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Requirements of Gulf and South Atlantic Estuarine Research [1]

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Abstract

In recent years biological research agencies became deeply concerned about estuarine alteration and the probability of its adverse effect on commercial fisheries. This concern stems from the recognition that most species occurring in Gulf catches spend a portion of their lives in estuaries. In 1962 the U.S. Bureau of Commercial Fisheries allocated funds for estuarine research in the Gulf of Mexico. Studies of the total estuarine complex are in progress. These include: (a) biological productivity and its relation to physical and chemical surroundings; and (b) the effects of natural and man-incurred alteration on estuarine biota and Gulf fisheries. As a part of the 1964 International Biological Year, a study of primary productivity in estuaries will be coordinated among a group of laboratories in the Gulf and South Atlantic Region.

THE TERM "ESTUARY" is subject to varying definitions and continues to be modified as estuarine studies intensify. At a recent research coordinating meeting of the Bureau of Commercial Fisheries, participants modified the definitions of estuaries by Ketchum (1953) and Pritchard (1952) and adopted the following concept:

> "Estuaries are those shallow waters with fluctuating salinities that differ from those of the adjacent sea. Usually, but not always, they are semi-enclosed bodies of water. Physical factors resulting from the mixing of fresh and salt waters and the resulting nutrient enrichment and high productivity of these waters constitute the unique features of estuaries."

The periphery of the Gulf of Mexico contains numerous indentations which may be included in that description. Planimeter measurements show that there are approximately 7,500 square miles of estuarine area extending from the southwest tip of Florida to Brownsville, Texas. This is exclusive of some 15,500 square miles of adjacent, rich marshlands.

The real value of estuaries in their natural state is not generally recognized. Odum (1961) stated that they are among the most naturally fertile areas in

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the world and that they usually produce more dry organic matter per acre per year than fertile farm land or the sea. Odum (1959) compared primary productivity in a "cross section" of the biosphere ranging from the oceans, across continental shelf waters and through estuaries, marshes, and terrestrial communities (Fig. 1). He depicted productivity variation between various habitat types. Production is shown to be greater in estuaries and shallow water areas than in other sectors.

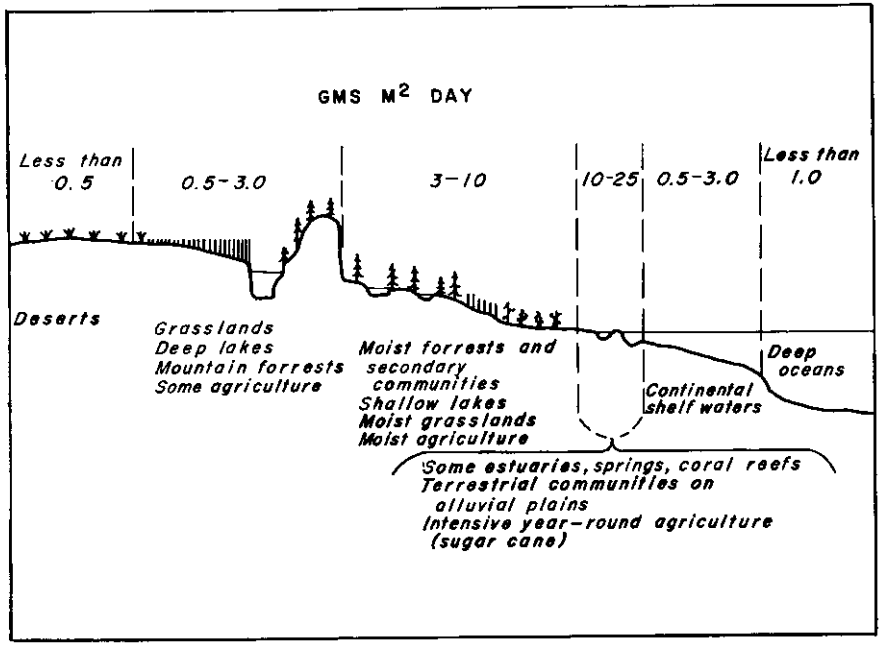

FIG. 1. World Distribution of Primary Production (Gms./m²/day). From Odum (1959) with permission of W. B. Saunders Company.

Hedgpeth (1957) stressed the importance of estuaries to the economy of neritic subtropical regions as nursery and feeding grounds. Skud and Wilson (1960) stated that the species which dominate Gulf of Mexico catches and account for 90% of the annual value are dependent upon estuaries as juveniles. Furthermore, Power (1962) showed that five estuarine dependent species, menhaden, shrimp, crabs, oysters, and mullet, comprised a catch of 1,131,000,000 pounds or 89.3% of the Gulf commercial catch in 1960. Our research in Tampa Bay has shown that at least 24 of the important species landed in Gulf fisheries occupy the estuary while immature (Table 1). Thus, it seems evident that Tampa Bay contributes to Gulf of Mexico commercial landings. The ex-vessel value of these landings in 1960 was $85,000,000 (Power, 1962).

In addition to the production of commercially harvestable species, estuaries provide excellent sport fishing and recreational areas. Sport fishermen land species which are commercially important as well as those not normally harvested by nets. One-sixth of all game fish landings in the United States are

made in coastal waters. By the year 2000 this percentage will be increased to one-third of total catches (Gresh, 1963).

TABLE 1

COMMERCIALLY IMPORTANT SPECIES OF THE GULF OF MEXICO WHICH OCCUR AS JUVENILES IN THE TAMPA BAY ESTUARINE SYSTEM

COMMON NAME	GENUS AND SPECIES
Large scale menhaden	*Brevoortia patronus*
Yellowfin shad	*Brevoortia smithi*
Pink shrimp	*Penaeus duorarum*
White mullet	*Mugil curema*
Fantail mullet	*Mugil trichodon*
Striped mullet	*Mugil cephalus*
Blue crab	*Callinectes sapidus*
Oysters	*Crassostrea virginica*
Black grouper (gag)	*Mycteroperca microlepis*
Red grouper	*Epinephelus morio*
Spanish mackerel	*Scomberomorus maculatus*
Spotted seatrout	*Cynoscion nebulosus*
Red drum (redfish)	*Sciaenops ocellata*
Bluefish	*Pomatomus saltatrix*
Crevalle jack	*Caranx hippos*
Black drum	*Pogonias cromis*
Pompano	*Trachinotus carolinus*
Sheepshead	*Archosargus probatocephalus*
Spotfin mojarra	*Eucinostomus argenteus*
Silver jenny	*Eucinostomus gula*
Striped mojarra	*Diapterus plumieri*
Spot	*Leiostomus xanthurus*
Sand seatrout	*Cynoscion arenarius*
Permit	*Trachinotus sp.*

The cultivation of estuaries in producing seafood has been practiced for centuries by the nations of the Old World. For instance, the Japanese have demonstrated how shallow areas may be cultivated to supply large quantities of edible protein (Cahn, 1950). We, too, should look toward better utilization of our own estuaries and means of increasing seafood production.

The estuary has become a choice area for man's infiltration, particularly in southeastern United States where lie some of the most fertile shallow water areas of the nation. Increased population and industrial development usually have brought the following: (1) domestic sewage, soluble synthetic compounds, and petroleum products, oftentimes dumped directly into the estuary, (2) bulkheading, dredging, and filling for the creation of water-front homesites, canals, channels, and causeways (Fig. 2), (3) hurricane barriers to protect growing cities, (4) bottom scouring resulting from bulkheading, and consequent alteration of current direction and velocity, and (5) diking or damming to raise water tables, to create fresh-water fishing reservoirs, and to augment domestic water supply.

In view of the known importance of estuaries and the present rate of development within them, we are confronted with diverse research problems.

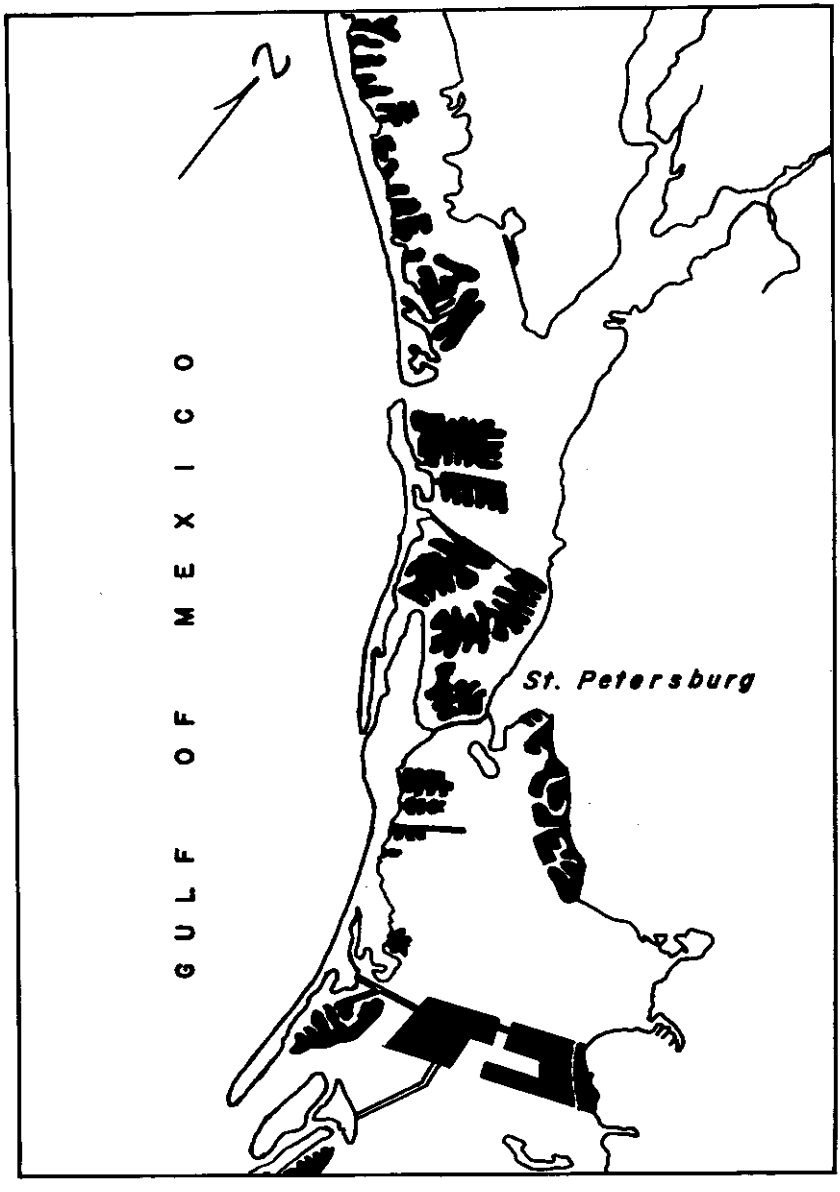

Fig. 2. Fill projects in Boca Ciega Bay, Florida, a part of the Tampa Bay system. Darkened areas depict real estate sites created artificially.

Prominent among these is the need for estimating the dollar value of estuarine biological resources and the extent to which major types of physical alteration affect biological production. We must also concentrate on the development of regulations and the modification of structures to insure protection of the resources from damaging projects.

Regarding protective measures, Rounsefell (1963) urged caution in the formation of recommendations for managing estuaries. He emphasized that management formulae were dangerous when based on narrow aspects of the problem without regard to the ecosystem complex.

The realization of those objectives requires a thorough understanding of fertilization mechanisms. Shelske and Odum (1961) listed five factors responsible for a high rate of plant growth and subsequent productivity: (1) three primary production units (grass, mud algae, and phytoplankton; (2) tidal action; (3) abundant supplies of nutrients; (4) conservation and rapid turnover of nutrients; and (5) year-round production. Their list forms a standard for evaluating estuaries. Variation within the five factors and between individual estuaries necessitates the investigation of each area under consideration.

Estuarine ecological research is underway at several federal, university, and state laboratories in the Gulf and South Atlantic region. In 1963 representatives of Bureau of Commercial Fisheries laboratories in this region met to review estuarine research programs and to discuss programming and coordination methods. Dr. Eugene P. Odum of the University of Georgia participated actively in discussions and planning. The following comments summarize briefly the federal estuarine programs discussed at the conference. There is no intention of implying that these are the only estuarine programs in operation. Most of the universities and states located on the Gulf and South Atlantic coasts are also active in this type of research, and in fact, communication and cooperative studies of mutual problems are advancing.

The U.S. Biological Station at St. Petersburg Beach, Florida, has undertaken the following studies:

1. BENTHOS.

A study of bottom ecology provides one of the better indicators of estuarine condition. For that reason, results of benthic studies are useful in estimating the effects of a changing environment. Series of sampling stations were located on transects across Tampa Bay in a survey of benthic sediments and associated biota. The stations cover the entire range of benthic types including oyster bars, rock outcrops, and shallow, deep, mud, sand, shell, and grass bottom. The association of benthic species with major substrate types is under investigation.

2. FAUNAL PRODUCTION.

This study is designed to account for species diversity, seasonal and areal occupancy of animals in the estuary, and the dependency upon estuaries of immature forms which are essentially marine in their environmental requirements. At present, attention is being focused upon seasonal species distribution of fishes. A report on macro-invertebrates, their distribution and relation to bottom type has been completed (Dragovich and Kelly, 1964).

3. HYDROLOGY-PLANKTON.

Phyto- and zooplankton are basic elements in the food chain. The extent and composition of their communities determines in large part the quality and

productive capacity of an estuary. Analyses are being made of zooplankton volumes and associated hydrologic parameters (temperature, salinity, and total phosphate-phosphorus) obtained in the investigations over the past one and one-half years. Concurrently with present plankton collections, determinations of temperature, density, salinity, pH, oxygen, phosphate-phosphorus, transparency, and plankton pigments are also made.

4. WATER CHEMISTRY AND PRIMARY PRODUCTIVITY.

The object of this project is to study the relation of hydrologic conditions to biological production. The chemistry laboratory is presently engaged in analyses of salinity, total nitrogen, total phosphate, inorganic phosphate, oxygen, calcium, and pH. Chlorophyll A is being analyzed in conjunction with solar radiation measurements for conversion to primary productivity values. Ultra-violet absorption rates are determined for possible use as indices of dissolved organics. Age diversity of phytoplanktonic populations is measured by absorption ratios of an acetone extract.

In designing East Gulf Estuarine Investigations, those studies appeared to be the ones which have the most significant bearing on estuarine ecology and biological production. Studies of circulation, flushing, and transport characteristics are contemplated.

Other Bureau of Commercial Fisheries laboratories of the South Atlantic and Gulf region are engaged in similar studies, although emphasis varies with laboratory and location. At the Radiobiological Laboratory, Beaufort, North Carolina, the rates of production of benthic plants and phytoplankton are being compared in shallow estuaries. Experiments are being conducted to determine the factors controlling the productivity of estuaries and to develop methods for regulating their productivity. The cycling of elements is traced in experimental environments designed to simulate conditions in nature. Rates will be determined for the movement of radioactive tracers from water to sediments and communities of estuarine organisms. Existing levels of radioactivity in estuarine ecosystems are measured to be used as base lines for future comparisons in the event radioactivity becomes a significant environmental factor. Likewise, the potential effect of radiation as an environmental factor is being evaluated in relation to the growth, reproduction, and life span of estuarine organisms.

The Biological Laboratory (fisheries) at Beaufort, North Carolina has for several years been active in the study of marine and anadromous species and their dependence upon an estuarine environment during early development. The commercially important species under study include menhaden, shad, striped bass, and blue crabs.

Major problems at the Galveston, Texas Laboratory involve modification and destruction of estuarine and marsh habitat arising from pollution, exploitation of mineral resources, flood control and hurricane protection, development of water-borne commerce, and land reclamation projects. In an effort to insure that fishery resources receive adequate consideration in multiple-use development of estuaries the Galveston Laboratory is: (1) obtaining background ecological data to depict the importance, contribution, and value of Gulf estuaries to commercial fisheries and the relationship of biological populations to environmental characteristics; (2) assisting the Bureau of Sport Fisheries and Wildlife in determining the probable effects of water development projects on estuarine dependent fishery resources; (3) evaluating published

and unpublished data describing and relating to Gulf coast estuaries; (4) cooperating with other agencies through the exchange of views, data, and assistance for mutual benefit; and (5) developing better methods for determining specific effects of construction projects upon fishery resources, and establishing criteria for project modifications that would best serve the interests of fishery resources.

The Gulf Breeze, Florida Laboratory is engaged in intensive examination of species diversity ratios by salinity regimes and by bottom type; also determination of the normal seasonal fluctuations in abundance of some commercially important species. Data have been recorded for 15 continuous years on seasonal fluctuations in appearance of sedentary organisms with parallel records of hydrographic and meterological measurements.

The laboratory at Brunswick, Georgia, is situated in the center of the rich marsh area of the Georgia coast. This laboratory specializes in the taxonomy, development, and distribution of the fishes of the western North Atlantic. A portion of the research takes place in estuaries of Georgia and northeast Florida.

One of the major objectives of the coordination conference was to develop a method for evaluating estuarine biological resources. It was recognized that industry can and does attach a dollar value to its operations and projected contribution to a community. Unfortunately, scientists and custodians of the natural resources have spent little time in converting information on bio-mass and productive potential to dollar estimates. The value of animals occurring in the fourth trophic level or the worth of a relatively few pounds of fish harvested in a one-year period is usually cited when monetary evaluation is required. In these instances unicellular plant production at the first trophic level, grazing herbivores at the second, or small carnivores at the third level are not accounted for. Furthermore, there are usually no estimates made for the value or potential utilization of energy existing between the first and fourth trophic levels. These components must be studied, documented, and recognized before estuaries can be placed in competition with industry and land development activities.

The first unified effort between laboratories of the Bureau of Commercial Fisheries and other interested state and institutional agencies will be to measure total primary production. This consists of a light-dark bottle study statistically designed to measure total production in grams of carbon per given time period for the combined estuarine areas in the Gulf and South Atlantic region of the United States. The study is designed to employ standard methods by all cooperating laboratories. This effort will constitute an integral part of the 1964 International Biological Year.

Although the study of primary productivity represents the initial coordinated effort, other mutually designed studies are anticipated. These include investigation of the role of detritus as food and structure in the habitat, assessment of factors limiting biological production such as oxygen and food supply, and the development of better ecosystem indices. Especially needed are means by which engineering activities may be modified to conform with the biological requirements of estuarine organisms. Man-made structures such as hurricane barriers, jetties, and artificial reefs might stabilize or even *increase* estuarine production if engineered in accordance with recommendations of ecologists. For instance, much loss of coastal oyster and clam beds has occurred as the

result of siltation from hurricanes. Here, the protection afforded by some of man's devices would have been welcome. This is but one example of the need for methods of constructing and modifying artificial structures to benefit the resource rather than degrade it. This involves consultation with engineering and industrial agencies prior to construction.

The need for research specifically applicable to estuaries has been recognized for several years. Progress in initiating studies which attack a multiplicity of problems and areas has been gradual. Financial and technical support has now intensified so that promise of estuarine research on a large scale can be visualized. The combined effort in studying primary productivity on a regional basis is encouraging and is the first step to be taken in proving the potential value of southeastern estuarine systems. The coordinated study should produce facts useful to governing agencies in retarding and eventually ending that part of man's estuarine invasion which inhibits that value.

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