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The Menhaden Fishery of the Gulf of Mexico United States: A Regional Management Plan

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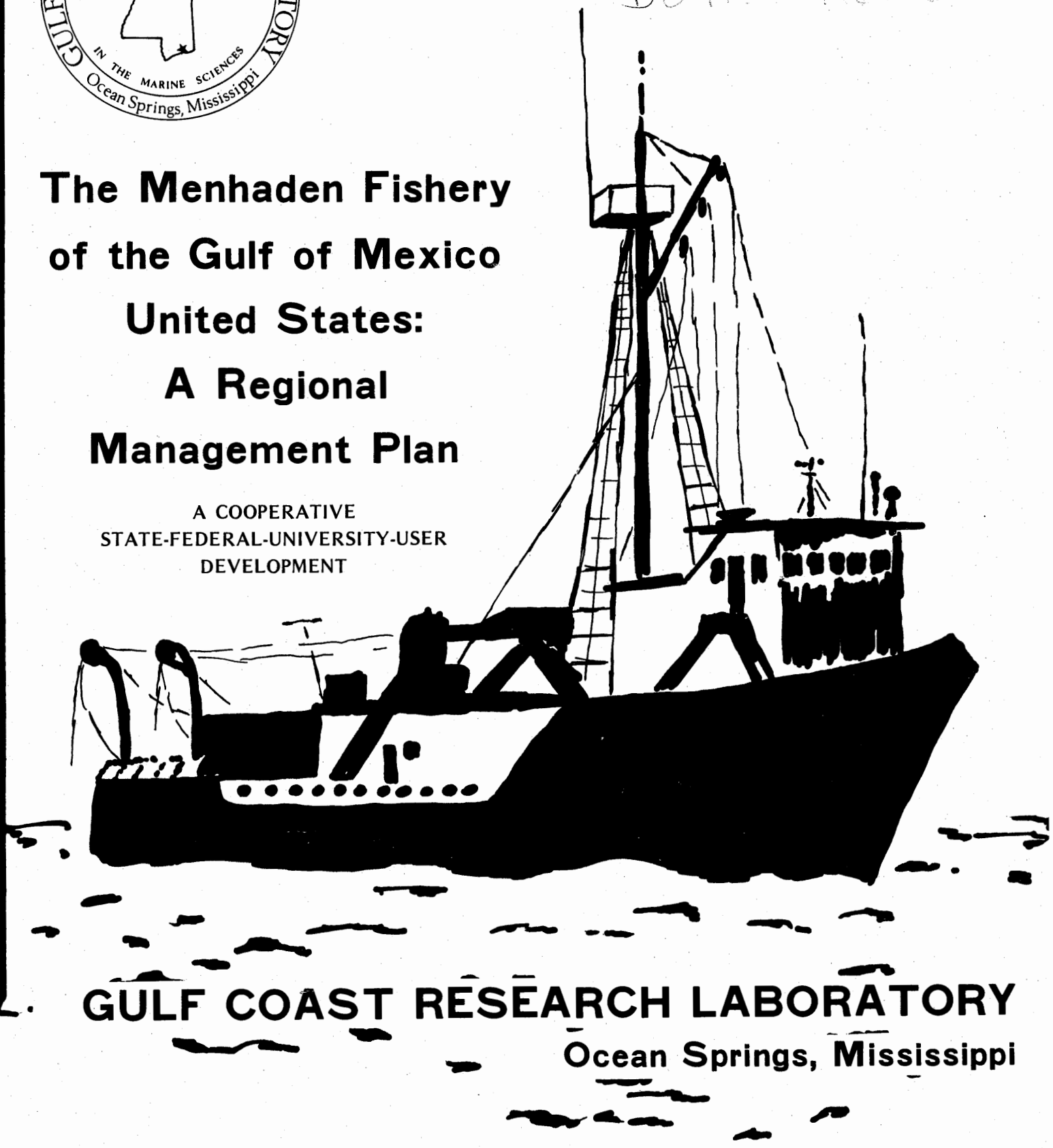

GULF COAST RESEARCH LABORATORY
Ocean Springs, Mississippi

Gulf Coast Research Laboratory
Ocean Springs, Mississippi

The Gulf Coast Research Laboratory is a Mississippi Institution of Higher Learning whose object and purposes are "to promote the study and knowledge of science including the natural resources of the State of Mississippi and to provide for the dissemination of research findings and specimens from the Gulf of Mexico."

THE MENHADEN FISHERY OF THE GULF OF MEXICO UNITED STATES: A REGIONAL MANAGEMENT PLAN

edited by

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Preface

The Gulf Menhaden Management Plan Task Force was established when the Gulf State-Federal Fisheries Management Board approved a project proposal for development of a Gulf Menhaden Management Plan. Representatives of each of the five Gulf states management agencies, each of the menhaden companies operating in the Gulf of Mexico, National Marine Fisheries Service and individuals from several universities contributed invaluable time to attending workshop sessions and completing "homework" assignments. The Task Force was comprised of the following members and alternates:

Dalton Berry, Petrou Fisheries
John Butler, National Marine Fisheries Service
Robert Chapoton, National Marine Fisheries Service
Tom Christopher, Standard Products Company
Jake Dermer, Petrou Fisheries
Tom Eymard, Louisiana Wild Life & Fisheries Commission
Charles Futch, Florida Department of Natural Resources
Paul Hooker, National Marine Fisheries Service
Terry Leary, Texas Parks & Wildlife
William Lunsford, Zapata Haynie Corp.
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Wayne Swingle, Alabama Department of Conservation
James Sykes, National Marine Fisheries Service
William Turner, National Marine Fisheries Service
Borden Wallace, Wallace Menhaden Products Inc.
Richard Waller, Gulf Coast Research Laboratory

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.

Gulf States Marine Fisheries Commission made all necessary arrangements for Task Force workshops and, under contract with National Marine Fisheries Service, funded travel for State agency representatives.

Plan development relied heavily on three documents. "The Shrimp Fishery of the South Atlantic United States: A Regional Management Plan (Eldridge and Goldstein, Editors, 1975) and "The Shrimp Fishery of the Southern United States: A Management Planning Profile" (Calder, Eldridge and Joseph, Editors, 1974) provided models for development of the Gulf Menhaden Management

Plan. Special thanks to the editors and authors who contributed to development of the South Atlantic Shrimp Management Plan. A draft of The Gulf Menhaden Fishery, A Discussion Paper (NMFS, 1976) included some of the descriptive information required for this document. Data and copy from the draft have been used freely in the Gulf Menhaden Management Plan. Our indebtedness to the many people who contributed to development of that draft paper is hereby acknowledged.

Dr. Ted Ford, Chairman of the Technical Coordinating Committee, Gulf States Marine Fisheries Commission, attended workshop sessions and offered valuable suggestions and advice.

Bill Turner, National Marine Fisheries Service Regional Office, not only served as a member of the Task Force, but provided continuing liaison with National Marine Fisheries Service at all levels.

The assistance of Buck Byrd, with his continuing interest in Regional Management under the State-Federal management concept, is gratefully acknowledged.

Special commendation and our thanks to Richard S. Waller, Gulf Coast Research Laboratory, who not only represented the State of Mississippi on the Task Force, but performed outstanding staff work in the organization and development of the plan.

Some others, but undoubtedly not all, who have our thanks are Joe Colson, former Director, Gulf States Marine Fisheries Commission; Harmon Shields, Florida Department of Natural Resources; Wayne Swingle, Alabama Department of Natural Resources; Charles H. Lyles, Director, Gulf States Marine Fisheries Commission; Burton Angelle and Dr. Lyle St. Amant, Louisiana Wild Life and Fisheries Commission; Clayton Garrison, Texas Park and Wildlife Commission; and Bill Stevenson, Director, Southeast Region, National Marine Fisheries Service.

This study was supported by a contract agreement with U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service issued to the Mississippi Marine Conservation Commission (MMCC) for execution by the Gulf Coast Research Laboratory with professional planning support from University of Southern Mississippi.

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Chapter 1. Summary

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 1,000 pounds were landed in West Florida. With considerable annual fluctuations, landings increased to the 1971 record of 1.6 billion pounds (728,868 metric tons). This amounted to 74.4% of the U.S. menhaden landings and over 32% of the total U.S. commercial harvest of fishery resources. Landings at Gulf of Mexico ports have exceeded 1 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 Gulf of Mexico 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.

Estimates of maximum sustainable yield (MSY), based on catch and effort data, have been completed by National Marine Fisheries Service (NMFS) since 1971 (430,000 metric tons). Estimates increased through 1975 (496,000 metric tons) as the data base was expanded to include years since 1970. For this reason and a general consensus that effort data are not reliable, MSY estimates calculated from the present data base have been questioned.

The Gulf menhaden industry is relatively stable. Five companies are currently operating 11 plants in the Gulf of Mexico fishery.

The Gulf Menhaden Subcommittee of Gulf States Marine Fishery Commission's (GSMFC) Technical Coordinating Committee (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 as well as 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 prepared by Gulf Coast Research Laboratory (GCRL) for Mississippi Marine Conservation Commission (MMCC) was presented on 5 May and approved by the Menhaden Subcommittee. The proposal was endorsed by TCC and the Gulf State-Federal Fisheries Management Board (GS-FFMB) on 6 May.

National Marine Fisheries Service issued Purchase Order No. 01-6-042-11157, dated 1 June 1976, to the MMCC for the development of a fisheries management plan for Gulf menhaden.

Chapter 2 presents a description of menhaden resources and the associated fisheries.

Chapter 3 describes the present management system. Chapter 3 also identifies and briefly describes problems of the present management systems especially with respect to needed research.

Chapter 4 lists the goal and objectives of the regional menhaden management plan.

Chapter 5 describes the proposed regional menhaden management plan.

Chapter 6 presents recommendations which will enable the plan to be implemented. Recommendations are ranked in order of priority; namely, high, medium and low, with a short description of potential benefits resulting from each recommendation. A total of 24 recommendations is presented with 16 ranked as high, 5 ranked as medium and 3 ranked as low priority.

Chapter 7 is a Management Action Program Summary, presented in chart form, showing time horizons, estimated funds needed, potential funding sources; and suggested responsibilities for activities which will be undertaken to begin implementation of the regional menhaden management plan.

A discussion of planning methodology and chronology is appended.

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Chapter 2. A Description of the Resource and Fishery

Menhaden are members of the family Clupeidae (herrings), genus *Brevoortia.* Adults are relatively small, usually less than 12 inches in length and 1 pound in weight. Generally, they inhabit coastal waters, occurring in large schools that contain as many as 600,000 or more fish weighing in excess of 180 metric tons.

There is considerable information on the biology of menhaden and most of the material published through 1973 is conveniently referenced in four 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) and Reintjes and Keney (1975).

2.1 SPECIES COMPOSITION

Gulf of Mexico menhaden landings comprises three species, one of which predominates.

Gulf menhaden (*B. patronus*) is the principal species landed in the Gulf States. Incidental catches of yellowfin menhaden (*B. smithi*) and finescale menhaden (*B. gunteri*) are landed also.

The NMFS conducted mark-recapture studies on Gulf menhaden in 1969 and 1970. A total of approximately 50,000 adult menhaden was tagged and/or marked and released. Returns from these mark-recapture experiments indicated that: (1) fish recaptured during the year of release showed very little movement between fishing grounds east of the Mississippi River Delta and those 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 or west-east migration (U.S. Department of Commerce, 1972; Kroger and Pristas, 1975). These studies indicate that Gulf menhaden may be split into two stocks in the northern Gulf by the Mississippi River Delta; however, meristic studies by Chrsitmas (unpublished) show no significant differences in populations on either side of the Mississippi Delta.

2.2 BIOLOGY

Menhaden are euryhaline, capable of living in water ranging from fresh to hypersaline. Adults spawn offshore, principally during the fall and winter. Larvae migrate inshore and enter estuaries while the fish are still about 1 ½ inches long and about 3 to 5 weeks old. Generally, the young utilize estuaries as nursery areas for 5 to 10 months and then migrate offshore where they reach sexual maturity and spawn.

The average size of Gulf menhaden at any particular age is less than that of Atlantic menhaden. Atlantic menhaden live to an older age than Gulf menhaden (10-year-old Atlantic menhaden have been recorded). Most Gulf menhaden taken by the industry are 1 or 2 years old and fish older than 4 years are rare.

One- and two-year-old fish average about 0.25 pound each and comprise over 90% of the Gulf menhaden landings. Menhaden have a high reproductive potential with some 1-year-old spawners and all mature sexually by age 3. The resource is, therefore, capable of rapid renewal.

Spawning. Actual spawning of Gulf menhaden has not been observed nor have the spawned eggs been described or positively identified. Location of ripe females, assumed similarity of Gulf menhaden eggs to those of other menhadens, and the abundance and location of eggs and larvae at sampling sites have all been relied upon to delineate spawning time and area.

Spawning Season. Data presented by numerous researchers over the last 3 decades corroborate a spawning season extending from about October to April with a peak during January and February. Spawning periods and spawning 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 as early as September and as late as July.

Eastern Gulf: Springer and Woodburn (1960) sampled monthly in Cross Bayou Canal located in the Tampa Bay, Florida area for 15 consecutive months and collected 1024 *B. patronus* having a standard length (SL) of 33 mm or less during 4 months: February (1), March (568), April (378) and May (72). They found small *B. smithi* (average 23.3 mm TL) most abundant during May and concluded that this species probably spawns during the spring, somewhat later than *B. patronus* which was most abundant in March (average 23.5 mm TL).

Turner (1969) collected menhaden eggs, larvae and ripe and spent adults in the eastern Gulf during winter cruises of the R/V *George M. Bowers* (1964-65 and 1965-66) off the coast of northern Florida (from Panama City to Cedar Key) and southern Florida (from Tampa to Cape Sable). Menhaden eggs were collected monthly from December through March, and larvae, 11 to 14 mm fork length (FL), were collected as early as December and as late as April. From this he concluded that spawning occurs in that area principally near shore (within the 10-fathom curve) from December through March and reaches a peak in January and February. He also collected adult *B. patronus* and *B. smithi* in northern Florida and both species and their hybrids in southern Florida; examination of gonads substantiated the spawning period from December through March.

Hettler (1968) reported the collection of ripe female yellowfin menhaden 10 miles north of Naples, Florida in 3 fathoms on 17 March 1966 and another ripe female of the same species 1 mile south of Sanibel Island in 2 fathoms of water on March 18. He also collected ripe yellowfin males, ripe male *B. patronus* 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 peak in February. In egg collections from the Mississippi Delta to Cedar Key, peak spawning was reflected by the December and February samples.

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 the Gulf over a 5-month period, 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 each month 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.

Turner (1969) collected menhaden eggs in a study of Mississippi Sound and adjacent offshore waters in December 1966 and January 1967 during cruises of the R/V *George M. Bowers.* 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.

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 *B. patronus* 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 *B. patronus* by Suttkus and Sundararaj (1961) corroborated these spawning dates for Louisiana waters.

Western Gulf: Perret, et al. (1971) conducted an intensive sampling program in Louisiana estuaries during the period of 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 Neches 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 the Laguna Madre of Texas during February 1956 and he collected 15-mm specimens during March, April and May.

Arnold, Wheeler and Baxter (1960) made collections in East Lagoon near Galveston, Texas from November 1953–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.

Menhaden eggs collected during cruises of the R/V *Gus III* in 1963, revealed that the spawning season in the northern and western Gulf of Mexico extended from mid-October through March (Fore, 1970).

Plankton samples collected from the western Gulf (Mississippi Delta to Brownsville, Texas) contained menhaden eggs from October through March, with spawning peaks

indicated during March in the southern part of this region and in December in the northern portion (Christmas and Waller, 1975).

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).

Spawning Area. Researchers have presented data which indicate that Gulf menhaden spawn offshore. 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 during cruises of the R/V *George M. Bowers.* Most of the eggs were collected within the 5-fathom curve which suggested that spawning takes place near shore in Florida waters. Combs (1969) did not delineate the geographical areas in which Gulf menhaden spawn, however, he provided evidence that spawning occurs only in high-salinity waters.

Fore (1970) inferred spawning areas of Gulf menhaden from the distribution of eggs collected during cruises of the R/V *Gus III.* The collection of eggs indicated that Gulf menhaden spawn mainly over the Continental Shelf between Sabine Pass, Texas and Alabama with greatest concentrations in waters between the 4- and 40-fathom contours off Texas and Louisiana and near the Mississippi Delta.

From the 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.

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.

Maturity. Age Groups I, II and III made up 8, 85 and 4%, respectively, of the spawning population of Gulf menhaden examined by Suttkus and Sundararaj (1961).

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 *B. smithi* with sperm from *B. smithi, B. patronus* 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 are lacking of *B. patronus* eggs and *B. gunteri* eggs and larvae. It is assumed that eggs and larvae of the three species found in the Gulf as well as the Atlantic menhaden are very similar or indistinguishable. Reintjes (1969) reported that fertilized Atlantic menhaden eggs are spherical, 1.2 to 1.3 mm in diameter, non-adhesive, buoyant in sea water and float in loose aggregations near the surface. Eggs of *B. smithi* artificially fertilized with sperm of *B. smithi, B. patronus* and hybrids, ranged from about 1.05 to 1.30 mm (Hettler, 1968; Reintjes, 1962).

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 *B. smithi* fertilized with sperm of *B. patronus* and held at 19.5 to 21.5°C. Hettler (1970) observed that *B. smithi* eggs began hatching 48 hours after artificial fertilization with *B. smithi* sperm.

Growth of Larvae. Hettler (1968) reported that larvae produced from *B. smithi* (female) x *B. patronus* (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. Larvae of *B. smithi* 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 *B. patronus* ranging in length from 18.9 to 58.4 mm TL (age unknown) were described by Suttkus (1956).

Scale Development. 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.

Food and Feeding Habits. Metamorphosis and development of larvae into juveniles are accompanied by a change in feeding habits from a selectively feeding carnivorous diet to a filtering omniverous diet; and 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 waters and that 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 suspended bacteria and material other than living plankton are important components of the food of menhaden in turbid estuaries.

Migration of Larvae. Whether the movement of larvae from their hatching area to estuaries represents passive drifting or 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). Reintjes (1970) surmised that larvae of Gulf menhaden are 3 to 5 weeks old when they enter estuaries. They move from the higher-salinity waters of the lower estuary to the lower-salinity waters in the upper estuary and tributaries. As the young fish grow, they move back toward the Gulf and begin to migrate from the estuaries by mid-summer.

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 6 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.

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 menhaden have been collected in Gulf estuaries at temperatures ranging from 5 to 34.9°C and in salinities as low as 0.0‰ and as high as 67‰ (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‰ 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 undoubtedly in other areas. Other factors that probably affect the well-being of menhaden in estuaries include currents, toxic pollutants, predators and parasites and diseases.

Stone (1976) correlated a number of environmental factors (air and water temperatures, salinity, rainfall, tidal data and wind speed and direction) in coastal Louisiana against menhaden catch-and-effort data. He found significant relationships between these environment factors and year-class survival and subsequent years catches. The catch prediction capabilities of this approach were found to be positive although he feels more research is needed.

Migration. Although there is evidence that indicates that some young-of-the-year menhaden overwinter in estuaries (Turner and Johnson, 1973), 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 0-age 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.

Distribution of Adults. Schooling is apparently an inborn behavioral characteristic of menhaden beginning at

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

Menhaden occur in schools in the open waters along the Gulf coast from southern Florida to Mexico (Reintjes and June, 1961). Horizontal migrations by Gulf of Mexico menhaden are not known to occur. 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 water 20 fathoms deep and by mid-water trawls where the total depths ranged from 40 to 55 fathoms (Christmas and Gunter, 1960).

There is a seasonal appearance of large schools of menhaden in the near shore Gulf waters from about April to November. This dictates the season for the Gulf of Mexico menhaden purse-seine fishery. Schools leave the nearshore waters during the fall and apparently move offshore and out of the fishery. The southern coast of Florida and the eastern coast of Mexico had been suggested as the most likely places of winter occurrence (Reintjes and June, 1961). Efforts to locate schools of adult menhaden during the winter have been generally unsuccessful, however, Roithmayr and Waller (1963) reported winter concentrations of *B. patronus* in the northern Gulf over depths ranging from 4 to 48 fathoms. They concluded that at least part of the stocks of *B. patronus* 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. His study indicated that menhaden do not move far offshore in that area of the Gulf along the Florida coast. Additional evidence that indicates that the bulk of menhaden winter relatively near the summer fishing grounds in the Gulf include: (1) no menhaden have 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 unlikelihood of local concentrations having traveled any great distance (Roithmayr and Waller, 1963).

Age and Size. Age and size distributions of Gulf menhaden taken by the purse-seines are different from those of the Atlantic menhaden and especially different from those of the north Atlantic area. From 1955 through 1968 the average age of Atlantic menhaden caught from the north Atlantic area was 3.7 years and in the south Atlantic area it was 1.4 years (Henry, 1971). Fewer age groups and lack of stratifications by age along the Gulf Coast apparently make the Gulf menhaden fishery less complicated than the Atlantic menhaden fishery. Chapoton (1972) reported that Gulf menhaden of Age Groups III and V are landed but contribute usually less than 15% of the total. The bulk of the Gulf landings are composed of Age Groups I and II.

Range of Gulf Species. The Gulf menhaden ranges from the Yucatan Peninsula in Mexico to Tampa Bay, Florida. The finescale menhaden ranges from Mississippi Sound westward and southward to the Gulf of Campeche in Mexico. The yellowfin menhaden ranges from Chandeleur Sound, Louisiana, eastward and southward 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 recently reported from Grand Bahama Island and this is the first authenticated record of a North American species from beyond the Continental Shelf (Levi, 1973).

2.3 FISHING METHODS–GENERAL

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

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 40'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.

1. Fish Spotting. Spotter planes are usually single-engine land-based aircraft with a single wing located above the fuselage. They are fully equipped with electronic navigation and communication systems. They 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. The planes

they use are either owned, or contracted for by the fishing company and are based at or 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 then, again by radio contact, directs the purse boats in the setting of the purse seine. One spotter aircraft usually serves several carrier vessels.

2. Carrier Vessels. Menhaden carrier vessels are specialized crafts 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-seine boats from which the actual fishing operation is conducted. A high bow, a low stern and a tall mast with a crow's nest are common characteristics of carrier vessels. The fish are stored below deck in central holds that are usually refrigerated. The wheel house, crew quarters and 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 1975 consisted of about 78 vessels.

Although fishhold capacity-registered net tonnage ratio varied considerably among menhaden vessels (66) active in the Gulf fishery in 1973, preliminary analysis (Figure 1) indicates agreement, or correlation (r = 0.87), between estimates of fishhold capacity and net tonnage. This agreement accounts for 76% of the variation in estimated vessel capacities. Fishing efficiency depends on many other factors, but this degree of accountability suggests that estimates of vessel capacity are fairly well indicated by the vessel's registered net tonnage.

3. Statistics on 78 Menhaden Carrier Vessels Operated in the Gulf of Mexico During 1975 (Latest information available.

	Range	Mean
Length (ft)	105–194	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 16 men, consisting of a captain, mate, pilot, chief engineer, second engineer, cook and 10 fishermen.

4. Purse Boats. Purse boats are of open construction of aluminum, approximately 36 to 38 feet long, about 10 feet wide and equipped with a diesel engine that propels the boat as well as furnishes power for the operation of the hydraulic seine block and allied fishing gear.

5. 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 200 fathoms 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.

During the fishing season the 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 will make several trips during the week.

The search for the 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

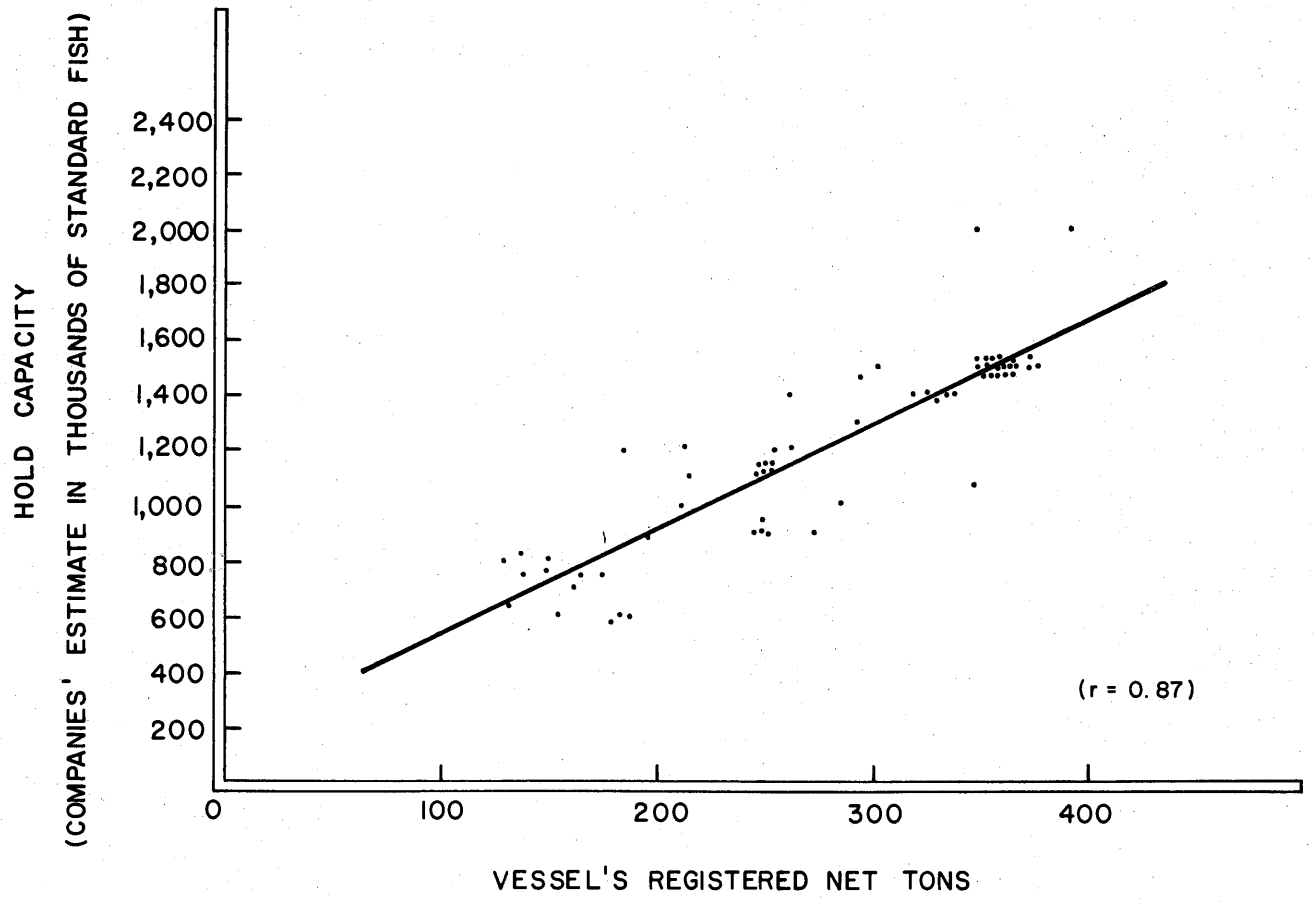


Figure 1. Fish-hold capacity versus carrier vessel registered net tons, 1973 Gulf menhaden fleet of 66 vessels. (Each dot represents one vessel. The line is the central or average relation.)

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 day's fishing 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.

2.4 SEASONS AND GEOGRAPHIC LOCATIONS OF THE FISHERY

Currently, the only operative U.S. Gulf menhaden reduction plants are located in Louisiana and Mississippi, where the fish are landed and the fishing fleets and spotter airplanes are based.

The boats are highly specialized and fish during daylight hours in relatively shallow water generally about 1 to 3 miles offshore along the coast from about Appalachicola, Florida to Matagorda Bay, Texas. In 1973, 88% of the catch was taken inside 3 miles, over 11% from water 3 to 12 miles off shore and less than 1% in water 12 or more miles offshore (Wheeland and Thompson, 1975). The fishing season generally begins about the middle of April and ends in mid-October.

2.5 INTERNATIONAL PARTICIPATION

There is no record of foreign participation in the Gulf menhaden harvest. In response to requirements of Public Law 94-265 relative to what portion of the Gulf menhaden resource could be allocated to foreign fishermen, NMFS Atlantic Estuarine Fisheries Center has taken the position with the Department of State that no fraction of the resource should be allocated to foreign fishermen.

This position is based on the following:

Manageable Unit: Gulf menhaden, *Brevoortia patronus*

Definition: A fishery conducted along the coast of the United States in the northern Gulf of Mexico from Florida to Texas. One stock consisting of one species throughout its range. Does not migrate into waters outside 200 miles.

OSY	Capacity of U.S. fisheries	Portion of OSY to be allocated to foreign fleet
500,000 mt (MSY)	Complete OSY	0

Recreational Fishery—none

Maximum historical catch 728,000 m.t. (1971)

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

2.6 EXTENT OF PARTICIPATION IN COMPLEMENTARY OR SUPPLEMENTAL FISHERIES

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, but 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.

Gunter and Christmas (1960) reviewed the literature on Gulf of Mexico menhaden and discussed the species composition of the menhaden fishery. They concluded that the menhaden fishery catches few other fish. Christmas, Gunter and Whatley (1960) sampled menhaden catches from Mississippi Sound and from around the Mississippi River mouth and found these catches included less than 3% by number other fishes. Miles and Simmons (1950) investigated the menhaden fishery in Texas and found menhaden catches included only 0.024% by number other species.

Filipich (1947) checked Mississippi factories on five unannounced occasions and out of 295 tons of menhaden landed found one mackerel and six white trout.

Gowanloch (1949) reported on the menhaden commercial versus sports fishery controversy and concluded the menhaden commercial fishery does no harm to sports fishes.

Dunham (1972) checked the menhaden fishery catch in Louisiana from June to October 1971 and found other species constituted only 0.5% by number of the catch, and in April through June 1972 found other species except Atlantic thread herring made up 1.59% by weight of the catch.

The same relationship has been found in studies, some as early as 1894 (Smith, 1896), on the Atlantic menhaden catch.

2.7 OTHER FISHERIES PARTICIPATION IN THE MENHADEN HARVEST

The menhaden resource is essentially directly utilized only by the fish meal and oil industry, although a small bait fishery does exist off the west coast of Florida. Some 500,000 pounds were landed in Florida west coast ports in 1975. This bait fishery is the only other direct pressure on the menhaden resource.

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.

Of much greater importance, however, is the shrimp 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 (pers. comm.) 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.

2.8 PROCESSING

Menhaden are unloaded by pumps from the hold of the vessel and conveyed to a continuous process steam cooker. Cooking coagulates protein and releases bound oil and water from the flesh.

As a result of cooking temperatures, the mass of solids and liquids is firm enough to undergo high pressures and is conveyed through a continuous pressing operation. This squeezes oil and water containing dissolved and suspended solids from the mass, leaving a damp intermediate known as press cake.

The press cake is conveyed to continuous process driers. The resulting product, fish scrap, is then milled into meal which is treated with an anti-oxidant. This allows the meal to maintain its superior protein and energy quality during storage and shipment.

The oil and water phase referred to as 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 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 an evaporator, generally multi-effect. The stickwater is concentrated to 50% solid matter and brought to a pH of 4.5 to preserve its nutritional qualities. This product is called condensed fish solubles.

At many processing plants, the stickwater is concentrated only to a level of approximately 30% solid matter and returned to the press cake. This results in all solids being returned to the meal which is then termed whole or full meal.

Also, some stickwater may be converted to a dry product by spray drying.

Figure 2 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, effluent satisfies the current federal and state standards. Data used for this figure are based on data collected at a Moss Point, Mississippi plant during one season. 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.

2.9 PRODUCTS

Wet reduction of menhaden yields three products: fish meal (about 20% of the weight of the raw fish), fish oil (10–20%) and condensed fish solubles (10–15%).

Menhaden meal. This product is a valuable ingredient for animal feeds. It contains a minimum of 60% protein having a well-balanced amino acid profile. High levels of the essential sulfur amino acids, lysine and methionine, are present.

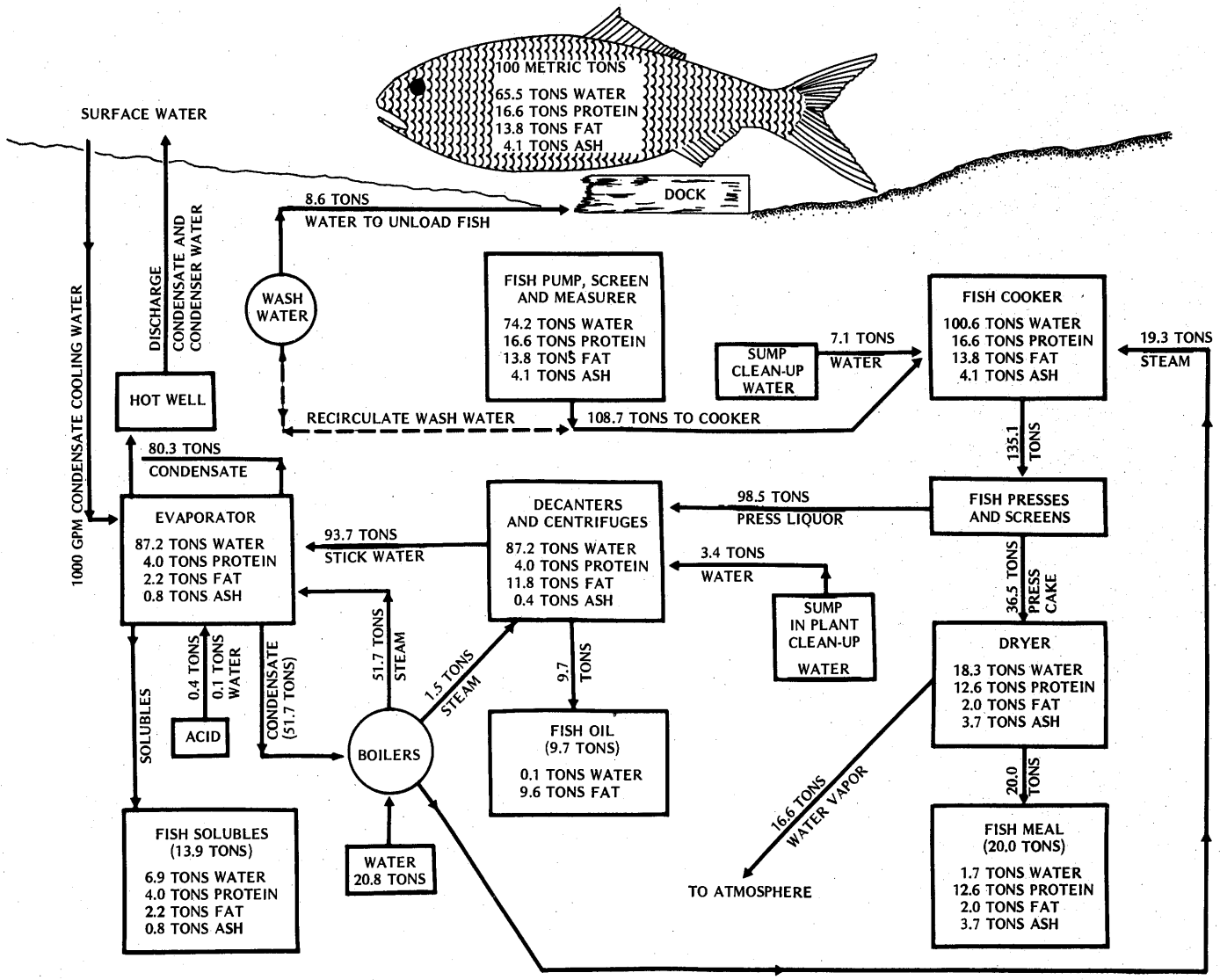


Figure 2. The processing of 100 metric tons of raw menhaden through a modern plant.

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 broiler industry is heavily dependent on fish meal as a feed ingredient to effect maximum rate of gain and to improve feed efficiency. The formulator, depending on price and availability of fish meal, may use up to 8% fish meal in broiler rations. Because of this specific use, and because the large broiler producing area is in the near Gulf region, a large percentage of the Gulf menhaden fish meal is committed to the broiler industry in the South.

Also, swine have high requirements for the fish meal amino acids and the high available energy levels. The utilization of fish meal as an ingredient in swine feeds is the second most valuable market.

The rather new industry, Aquaculture, demonstrates ever increasing demands for menhaden fish meal. Formulated feeds for catfish, trout and shrimp require up to 40% fish meal to produce efficient growth.

Most menhaden companies have their own sales departments and sell their fish meal directly to the consumer or feed manufacturer. However, fish meal brokers and jobbers play an important role in the sales and distribution of menhaden meal. All sales are in bulk and are truck lot, car lot or barge lot quantities.

Menhaden oil. This commodity has been used in the production of hydrogenated cooking oils and margarines in Europe for years. In fact, until just recently, some European countries required a minimum of 17% marine fish oil in the fat formulations for edible products. Thus, the largest and most valuable market for menhaden oil is in its export.

Although fish oil is not used for edible products in the United States, it does have valuable technical uses in this country. Menhaden fish oil is easily emulsified with water. This quality makes it a valuable component of marine lubricants and greases. Fatty acid manufacturers fractionate menhaden oil to recover the highly 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.

Fish oil is sold in barge lot, truck lot or car lot quantities. Sales are made directly by the companies or through brokers to consumers, dealers or processors.

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. The amino acid composition of solubles protein is slightly different from that of fish meal in that it contains a higher percentage of glycine. It also contains an important "unidentified growth factor."

Solubles are used as a feed ingredient by nutritionists in the broiler 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. The largest market for menhaden solubles is in the mid-west 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.

Fish solubles are sold in barge lot, truck lot or car lot quantities. Sales are made directly by the companies or through brokers, to consumers, dealers or processors.

Presently menhaden is not used directly as a food item, however, according to Dubrow, Hale and Bimbo (1976), the NMFS (then the Bureau of Commercial Fisheries) utilized menhaden in the development of fish protein concentrate (FPC). If produced hygienically by the isopropyl alcohol process, menhaden fish protein concentrate is approved by the U.S. Food and Drug Administration as a food additive.

Figure 3 illustrates product flow from harvest to secondary consumer. Notably, most of the final product is food for human consumption.

2.10 ECONOMICS

Harvesting and Processing. The Gulf menhaden fishery is currently composed of five harvesting and processing firms. It is an unusually stable fishery 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. Since the one surviving new entry (Ocean Protein, now Zapata Haynie, Inc.) about 10 years ago, no firms have entered or left the industry. The only changes have been changes in ownership. There have, of course, been changes in fleet size and numbers of operating plants, but even these changes have not been extreme. (See Table 1).

Firms in the industry would be ranked in size approximately as shown in Table 2. There are some substantial differences in firm size from the largest to the smallest, but, 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. There are, of course, year-to-year fluctuations in interfirm catch and hence market share, but none of the firms is undergoing a large-scale vessel expansion program. The locations of the various plants are shown in Figure 4.

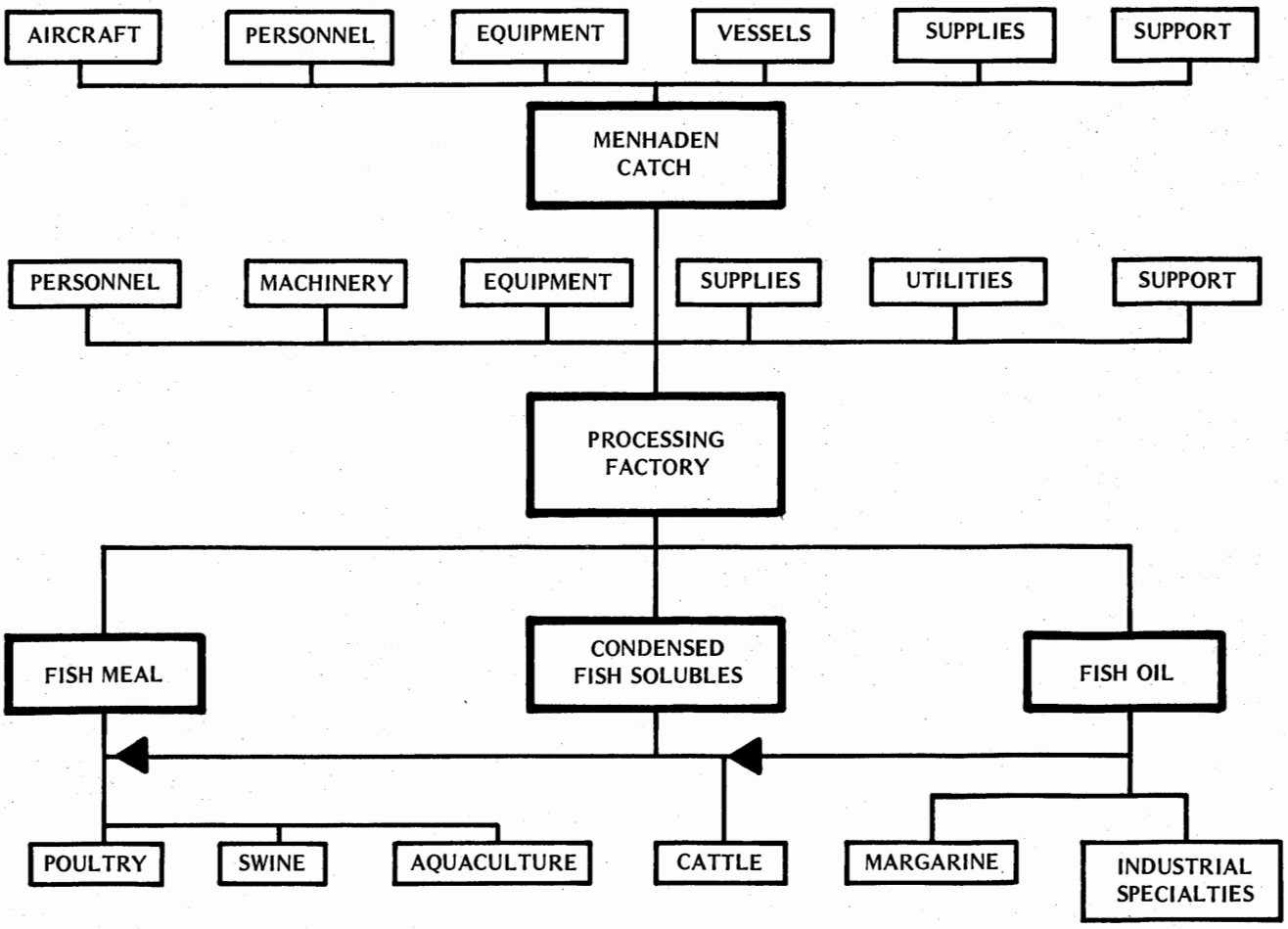


Figure 3. Product flow from harvest to secondary consumer.

TABLE 1.

Gulf menhaden purse-seine fishery, 1970–76

Year	Number Vessels	Number In Crew	Number Vessel Weeks	Number Plants	Shore Based Personnel*
1970	76	1,292	1,628	13	NA
1971	85	1,445	1,862	13	NA
1972	75	1,275	1,670	11	865
1973	66	1,122	1,500	10	843
1974	71	1,207	1,685	10	973
1975	78	1,326	1,847	11	962
1976	81	1,377	1,959	11	880

Source: Robert Chapoton, Leader, Menhaden Resource Monitoring and Management Task, Beaufort Laboratory, National Marine Fisheries Service.
*Based on Industry Estimate
NA = Not Available

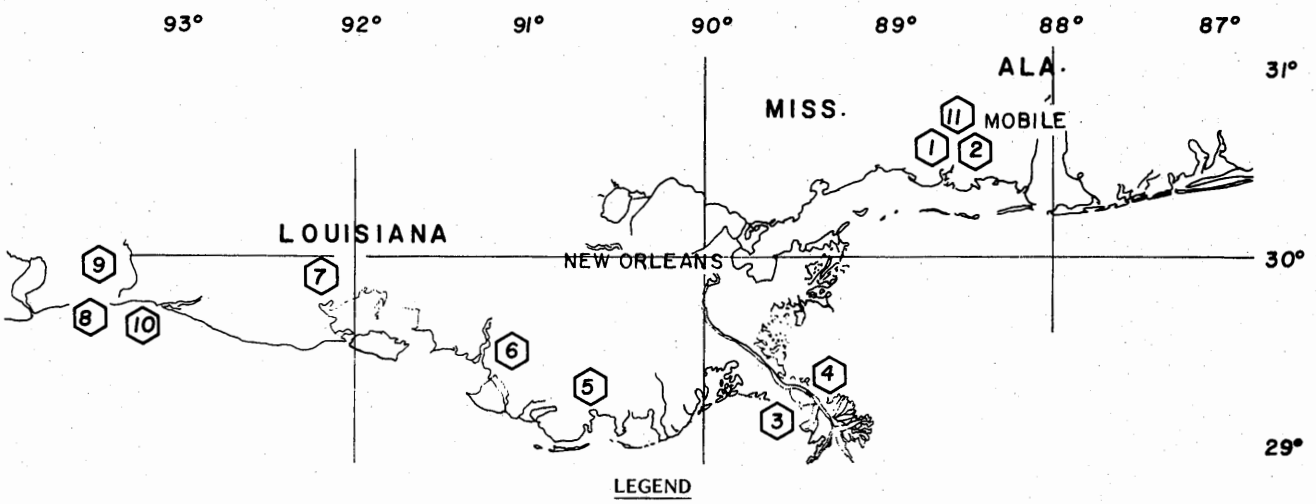
TABLE 2.

Number of processing plants by firm

Firm	No. of Processing Plants
Seacoast Products Inc.	4
Zapata Haynie Corporation	3
Wallace Interests	2
Petrou Fisheries, Inc.	1
Standard Products Company, Inc.	1

In short, the Gulf menhaden fishery is a very stable industry measured by market structure, product exploitation levels and similar factors. Member firms within the industry appear healthy enough for survival and sufficiently strong financially to continue to maintain a harvesting fleet of adequate size. This is not to say that all firms always show a profit. In fact earnings fluctuate widely. This is 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 the vicinity of 1.5 million dollars. It is a specialized vessel and not adapted well to other fisheries



LEGEND

Location Symbol	Company	Location Symbol	Company
1	Standard Products Mosspoint, MS	7	Sea Coast Products Intra Coastal, LA
2	Zapata Haynie Co. Moss Point, MS	8	Zapata Haynie Co. Cameron, LA
3	Petrou Fisheries Empire, LA	9	Seacoast Products Inc. Cameron, LA
4	Empire Menhaden Empire, LA	10	Louisiana Menhaden Cameron, LA
5	Zapata Haynie Co. Dulac, LA	11	Seacoast Products Inc. Moss Point, MS
6	Seacoast Products Inc. Morgan City, LA		

Figure 4. Locations of Gulf of Mexico menhaden plants.

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. As a practical matter Gulf menhaden vessels are not readily adaptable for use in other Gulf fisheries in the off season or in the event of a decline in the menhaden fishery. 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 neighborhood of 4 to 5 million dollars. It would take at least three vessels to supply one processing plant, and five or more vessels would be a more practical scale on which to operate. One spotter aircraft would be needed on a purchase or contract basis for every two or three menhaden vessels. So the overall cost of new entry would be probably in the vicinity of 10 million dollars or more. Added to this cost barrier would be the difficult start-up costs of obtaining qualified captains and crew, and developing a qualified management staff and sales force. Because these things take time, a newly entered firm would have to be prepared for heavy losses, perhaps for a substantial period.

From the foregoing it can be seen that the economic structure of the Gulf menhaden industry is not at all like that of 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. Further, the Gulf menhaden fishery is not a fishery in trouble in the crisis sense. Nonetheless, the industry does experience some problems that could pose future consequences of a serious nature for the industry.

1. Based upon the current estimate of maximum sustainable yield (MSY) by the NMFS, it appears the industry is approaching or may have reached MSY. Whether or not the industry has exceeded maximum economic yield (MEY) has not been established. A difficulty in both evaluations is that trends in the presently employed vessel-ton-week (VTW) measure of fishing effort are not a good guide to trends in actual fishing effort. This is because variations in catch per vessel often are less a function of the size of the vessel than they are of the ability, skill and drive of the crew.

2. The question of season length, an economic question with some biological ramifications, has been a problem in the past. For the last several years the season has had a common opening and closing date for the entire industry. These common dates removed many of the competitive problems which staggered opening and closing

dates used to produce. There still are suggestions from time to time that season dates might be changed, but a majority of the industry is currently comfortable with the common opening and closing dates.

3. U.S. menhaden landings approximate half the tonnage of U.S. fishery landings, including landings of shellfish. Since menhaden could be consumed by humans directly, and since there are many forms that processed menhaden may take and uses these forms might be put to, the whole question of product upgrading needs additional emphasis and study with federal government support.

Labor. In general the labor used in the Gulf menhaden industry also does not fit the common fisheries case; that is, of coming from an isolated fishing village with little or no employment for workers except employment in the principal fishing occupation. This is primarily because all the Gulf menhaden processing plants, and hence also the home ports for the vessels, are in areas where competing employment alternatives exist for labor. Some of the processing plants are in city areas, others are in offshore oil industry exploitation areas and so on. Available alternatives to employment in the menhaden fishery have not always existed during the years this fishery has been active, but that appears to be the situation presently.

Employment within the processing plants is fairly steady throughout the year for many workers, but, plant work involves heavy overtime during the 6-month operating season. Generally, work in the processing plants is not regarded as highly skilled, and periods of waiting or resting are common even during the season. About 75% of processing plan employment is year-around. About 25% would be peak season employment only.

Vessel labor is almost entirely seasonal employment, but again the Gulf menhaden fishery is competing for labor with other employers. The isolated fishing community with no employment alternatives model does not seem to apply well to this industry. Captain-crew pay depends upon catch levels, with an incentive built in to work the entire season. The general trend in the industry is to pay a guaranteed minimum each payday, but, not every company follows this practice. Some firms pay entirely on a quantity of catch basis. 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 sustainable yield (OSY) do not seem to be sharply limited by local labor employment traditions and/or employment of redundant fishing labor.

2.11 BACKGROUND OF THE GULF MENHADEN FISHERY

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 and moved westward from Florida. 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. 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 oleomargarine and in numerous manufacturing processes. The amount of menhaden consumed directly as food is insignificant today despite a prediction by Carson (1944) that canned menhaden would become familiar to a much larger public after World War II.

Commercial exploitation of menhaden began on the Atlantic coast by the early 1800's but did not gain impetus until after the Civil War (Deblois, 1882; Whitehurst, 1973). By 1900, the industry was well established in the South Atlantic States. There were 48 factories and 147 vessels operating on the Atlantic coast in 1912 (Greer, 1917). Atlantic landings generally increased for the next 50 years, exceeding 300 million pounds in 1917, 380 million pounds in 1927, 600 million pounds in 1937, and 800 million pounds in 1947. An annual average of 780 million pounds was landed during the following 5-year period (1948–1952), and an annual average yield of over 1.3 billion pounds was realized for the next 10 years (1953–1962) (Lyles, 1967a; 1967b; 1967c; 1967d). A declining trend in production in the Atlantic states began in 1963 and continued through 1970. Henry (1971) attributed the decline principally to a series of poor year classes following a superabundant 1958 year class.

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 (Lyles, 1967e) and Louisiana, 1941. 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

TABLE 3.
Quantity of menhaden landed by purse seines in the Gulf states from 1948 through 1975
(Thousands of pounds)

Year	Louisiana	Mississippi	Texas	Florida W. Coast	Total
1948	88,110	68,636	28,185		184,931
1949	165,914	44,579	41,135	24,879	276,507
1950	207,775	69,550	47,191	1,534	326,030
1951	209,574	114,895	30,121	3,375	357,965
1952	283,373	112,890	52,984	10,737	459,984
1953	307,492	58,933	66,589	4,031	437,045
1954	270,094	79,445	51,702	2	401,243
1955	298,309	128,123	52,625	1,935	480,992
1956	320,521	172,592	66,691	32	559,836
1957	162,817	142,124	57,585	7	362,533
1958	241,813	123,346	68,559	9,108	442,826
1959	442,740	174,082	117,424	17,590	751,836
1960	470,108	218,644	145,575	6,580	840,907
1961	581,682	301,271	134,105	3,375	1,020,433
1962	689,157	263,574	103,874	20	1,056,625
1963	633,484	250,429	83,874	44	967,693
1964	599,538	237,833	66,736	84	904,141
1965	682,435	278,104	61,866	432	1,022,837
1966	555,852	190,654	38,863	7,302	792,671
1967	510,414	166,527	23,020	127	700,088
1968	622,291	149,535	51,073	457	823,356
1969	856,251	225,377	73,193	332	1,155,203
1970	959,810	205,980	43,060	617	1,209,467
1971	1,237,093	306,055	62,930	800	1,606,878
1972	928,252	178,272	–0–	600	1,107,124
1973	894,930	177,404	–0–	–0–	1,072,334
1974	1,079,304	215,674	–0–	–0–	1,294,978
1975	984,105	212,071	–0–	–0–	1,196,176

in Louisiana, 22.3% in Mississippi, 7.2% in Texas and 0.4% in Florida. 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 million pounds in 1960 and 1.2 billion pounds in 1970. Peak landings, in excess of 1.6 billion pounds, occurred in 1971, Table 3.

The Gulf of Mexico menhaden purse-seine fishery has a significant influence on the economy of the area and is the single largest fishery in the United States, a position held since the decline of Atlantic menhaden began in 1963. In 1971, a total of 2.2 billion pounds of menhaden were landed in the United States. Of this amount, 1.6 billion pounds (73% of the national total) were landed in the Gulf states. This represented 32% by weight of all species of fish and shellfish landed in the United States.

2.12 EVALUATION OF HISTORICAL PURSE-SEINE CATCH AND EFFORT DATA

Records of catch and effort in the Gulf menhaden fishery are available from about 1948. Because of rapid changes in gear efficiency in the mid-1950's, however, measures of effort are comparable only from the late 1950's to the present. The basic unit of effort has been the VTW, which is the product of a vessel's net-registered-tons (NRT) and the number of weeks it fishes each season. Historically, there has been a strong correlation between the net tonnage of a vessel and its fishing power. For the average of several vessels, the catch-per-vessel-week (CVW) increases as the NRT increases. There are, however, some problems associated with this measure of effort. In recent years, the correlation between the CVW and the NRT has declined. Increases in the number of VTW resulting from increases in the average NRT of vessels in the fleet may therefore exaggerate changes in real or effective effort. In some years when many vessels did not fish full weeks, or when their catches were reduced by factors other than decreases in fish abundance, the VTW tended to exaggerate effective effort. At the present time NMFS, Beaufort, North Carolina is exploring new ways of measuring fishing effort that will eliminate or reduce these biases.

2.13 CATCH COMPOSITION

Gulf menhaden is the principal species landed in the Gulf states. Incidental catches of yellowfin menhaden and finescale menhaden are landed. In some years, unusually large quantities of finescale menhaden are landed at Louisiana ports (Gordon Gunter, pers. comm.). Incidental catches of Atlantic thread herring also occur. The range of yellowfin menhaden and finescale menhaden indicates that larger quantities of these species may occur east and west of areas currently harvested by the fishery.

2.14 APPARENT TRENDS IN SIZE COMPOSITION DATA OF COMMERCIAL LANDINGS

From 1964, when sampling of Gulf menhaden catches first began, until the present, the average fish length has neither increased nor decreased. Annually, the mean length has varied from 147 to 165 mm FL for Age Group I fish and from 181 to 188 mm FL for Age Group 2 fish. These two ages account for 94–99 percent of the catch. The mean lengths of all fish in the samples combined has varied from 153 to 177 mm FL. Although there is annual fluctuation in mean length of Gulf menhaden, there are no upward or downward trends at present, and no indications of changes in size composition for the Gulf fishery.

2.15 SEASONAL DISTRIBUTION OF LANDINGS

Monthly landings of menhaden are shown in Figure 5 for 1971 through 1976. In most years landings reach a peak in July. In 1971 the peak occurred in June. In 1972 peak landings occurred in May and August.

2.16 YIELD

There exists several descriptive modifiers to the term yield; for example, maximum sustainable yield (MSY), maximum economic yield (MEY), optimum sustainable yield (OSY) and the like.

The term yield, as described in Webster's 3rd New International Dictionary, Unabridged, is as follows: "the quantity of a product resulting from exploitation of natural resources. (Ex: fishermen are finding that the yield per hour of trawling is dropping)."

Optimum yield is defined as that part of a fishery that will provide "the greatest overall benefit to the nation, with particular reference to food production & recreational opportunities. . ." In other words, a variety of economic, social and ecological factors are taken into account as well as biological factors.

Ricker (1975) defines various aspects of fishery yield with modifiers as follows:

> EQUILIBRIUM YIELD (Y_E): The yield in weight taken from a fish stock when it is in equilibrium with fishing of a given intensity, and (apart from effects of environmental variation) its biomass is not changing from one year to the next. Also called: sustainable yield, equivalent sustainable yield.

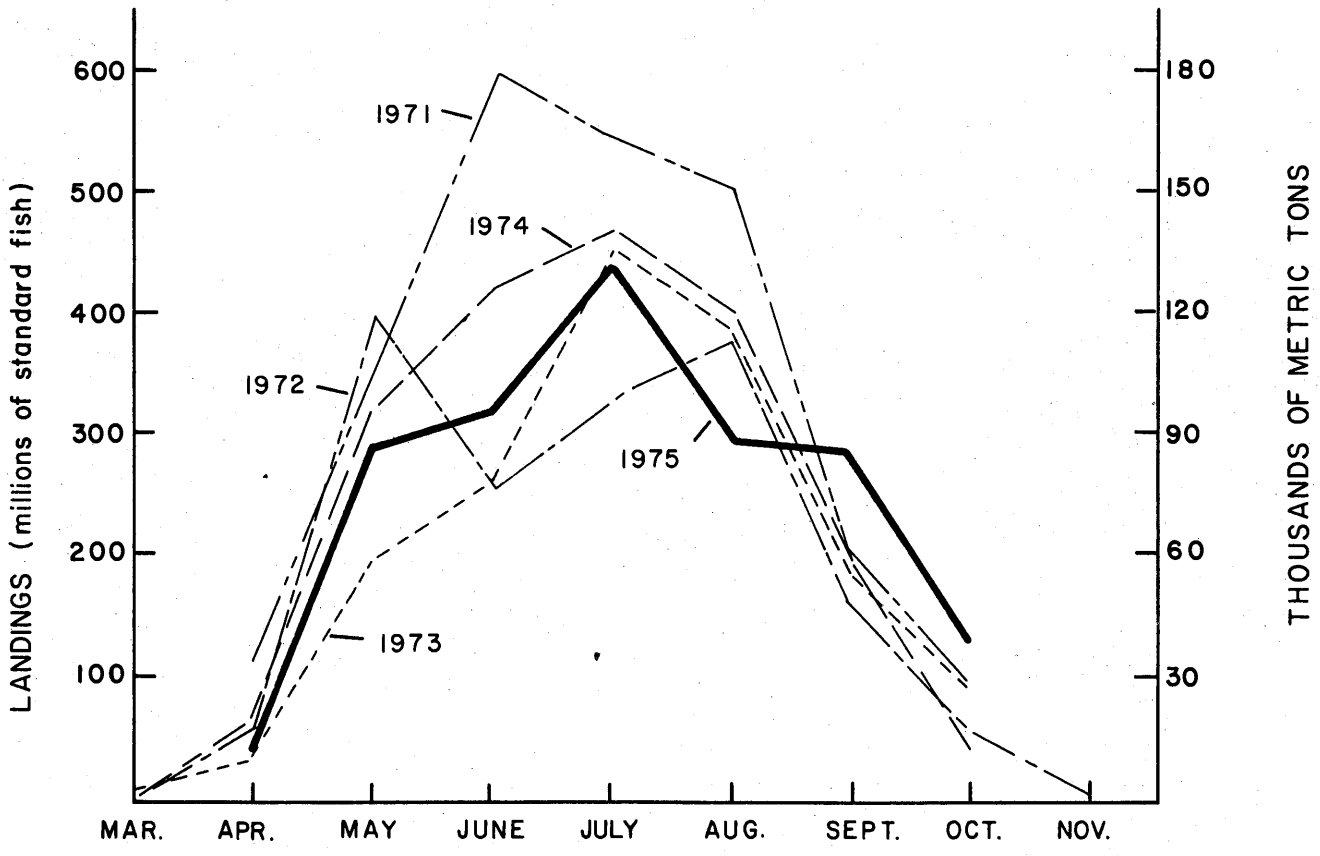


Figure 5. Gulf menhaden landings, 1971–1975 (monthly).

MAINTAINABLE YIELD: "The largest catch that can be maintained from the population, at whatever level of stock size, over an indefinite period. It will be identical to the sustainable yield for populations below the level giving the MSY, and equal to the MSY for populations at or above this level" (Gullard).

MAXIMUM EQUILIBRIUM CATCH (See MAXIMUM SUSTAINABLE YIELD).

MAXIMUM SUSTAINABLE YIELD (MSY OR Y_s): 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.) Also called: maximum equilibrium catch (MEC); maximum sustained yield; sustainable catch.

SUSTAINABLE YIELD: Equilibrium yield.

Eldridge (1974) discussed yield strategies as follows:

Gulland and Boerema (1973) have described a number of yield strategies for managers of commercially exploited species. This section relies heavily upon their ideas; readers are urged to review their article for additional details.

The concept of maximum sustainable yield (MSY) has gained wide recognition in the field of fisheries management, and an estimated MSY for penaeid shrimp in the Gulf of Mexico was recently put forth by Griffin, et al. (1973). Some comments are warranted relative to the properties and limitation of the MSY concept, and whether it is applicable to the southeastern Atlantic shrimp fishery.

The MSY concept treats the population as a single unit and ignores all disturbing influences on the population other than removals by man (Gulland and Boerema, 1973). The model also assumes that recruitment to the population will depend only upon the biomass of the population, with low recruitment resulting when the abundance of the population is either relatively high or low and a maximum recruitment resulting when the population is at an intermediate level of abundance, perhaps 1/3 to 2/3 of the virgin state. Silliman (1971) discussed the advantages and limitations of "simple" fisheries models which have been used extensively to estimate maximum sustainable yields, namely the logistic described by Schaefer (1954, 1957), an adaptation of the Gompertz growth curve developed by Fox (1970), and a generalized model which includes the other two as special cases (Pella and Tomlinson, 1969). All of these models assume that the exploited population will attain states of equilibrium permitting a rather constant level of recruitment for a given size of parental stock. Thus, the simple models do not have the capability of coping with significant lags in recruitment, pronounced changes in climatic conditions which may alter the basic growth curve of the population, or the situation in which the pattern of exploitation is such that the exploited component of the population never achieves a state of equilibrium. Moreover, these models are generally employed in fisheries where the catch has significant components of two or more year classes, and there is evidence that the level of exploitation on one year has an impact on the abundance of the stock in future years.

In addition to the biological problems associated with MSY, economists (Christy and Scott, 1965) have roundly criticized the concept because it does not consider economic objectives such as maximizing employment or potential economic rent which could be derived from an ocean resource. Further, the MSY concept does not adequately account for sociological and institutional constraints which often limit management alternatives, particularly when diverse user groups exploit a common resource.

Work on yield estimates for Gulf menhaden yield is described in "The Gulf Menhaden Fishery, A Discussion Paper" (1976) as follows:

Analysis and Status of the Gulf menhaden fishery: The NMFS menhaden staff at Beaufort, North Carolina, has more recently focused attention on the development and refinement of methods for predicting landings and for estimating optimum yields. As summarized by Schaaf, Sykes and Chapoton (1975) it appears that one population of Gulf menhaden ranging from southern Florida to Yucatan supports the current fishery from Florida to Texas. Although the longevity of Gulf menhaden may be 5 years, the fishery is supported mainly by age 1 and 2 fish. Some age 0 fish are recruited in late summer, but most are recruited at age 1. Apparently there is no extensive coastwise movement of fish by age and size throughout the fishing area. They move out of coastal waters in October and November to offshore areas in the Gulf and return to coastal waters in March and April. Fishing occurs from April to October. The magnitude of the landings during a fishing season can be reasonably predicted one year in advance.

Catch Forecasting: According to Schaaf, Sykes, and Chapoton (1975), a multiple regression equation using catch and effort data provides a reliable method of estimating catches in the Gulf fishery. The equation that was developed accounted for 86 percent of the variance between actual and estimated

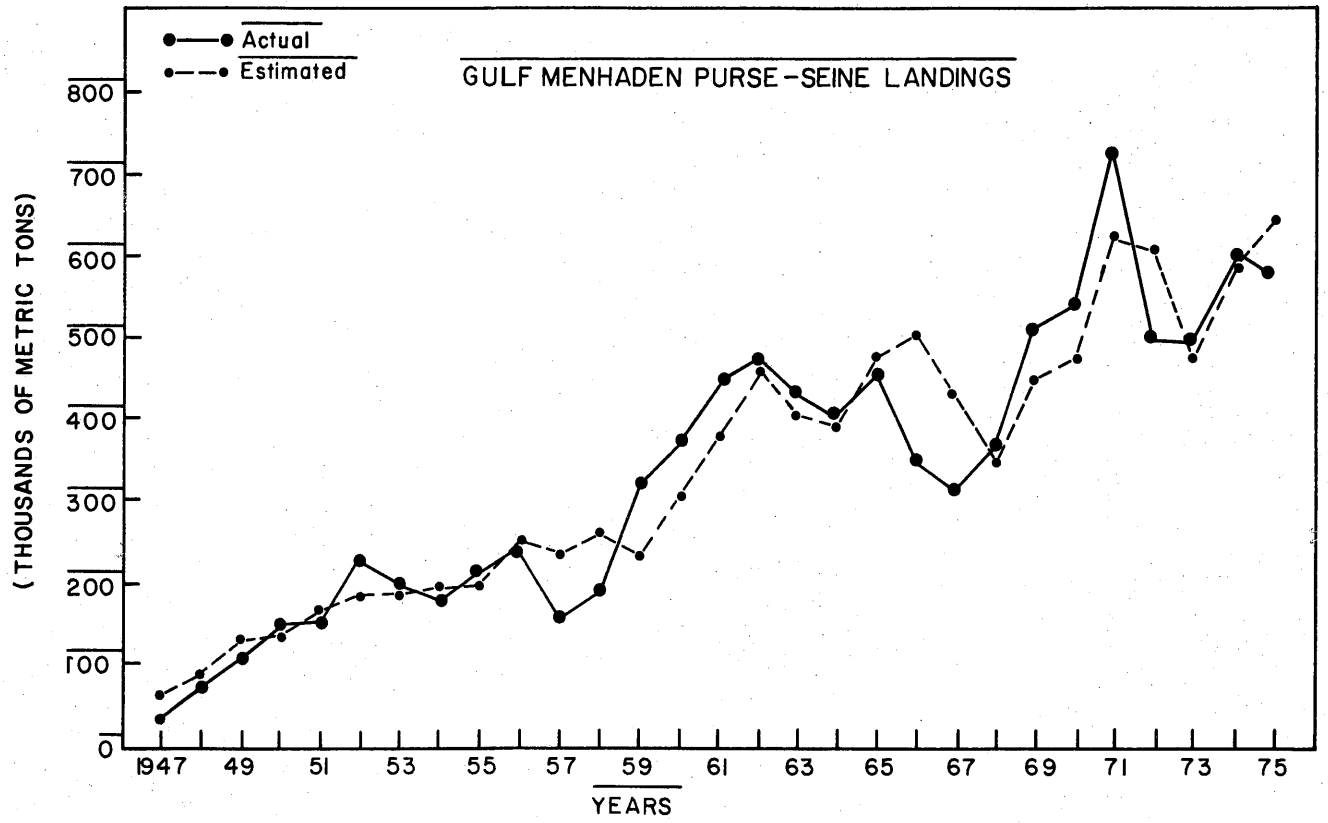


Figure 6. Actual and estimated landings of Gulf menhaden in thousands of tons by multiple regression, 1947–1975.

catches over a 27-year period, 1946–72 (see Figure 6). Agreement between actual and estimated catches was closer during the earlier years of the fishery (1947–1956) than during later years (1957– 1972). Greater divergence during the later years was attributed to variations in year-class strength exerting more influence attendant with increases in effort and catch. Since age 1 and 2 fish constitute the bulk of the catch, variations in year-class strength have a considerable effect.

This model has been updated by Chapoton to include estimated and actual catches for recent years (see Figure 6). In 1973, actual catches differed from those forecast by 2 percent after adjustments for fishing effort were made. In 1974, the actual catch was 1 percent greater than the predicted, and in 1975, actual landings were 17 percent lower than the predicted catch. Considering the structure of the fish population and that the model does not incorporate other variables such as juvenile abundance, weather conditions and the like, estimates for the past 3 years (1973–1975) have been reasonably accurate. Average yield, therefore, can be reasonably predicted for a given level of effort.

MSY Estimation: Schaaf (1975) discussed the Gulf menhaden fishery up to the 1973 fishing season. Since that time, data for three additional fishing seasons (1973) have become available and have served to update various calculations, including estimates of MSY. Accordingly, the MSY values estimated from the 1946–1972 catch and effort data are presented as well as the values derived when the 1973–1975 data are included.

Figure 7 shows the estimated average maximum sustainable yield for the Gulf menhaden purse-seine fishery based on catch/effort data from 1946–1972 as 478,000 metric tons with 460,000 units (vessel-ton-weeks) of fishing effort. When the data for the three most recent points (years 1973–1975) on the graph are included in the calculation, the estimated MSY increases to 496,000 metric tons with 482,000 units of effort.

As stated by Schaaf (1975) the Schaefer-type, or linear surplus yield model "required only catch and effort data (and provides a minimum amoung of insight into the dynamics of the stock and should be used with a great deal of caution in formulating any management plans. Deducing the long-term response of the stock to exploitation from a model of this sort is extremely uncertain, unless information on age structure, growth rates, and mortality rates is considered also. One especially troublesome technical

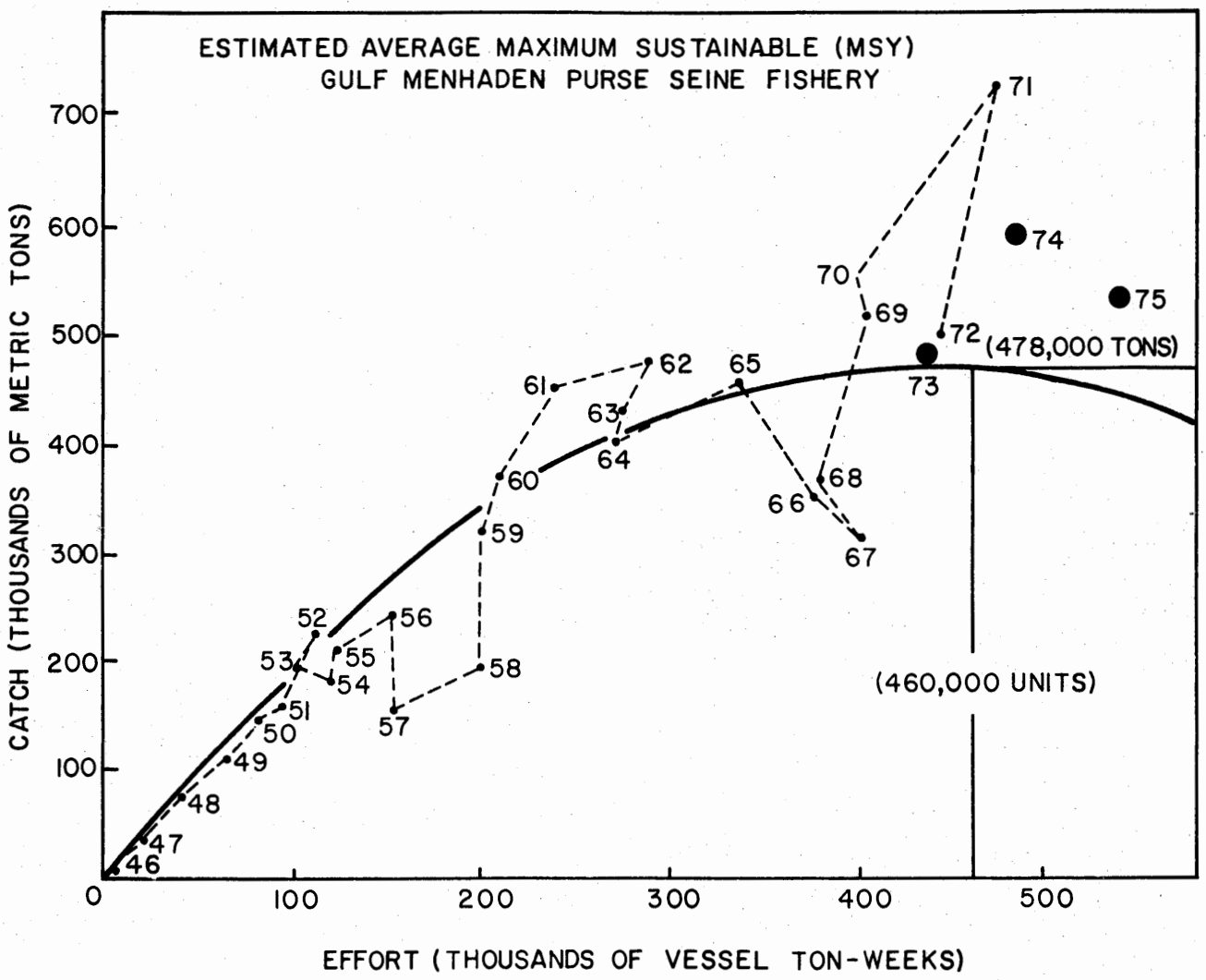


Figure 7. Estimated average sustainable yield of the Gulf menhaden purse-seine fishery, 1946–1975.

difficulty with this approach is the sensitivity of the parameters (which determine the maximum catch and associated effort) to the data set included in the calculations. An estimation of the maximum catch is especially uncertain when there are no data points on the descending portion of the curve."

The economic impact of low approximations of MSY becomes evident when estimates are compared using catch/effort data compiled from 1946 through each of the years 1970, 1972, and 1975. Data through 1970 provide an MSY estimate of 430,000 metric tons (Chapoton, 1972); data through 1972 provide an MSY estimate of 478,000 metric tons (Schaaf, 1975); while data through 1975 provide a further increase in estimated MSY to 496,000 metric tons. If catches had been limited to the most recent estimates of MSY during the intervening fishing seasons from 1970–1975, industry would have suffered substantial losses. For this reason, MSY estimates must be adjusted annually and must incorporate sufficient flexibility (confidence limits) to avoid resource wastage and concomitant economic losses to the industry and society.

Chapter 3. Present Management System and Associated Problems

Present System. Menhaden management at the present time is left mainly in the hands of the industry which harvests the resource on an economic basis. The states exercise few management controls other than setting of seasons and defining sanctuary areas in response to pressures generated by long-standing institutional conflicts. This system has worked quite well in the past but concern for this valuable fishery resource has increased since the decline in Atlantic menhaden stocks and as the estimated MSY for Gulf menhaden, based on current technology, is presently being harvested.

The present system is not flexible enough to readily incorporate biological and other pertinent data into management procedures which suffer from political pressures generated by the public's adverse reactions to certain menhaden harvesting techniques. A continuing problem of management has been to counteract the largely unwarranted reactions of the public.

3.1 PRESENT STATE MANAGEMENT SYSTEMS

A synoptic review of the state's management structures and other features pertinent to the Gulf menhaden fishery is presented in Table 4. A more comprehensive review by state follows.

3.1.1 Florida (taken from Knight and Jackson, 1973 and Calder et al., 1974)

Administrative Organization. The agency charged with the administration, supervision, development and conservation of the natural resources is the Department of Natural Resources which is headed by an Executive Director. Within the Department there exists the Division of Marine Resources whose duties include the preservation, management and protection of marine fisheries, and the regulation of all fishing operations in the state and of its citizens engaged in fishing activities within and without the State. In Florida, the Governor and the elected Cabinet sit as a board which approves all rules and regulations promulgated by the Director of the Department. The state does not have a board or commission of natural resources or conservation.

Legislative Authorization. The rules applicable to coastal fisheries are contained in Chapter 370 of the Florida Statutes Annotated. The statutes encompass: (a) license and licensee fee provisions; (b) enforcement; (c) seafood dealers; and (d) general gear restrictions.

A unique feature of Florida statutory law, at least in the past, has been the existence of "local laws" and "general bills of local application." The 1973 Florida Legislature passed Bill 73-208 which provides:

> The power to regulate the taking or possession of salt water fish. . .is expressly reserved to the state.

It should be noted, however, that the preemption bill only affects those local laws and general bills of local application which have actually been adopted as county ordinances. Apparently some local laws and general bills of local application have not in the past been adopted as county ordinances and are therefore not affected by the preemption bill. It is not possible from a reading of either statutory or regulatory law to determine which is the case and a review of the filing records with the Secretary of State is required.

Licenses.

Purse Seine License—An annual license fee of $25.00 is required for operation of a purse seine in Florida waters (Chapter 370.06, F.S.).

Alien and Nonresident Commercial Fishing License—Aliens and nonresidents pay an annual license tax of $25.00 to fish commercially in Florida waters (Chapter 370.06, F.S.).

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

All boats less than 12 feet (length)	$ 2.00
More than 12 but less than 16 feet	6.00
More than 16 but less than 26 feet	11.00
More than 26 but less than 40 feet	31.00
More than 40 but less than 65 feet	51.00
More than 65 but less than 110 feet	71.00
110 feet or more	76.00
Dealer classification	10.00

An additional fee of $50.00 is required of aliens and nonresidents (Chapter 371.65, F.S.)

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

Resident wholesale dealer	$100.00

TABLE 4.

Synoptic overview of present State management systems.

	Florida	Alabama	Mississippi	Louisiana	Texas
Administrative Organization	Department of Natural Resources, Division of Marine Marine 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	Mississippi Marine Conservation Commission	Louisiana Wild Life and Fisheries Commission	Parks and Wildlife Department; Fish and Wildlife Division, Branch of Coastal Fisheries
Legislative Authorization	Chapter 370: Florida Statutes Annotated. Allows for local laws and "General Bills of Local Application."	Title 8, 1940: Code of Alabama. Some Statutory Laws Concerning Fisheries	Chapter 15; Article 1 Mississippi Code of Statutes, Annotated. Some Statutes Concerning Fisheries	Louisiana Const. Art. VI, Sec. 1. Some Statutes Concerning Fisheries	"Uniform Wildlife Regulatory Act" (Vernon's Ann. P.C. Art. 978j-1) 2 counties are excluded.
Licenses	Purse Seine–$25 Non-Resident–$25 Purse Boat–$31 Carrier Vessel–$76 Dealer Classification–$10 Wholesale Dealer Resident–$100 Non-Resident–$150 Alien–$500	Purse Seine–$200 No vessel fees	Each net, type or size–$50 Each vessl–$50 Plant–$500	Purse Seine over 1000′–$50 Vessel over 50′–$50 Wholesale Dealer–$50	Purse Seine–$1.00/100′ Each vessel–$200 Plant–$50
Taxes	None	None	None	None	None
Reciprocal Agreements	Limited to fishery access, may not extend to management agreements	Limited to fishery access	Possible in all areas of fishery access, research and management	Limited to fishery access, Texas and Mississippi	None possible
Regulations Season	None set	Third Monday in April–Second Tuesday in October	Same as Alabama	Same as Alabama	April 1–November 30
Mesh Size	None set	None set	None set	Not less than 1 3/4″ stretched	Not less than 3/4″ bar
Net Length	None set	None set	None set	None set	None set
Sanctuaries	See Figure 5	See Figure 6	See Figure 7	See Figure 8	See Figure 9
Other	No food fish other than tuna may be taken in a purse seine	None	1. Each company must report landings and catch data to MMCC 2. Companies must clean up any beach spill they incur.	No explosives or electrical devices may be used for taking or finding fish.	1. No edible products can be taken for sale, barter or exchange in purse seines. 2. Other edible products may not exceed 5% by volume of catch.
Penalties	A fine of not more than $500 and/or 1 year in a county jail and possible seizure and forfeiture of any equipment used in illegal fishing.	$25 to $100 and possible imprisonment for non-payment of fine.	1st–$50 to $100 2nd–$100 to $500/or 30 days or less imprisonment 3rd–Revocation of license for 1 year	1st–$200 to $500 and/or 15 to 30 days imprisonment 2nd–$500 to $1,000 and 60 to 90 days 3rd–$750 to $1,000 and 90 to 120 days and revocation of license for 1 year Provisions for seizure and forfeiture of equipment	1st–$20 to $100 and possible license suspension 2nd–$50 to $500 and possible license revocation

Nonresident wholesale dealer	$150.00
Alien wholesale dealer	500.00

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.

Regulations. The rules applicable to coastal fisheries are contained in Chapter 16B of the Florida Administrative Code. The regulations concerning menhaden generally reiterate the statutory provisions, or amplify them, with very little management discretion being left to the Department.

Several deserve recognition in this document. Chapter 370.08, 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 net in its territorial waters (see Figure 8).

Scientific Collecting Permits. Such permits are available from the Division of Marine Resources upon request, and the Division's approval.

Penalties for Violations. Section 370-021(2) specifies general penalties for violations of the provisions of Chapter 370, unless otherwise provided. This section provides for a fine of not more than $500.00, or imprisonment for 1 year in the county jail, or both. Other sections provide that fishing gear, vessels, catch, and vehicles shall be seized upon arrest and conviction for illegal taking, sale, possession, etc., of saltwater fish or fishery products in Florida.

3.1.2 ALABAMA

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. The Department's authority over marine fisheries is contained in Code of Alabama, Title 8, 1940. Authority to establish regulations is contained in Title 8, Section 4.

Reciprocal Agreements. The authority to enter into reciprocal agreements with other states is contained in Title 8, Section 171 (13a). It authorizes nonresidents to fish in Alabama waters on a reciprocal basis if they reside in a state where Alabama fishermen are not required to purchase nonresident fishing licenses.

Laws. The only law concerning menhaden requires a $200 license on purse seines. Vessels are not licensed.

Regulations. The only Departmental regulations concerning menhaden restrict fishing to areas of Mississippi Sound and the Gulf of Mexico within Alabama territorial waters west of a line extending south from Marsh Island to Intrrcoastal Waterway range "C" then due south into the Gulf for a distance of 3 miles. The regulation also prohibits fishing within 1 mile of the west end of Dauphin Island (Figure 9). The menhaden season is set from the third Monday in April through the second Tuesday in October.

3.1.3 Mississippi

Administrative Organization. The administrative organization of the State of Mississippi with respect to coastal fisheries is the Mississippi Marine Conservation Commission (MMCC). The Commission consists of 13 members, 9 of which are appointed by the governor. The remaining four are directors of the following agencies: the Boat and

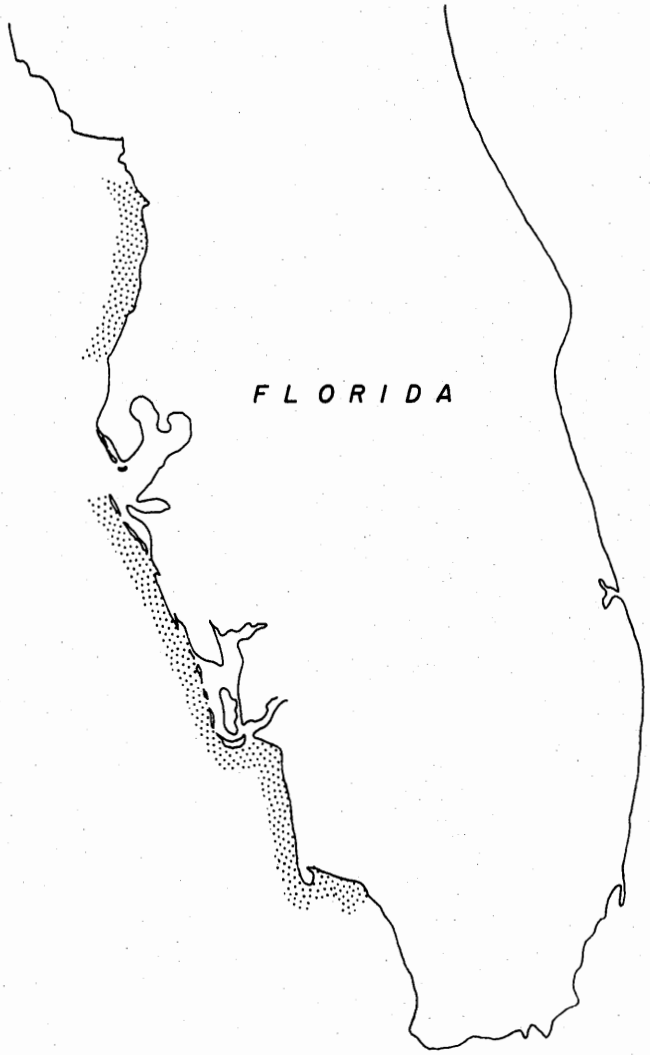


Figure 8. Areas closed to menhaden fishing by purse-seine in Florida.

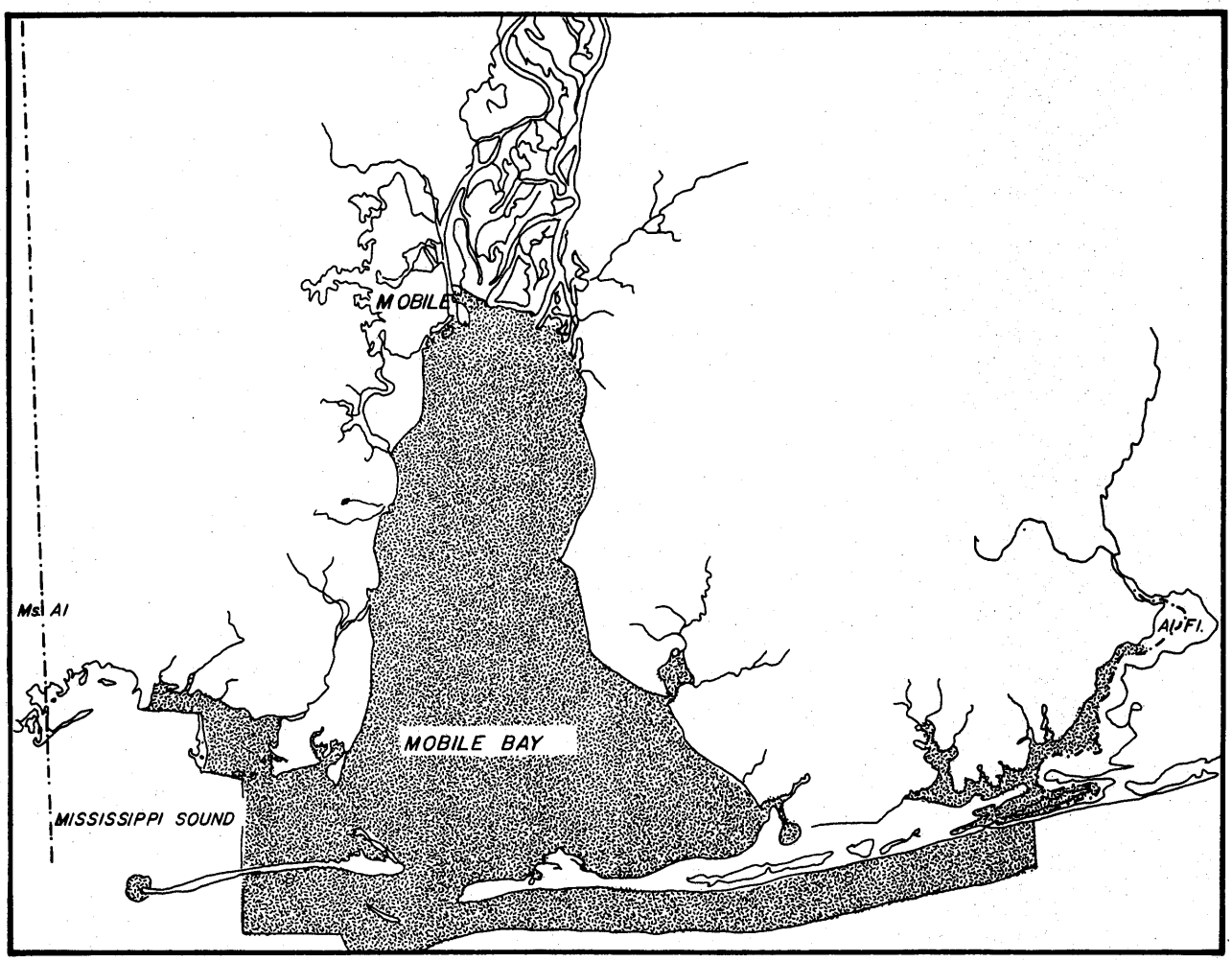


Figure 9. Areas closed to menhaden fishing by purse-seine in Alabama.

Water Safety Commission, the Marine Resources Council, the Gulf Coast Research Laboratory, and the State Board of Health. The Commission is headed by a director hired by the Commission.

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

Legislative Authorization. Statutory provisions are set forth in Chapter 15, Article 1, paragraphs 49-15-1 thru 49-15-69. The Act gives the Commission 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.

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

License for each plant or factory	$500.00
License for each net, type or size	50.00
License for each boat or vessel in catching or transporting menhaden	$50.00

There are no taxes levied on menhaden taken from Mississippi waters.

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.

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 ($50.00), nor more than ($100.00), for the first offense; and not less than ($100.00), nor more than ($500.00), or imprisonment in jail for a period not exceeding (30) days for any subsequent offense; and upon the conviction of a third offense, it shall be the duty of the court to revoke the license of the convicted party and of the boat or vessel used in such violation, and no further license shall be issued to such 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 1 year following such conviction.

Regulations.

1. Fishing for menhaden is prohibited within 1 mile of the shoreline of Harrison and Hancock counties (Figure 10).
2. Menhaden companies are responsible for beach clean-up of any fish spill they incur.
3. The menhaden season is set by statute as to open on the 3rd Monday of April and close on the 2nd Tuesday of October. Seasons may be opened earlier or closed later by action of the MMCC.
4. Each menhaden company is required to report its landings and pertinent catch data (e.g., number of sets, catch locations, etc.) to the MMCC.

3.1.4 Louisiana (from Knight and Jackson, 1973)

Administrative Organization. The Louisiana Wild Life 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 Director of Wild Life and Fisheries is an appointee of the Commission to serve at its pleasure. The Director's duties consist of serving in an administrative and executive capacity "in accordance with the policies. . .of the Commission." The Director is accorded the duty of preparing and recommending wildlife regulations to be considered for adoption by the Commission. Within the administrative hierarchy, the Assistant Director is responsible for the administration of "commercial fur and fishing laws of the state." Finally, below the Assistant Director is the Division Chief of Oysters, Water Bottoms and Seafoods.

Legislative Authorization. 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.

Licenses and Taxes. Louisiana license fees include:

License for menhaden net over 1,000 feet	$50.00
Wholesale dealer license	50.00

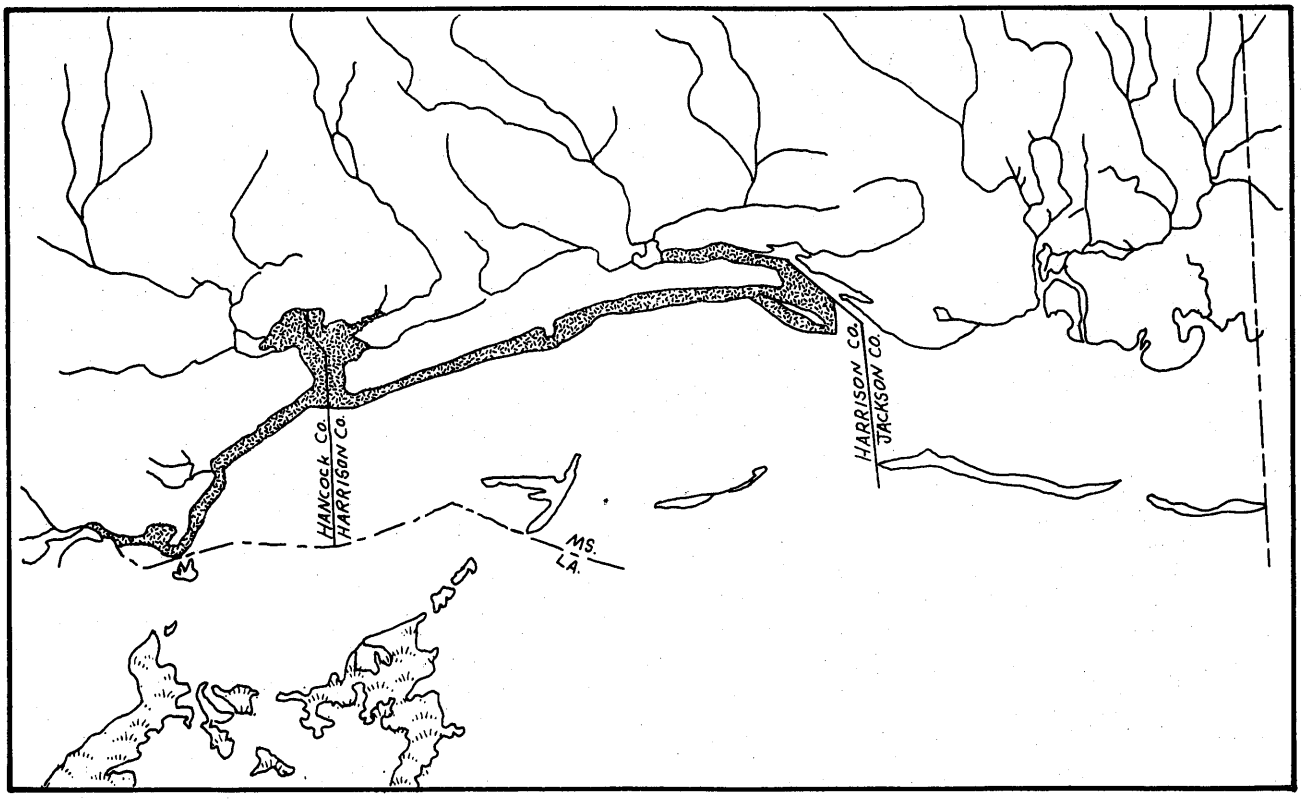


Figure 10. Areas closed to menhaden fishing by purse-seine in Mississippi.

License for commercial fishing vessel over 50 feet	$50.00

Reciprocal Agreements. The Louisiana Wild Life 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. The former appears to be restricted to fishing license agreements only and would not contemplate broader management systems. The latter statute does not seem to be applicable to coastal fisheries management agreements since the Gulf of Mexico is not a body of water which forms "the common boundary" between Louisiana and the reciprocating states.

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

Penalties for Violations. Unless otherwise specified a mandatory fine of $200–$500, jail sentence of 15–30 days or both are provided for first offenders; a fine of $500–$1,000 and 60–90 days in jail for second offenders; and for third and subsequent offenses, a fine of $750–$1,000 and 90–120 days in jail plus revocation of license for 1 year. There are also provisions for seizures and forfeiture of vessels or equipment used illegally.

Scientific Collecting Permits. The Louisiana Wild Life and Fisheries Commission 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 commission 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 Commission. The director may issue permits to any persons to take fish for scientific or educational purposes or for propagation or for 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 Commission, 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.

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.

Regulations.

1. The menhaden season is set as the third Monday in April to the second Tuesday in October.
2. Purse seines must be of a mesh size not less than 1 3/4-inch stretched.
3. Menhaden fishing is restricted to waters seaward from 750 feet from the inside shrimp line in LaFourche and Terrebonne Parishes (Figure 11).
4. Sanctuaries in which menhaden fishing can be excluded can be formed under Louisiana law. At this time this sanctuary provision is in effect in waters within 3 miles of Grand Isle, Louisiana.
5. Menhaden may not be fished in inside waters west of the Mississippi River (Figure 11).
6. Fish may not be taken by poisons, explosives, electricity or any instrument or device capable of producing an electric current used in shocking said fish.

3.1.5 Texas (taken from Knight and Jackson, 1973)

Administrative Organization. The lead agency for coastal fisheries management in Texas is the Parks and Wildlife Department and the policy function has been assigned to the 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 that 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.

Legislative Authorization. The basic fisheries management law in Texas is the "Uniform Wildlife Regulatory

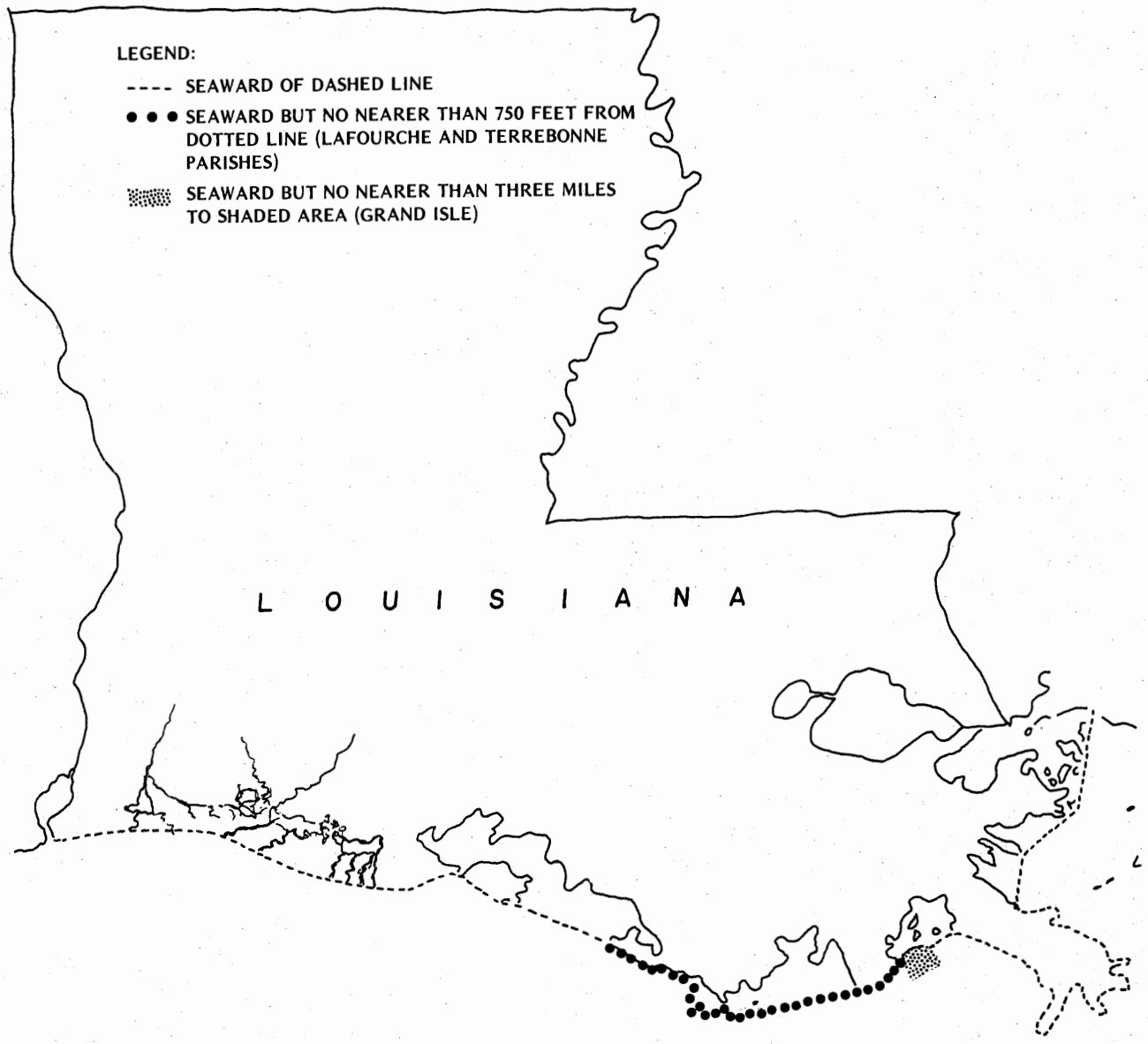


Figure 11. Areas closed to menhaden fishing by purse-seine in Louisiana.

Act." However, coastal waters of two of the eighteen coastal counties are excluded from the Uniform Act.

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

Menhaden fish plant	$ 50.00
Each boat	200.00
Net size $1.00 per 100 feet	

There are no taxes levied on menhaden taken in Texas waters.

Reciprocal Agreements. The State of Texas has, at the present time, 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.

Regulations. The Commission has authority to establish all rules and regulations permitted by statute concerning coastal fisheries within its jurisdiction. Texas has both little flexibility and complications arising from the "county option" regulatory system now in effect.

Penalties for Violations. Fines and penalties for violations of Texas menhaden regulations: On first conviction,

$20 to $100 and possible license suspension; on second and subsequent convictions, $50 to $500 and possible license revocation.

Limited Entry. In 1949 the Texas Legislature enacted a law providing for limited licensing of commercial fishing vessels. The provision allowed the Fish and Game Commission discretion 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.

Regulations.

1. The menhaden season is set from April 1 through November 30.
2. Fishing is not allowed in the waters of Chambers and Galveston counties (Figure 12).

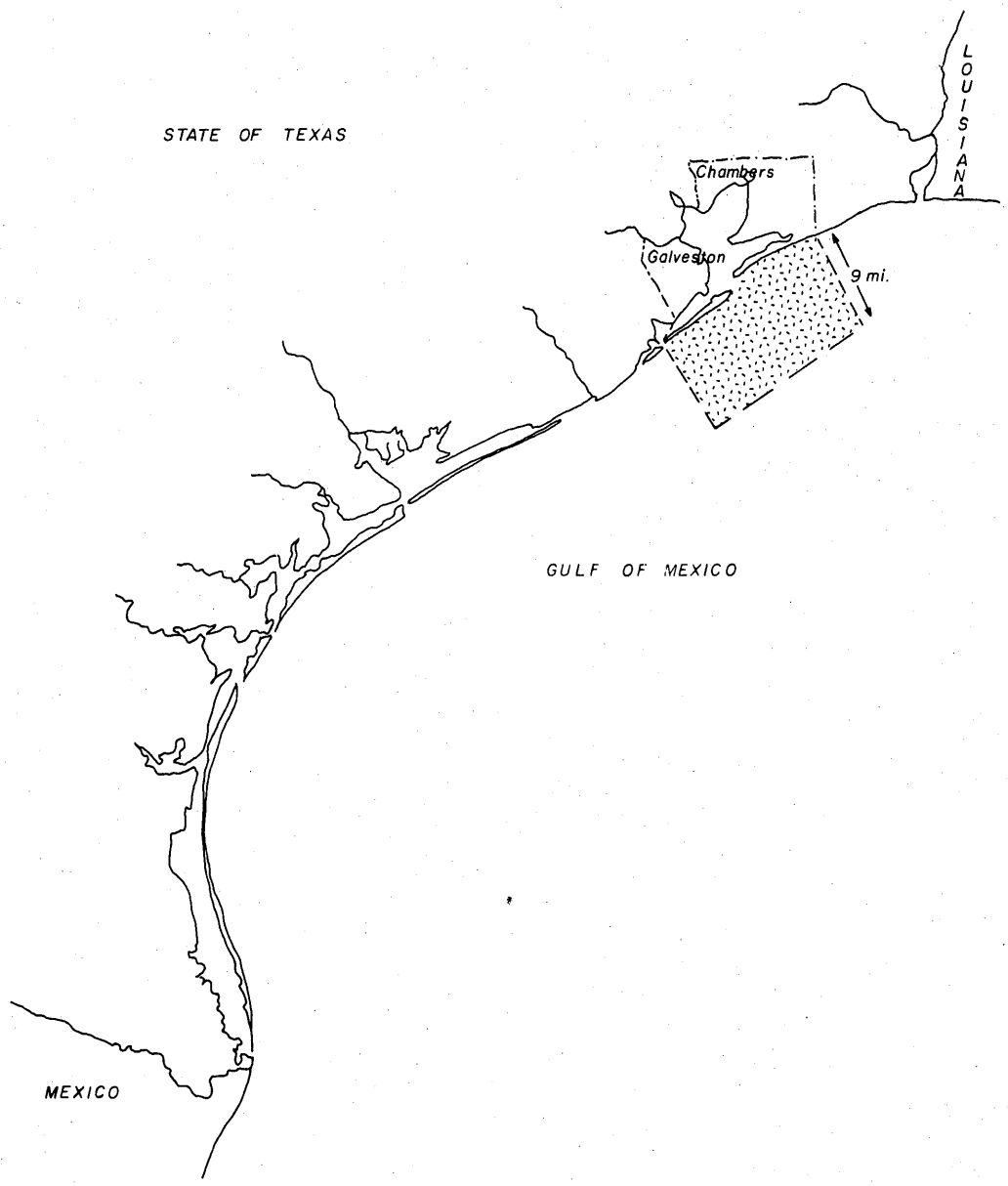


Figure 12. Areas closed to menhaden fishing by purse-seine in Texas.

3. Purse seines must not be a mesh size less than 3/4 inch-bar.

4. Menhaden may not be fished in any bay, river, pass, within 1/2 mile from shore in Gulf waters or within one mile of any jetty or pass (Figure 12).

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

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

3.2 IDENTIFICATION OF PROBLEMS

To properly develop a management plan for a fishery resource, an awareness of problems and potential problems within the fishery is necessary.

The Gulf Menhaden Management Task Force addressed this question and enumerated the following problems. The numerical arrangement does not imply an attempt to prioritize these items in terms of any subsequent research timetables.

3.3 PROBLEMS ANNOTATIONS

3.3.1 Biological

1. Inadequacy of data to establish a satisfactory estimate of maximum sustainable yield of all menhaden stocks.

a. Estimate MSY for Gulf menhaden. Several problems identified by the Gulf Menhaden Task Force logically fall into one major problem area—that of identifying the effects of fishing on the stocks and the subsequent calculation of MSY. To determine the impact of fishing, and to determine dynamics of Gulf menhaden, the following problems have been grouped:

Inadequate estimate of MSY for menhaden
Estimates of unit of effort, as currently used, require better input data.
Natural mortality of menhaden is unknown
Biological Break Even Point (BBEP) for menhaden stock(s) has not been clearly defined.

b. Management of the Gulf menhaden is dependent on the establishment of a maximum sustainable yield value which can be used with economic and social information for the development of an optimum yield. The MSY value is obtainable through analysis of catch/effort data and through knowledge of reproductive potential, natural mortality and yield per recruit. This information has not yet been established.

The solution to establishment of MSY in the Gulf of Mexico hinges on a resolution of problems identified in the determination of a unit of effort which effectively describes fishing pressure, which can be back calculated to provide a historic catch/effective effort data base. Once an effective unit-of-effort has been established, fishing mortalities can be determined and natural mortality rates can be calculated from the present data base on total mortalities. The BBEP cannot be determined until an MSY curve is calculated. Determination of the BBEP is necessary to insure the continuance of the resource.

c. Change in the efficiency of the menhaden fishery has created a situation where the effective effort of a vessel has increased in relation to the total stock of Gulf menhaden. Efforts have been underway by NMFS since the late 1960's to standardize effort and to account for technological improvements. These efforts have been unsuccessful to date.

2. Annual fluctuations of menhaden population are not satisfactorily predictable.

a. Since year-class strength is strongly influenced by environmental factors, problem "Inadequate Knowledge of Environmental Factors that Influence the Abundance of Menhaden" is included under the general problem of predicting year-class fluctuations.

b. Environmental conditions that favor or inhibit growth and abundance, spawning and spawning success, migration of young, etc., have not been defined. Prediction of the number of fish available for harvest is not practical at the current level of knowledge.

c. Reasons Why the Problem Exists

1) Lack of data on natural mortality; 2) Lack of data on environmental factors that influence menhaden abundance; 3) Lack of data on catch of menhaden by other fisheries; 4) Lack of funding for items 1, 2 and 3.

3. Knowledge of menhaden year-class composition, and distribution beyond the currently exploited fishing grounds have not been determined.

a. Work has not been undertaken to determine if any appreciable numbers remain offshore throughout the year and do not enter the fishery. Information of the biology of menhaden in offshore waters is scanty.

b. 1) Lack of funding for offshore research; 2) Difficulty in pursuing offshore research on a pelagic, schooling species.

4. Detailed location data concerning the menhaden catch is not available.

a. Data on actual catching sites and all set sites are required.

b. This information has not been made mandatory for release.

5. Current annual estimates of juvenile populations cannot be satisfactorily used for predictive purposes.

a. Current estimates are not made on extensive enough data and background knowledge, such as natural mortality, is lacking. This deficiency has not allowed for following the juveniles to catchable size.

b. A historical data base involving these aspects has not been broad enough to date to construct a predictive model. The level of predictive precision and accuracy desired has not been defined. This level will be

required to select both a method of sampling and the degree of effort expended.

6. Stock composition of Gulf menhaden has not been adequately determined.

Existing investigations indicate that the Gulf menhaden in the northern Gulf is a panmictic species; however, tagging experiments indicate that there is little migration between fish stocks east and west of the delta. If separate stocks do exist, it may be necessary to devise different management procedures for each stock.

7. Inadequacy of data to establish a satisfactory estimate of optimum sustainable yield of all menhaden stocks.

Accurate estimates of OSY is necessary to insure maximum benefits for both the industry and the consumer. Data is not available to ascertain MSY, ESY or social inputs to produce the needed OSY figures. Research is needed in all these fields.

8. The interaction between menhaden and other fisheries is relatively unknown.

Existing data on the bycatch and catch of other fisheries (notably the inshore shrimp and industrial bottomfish) are not sufficient to indicate their impact on menhaden populations although research into the shrimp bycatch is now underway and preliminary results indicate the impact may be considerable. Updating the studies done on the species composition of the menhaden catch and its impact on other fisheries (notably the recreational fishery) is also needed.

3.3.2 Economic

1. Lack of knowledge of areal and seasonal age and size variations in fat, moisture, ash and protein components in menhaden.

The lack of information in these areas hinders the industry in assessing the economic potential of fish from a certain area or at a certain time during the season. Advance information on these factors could allow for more efficient operation of plants and allocation of fishing time. If the fish from a certain area or time of the season were found to be "richer" in these biochemical components than those from another area or time during this season, the economic return would be greater from fishing the "richer populations.

2. Inadequacy of available data to establish satisfactory estimate of economic sustainable yield of all menhaden stocks.

This data, although on hand within individual companies, is not available on an industrywide basis. Managers lacking this type of data are not able to make decisions that provide for the most benefits for both the industry and the public.

3.3.3 Social

1. Lack of adequate sociological data for input into management considerations.

The management of any fishery, with respect to the concept of optimum yield and other management objectives, must be based on adequate knowledge of the preference patterns, traditions, values and lifestyles of all of the people involved in the fishery. Research should be performed by trained social scientists in order to enhance a properly balanced management program.

2. Lack of knowledge and documentation of the political/legal systems involved in coordinating management schemes on a regional basis with respect to the Gulf menhaden industry.

Once baseline data in the areas of biology, sociology, economics and ecology have been established, it is necessary to become familiar with the legal and political systems which are necessary to the implementation of fishery management schemes. A lack of scientific collection and presentation of information of this sort may lead to decision-making based on misinformation, uninformed opinion or historical perceptions which may create artificial blockages to cooperation and effective fisheries management.

3. Lack of understanding of the relationship between the menhaden industry, the general public and other resource users in the social environment.

An effective fishery management plan must take into account the relationships between the various users of the resource and members of the general public who are involved in the biological and social ecology of the fishery system. Lack of information and education concerning the goals, practices and policies of the fishing industry, or false impressions or distortions of these matters, may combine with ignorance of the role and importance of the fishing industry in local cultural and economic systems to produce unnecessary conflict and create impediments to rational management.

3.3.4 Other

1. Development of more energy-efficient methods of hauling the catch to the processing plants.

The contemporary menhaden carrier vessel is designed to meet critical criteria-speed and hold capacity. To satisfy these criteria it takes high horsepower engines with high fuel consumption rates. Large savings in fuel, as well as fuller utilization of boats and crews, could be achieved if the vessel could remain on the fishing grounds for as long as a week instead of periodically hauling the catch to the processing plants during that week.

2. More efficient fish-spotting techniques.

Spotter aircraft are presently used extensively for scouting and directing in the fishing operation. Since each company has its own fleet of aircraft, there is much duplication of effort for fleets working the same area.

3. More cost-effective vessel unloading system.

The average carrier vessel has refrigerated holds

with total capacities of 1 to 1.5 million fish. Unloading at the processing plants is done with gear pumps requiring hold flooding to move the fish through 10-inch pipes and hoses. Pollution abatement requires judicious but costly disposition of pump water. A cost-effective system to minimize or eliminate the use of pump water is urgently needed.

4. Improvement in purse-boat safety.

Transfer of personnel to and from the carrier vessel as now practiced is somewhat hazardous at times. A large number of accidents in menhaden fishing operations occur in transferring to and from the purse boats.

5. New seining gear and methods.

The two-boat purse seine presently used by the industry is very efficient as a harvesting system but requires a large crew to handle. The large crew represents a significant overhead cost, but more importantly, results in many lost fishing days because of the problems associated with hiring and maintaining the number of people necessary to fish the two-boat purse seines.

6. Deficiencies, if any, of the menhaden purse seine are not defined.

An operational in-situ evaluation of the purse seine is needed to determine if deficiencies exist that can be corrected to increase production efficiency.

7. Evaluations of the menhaden purse seine and vessels are not available.

The operational characteristics of a carrier vessel, its purse seine and its handling and deployment, and the unloading of fish from the net need study to outline potential improvements in efficiency, safety or ease of operation.

3.4 ONGOING AND PROJECTED RESEARCH AND MONITORING

3.4.1 Florida

Florida has no ongoing or projected research that directly concerns menhaden at the present time.

3.4.2 Alabama

Alabama has no ongoing research or monitoring on menhaden. Although the menhaden fishery benefits the State of Alabama indirectly through industry-related services such as vessel construction and repair, net construction and others, menhaden is a low-priority research item due to the small biological staff and budget of the Marine Resources Division.

3.4.3 Mississippi

For the past 3 years the Gulf Coast Research Laboratory has carried on a Fisheries Assessment and Monitoring program aimed at monitoring commercial species stocks. Populations of menhaden, principally larvae and juveniles, were sampled but the results may not be reliable in assessing year-class strength this early in the study.

At the present time no studies aimed principally at menhaden are projected but continuation of the monitoring program is proposed.

3.4.4 Louisiana

A Study of Larval and Juvenile Gulf Menhaden, *Brevoortia patronus,* in Barataria and Terrebonne Estuaries

Problem Addressed. Presently, knowledge exists on larval migration into the passes and on relative abundance and distribution of juveniles in the upper estuaries. But a gap exists concerning the factors affecting growth and migration from the passes to the upper estuaries. Additional data are needed on survival rates, migration patterns and production rates of various estuaries which can be learned through additional tagging. Finally, the aging process and factors affecting the formation of an annulus are unknown.

Objectives. To determine larval influxes, their abundance, distribution and growth in the estuaries and their subsequent outward migration as juveniles. Tagging studies are needed to further determine migration, growth, and importance of certain juvenile menhaden populations in the estuaries. To further determine scale development of pond-raised Gulf menhaden through succeeding years.

FY 1977 funds $40,000 3.0 man years

3.4.5 Texas

The Menhaden Subcommittee of the Gulf States Marine Fisheries Commission's Technical Coordinating Committee listed various needs for improved management of the menhaden fishery. One such requirement was the identification of Texas menhaden stocks as a possible source of recruitment to the fishery off Louisiana.

During the late summer of 1977 the Texas Parks and Wildlife Department proposes to tag and release juvenile menhaden in estuaries of the Galveston and Matagorda Bay Systems. Internal "magnetic" tags will be used, and recovery will be made in the fish plants. Activities will be coordinated with the NMFS menhaden program.

3.4.6 National Marine Fisheries Service

Fishery Analysis of Atlantic and Gulf Menhaden—AEC-016

Problem Addressed. Determine how the Atlantic menhaden fishery can be rehabilitated to its former level of production and then sustained at that level and to insure maintenance of the Gulf menhaden fishery at its present high yield.

Current Year Objectives. Continue evaluation of data bank, sampling and archival system. Continue juvenile sampling and tagging for migration, mortality and area contribution to fishery determinations. Update fishing effects information, population age, size and distribution. Develop yield-per-recruitment and population models

(Atlantic). Develop recruitment, effort and fecundity information (Gulf).

General Approach. Combine data from landings of fishery and field studies to develop population models for long- and short-term yields and impact of fishing. Cooperative studies should be conducted with the Atlantic Estuarine Center (AEC), other NMFS facilities and the various states.

FY 1977 funds $239,500 8.5 man years

Monitoring and Management of Atlantic and Gulf Menhaden—AEC-017

Management is necessary to sustain the current high yield in the Gulf menhaden fishery and to increase the yield in the Atlantic menhaden fishery to former levels. Both species are a common property resource, both occur in coastal waters and estuaries and both move or migrate across state boundaries and into international waters. The purposes of this task are to (1) monitor the Gulf and Atlantic menhaden purse-seine fisheries for age, length and weight, and landings and recaptured tags and, in general, to establish information on their status; (2) to explore methods of formulating management proposals acceptable to all parties, to identify the factors essential to a management plan and to seek ways of acquiring the necessary data.

FY 1977 funds $153,900 5.3 man years

Automatic Data Processing of Menhaden Data at Beaufort, N.C. Lab

This task performs biometrical, statistical and data processing services for the two menhaden tasks as well as for all other tasks at Beaufort. This task helps task leaders to plan research and to establish data requirements and appropriate statistical methods. In addition, this task assists in storage, retrieval of processing of laboratory and field observations and in developing dynamic models of biological populations and ecosystems.

Types of data processed and operations include: Compile and summarize Atlantic and Gulf menhaden catch and effort data; compile and summarize length, weight and age data for Gulf and Atlantic menhaden; and analyze data from experiments and surveys and derive statistical and fisheries models.

$55,000 per year and 2.1 man years

Remote Sensing. The use of aerospace remote sensing for fisheries is relatively new and is in a research and development stage. Earth Resources Technology Satellite-1 (ERTS-1) in 1972 and SKYLAB in 1973 were two studies utilizing satellite sensors to measure certain environmental features associated with fish distribution. These studies were forerunner to the LANDSAT Menhaden and Thread Herring Investigation conducted in 1975 and 1976. ERTS-1 dealt with menhaden in Mississippi Sound and SKYLAB dealt with oceanic game fish in the northeast Gulf of Mexico.

A 15-month study was initiated by Southeast Fisheries Center, NMFS to demonstrate the potential of using satellite-acquired data to provide fisheries information. Imagery from ERTS-1 was used in conjunction with aerial, photographically-sensed menhaden distribution information, sea-truth oceanographic measurements and commercial fishing information from a 8670-km^2 study area in Mississippi Sound. The ability to demonstrate a relationship between selected oceanographic features and menhaden distribution in the test area generated the interest to further pursue the experiment.

The LANDSAT Menhaden and Thread Herring Investigation, a cooperative experiment, is utilizing inputs from various sources: government, industry and academic. NMFS Fishery Engineering Laboratory, Bay St. Louis, Mississippi and NASA Earth Resource Laboratory, Slidell, Louisiana, along with five menhaden companies of the National Fish Meal and Oil Association, were the major contributors.

During the 1975 menhaden fishing season six primary missions were conducted, three each in test sites off Louisiana and in Mississippi Sound. Environmental features were measured by two satellites, LANDSAT 1 and LANDSAT 2, two NASA-instrumented aircraft and one NMFS chartered photographic aircraft. Groundtruth data were obtained from industry spotter aircraft, industry fishing vessels, NASA-operated oceanographic vessels and from oil well platforms in the Louisiana test site. The features were surface water temperature, salinity, color, turbidity and chlorophyll a content. Analysis and classification of the data established that computer models, using LANDSAT multispectral scanner data, could accurately predict high-probability fishing areas for menhaden. Surface water temperature and salinity did not appear to be features usable in the models. The use of chlorophyll a data was inconclusive.

The results gained during the 1975 operation stimulated interest to extend the experiment into the 1976 fishing season. The purposes of the extension were to simulate an operational system in near-real time, to determine persistence of the environment as viewed from space and to test a high resolution color sensor mounted in a U-2 high altitude aircraft for sensor optimization. The field activities were successfully conducted in July 1976. LANDSAT 1 overflew the Louisiana area south of White Lake at 10:26 a.m. on July 19. By 7:15 a.m. on July 20 the data were processed, classified and predictions made for high-probability fishing areas within a 100-mile swath covered by the satellite. All but one of these high probability areas were confirmed by the fishing fleet as areas of high fish concentration (Figure 13). Data from the two U-2 passes on July 20 and the three LANDSAT 2 passes on July 27, 28 and 29 have not been analyzed. (Figure 14 describes the areas).

The LANDSAT experiment demonstrates that certain

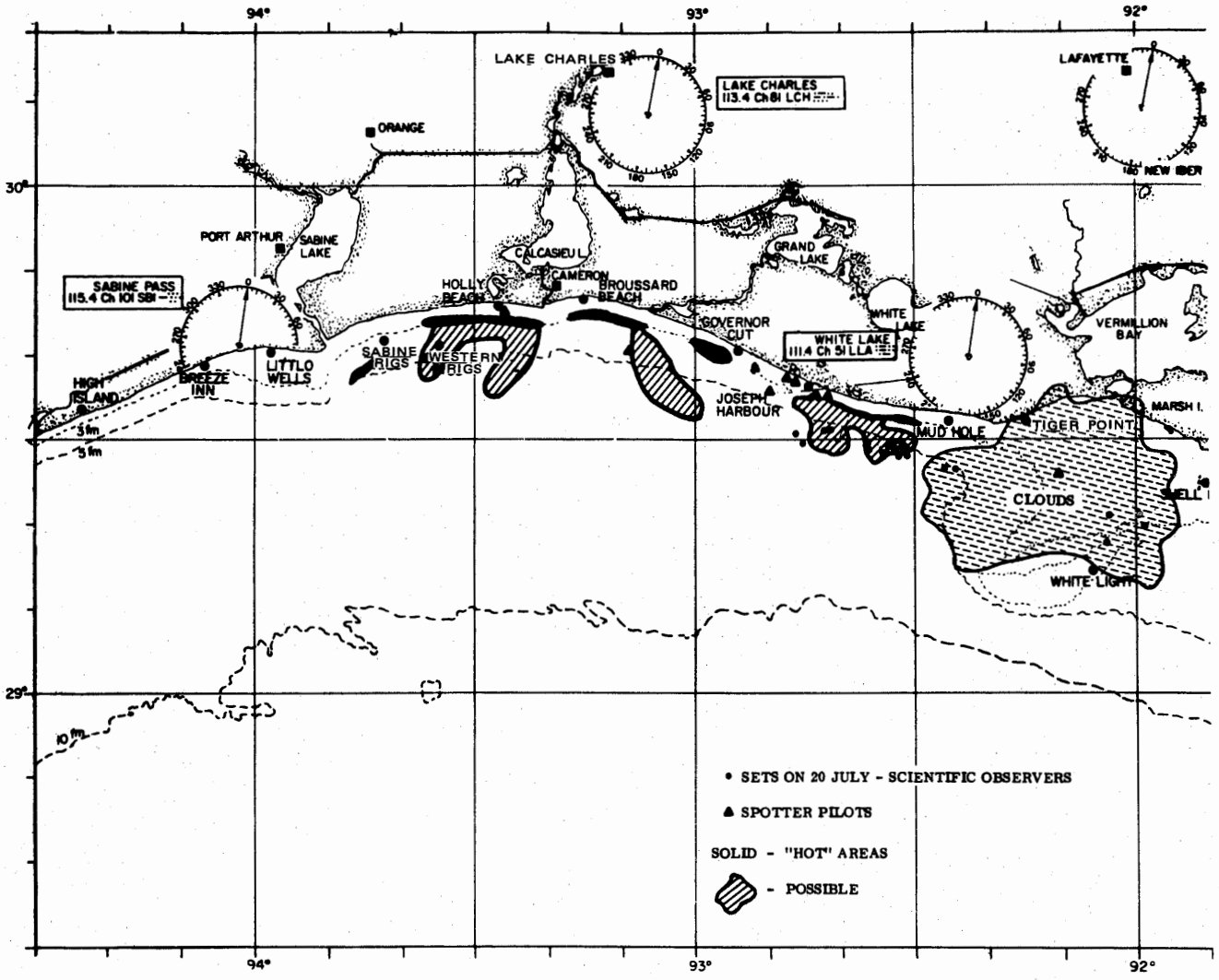


Figure 13. Satellite (LANDSAT) observations on 20 July 1976.

environmental features, measurable by satellite seansors, are reliable enough to permit the use of computer models to predict distribution of menhaden. With environmental persistence, future satellites such as Nimbus G, scheduled for launch in 1978, could provide tactical information to the fishing industry as well as data for fisheries management. LANDSAT 1 and LANDSAT 2 cover each segment of earth every 18 days thereby providing data for a specific area every 9 days. Nimbus G's orbit will provide coverage every 3 days. Perhaps a future geostationary satellite will be positioned over the menhaden grounds and equipped to provide all pertinent environmental data covering the full life span of menhaden. Such a system could continuously monitor the offshore spawning areas, the estuarine area where their early life is spent as well as the coastal waters where harvesting takes place. Instruments are under development that may measure surface currents from space. This could provide information during spawning periods for estimating larval stocks entering the estuaries. These remote sensors on space platforms could be a tremendous boost to the knowledge of fisheries for management and economic utilization.

Figure 15 is an artist's conception of such an operational system.

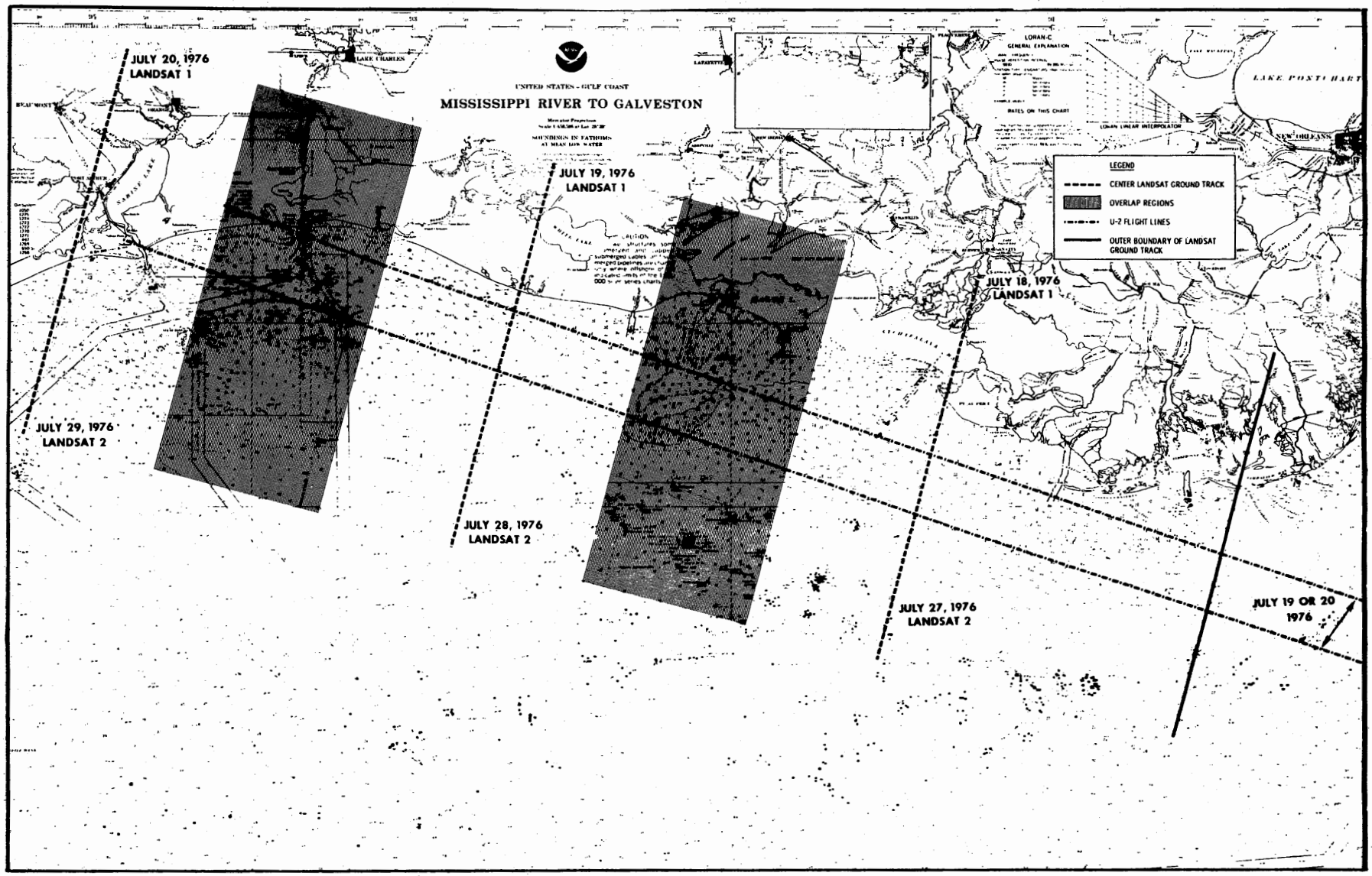


Figure 14. Test areas for LANDSAT overpasses.

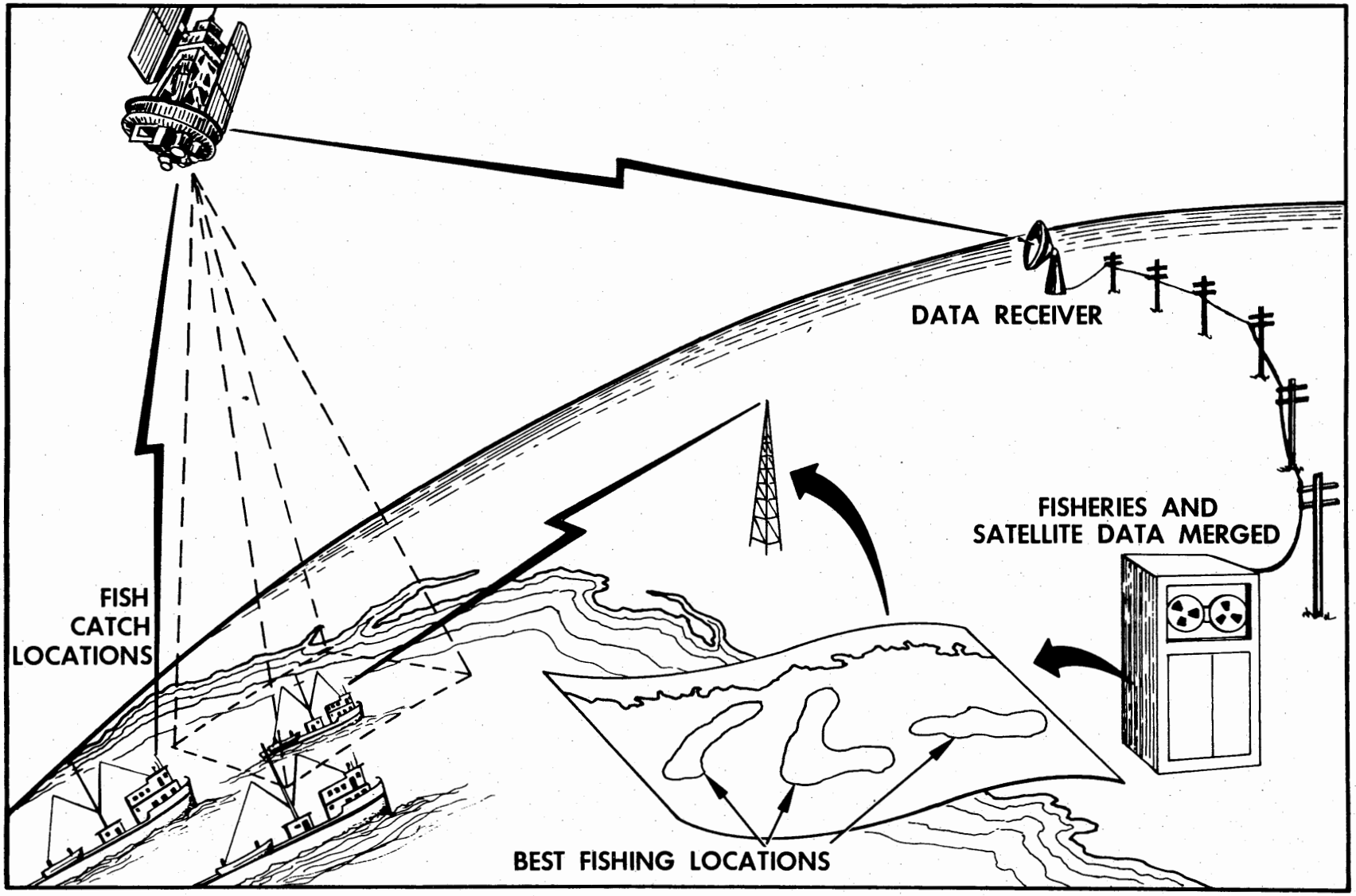


Figure 15. Conceptual system for coastal fishery applications.

Chapter 4. Goal and Objectives

The goal and objectives developed are shown below:

Goal. A Gulf Menhaden Management Plan that will allow an annual maximum harvest which will not exceed the biological break even point (BBEP).

To develop a management plan for the Gulf Menhaden resource which will permit a harvest at maximum sustainable yield, annually.

Objectives.

1. To determine, maintain and improve the biologically sustainable yield of Gulf of Mexico menhaden stocks based on available data and:

a. Improved standard unit of effort.

b. Improved statistical data base to include detailed information on location of fishing effort and catch.

c. Increased knowledge of the influence of environmental factors that affect the abundance of menhaden.

d. Stock composition of Gulf menhaden, (*Brevoortia patronus*).

e. Additional understanding of menhaden dynamics, including natural mortality of Gulf of Mexico menhaden.

f. Improved capability for predicting annual fluctuations in abundance of Gulf of Mexico menhaden.

g. Interaction of menhaden and other fisheries.

h. Understanding of the species and year class composition and seasonal and areal distribution of menhaden stocks in the Gulf of Mexico beyond currently utilized fishing grounds.

i. Utilization of a standard unit of measure.

j. Knowledge of areal and seasonal variations in fat, moisture, ash and protein composition of menhaden.

k Additional knowledge to be acquired as the need becomes evident.

2. To define and improve or establish:

a. Estimates of MSY from Gulf of Mexico menhaden stocks.

b. Estimates of Economic Sustainable Yield (ESY).

c. Socio-Political problems.

d. Estimates of Optimum Sustainable Yield (OSY) from Gulf of Mexico menhaden stocks.

3. Identify and evaluate current data base available for management.

4. Develop alternate management systems using the best available data.

This plan has been developed to show what inputs are needed and how these inputs may be used to arrive at policies to improve the menhaden fishery through better and more timely decision making. Because changing conditions will alter some of the stated objectives, as well as their order of importance, the management system must be capable of responding when and where necessary. The users of this plan should consider that adjustments will be required from time to time.

Chapter 5. Proposed New System

I. The proposed new management system is recommended after consideration of several options to accomplish goals and objectives through the conceptual model of the system shown in Figure 16.

A. The system is contingent on a regional data base that will provide 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.
5. Determination of environmental parameters which can be monitored to provide continuous information concerning the status of the resource as well as the condition of the environment which supports the menhaden resource.

B. This information will be 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.
   b. The social impact of management decisions.
4. Suggest guidelines to advise members of the industry and the 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 new 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 and sociological effects of management policies.
4. Develop alternate management schemes using the best available scientific data base.

E. The principal advantage of the new system is that it 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. Other advantages include:

1. Development of a dependable predictive ability that will:
   a. Reduce economic loss to the industry from overinvestment.
   b. Increase effectiveness of management through coordination of research efforts.
   c. Enable managers to evaluate the biological, economic, environmental and social effects of their decisions.
   d. Allow states to coordinate administrative research and enforcement policies.
   e. Allow managers to fully document biological and economic trends in the menhaden fishery.
   f. Improve catch and effort data in the event that the Federal government receives applications for foreign participation in the menhaden fishery.
   g. 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.

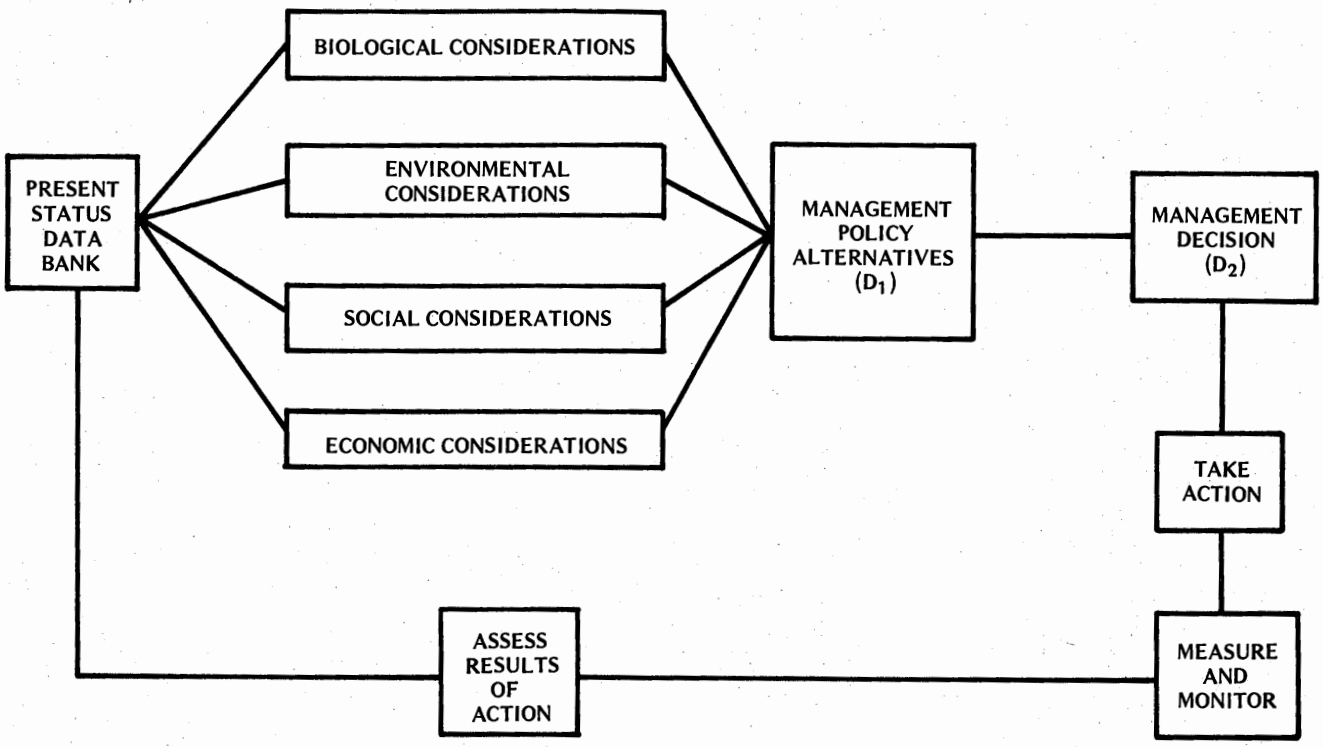
F. Disadvantages of the new system include, but are not necessarily limited to, a high initial cost that may not receive funding proportionate to the importance of the menhaden fishery.

II. Options

A. Management structure composition.

The Gulf State-Federal Fisheries Management Board (GS-FFMB) will have responsibility for regional management in the new system.

It is recommended that GS-FFMB use a menhaden advisory committee comprised of one member from each state fishery agency, one member from each operating menhaden company in the Gulf, all of whom shall be voting members and one non-voting member from the NMFS. All recommendations of the Advisory Committee should be approved by a two-thirds majority vote of those present and voting. There should be a minimum of two meetings of the advisory committee each year as



EXPLANATION OF DECISIONS TO BE MADE

D_1 At this point biological, environmental, social, economic and other considerations must be taken into account to produce alternative actions which may be 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 Technical Committee investigating the problems will develop these alternative solutions.

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

Figure 16. Conceptual model of future management system.

deemed necessary by two or more members or at the direction of GS-FFMB.

Basic organization of the management structure is shown in Figure 17 which illustrates the preferred recommendation.

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

The advantages of this option are that all members of the Board 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. Also they are members of the GSMFC and, therefore, can coordinate the activities of the Board and GSMFC. Inclusion of the NMFS Regional Director as a member provides representation of Federal interests.

There are two disadvantages of this option. The first is that the member state administrators can commit their respective state agencies to a course of action only with the approval of their management body and through legislative or gubernatorial action. Secondly, this or any formalized regional management scheme would require legislative approval to enter into reciprocal management programs in most cases.

B. Continue to manage the Gulf Menhaden fishery in the same manner as currently exists (no action).

1. Advantageous current management practices include:

a. Voluntary restrictions of effort self-imposed by the existing industry which, despite numerous changes, has remained relatively stable over a long period.

b. Concurrent open seasons set by Alabama, Mississippi and Louisiana at the request of industry.

c. Production from the resource is at or near the best available MSY estimates.

d. The cost of management under the present system is relatively low for a fishery of such great importance.

2. Disadvantages of the current system include, but are not necessarily limited to:

a. Management responsibility has not been

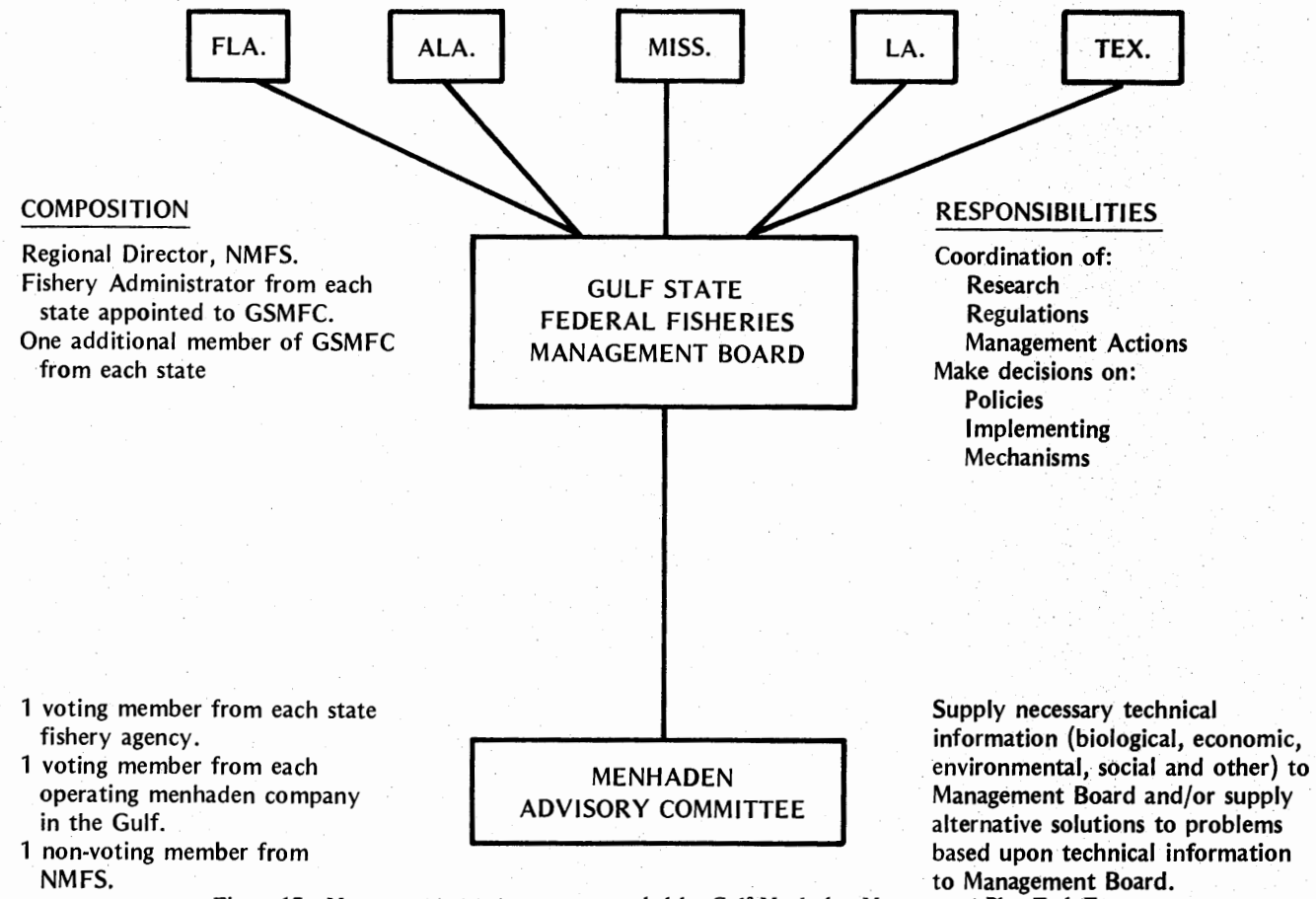


Figure 17. Management structure recommended by Gulf Menhaden Management Plan Task Force.

delegated to a regional agency that can provide for implementation of the proposed new system.

b. The best current estimates of MSY are not satisfactory and additional funding under a regional management system is essential for the achievement of significant improvement.

c. Economic, environmental and social factors are not always considered in management under the present system nor is any apparent means for either acquiring the necessary data or including such data in management considerations under the present system.

d. State regulations have closed areas to menhaden fishing without due consideration of biological, ecological and economic information that is already available.

C. Manage the fishery by the Gulf Regional Fishery Management Council.

1. Advantages

a. The Council has funding to recommend management of fisheries beyond territorial waters.

b. The Secretary of Commerce may accept, implement and enforce regulations recommended by the Council.

c. Most of the menhaden population spends the winter spawning season offshore.

2. Disadvantages

a. About 90% of the menhaden harvest is taken in territorial waters where states have jurisdiction.

b. The menhaden industry prefers that management under the new system remain with the states.

c. Menhaden production depends on maintenance of estuarine nursery areas located in territorial waters as well as successful spawning in offshore waters.

D. Manage the Gulf Menhaden fishery by some regional body yet to be created.

Since two regional management bodies are already established the task force found no advantages in the creation of a new management body.

E. Manage the Gulf Menhaden fishery by some combination of variation of the other options.

No satisfactory combination or variation of existing management bodies found any support in the task force.

III. Contents of the Proposed System

Stock Identification. At present Gulf menhaden

is considered to be a single entity or stock. However, if future research shows this not to be true, then the plan, on recommendation of the menhaden advisory committee, may require modification to accommodate the research findings.

License Fees. There shall be a licensing fee for each menhaden vessel and/or net. The fees shall be paid to each state in which each vessel fishes and the rates shall be established by each state. This licensing process has worked satisfactorily for many years and the task force found no reason for any change.

Open Seasons. There should be a concurrent season established for menhaden throughout the Gulf. The present season, effective in Alabama, Mississippi and Louisiana is from the third Monday in April through the second Tuesday in October. The ending date should be changed to the second Friday in October to provide for a full week of fishing during the last week of the season. The closed season as it now stands approximately coincides with the Gulf menhaden spawning season and migrations from the open Gulf of Mexico to the fishing grounds. Few 0-age class menhaden are taken during the open season.

Net Regulations. A Gulf-wide regulation on nets should be set. Menhaden purse seines should be no more than 2,000 feet in length and have an average stretched mesh size of not less than 1 1/2-inch-bar when a minmum of six consecutive meshes are measured.

State Laws. Regional management should provide for uniformity in state regulations to the extent practicable. Local conditions may dictate that some regulations differ from state to state. Restricted areas are mapped in Chapter 3. In general, these areas have been established in response to demands of other interests with little consideration of biological and economic factors.

Maximum Sustainable Yield (MSY). Menhaden harvest now approximates the best current estimate of MSY. After due consideration of existing conditions, it is not felt that any restrictions other than those presently enforced by the States are necessary. However, should improved estimates of biological, economic, environmental and social factors show a need for additional regulations, then these should be contemplated for implementation. within the framework of the future Management Plan.

Research. Continuing research is required to improve confidence in management options that may be recommended and selected by the board for action. Research recommendations are presented in Chapter 6.

IV. Options; Contents of the Proposed System.

"Management Considerations" included in "The Gulf Menhaden Fishery, A Discussion Paper" (NMFS, 1976) were considered. The Task Force agreed that the establishment of quotas at this time should not be recommended. Selected suggestions were incorporated into the Plan. The pertinent parts of the draft paper are presented in the following pages.

Management Strategy.

"Following the rationale employed by Schaaf, a quota system is proposed as an initial step toward managing Gulf menhaden. As stated by Schaaf (1975):

'. . .the system must not be too restrictive, but must allow for expansion, until there is clear evidence that we have reached, or slightly passed, the peak of production. Setting annual quotas would simply allow the industry to approach the peak systematically and gradually, with fixed catches each year. Effort must be closely monitored each year to help us determine the validity of our estimated MSY. Even when we are more certain of the MSY, it might be necessary to adjust the quota frequently in response to fluctuations in the size of incoming year classes. Gradually increasing the quota past our predicted MSY is predicted on the assumption that Gulf menhaden, which have a high reproductive potential are resilient enough to withstand overfishing (i.e., removing more than the annual surplus) for a couple of years. Thus we can set liberal quotas, which would not penalize the industry.'

If the system were implemented for the 1976 fishing season, the quota established would be based on the current estimated MSY (1975) of 496,000 metric tons plus an increment based on statistical confidence limits around this point estimate. Using an 80 percent confidence level as suggested by Schaaf (1975), an upper MSY limit of 535,000 metric tons is established as the tentative harvestable quota for the 1976 fishing season.

Management Considerations.

Based upon the foregoing review of the fisheries, a number of considerations become evident with respect to implementing a management program for Gulf menhaden. The following items are advanced for consideration by the Committee:

Allowable Catch.

Sufficient information is currently available to initiate a flexible catch quota system as an interim management measure. As indicated by Schaaf (1975), the allowable catch would be adjusted annually by incorporation of each successive year of data that becomes available. This procedure would allow the industry to approach MSY in a systematic manner.

Limited Entry.

Under an allowable catch or quota management system, it may also become necessary to regulate entry into the fishery and to allocate catch among the participating companies. Establishment of a quota system would discourage new companies from

entering the fishery since it appears that the capability for fully utilizing the resource already exists. The entrance of additional companies into the fishery or the expansion of existing companies should be carefully evaluated or possibly restricted until the resource indicates that it can biologically and economically accommodate increased effort. An orderly presentation of the legal constraints with limiting entry has been compiled by Knight and Jackson (1973) and Knight and Lambert (1975).

The implementation of a quota system could conceivably lead to overcapitalization in the fishery in the absence of a plan for allocating the allowable catch among users. Such an allocation system could be based upon historical catch/effort records in individual companies.

Additional Research.

Despite the vast amount of knowledge that has been accumulated, the absence of certain data elements preclude a full understanding of the Gulf menhaden fishery. Oceanic research during the non-fishing season would provide information on the location of overwintering populations and offshore spawning areas. The location of major spawning activities would in turn provide material to establish a developmental series of the early life stages of Gulf menhaden for verification (identification is presently based upon assumed similarity to other species). At the same time, more complete information would be obtained on spawning age, fecundity and reproduction.

Additional effort is needed to evaluate the environmental factors and biological processes that inseparably link the menhaden to the estuarine ecosystem. Until we understand the dynamics involved in estuarine dependency, we can only speculate on the possible demise of the menhaden resource in response to alteration of the estuarine habitat. We should make efforts to determine what typifies the environment occupied as nursery area during this critical phase of their development. Surveys, therefore, should be expanded as necessary to thoroughly evaluate these functional relationships in selected estuaries throughout the Gulf. At the same time, attempts should be made to refine and quantify estimates of year-class strength for improving prediction capabilities and for modifying estimates of allowable catch as appropriate.

Obviously, there are other considerations and options available than those introduced in this report. The intent of this report, however, is to stimulate thought and discussion by those concerned with the fate of the Gulf menhaden fishery and have, for one reason or another, a vested interest in conserving and enhancing this valuable resource. Optimization of the fishery will require a composite of multidisciplinary skills—at the State, Federal, local and industry levels—solidified into a coordinated research and management process."

V. Plan Implementation and Evaluation.

Plan implementation will begin after the appropriate committees and Board have approved the plan. The plan will be implemented and administered by the designated Menhaden Fishery Management Group.

The first steps in implementation will consist of those recommendations given the highest priority.

The Menhaden Fishery Management Group will review and evaluate research proposals for applicability, as well as evaluating results obtained by actions taken to satisfy recommendations. The project evaluations process will allow 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 will evaluate 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 to develop a work breakdown structure for each objective of the plan.

The group 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.

Chapter 6. Recommendations

The following recommendations have been developed for consideration. Recommendations are classified as high, medium or low priority. The identification designations in parenthesis refer to Table 5, Chapter 7.

A. High Priority

1. That the TCC menhaden Sub-Committee continue its present function at least until the Management Board assumes responsibility for regional management.

This is necessary to maintain the program in that interval between completion and implementation of the plan.

2. That each state participate in and support a Gulf regional menhaden management plan.

This is essential because the ultimate management authority is vested in the several Gulf States.

3. That an advisory committee be appointed by the Board.

This committee is needed to supply input to the Board and/or to supply alternative solutions to current problems.

4. That the advisory committee should meet at least twice each year.

This is necessary to review current conditions and to make appropriate recommended changes for the Board to improve plan implementation.

5. That a study be conducted to establish a more satisfactory estimate of MSY (B-1).

Potential benefits are: to define stock size; to permit maximum long-range utilization of resource; and to provide basis for further management measures, if necessary.

6. That a study be conducted to satisfactorily predict annual fluctuations of menhaden populations (B-2).

Potential benefits are to allow industry to properly prepare for a season and to permit rational exploitation of the resource on a year-by-year basis.

7. That a study be conducted to determine detailed location of the menhaden catch (B-4).

Potential benefits are the determination of whether the fishery is inshore or offshore, and the determination of migration patterns of tagged juvenile menhaden after recruitment into the fishery.

8. That a study be conducted to improve current annual estimates of juvenile populations for predictive purposes (B-5).

Potential benefits are: More efficient application of commercial gear with respect to (1) where to fish (increase effort in unexploited areas), (2) how, when, where and amount to take, (3) increase lead time for allocation of fishing effort, shore facilities and marketing plans; and maximization of yield (landings).

9. That a study be conducted to develop data (biological, economic, social, environmental) to satisfactorily estimate menhaden stocks with respect to optimum sustainable yield (B-7).

Potential benefits are the assurance of optimum benefits from proper utilization of resource.

10. That a study be conducted to obtain adequate data to determine the economic sustainable yield of Gulf menhaden stocks (E-2).

Potential benefits are the development of economic data in consort with biological (and other) data so that an OSY may be determined.

11. That a study be conducted to obtain adequate sociological data for input into management considerations (S-1).

Potential benefits are the development of adequate sociological knowledge of the menhaden fishery in order to make better management decisions.

12. That a program be conducted to improve knowledge and documentation of the political/legal systems involved in coordinating management schemes on a regional basis with respect to the Gulf menhaden industry (S-2).

Potential benefits are that the research will clarify and present as a package the various State laws and policy and management practices which each state presently uses to deal with its own menhaden fishery industries. This knowledge will enable regional management bodies to fully take advantage of the benefits of the States' experience, and at the same time work to eliminate unnecessary conflicts or inconsistencies in those laws, policies and practices.

13. That a program be conducted to improve the understanding among the menhaden industry, the general public and other resource users in the social environment (S-3).

Potential benefits are that this project will create a better understanding of the role of the menhaden industry in the social, economic and ecological systems of the larger community. This will in turn reduce barriers to effective management and create a stable environment in which to rationally acknowledge and distribute the benefits of the fishery system.

14. That a study be conducted to improve vessel unloading system (O-3).

Potential benefits are in developing a cost-effective unloading system to minimize or eliminate the use of pump water.

15. That a study be conducted to improve purse boat safety (O-4).

Potential benefits are in decreasing personnel accidents and to lower company insurance rates.

16. That a study be conducted to develop more economic harvesting gear and fishing methods (O-5).

Potential benefits are in reducing the large purse-seine crews.

B. Medium Priority

1. That a study be conducted to determine menhaden year class composition and distribution beyond the currently exploited fishing grounds (B-3).

Potential benefits are in determining if a segment of the spawning populations does not enter the fishable stocks creating a spawning "bank"; greater delineation of spawning areas and times; better definition of stock composition and clarification of migratory patterns.

2. That a study be conducted to determine stock composition of Gulf menhaden (B-6).

Potential benefits are in helping maintain resources and possibly increasing the harvest potential.

3. That a study be conducted to obtain knowledge of areal and seasonal age and size variations in fat, moisture, ash and protein components in menhaden (E-1).

Potential benefits are that industry could more efficiently allocate fishing time in those areas that produce the "richest" fish for a greater economic return.

4. That a study be conducted to conserve energy and increase utilization of boats and crews (O-1).

Potential benefits are in increasing savings in fuel, as well as to obtain better utilization of boats and crews.

5. That a study be conducted to reduce fish spotting costs (O-2).

Potential benefits are in eliminating duplication of use of airplanes by the several companies when replaced by a useable operational satellite system.

C. Low Priority

1. That a study be conducted to determine the interaction between menhaden and other fisheries (B-8).

Potential benefits are in determining impact of other fisheries on the menhaden populations, and determining impact of menhaden industry on other fisheries.

2. That a study be conducted to evaluate the actual performance of menhaden purse-seine performance (O-6).

Potential benefits are in locating problem areas in the purse seine and to recommend improvements which will increase production efficiency.

3. That a study be conducted to perform an engineering study of vessels' purse seines operational characteristics (O-7).

Potential benefits are in outlining and describing changes, benefits and recommendations of improvements for future considerations.

Chapter 7. Management Action Program Summary

This section describes the cost and time horizons of the first 5 years of the regional menhaden management plan. Costs have been estimated where possible. Costs not shown in Table 5 will be obtained once detailed proposals are prepared for specific activities. The reader should note that Table 5 only describes the first 5 years of the plan. The Homogeneous Area of all research recommendations includes the range of stock.

The entire cost of the plan for the first 5 year period in 1976 dollars will be approximately $14,064,000. This total amount of money includes all costs necessary to perform the research projects, but is not necessarily new money in all cases. Some of the projects, or parts of them, are already in process. In addition, some efforts may be reduced, which will lower the costs, as well as the confidence of the results.

Costs broken down by type of action, are as follows:

	1	2	3	4	5	Total
Biological	$3,296K	$3,217K	$3,042K	$712K	$462K	$10,729K
Economic	115K	95K	60K	60K	20K	350K
Social	103K	76K	65K	51K	–	295K
Other	1,340K	1,275K	75K	–	–	2,690K
TOTAL	$4,854K	$4,663K	$3,242K	$823K	$482K	$14,064K

Approximate dollar percentages of totals by type of action:

Biological	76.3%
Economic	2.5%
Social	2.1%
Other	19.1%
TOTAL	100.0%

Potential sources of funding are:

1. NOAA/NMFS
2. States
3. State-Federal
4. Sea Grant
5. Coastal Zone Management
6. Industry
7. U.S. Army Corps of Engineers

TABLE 5.

Management Action Program Summary

Type of Action	Function of Task	Identification Number	First Year Amount	Second Year Amount	Third Year Amount	Fourth Year Amount	Fifth Year Amount	Responsibility	Priority
Biological	To establish a satisfactory estimate of MSY	B-1	410K*	410K	410K	410K	410K	Fed/States	High
Biological	To satisfactorily predict annual fluctuations of menhaden populations	B-2	1,825K	1,825K	1,675K	–	–	Fed/States	High
Biological	To determine Menhaden year class composition and distribution beyond the currently exploited fishing grounds	B-3	750K	680K	655K	–	–	Fed/States	Medium
Biological	To determine detailed location of the Menhaden catch	B-4	25K	25K	25K	25K	25K	Fed/Ind./States	High
Biological	To improve current annual estimates of juvenile populations for predictive purposes	B-5	250K	250K	250K	250K	–	Fed/State	High
Biological	To determine stock composition of Gulf Menhaden	B-6	9K	–	–	–	–	Fed/States	Medium
Biological, etc.	To develop data (Biol., Econ., Social, Env.) to satisfactorily estimate Menhaden stocks OSY	B-7					**	NMFS/Fed/States	High
Biological	To determine the interaction between Menhaden and other fisheries	B-8	27K	27K	27K	27K	27K	States/Fed	Low
Economic	To obtain knowledge of areal and seasonal age and size variations in fat, moisture, ash and protein components in Menhaden	E-1	20K	20K	20K	20K	20K	Universities	Medium
Economic	To obtain adequate data to determine ESY of Gulf Menhaden Stocks	E-2	95K	75K	40K	40K	–	Univ./Fed/Sea Grant	High
Social	To develop adequate sociological data for input into management considerations.	S-1	63K	39K	39K	25.5K	–	Sea Grant	High
Social	To obtain improved knowledge and documentation of the political/legal systems	S-2	20.5K	20K	19K	18.5K	–	Sea Grant	High
Social	To improve the understanding among the menhaden industry, the general public, and other resource users in the social environment.	S-3	19.5K	17K	7K	7K	–	Ind./States	High
Other	To conserve energy and increase utilization of boats and crews	O-1	875K	875K	–	–	–	Fed/Ind.	Medium
Other	To reduce fish spotting costs	O-2	200K	250K	–	–	–	Fed/Ind.	Medium
Other	To improve vessel unloading system	O-3	10K	10K	–	–	–	Fed/Ind.	High
Other	To improve purse boat safety	O-4	25K	–	–	–	–	Fed/Ind.	High
Other	To develop more economic harvesting gear and fishing methods	O-5	175K	100K	75K	–	–	Fed/Ind.	High
Other	To evaluate the actual performance of Menhaden purse seine performance	O-6	55K	–	–	–	–	Fed/Ind.	Low
Other	To perform an engineering study of purse seines	O-7	–	40K	–	–	–	Fed/Ind.	Low
TOTALS			$4,854K	$4,663K	$3,242K	$823K	$482K		

*K = $1,000

**Inasmuch as OSY is a function of MSY, ESY, SSY, etc., this task costing must await future findings of other tasks prior to costing and initiation.

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Technical Report Series, No. 1, May 1977

Appendix. Planning Methodology and Chronology

Methodology.

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 plan implementation. A system for monitoring and evaluating the effectiveness of the management program will be designed.
>
> The Gulf Coast Research Laboratory, 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 Wild Life 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 analyses, 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.

Chronology.

National Marine Fisheries Service issued a contract dated 1 June 1976 for the development of a fisheries management plan for Gulf menhaden.

Dr. David Etzold, University of Southern Mississippi (USM) and Mr. J. Y. Christmas, Gulf Coast Research Laboratory (GCRL), worked with TCC and NMFS personnel to develop the proposal. On completion of the contract, a letter of agreement provided that GCRL and USM would jointly conduct the project in accordance with contract requirements with J. Y. Christmas as Principal Investigator and Dr. David Etzold as Chief Planner. The USM agreed to provide all planning services required for successful completion of the project.

Mr. W. J. Demoran, GCRL, was subsequently assigned duties as Assistant Principal Investigator.

This staff proceeded with planning for plan development using "Management by Objectives" techniques. Dr. Etzold was in residence at GCRL from 21 June through 2 July 1976.

Florida Department of Natural Resources, Alabama Department of Conservation and Natural Resources, Mississippi Marine Conservation Commission, Louisiana Wild Life and Fisheries Commission and Texas Parks and Wildlife Department assigned personnel for workshop participation. GSMFC, under contract with NMFS, paid travel costs for State representatives to attend Task Force workshops. Each of the five menhaden companies operating in the Gulf, the NMFS Regional Office and Atlantic Estuarine Fisheries Center assigned personnel to the project. These assignments represented a large contribution to the planning effort by the respective companies and agencies in addition to contractual costs.

A mailing list including all State Directors, TCC

members and other persons known to have an interest in Management Plan Development was prepared so that current information could be provided.

After a preliminary canvas of Task Force members, July 7, 1976, was announced as the date for the first workshop. The agenda and appropriate materials, including Scope of Work, were mailed to all persons on the mailing list.

Workshop I.

The first workshop was opened on schedule with all Task Force members present. Workshop procedure, following the agenda, resulted in the following conclusions and action:

1. Task Force is not a committee but functions as a Task Force whose output will be subject to approval by the menhaden subcommittee of TCC.
2. In the event any questions could not be resolved by consensus in workshops, options would be presented to the subcommittee for decision.
3. Proxy members would be qualified by notice to the chairman at the beginning of a workshop. All workshops are open meetings.
4. Log sheets would be maintained to accumulate cost of contributions to management plan development that are not funded under NMFS contract for this project.
5. Description of the fishery, to be included in the plan, would be based on the draft "The Gulf Menhaden Fishery, a Discussion Paper" released by NMFS in January 1976. Numerous changes were suggested in the review process.
6. Two options for statement of the Mission (or Main Goal) were developed.
7. A list of 18 objectives was generated.
8. A preliminary Gulf menhaden planning schedule, including dates for monthly workshops through December 1976, was adopted.
9. A plan flow diagram prepared by the staff was adopted with minor changes.
10. "Homework" assignments to be carried out in preparation for Workshop II were accepted by Task Force members as follows:
    a. Review of each state's management procedures.
    b. Development of input for the industry description or "profile."
    c. Development of problems to be considered by the Task Force.
    d. Compilation of existing data files.
    e. Preparation of a listing of pertinent papers.

In the period following Workshop I, the staff had several planning sessions to prepare for Workshop II and worked on assignments developed in Workshop I. Task Force members provided significant input from "Homework" assignments.

Workshops were held each month thereafter as follows:

August	Mobile, Alabama
September	Kenner, Louisiana
October	Kenner, Louisiana
November	Kenner, Louisiana
December	Kenner, Louisiana

Procedures established in Workshop I were successfully applied in all other workshops. Rigorous scheduling, updated for each workshop and specific "homework" assignments with beginning and completion dates, insured completion on schedule.

Participation by all Task Force members in all workshops was utilized in plan formulation, which contributed greatly to a coordinated regional plan.

Ad hoc subcommittees were formed and utilized as required. Expertise in economic and sociological fields was incorporated into the Task Force team when Dr. Charles Rockwood and Dr. Mike Orbach joined the effort.

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