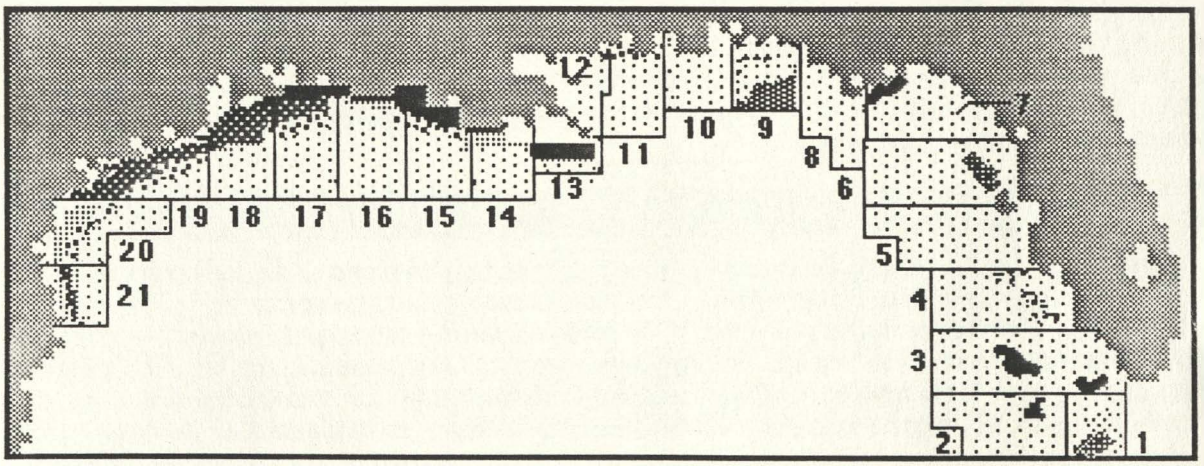
Evolving Assessment Capabilities for Fisheries Management

Computer Mapping and Analysis System for Analyzing Shrimp Harvest Data



January 1989

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Strategic Assessment Branch

The Strategic Assessment Branch (SAB) of NOAA's Office of Oceanography and Marine Assessment conducts comprehensive interdisciplinary assessments of the effects of human activities on estuarine and coastal environments and on the resources of the U.S. Exclusive Economic Zone (EEZ). The purpose of these assessments is to identify strategies for balancing resource development and conservation for maximum benefit to the Nation with minimum environmental damage and minimum conflict among multiple users. SAB's *Living Marine Resources Program* synthesizes the best available information on the distribution and life history of ecologically and economically important species found in the Nation's EEZ. Information is gathered from published and unpublished sources in cooperation with NOAA scientists, primarily of the National Marine Fisheries Service (NMFS), and other experts. Once assembled, these data are synthesized and presented in a series of atlases and technical reports and entered into a NOAA Living Marine Resources Computer Mapping and Analysis System *(Cmas)* for analysis.

Computer Mapping and Analysis System. - This microcomputer-based system allows rapid spatial and temporal comparisons and statistical analyses of any user-specified combination of species and their attributes. It can be used to portray spatial and temporal distributions, providing a suite of analytical tools that allows examination of the data base across space, time, and function. *Cmas* has been developed for use by resource managers and scientists concerned with regional and national issues. A special *Cmas* application has been developed in conjunction with the Galveston Laboratory to augment existing capabilities to analyze the NOAA's commercial shrimp harvest data base.

Galveston Laboratory

The Galveston Laboratory of NOAA's National Marine Fisheries Service is one of six laboratories in the Southeast Fisheries Center. Programs at the Galveston Laboratory provide scientific information for the management of commercial and recreational shrimp and fish and the conservation of endangered species throughout the Gulf of Mexico. Present programs on shrimp and fish are designed to obtain information on reproduction, growth, survival, feeding, and migration of shrimp and fish stocks as well as determing potential commercial and recreational yields. Sea turtle research is designed to prevent extinction of the seriously endangered Kemp's ridely, *Lepidochelys kempi*.

Acknowledgements

The current Gulf of Mexico fishery collection system for shrimp statistics was established by Mr. Charlie Lyles in 1956. This system is little changed from the original contemplated, implemented and developed by Mr. Lyles. We gratefully acknowledge his dedication, foresight and implementation of one of the truly finest fishery-dependent collection data systems. We are also indebted to all of the many men and women of the Bureau of Commercial Fisheries and National Marine Fisheries Service who have dedicated long hours to the collection of the shrimp fishery statistics in the Gulf of Mexico.

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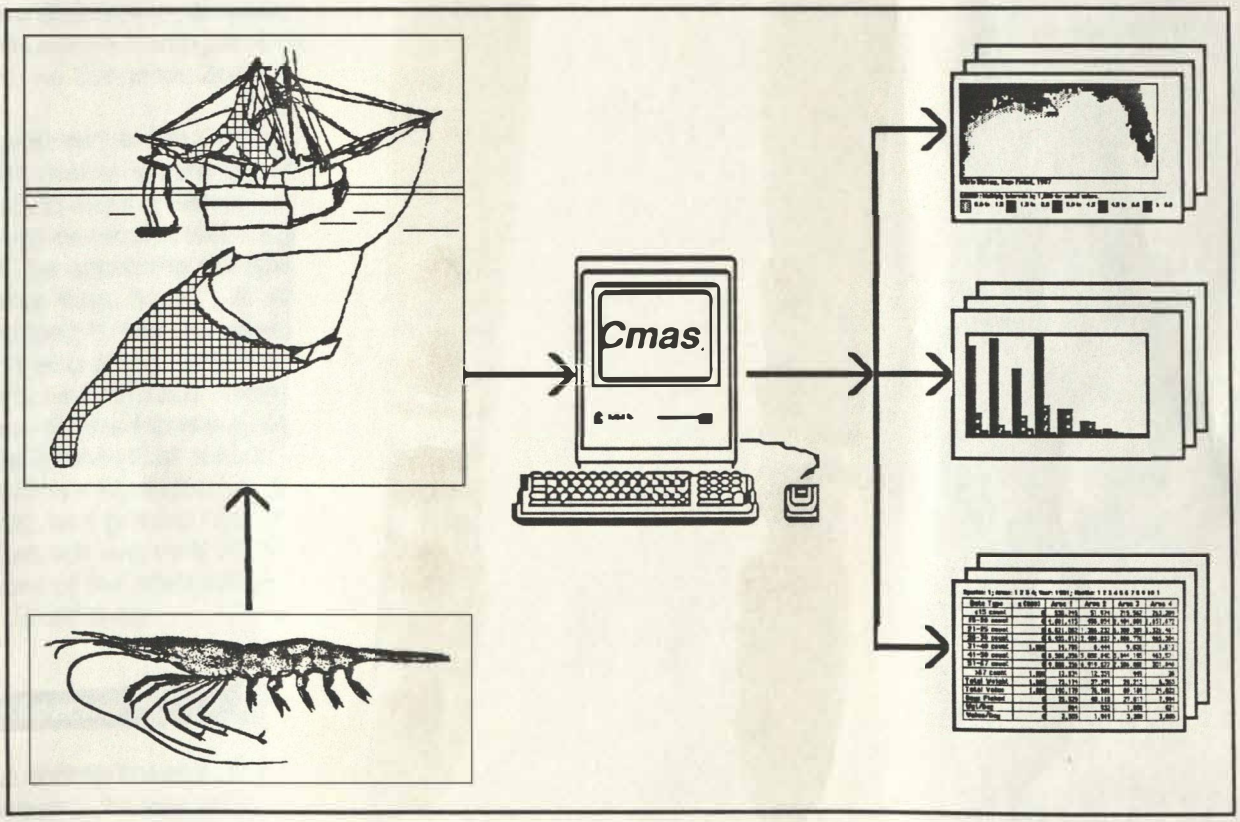


Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessments
National Ocean Service

Galveston Laboratory
Southeast Fisheries Center
National Marine Fisheries Service

Introduction

This paper describes part of an evolving process that the National Oceanic and Atmospheric Administration (NOAA) is undertaking to develop desk-top information systems to improve the application of large NOAA data bases for decision-making. The Strategic Assessment Branch (SAB) of the Office of Oceanography and Marine Assessment, National Ocean Service, and the Galveston Laboratory of the Southeast Fisheries Center, National Marine Fisheries Service (NMFS), are jointly developing a desk-top, microcomputer-based information system to enable rapid analyses of the NMFS Gulf of Mexico commercial shrimp harvest data base. This system is a special application of SAB's Computer Mapping and Analysis System (*Cmas*). *Cmas* enables comparisons, analyses, and mapping of information on the distribution, abundance, and life history of marine species throughout major regions of the U.S. Exclusive Economic Zone.

Development of the *Cmas - Shrimp Harvest* desk-top information system began in the fall of 1987 when both SAB and the Galveston Laboratory agreed that the framework and technology developed for *Cmas* could be applied to the NMFS commercial shrimp harvest data base. A sample data base was developed to test the usefulness and feasibility of developing a special *Cmas* application to analyze shrimp harvest data. The results of this effort is the *Cmas - Shrimp Harvest* desktop system that provides a rapid analytical tool to evaluate management decisions and alternatives through a series of maps, tables, and graphic outputs. The first use of the system will augment the evaluation of the Federal closure of the offshore brown shrimp fishery along the Texas coast.

The Species

Nine shrimp species contribute to the Gulf fishery. However, brown, white, and pink shrimp of the *Penaeus* genus comprise over 95% of the commercial harvest. These shrimp are found in all continental shelf waters in the U.S. Gulf of Mexico inside 60 fathoms (fm). The greatest portion of the reported offshore catch of brown shrimp is taken at depths of 11-20 fm, white shrimp in 5 fm or less, and pink shrimp in 11-15 fm. Largest densities of brown shrimp occur off the Texas/Louisiana coast, the largest concentrations of white shrimp occur off the Louisiana coast, and the greatest densities of pink shrimp occur off the southwest coast of Florida.

Figure 1 shows the Gulf-wide biogeographic distribution of adult brown, white, and pink shrimp.

Brown, pink, and white shrimp have a similar life cycle in which spawning occurs offshore. However, the time that recruits enter the fishery differ for the three species. Eggs generally hatch into planktonic larvae after 10-12 hours. During the next 12-15 days, these larvae metamorphose through additional planktonic stages into post–larvae. Upon entering the estuaries, these post–larvae become benthic and develop quickly into juvenile shrimp. The average life span of these three species is thought to be about 12 months, although some live for 2-3 years.

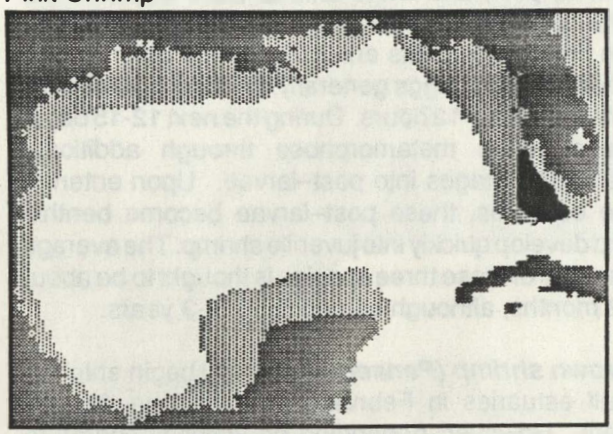
Brown shrimp (Penaeus aztecus) begin entering Gulf estuaries in February and continue through April. However, depending on water temperature and environmental conditions, immigration can occur through July. Several "waves" of post–larvae may enter an estuary, but peak recruitment occurs in March and April and again in September (Baxter and Renfro 1967). The post–larvae use the estuary as a nursery and eventually migrate back into the Gulf as subadults. While in the bays, the juvenile shrimp may be harvested by recreational and commercial fishing during the spring and summer months. Emigration of juveniles to offshore waters begins in May and ends in August with peak emigration occurring in May, June, and, to some extent, July.

White shrimp (Penaeus setiferus) post–larvae begin entering Gulf estuaries from May to November, with peaks in June and September (Baxter and Renfro, 1967). These post–larvae use the estuaries as nurseries during summer and fall and grow to harvestable size (120-160 mm total length) in the bays, where they are harvested by recreational and commercial fisherman during late summer. White shrimp emigration is a function of size and environmental conditions within given bay systems. Usually they begin emigrating in September and end in December.

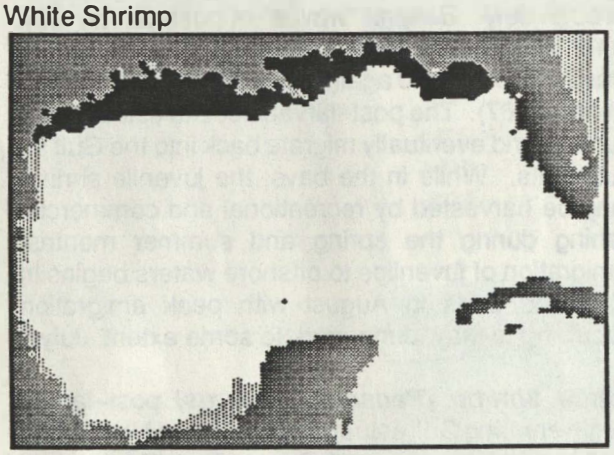
Pink shrimp (Penaeus duorarum) post–larvae begin to enter Gulf estuaries in the summer and peak in the fall. They spend two to six months in nursery areas. Pink shrimp attain a size of 95 to 100 mm total length before emigrating from estuarine nursery areas to offshore waters of southwestern Florida. However, size is probably seasonally and areally-dependent. Emigration occurs year-round with peaks in the spring and fall (Costello and Allen, 1966; Costello and Allen, 1970).

Figure 1. Biogeography of Gulf Shrimp

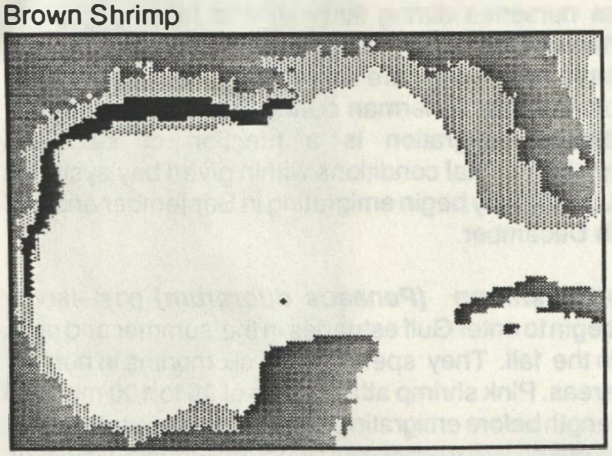
Pink Shrimp



White Shrimp



Brown Shrimp



General Distribution of Adults

Areas of Adult Abundance

The Shrimp Fishery

Shrimp have been fished commercially in the Gulf of Mexico since the latter part of the 19th century. However, Gulf Coast shrimping began in its present form with the introduction of the otter trawl in 1915. The otter trawl has changed little in design over the years, but the size and number of trawls used to capture the shrimp have. Commercial fishermen began testing and using twin trawl systems in 1972. This is done by towing two trawls from each side of the boat. Currently, the twin trawl is the most common technique used by offshore shrimp vessels.

The shrimp industry is the most valuable commercial fishery in nearshore U.S. waters with the brown, white, and pink shrimp dominating the harvest. The 1987 U.S. harvest was 223 million pounds (heads off) with the Gulf of Mexico shrimp fishery accounting for 71% of the catch.

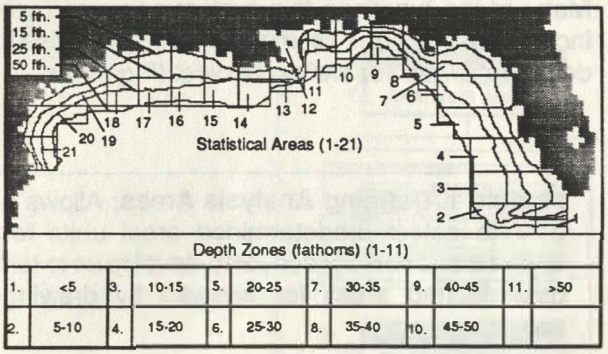
The Southeast Fisheries Center of NMFS evaluates shrimp management measures using a 30-year shrimp harvest data base. Statistics describing the U.S. Gulf of Mexico shrimp fishery began in 1956; the procedures used to collect these data are described by Klima (1980). To enable geographical assignment of commercial trawling effort and harvest and hence, classification of shrimp landings as to their origin, the continental shelf of the entire Gulf of Mexico coastline is divided into 40 statistical subareas. The U.S. Gulf of Mexico region is divided into 21 statistical subareas and each of these subareas are segmented into depth zones (Figure 2).

Primary catch data are recorded in pounds of shrimp (heads off), size category, statistical area, depth zone, and month. The total U.S. 1987 annual catch of shrimp for statistical areas 1 through 21 is shown in Figure 3. These data are used to derive catch per unit effort (CPUE) per 24 hours of fishing. In addition, surveys of inshore waters are reported and analyzed by the five U.S. states bordering the Gulf of Mexico.

Developing a Desktop Information System

Recent developments in microcomputer technology now make it possible to bring to the desk of the researcher or manager a wide range of capabilities and data that previously could only be accessed on larger mainframe computers. However powerful, desk-top systems are not yet replacements for most existing mainframe data base systems. They serve a different purpose, and if properly

Figure 2. Statistical Areas and Depth Zones



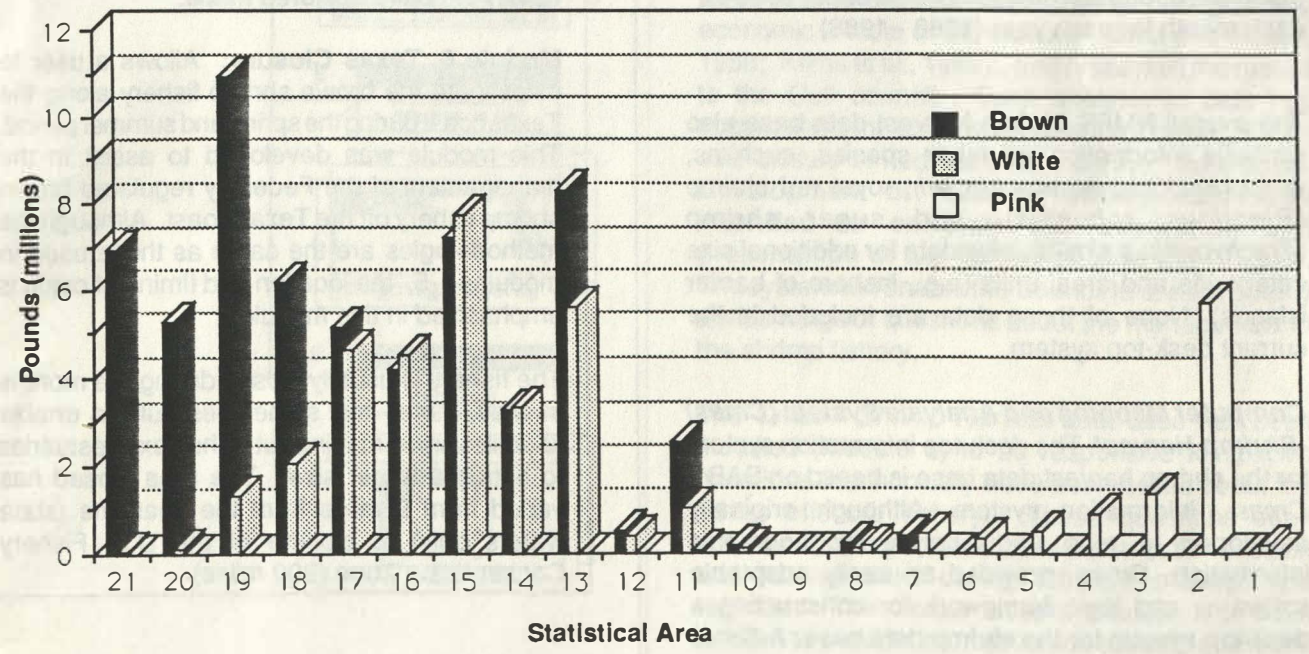
constructed can augment considerably the use and interpretation of large mainframe data bases.

Effective and efficient desk-top information systems have several characteristics. *First,* they are developed to be either problem or theme-specific (e.g., shrimp harvest in the Gulf of Mexico) so that the logic of how the data can be used is clear, almost transparent, to a user. *Second,* they are designed to answer a *limited number* of questions well, and do not attempt to provide a generic capability to answer *any* question that could be asked of a data base. Consequently, they typically contain a subset of the data in the larger data base. Third, they typically are more user-friendly than most mainframe systems. Little or no training is required to perform operations, often complex, with the desk-top system. A user does not need to understand programming nor specialized syntax. This broadens the number of users and use of a data base, often leading to new and innovative uses of existing data and providing insights into improving the larger overall data base.

However,a note of caution is worth mentioning. **The more simplified and aggregated the data contained in a desk-top system, the higher the level of expertise required to interpret results accurately.** Although the data are more accessible to non–ADP professionals, a high level of experience and understanding of the data is still required to interpret results. Streamlining and making computer operations user-friendly are not substitutes for an in-depth working knowledge of a subject.

The Shrimp Harvest Data Base. Since the late 1950s, the National Marine Fisheries Service (NMFS) has been collecting data on the harvest of shrimp in the Gulf of Mexico. This large data base resides on the NMFS mainframe computer in Seattle, WA. The data are collected primarily through an extensive reporting system. Shrimping vessels are met at the dock by NMFS port agents who record the amount, size, and type of shrimp caught by each vessel. Agents also interview a sample of boat captains to obtain information on fishing location (by statistical area and depth zone as described above) and fishing effort. The data base is used to provide information for a variety of uses, from basic fisheries research, e.g., population dynamics and movements, to

Figure 3. 1987 Total Shrimp Catch in Pounds for the Gulf of Mexico Statistical Areas



management decisions by the Gulf of Mexico Fishery Management Council concerning catch limits, seasonal closures of the fishery, trends in ex-vessel prices, and the economic value of the fishery.

Table 1 shows the subset of data elements extracted from the overall NMFS shrimp data base for use in the desk-top Computer Mapping and Analysis System (*Cmas*) – *Shrimp Harvest*. These data elements were selected for brown, white and pink shrimp only, as these three species account for most commercial shrimp harvest.

Table 1. Data Elements Included in *Cmas - Shrimp Harvest**

Data Element	Explanation
Total weight (heads off)	Pounds landed at dockside.
Weight by size category	Pounds landed by size category: <15, 15-20, 21-25, 26-30, 31-40, 41-50, 51-67, and >67 counts (heads-off shrimp) per pound.
Total value	Ex-vessel dollar value of total catch.
Value by size category	Ex-vessel dollar value of total catch by size category.
Days fished	Total number of 24 hour periods of fishing

* Compiled for each statistical area/depth zone for each month for each year (1960 - 1988)

The overall NMFS Shrimp Harvest data base also contains information on other species, such as, seabobs (*Xiphopeneus kroyeri*), royal red shrimp (*Pleoticus robustus*), and sugar shrimp (*Trachypeneus similis*), plus data for additional size categories and areal units (e.g., inshore of barrier islands). None of these data are included in the current desk-top system.

Computer Mapping and Analysis System (Cmas) -Shrimp Harvest. The desk-top information system for the shrimp harvest data base is based on SAB's *Cmas* information system. Although originally developed to map and analyze biogeographic information, *Cmas* provided an easily adaptable software and logic framework for constructing a desk-top system for the shrimp data base. A *Cmas* application for fish and invertebrate biogeography had already been developed for the Gulf of Mexico. Many of the functions this system contained were incorporated into the six modules that comprise the desk-top *Cmas* for shrimp harvest (Figure 4).

Module 1. Defining Analysis Areas: Allows a user to select predetermined areal units for analysis and comparison; or to develop up to ten user–defined areas for analysis by drawing polygons.

Module 2. Making Maps and Simple Summations: Allows a user to develop maps and tables portraying various aggregations by species, size category, month(s), year(s) and analysis area(s) for an individual data element (Table 1).

Module 3. Time-Series Histograms: Allows a user to develop histograms of individual data elements for specified selections of species, size category, month(s), and year(s).

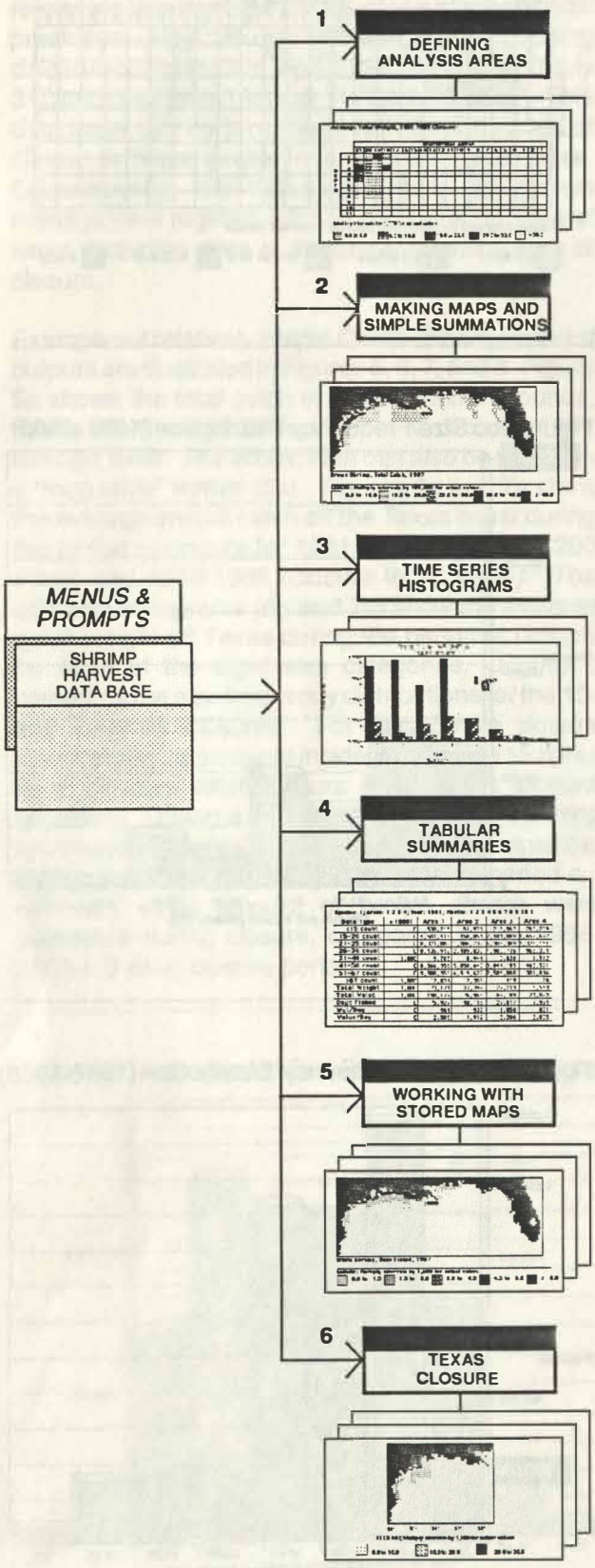
Module 4. Tabular Summaries: Allows a user to develop summary tables of data elements for specified species, years, months, and analysis areas.

Module 5. Working with Stored Maps: Allows a user to work with previously generated maps, either examining a map or maps by subarea, computing areal averages by subarea, or performing simple arithmetic operations (e.g., ratios) on pairs of stored maps.

Module 6. Texas Closure: Allows a user to investigate the brown shrimp fishery along the Texas coast during the spring and summer period. This module was developed to assist in the management of the Federally regulated brown shrimp fishery off the Texas coast. Although the methodologies are the same as those used in modules 1-5, the location and timing of catch is emphasized in this module.

The fishery is usually closed during the months of May, June, and sometimes July to enable juvenile shrimp moving out of the Texas estuaries to obtain a larger size. The area closed has varied from 9 miles from the coastline (state waters only) to closure of the U.S. Fishery Conservation Zone (200 miles).

Figure 4. *Cmas* - Shrimp Harvest Flow Chart



Cmas - Shrimp Harvest is configured to run on an Apple Macintosh micro-computer. The system is menu driven and prompts the user to make selections of the data to be used and outputs for portraying results. Although the system is user-friendly, extensive knowledge of the data and how they were collected is required to interpret results. The Galveston laboratory has conducted extensive experiments with the system to ensure that accurate and clear outputs are generated. Initial application of the *Cmas - Shrimp Harvest* desk-top system is to assist in development of the management strategy for the Texas offshore brown shrimp fishery in January of 1988.

Texas Closure Decision - An Initial Application

The Texas offshore fishery is managed by the Gulf of Mexico Fishery Management Council, one of eight such councils established under the Federal Fisheries Conservation and Management Act of 1976. One of the most controversial shrimp fishery management measures adopted by the Council is the annual, early summer closure of Federal waters off the coast of Texas to coincide with a closure of state waters. The Federal closure has been in effect since 1981. However the size of the area closed was reduced from 200 miles to 15 miles in 1986. The objective of the closure is to enable brown shrimp to reach a larger size before harvesting to increase the value of the fishery, because larger shrimp bring a higher price than smaller ones. Also, this eliminates discard of undersize shrimp caught during a period in their life cycle when they are growing rapidly.

Each year NMFS has monitored the biological and economic effects of the closure (Klima and Nance, 1988; Klima et al., 1982)), and presented the results to the Gulf council. Each analysis to date has documented the economic benefits of having a 200-mile closure of Federal waters off the Texas coast. **Development of *Cmas - Shrimp Harvest* is intended to enhance the evaluation and presentation of the fishery data to the Council.** The system will enable the Council to assess quickly a wide range of questions about the management of the shrimp fishery.

The *Cmas - Shrimp Harvest* data base has been modified (Module 6) to be responsive to specific questions that normally have been asked about the Texas offshore fishery. These questions often address the temporal and spatial distribution of catch and fishing effort during different management regimes. The Texas closure module has been tailored to provide information on specific questions

Figure 5a. Brown Shrimp, Total Weight, 1981-1988

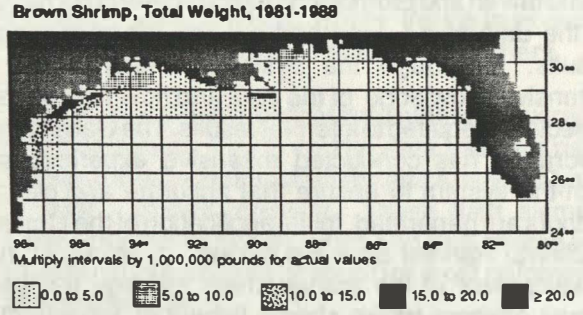


Figure 5b. Brown Shrimp, Total Weight, 1981-1988

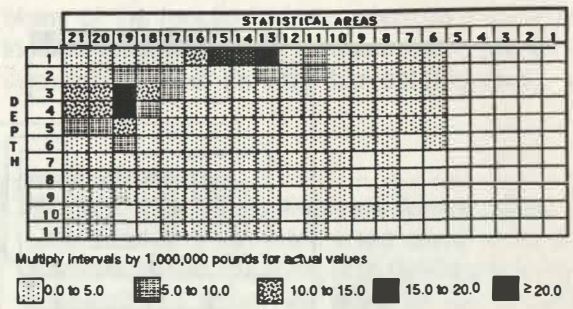
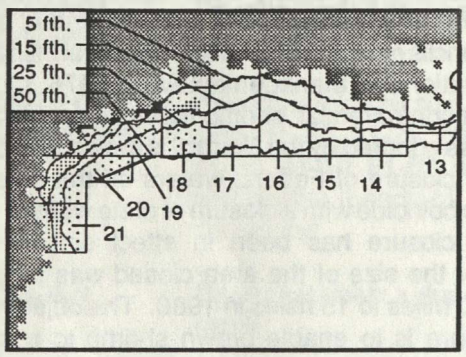


Figure 6a. Average Total Weight, 1981-1985 Closure



Multiply intervals by 10,000 pounds for actual values

0.0 to 2.0 2.0 to 4.0 ≥ 4.0

Figure 6b. Size Frequency Distribution (1981-1985)

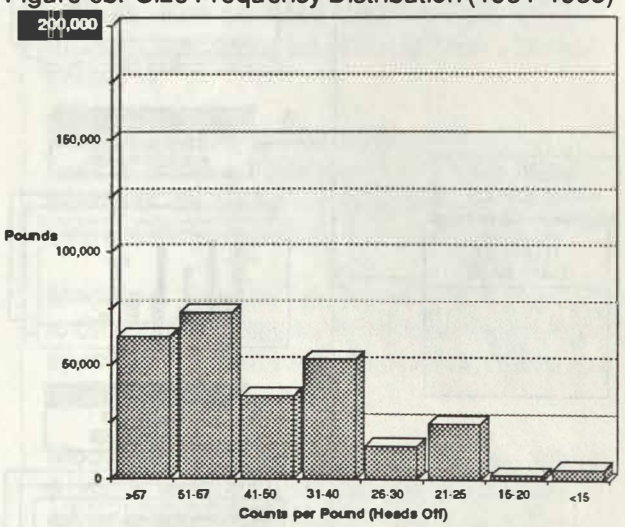
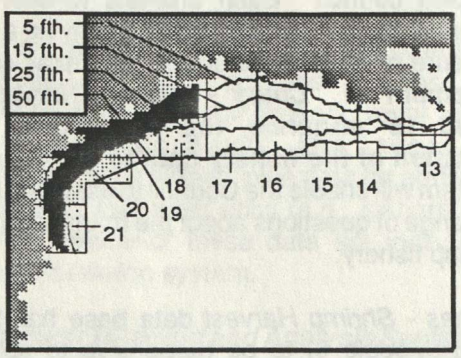


Figure 7a. Average Total Weight, 1986-1988 Closure

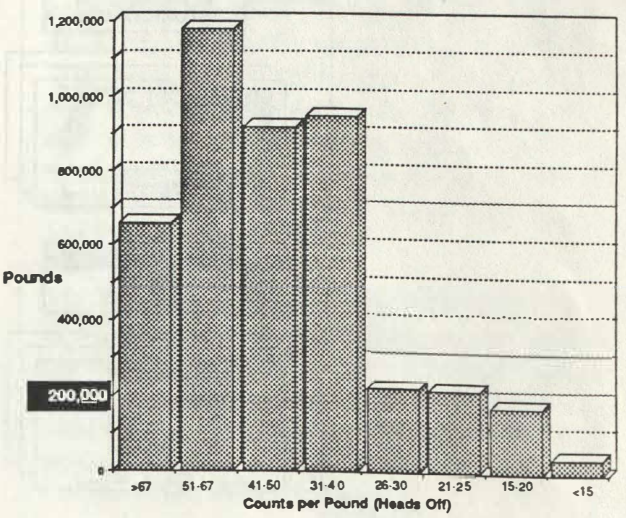


Multiply intervals by 10,000 pounds for actual values

0.0 to 2.0 2.0 to 4.0 4.0 to 6.0

6.0 to 8.0 ≥ 8.0

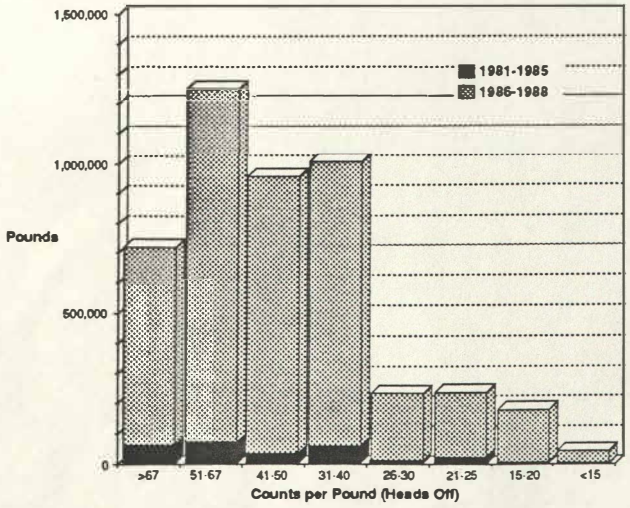
Figure 7b. Size Frequency Distribution (1986-1988)



that are used to manage this fishery. This module accesses a data base specifically constructed for this purpose. This data base divides the historical record of catch from 1981-1988 into four time periods: preclosure (May 1 to closing date); closure (closing date to reopening date); open (reopening date to July 31); and post-open (August 1 to December 31). This data base can be processed with the full range of *Cmas* software available to the larger data base. Consequently, the historical record of various management regimes may be compared in several ways, including time of closure and spatial area of closure.

Examples of relatively simple *Cmas – Shrimp Harvest* outputs are illustrated in Figures 5, 6, 7, and 8. Figure 5a shows the total catch of brown shrimp (pounds, heads off) throughout the Gulf of Mexico for 1981 through 1988. The information can also be shown in a "map table" format (5b). Figures 6a and 7a show the average annual catch off the Texas coast during the period of closure for 1981-1985 (closure to 200 miles) and 1986-1988 (closure to 15 miles). The adjacent histograms (6b and 7b) show the average catch weight off Texas during the period of closure for each of the eight size categories. Figure 8 compares the size frequency distributions for the 15- and 200-mile closures. For the 15-mile closure brown shrimp are caught incidentally inside 15 miles or a directed effort occurs beyond the closure boundary. During a 200-mile closure brown shrimp are caught incidentally while fishing for other species. During the 1981-1985 (200 mile) closure period a relatively small amount of brown shrimp were harvested during closure, compared to the 1986-1988 (15 mile) closure period.

Figure 8. Comparison of Size Frequency Distributions



Concluding Comments and Future Plans

Development of the desk-top *Cmas - Shrimp Harvest* system is an evolving process. The system will continue to be refined as more experience is gained with its use, especially by other users. A major objective is to increase and expand the range of communication between scientists and managers of the shrimp fishery.

This work should also provide insights into how NOAA is experimenting with new technology and concepts in "expert systems" and "information science" to make maximum use of its data bases. Plans are to incorporate additional complementary information, such as, inshore shrimp harvest data and sea turtle sitings and strandings, into the desk-top *Cmas - Shrimp Harvest* system. Longer term plans are to link *Cmas-Shrimp Harvest* to other *Cmas* and NOAA data bases, including those on species biogeography, pollutant loading, habitats, and estuarine processes.

Additional information on *Cmas-Shrimp Harvest* is available from either:

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Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service, NOAA
11400 Rockville Pike
Rockville, MD 20852
(301) 443-8843

or

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Southeast Fisheries Center
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(409) 760-3500

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