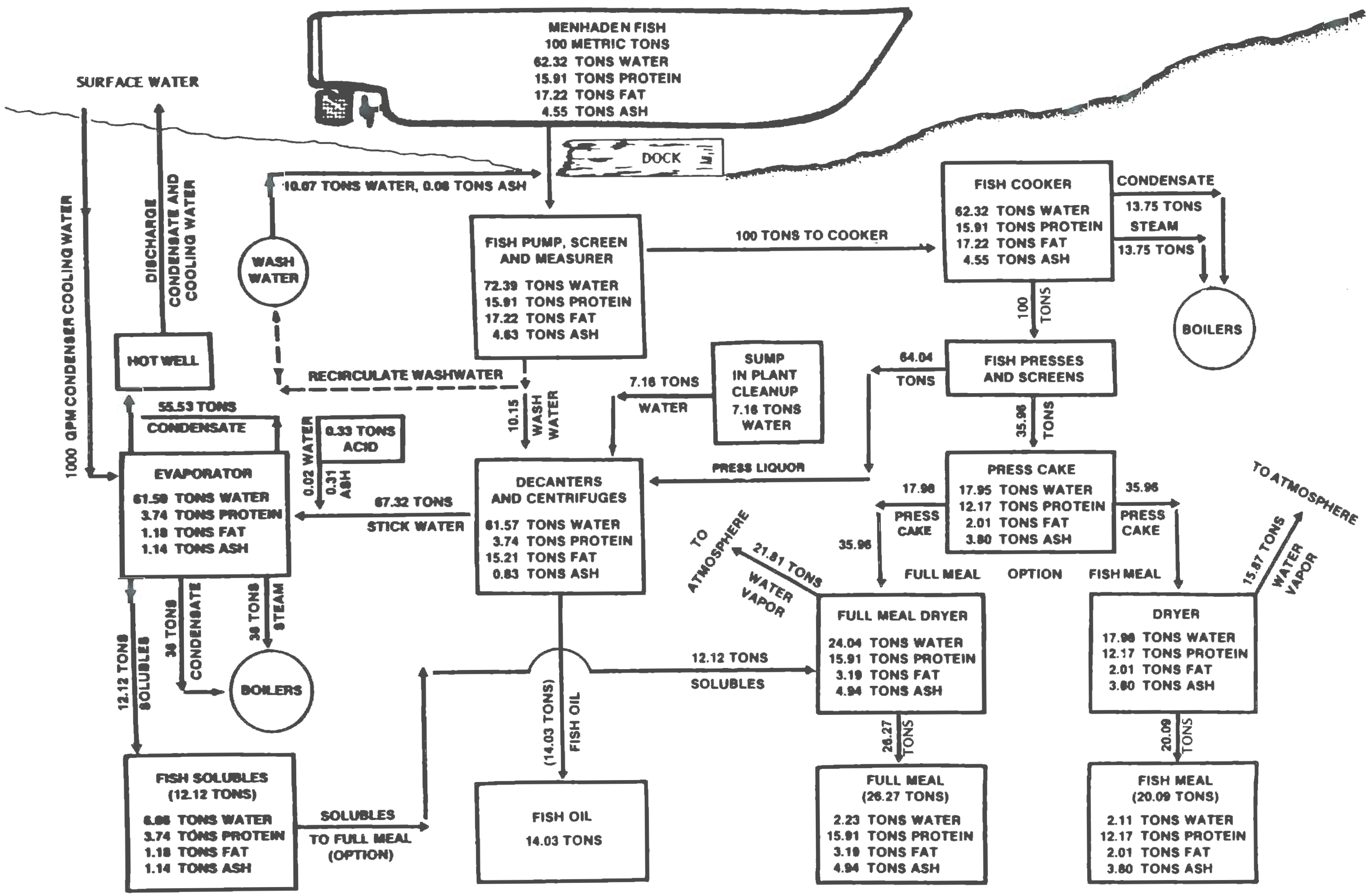


Figure 8.3. The processing of 100 metric tons of raw menhaden through a modern plant.

Menhaden oil also has valuable technical uses in this country. It is easily emulsified with water which makes it a valuable component of marine lubricants and greases. Fatty acid manufacturers fractionate menhaden oil to recover the high unsaturated fatty acids peculiar to this oil. These fatty acids are used as plasticizers for the rubber industry. Fish oil is also sold to feed manufacturers who combine it with supplemental fats for animal feeds. Menhaden fish oil is further used in the manufacture of alkyd resins and processed oil for the paint industry.

c. Menhaden Solubles. This liquid contains 50% water and 50% fish solids. This feed ingredient has the consistency of molasses and contains about 30% protein, 10% fat and 10% mineral. It also contains an important "unidentified growth factor."

Solubles are used as a feed ingredient in the poultry industry to complement or replace fish meal. Its value as a feed ingredient for swine is enhanced by the glycine levels. A large market for menhaden solubles exists in the midwest where solubles are dried on a carrier such as soybean meal or mill feeds and sold as a dry product to formulators of swine feeds. Another use of fish solubles is in liquid feeds. Fish solubles are compounded with molasses and fortified with soluble nutrients and used as a liquid feed supplement for cattle.

8.3.4.4 Product Distribution

Figure 8.4 illustrates the distribution of 1987 menhaden meal from gulf menhaden plants to secondary consumers in the United States. The role of the menhaden in feeding the nation is emphasized when we recognize that there is a much broader distribution of the final product to the tertiary consumer (people). Notably, most of the final product is indirectly used as food for human consumption. When compared to the percentage of edible portions produced from the live weight of many other seafoods such as crabs and oysters, a relatively high percentage of the live weight of menhaden is ultimately consumed by humans as poultry, pork, fish, margarine and baking products.

8.3.4.5 International Trade in Fish Oil and Fish Meal

8.3.4.5.1 Fish Oil

Although much of the fish oil produced in other countries is a small percentage of the fish reduction process, menhaden oil represents one of the two major products derived from menhaden fish and contributes a large percentage of the annual revenues for the United States producer.

Due to the past exclusion of menhaden fish oil from domestic edible products by the FDA, more than 90 percent of the total production is exported to Europe where historically fish oil has been the cheapest source of raw material in the production of edible fats.

Traditionally, menhaden oil competed in the world markets with other fish oils; however, in recent years soyabean oil and the growing use of rapeseed oil and palm oil have provided strong competition. Additionally, one major fat processor purchases 70-75 percent of the total fish oil trade, thus often controlling the prices of fish oil at that company's convenience and valuation.

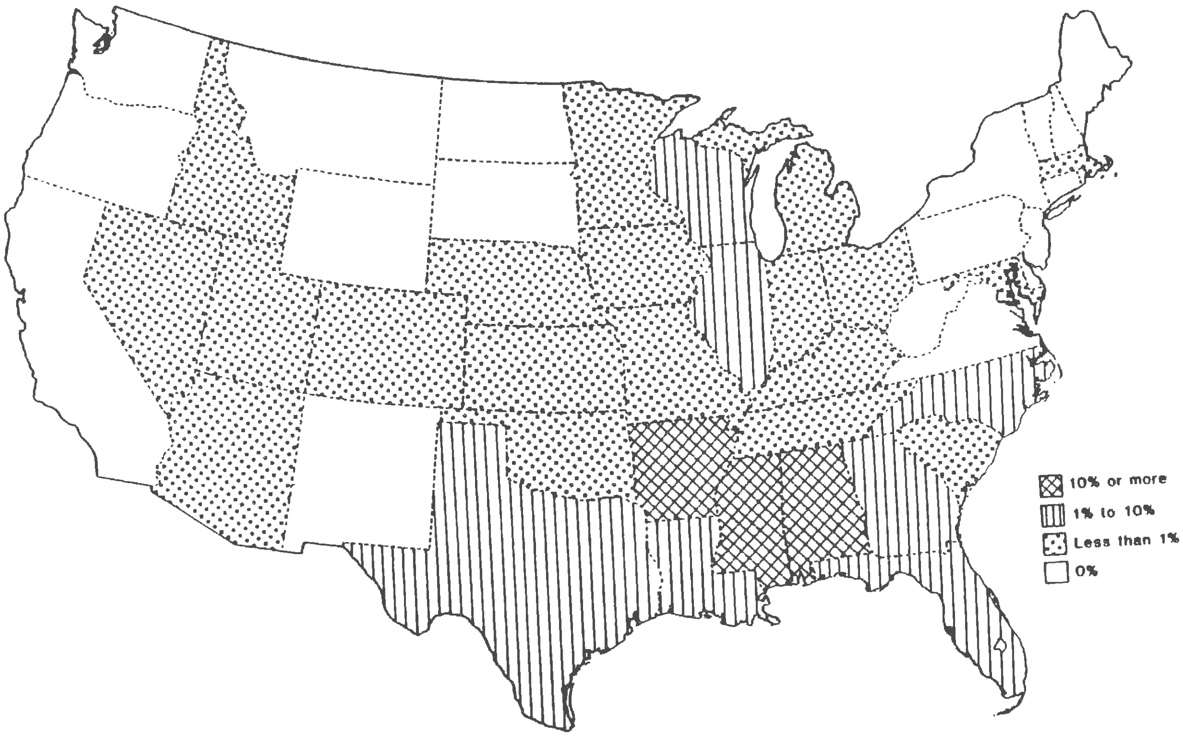


Figure 8.4. Product Distribution

Other competing nations are Norway, Denmark and to a lesser degree Chile, Peru and South Africa. The latter two nations have, until recently, consumed their own production. During the last few years they have on occasion been importers of fish oil.

8.3.4.5.2 Fish Meal

The world markets are dominated by fish meal exports from Chile, Peru, Ecuador, Denmark, Iceland and Japan. Only small quantities of United States menhaden meal are exported. Fish meal is an important source of protein and amino acids to the United States poultry industry and is making important inroads into developing markets for early weaned pigs, ruminants and aquaculture. The United States is generally a net importer of fish meal and can consume up to 150,000 metric tons depending on price.

8.3.5 Seasonal Schedules

As a result of recommendations made by the Gulf State-Federal Fisheries Management Board the menhaden fishery season opens and closes with the exception of Florida on the same date in all Gulf States. The Menhaden Advisory Committee has considered and, until the present time, rejected proposed season change.

Monthly landings (Figure 8.5) fluctuate within seasons and peaks occur from May to August in various years. When peak landings occur, processing plants operate on two 12-hour shifts for continuous operation (Hu 1983). The number of operating days is not a function of plant size but depends on weather and other factors that affect the availability of fish.

Except for Louisiana, the landing of menhaden caught outside state waters, where the seasonal closure applies, is not prohibited, and the bait fishery for menhaden in Florida operates year round. The amount of menhaden landed for bait is lowest from January through March in Florida with peak production in July.

8.3.6 Availability of U.S. Vessels to Supply Fish

In the vertically integrated menhaden industry each company maintains its own fleet of U.S. vessels. Fishing strategy is designed by each company to supply fish for plants operated by that company.

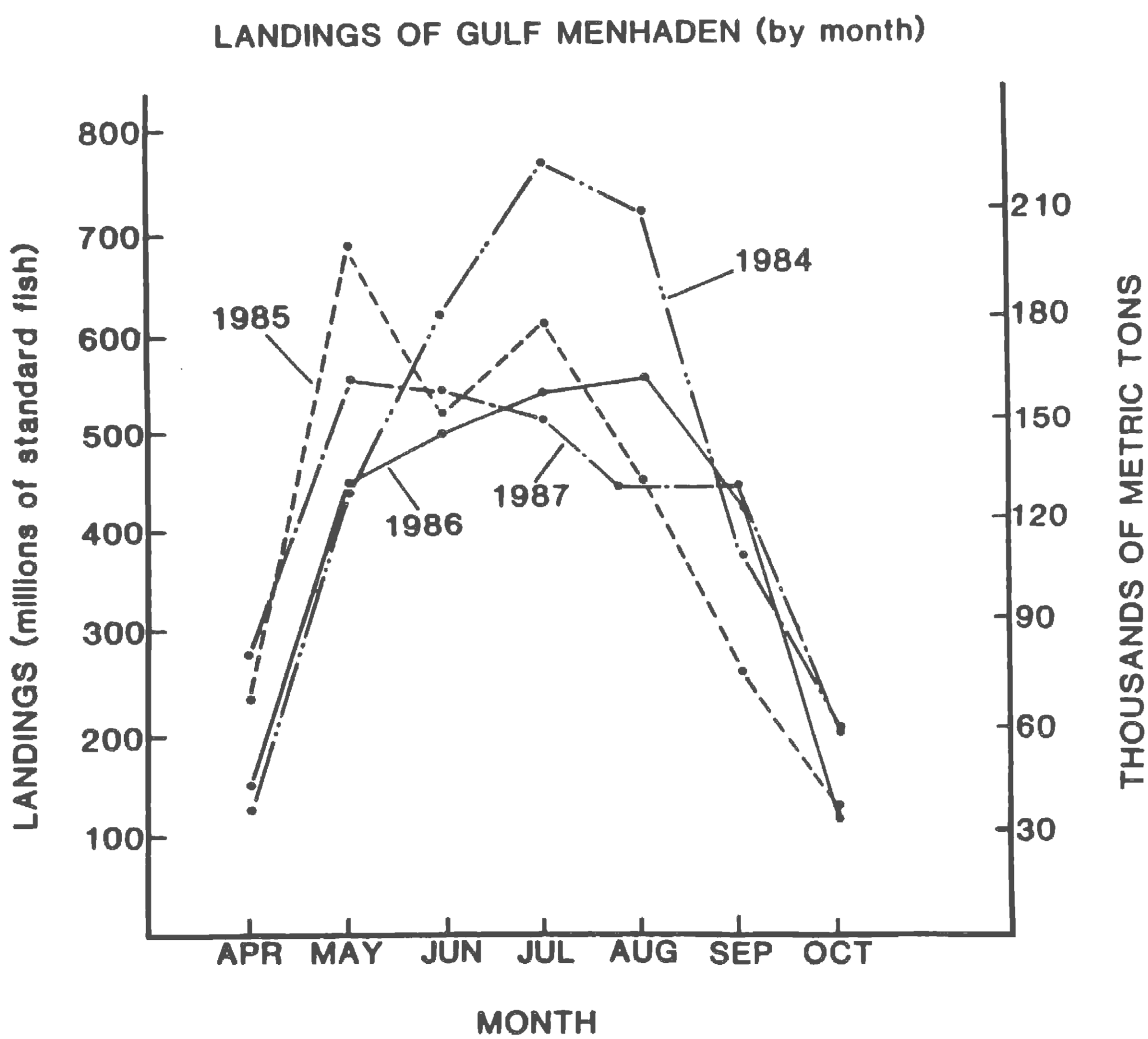


Figure 8.5. Landings of gulf menhaden by month.

9.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS

9.1 Domestic Harvesting Sector

The menhaden fishery is one of the United States' oldest and most valuable fisheries and is the largest in volume of landings. State and Federal agencies, serving as public trustees of all fishery resources, have the responsibility to establish management procedures that will insure optimum sustained use and viability of this important resource.

The menhaden industry originated about 1800 on the east coast of the United States. The industry expanded southward along the Atlantic coast and entered the Gulf of Mexico around 1900 in Florida and then westward. Native Indians and European immigrants along the Atlantic coast used menhaden for soil enrichment prior to the nineteenth century (Lee 1953; Whitehurst 1973). Menhaden are no longer used for fertilizer except for special culturing. Today menhaden are processed to produce fish meal, oil and solubles. Fish meal and solubles are used as an important component in animal feeds. Oil is used for producing shortening and margarine and in numerous manufacturing processes. The amount of menhaden consumed directly as food has been insignificant; however, recent developmental work suggests that it may be feasibly marketed as an intermediate or restructured form.

Chapoton (1970; 1972) reviewed the history and status of Gulf menhaden purse-seine fishery through 1970. Menhaden were landed on the west coast of Florida prior to 1900; however, records for that period are incomplete or unavailable. The first records of menhaden landings in the Gulf states were: Florida west coast in 1880; Alabama in 1902; Texas, 1918; Mississippi, 1939 and Louisiana, 1941 (Lyles 1967). Although they are taken from Alabama waters, no menhaden have been landed in that state since 1931. Landings in Florida and Texas have fluctuated considerably since 1948. Of the total menhaden landed in the Gulf States from 1948 through 1975, 70.1% were landed in Louisiana, 22.3% in Mississippi, 7.2% in Texas and 0.4% in Florida. The gulf menhaden industry has not landed fish in Florida since 1972 or in Texas since 1971. In 1975-87, 18% of total gulf landings were landed in Mississippi, 37% in East Louisiana and 45% in West Louisiana. The purse-seine fishing fleets and menhaden plants are concentrated in Louisiana and Mississippi. Total landings in the gulf have generally increased since 1948, exceeding 326 million pounds in 1950, 840 million pounds in 1960 and 1.2 billion pounds in 1970. Peak landings in excess of 2.2 billion pounds occurred in 1984 (Table 9.1).

Table 9.1. Quantity of menhaden landed by purse seines in the Gulf States from 1983 through 1987 (thousands of pounds).

	Louisiana				Gulf
Year	East	West	Total	Mississippi	Total
1983	703,611	967,428	1,671,039	364,084	2,035,123
1984	846,243	910,037	1,756,280	410,576	2,166,856
1985	556,956	970,450	1,527,406	415,109	1,942,515
1986	557,240	901,634	1,458,874	353,592	1,812,466
1987	613,741	976,926	1,590,667	380,799	1,971,466[a]

[a]preliminary estimate

The gulf menhaden purse-seine fishery has a significant influence on the economy of the area and is the single largest fishery in the United States. In 1986, a total of 2.4 billion pounds of menhaden were landed in the United States. Of this amount, 1.8 billion pounds (76% of the national total) were landed in the Gulf States. This represented 39% by weight of all species of fish and shellfish landed in the United States. The gulf menhaden fishery, currently composed of four harvesting and processing firms, is unusually stable in terms of firms entering and exiting. The gulf operators today are all well seasoned with broad experience throughout the fishery. Groups who have entered the gulf fishery without this experience, expertise and adequate capital have not generally been successful. Changes, however, have occurred in fleet size and numbers of operating plants, but even these changes have not been extreme (Table 9.2).

Table 9.2. Gulf menhaden purse-seine fishery, 1982-1987.

Year	Number Vessels	Number In Crew[1]	Number Vessel Weeks	Number Plants	Shore Based Personnel[1]
1982	82	1,312	2,068	11	851
1983	81	998	2,064	11	679
1984	81	1,118	2,032	11	629
1985	73	1,044	1,703	7	678
1986	72	1,008	1,810	8	714
1987	75	1,036	1,789[2]	8	732

[1] based on industry estimates
[2] preliminary estimate, November 27, 1987

Substantial differences exist in firm size from the largest to the smallest. Although market shares are not made public, it does not appear that the industry currently is undergoing any important change in relative shares, or that it has done so for a number of years. Year-to-year fluctuations occur in interfirm catch and hence market share, but none of the firms are undergoing a large-scale vessel expansion program. The locations of the various plants are shown in Figure 9.1.

The gulf menhaden fishery is a very stable industry measured by market structure, product exploitation levels and similar factors. Although recent prices for the products have been extremely low, member firms within the industry were sufficiently strong financially to continue to maintain an adequate harvesting fleet. All firms, however, may not always show a profit. In fact, earnings fluctuate widely because both gulf menhaden harvest levels and the markets for fish meal, oil and solubles fluctuate considerably from year-to-year.

Reasons for the relative stability of the industry are undoubtedly varied and complex, but would certainly include the high capital cost required of a new firm entering the industry. At current prices a modern menhaden vessel would cost in excess of two

LEGEND

Location Symbol	Company	Location Symbol	Company
1	Zapata Haynie Cameron, LA	5	Petrou Fisheries Empire, LA
2	Louisiana Menhaden Cameron, LA	6	Empire Menhaden Empire, LA
3	Zapata Haynie Abbeville, LA	7	Zapata Haynie Moss Point, MS
4	Zapata Haynie Dulac, LA	8	Standard Products Moss Point, MS

Figure 9.1. Locations of Gulf of Mexico menhaden plants.

million dollars. The vessel is of a specialized nature and not adaptable to other fisheries or even other waters. Gulf menhaden vessels are somewhat shallower in draft and have a flatter bottom than vessels commonly used in the Atlantic and in many other purse-seine fisheries in the world. Processing plants are also expensive. Depending upon such factors as plant size, cost of a well-located land site and equipment choices, a processing plant built today would probably cost in the range of 10 to 15 million dollars. It would take at least three vessels to supply one processing plant, and five or more vessels would be optimum. One spotter aircraft would be needed on a purchase or contract basis for every one to two menhaden vessels. The overall cost of new entry would probably be in the vicinity of 20 million dollars. In addition to this investment, there would also be the difficult start-up costs of obtaining qualified captains and crew, and developing a qualified management staff and sales force. A newly entered firm would have to be prepared for heavy losses, perhaps for a substantial period because of the extremely high initial capital costs and the time to develop qualified boat crews and management staff.

From the foregoing it can be seen that the economic structure of the gulf menhaden industry is unlike most fisheries in the United States. There are only a few firms, the capital costs are larger than commonly found in other fisheries, and the industry uses an advanced technology. Spotter aircraft, purse-seines, mechanized processing and other characteristics make the fishery somewhat atypical for the United States.

9.2 Labor

The labor used in the gulf menhaden industry presently does not fit the classic fisheries case; that is, of coming from an isolated fishing village with little or no employment except in the principal fishing occupation. All the gulf menhaden processing plants and hence also the home ports for the vessels are in areas where competing employment alternatives exist such as city associated or offshore oil industry employment. However, in the past available alternatives to employment in the menhaden fishery did not always exist.

Employment within the processing plants is fairly steady throughout the year for many workers. Approximately 50% of processing plant employment is year-round.

Vessel labor is almost entirely seasonal employment, but again the gulf menhaden industry is competing for labor with other employers. Captain-crew pay depends upon catch levels, with an incentive built in to work the entire season. Within the industry considerable competition exists for the more highly skilled captain and crew members, as this "human factor" is a large ingredient in vessel landings and corporate profitability.

From this general description of the menhaden labor market, it is clear that the sociological problems faced by some U.S. fisheries are not present in this fishery to a serious degree. Fishery management alternatives and optimum yield (OY) are not sharply limited by local labor employment traditions and/or employment of redundant fishing labor.

9.3 An Economic Profile

The task force subcommittee on gulf menhaden economics reviewed documents with intent to consider incorporating applicable portions in the Gulf of Mexico Menhaden Plan update. The reports, however, treat and summarize data from the combined Atlantic and Gulf of Mexico menhaden fisheries, thus the following is modified after these reports with appropriate qualifications. Unfortunately, the literature does not contain economic analyses based solely upon the gulf fishery.

9.3.1 Ex-Vessel Values

The processors own their vessels and market their products and, as such, the menhaden industry is vertically integrated. Since each company is using raw production landed by its own vessels, no true market price or ex-vessel price is established. The U.S.

Department of Commerce annually reports the ex-vessel value, but in view of the above, this value may be used to examine trends or compare relative values from year to year, but otherwise has limited usefulness. In 1982, the U.S. Department of Commerce placed the value of the ex-vessel catch of gulf menhaden at $72.7 million which represents approximately 3% of the total value of United States commercial landings (Hu, Whitaker and Kaltreider 1983).

9.3.2 Products

9.3.2.1 Reduction

U.S. Department of Commerce also annually publishes statistics concerning volume, value and price of the three menhaden products. These statistics do not separate Atlantic and Gulf of Mexico production value or price. Due to the difference in season, location of plants, and significant differential in production yields from the two coasts, a prorata proportioning based on landings to determine values for the Gulf of Mexico will lead to erroneous results. It should be carefully noted that production figures in some cases are actual and in some cases estimated. It should also be noted that production from a given year may be stored and sold at a later time and therefore price and value can be misleading.

Production trends for the three primary menhaden products were summarized and discussed by Hu, Whitaker and Kaltreider (1983). The tables were taken from their report and updated where possible.

Table 9.3 shows the production value and price of menhaden meal for the period 1960-1982. Production is measured in thousand short tons, and it may be noted from this table that the real price per ton undergoes large variations from year to year. This is due in large part to the variation in price of soybean meal.

Gulf menhaden is just one of the several species of fish used to produce fish meal in the U.S.; however, as can be seen in Table 9.4, U.S. Supply and Utilization of Fish Meal, menhaden supply the major share of the U.S. fish meal production. It may also be noted that in most recent years total domestic utilization has been far in excess of domestic production by the menhaden industry. Table 9.5 lists the U.S. volume, value and price of menhaden oil. It should be noted here that the real price per pound demonstrates considerable variation as does the real price of meal. The market factors influencing price are particularly complex in view of the fact that almost all menhaden oil is exported and is competing in the international marketplace (Table 9.6).

Menhaden solubles volume, value and price is listed for the period 1960-1980 (Table 9.7) and its supply (Table 9.8). These tables can be very misleading, since most producers add the material back to fish meal to be sold as "whole meal," rather than liquid solubles. Especially, the volumes as reported may be significantly different from the actual available production. If it were not for stringent water quality regulations, many processors, due to high energy costs, would not produce solubles.

9.3.2.2 Bait

Menhaden caught for bait are used principally in the crab and crayfish fisheries.

Table 9.3. U.S. volume, value, and price[1] of menhaden fish meal, 1960-1986.

Year	Production (in thousand tons)	Value (in million dollars)	Price (in dollars) Actual (per ton)	Real[2] (per ton)
1960	218.4	19.2	87.91	92.73
1961	247.6	25.9	104.60	110.69
1962	239.7	28.3	118.06	124.67
1963	182.4	22.3	122.26	129.37
1964	160.4	20.0	124.69	131.67
1965	176.0	25.9	147.16	152.50
1966	135.0	20.5	151.85	152.31
1967	119.1	19.2	161.21	161.21
1968	143.2	19.5	136.17	132.85
1969	159.5	27.0	169.28	158.95
1970	188.6	34.7	183.99	166.81
1971	221.0	35.0	158.37	139.04
1972	193.6	35.3	182.33	152.84
1973	188.8	84.9	449.68	333.84
1974	203.9	60.4	296.22	185.14
1975	191.4	46.0	240.33	137.49
1976	212.6	72.7	341.96	186.86
1977	193.3	71.8	371.44	191.27
1978	276.5	96.6	349.37	166.92
1979	280.8	103.6	368.95	156.60
1980	271.2	102.1	376.47	140.11
1981	230.8	89.4	387.35	132.02
1982	301.9	100.0	331.24	110.67
1983	315.9	111.6	353.28	116.55
1984	314.9	97.9	310.89	100.19
1985	307.5	73.4	238.70	77.32
1986	296.3	73.1	246.71	82.29

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service.

[1] FOB processing plant

[2] deflated by Producer Price Index

Table 9.4. United States supply and utilization of fish meal, 1960-1986 (in thousand short tons).

Year	Production[1] Menhaden	Tuna and Mackerel	Total[2]	Imports	Total Supply	Exports[3]	Total Domestic Utilization
1960	218.4	26.5	281.4	131.6	413.0	--	--
1961	247.6	21.2	300.5	217.8	518.3	--	--
1962	239.7	26.6	301.0	252.3	553.3	--	--
1963	182.4	27.0	248.0	376.3	624.3	--	--
1964	160.4	21.1	225.1	439.1	664.2	--	--
1965	176.0	25.4	242.3	270.7	513.0	--	--
1966	135.0	25.3	212.4	447.8	660.2	--	--
1967	119.1	25.5	201.4	651.5	852.9	--	--
1968	143.2	28.8	227.0	855.3	1082.3	--	--
1969	159.5	26.9	224.1	358.4	582.5	--	--
1970	188.6	26.7	257.0	251.5	508.5	4.7	503.8
1971	221.0	29.3	282.9	283.2	566.1	10.1	556.0
1972	193.6	43.2	274.1	392.0	666.1	10.4	655.7
1973	188.8	43.6	279.1	68.5	347.6	36.7	310.9
1974	203.9	48.2	291.7	68.3	360.0	55.5	304.5
1975	191.4	37.2	279.2	118.4	397.6	11.8	385.8
1976	212.6	40.1	299.0	140.4	439.4	33.1	406.3
1977	193.3	39.2	273.0	81.5	354.5	36.1	318.4
1978	276.5	50.6	353.7	43.9	397.6	50.7	346.9
1979	280.8	47.4	363.3	89.6	452.9	15.7	437.2
1980	271.2	47.0	355.3	49.5	404.8	85.3	319.5
1981	230.8	47.2	310.1	59.4	369.5	47.0	322.5
1982	301.9	35.4	364.2	84.3	448.5	17.9	430.6
1983	315.9	41.7	373.7	67.9	441.6	77.4	364.2
1984	314.9	37.1	368.2	83.4	451.6	20.2	431.4
1985	307.5	34.5	352.3	255.3	607.6	34.6	573.0
1986	296.3	37.1	339.7	185.3	525.0	38.5	486.5

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service

[1] excludes meal made from shellfish

[2] total includes amounts from other categories not detailed here

[3] exports not available until 1970

Table 9.5. United States volume, value, and price[1] of menhaden oil, 1960-1986.

Year	Production (in thousand tons)	Value (in million dollars)	Price (in dollars) Actual (per pound)	Real[2] (per pound)
1960	183.4	11.6	0.06	0.07
1961	235.2	12.9	0.05	0.06
1962	232.6	10.1	0.04	0.05
1963	167.6	9.9	0.06	0.06
1964	157.7	11.7	0.07	0.08
1965	175.2	13.2	0.08	0.08
1966	144.2	11.0	0.08	0.08
1967	101.4	4.7	0.05	0.05
1968	152.0	6.2	0.04	0.04
1969	149.2	8.3	0.06	0.05
1970	186.3	16.8	0.09	0.08
1971	244.0	19.2	0.08	0.07
1972	167.0	11.6	0.07	0.06
1973	200.5	23.1	0.12	0.09
1974	217.0	46.1	0.21	0.13
1975	213.3	29.2	0.14	0.08
1976	186.4	28.9	0.16	0.08
1977	116.1	25.1	0.22	0.11
1978	284.0	58.7	0.21	0.10
1979	251.3	51.6	0.21	0.09
1980	291.4	54.2	0.19	0.07
1981	170.0	30.8	0.18	0.06
1982	338.1	52.2	0.15	0.05
1983	385.8	64.3	0.17	0.05
1984	365.9	60.0	0.16	0.05
1985	278.4	41.2	0.15	0.05
1986	332.0	43.3	0.13	0.04

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service.

[1] FOB processing plant

[2] deflated by Producer Price Index

Table 9.6. United States supply and utilization of fish oil, 1960-1986 (in million pounds).

Year	Production[1] Menhaden	Tuna/ Mackerel	Other	Total	Imports[2]	Total Supplies[3]	Exports[4]	U.S. Industry Utilization[2]
1960	183.4	3.8	18.4	205.6	8.9	214.5	143.7	56.8
1961	235.2	5.7	13.7	254.6	8.4	263.0	122.5	64.8
1962	232.6	5.0	9.9	247.5	10.8	258.3	123.0	62.9
1963	167.6	5.9	10.2	183.7	8.6	192.3	262.3	52.1
1964	157.7	4.8	14.5	177.0	11.8	188.8	151.5	47.7
1965	175.2	4.8	12.8	192.8	6.0	198.8	103.8	44.5
1966	144.2	4.1	14.4	162.7	12.7	175.4	77.3	38.8
1967	101.4	5.2	13.3	119.9	7.0	126.9	76.8	35.8
1968	152.0	4.5	15.2	171.7	5.9	177.6	65.1	30.0
1969	149.2	4.2	14.6	168.0	4.2	172.2	196.1	34.1
1970	186.3	3.5	16.3	206.1	5.5	211.6	158.8	31.4
1971	244.0	4.9	16.1	265.0	7.5	272.5	229.9	26.5
1972	167.0	5.0	16.4	188.4	9.5	197.9	193.2	29.8
1973	200.5	7.4	16.7	224.6	6.7	231.3	247.8	26.5
1974	217.0	5.8	14.1	236.9	12.4	249.3	199.1	35.0
1975	213.3	6.4	25.9	245.6	11.3	256.9	191.8	36.8
1976	186.4	6.3	11.8	204.5	20.9	225.4	179.2	38.4
1977	116.1	3.8	13.2	133.1	13.7	146.8	90.6	35.4
1978	284.0	4.4	7.9	296.3	16.0	312.3	222.0	33.8
1979	251.3	5.4	11.2	267.9	14.5	282.4	198.5	32.3
1980	291.4	4.1	17.0	312.5	21.4	333.9	284.0	21.9
1981	170.0	4.5	9.8	184.3	18.3	202.6	238.3	19.6
1982	338.1	3.1	6.4	347.6	12.7	360.3	202.3	N/A
1983	385.8	2.5	11.0	399.3	15.3	414.6	404.1	N/A
1984	365.9	1.7	5.2	372.8	13.4	386.2	399.4	N/A
1985	278.4	0.0	6.7	285.1	17.3	302.4	279.1	N/A
1986	332.0	0.0	4.8	336.8	19.2	356.0	192.2	N/A

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service.

[1] excludes whale and sperm oils

[2] excludes liver, whale and sperm oils

[3] production plus imports

[4] does not include exports of foreign merchandise

Table 9.7. Value[1] and price[2] of menhaden solubles and price ratio of menhaden meal and menhaden solubles, 1960-1986.

Year	Value (in million dollars)	Price (in dollars) Actual (per short ton)	Price (in dollars) Real[3] (per short ton)	Meal to Solubles (price ratio)
1960	2.68	40.66	42.89	2.16
1961	3.57	48.74	51.58	2.15
1962	4.54	53.25	56.23	2.22
1963	4.70	62.88	66.54	1.94
1964	4.17	60.69	64.08	2.05
1965	4.58	62.58	64.85	2.35
1966	3.76	61.80	61.98	2.46
1967	3.18	61.41	61.41	2.63
1968	2.75	51.63	50.37	2.64
1969	3.19	50.47	47.39	3.35
1970	3.74	52.06	47.20	3.53
1971	4.15	45.38	39.84	3.49
1972	4.44	42.62	35.72	4.28
1973	11.73	112.33	83.40	4.00
1974	8.80	85.50	53.43	3.46
1975	5.73	68.49	39.18	3.51
1976	10.21	107.11	58.53	3.19
1977	9.97	114.02	58.71	3.26
1978	18.12	137.25	65.58	2.55
1979	11.72	111.75	47.43	3.30
1980	10.76	108.27	40.29	3.48
1981	11.60	116.33	39.65	3.33
1982	13.50	104.43	34.89	3.17
1983	12.58	99.05	32.68	3.57
1984	13.99	121.97	39.31	2.55
1985	18.96	117.38	38.02	2.03
1986	11.56	118.42	39.50	2.08

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service.

[1]Value of menhaden solubles was calculated by multiplying the production of menhaden solubles by the actual price of fish solubles. This assumes that the price of all fish solubles combined was also the price of menhaden solubles.

[2]FOB processing plant

[3]deflated by Producer Price Index

Table 9.8. United States supply of fish solubles, 1960-1986 (in thousand short tons).

Year	Production			Imports[1]	Supplies
	Menhaden	Other	Total		
1960	65.8	33.1	98.9	3.2	102.1
1961	73.8	38.9	112.2	6.7	118.9
1962	85.2	39.4	124.6	6.3	130.9
1963	74.8	32.6	107.4	7.1	114.5
1964	68.7	24.6	93.3	4.5	97.8
1965	73.2	21.7	94.9	5.1	100.0
1966	60.8	22.7	83.5	4.3	87.8
1967	51.8	22.9	74.7	3.7	78.4
1968	53.2	18.6	71.8	1.8	73.6
1969	63.3	18.4	81.7	0.2	81.9
1970	71.9	23.1	95.0	0.5	95.5
1971	91.5	19.7	111.2	0.1	111.3
1972	104.1	30.3	134.4	0.1	134.5
1973	104.4	33.1	137.5	0.3	137.8
1974	102.9	34.3	137.2	-	137.2
1975	83.6	44.2	127.8	0.1	127.9
1976	95.3	37.8	133.1	1.2	134.3
1977	87.4	34.9	122.3	0.8	123.1
1978	132.0	30.5	162.5	-	162.5
1979	104.9	30.0	134.9	-	134.9
1980	99.4	34.3	133.7	0	133.7
1981	99.7	28.9	128.6	-	128.6
1982	129.3	23.2	152.5	-	158.5
1983	127.0	31.5	158.5	-	126.0
1984	114.7	11.3	126.0	-	126.0
1985[2]	-	-	161.5	-	161.5
1986	-	-	97.6	-	97.6

Source: Fisheries of the U.S., Annual Summaries, National Marine Fisheries Service.

[1] imports not reported separately after 1977

[2] Soluble production of menhaden not reported separately after 1984.

9.3.3 Cost

Vertical integration of the industry also complicates the examination of processing costs and profitability. Processing costs are generally divided into two categories: operating costs and fixed costs. Operating costs vary with the amount of output, while fixed costs reflect the vessel's and plant's overhead. Raw materials (catching), labor, and energy costs comprise the bulk of operating costs. Individual plant costs for raw materials will vary depending on the amount and yield of the product, seasonal and geographical variations, and the location of the plant relative to where the fish are caught. It is estimated that the cost of landing menhaden as raw material to the plant is about two-thirds of the total cost of the processed products. Of the remaining one-third, labor and energy are the most significant contributors.

Fixed costs are commonly referred to as overhead and are incurred to maintain the plant irrespective of actual production levels. The seasonal operation of the gulf menhaden processor causes fixed costs to be quite high. Also, plants must be capable of handling large variations in catches from day to day, and, thus, operate below full capacity. The combination of high fixed costs and under-utilization of asset capacity causes a high fixed cost per unit of product. Especially in the last ten years, the increase in processing costs, mostly energy related, has been significant, while the real price for the product has dropped. This has placed the gulf menhaden industry in a cost-price squeeze.

10.0 DESCRIPTION OF THE BUSINESS, MARKETS, AND ORGANIZATIONS ASSOCIATED WITH THE FISHERY

10.1 Marketing

Until the end of World War II, all fish products were sold through brokers. At that time, there were few customers for fish meal, and they were large companies consuming large quantities of fish meal each year. The feed industry, particularly the poultry feed industry, expanded rapidly in the decade following World War II. This expansion created many new but smaller feed companies throughout the Midwest as well as along the Atlantic and Gulf Coasts. Menhaden companies observed that they were using the same brokers to distribute their products to a rapidly increasing number of customers and reasoned that to fully exploit the expanding market they should have their own sales staff. Today each menhaden company has its own sales department, and each sells directly to consumers or to brokers and jobbers who in turn sell to the feed industry.

Today few feed mills carry more than several days supply of fish meal (or other bulk ingredients) and are dependent on the supplier and the railroads or trucking companies to deliver the material to their plant as needed. Thus most fish meal inventory is held in company warehouses with their sales departments directing the sale and shipment of the product. The shipments are in units of truckloads (25 tons), or rail carloads (60 tons), or barges (1400 tons). Sales contracts may be executed for a single truckload for immediate delivery or they may be for hundreds or several thousands of tons for delivery over an extended period of time. The price may be fixed at the time of sale, or the contract may provide for the buyer and seller to agree on the price on the date of shipment, or periodically throughout the life of the contract.

Fish oil and fish solubles are sold in multiple units of truckload, rail carload or bargeload quantities. A producer may sell the entire season's production of fish oil for a plant in two or three individual sales. Fish oil that is exported is transported in large quantities by ship. Bait is used in the domestic crab and crayfish fisheries.

10.2 Trade Organizations

The principal trade organization for the gulf menhaden producing companies is the National Fish Meal and Oil Association (NFMOA) which is a division of the National Fisheries Institute (NFI). All major menhaden fish meal producers belong to this organization. Most fish meal brokers and jobbers that trade with menhaden producing companies also are members of the NFMOA and the American Feed Manufacturers Associations, as well a many regional feed producers groups.

11.0 SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

No known social or cultural research effort has been performed in the gulf menhaden fishery.

Reference is made to the following:

1. "The Menhaden Fishery of the Gulf of Mexico United States: A Regional Management Plan," 1983 Revision, identifies the need for developing sociological data for management considerations.

2. This document--Section 16, specifies the need for research to be conducted in this area.

3. This document--Section 9, describes labor patterns in the gulf menhaden industry.

4. Fishery Management Plan for Atlantic Menhaden, August 1981, pages 93-98, describes a study conducted in the Atlantic menhaden fishery.

12.0 DETERMINATION OF OPTIMUM YIELD

12.1 Goal and Objectives

12.1.1 Goal

The goal of this plan is a gulf menhaden strategy that will allow an annual maximum harvest which protects the stock from overfishing on a continuing basis.

12.1.2 Objectives

Objectives of the strategy include:

a. To determine, maintain and improve the biologically sustainable yield of Gulf of Mexico menhaden stock based on best available scientific data.
b. To monitor and improve or establish useful estimates of MSY and OY for Gulf of Mexico menhaden stock.
c. To update and evaluate the current data base available for management.

12.2 Analysis of Beneficial and Adverse Impacts of Potential Options

12.2.1 Foreign Catch

It has been generally agreed that the resource is being fully utilized by the U.S. fishery and there is no history of foreign fishing for gulf menhaden (Table 12.1). Foreign allocations could only be considered after a request for a Governing International Fishery Agreement (GIFA) by a foreign country. Approval would require that a surplus existed which could not be harvested by the domestic industry. The industry can and does harvest the total amount available and no surplus exist; therefore no amount could be made for foreign harvest. Further, no foreign country has requested a GIFA and application from the State Department to engage in menhaden fishery. Therefore, identified management options need only involve domestic U.S. fishing.

12.2.2 Identified Management (Regulatory) Options, Pros and Cons

12.2.2.1 No Action

The fishery would be managed under existing rules and regulations with flexibility as provided for in the fishery management system and structure.

The existing management authority (Section 7) was examined in 1980 and found to be (Condrey et al. 1980):

a. Rational in that the menhaden resource is of national importance and of a finite, though renewable nature,
b. Supported by a proposed bio-socioeconomic data base which is sufficient to provide management with the information it needs to monitor the resource and evaluate alternative management decisions,
c. Broad enough to encompass most of the resource, and
d. Flexible.

Table 12.1. United States and foreign catch from Gulf of Mexico menhaden resources from 1965 through 1987 (in metric tons).

Year	U.S.	Foreign
1965	461,200	0
1966	357,600	0
1967	316,100	0
1968	371,900	0
1969	521,500	0
1970	545,900	0
1971	728,500	0
1972	501,900	0
1973	486,400	0
1974	578,400	0
1975	542,600	0
1976	561,200	0
1977	447,100	0
1978	820,000	0
1979	777,900	0
1980	701,300	0
1981	552,600	0
1982	853,900	0
1984	982,800	0
1985	881,100	0
1986	822,100	0
1987	894,200	0

The management scheme was found deficient in only one area -- that of suggesting guidelines for establishing when MSY has been exceeded. Condrey et al. (1980) proposed that until a more meaningful model could be applied a generalized stock production model (Pella and Tomlinson 1969; Fox 1975) using catch-effort data be applied annually to determine whether MSY had been exceeded. They then identified and examined the pros and cons of alternative management options which could be applied to reduce the catch of a menhaden stock to a seasonally determined acceptable catch if it was found that the stock's MSY had been exceeded.

A more meaningful population dynamics approach was developed in 1982 (Nelson and Ahrenholz 1986) and an updated analysis (Vaughan 1987) has been made a part of this plan (Section 5). The menhaden population appears to be healthy, highly productive and capable of supporting yearly harvests exceeding 800,000 metric tons with considerable variation (Section 5.4.1). Stocks are being harvested at or near MSY. Therefore consideration of alternative management options which might be used to reduce the catch of a menhaden stock to a seasonally acceptable catch is not indicated at this time. Continued monitoring and flexibility of the system provides for such consideration if indicated. Specific management measures are outlined in Section 14.

12.3 Optimum Yield

12.3.1 Specification

Optimum Yield = Maximum Sustainable Yield

12.3.2 Summary of Information Used in Specifying OY

Information on the fishery economics and social and cultural framework of domestic fishermen and their communities were reviewed in Sections 9, 10 and 11. There is no recreational fishery for menhaden. There is no indication that OY should be altered to provide for a different long term yield than provided for by MSY.

13.0 MANAGEMENT MEASURES - GENERAL REQUIREMENTS

13.1 General

The generally acknowledged purpose for a fishery management plan and the subsequent regulations promulgated to implement the plan are to provide effective and responsive action in a manner consistent with the best interests of the nation. These actions must consider several factors, among them; conservation of the resource and economic stability of the fishery; economics; social interactions; the habitat and others. These factors are contradictory and conflicting in many instances; however, in the plan development process they all must be considered and weighed if sound integration of those concepts are to be achieved.

13.2 National Standards

In the plan development process and the resulting document the Menhaden Task Force was guided by the National Standards set forth in Title III of P.L. 94-265 (the Magnuson Fishery Conservation and Management Act). This group is highly qualified to handle the technical aspects encountered developing the Menhaden Management Plan. The National Standards as referenced are:

1. Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery.

2. Conservation and management measures shall be based upon the best scientific information available.

3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

4. Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be: (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

5. Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources except that no such measure shall have economic allocation as its sole purpose.

6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

14.0 SPECIFIC MANAGEMENT MEASURES TO ATTAIN MANAGEMENT OBJECTIVES

14.1 Outline of the Gulf Menhaden Management Measures

14.1.1 Goal

A gulf menhaden management strategy that will allow an annual maximum harvest which protects the stock from overfishing on a continuing basis.

14.1.2 Objectives

a. To determine, maintain and improve the biologically sustainable yield of Gulf of Mexico menhaden stock based on best available scientific data.

b. To monitor and improve established estimates of MSY and OY from Gulf of Mexico menhaden stock.

c. To update and evaluate current data base available for management.

14.2 Institutional Structure and Functions

The structures and functions are as outlined in Sections 7.1 and 17.

14.3 Permits and Fees

Licenses are required by all Gulf States (see Table 7.1 and Section 7.4 for details). Fees are established by statute and are not considered to be management measures.

14.4 Time and Area Restriction

14.4.1 Time Restrictions

Time restrictions (fishing season) are the same (third Monday in April through Friday following second Tuesday in October) for all gulf menhaden fishing areas with the exception of Florida which has no set season. Louisiana prohibits the landing of menhaden during the closed season. Mississippi prohibits closing of the season before the second Tuesday in October.

14.4.2 Area Restrictions

Each of the Gulf States has imposed restrictions on menhaden fishing in specified areas (Section 7.4 and Figures 7.3 - 7.7).

14.5 Catch Limitations

14.5.1 Total Allowable Level of Foreign Fishing (TALFF)

Since the U.S. fishery is capable of fully utilizing the resource, there is no surplus available for foreign allocation.

14.5.2 Domestic Fishery Catch Limitations

All Gulf States except Mississippi have limited the allowable catch of species other than menhaden in menhaden purse seines (Section 7.4 and Table 7.4). Limitations on the catch of menhaden are not required at this time. Continued monitoring of the stock is essential.

14.6 Type of Vessels and Gear

14.6.1 Vessels

There are no legal restrictions on the type of vessels than can be used in the gulf menhaden fishery. The fishery for reduction uses large purse seiners (see Section 8 for details). The smaller but growing bait fishery uses smaller purse seiners.

14.6.2 Gear

Alabama and Texas set minimum mesh size for purse seines at 3/4" bar.

14.7 State, Local and Other Laws and Policies

A legal matrix, incorporating all of the state laws pertaining to the Gulf of Mexico menhaden fishery, is presented in Section 7.4. The matrix includes information on licensing, closed seasons and areas and penalties for violations.

14.8 Institutional Arrangements

No change in institutional arrangements as described in Section 7.1 is contemplated.

14.9 Limited Entry Systems

No limited entry systems are currently existent in the Gulf of Mexico menhaden purse seine fishery. The number of processing plants and vessels in the fishery has remained relatively stable for many years.

Legal ramifications affecting limited entry systems have been explored by Knight and Jackson (1973), Knight and Lambert (1975), Schoenbaum and Wascom (1981), Condrey, et al. (1980). Schoebaum stated:

> It would appear that, of the management options being considered for the Gulf menhaden fishery, allocating stock quotas or licenses among existing companies, plants or boats would present the greatest difficulty in complying with the national standards. Quota or license allocation is permissible under these standards but the allocation should be (1) fair and equitable, (2) reasonably calculated to promote conservation, and (3) carried out in such a manner that no entity acquires an excessive share. Furthermore, the opportunity for new participants to enter the fishery should be provided in some manner....

Condrey, et al. (1980), after noting that the study was not generated over fear that gulf menhaden are spawner-recruit overfished, conducted a simulated implementation of the menhaden management system. They found that among the alternative management options that could be applied to limit effort if MSY should be exceeded only the quota options satisfied criteria requiring that the harvest be reduced to a seasonably limited allowable catch (AC) and that potential socioeconomic impacts not be severe. They noted that:

> Although the fisheries laws of Alabama, Florida, and Mississippi do not give their fishery agencies express authority to implement any of the Quota Options (Option 1A-1D in Table 2), these states have given their fishery agencies broad statutory authority to regulate with respect to the conservation, management, development, and protection of their fishery resources which would allow these state agencies to implement any of the Quota Options without any further enabling legislation. The implementation of these options would not require changes in the existing laws of Alabama and Florida. With respect to Mississippi, the only statutory provision that would be necessary to change is the current provision of Mississippi law that requires the Mississippi menhaden season to end no sooner than the second Tuesday in October. Since the Quota Options require the menhaden season to end at sunset on the day the seasonally determined Acceptable Catch is reached, this provision of Mississippi law would need to be repealed.
>
> There are also no provisions of the fishery laws of Louisiana and Texas that give their fishery agencies express authority to implement any of the Quota Options. These states have not given their fishery agencies the broad statutory authority to regulate that has been given to the fishery agencies in Alabama, Florida, and Mississippi. Consequently, legislation empowering the Louisiana and Texas fishery agencies to implement any of the Quota Options would have to be enacted by the two states. In addition, if Option 1C [stock quota -- allocation of AC among existing companies] is chosen for implementation, the Texas statutory provision governing the licensing of new, additional menhaden plants, would need to be repealed since that option deals with a quota allocation among existing menhaden plants and thus does not provide for additional plants.

Those constraints would apply to any limited entry system.

14.10 Habitat Conservation, Protection and Restoration

Habitat conservation, protection and restoration are essential to accomplishment of the goals and objectives of this plan. Each state has statutes, regulations and ongoing programs directed toward environmental enhancement favorable to menhaden habitat. The Menhaden Advisory Committee monitors proposed changes in menhaden habitat and, where necessary, recommend specific action.

15.0 GULF MENHADEN DATA NEEDED FOR RESOURCE MANAGEMENT

15.1 Needs

Management of the gulf menhaden resource will require long-term continuation of several on-going research programs and special projects of shorter duration. Research projects needed to support the gulf menhaden program are listed with priority designation in Section 16. Specific fishery related data should be acquired by National Marine Fisheries Service (NMFS), state agencies, and/or universities for accessing appropriate data bank files in a form that will not violate confidentiality requirements. Data presently available through NMFS Southeast Fisheries Center at its Beaufort Laboratory, include daily landings records, fleet composition data, captain's daily fishing reports, sampling for age and size of menhaden and collection of recovered tags in reduction plants. Existing data collecting efforts must be continued and, as necessary, expanded to provide data to:

a. Obtain age, size, catch and effort data from the gulf menhaden purse-seine fishery.

b. Evaluate mark-recovery studies of juvenile gulf menhaden to determine area of origin of stock, mortality rates, and recruitment patterns.

c. Continue studies and data acquisition to develop a methodology to determine year class strength of gulf menhaden prior to recruitment.

d. Identify temporal and spatial boundaries of the gulf menhaden stock.

e. Obtain socio-economic data on the fishery and end products.

f. Identify and quantify the incidental by-catch of gulf menhaden by gear and fishery.

g. Complete understanding of the life history of gulf menhaden.

h. Maintain current information on the regulations governing the gulf menhaden purse-seine fishery and its products.

15.2 Captain's Daily Fishing Report

The captain's daily fishing report (CDFR) project is a joint industry, state, and Federal undertaking. Data obtained from these reports will provide a new source of information about the fishing process and the gulf menhaden resources. The information requested will provide new and otherwise unavailable data. This information will be useful to help guide the industry, for biological analyses and assessment of the resource, and for state use where appropriate.

Several purposes for the collection of this data exist, depending on the different users in industry, and in state and Federal agencies. The information obtained permits time-dependent analyses on fishing effort and other approaches at improving estimates of effective fishing effort. Problems associated with sampling for mean weight and age class abundances also can be investigated with this data. Furthermore, summaries by vessel or by plant will provide useful information to industry for improving the operation of their vessels and facilities.

An example of the CDFR is shown in Figure 15.1. This report is completed for each fishing day (generally Monday through Friday) during the fishing season (mid-April through mid-October). Blocks 1 through 7 provide information about the vessel (1), plant out of which the vessel operates (2), date the sets were made (3), date and time the vessel left the dock or anchorage prior to the sets (5), reasons for not leaving dock (6), or reasons for not making any sets (7). Additional information for each set is given in blocks 8 through 14. This information, in addition to uniquely identifying each set (8), contains the time of day each set began and ended (9), the estimated number of standard fish per set (10), a numeric code for spotter planes when a set is made with spotter plan assistance (11), set location based on shoreline landmarks (12), distance and direction to shore (13), and a code for weather conditions (14). Actual pumpout at trip end is recorded in block 16 and date and time of returning to port is requested for block 17. A summary of CDFRs received at the Beaufort Laboratory is presented in Table 15.1.

CAPTAIN'S DAILY FISHING REPORT

NAME OF VESSEL 1	PLANT 2	DATE OF SETS 3	4

LEFT DOCK 5 ANCHORAGE	IF DID NOT LEAVE DOCK (CHECK ONE) 6	IF NO SETS WERE MADE (CHECK ONE) 7
DATE	☐ WEATHER UNFIT FOR FISHING ☐ UNLOADING	☐ ROUGH SEAS ☐ OTHER_____
	☐ LACKING SUFFICIENT CREW ☐ RADIO	☐ FOGGY
TIME	☐ MECHANICAL ☐ OTHER_____	☐ NO FISH SHOWING
: ☐AM ☐PM	☐ NET	☐ NO PLANES
		☐ CHANGING LOCATION

8 SET NO.	9 TIME START	END	10 FISH (000)	11 PLANE NO.	12 LOCATION		13 MILES AND DIRECTION TO SHORE		14 WEATHER CONDITIONS AND REMARKS	15
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

16	REMARKS & COMMENTS 17
	DATE/TIME RETURN TO DOCK: _____ CAPTAIN'S SIGNATURE 18

This form is required by State Law

Figure 15.1. Captain's Daily Fishing Report.

Table 15.1. Captain's Daily Fishing Reports from gulf menhaden purse-seine reduction fishery on file at Southeast Fisheries Center (Beaufort Laboratory) by port, 1979-1987.

	Port[1]					
Year	MP	E	D/MC	IC	C	Total
1979	1690	1520	1696	494	1936	7336
1980	1762	1511	1871	606	2279	8029
1981	1717	1675	1832	518	2526	8268
1982	1836	1560	2034	580	2541	8551
1983	2021	1782	2099	849	3059	9810
1984	1660	1795	2075	996	3224	9750
1985	1525	765	1058	1090	2521	6959
1986	1650	1550	1187	1200	2372	7959
1987	1789	1403	1283	1160	3033	8668

[1] MP = Moss Point, MS (3 plants until 1984, then 2 plants)
E = Empire, LA (2 plants except 1 plant during 1985)
D/MC = Dulac and Morgan City, LA (2 plants until 1985, then 1 plant)
IC = Intracoastal City, LA (1 plant throughout)
C = Cameron, LA (3 plants until 1985, then 2 plants)

16.0 RESEARCH PROJECTS TO SUPPORT THE GULF MENHADEN PROGRAM

Table 16.1. Research Projects.

TYPE OF ACTION	FUNCTION OF TASK	STATUS		
		ONGOING	IMPROVED	NEED
Biological	see 1 in list	X	X	
Biological	see 2 in list	X		
Biological	see 3 in list	X	X	
Biological	see 4 in list	X	X	
Biological	see 5 in list	X	X	
Biological	see 6 in list	X	X	
Biological	see 7 in list			X
Biological	see 8 in list			X
Biological	see 9 in list		X	
Economical	see 10 in list			X
Economical	see 11 in list			X
Sociological	see 12 in list			X
Sociological	see 13 in list			X

16.1 Research Priority Needed

16.1.1 Biological

1. Monitoring of harvest.

   Harvest from the directed and non-directed fishery should be monitored.

2. Monitor effects of the fishery on the Gulf menhaden stock.

   The gulf menhaden resource is a large, valuable, and dynamic resource and one which has supported a catch of 894,000 metric tons in 1987. The resources's well-being and future productivity requires that harvest levels by the various users be monitored so that man's activity does not impair the stock's ability to continue at a high level and to define at what level the resource can sustain or be increased to.

3. Annual predictions of gulf menhaden harvest levels.

   Annual harvest predictions are presently made by the National Marine Fisheries Service (NMFS) since 1973, based on the historical relationship between catch and effort. The Louisiana Department of Wildlife and Fisheries (LDWF), based on juvenile abundance and environmental conditions has predicted the catch-per-effort (CPE) of age 1 fish in 1982 and 1983. These projections should be continued. In addition, research should be undertaken to improve the present methods of harvest forecasting.

4. The effect of selected environmental factors on gulf menhaden larval growth, mortality, abundance, and distribution.

   Environmental conditions associated with various recruitment levels of age 1 gulf menhaden have been identified by Guillory, et al. (1983); however, the responses of larvae to different levels of environmental factors has not been adequately quantified for gulf menhaden. This information should be gathered from laboratory and field experiments.

5. Development of a new catch-per-unit effort index.

   Data from the vessel trip reports and other sources should be analyzed to determine if there is a better catch-per unit effort index.

6. Analysis of vessel catch records.

   Detailed location data concerning menhaden catches is available. The NMFS should continue to gather trip reports from the menhaden industry and analyze the data as effort and funds permit.

7. Determination of gulf menhaden year-class composition and distribution beyond the currently exploited fishing ground.

   Information on the gulf menhaden east, west and south of the traditional purse-seine fishing grounds is scanty.

8. Determination of gulf menhaden stock composition.

   The presence of separate gulf menhaden stocks east and west of the Mississippi River Delta has not been verified or disproved. If separate stocks do exist, different management strategies may have to be developed for each stock.

9. Continue development of a model to simulate the gulf menhaden fishery along with its socio-economic components for subsequent evaluation of fishing strategies.

   A reliable model that simulates the gulf menhaden resource could assist state and industry managers in making policy decisions and carrying out a plan to manage the resource wisely and for maximum benefit to all users and the Nation.

16.1.2 Economical

10 Determination of gulf menhaden Economic Sustainable Yield (ESY).

   Available data are inadequate for determining gulf menhaden ESY.

11. Determine the economic basis and values of the fishery and its products and of the labor force, and the impact of the fishery on the market place.

16.1.3 Sociological

12. Development of an adequate sociological data base.

    The management of any fishery must be based, in part, on adequate knowledge of the preference patterns, traditions, and life styles of all the people involved in the fishery.

13. Determine the extent and impact of regulations governing the fishery and factors affecting the use and distribution of its end products.

16.2 Ongoing Economic Evaluations

In the menhaden industry, improvements in techniques will increase the efficiency of operations, reducing costs, and thus enhancing continuing economic gains, which is a prime function of any profit-seeking firm. More important, it will enhance the number one objective of industry--survival.

To support the above objectives, the following tasks are cited for consideration by the industry, with technical support by the NMFS:

1. To conserve energy and increase utilization of boats and crews;
2. To reduce fish spotting costs;
3. To improve vessel unloading system;
4. To improve purse boat safety;
5. To develop more economic harvesting gear and fishing methods;
6. To evaluate menhaden purse seine efficiency and to conduct an engineering study of purse seines.

17.0 REVIEW AND MONITORING OF THE PLAN

17.1 Review

The Menhaden Advisory Committee in consort with the Gulf State-Federal Fisheries Management Board and Gulf States Marine Fisheries Commission (Section 7 and Appendices B and C) will annually review the status of the stock, condition of the fishery and habitat, and effectiveness of management regulations and research efforts. Results of this review will be presented to the management authorities in the gulf.

17.2 Monitoring

Gulf States Marine Fisheries Commission, National Marine Fisheries Service, states and universities should document their efforts at plan implementation and will review these with the Menhaden Advisory Committee as required.

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19.0 **APPENDIX**

19.1 Historical Plan Implementation

19.1.1 Introduction

The Gulf Menhaden Management Plan Task Force was established in 1976 when the Gulf State-Federal Fisheries Management Board (GS-FFMB) approved a project proposal for development of a Gulf Menhaden Management Plan. Representatives from each of the five Gulf States' management agencies, from each of the menhaden companies operating in the Gulf of Mexico, National Marine Fisheries Service (NMFS) and individuals from several universities contributed invaluable time to attending workshop sessions and completing "homework" assignments. The task force was comprised of some twenty members, including alternates. Each member of the task force contributed in the area of his expertise and in discussions that resulted in changes in draft material.

19.1.2 Plan Background

The menhaden fishery is one of the United States' oldest and most valuable fisheries and is the largest in volume of landings. Menhaden landings were first recorded in the Gulf of Mexico in 1880 (Lyles 1965) when less than .5 metric tons were landed in West Florida. With considerable annual fluctuations, gulf landings increased to the 1982 record of in excess of 1.8 billion pounds (854,131 metric tons). This amounted to 70.4% of the total U.S. menhaden landings and over 43% by weight of all species of fish and shellfish landed in the United States. Landings at Gulf of Mexico ports have exceeded one billion pounds each year since 1971.

Throughout this long history, regulation of the fishery has largely consisted of local restrictions imposed by state governments or local political entities. In most cases these regulations were established in response to political pressure resulting from long standing institutional conflicts. Since drastic declines in Atlantic menhaden resources occurred in the 1960's there has been increasing concern about the well-being of the gulf menhaden resources.

Available information on gulf menhaden includes the results of many biological research projects, but there are still important information gaps. The fishery depends almost entirely on one species, gulf menhaden (Brevoortia patronus). A long winter spawning season over the continental shelf in the Gulf of Mexico has been demonstrated. Movement of larval menhaden into estuarine nursery areas and estuarine dependence of the resource are well documented. Migratory patterns, with inshore movements of adults in the spring, determine fishing seasons.

The NMFS began an intensive biological research program on the gulf menhaden fishery in 1964. That program involved sampling daily landings of gulf menhaden for age, length, weight and sex. Tagging adults with numbered ferromagnetic tags was started in 1969 and expanded to include juveniles in 1970. Other research involved an annual survey of relative juvenile abundance in the estuaries from Florida to Texas. Chapoton, in a 1972 report to the Gulf States Marine Fisheries Commission's (GSMFC) Technical Coordinating Committee (TCC), reviewed progress of the research program and noted that "available biological data indicate that the gulf menhaden fishery is probably producing near its maximum. ...It appears that the time has come for state and industry representatives to meet, review the data in detail and discuss and consider possible future action."

The Gulf Menhaden Subcommittee of GSMFC's TCC, was formed on March 21, 1973, at the request of the Menhaden Council of Louisiana (industry group) with state, Federal and industry representation. While the initial request was for the subcommittee to study the need and procedure for establishing uniform seasons in the Gulf States, its activities have expanded to include the identification of existing and potential problems and to formulate solutions to these problems.

In January 1976, NMFS issued "The Gulf Menhaden Fishery, a Discussion Paper." This draft included a description of the gulf menhaden fishery and a management proposal intended "to stimulate thought and discussion by those concerned with the gulf menhaden industry and having, for one reason or another, a vested interest in conserving and enhancing this valuable resource." The Menhaden Subcommittee and TCC, meeting on March 30-31, 1976, agreed that a management plan for gulf menhaden should be developed by a state natural resource agency working with industry and Federal agencies. A proposal was prepared and presented on May 5, 1976, and approved by the Menhaden Subcommittee. The proposal was endorsed by TCC and the GS-FFMB on May 6, 1976. NMFS issued a purchase order, dated June 1, 1976, for the development of a fisheries management plan for gulf menhaden.

The plan (issued in May 1977) presented a description of menhaden resources and the associated fisheries, described the present management system, identified and briefly described problems of the present management systems especially with respect to needed research, listed the goal and objectives of the regional menhaden management plan, and described the proposed regional menhaden management plan; presented recommendations, ranked in order of priority which would enable the plan to be implemented with a short description of potential benefits resulting from each recommendation. Upon implementation of the Gulf Menhaden Mangagement Plan, the Menhaden Advisory Committee became the technical group which makes recommendations to the GS-FFMB (Section 7).

19.1.3 Planning Methodology and Sequence of Activities

Methodology used in development of the Gulf Menhaden Regional Management Plan described in the following excerpt from "Scope of Work" included in the contract:

> The Gulf States Menhaden Management Plan will contain a clear statement of mission and objectives, utilizing the "management by objectives" technique. Problem identification will focus on profile work already completed; for example, the discussion paper on menhaden fishery management, NMFS. Problems will be identified by type (administrative, legal, institutional legislative, biological, technical, economic, social, environmental, etc.), by degree and homogeneous area (state, international, range of stock, or section of Gulf). Problems will be analyzed, and potential alternative solutions will be developed, which will in turn reflect needs for problem solution. An action program will then be developed to delineate and prioritize the most feasible actions necessary to meet the established mission and objectives.
>
> Funds required to implement the proposed actions will be estimated, together with who should provide the funds and the responsibility for taking the necessary actions and the potential benefits that may accrue to the fishery if the funds are spent. Priorities for action will be scheduled, as required, for task(s) accomplishment.

A recommended approach for coordinating the management program will be outlined, including responsibilities for assuring the effectiveness of the management program will be designed.

The Gulf Coast Research Laboratory and the University of Southern Mississippi, working with the aid of representatives from the Gulf States (Florida Department of Natural Resources, Alabama Department of Conservation and Natural Resources, Mississippi Marine Conservation Commission, Louisiana Wildlife and Fisheries Commission and Texas Parks and Wildlife Department), National Marine Fisheries Service Laboratories and other agencies as appropriate will develop from existing secondary data and necessary interview data a concise description of the gulf menhaden fishery.

Consultants with expertise in areas such as planning, statistical analysis, economic, social, and/or other specialties will be employed as required (within the limits of available funds). Periodic planning and workshop conferences will be conducted in cooperation with the Gulf States Marine Fisheries Commission.

19.1.4 Plan Implementation

Plan implementation began after the appropriate committees and the GS-FFMB approved the plan and was implemented and administered by the recommended Menhaden Advisory Committee. The first steps in implementation consisted of those recommendations given the highest priority.

The Menhaden Advisory Committee periodically reviews and evaluates research proposals for applicability, as well as evaluating results obtained by actions taken to satisfy recommendations. The project evaluations process allows the group to judge the success and impact of individual projects on regional management and to readjust priorities of other projects as appropriate. Also, the group at periodic intervals evaluates the effectiveness of the entire regional management system, particularly concerning the solution of problems identified.

One way of evaluating and ascertaining the success of projects and the plan is in developing a work breakdown structure for each objective of the plan. The committee can use the technique of work breakdown structures to coordinate projects, to judge their success concerning contributions to satisfying plan objectives and their relevance to solution of problems confronting the menhaden fishery.

Since implementation, the Menhaden Advisory Committee has met regularly two times each year, with additional special meetings, when necessary. All meetings have been fully attended with prime consideration being improvements in ways and means to manage the fishery more effectively. The plan, as developed, approved, and implemented has proven quite effective.

To verify the plan effectiveness, a simulation exercise was conducted using the assumption that the fishery had been overexploited (MSY--maximum sustainable yield--had been exceeded.) The simulation was developed and demonstrated utilizing an interdisciplinary group. Lawyers, planners, economists, statisticians, menhaden industry personnel, marine fishery biologists, and other disciplines continue to participate in the program. Interdisciplinary research and management planning and control continues in a very compatible and effective manner.

The original strategic management plan, developed in 1977, has been reviewed and updated to incorporate the changes that have ensued in the past five years. Most of the present task force members also participated in the original plan development workshops.

19.1.5 Plan Revision

The 1983 revision has been reviewed and updated to incorporate the changes that have ensued in the past five years. The Menhaden Advisory Committee appointed an Ad Hoc Subcommittee to develop the revision and participated in the development process.

19.2 Gulf State-Federal Fisheries Management Board Charter

Establishment:

The states of Florida, Alabama, Mississippi, Louisiana, and Texas through their respective agencies for marine fisheries conservation, management and development, and upon the legal authorities contained in their respective constitutions or otherwise, do hereby agree to the formation of a regional fisheries management body to be known as the Gulf State-Federal Fisheries Management Board (hereinafter referred to as the Board) based on the general approval of Congress contained in the Gulf States Marine Fisheries Compact Act of May 19, 1949 (PL 81-66).

Purpose:

1. Recognizing that certain fisheries, and fisheries resources upon which those fisheries are based, move between, or are broadly distributed among, the territorial waters of two or more states, or the territorial waters and areas seaward thereof;

2. And recognizing the need for the development of uniform or coordinated management systems;

3. And, recognizing the need to optimize economic and social returns and to take appropriate actions to develop and implement certain management plans for the conservation and management of certain identified fisheries resources of the Gulf States;

4. The Board, therefore, agrees to take the necessary steps to accomplish the objectives and purpose of this charter:

   (a) Identify management plan priorities for fisheries and fisheries resources of common or interstate interest; and

   (b) Identify and promote institutional arrangements which will foster integration of efforts among the states; and

   (c) Encourage meaningful participation by user groups and the general public, in the development of management plans; and

   (d) Develop and recommend suitable policies and strategies to each member State, and encourage the implementation to the extent possible, of programs, laws and regulations for the effective management of fisheries to accomplish the objectives and purposes set out in this section.

Composition

1. The states of Florida, Alabama, Mississippi, Louisiana, and Texas shall be represented on the Board by the Administrative Commissioner and one other member of that state appointed to the Gulf States Marine Fisheries Commission, or their proxies by that state.

2. The Federal Government shall be invited to participate through the Southeast Regional Director of the National Marine Fisheries Service or his proxy from that region and Region IV Director of the U.S. Fish and Wildlife Service or his proxy from that region.

3. The Executive Director of the Gulf States Marine Fisheries Commission shall be a non-voting member of the board.

Administrative Provisions:

1. Each member state shall be entitled to one vote on all matters properly before said board.

2. Each designated Federal official shall be entitled to one vote on all matters properly before said Board.

3. A chairman shall be elected by majority vote to preside over all board business and activities.

4. The board shall meet:

   (a) at the call of the chairman, or

   (b) at the request of any three or more states acting jointly.

5. The place of each meeting shall be determined by the chairman.

6. All regular business of the board shall be conducted by a quorum of not less than fifty percent of the voting members/or their proxies.

7. Regular minutes showing questions offered, votes taken, and a summary record of discussions shall be maintained by a person designated by the chairman and shall become the official record of the board upon approval by consensus of the board at the next succeeding meeting.

8. An annual report shall be prepared for the benefit of the member states by April 15 of each year summarizing the previous year's activities and accomplishments.

9. The board may consider any issue properly before it except that if Federal funds are accepted to defray the costs of Board meeting and operating expenses, it may not vote upon, record, or otherwise collectively express any official position concerning any measure, proposal or bill before the Congress of the United States in contravention of the "Lobbying with Appropriated Money Act," 18 U.S.C. 1913.

Operating Procedures:

1. The board may establish one or more subsidiary committees known as sub-board, management plan committees, advisory committees and management committees. The board may invite scientific and technical personnel from the state and Federal governments, as well as user groups, persons interested in the conservation of fisheries resources and the general public, to serve on these committees, as appropriate.

2. The board will establish its own rules and procedures for conduct of business.

3. Amendments, deletions or additions to this charter may be made at any meeting of the board by a majority of the voting members providing that a ten (10) day notice of proposed change was given to all members.

4. This board may be dissolved by majority consent of the undersigned.

It shall be the responsibility of the board to oversee the work of such sub-boards and committees and insure that suitable participation by user groups and appropriate advice has been obtained. The board shall transmit upon adoption those findings to the Gulf States Marine Fisheries Commission and member states authorities for consideration, including recommending the adoption and implementation of rules, regulations, laws or other management measures as may be deemed necessary for effective fisheries management.

19.3 Charter of Menhaden Advisory Committee for the Gulf State-Federal Fisheries Management Board

A. Establishment

The Menhaden Advisory Committee for the Gulf State-Federal Fisheries Management Board is hereby established under the authority, and in accordance with the provisions contained within the Charter of Board (ref. Operating Procedures, paragraph 1, page 4).

B. Responsibilities

The responsibilities of the committee shall be:

1. To develop and advise the board of alternative approaches to fishery management.

2. To aid the board in describing the biological and socio-economic impacts of these alternatives.

3. To assist the board in implementing various activities to attain the goals and objectives of the Gulf Menhaden Management Plan.

4. To define and establish criteria for evaluating the effectiveness of actions that are implemented.

5. To provide advice to the board in framing regional menhaden management policies and assist in evaluating their effectiveness once in operation.

C. Composition

1. The advisory committee shall be comprised of one member from each of the five Gulf States' fishery agencies, one member from each of the four operating menhaden companies in the gulf, and one non-voting member from the National Marine Fisheries Service -- a total of ten members.

2. The chairman of the committee shall be appointed by the board.

3. No staff is assigned to the committee, but support may be requested from the chairman of the board.

4. The committee may solicit assistance from other areas of expertise not represented within its structure, as appropriate.

D. Administrative Procedures:

1. The committee shall meet a minumum of twice each year as deemed necessary by two or more members or at the direction of the board.

2. The committee shall meet in the area encompassed by the board's constituent states.

3. All recommendations of the committee shall be approved by a two-thirds majority of those present and voting.

4. The designated Federal representative shall have no vote but may serve as committee chairman.

5. All regular business of the committee shall be conducted by a quorum of not less than 60 percent of the voting members or their proxies.

6. Changes of this charter shall be at the pleasure of the board.

7. Industry Advisory Committee will report recommendations back to the board.