# THE COASTAL RESOURCES MANAGEMENT PROGRAM OF TEXAS

APPENDICES
to the
INTERIM REPORT

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## INTERIM REPORT



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# SPECIAL REPORTS

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for

COASTAL RESOURCES MANAGEMENT PROGRAM

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OFFICE OF THE GOVERNOR

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*This report contains several papers of interest/importance to the Coastal Resources Management Program of Texas. The first two, Technology and the Future and Economic Implications of Alternative Uses of Natural Resources are papers prepared especially for this project. The other two, Conservation in the Coastal Zone and Role of Mineral Resources in Coastal Zone Development are edited speeches given at the Governor's Conference on Coastal and Marine Resources (Houston, 1970).*

# *I. TECHNOLOGY AND THE FUTURE**

*Technological forecasting is still more of an art than a science* but regardless of the category in which one places it, *forecasting technological change is an increasingly necessary part of planning.* In today's industrialized world, decisions that affect our resources and our environment will increasingly determine the way we live tomorrow and it is likely that technological change will no longer be permitted to proceed unguided. We have come to recognize that our future is inextricably dependent on our management of science and technology. The growing number of pollution problems of all kinds suggests that *social pressures* will impose greater restraint on technological change in the future than they ever have in the past. Obviously this makes the job of the forecaster much more difficult, since *his predictions must include considerations of social values in addition to technological ones.*

Planning by the electric utilities has, for several decades now, been governed by the more or less steady growth in the demand for electricity. There are month-to-month and year-to-year fluctuations in the demand for electricity but they are not as severe as those that affect most industrial products. There is of course no rule of nature that says that electric power needs will continue to grow indefinitely at the same rate. *In fact, they obviously cannot.* However, the utility's responsibility, *imposed by law,* requires it to maintain continuously the capability of supplying electricity to anyone who needs it. For the short term at least, the power companies can hardly do other than plan for a continued growth in power needs.

Today the lead time from the point of decision to plant operation is about *5 years* in the case of gas-fired power plants and *7 or 8 years* in the case of nuclear plants. These times are growing longer. Even before beginning definite plans to build a plant, a site must be acquired and routes for new transmission lines must be planned. The lead time for acquiring power plant sites has increased through the years and many utilities now must begin thinking about plant sites that may not be needed twenty years hence and begin acquiring sites that may not be used for ten to fifteen years. The *siting problem is becoming increasingly complicated* by shortages of land, considerations of fuel and water supply and air and water pollution control requirements.

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*Pollution controls pose an especially difficult planning problem because the rules keep changing.* A recent example is the action of the Texas Air Control Board in lowering the air quality standards for three metropolitan regions of Texas below those which the Board had established on a state-wide basis *only* two years earlier. Industries now find they must attempt to *anticipate years in advance* the quality of environment that people are going to want. The planner's dilemma of course is the necessity of making investment decisions involving substantial sums of money on the basis of predictions whose reliability is at best very questionable.

*The future is of course unknowable but it is not unthinkable.* The commercial technology of tomorrow already exists in today's science and we ought to be able to visualize the implications of new scientific developments and identify the social, economic, and industrial interactions that will result. David M. Kiefer[1] has listed a number of ways in which technological forecasting may be refined. The "Delphi technique," developed at the Rand Corporation, seeks to arrive at some sort of panel consensus regarding the future by soliciting opinions from a panel of experts and feeding these opinions back through the panel one or more times in sort of a brainstorming approach. A technique popularized by Herman Kahn is the writing of a scenario which attempts to describe qualitatively but systematically the logical sequence of events that might plausibly evolve step by step from any given situation. There are other approaches, but probably *most forecasting is based upon attempts to hang the future on the framework of the past.*

When quantitative historic data are available, *trend extrapolation* is widely used. A series of data is plotted against time to form a pattern through which some type of curve can be drawn and then extended beyond the present. Extrapolation has many advantages, principally its simplicity and the fact that it produces quantitative results; and since technological progress is often a result of a large number of small individual advances, there is considerable logic in the assumption that past progress in any given field of technology will continue.

*But events can override trends.* For example a chart of the price of natural gas to large users would show a steady increase for many years up to the time at which the Federal Power Commission began active control of the price of gas shipped in interstate commerce. At that point the price chart abruptly levels off. Technological decisions in the late 50's based upon a continuing increase in gas prices would have been in error, perhaps expensively so.

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[1] *Kiefer, David M., "The Futures Business,"* *Chemical & Engineering News, August 11, 1969.*

For many years the thermal efficiency of electric power plants in the United Stated increased at a steady rate as manufacturers applied new technology to increase steam temperatures and pressures. But a few years ago limitations imposed by the strength of available materials finally halted the rise and the trend has leveled off. This development is something that might reasonably have been forseen by anyone interested enough to try to do so but a governmental action, such as the Supreme Court decision that established FPC jurisdiction over natural gas pipelines, cannot be forseen by any ordinary system of forecasting. *Consideration of social goals and probable governmental actions to achieve them now must be included as a new part of the "art" of the forecaster.*

An error frequently made in technological forecasting is failure to maintain a broad enough perspective. *Too many times, experts will point out the impossibility of doing something instead of considering in broad context the many alternatives that might make it possible.* A prime example is the statement of Admiral William Leahy in 1945: "This is the biggest fool thing we have ever done. The (atomic) bomb will never go off, and I speak as an expert in explosives." The great American astronomer, Simon Newcomb, proved conclusively in 1903 that it was impossible for man to fly long distances through the air.

Closer to home, there is in the files of the University of Texas a geologist's report made in *1935* which states that a dam could be built at *Possum Kingdom Bend* on the Brazos River capable of generating 13,000 kilowatts of electricity which *"will insure a power supply sufficient for any future need of North Texas."* The dam was indeed built, but today this amount of power would be inadequate even to supply the nearby city of Graham.

Technological forecasting and research are closely related. In 1954 Texas Electric Service Company joined with the U. S. Geological Survey in a study at *Lake Colorado City* in West Texas aimed at learning more about the effect of heat addition to the reservoir by the power plant there. When this research began, *no one cared* very much how much water was consumed by steam electric power plants and the term "thermal pollution" had not even been thought of. The motivation for the project was a desire for a better knowledge of the effects of power plant operations on reservoirs simply because it was predictable that there would be more installations of this kind and we wanted to know as much as we could about them. Today, because of this and other research projects that followed it, we are able to state *with good accuracy* how much water a power plant does consume and we are also able to show that, on the *artificial reservoirs in Texas,* the effects of power plant operation are *beneficial* to the native game fish population in the reservoirs. Important social decisions relating to the state's water resources will be influenced by this kind of research. It is an example of the long-term benefits that can be realized from research whose goal is no more specific than a desire for a better understanding of what is forseen to be an increasingly important technological function.

The electric utilities are involved in a number of such research efforts, aimed at solving environmental problems. Here in Texas one research project aimed at making beneficial use of the waste heat from a power plant has already paid off in the *commercial production of catfish* grown in the warm water discharge of the plant during the winter when fish growth normally does not occur. In other parts of the country waste heat is being used in *industrial processes, for home and office building heating, for increased production of various aquatic organisms and for increased agricultural production.*

Nationally, the industry has set up through the Edison Electric Institute a series of committees aimed at evaluating and reporting on new developments in a number of fields relating to *energy production, transmission and use, such as superconducting transmission lines, magnetohydrodynamics, fuel cells, nuclear fusion and battery-powered cars.* EEI supports research in several of these areas. In this way the industry seeks not only to stay abreast of technological developments but also to influence them.

The development of nuclear power in this country offers an illustration of the way in which industry can *both influence and be influenced by a major technological development.* The discovery of nuclear fission and the demonstration in 1942 of the practicality of controlling and putting it to use was closely followed by a major effort in which the manufacturers, the utilities and the government joined in the design and construction of nuclear power demonstration plants. By 1966 the utilities were buying nuclear plants on a commercial basis and the approximately *$2 billion* expended by government and industry in the development of atomic power began to pay off for the nation's power users. In the light of the long time span needed for the development of earlier technologies, the Corliss engine for instance, the fact that nuclear power went from proof-of-principle to commercial feasibility in only a quarter of a century illustrates very well the accelerating nature of technological development and the problems it poses for planners. Now the utilities are actively participating in nuclear breeder research aimed at achieving commercially feasible fast breeder power plants by 1990.

The possibility of obtaining power from nuclear fusion reactions is an example of a technological development that is still in its infancy but which probably will have an even greater impact than nuclear fission on energy use in this country. Fusion power plants would use deuterium as fuel, a substance which is so abundantly available in nature that it can be considered virtually inexhaustible. Fusion reactors would, in principle, be very safe and would not generate objectionable radioactive by-products. Ultimately, fusion power may eliminate entirely the problems of the disposal of waste heat produced during power generation.

*At present these are little more than dreams.* Fusion is only at the stage that fission reached in the early days of the Manhattan

Project. Feasibility has not yet been conclusively demonstrated. Yet as early as 1957, when the subject was still classified, the electric utilities of Texas were supporting research aimed at the ultimate use of fusion for power generation. More recently, the electric industry nationally, through the Edison Electric Institute, joined with the Texas power companies in supporting part of the substantial fusion research program that has developed at the University of Texas at Austin. Texas is now a key participant in the national fusion research effort whose success could benefit all mankind.

*Technological forecasts can be self-fulfilling.* President Kennedy's promise to put a man on the moon before 1970 was not only a remarkably accurate technological forecast but also, because of the backing it received from the American public, it became a goal that had to be reached. *One is tempted to speculate whether a similar chain of events might occur if our president were to announce that we would achieve power production from nuclear fusion within a similar time period.*

## *II. ECONOMIC IMPLICATIONS*

## *OF*

## *ALTERNATIVE USES OF NATURAL RESOURCES**

*Natural resources are defined as those resources which man has had no part in creating.* Among the familiar examples of natural resources are land, water, minerals, the air, space, and wild plant and animal life. Man uses natural resources as inputs to produce currently consumable goods and services he desires and to produce or create other forms of capital such as plants, equipment, machinery, instruments, facilities, such as highways and airports, and housing for business and residential uses. The quantity of resources used annually (natural and man made capital resources, labor and management) and the efficiency of use are determinates of the size of the bundle of goods and services produced annually by the economy. The composition of annual production and the quantity produced are measures or indicators of the performance of the economy and the economic welfare of the economy's population. The physical characteristics of size and quality of the natural resource supply, the organization of the economy, i.e., the manner in which man decides to combine resources into production units, the skill and efficiency with which he does this, and the kind and quality of products produced affects the size and quality of the bundle of goods and services produced and thereby influences welfare of the economy's populations. The purpose of the following discussion is to *outline the process whereby resources are allocated and the implications of these allocations insofar as consumer welfare is concerned.*

The total bundle of goods and services may contain many items, but in relation to the desires of the consumers, the total size of the bundle of goods and services is usually *inadequate to satisfy consumers' seemingly insatiable desires.* Since the quantity of goods and services produced is a function of the resources employed, including natural resources, man made capital, labor and management, the inference is directly made that the quantity of resources employed per production period is inadequate to supply all consumers' demands. Since resources are scarce, consumers demands are seemingly insatiable, and the economy's production mechanism is limited in size and scope, choices must be made and the quantity of goods and services produced per production period must be rationed among consumers. *Among the most important functions of an economy are the functions of allocating scarce resources among competing uses and rationing products produced among consumers.*

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In a freely operating competitive market economy, both consumers and producers are considered to be sovereign. That is to say that *consumers* are free to express their demands to the market and to use incomes and the resources they own for the purpose of making transactions among themselves and with producers to secure the goods and services desired. *Producer sovereignty* means that individual business establishments are free to organize capital, hire labor, secure financing, and arrange for resources and other production services as they see fit. That is to say that producers are free to engage in manufacturing and supplying goods and services desired by consumers. Through a freely operating market in which producers' wishes, consumers' wishes, and resource availability is freely and widely known, the collection of producers deals with the collecting of consumers for the purpose of achieving satisfaction on both the demand and the supply sides of the economy. The process of bidding for resources and trading among the producers on the one hand and the consumers on the other hand results in allocation of the economy's available resources among the alternative and competing uses. The system, of course, relies upon the exchange of information between the two groups so that each has knowledge of the other's desires.

*The price mechanism of the market economy is the mechanism whereby the desires of consumers are transmitted to the producers, and vice versa,* in a single common denominator so that resources which can be used in the production of many things are allocated so as to attempt to maximize the degree of satisfaction achieved by both producers and consumers. *In a market economy, prices serve as the basis for making choices in solving resource allocation problems and, in addition, serve to ration the quantity of goods and services produced among the consumers.*

Obviously, the level of welfare achievable by any individual consumer within the economy is dependent upon his level of income, prices of the products and services he wishes to buy, the range or variety of goods and services available and the quantity of these goods and services offered for sale. Consumers' incomes are a function of the quantity of resources owned which can be exchanged in the market place and the quantity of wages or salaries the individual can secure from sale of his personal services. Thus, *distribution of ownership of natural resources* and the *willingness of owners of natural resources of offer such resources to producers,* or to use such resources in production, is an important determinant of the size of the bundle of goods and services produced by the economy. In general, in a market economy, resources, including labor and management, are paid in accordance with their productivity in use. That is to say that the contribution of an individual resource to the overall value of production resulting from its employment determines its value in production and, consequently, its value to the economy. Demand for resources is derived from consumer's demand for goods and services, and, consequently, the resource's value is determined by markets.

Under the condition of consumer and producer sovereignty, economic forces of prices and incomes within a market economy determine resource allocation and ultimately determines economic value of individual resources. *In equilibrium, the optimum resource allocation is that which simultaneously satisfies the desires of consumers and producers, given their respective demand and supply schedules.* A change in consumer's desires, as is reflected by a change in price consumers are willing to pay for goods and services, will result in a change in resource allocation by producers and potentially an entirely different bundle of goods and services could be produced from resources. Likewise, a change in resource supplies which affects costs of production will change the price of goods to consumers and, thus, a new, but presumably equivalent, optimal resource allocation will result. Shifts in resource allocations among products and among producers will no doubt result in shifts of consumer's welfare among groups of consumers who prefer different kinds and types of products. That is to say that an increase in cost of using some natural resource, such as increasing costs of water to a manufacturer, will force the manufacturer to increase his asking price for the same level of product. In the market, an increased price of product to consumers is observed to reduce consumption of the product since some of the consumers will no longer desire the product at the higher price, or some consumers may desire less of the product at the higher price than at the previous price. Therefore, the new higher price of a resource results in reduced consumption of the products produced from the resource and, thus, implies that less of the resource will be employed. *Unless substitute resources can be found which will permit production and sale of commodities at lower prices, an increase in a resource cost results in a reduction of output and, consequently, results in a reduction of employment of the resource.* Analogously, a reduction in the price of a resource is expected to result in increased employment of that resource, other things equal, and an increased quantity of goods and services will be placed on the markets. Increased quantities of goods in the markets ordinarily results in lowered prices and, thus, consumer welfare increases due to increased purchasing power and the larger quantity of goods that can be purchased.

*In most productive processes, more than one resource is required.* Some resources substitute for each other over certain ranges of inputs and some resources are complimentary as inputs. When possible, producers will substitute resources so as to reduce overall cost of production, i.e., will select the lower cost inputs, and will substitute so as to reduce total outlays. An example of such substitution is the case of adoption of labor saving machines as the wage rates increase. Some resources are compliments as opposed to substitutes, which means that fairly constant proportions of different resources must be used if production is to take place. In this case, a change in the level of use of a resource results in a proportionate change in the inputs of complimentary resources. Thus, price changes which adversely affect the use of one resource will have spill-over effects upon the employment of other resources.

Ordinarily, when resource employment is reduced, resource owners will be willing to lower prices in an effort to secure employment; i.e., to sell their resources as opposed to foregoing resource sales and the resulting incomes therefrom. *A change in the supply of or the cost of a single natural resource can effectuate reallocation of not only the resources affected directly but also can result in a reallocation of complimentary natural and man made resources.* The economic implications of reallocating resources to alternative uses are that new levels of economic welfare will be the result. Ordinarily, reallocations are not made unless both the producer groups and the consumer groups expect to gain new levels of satisfaction. In monetary terms, a new level of satisfaction would be expressed if the real dollar value of products and services produced were increased in relation to that previously produced. Presumably, consumer's tastes and preferences are reflected in monetary units through the price mechanism. Thus, a change in tastes and preferences would be expected to effectuate a reallocation of natural resources among producers and users. For example, if consumers decide to shift from automobiles for transportation services to use of mass transit transportation services, in order to reflect their distaste for polluted air, then consumers can reflect this change in taste by increasing their willingness to pay mass transit fares and failing to purchase automobiles. Obviously, producers of mass transit would increase operations which implies an increase in use of resources, and automobile producers would reduce their level of resource use. Or, the decision-makers of the economy would shift resource use away from automobiles and into mass transit production. Such a shift would involve reallocation of resources used by producers of transportation services and would involve all resources complimentary to production of transportation services.

*A shift in resource allocation will have many economic implications, including perhaps a negative effect upon some consumer groups.* For example, if producers of *mass transportation* services increase the use of resources previously available in relatively small quantity, then prices for these resources will increase and those producers and consumers who utilize such resources prior to the price increase will be faced with higher prices and will suffer losses in overall welfare unless suitable substitutes can be found. Another illustration of effects of alternative resource uses is found in the case of *air pollution.* For example, members of society who do not utilize air polluting types of transportation vehicles share at least indirectly in the costs of air pollution. They have only polluted air available for use and do not enjoy the benefits of the transportation system which polluted the air. Wereas, users of such a transportation system have the same quality of air as non users but also have the benefits of the transportation system.

*Natural resources are used as the basic ingredients of the goods desired by consumers.* The employment of these resources is done in many ways and in many combinations. The desires of consumers operate through the price mechanism to create the basis whereby producers allocate their scarce quantities of resources among alternative uses so as to attempt to maximize their own satisfactions; i.e., profits. In the process of resource allocation for economic production, the overall level of economic welfare is ultimately determined. Economic efficiency is the criterion whereby alternative resource uses are evaluated. When either producers or consumers can realize a benefit from changing resource allocation, economically efficient criteria would indicate that such changes should be made. Presumably, the resulting new allocations will be superior to those previously used.

The economy is the collection of the different producers and consumers. *For convenience and ease of understanding the economic effects of alternative natural resource allocation, the producers can be grouped into economic sectors.* An economic sector is the collection of producers that produce the same kind or quite similar products; i.e., the automobile manufacturers compose the automobile manufacturing sector, while the dry cleaners and laundries may be grouped into a clothes cleaning sector. The cotton farmers are a fairly homogeneous group of producers; thus, cotton farmers can be viewed as an economic producing sector.

In modern, complex economies, individual sectors specialize in the production process and trade with each other to dispose of products and secure inputs. The basic industries begin the process of creating goods desired by consumers often by extracting natural resources, performing the first stages of processing and then selling a partially finished product to a sister industry, which in turn adds value by changing the form and either sells the resulting product to another industry or, if the resulting product is in finished form, sells it to the trades sectors which, in turn, make the sale to consumers. As raw materials are processed and moved through the producing sectors of the economy, services, such as transportation, finance, insurance, legal, accounting, engineering, and perhaps many other professional services are used at various stages of the process.

The economic implications of alternative uses of natural resources can perhaps be illustrated best with a *simple example. Ferrous metals* can be used in the production of a multitude of items desired by consumers ranging from bridges and automobiles to eating utensils and toys. Various manufacturing sectors have been organized to produce these many iron and steel products. Each of them uses different processes and resources with the exception of the basic metal, which is purchased from the iron and steel foundries and mills. Some of these manufacturing processes utilize highly skilled designers and craftsmen. Others do not. The ultimate value placed on the finished goods by consumers determine the quantity of metal used by each different manufacturer and the price that can be paid for the basic metal.

A similar example to that of metals is the *case of land.* Land is presently used to produce crops and livestock from which food is manufactured, as the site for locating manufacturing and business establishments, homesites and recreation. Although not all land is equally suited for each purpose mentioned above, different types of land can be substituted among uses and some land is suited to many uses. Thus, landowners and society are continually faced with the problem of deciding how many acres to allocate to each of the many agricultural uses and how many acres to shift to other uses, including lands for outdoor recreation.

If farmers plant too many acres of land to vegetables, in relation to consumers' market demands, then vegetable prices will decrease through farmers efforts to sell vegetables. If prices decrease too much, some acres probably will not be harvested, some farmers will lose the production outlays already spent, and the vegetables will be left in the fields to waste. Not only are the vegetables from such efforts lost, so were the opportunities to grow some other crop such as fruit, grain or grass which could have been used to produce milk, mutton or beef. Most Americans are familiar with another example of planting too many acres to grains and cotton. In this case, society, through the National Congress, decided to purchase and store the "surplus" grains and cotton and thereby support the prices of these commodities. The net result has been a prolonged allocation of too many acres to grains and cotton in relation to consumers' demands for these commodities as is reflected by the market prices. Some "economic welfare" was realized, however, in the form of income transfers, since surpluses have been distributed at relatively favorable prices to low income and disadvantaged groups through surplus commodity programs. In addition, farmers, whose range of resource allocation choices were very narrow, benefited through the income support received from such programs.

In addition to farmers, *society has other choices to make concerning land use for such things as public recreation places and public facilities.* When society decides, through various arms of the public sector of the economy, to allocate more land to recreation uses, then such lands are purchased, usually from farmers, and placed in parks and other public recreation places. Such purchases obviously remove the land from other uses and thereby natural resource reallocation is effectuated away from agricultural or forest production and into recreation production. To make such a choice, society must be able to judge that consumers desire the recreation space in comparison to the agricultural commodities from the land in question. A purely rational market transaction which reflects this desire would be that society would willingly pay more for the land per acre than farmers would pay per acre; otherwise, farmers, whose decisions are based on prices consumers offer for food and fiber commodities, would keep such lands for production on the basis that the markets for food and fiber signaled what amounted to a higher price for food and fiber than for recreation uses of the land.

*Prices received for products produced are major guidelines for natural resource allocation among the competing uses in both the case of land and metal allocation described above. The price received for the final product is used to pay contributing material and service resources.* Any value remaining after purchased resources are paid is used to pay taxes and returns to capital. All residuals above normal returns to capital can be considered as profits. Profits in an industry are the signals that attract new investors and result in increased resource employment and increased output by the industry. Increased outputs contribute to overall welfare through the added products available for consumption and through reduced prices of the products of the industry affected. Thus, in the final analysis, the manner in which natural resources are allocated among industries determines the level of complimentary resource and service employment, and the quantity and quality of products and services available for consumers to buy and use. *The overall welfare of the population of the economy is determined by the size, quality, and distribution of the products and services produced.* Thus, the economy is continually in need of improved technology to increase technical efficiency of resource inputs to outputs and improved communications among consumers, producers, and resource owners if natural resources are to be employed at the desired level and allocated in the most advantageous manner insofar as consumers are concerned. *Improving resource efficiency and resource allocation techniques are particularly important since the supply of natural resources is limited, populations of consumers are continually increasing, and consumers are observed to continue to desire steadily increasing per capita levels of economic welfare.*

## *III. CONSERVATION OBSERVATION IN THE COASTAL ZONE**

*Conservationists believe that society should create an environment in which people have the best opportunity to live the good life.*

Admittedly, this is a vague and ill-defined aim. People can't agree on what a "good life" is. People don't know what they really want. But they are beginning to learn what they do NOT want. A great deal of what they do not want will be enthusiastically recommended to this seminar in terms of the highest public good. I wonder if this entire seminar will not turn out to be an elaborate Establishment exercise in self-delusion - in which the extractors, developers, and builders, and the bankers who finance them, and the politicians who presumably regulate them, and the academicians who collaborate with them, all come together here in Houston to talk about our coastal resources *in a frame of reference already obsolete.*

I probably differ from most of the speakers who will appear on this platform, in that I do not believe that growth and progress, as we have known them, can continue. We have, in my opinion, passed over a great watershed. *We are the first generation of Americans who will have to tell their children that things will be worse for them than they were for us.* The twin problems of *environment* and *population* are the central issue of our time. They are altering our lives, our values, our politics, and our business climate.

In the brief period allotted to me, I would like to throw out some of the ideas of conservationists of Texas concerning our coastal regions. They deal with the General Land Office, state action on the population front, pipelines, unitization of state oil leases, dredging, preservation of barrier islands, and coastal zoning. One of Texas' greatest opportunities to introduce ecological and environmental values into public decision-making is to reform the General Land Office.

### *General Land Office*

Including mineral acres, the General Land Office controls some 22 million acres of land, much of it submerged. *In the past the office has been administered to maximize the immediate income to the School Land Fund, regardless of long-range effects.* We have a

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*Address given by Edward A. Harte, Publisher of Corpus Christi Caller-Times, to the Governor's Conference on Coastal and Marine Resources, Houston, Texas, September, 1970.

new commissioner, whom we will have the privilege of hearing this afternoon. I have every hope that he will institute a new system of values in the Land Office, in which *conservation will get more consideration* than it has in the past.

But I submit that our political leaders should give high priority to a constitutional amendment by which the Land Commissioner would cease to be an elected official and would become an appointive one, accountable to the governor and the legislature. As it is now, the Land Commissioner - whoever he is - is the least accountable among all the executive office-holders in Austin.

*Population Office*

I would also suggest that if Texas officialdom really wants to do something about preserving the coastal and marine resources of the state, we should set up in Austin a State Population Office. *Population is the polluter and the destroyer of our natural resources.* The population growth which we have seen in the last generation cannot be sustained in Texas, or in the United States, or in the world. The place to start reversing it is at home, and the task requires and deserves top priority from state officials.

*Pipelines*

You already know how fragile are the environment and the biological balance of our bays and estuaries. Oil pollution is recognized as a major threat to coastal ecology. Yet, *neither state nor local authorities know where all the pipelines are that crisscross this vulnerable region, what those pipelines carry, or what condition they are in.* The City of Corpus Christi comes nearer than any governmental agency I know of in being able to say where pipelines are within the waters it controls. Detailed knowledge about all pipelines is clearly necessary for control of pollution, and obviously some agency of government bigger than cities and counties is going to have to coordinate and put together that information. I submit that the Land Office and the Railroad Commission have been far less energetic than they should have been in supervising pipelines, and that the resulting absence of information could lead to serious ecological blunders.

*Unitization of Oil Leases*

It seems axiomatic to conservationists that the state should seek by every means to keep to a minimum the number of wells drilled in the coastal waters. But in the past, the General Land Office has discouraged, rather than encouraged, unitization - at least in those cases in Corpus Christi Bay of which I have intimate knowledge. It seems to me that unitization, in the interest of fewer wells and fewer possibilities of pollution, should be public policy in any state which really values its submerged lands.

*Dredging*

To conservationists, dredging is probably the most harmful activity going on in our coastal region. We used to hear that there was only a 7-year supply of shell left ...that was about 7 years ago. Then we heard, "Give us a little more time to depreciate our equipment, in which we have millions invested - then we'll all go to limestone." But shell dredging continues today on almost as great a scale as ever. *In the conservationist's view, a state which literally turns over to the dredgers its entire coastline cannot pretend to give serious weight to the long-range stability of its coastal biotic community.*

In addition to shell dredging, conservationists object to shoreline development in which there is bulkheading, dredging, and filling. This practice - which is growing in popularity - is extremely damaging to the marine nursery and the productivity of the bays.

*Barrier Islands*

I suggest that Texas needs a *policy on its barrier islands.* These islands serve a purpose, in providing storm protection to the mainland, a purpose they are not going to serve as well, if at all, when they have been levelled, subdivided, and covered with conventional home construction.

I think we are fortunate that more than half of Padre Island is federally owned as a National Seashore. Mustang Island is virtually in single ownership, and the owners are negotiating now with Parks and Wildlife and the Department of Interior, trying to put 75% of their holdings into public hands. St. Joseph's and Matagorda Islands are also essentially in single ownership and undeveloped.

*The State of Texas should determine now whether development of these islands is in the long-range best interest of the coastal region.* If it is not, the state should acquire the islands to preserve them from undesirable and inappropriate development.

*Zoning*

The essence of my argument is that the *entire coastline is going to have to be zoned.* That is what the legislation which led to this conference is all about. The purpose of the inter-agency study, of which this seminar is a part, is to identify the resources up and down the coast, and then to determine which will be given priority in certain areas - in other words, which areas can be developed and which must be left in the natural state.

*Conclusion*

Dr. Flawn has said, correctly I am sure, that there will be change and development in the coastal area of Texas. I have taken it as my role in this conference to point out that a growing number of Texans regard these changes as a threat to their future. AMERICA'S LOVE AFFAIR WITH TECHNOLOGY AND APPLIED SCIENCE IS ABOUT OVER.

## *IV. ROLE OF MINERAL RESOURCES*
## *IN COASTAL ZONE DEVELOPMENT**

### *A. Address*

*The role on mineral resources in the development of the coastal regions of the State of Texas is of such obvious and overwhelming importance that we are inclined to take it for granted,* and more or less forget it. This would be a very grave mistake for any planning or legislative body to make, for all available indicators tell us that we are about to enter a time when it will be critical to the economic and strategic welfare of this nation, as well as to the industry of this state, to *insure that maximum incentives are provided for the development of the mineral resources of Texas, both onshore and offshore.*

Let us place things in perspective. In 1967, according to Sea Grant Publication 105, Texas produced $1.3 million of edible finfish, $1.6 million of oyster meats, a little less than a quarter of a million dollars of blue crab, and shrimp valued at $46.4 million, or a total of $49.7 million for edible fish and shellfish - i.e., *just under $50 million.*

In 1968, by comparison, offshore federal oil and gas lease sales *alone grossed $593.9 million, or just about 12 times as much as the combined value of fish and shellfish,* just for the privilege of hunting for oil and gas. These federal leases were outside the three-marine-league Texas leases, and additional values are assignable to Texas' state-owned hunting rights. Even highly speculative mineral deposits far outweigh in cash value other marine resources. *Actually oil and gas production from coastal counties is worth millions of dollars per day.*

When and if oil and gas are found, then values are measured in terms of millions of barrels and trillions of cubic feet. These are the resources that ensure the continued operation of coastal refineries and petrochemical plants, that provide work for shipyards, marine engineering and supply firms, and employment for all of the many types of oil field specialists. Even more important, *they provide economic, industrial and strategic stability for our society in an age that is completely dependent upon petroleum products for everything from transportation to heat and chemical raw materials.* That tourist from California would never get here, that sport fisher-

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*Frank B. Conselman, Director of International Center for Arid and Semi-Arid Land Studies at Texas Tech University, at the Governor's Conference on Coastal and Marine Resources, Houston, Texas, September, 1970.

man from Dallas would never reach salt water, and no shrimp boat or dredge would put to sea, without the help of petroleum products. *And I might add, no newspaper would be printed, either.*

In this day and age we hear much about protecting the "environment" and the "ecology." In general terms these are praiseworthy objectives, and every one with decency and sensibility subscribes to them in principle. But we must nevertheless always remember that *Man got where he now finds himself, for better or worse, by overcoming his environment, and by subordinating the ecology of other organisms to his own material progress.* This is selfish and can be overdone, but it must be done to a degree if we are to survive. The way to prevent abuses is not to eliminate or penalize the development of the raw materials on which so much depends, but to control their development intelligently and cooperatively. This has already been stressed by previous speakers; I subscribe to their views and will not belabor the point. I am in fact delighted that all of us appear to be dedicated to a joint, cooperative effort.

All of us are aware of the hue and cry over Santa Barbara, which has become one of these *capsule condemnations* of which superficial commentators are so fond. We deplore the damage to wildlife, on whatever scale. But when the smog of exaggeration rolls away, and the crocodile tears of sympathy for the grebes and the cormorants, whom I love as dearly as the next man, are reduced to a mere running off at the nose, the record of history may show that what *Santa Barbara actually marked is an all-time high in local hysteria and national over-reaction to the detriment of our own long-range best interest.* Lack of proportion combined with fuzzy observation could result in the self-denial to the United States of one of its most vital areas of self-sufficiency.

*We cannot afford an oil leak like Santa Barbara off Texas,* and the state and federal governments must join industry in preventing it. More important, we cannot afford to have Texas deny itself its rightful heritage of wealth and material for the sake of political masochisms or a popular emotional binge. *It is hoped that the results of this conference may help set the relative values in focus.* In my opinion, this is one of the most pressing and immediate questions to which this conference should address itself. *This is a time for compromise by reasonable men so that all of our State's best interests can be developed in collaboration rather than in competition, for the maximum benefit of all of the citizens of Texas.* No one should expect, and I am sure no one really wants, a monopoly of all of the rights and priorities of resource development. We have yet to learn the full value of what is involved in submarine resources, but until we do the current federal policy of voluntarily relinquishing sovereignty rights to mineral resources beyond the 100 fathom mark may not be in the best national interest. The coastal states have a definite stake in this matter.

Not all offshore mineral wealth is petroleum. In addition to the dissolved substances such as magnesium and iodine of the Gulf waters themselves, there are likely to be values obtained from offshore deep sulfur and from bottom-distributed pellets of concretionary materials like manganese. The Atomic Energy Commission has just announced a sensitive sea-floor probe that can detect minute quantities of critical elements, and this may be of eventual commercial significance. *More important to the immediate practical welfare of the Texas Gulf, however, is such a workaday material as oyster shell.* Onshore salt, sulfur, and sand, and inland lignites and uranium ore are also of substantial value in the Gulf region. And we must not lose sight of the Gulf water itself. Desalination plants using the salt water of the Gulf may eventually prove to be the most important source of consumable water in the state. After all, neither Dallas nor San Antonio nor El Paso has an inexhaustible supply of water lapping at the city gates, but many Gulf communities do.

Mr. Charles Parker, of Parker Brothers Compnay, will serve as keynote speaker on the non-petroleum minerals of the Texas Gulf. Mr. Edd R. Turner, Jr., offshore manager of Getty Oil Company at Houston, will keynote the oil and gas aspects of Gulf mineral resources. Following their addresses, I shall turn the meeting over to Panel Chairman Kenneth E. Montague, president of General Crude Oil Co. and also of the Texas Mid-Continent Oil and Gas Association, who will introduce his panel to you. You will find, I am sure, that each of these gentlemen has a personal contribution which he is particularly well qualified to make. After that, the meeting is yours, the only limiting factor being presumably, but not necessarily, the Social Hour from 5:30 to 6:30 P.M. Please consider yourselves personally invited to express your viewpoint on any matter that moves you to do so. After all, that is why we have a conference of 300, rather than a simple meeting of the panelists.

### B. *Summary of Mineral Resource Panel Session*

The State of Texas can further the development of the coastal zone and of the sea by providing a *mature, reasoned and benevolent climate for continued mineral resource production,* within the framework of optimum multiple use of *all* the resources of the region, in a cooperative and responsible manner compatible with the overall public interest.

To achieve this we must establish a unity of purpose while eliminating mistrust of the co-users' motives and artificial conflicts for selfish purposes. Communication among the various interested groups is the surest way to minimize misunderstandings, and the Houston Conference marks a very useful beginning in this direction.

*The State of Texas is the proper authority to sponsor and administer the necessary cooperative arrangements for coastal and offshore use.* It should establish for this purpose a specific agency of highest quality, made up of prestigious representatives of all the principal contributing sources of knowledge and experience, to function as a blue-ribbon, multi-disciplinary, inter-industrial and socially responsible policy-making group, reporting directly to the governor, who would assign appropriate regulatory authority. The Coastal and Offshore Administration of the State of Texas (COAST) would be charged with the following responsibilities:

a. *Formulation of recommendations* of Texas policy on the various aspects of developmental activity under the American free enterprise system, and encouragement of the enunciation of these policies for public guidance.

b. *Planning for each decade,* extending progressively at least ten years into the future. Plans should include harbor and coastal improvement schedules, pollution control, park and resort development, mineral lease sales, training programs, fresh water supplies, industrial zoning, etc.

c. *Investigation and reconciliation of conflicts* of interest where these interests overlap or become competitive and cannot be adjusted by the parties concerned.

d. *Liaison* with other states, the federal government's counterpart agencies, and international bodies.

e. *Public information* and orientation on a factual basis.

f. *Such additional duties* as the Governor of Texas may from time to time prescribe.

While these activities are being planned, *their integration with the economic well-being of non-coastal Texas must not be overlooked. It would be detrimental to the State if the inland oil industry were destroyed by unlimited imports of petroleum, or if all river waters were reserved for estuarine or river-mouth use, or if other advantages were provided to the coastal zone that became disadvantageous elsewhere.*

It has already been established that mineral resources can be successfully, safely and economically extracted on shore under multiple use conditions. We have operated under the multiple use philosophy of consideration of the other fellow's rights and interests.

The lessons learned on land can be applied at sea and on the tidelands, given goodwill on all sides and a decent economic incentive. *The State of Texas can and should supply the necessary groundrules and guidelines so that coastal development may be both economically and ecologically sound.*

# TRANSPORTATION IN THE COASTAL ZONE

Prepared by

The Texas Transportation Institute

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October 1970

for

COASTAL RESOURCES MANAGEMENT PROGRAM

INTERAGENCY NATURAL RESOURCES COUNCIL

DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

*CONTENTS*

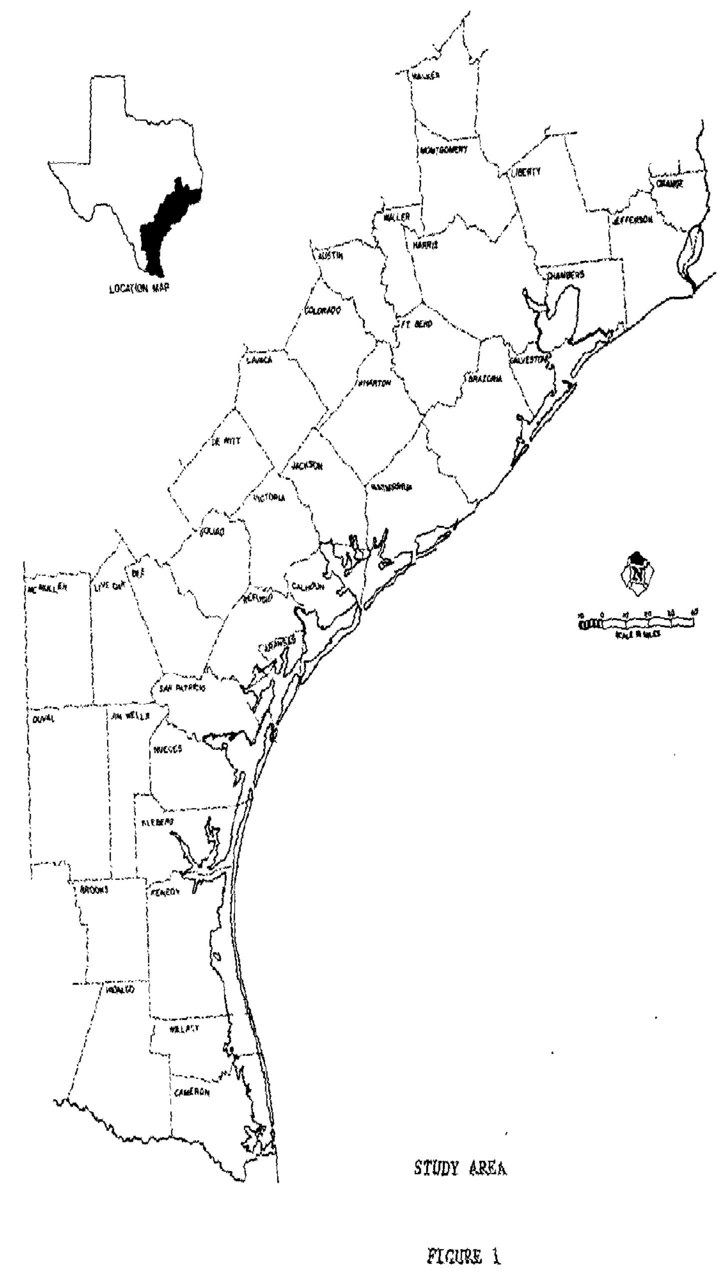
# TRANSPORTATION IN THE COASTAL ZONE

## I. *THE PROBLEM*

Texas' Coastal Zone has never been clearly defined. For the purpose of this exercixe it has been agreed that the Zone embraces all State of Texas Planning Regions which contain one or more counties bordering on the Gulf of Mexico; see Figure 1. It extends seaward 10½ miles from the coastline. These regions and their included counties, from south to north, are:

| | | |
|---|---|---|
| Lower Rio Grande Valley | Cameron<br>Hidalgo | Willacy |
| Coastal Bend | Kenedy<br>Brooks<br>Kleberg<br>Jim Wells<br>Duval<br>San Patricio | Refugio<br>Bee<br>Live Oak<br>McMullen<br>Nueces |
| Golden Crescent | Calhoun<br>Goliad<br>Victoria | Jackson<br>Dewitt<br>Lavaca |
| Gulf Coast | Matagorda<br>Brazoria<br>Wharton<br>Fort Bend<br>Colorado<br>Galveston<br>Harris | Waller<br>Austin<br>Chambers<br>Liberty<br>Montgomery<br>Walker |
| South East Texas | Jefferson | Orange |

It is recognized this delineation of the Coastal Zone is subject to challenge and does not agree exactly with the boundaries established by the Interagency Natural Resources Council in its 1969 Coastal Resources Plan Program Guideline. The total absence of any clearly defined topographical barrier or other distinguishing characteristic, such as marked agricultural, industrial or population changes as one proceeds inland from the Gulf, forces what may seem to be an arbitrary delineation. The area could be expanded or curtailed without greatly affecting the planning which should be done. It is strongly recommended, however, that the *integrity of Texas Planning Regions be maintained wherever practical* in order that this work be in harmony with other planning under the *"Goals for Texas"* program.




STUDY AREA

FIGURE 1

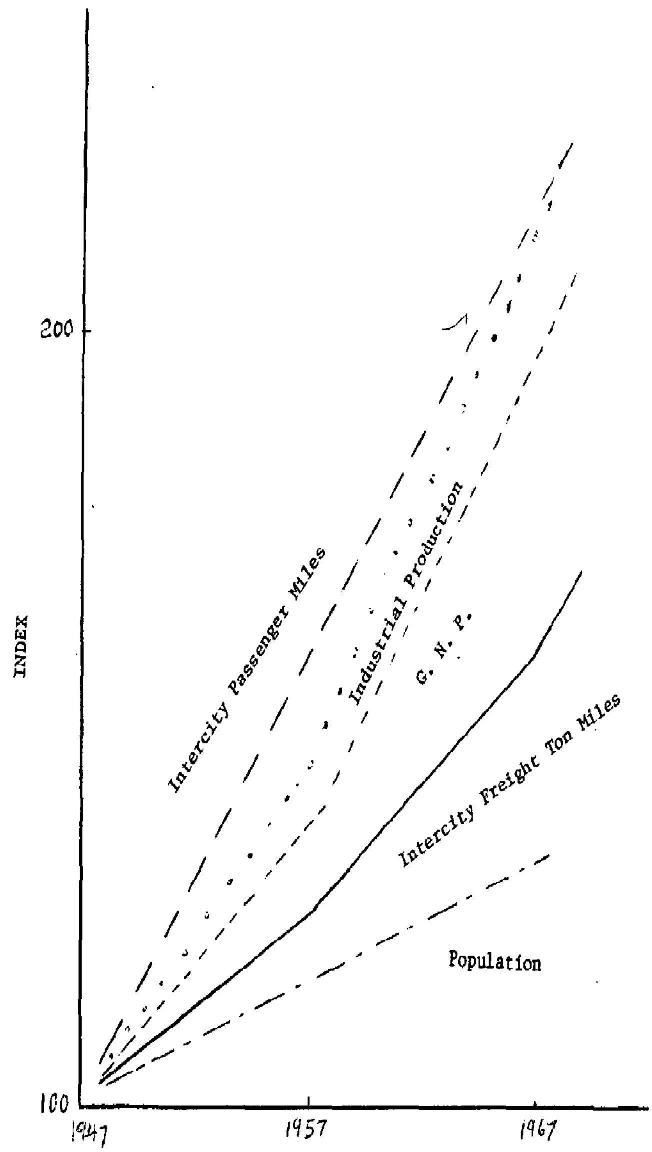
This would require adjustment of the Council guideline. It is also recognized, however, that efficient transportation planning must transcend such regional boundaries since by its very nature it does link-up regions.

The multiplicity of governmental activities within the Coastal Zone as defined above contributes to the difficulty of comprehensive planning for this area and emphasizes the essentiality of strong leadership at State level. In addition to the five planning regions, containing thirty-five counties, there are *twenty-five points at which liquid and dry commodities are interchanged between land and water transportation.* Eleven of these ports handle more than ninety percent of the total tonnage so interchanged and are in competition with each other to varying degrees. This tradition of competition at local level coupled with the heterogeneity of agricultural and industrial activity and of population densities in the Zone will require the utmost effort to develop the spirit of cooperation necessary to maximize the potential of Texas' Gulf Coast.

On the national level transportation demand grows faster than the population (Figure 2). Over a number of years expenditures for transportation in one form or another have accounted for an almost constant twenty percent of our gross national product. A high ratio of transportation expenditures is characteristic of the more highly developed nations. While no breakout of these data has been made for the Coastal Zone, there is no reason to believe the ratio differs significantly therein.

Projections made by the Department of Transportation indicate that the United States, in the next ten years, will have to *approximately double its present transportation capacity* if current trends continue. This does not necessarily mean doubling the physical plant, although some expansion will be required. *Better utilization of the transport complex as a whole,* with less avoidable waste of time, space and other resources resulting from better planning can provide much of the needed capacity.

Many phases of transportation have grown without the benefit of system planning. Fortunately, transportation planners have now recognized the need for tying transportation to land use and other developmental planning. This is nowhere as evident as in highway planning by the Texas Highway Department. Efforts of the Highway Department to maintain smooth flows of traffic as the people of Texas became more mobile permitted occurrence of the inevitable transition from rail to highway travel with a minimum of disrupted service. Many miles of railroad have been abandoned as they outlive their usefulness. Traffic generation centers have arisen because of income and employment opportunities, with many of these centers having *explosive rather than gradual* growth characteristics. Naturally, transportation services had to *react* to the growth of these centers *rather than plan* for them. A better understanding of the complexities of transportation by the general public as well as public officials whose actions however remotely affect transportation is essential to the success of future planning.




NATIONAL TRANSPORTATION DEMAND

FIGURE 2

Source: Transportation Institute of America

Transportation differs from all other industries in many ways. Unlike, for example, electrical power or telephone service, part of its product is subject to economic regulation (price, points served, etc.) while being in direct competition with unregulated service in the same area. Some of the operators (rail, pipe line) use private way constructed and maintained at private cost while others use publicly provided way at costs proportional to use (truck, air) and one, inland water, uses tax supported facilities at no cost whatever. Another difference often forgotten is the varying service characteristics of the several carrier modes. To many, transportation of goods is just that whereas, to the user, the difference of time in transit; loss and damage; and other service factors are often more important than price differentials.

Despite the personal feelings of railroad presidents, trucking executives and ship operators, *transportation is no end in itself.* While, as we shall see later, it is more than just a service, as such *it exists only to satisfy the needs of its users* - a public utility - along with electric power, telephone communication, and the rest. Unlike other public utilities, most of which are regional and local monopolies, transportation companies engage in fierce competition within modes and between modes for the larger portion of their business. The result is, with some execptions, a low rate return on investment which translates into extreme difficulty in generating and attracting essential equity capital. This, in turn, impedes expansion and modernization. The sole exception to this generality is pipe line transportation which enjoys a unique position in the transport complex.

Many of the problems of transportation are blamed upon regulation. It has become fashionable to call for "deregulation," to claim that "free competition" is the magic button which would provide all the answers (Others often prefer to think of "re-regulation" as being the solution.). Nothing could be more fallacious despite our national dedication to what we choose to call "--free competition."

Rightly or wrongly, our infant nation adopted as national policy the concept that a small business is as entitled to freedom from discriminatory treatment by suppliers of goods and services as his larger competitors. Price discrimination by suppliers of transportation was the target of early regulation. Control of *maximum transportation prices* (rates and fares) resulted. It is important that this was no action of a paternalistic central government but *originated by popular demand at the State level* and in the presence of cut-throat competition between carriers. The Federal Government entered the scene only when it became apparent that fragmented economic regulation by individual states was ineffective and destructive of the best interests of our budding nation as a whole. *We invented regulation by commission as an alternative to nationalization of transportation (the railroads), then common in most other nations.* As newer modes came into general use the rail regulatory pattern was extended to them without adequate analytical thought (Hindsight).

Later on, at a time when our railroads were suffering a wave of bankruptcies and when nationalization was again being advocated, we found ourselves about to lose private enterprise rail transport on which the national economy then depended, and to a large degree, still does. We found it necessary to exercise some degree of control over the prevailing intense competition. Control of entry and *minimum rates* (price) resulted. These provisions also were carried over into regulation of other modes when, beginning in 1935, they were partially regulated.

It must be concluded that, in 1970, generalized advocacy of "deregulation" is arrant nonsense. We may change the form of economic regulation. We might even transfer the job from the regulatory agencies to some more politically responsive body, such as the Department of Justice or the Department of Transportation, *though doing so would create a whole new set of troubles.* However, until public service replaces private profit as personal and corporate motivation and the biblical Golden Rule generally prevails, we will continue to have transportation regulation in some form, by some agency of government, at both State and Federal levels. *The real task is to stop fighting windmills, study the fundamentals, decide what we want and why, then make it work.* Decision making is not the proper function of planners or analysts, who can and should, however, provide the decision makers with the factors essential to an informed decision.

## *II. MAJOR TEXAS PORTS*

One of the major factors accounting for the dynamic growth of the Gulf Coast area in Texas has been the development of deep water ports. Of the 25 points shipping and receiving dry and liquid commodities along the Texas Coast, 11 ports annually handle more than 90 percent of the total tonnage shipped. Figure 3 gives the name of the 11 major ports in the Texas Coastal Zone and indicates the approximate relative size and location of each port.

These 11 Texas ports accounted for over *168 million short tons* of cargo shipped during 1967. With over 58.3 million tons, Houston led all other Texas ports in volume for this time period. Beaumont, Corpus Christi and Port Arthur ranked 2nd, 3rd and 4th after Houston with 31.0 million tons, 23.4 million tons and 23.1 million tons, respectively. Figure 4 shows the types of cargoes handled by the major ports in Texas during 1967.

Table A shows the general characteristics of the 11 major ports on the Texas Gulf Coast for 1967, including domestic and foreign shipments, channel depths, accommodations and other facilities available to shippers. Consistent with the total volume handled, the Port of Houston leads in all categories relating to domestic and foreign shipments.

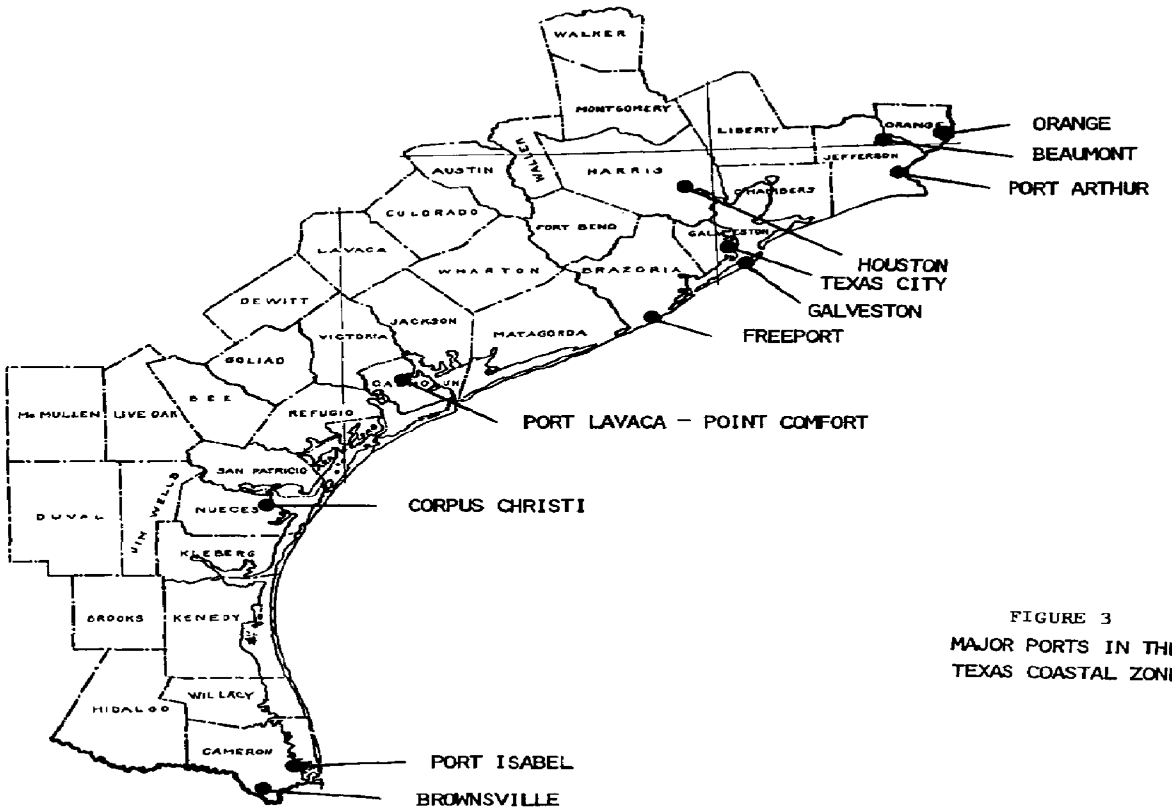



FIGURE 3
MAJOR PORTS IN THE
TEXAS COASTAL ZONE

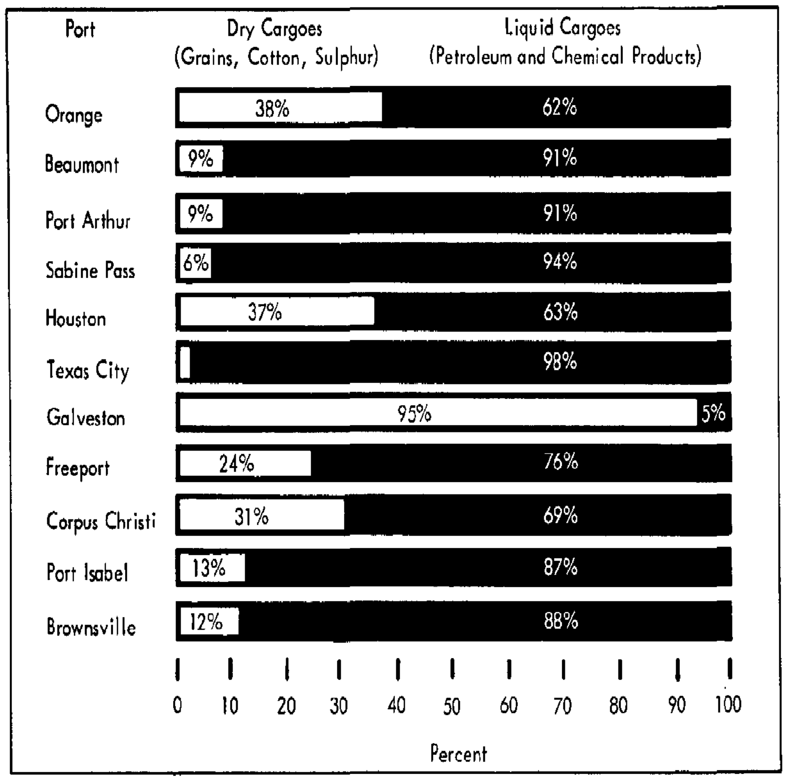
With the rapid development of superships and supertankers, those Texas ports unable to accommodate super draft vessels due to channel limitations now fear *they face an immense and crucial challenge to their economic future.* Partial solutions to these gigantic ships are available through containerization and Lighter-Aboard Ship (LASH) concepts. Full resolution of the supership problem to allow major Texas ports to maintain orderly growth patterns may only occur through the establishment of offshore terminals in deeper waters to accommodate such superships, or alternative arrangements. Specific problems of such facilities are addressed in Section IV, "Super Draft Water Ports."

## *III. WATER TRANSPORTATION*

The comparatively recent advent of so-called superships has served to focus attention on these craft and their port facility requirements almost to the exclusion of older, more conventional shipping. *There can be no question that planning of needed facilities is a matter of extreme urgency if Texas is to retain her place in water transportation.* It must be remembered, however, that to date these ships are planned for specific commodities over specific trade routes. It must also not be forgotten that Texas' water borne traffic is presently carried in shallow draft vessels and conventional ocean shipping. In 1968, barge traffic operating on the Gulf Intracoastal Waterway handled 63.3 million short tons of freight. This is practically all domestic freight moving directly to/from origin/consignee facilities and as such it *does not* go thru port authority or private terminal facilities. Thus, most of it would never be candidate traffic for superships. Planning for water transportation in the Coastal Zone must, of necessity, start with *analysis in depth* of existing traffic flow patterns by commodity, origin, destination and volume and the application thereto of projections of change resulting not only from technological development but from such factors as user preference and identifiable changes in the commodity mix, its origins and destinations. Up until now, we've relied almost entirely upon inputs from the modes themselves, with limited guidance from organizations such as the Federal Maritime Administration, and now the time may have arrived that we should broaden and include other related considerations. A number of these factors depend on other than transportation inputs.

## *IV. SUPER-DRAFT WATER PORTS*

As used in this section, super-draft should be understood to mean channel, docking and loading facilities capable of accommodating superships as these may develop. At present *drafts of 40-80 feet* are being considered.




TYPES OF CARGOES HANDLED BY THE
MAJOR TEXAS PORTS IN ]967

FIGURE 4

Source: Industrial Economics Research Division
Texas A&M

TABLE A

GENERAL CHARACTERISTICS OF MAJOR PORTS
ON THE TEXAS GULF COAST

| | SHIPMENTS* | | | | | CHANNEL DEPTH (FEET) | ACCOMMODATIONS | |
|---|---|---|---|---|---|---|---|---|
| | DOMESTIC | | FOREIGN | | | | | |
| | RECEIPTS | SHIPMENTS | IMPORT | EXPORT | TOTAL | | TRANSIT SHEDS (SQUARE FEET) | OPEN DOCKS (SQUARE FEET) |
| Houston | 9,432 | 35,092 | 3,632 | 10,149 | 58,305 | 40 | 3,532,625** | N.A. |
| Beaumont | 8,963 | 18,733 | 48 | 3,257 | 31,001 | 34 | 349,000 | 235,000 |
| Corpus Christi | 3,004 | 14,815 | 3,021 | 2,634 | 23,474 | 40 | 508,000 | N.A. |
| Port Arthur | 7,971 | 12,729 | 114 | 2,291 | 23,105 | 36 | 108,000 | 360,000 |
| Texas City | 8,547 | 7,245 | 54 | 276 | 16,122 | 40 | N.A. | 40,000 |
| Brownsville | 313 | 1,989 | 1,900 | 857 | 5,059 | 38 | 100,000 | N.A. |
| Port Lavaca - Point Comfort | 590 | 934 | 3,090 | 101 | 4,735 | 36 | N.A. | 15,000 |
| Freeport | 1,566 | 1,542 | 91 | 993 | 4,192 | 36 | 156,720 | N.A. |
| Galveston | 316 | 86 | 200 | 2,064 | 2,666 | 36 | 4,484,952 | 929,100 |
| Orange | 833 | 576 | 2 | 143 | 1,554 | 30 | 285,350 | 41,400 |
| Port Isabel | 42 | 307 | 2 | 3 | 354 | 38 | 52,000 | 50,000 |

* In thousands of short tons - 1967
** Includes 1,616,004 square feet enclosed and 1,916,621 square feet open area
N.A. Not Available
Note: Houston has recently announced plans for major port construction in the Barbour's Cut area.
SOURCE: Respective Port Authorities directly from IERD report.

The eleven major water ports of Texas are understood to be exploring the advantages of off-shore terminals for the accommodation of superships. *While each of these ports naturally seeks to attract the supership traffic, there seems to be no present evidence that the volume will justify expenditure of public funds to provide more than one or, at most, two facilities of this nature on the Texas Gulf Coast.* On the upper Texas coast, a casual inspection of greater water depths seems to indicate that the Port of Freeport is nearest to 60-foot and greater depth in the Gulf of Mexico (approximately 6.5 miles as compared to 23 miles off Galveston and 38 miles off Sabine Pass). See Figure 5. However, distance from shore to deep water *is by no means the only sufficient* criteria to locate such facilities. In fact, in the final analysis, it may be *relatively unimportant*. Considerable additional research would seem to be in order to determine priorities, cost factors and economies of scale for the location and construction of an offshore terminal. *It would seem that our competition in this area should be with Louisiana and Alabama rather than between Texas port cities.* It has been suggested that only strong *State leadership* can avoid wasteful expenditures by premature construction not justified by predictable demand. Others believe the converse: namely that the *local entities* through the effects of their competition will provide sufficient leadership and arrive at an "optimal" solution. All possible alternatives should be thoroughly explored. It could be that comprehensive planning might indicate construction of a new port or development of a smaller existing facility favorably located in relation to the ten - fifteen fathom depth contours *vis-a-vis* more costly construction and maintenance at an existing port having wider reaches of shallow water. The solution here has not, at this time, been determined; in fact, the various groups studying the many trade-offs involved in this complex problem are still identifying parameters and relevant factors.

Present channel depths of major Texas ports reveal 40-foot channel depths available at the ports of Houston, Corpus Christi and Texas City. The ports of Galveston and Corpus Christi are in the process of developing 45-foot channels for deeper-draft ships. Noteworthy is the new proposed Barbours Cut port facility for the Houston area which is to be operating by 1972. With a channel depth of 40-feet, the Houston port authorities apparently feel such a channel depth will be sufficient to accomodate most general cargo carriers for the near future.

The concept of developing a super-draft port in a less developed region *has many interesting aspects*. For example, it could result in *population dispersion* or decentralization - an occurrence which many sociologists believe desirable; but conversely, if such an action caused *adverse economic effects* of the older areas this would be most undesirable. And, certainly not least, many *conservationists* would be upset at the idea of industrial development moving into a new area. The total benefit/cost analysis must, of course, include the costs of interfacing with land, barge and, possibly, air transport. The effect of port location on super-ship turn-around time will be of vital importance in attracting this traffic. Because of the present inter-port competition, such rational evaluation will almost certainly have to come from some other source than the existing local port authorities, unless of course, their existing attitudes change as they realize that the Texas Gulf Coast is engaged with *all the rest of the nation in a fierce struggle* for much of the developmental enterprises which will follow the super-draft facilities. In order to successfully pluck this "national plum" an *unprecedented* amount of inter-port cooperation may be necessary; however, there is *no reason to believe* that the existing organizations will fail to meet the challenge.

## *V. PORT ORGANIZATION*

There seems to be *little uniformity throughout America* among the organizations formed to promote and/or operate ports. They all, however, seem to have *one thing in common*--to do everything possible to increase the tonnage handled by the individual port as a means of promoting growth of the port city. Some have taxing authority without direct accountability to the electorate upon whom the tax burden falls. Some, such as the Port of New York Authority, operate or otherwise control transportation facilities not directly related to any water port function. So far as is known, none of them is charged with overall responsibility for land use compatibility with any set of comprehensive regional objectives. None is charged with relating growth ambitions to other social or economic goals. Until recently this single-minded devotion to bigness was considered acceptable or even desirable. *Today, there is considerable doubt that sheer growth is, in all cases, the proper target.* There is a rising certainty that the actions of any sizeable community cannot fail to impact other communities, some of which may, by older standards, seem quite distant from the action, under a separate local political jurisdiction, and with no readily available means of effective protest.

Embarking upon a program of Coastal Zone development, Texas may well profit in the long run by clearly defining the desired relationship of the Zone to the rest of the State and the creation of governmental machinery by which compatible development may be fostered and, if need be, insured while maintaining a *reasonable balance between individual rights and the public interest.* For example, some industries such as mining or oil and sulphur extraction must exist where nature has placed the resources. Salt water fisheries, as well as recreation, depend upon natural factors, as does agricultural production which must be suited to the soil and climate available. On the other hand, a number of activities unrelated to the Gulf have located in the coastal counties and there may be some doubt that these, in the long run, will contribute to the overall desirability of Texas as a place to work and live. To the extent such activities are unnecessarily exposed to wind and water damage they may prove an economic liability to the State and the Nation. Note the combined implication of the attached clippings. The Chief of the National Hurricane Center told President Nixon's Disaster Preparedness Conference, "I am enormously concerned with development of high density populations right at the shore lines." (Figure 5)

Guidance of Coastal Zone development will be, in any event, *a long, slow process, depending essentially upon public acceptance and clear delineation of regional objectives.* It will not be accomplished by uncoordinated efforts of private enterprise nor by competitive strife between the cities and counties of the Zone. Meaningful State leadership is definitely needed to show the way, to encourage cooperative effort and to insure compatibility with the overall Goals for Texas. Several courses of action appear to be possible, though each most certainly will have its merits/liabilities, and thus attract a strong crowd of either followers or opponents. They include the following "possible" candidates:

One action might be for the Legislature to create a *Texas Port Commission* empowered to approve or reject all private and public port construction and modification; to act for the State in relation to Federal port and water transport programs; and further, charged with developing port objectives in relation to Coastal Zone and Texas objectives and insuring compatibility of port projects therewith. Such a Commission would provide full time specialized attention to Texas' important port activity as a valuable adjunct to and in no conflict with the overall function of the Interagency Natural Resources Council (of which it would be a member). Texas ports, collectively, would gain a voice in government which they do not now possess.

The existing port organizations might join together in some type of *organization stronger than their existing TPA.* Such a federation would have the "final say" about the expansion or modification of their own facilities when it came to major matters in which the whole region was competing with another major section of the United States. Yet on minor things, inter-port competition would still exist.

A strong *Inter-Agency Transportation Council* might be developed. Here the port organizations would join with other transportation-related groups in developing a State/regional approach. Under the influence of the unbiased non-port members, possibly a good, workable plan could be developed.

Yet another possibility - though most feel it is both infeasible and impractical - would be a *State Department of Transportation.* However, such a monster would almost certainly create more problems than it would solve.

As stated under Water Transportation, it is *important that concentration on deep water Coastal Zone ports not obscure the present and potential value of inland water ports and shallow-draft water transport.* Development of the LASH (lighter-aboard-ship) and off-shore terminal concepts will enhance the already high value of these facilities. Inland ports should be within the scope of the responsibility of whatever organization(s) that evolve.

## *VI. RAILROADS*

It is a rather common fallacy to believe all the railroads of America are dead or dying because of the publicity attending rail passenger discontinuances and the financial troubles of some railroads. While it is true that, except for the war years, the railroad *share of intercity freight* - the bread and butter - has declined steadily from 62.3% in 1939 to 41.0% in 1969, this is only part of the story. Such *relative* decline was to have been expected as alternative transportation developed. Once this share was close to 100%. The other side of the coin is that, in *absolute ton-miles carried, the railroads have, in thirty years, gone from 339 billion ton-miles in 1939 to an all time record high of 780 billion in 1969.* It can confidently be expected that railroads will continue to play a vital role in the industrial future of the Coastal Zone although their role in *passenger transportation is most doubtful.*

The Coastal Zone is served by a comprehensive rail network (see map). The eleven major ports, accounting for the lion's share of ocean tonnage, benefit from competitive rail service as follows: (also, see Table B)

| Port City | Number of Railroads (1) |
|---|---|
| Beaumont | 4 |
| Brownsville | 2 (4) |
| Corpus Christi | 3 |
| Freeport | 1 |
| Galveston | 6 |
| Houston | 6 |
| Orange | 2 (2) |
| Port Arthur | 2 |

| Port City | Number of Railroads (1) |
|---|---|
| Port Lavaca-Point Comfort | 1 |
| Port Isabel | 1 |
| Texas City | 6 (3) |

(1) Not including local belt or terminal companies.
(2) By connection with port owned railroad.
(3) By connection with terminal railroad.
(4) Plus Mexican National RR.

All of these railroads connect with the interior directly or by interchange. The most direct coastwise rail transport from Brownsville to Beaumont and intermediate points is over the trackage of two parallel railroads, Southern Pacific and Missouri Pacific.

Development of the Coastal Zone as an interface between inland points and ocean transportation will continue to depend to a large degree on the efficiency of rail transportation. *A key factor in this efficiency are the railroad yards, modernization of which require substantial capital expenditures.* Traditionally, these improvements and choice of location have been left to the private initiative of the railroads which has resulted in total overcapacity at some locations, undercapacity at others, and general failure to achieve the full potential of interchange, with minimum delay and cost incident thereto.

Any sound developmental plan for the Coastal Zone should require *treatment of the rail network as a whole*--designed to best satisfy the total zone rail transport requirements in the most efficient manner. Strategic location of modern yards, operated as joint undertakings by the using railroads and with appropriate governmental financial assistance could possibly advance the regional economy. Incident to this concept, obsolete rail terminal facilities in localities unsuited to present and projected metropolitan needs should be encouraged to relocate.

As ship capacity grows and as port facilities are developed, consideration should be given by port planners to provision of *facilities to handle unit-train movements as the land-water interface.* The economics inherent in this comparatively recent development in rail transportation of such commodities as grain should not be overlooked.

Because of anti-trust and economic considerations, strong leadership on the part of the State or other overall regional governmental authority will be required. Should Coastal Zone development entail construction of port facilities at a new location or material augmentation at old locations such leadership will be indispensable to insure coordination with land use planning.

TABLE B

RAILROADS SERVING MAJOR TEXAS PORTS

| PORT | |
|---|---|
| Beaumont | Kansas City Southern; Atcheson, Topeka and Santa Fe; Missouri Pacific; and Southern Pacific. |
| Brownsville | Missouri Pacific; Southern Pacific; and National Railways of Mexico. |
| Corpus Christi | Missouri Pacific; Southern Pacific; and Texas Mexican Railway. |
| Freeport | Missouri Pacific. |
| Galveston | Atcheson, Topeka and Santa Fe; Chicago, Rock Island, and Pacific; Fort Worth and Denver; M-K-T; Missouri Pacific; and Southern Pacific. |
| Houston | M-K-T; Missouri Pacific; Atcheson, Topeka and Santa Fe; Southern Pacific; Fort Worth-Denver; and Rock Island Lines. |
| Orange | The port owns 1.6 miles of trackage to provide rail transportation to the Missouri Pacific and the Southern Pacific. |
| Port Arthur | Kansas City Southern and Southern Pacific. |
| Port Lavaca-Point Comfort | Point Comfort and Northern Railroad. |
| Port Isabel | No railroads serve the port at the present time. |
| Texas City | Texas City Terminal Railway Company has daily connections to the Atcheson, Topeka and Santa Fe; Missouri Pacific; M-K-T; Southern Pacific; Rock Island; and Fort Worth and Denver Railroads. |

## *VII. HIGHWAY TRANSPORTATION*

Highway transportation is, of course, the most visible form of transport to everyone. Because of the personal relationship between people, automobiles and highway traffic it is the first transportation mode in the minds of nearly all. Nevertheless, highway transport is but one part of what should be a balanced system designed to best satisfy the needs of all users--both as to service characteristics and as to cost.

As is true with most parts of Texas, the Coastal Zone is served by *a network of excellent highways.* With the exception of the Beaumont-Houston-Galveston triangle, however, little of this network is now constructed to Interstate standards. If development of the Coastal Zone *is* to be a matter of priority, *efforts to expedite construction of an "Interstate quality" highway from Brownsville to Houston are indicated* despite the fact that existing traffic volumes may not seem to justify the expenditures at this time. The developmental effect of better transportation is of major interest to this area.

In addition to local drayage and other unregulated motor transport the eleven major port cities are served by regulated intrastate and interstate motor common carriers as follows:

| Port City | Number of Carriers |
|---|---|
| Beaumont | 13 |
| Brownsville | N.A. |
| Corpus Christi | 7 |
| Freeport | 4 |
| Galveston | 10 |
| Houston | 34 |
| Orange | 9 |
| Port Arthur | 7 |
| Port Lavaca - Point Comfort | 3 |
| Port Isabel | 2 |
| Texas City | 2 |

Incident to planning for highway development, the space requirements and location of highway terminal facilities, and truck-rail, truck-water and truck-air interchange facilities for both unitized and non-unitized cargo should be provided for. The important aspect of the transportation interface should no longer be left to chance or the uncoordinated actions of individual interests.

## *VIII. AIR TRANSPORTATION*

Interstate common carrier air transportation of both passengers and cargo originating or terminating in the Coastal Zone presently requires routing through Houston Intercontinental Airport and, usually, interchange at that point. This condition will prevail for an indefinite period. Some exploration of an air cargo center primarily oriented toward transporation of perishables, generally South and East of San Antonio, has been initiated but, to date, no proposals have been formulated.

The Texas Aeronautics Commission is engaged in long range planning for intrastate air transportation and facilities. This planning process could be a model for Coastal Zone transportation planning which, in any case, must be closely coordinated therewith. This would seem to be a factor favoring establishment of a *Texas Interagency Transportation Council* to assist the Governor in performing his statutory responsibilities for overall planning in Texas.

At some future date, coincident with material expansion of the all-cargo air carrier fleet (possibly 1980) *an air cargo center on the Houston-Galveston axis will probably be required to relieve air space congestion at Houston Intercontinental.* It is not too soon to set aside land required for such a facility. *The location should be carefully coordinated with the main routes of surface transport.*

The Texas Air Transportation Plan, now in early developmental stage, should be carefully reviewed in connection with Coastal Zone planning.

## *IX. PIPE LINE TRANSPORTATION*

The unique operating and ownership characteristics of pipe line transportation set this mode apart from all other forms of transport, although in the movement of some commodities pipe lines are highly competitive with other forms of surface transport.

Portions of the Coastal Zone are a maze of interstate, intrastate, gathering and inter-plant pipe lines carrying petroleum products, natural gas and chemicals. *It has been said with apparent justification that there is no single public or private agency having readily available* *full knowledge of the location and activities of all Texas pipe lines. If true, this is a situation which should be speedily corrected at State level for reasons of safety as well as economics.*

In addition to transportation of liquids and gasses by pipe line, other commodities are now being moved in this manner. As technology permits and demand justifies, there is every reason to expect this form of transportation to increase. Coastal Zone, and all other regional planning in Texas, should keep abreast of these changes and integrate them into the planning process.

It is a foregone conclusion that new port development and augmentation of existing facilities, on-shore or off-shore, will require adjustment of the pipe line complex which, as stated elsewhere in this commentary, must depend on comprehensive, in-depth commodity flow analysis. Once again, *uncoordinated actions by individual interests, public or private, can be expected to maximize cost and impede the attainment of overall Texas objectives.*

## X. RECREATIONAL AND ECOLOGICAL FACTORS

In addition to being an important factor in Texas' economic development, the Gulf Coast is, perhaps, the major playground for all Texans and a valuable attraction for out-of-state visitors. The amount of coastal space available for this purpose and for preservation of wildlife is *steadily shrinking*. A Texas Interagency Transportation Council, such as the one mentioned under AIR TRANSPORTATION, *could be most valuable here*. It could, through proper coordination with the already existing Natural Resources Council, allow for the *compatible, complimentary development* of transportation systems and natural resources.

There are comparatively minor industrial traffic demands generated by this use. Of greatest importance, major industrial transportation centers are, to a large degree, incompatible with recreation and the preservation of natural attractions. The close relationship between ease of transportation and recreational development is too well known to require detailed comment.

Land use planning should carefully weigh the impacts of industrial development upon other objectives for this area in order to avoid costly mistakes so often committed in the past. In this case, *land-use planning and the resulting decisions should precede transportation planning*. Consideration should be given Statewide as well as local impacts, since conflicts of interest are most likely to occur in this area.

# Texas Growth Patterns Told

Dr. R.L. Skrabanek, head of the new Department of Sociology and Anthropology at Texas A&M, told Extension workers Tuesday the population of Texas is increasing faster than the United States or world population.

Dr. Skrabanek spoke at the State Extension Conference being held on campus this week. He spoke as a member of a panel which tried to help the county agents better analyze their county's census data.

"The United States is growing at a more rapid rate than the world in general and Texas is increasing at an even more rapid rate," he said.

Skrabanek admitted he was one of the many who anticipated higher census counts, but said that as the results have come in, he feels the census bureau did a very good job.

He attributed the over estimates to anticipated population growth that didn't occur. "We didn't grow as much between 1960 and 1970 as we did between 1950 and 1960," he said.

"We have simply had a further decline in the birth rate," Skrabanek explained. "I don't want to overplay the word 'slowdown' because we are still growing at a very rapid rate," he added.

Skrabanek pointed out to the group of county agents that the population of Texas is very unevenly distributed. "Two out of every three counties lost population during 1960-70," he said.

"Those one third of the counties that are increasing really had to pack the people in because they make up for the other 2-3 of the counties plus they added a half million new people."

Skrabanek illustrated density by contrasting Dallas County which has 1,500 people per square mile to Loving County which has one person per four square miles.

"As a general rule, the smaller the town the more likely it is to be losing in population and the bigger the town the more likely it is to be growing," Skrabanek said.

He said that three out of four Texans live in the 23 Standard Metropolitan Statistical Areas of Texas. "Five of these areas hold over one half of the state's people," he said, "and Dallas and Houston alone hold one third of the people."

Skrabanek said he saw no increases in rural population but felt it would remain about the same. "We now have 66 counties in Texas which have more deaths than births annually," he added. He felt that this meant that the older people are being left behind when others migrate to the city.

Dr. W. Kennedy Upham of the Sociology and Anthropology department told the agents how to interpret mortality rates, fertility rates, etc. And R. L. Copeland, of the same department, explained ethnic group trends.

The convention will continue through Friday with speeches and workshops for the Extension agents.

## Hurricane Danger

# Chief Calls For Evacuation Route

MIAMI (AP) — Expanding populations along the warm weather coasts of the Atlantic and Gulf states could become "sitting ducks for disaster" unless escape routes are provided from tropical storms, says the chief of the National Hurricane Center.

"A hurricane in the near future could kill 20,000 or 30,000, even 50,000 people unless we have sound planning," Dr. Robert H. Simpson told President Nixon's fourth regional Disaster Preparedness Conference Tuesday.

"I am enormously concerned with development of high density populations right at the shore lines," Simpson said. "If we stack in people by hundreds of thousands and fail to provide escape routes, we will be sitting ducks for disaster one of these days."

Simpson said Dade County—Miami—is a prime example of mushrooming population and poor planning.

If a major hurricane struck south of Miami, he said, 250,000 people jammed between U.S. 1 and Biscayne Bay would have only the one highway on which to travel to shelter.

"A very high percentage of these people would be drowned or killed by flying debris," he said.

Simpson told disaster officials from 12 Southern and Southwestern states that Hurricane Celia, which ravaged Corpus Christi, Tex., Aug. 3, was "a meteorological enigma which will give forecasters and building engineers something to think about for years."

The highest gusts registered by the Weather Bureau hit 161 miles per hour, Simpson said "But who can say how high they actually were? They might have been 40 per cent higher.

Simpson said it was the first time on record that the major damage from a hurricane was done by gusts rather than sustained winds.

"Building engineers have told us through the years that they design for sustained winds and do not bother about gust loads," Simpson said.

"We can measure these sustained winds but there is no known means of predicting gust speeds. This calls for new thinking in meteorology and ... designing of our building structures," he said.

## *XI. MASS RAPID TRANSIT**

The mechanics of moving a large number of people speedily and in relative comfort presents a major problem in and around any major urban area. Conflicts arise from the unbalanced distribution of demand over time, arising from the AM and PM "rush" hours. This creates many problems including delays, frustrations, accidents, and injuries, and provides headaches for both the urban trip-maker and the urban transportation administrator. There appears to be four alternative ways to alleviate the problem:

*Rescheduling of some trip-makers*

*Rerouting of some trip-makers*

*Increasing the size (capacity) of the facilities*

*Increasing the movement capability by providing for larger passenger loads per vehicle*

Each of these has its pros and cons. Unfortunately, polarization has developed between proponents of the two major alternate means: "rail transit" vs "highway transit." Each, of course, has both its merits and its limitations. However, while rail transit has its place in certain highly congested areas with population densities *in excess of 20,000 persons per square mile*, it most certainly is NOT the answer to all - or even most - of our present problems.

"Rubber-tired" or highway-based mass transit systems present a different picture, for a variety of reasons.

> The maximum population density in Texas is 3,528 persons per square mile and this occurs *only* in one very small area. For the major Texas cities, this maximum density is on the order of less than 2,800 persons per square mile. Also, *national trends even in the urban areas indicate a strong move toward dispersion rather than concentration.* (While the final result remains to be seen, there is considerable speculation that San Francisco's BART will not be able to support itself by bringing commuters from the relatively settled suburban communities.)
>
> The highway-oriented system can respond to *rapid relocations of demand generation/attraction centers.* In

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**Taken in part from A System to Facilitate Bus Rapid Transit on Urban Freeways by Texas Transportation Institute, 1968.*

our rapidly changing country this should be a paramount consideration. (New York City provides an excellent example how shift in demand causes the abandonment of rail systems. At one time rails connected Harlem with the textile/garment district; then as that industry moved south, the area needed stevedores which came from a different section of the city. These rail-oriented facilities have since been abandoned and removed since they could not respond to changes.)

The costs of such systems are much less, since in most cases *existing freeways would form the backbone of such rubber-tired transit systems.* Also, they provide valuable transportation linkages in non-peaking hours - and who wants to wait two hours for a train at 1:30 A. M.!

Our existing and proposed network of excellent highways, freeways, and other roadways, is capable of handling our present and projected surface passenger loads. On the other hand, anyone who commutes daily through the freeway rush-hour can't help but wonder that if, for the particular problem of going to work, *a better mousetrap is possible.* Also, he may be inclined to ponder the massive amount of natural resources being expended by all the 5-passenger automobiles - each with one occupant - that sit motionless on the 4-lane concrete path below him; he may even begin to think about the cost of his 2nd or 3rd car.

If any type of mass rapid transit system is to succeed, it must attract and capture this individual. For it to do so, it must *equal or excel* the automobile in the following ways:

*Convenience,*

*Comfort,*

*Cost,*

*Speed, and*

*Security.*

*Only if a system meets these criteria will it gain public acceptance.* (The present shuttle-bus system at the University of Texas at Austin campus is a perfect example of a mass system *providing an alternative more palatable than driving* in a very specific situation.) At present, and well into the future, the only possible solution, if we are to consider the mass transit alternative, appears to be the rubber-tired, highway-oriented version. Such a system, utilizine existing structures and maintaining a maximum degree of flexibility, might relieve the congestion in the most urbanized areas. These routes must exist for the movement of goods and services *even if there was no passenger demand.* In speaking of mass transit systems, people often forget that the streets and roads must exist for the local movement of non-human cargo anyway. However, for the present, the automobile is far and away the best solution to existing problems. Before any rash decisions are made, much more consideration of the alternatives will be needed. This is only one part of the total transportation system for the Gulf Coast and it should be considered in any planning efforts.

# ELECTRIC POWER IN THE COASTAL ZONE

Edited by

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for

COASTAL RESOURCES MANAGEMENT PROGRAM

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# I. ELECTRIC POWER IN THE COASTAL ZONE

## Present Patterns

Electric energy for the Texas Gulf Coast has been principally supplied for many years by three large, investor-owned companies and one municipality. Gulf States Utilities Company of Beaumont serves six counties in the area under study by the Coastal Resources Management Program as well as sixteen other counties in Texas and seventeen parishes in Louisiana. Houston Lighting and Power Company serves six counties in the Houston-Galveston area while Central Power and Light Company of Corpus Christi serves 21 counties in the Coastal Resources Management Program area along the middle and lower coast and 22 other counties in South Texas. In addition, the City of Brownsville generates enough power to substantially meet its needs.

Customers in McMullen and Lavaca counties are served by electric cooperatives and river authorities whose sources of power are generated inland, and approximately 42,000 customers in Galveston and Brazoria counties are served by Community Public Service Company of Fort Worth with power purchased from Houston Lighting and Power Company. This paper will be primarily concerned with the companies and political subdivisions which generate power within the study area of the Coastal Resources Management Program.

The present status of the electric power industry in Texas is one of steady, predictable growth. For the last 20 years, electric power usage in the State has been steadily increasing which has required the companies to meet a two-fold energy demand increase every ten years. However, in the last two years total use has grown even faster--nine percent a year. If trends continue to persist in the next two decades, the present demands for electric power will triple or quadruple.

All generating companies in the coastal region are committed to multi-million dollar power plant building programs. In 1971, an estimated 1255 megawatts of additional generating capacity will be added to the coastal area system. By 1975, total system capacity is expected to increase to an estimated 14,000 megawatts.

While individual power companies must provide stand-by generating capacity, a much greater degree of system reliability is achieved through the Texas Interconnected System (TIS). This power pool connects almost all generating facilities in the State and provides connected companies with tremendous flexibility to continuously meet power demands in all portions of the State if some portion of the system is idled due to natural disaster, generator failure, or routine equipment maintenance.

The TIS was designed to maximize service reliability while taking into consideration the great distances between most major load centers in the State. As a result, each connected operating entity, whether it be an investor-owned company, municipality, river authority, or cooperative is responsible for generating enough power and maintaining sufficient stand-by reserves to meet its own needs.

Although power pools have been severly criticized and have come under close scrutiny by the public and some regulatory authorities after the Northeastern Blackout of 1967, the Texas Interconnected System is considered by the Federal Power Commission and other electric distribution specialists to be one of the most reliable systems known.

The only major blackout in Texas occurred in 1968 at El Paso which is connected to the New Mexico Power Pool. An accumulation of fluid in the natural gas regulating equipment of El Paso Electric Company created a loss of generating capacity causing an outage of about two hours.

Power pools are most successful when stand-by and spinning reserves are high. This is the key to success of the Texas system. Up to now Texas companies have not encountered significant delays from government or environmental groups in getting planned generating capacity "on line" as have some of the northeastern utilities. While reserves in some parts of the country have dropped to below zero during peak load times, resulting in voltage reductions or "brownouts", the Electric Reliability Council of Texas (ERCOT) expects spinning and stand-by reserves to drop no lower than 13.67% in August, 1971, based on projections of anticipated summer load. It might be noted that Gulf States Utilities is not a member of ERCOT, but of the Southwest Power Pool, and likewise plans to maintain reserves in the range of 15%.

Texas is unique among the fifty states in that it does not have a utility regulatory commission. Several serious attempts have been made in the legislature recently to bring some or all of the various public utilities under state regulatory jurisdiction, but all have failed. Notably absent throughout legislative hearings and debates, have been complaints against the electric utility industry regarding service or rates.

Statutory regulation of rates, rights-of-way, and franchises has long been vested in the municipalities, and this method seems to have worked well. Through municipal regulation the electric utilities are made directly answerable to the people with the result that they are good corporate citizens of the communities they serve. It is this regulatory climate which has allowed the electric utilities to be more attentative to customer needs and opinion, and at the same time has permitted the establishment of an interconnected system with highest reliability while charging the customer some of the lowest rates in the nation.

More than 9400 megawatts of electric power is generated in the Gulf Coast area by the three investor-owned utilities and the City of Brownsville. Some on-site generation is done by the large petrochemical and aluminum reduction complexes in and around the Houston-Galveston and Corpus Christi-Ingleside areas, but that amount is relatively insignificant and is used internally.

The steam-fossil fuel method of generating power is used almost 100% in the Coastal Zone. Some gas turbine driven generators are in use, particularly by Houston Lighting and Power Company, but they contribute little more than 2% of the total generating capacity of the area. Electric power is generated at nineteen locations with two additional sites scheduled to be placed in service during 1971.

The availability of an inexpensive supply of natural gas almost "at the back door" of the plants in the coastal region is the principal reason for the use of the steam-fossil fuel method of generation. Natural gas is a clean burning source of energy with a low sulfur content whose chief product of combustion is the oxides of nitrogen ($NO_x$). The emissions are dispersed through 100-400 foot high stacks into the upper atmosphere. Atmospheric conditions are such in the Coastal Zone that it is highly unusual for an inversion condition to exist which brings the noxious emissions from the stacks back to ground level.

The Texas Air Control Board has issued ambient air quality standards for some of the products of combustion of natural gas and emission limits for Harris County (Houston) only. As of January 1, 1971, all power companies were in compliance with the State and Federal standards. However, there has been some indication that if the Environmental Protection Agency sets an emission standard for the oxides of nitrogen ($NO_x$), it may be sufficiently low that the electric utilities may have some difficulty complying. The technology for $NO_x$ control is almost nonexistent. Power plant operators will have to pay more attention to the air-gas mixture of their burners in order to minimize the emission of $NO_x$ in the future.

At the present time there is no commercially feasible method of generating electricity without the use of enormous quantities of thermal energy. Whether the generator is turned by a diesel engine or by steam pressure created by nuclear fission, under the most efficient conditions approximately 9,000 BTU of energy is needed to generate one kilowatt hour of electricity. Because of the relative inefficiency of even the most modern power generating facilities, the dissipation of waste heat energy has become the most important environmental problem facing the electric utility industry today.

## Future of Nuclear Energy

Without a doubt the generation of power by means of nuclear energy will become necessary in Texas. At this point in time it is difficult to determine when it will become economically feasible to abandon natural gas as a primary energy source. The fact that some of the plants currently in operation sit literally on top of such a cheap source of energy make the advantages of nuclear power with its estimated 50% higher KWH generating cost a difficult case to argue. Most experts in Texas agree that, assuming that our remaining supplies of natural gas have been calculated correctly and no significant political events or technical breakthroughs occur which would make the use of nuclear energy less attractive, a nuclear plant should not be expected to be in operation before 1980. However, concern is being expressed nationwide over our dwindling reserves of natural gas and a re-evaluation of priorities and needs for that fuel may eventually be made. Gas transmission companies are turning down new customers and are already beginning to move to production from marginal fields.

The power plant of the future, that is, the type of fuel it will require, will have a significant bearing on plant siting. It ia anticipated that by the year 2000 nuclear power plants will be generating about one half of the electric power in the United States. In Texas, with its presently adequate supplies of natural gas and oil, the ratio may not be so dramatic.

Conceivably the 1970 plant site that has been acceptable to the area for many years as a burner of natural gas could become the site of of a much more powerful nuclear power plant.

Site studies are not being restricted to land areas along the coast. One of the possibilities is the creation of an island in contiguous coastal waters. Nuclear power plants require greater quantities of water for cooling than fossil-fueled plants. In the offshore plants some small quantities of sea water would be desalted and used for boiler feed water. Also, large quantities of sea water would be used for cooling purposes on a once-through basis and then be discharged at such distance from the shore as to have no adverse effects on highly sensitive estuarine areas.

The twelve investor-owned electric utilities through their association with the Texas Atomic Energy Research Foundation, have for more than fourteen years been pioneering in research directed at finding a practical way to utilize the process of nuclear fusion to generate electricity. In fusion, the conversion of part of the mass of the nucleus into energy occurs when the nuclei of light elements such as hydrogen combine at very high temperatures. Such reactions occur at appreciable rates only at temperatures of millions of degrees, the rates increasing with the temperatures. Deuterium, the isotope of hydrogen of mass 2, or heavy hydrogen, is the most likely fuel for fusion reactors. Deuterium is available in limitless supply in the waters of the oceans of the world. This research is now being conducted at The University of Texas t Austin.

It is very unlikely that commercial production of electric power from fusion will be achieved before 1990; fusion is more probably a process that will not begin to influence power generation before the beginning of the next century.

## Environmental Effects

The generation of electricity inevitably involves some environmental changes with resulting biological responses about which it is difficult to generalize. Much of the current concern about the environmental impact of such large and technologically complex industrial operations has resulted from the lack of specific methodology to predict precisely the ecological impact of their efforts.

One of the products of combustion of natural gas is carbon dioxide ($CO_2$). It is being added to the earth's atmosphere at the rate of about six billion tons per year with the electric power industry contributing a large share. The Environmental Pollution of the President's Science Advisory Committee has said that the $CO_2$ content of our atmosphere will increase 25% by the year 2000.

## Water Requirements

The present fossil fuel plants circulate tremendous quantities of condenser cooling water. The most efficient fossil fueled plants operating today use only about 40% of the heat energy in the fuel. Less than one-third of the waste heat is dissipated directly into the atmosphere. The remainder is carried off by the cooling water which ultimately transfers it to the atmosphere.

## Fuel Storage Requirements

Some Texas plants have maintained stand-by fuel oil storage which require storage tanks and associated pumping equipment with sufficient diking to contain the contents of the tanks in case of leakage. Gas fired plants require some on-site hold-up supply, and some plants may install underground or insulated tanks for the storage of liquified gas.

## Space Requirements

Land area required for a fossil fuel plant in the Coastal Zone may vary widely depending upon the type of cooling method or methods used. If extensive ponds are needed, future sites could range up to several thousand acres.

# II. WASTE HEAT DISPOSAL

In steam electric generating stations, the exhaust side of the steam turbine must be cooled in order to bring the efficiency of the turbine up to a practical level. To accomplish this, large surface area condensers are employed in which large quantities of water are pumped through metal tubes of less than 1 inch to about 1-1/4 inches in diameter. Heat is transferred from the steam to the cooling water, which condenses the steam and forms a vacuum on the exhaust side of the turbine. The temperature rise in the water depends on the design of the condenser and the flow rate of water through the condenser.

Whether the excess heat goes up the stack or is carried off by the cooling water, ultimately it is dissipated into the atmosphere, where it is radiated into space. The choice of methods depends on a number of factors--quality and quantity of water available, natural temperature of the water, effects on the ecology in the receiving waters, meteorological conditions, and economics.

The present state of the art in electrical power generation results in the production of substantial amounts of waste heat that must be used or disposed of in some manner. The atmosphere surrounding the power plant is the eventual destination of this excess thermal energy. Although different types of plants (such as coal, fuel oil, or nuclear fueled plants) produce different amounts of waste heat, the construction of the plant is also important. In recent years, the industry has built more efficient units and upgraded existing operations, either to minimize excess fuel consumption or to meet tighter environmental quality constraints.

Heat may be dissipated by four basic processes: evaporation, convection, conduction, and radiation. In reality, all operational facilities depend upon a combination of these basic physical processes. For example, cooling ponds significantly utilize radiation, convection, and evaporation. As the warm water effluent flows out into the lower temperature receiving pond, initially hydraulic currents are set up in the vicinity of the outfall as a result of simple physical mixing. Next, density currents, which are a result of the different densities due to temperature differentials, are set up, which cause further mixing. These mixing actions produce a cooling effect due to convection, the bringing together water masses of different temperatures. Also, substantial amounts of heat are transferred across the air-water interface, with evaporation and radiation being the primary transport mechanisms.

The basic physical processes are known and fairly well understood; thus it is possible to make quantitative predictions concerning the physical phenomena associated with the waste heat disposal. This analysis will tell us the areal distribution and the temperature rises associated with a particular situation. Because of the complexity of the many simultaneous processes and the basic random nature of many factors, exact predictions simply are not possible. For example, it is not possible to say that it will be 82.4°F at 10:00 a.m., at a point 955 feet east-northeast of an outfall discharging 200 MGD into Corpus Christi Bay. Many other factors, including winds, air temperatures, by currents, etc., are statistically random processes. However, we can predict the general patterns of thermal energy distributions based on any specific set of inputs and ambient conditions. For most studies we would be interested in the average and extreme existing conditions, which would give us an idea of what we would expect under the worst possible set of circumstances, e.g., very little run-off, no significant winds, prolonged hot weather, minimal dispersive currents. Such "contour maps" of temperature gradients for both average and extreme conditions were obtained using a mathematical model. This model simulates the hydrodynamic performance of the bay, then couples with this the effluent-induced effects and the air-water interface energy transfers. This simulation is costly, but it will tell us the physical response of the bay. The next step, that of simulating the ecological response is not so well developed. At present a good bit of heuristic intuition and experience with the particular receiving environment is necessary. Nevertheless, the two do provide us with a valuable tool for evaluating alternatives.

Systems for the handling of waste heat from a thermal generating facility need not be restricted to a single process. For example, the use of once-through cooling water can be coupled with a cooling pond and cooling tower to lower the water temperature before it is put back into the natural water body. Such combinations of processes offer numerous opportunities for developing heat disposal methods which can protect the receiving body without creating an unbearable economic burden.

In attempting to determine the best ways to protect the environment from "thermal pollution", the possibility of using this energy in some fashion which would enhance the ecosystems into which it was released should not be overlooked. The possibilities of the using of this energy to help mariculture activities is being intensively explored in Texas since productivity of warm water biologic communities usually tends to be greater than in cold ones.

Presently the possibility of using waste thermal energy from power plants to manage deep reservoirs is being explored. In most such impoundments the water body undergoes thermal stratification, i.e., the colder water stays near the bottom (hypolimnion) and the warmer water near the top (epilimnion). The line between the two is called the thermocline. A-

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Appendix G contains a discussion "Cooling Water Requirements for Steam Electric Plants" by H.R. Drew.

side from being considerably colder, the waters below the thermocline are characterized by low D.O. (dissolved oxygen), very limited circulation, little light, and comparatively little biologic activity. Some researchers* are exploring the possibility of discharging heated waters into the deeper zones to achieve mixing - with the hope of bringing increased biologic activity to the depths. (Related studies are being done using selective withdrawal techniques in an attempt to achieve similar results.) At this time, the scientists do not know enough about all the relevant, related phenomena to make any final judgement.

## SOURCES OF COOLING WATER

### Oceans

Electric utilities in coastal areas may find use of sea water as a source of cooling water attractive although many other factors must be considered in such a plant siting. The supply of water, of course, is almost unlimited.

### Bays and Estuaries

Large bodies of water, such as Galveston, Matagorda, and Corpus Christi Bays, theoretically could serve as almost unlimited sources of water, but they are also very important ecologically and the hydrolytes of each must be considered. Texas bays have high ambient temperatures during the summer months, and thus may tolerate only limited temperature elevations without major ecological effects.

### Rivers and Streams

The advantage of non-tidal rivers over other sources of cooling water is that the heat is carried downstream from the plant quickly and cooler water is available from upriver. However, there are no rivers in Texas that can supply the tremendous quantities of water needed for a once-through system for today's large plants. Furthermore the very features that make these sites attractive to the power industry also serve to attract other industries with potential harmful synergistic effects on the river's ecosystem.

Where large flows are not available, recycling of water may be practical. Rapid cooling is accomplished by evaporation in forced draft or natural draft towers. In this way, only losses due to evaporation, periodic blowdown, and bleedoff to prevent the accumulation of minerals need be made up.

### Lakes and Reservoirs

Large impoundments of water may be attractive because of natural stratification, where cool water can be drawn from the cooler water in the bottom of the reservoir, and warmer water discharged at the surface, where evaporation, conduction, and radiation dissipate the heat. The closed nature of this type of system is especially important in areas where water

*Fruh and Hubbs at the University of Texas are presently engaged in such activities.

is limited. Increased evaporation, due to cooling with the resulting need for make-up water can provide for a highly efficient system and yet ecologically controlled engineered system. Water impoundments of this nature, however, can influence flow patters in downstream areas and, therefore, must be planned so as to prevent salinity changes in tidal systems through evaporative losses or alterations of flow patterns and volumes by reservoir operations.

## COOLING PROCESSES

There are a number of methods available for the disposal of waste heat energy from power plants. All utilize the same basic energy transfer mechanisms, and, unless they are air-based processes, they depend on one of these for a supply of cooling water. These include:

- Once through cooling
- Cooling Towers (evaporative)
  - Wet-type, natural draft
  - Wet-type, forced draft
  - Dry-type
- Cooling Ponds
  - Fresh Water
  - Salt Water

Each of these has its own set of assets and liabilities. For example, cooling ponds cause very little environmental upset to aquatic communities, but they do require vast amounts of flat land, thus precluding their use in densely settled areas or very rugged terrain. In the past, the once through method was generally used in almost all cases. However, in recent years, other methods have come into practice in some localities, and each of these will be discussed below.

### Once-Through Cooling

In this process, the water is pumped into the plant from a nearby surface supply such as river or estuary. Sometimes it receives minimal treatment before going to the heat exchangers in order to reduce scaling or other undesirable side-effects. After use it is then discharged directly back into the surface waters. This discharge is made downstream of the intake in the case of rivers, or around a point, peninsula, or other promontory in the case of bays or lakes.

Advantages

1. Low Cost - requires no extra land or any capitol investment except pumps.
2. Consumes Relatively Small Amounts of Water - since its cooling effect is gained almost totally by process other than evaporation, no significant amount of water is lost to the atmosphere.
3. Reliable - except for a water shortage, it is nearly 100% reliable. For example, it is not very susceptible to natural occurances such as hurricanes, floods, etc.

4. Reuse Potentials - water, after it comes out of a plant, can be used for other purposes such as municipal supply. In fact, this warmer water is often easier and cheaper to treat than water before it has gone through the plant. This occurs since municipal water treatment involves chemical coagulation and flocculation, and the reaction proceeds better at higher temperatures; thus, fewer chemicals are required to achieve the same softness.
5. No Chemical Wastes - such as cooling tower blowdown
6. Requires No Additional Land.

Disadvantages

1. Environmental Upset - depending on the particular situation involved, damage to the ecology of the receiving body of water may - or may not - occur.

Cooling Towers

Cooling towers bring the hot water from the plant into direct contact with the atmosphere. Cooling is accomplished completely by evaporation, thus there is a significant consumptive use of water. Fresh water cooling towers are in use across the country, but towers utilizing salt or brackish water still have some technical problems.

Advantages

1. Cooling towers do not discharge large volumes of heated water in surface water courses.
2. They require relatively little land.
3. The technology is available to cope with fresh water towers but problems still exist with salt water towers.
4. They are not prohibitively expensive to build.

Disadvantages

1. They consume significant amounts of water, and this presents a problem in water-short regions.
2. Tower blow-down (wind carried spray) from salt water towers would present significant problems in the immediate area. See Appendix L.
3. Cooling tower blow-down represents a source of additional chemical load on the receiving waters.
4. Corrosion and sealing from salt-buildups will also be bothersome on facilities using highly mineralized waters.
5. Towers may be very tall (in excess of 400 feet) and in hurricane prone areas such as the Texas Gulf Coast they could be destroyed by high winds.

Cooling Ponds

Many persons believe that ponds are the answer to heat disposal in Texas. Cooling ponds may be used in two ways. Water may be continuously circulated between the plant and the pond with just enough new water being added to make up for evaporative losses; this is as close to a "closed-cycle" system as one can get. The other option involves employing cooling ponds at a plant's discharge, but rather than recirculating the water back to the plant, discharge it into a surface water course. Essentially such a usage involves using ponds as a "treatment plant" for temperature control.

Advantages

1. In the case of fresh water ponds, relatively little water is used, thus consumptive demands are not great compared to evaporative cooling towers.
2. Ponds or reservoirs may provide a body of water for multi-purpose use. For example, Lake Bastrop near Austin was built as a cooling pond, but is one of the better bass fishing lakes in Texas, and provides other recreational amenities. Extensive experimentation is being conducted to assess their feasibility for mari-culture purposes, and some are used for municipal water supplies.

Disadvantages

1. Cooling ponds require substantial land areas, and for densely settled regions where land is expensive, land costs can become prohibitive. As a general rule, about 1-1/2 acres of water surface are required for each megawatt of electricity generated. Based upon this and the current generation of 9400 MW in the Coastal Zone, approximately 15,000 acres (23.4 square miles) of cooling surface would be needed to handle waste heat.
2. Closed cycle salt water ponds do not appear feasible since the continual evaporation would result in very highly mineralized waters which would tend to clog the heat exchanges.

Forced Draft or Dry-Type Cooling Towers

Theoretically it is possible to dispose of waste heat directly to the atmosphere from steam-electric plants without using water as an intermediate heat transport mechanism. Most processes utilize water because it has the ability to absorb and hold very large amounts of heat per unit volume. However, some work has been done using air as the medium. The disadvantage of air as a transport mechanism is that it has about one-tenth the carrying capacity of water. Thus if one wants to use air as the heat-transport substance, it becomes necessary to force very large amounts of air past the condensers, which creates such problems as excessive noise and great, high-velocity updrafts. At present, dry towers do not appear to offer a solution to the disposal of waste heat which is either technically or economically sound.

Relative Costs

Considerable study has been given to all of these methods from a cost standpoint as well as an environmental viewpoint. The most extensive study to date has been done by Riley D. Woodson. Appendix K shows the comparative costs for various cooling alternatives for an 800 MW generation facility. The comparison is made for both fossil and nuclear fueled units.

From this table, it can be seen that the cooling costs per unit of electrical energy output for fossil fueled plants are about 2/3 the cost of cooling for nuclear facilities. Each group exhibits quite a range.

As expected, costs are lowest for once-through cooling; go up for cooling ponds, then continue to increase for wet and dry draft towers.

## III. THERMAL EFFECTS

Thermal effects on aquatic organisms are most pronounced when water bodies are used for heat dissipation since water is drawn from the environment, heated, and returned to the environment. Life in the receiving body will be affected to varying degrees, depending on the distance from the heat source, method of discharge, absolute temperature, type of aquatic community, etc., while organisms entrained in the cooling water as it passes through the plant will be exposed directly to a rapid temperature rise of 10 to 20° F or more depending on the particular plant design.

### Dissolved Oxygen

The saturation capacity of water for dissolved oxygen (DO) decreases with increasing water temperature and increasing salinity. However, natural bodies of water seldom are saturated with oxygen. Experience with power plant condenser discharges in a number of field research projects has shown that deoxygenation of water from heating is not a problem. In fact plants frequently increase dissolved oxygen content of water used for cooling.

An increase in temperature, however, does affect oxygen demand. The biological oxygen demand (BOD) increases about 2% for each 1.8° F rise in temperature above 68° F. In accordance with the van't Hoff principle that the rate of chemical reactions rises with increasing temperature, metabolic chemical reactions also increase. In general, the metabolic rate doubles with each 18° F rise in temperature. As a result, in polluted areas where there is a high BOD or COD, the resulting dissolved oxygen demand will be satisfied more rapidly with increased temperature. Experience at the Chesterfield Station of Virginia Electric Company has shown that when intake DO values are less than 5.0 parts per million, turbulence and entrainment of air within the water as it goes through the plant actually add oxygen to the polluted waters of the James River.

### Poisons and Inhibitors

The toxicity of most poisons which might be found in surface waters is raised by an increase in temperature. H.R.N. Hayes of the University of British Columbia has shown that the toxicity of most poisons is increased at low concentrations of dissolved oxygen. Chlorine is used extensively as a biocide in steam electric stations to prevent fouling of condenser tubes and associated equipment. It acts nine times faster at 104° F than at 46° F. Temperatures thus determine the chlorine's initial and final mortalities, rate of mortality, and duration at low concentrations. Potassium cyanide was found to be twice as toxic at low concentrations at 64° F as at 46° F. Chlorinated hydrocarbons, such as DDT, increase in toxicity with a rise in the metabolic rate. Therefore, they are two to three times more toxic in summer than in winter. Most organic phosphates, on the other hand, are degraded quickly in warm water, hence are more toxic to aquatic animals in winter than in summer.

It should be pointed out that no power plants contribute toxic substances of appreciable quantities on a regular basis. However, some plants presently in operation or in the planning stages may be forced to use cooling waters that have been polluted with toxic elements. As the water is heated, toxicity is increased.

## Heated Water Effects on Aquatic Organisms

### Natural Temperature Distribution

It must be understood that each natural area is characterized by its own particular set of physical and chemical parameters, such as temperature, currents, light pH, salinity, alkalinity, and nutrients. The animals and plants which live in a particular place do so because they are adapted to these conditions and can maintain themselves competitively.

These conditions are not static but everchanging within certain limits. The species present also change since new conditions favor one species over another. An artificially induced change, such as increased temperatures, can bring about a shift in the equilibrium. Within limits, most species can adjust or acclimate over a period of time if the change is not too sudden or too severe. This adjustment within the aquatic ecosystem occurs more readily and rapidly in warm water communities than in cold water regions. Thus, the warm water species found in Texas are much more tolerant to power plant discharges than are the northern species such as in Lake Michigan.

Biologists group species by the temperature range in which they can survive. Stenotherms are those that can live within narrow temperature ranges. There may be cold or warm stenotherms. Warm water stenotherms are most numerous in the oceans where temperatures are relatively constant. Cold stenotherms are found in the hypolimon of stratified lakes and reservoirs and in cold streams. Salmon and trout are examples of such stenothermic species.

Eurytherms are those species which can withstand wide variations in temperature. Barnicles are exceptionally eurythermic as are many bivalves. The American oyster survives temperatures from 39 to 93° F on the Gulf Coast. Species found in the intertidal zone are generally eurythermal.

There are gradations between stenothermic and eurythermic organisms, hence there is an overlapping distribution of many species.

### Reproduction

Thermal tolerances vary for different life stages. Many eurythermal species have a narrow temperature for breeding. Anadromouns species, such as striped bass, shad, herring, and sturgeon, depend for their existence on the ability to transverse the estuaries to reach fresh water to spawn and their migration appears to be dependent upon water temperature. The young of these species remain in fresh water nursery grounds during the first summer and return to the sea in autumn when water temperatures fall. The time required for the eggs to hatch and the rate of growth of the larvae and juveniles is a function of temperature.

The oyster is another example of a species which can live successfully at temperatures well above and below that required for spawning. P.A. Butler of the Gulf Breeze Laboratory has shown that reproductive activity in the oyster is regulated by changing temperatures, rather than heredity response to a specific temperature.

Most animals begin to breed at a particular temperature, which seems to be a physiological constant for the species, or at a particular temperature change. A slowly falling or rising temperature stimulates gonadal development and, if followed by a more rapid change in the same direction, spawning may be induced.

Optima and Extremes. All lower vertebrates or invertebrates are poikilotherms; a term which refers to a relatively simple type of body temperature control. G. Gunter of the Gulf Coast Research Laboratory has pointed out that the optimum temperature of a living system is the one in which metabolic processes function at a maximum rate consistent with the maintenance of the system. "These optima are not sharp but range over several degrees and are usually nearer the maximum than the minimum temperatures which life withstands."

Many organisms are killed by temperatures not far above those to which they are acclimated, and it is not uncommon for heat death to occur in the natural environment. This is particularly true of tropical animals, as they normally live at temperatures close to their thermal death point.

L.D. Jensen and others at John Hopkins University, in their review of literature relating to fresh water and marine invertebrates, have concluded that the heat stability of an intact organism depends upon its most sensitive and most exposed part, which happens to be its soluble protein complexes, including limpids, nucleic acids, sugars, and other organic compounds. Furthermore, the adult's most vulnerable soluble protein complex involve its highest level of organization, neuro-endocrine transmitter substances which function outside of cellular membranes.

Lack of complexity in gametes and zygotes of a species permits greater thermo-stability in such cells, but as complexity develops, thermo-stability decreases. The organism gradually exchanges its ability to withstand heat for the ability to compensate metabolically and behaviorally.

The breeding adult is the most sensitive of all life stages to thermal conditions (range, rate of change, maximum temperature, and frequency of exposure). However the survival of a species depends on survival during the most critical portion of the life cycle. J.R. Clark of the Sandy Hook Laboratory of the U.S. Fish and Wildlife Service had listed a number of species which range from cold water stenothermal species to warm water highly resistant species. Appendices C and D show lethal maximum temperature, preferred temperatures, and spawning temperatures.

Acclimation. Neither optimum or lethal temperatures are fixed points, and many animals can be acclimated to temperatures beyond their usual tolerancy by intermittent or continuous exposure to sublethal extremes. In general, younger animals have a greater capacity for acclimation than older animals, although they may be more susceptible to extreme conditions.

Acclimation probably occurs seasonally in the temperate zones, as J.R. Brett of the Fisheries Research Board of Canada has shown that lethal temperatures for certain fishes in Canadial lakes rise with increasing lake temperature in the spring. The mechanism for acclimation is quite complicated, but some cold-blooded animals shift their metabolic rate by means of this mechanism so that their pattern of response and activity level after temperature increase approximates that before the increase.

A translation of the rate temperature curve results in no change in $Q_{10}$ (the biochemical reaction rate due to a 10C (18° F) rise or fall in temperature.

Some more advanced poikilotherms can change their $Q_{10}$ with change in temperature (presumably by some equivalent mechanisms), and thus conserve energy. In any event, these changes take days or weeks to adjust to the new conditions. The immediate response to sharply elevated temperature is one of shock, followed by increased metabolic rate in proportion to the increase in temperature.

## Thermal Effluents and Natural Populations

Fishes. The Federal Water Quality Administration has maintained a national inventory of reported fish kills since 1962. These reports are submitted by cooperating state and local water pollution and conservation agencies, and constitute after-fact data which are difficult to interpret. The recorded incidents of fish kills, where the cause was directly identified as thermal discharges from electrical generating facilities, are shown in Appendix H.

All of the 18 reported fish kills occurred at conventionally fueled power plants and the circumstances surrounding the incidents generally have not been fully investigated. Some reported fish kills in connection with power plant operation, upon investigation have been attributed to improperly designed intake and outfall structures rather than heated discharges.

Studies made at the Chalk Point Generating Station of Potomac Electric Power Company in Maryland before and after the installation of the plant showed that striped bass increased in abundance, while white catfish and hog chokers declined. White perch remained constant. Total gillnet catches by commercial gear were approximately the same at the station nearest the power plant and increased at the two other stations further downstream. Sport fishing in the area has increased in recent months.

At the Dickerson (Md.) Generating Station of Potomac Electric Power on the Potomac River, species diversity of all sampling stations decreased, but no adverse effects on fish were attributed to the plant operation. Sport fishing was better in the heated water, during all seasons except summer.

Invertebrates. Studies of the oyster Crassostrea Virginica on beds within 1,200 feet of the discharge canal at the Chalk Point Plant showed no major effects on the growth, condition and gonad development as a result of plant operation. Studies also showed that invertebrates harmful to the oyster, the oyster crab Pinnotheres Osterum, and the worm Polydora were no more common in 1965-67 than 1962-63. The accumulation of copper in oyster tissues also was reported from oyster beds in the vicinity of the Chalk Point Station. Subsequent investigation showed that the copper concentration in water upstream for the power station was 1.97 parts per billion, while that in the outfall was 3.01 parts per billion. This apparently is not common to power plant operation in estuarine areas, but was the result of improper design and metalurgy in the condenser tubing. R.L. Cory and J.W. Nauman of the U.S. Geological Survey concluded that the number of fouling organisms, including barnacles increased at the locations influenced by the decreases at the Chalk Point Station and decreased upriver from the power plant, and that the increase was associated with warmer effluent waters.

At the Dickerson site, a decrease in the diversity of species at all sampling stations, including the control station, indicated a general change in the biota of the river that was more pronounced in the vicinity of the discharge.

J.E. Warinner and M.L. Brehmer of Virginia Institute of Marine Science studied the effects of condenser discharge water on the benthis invertebrates in the York River estuary at the Yorktown Generating Station of Virginia Electric Power Company. Community composition and abundance were affected over a distance of 300 to 400 meters from the discharge canal. All sampling stations, including the controls, showed a marked seasonal change in abundance, with a minimum in the summer and a maximum in winter. The lowest diversity of species was found in a small area within 300 meters of the discharge, and this was interpreted by the authors to be an indication of stress on the benthis community in which only the more thermally tolerant species could survive.

C.C. Coutant of the Oak Ridge National Laboratory has investigated the effects of condenser discharge in macroinvertebrate fauna in the Delaware River. In the 1,600 feet of river maximally heated from 20-25°F above ambient, the summer fauna exhibited a drastic reduction in numbers of 5 square feet, as compared with a control above the discharge. A tolerance limit for most of the fauna was 90 to 95° F.

Phytoplankton. Studies by R. Patrick of the Philadelphia Academy of Natural Sciences on the Chalk Point Station indicated a well-diversified flora throughout the area, influenced by the thermal discharge in August, 1968. Nutrient additions upriver from the plant were reported by Patrick to complicate the assessment of the effects of plant operation on the standing crop of algae, through the cyclic seasonal pattern observed before the plant went into operation were lost at stations above and below the discharged canal.

R. Morgan of the Natural Resources Institute at the University of Maryland studied the effect of temperature on the passage of phytoplankton through the condensers of the Chalk Point plant and found that when the effluent temperatures were between 88.7 and 92.4° F, photosynthetic capacity was reduced by as much as 85.7%. However, chlorination was believed to be responsible for the reduction.

Studies with a laboratory heat exchanger using natural York River water without chlorination showed that primary productivity of natural phytoplankton was depressed by a 10.1° F increase in water temperature when the ambient temperature was 59 to 68° F. A temperature rise was sufficient to depress production when the ambient summer water temperature was 80.6° F. In cold weather productivity was enhanced after passage through the exchanger. Algae are classified into three groups each associated with a particular range of temperatures. For example, diatoms develop rapidly at temperatures between 59 and 77° F, greens at 77 to 95° F, and blue-greens at 76 to 104° F; blue-greens become dominate and may cause taste and odor problems in the drinking water supply.

Zooplankton. Patrick found no significant difference in the composition of the zooplankton and/or phytoplankton at the Chalk Point Station at similar times of the year in 1963, 1967, and 1968.

Two microscopic crustacea, the copepods *Acartia tonsa* and *Eurytemora affinis*, were the dominant species and *Acartia tonsa* standing crops were greater during the summers after the Chalk Point plant began operating. Two jellyfish, *Mnemiopsis leidyi* (a comb jelly ctenophore) and *Chrysaora quinquecirrha* (a sea nettle) were more prevalent before the plant went into operation. J.A. Mihursky of the National Resources Institue of the University of Maryland suspected that thermal changes were responsible for this decline.

Parasitism. Temperature affects all stages of development of parasites. O.N. Bauer has summarized these effects of increased temperatures:

1. Speeds process of division (protoza).
2. Increases rate of egg deposition (monogenea).
3. Speeds embryonic development (all parasitic helminths and crustacea).
4. Speeds growth and maturation of larval stages (cestodes, nematodes, acanthocephalans) within the bodies of the intermediate hosts.
5. Growth and maturation of parasites in the definitive host also increases in rate (some protoza and all helminths).
6. Various infective stages are very sensitive to fluctuations in temperature.
7. For a number of parasites there are those which reproduce and develop most successfully at relatively high temperatures and others which do so only at relatively low temperatures.

Fish generally harbor more parasites in summer and early fall than in winter and early spring. At the warmer temperatures the metabolic rate is higher, more food is required, and with a higher food intake, fish acquire a higher degree and variety of parasitism.

The Soviets have done a great amount of research on parasites in reservoirs built for hydroelectric power. Since these reservoirs also are utilized as fisheries, the program is of considerable importance to them. They have found that free living planktonic and parasitic copepods drop drastically in abundance during filling of reservoirs, but increase thereafter. Tremetods, which have lammellibranch mollusks as their intermediate host, gradually decrease after filling, then increase again as the population of mollusks becomes established. The cestode, *Ligula*, is found to be in the host fish in great numbers in some reservoirs but not in others. This is thought to be related to temperature, since the high summer temperatures favor development of liquids.

Disease-temperature correlation. Seasonal mortalities in oysters caused by the fungus *Dermocystidium marinum* is closely related to water temperature. J.D. Andrews of the Virginia Institute of Marine Science relates the severity of a particular summer's epizootic of *Dermocystidium* in Virginia waters to the number of cases carried through the previous winter and on the duration of and level of water temperature during the warm season.

When the water temperature reaches 77° F, the fungus grows rapidly, causing oyster mortalities in July. Spores released from dead and dying oysters cause widespread infection which can cause subsequent death in four to six weeks. August and September are the months of highest death rate. By October, temperatures have dropped, fungus actively declines, and new infections are inhibited. The disease becomes dormant through December and January and all clinical evidence of the disease is lacking by March.

All infection is not eradicated by cold temperatures and the remaining cases began to proliferate when the temperature rises again. The implication is that an increase in water temperature could trigger an earlier growth of the fungus, a prolonged epizootic season, and possible a greater carry-over of winter cases of infection. Until the epizootic of MSX in oyster populations on the East Coast in the 1960's, Dermocystidium played a dominant role in oyster mortalities in the Chesapeake Bay.

The sporozoan, Minchinia nelsoni, which causes the epizootic disease known as MSX in oyster populations, apparently is the most infectious during the period late May through October, though deaths do occur year around. The disease is prevalent in waters above 15% salinity. It is more resistant to cold than Dermocystidium and a warming of the water may extend the period of greatest infection rate.

Rooted aquatic plants. After the Chalk Point plant went into operation, one submergant species practically disappeared while another extended its range. Two emergent plants, Spartina alterinflora and Phragmites communis, were found to be quite tolerant to high temperature, while the Scirpus americanus normally associated with these two was not found in the heated water.

## Chemical Effects

As mentioned earlier, biocides are used in the cooling water intake system for the control of setting and growth of fouling organisms in intake structures of estuarine and marine stations, as well as the condenser cooling system of most thermal power plants. Chlorine is the most commonly used biocide because of its wide spectrum effectiveness on living organisms and its reactiveness with organic materials generally results in a low residual in the effluent stream.

It is desirable to keep the chlorine concentration as low as possible so as to minimize damage to entrained planktonic organisms including fish eggs and larvae. However, low chlorine residuals have been observed to prevent setting of mollusk larvae, which are significant to surface fouling control in intake structures. Modern plants are employing mechanical means of keeping the condenser tubes clean. One process uses abrasive balls that are introduced into the intake side of the condenser and retrieved on the exhaust side.

Biocides, however, may be necessary for control of surface fouling in intake structures, and intermittent low-level chlorination has proved to be effective to this end. The effects of the thermal power plants on fish eggs and larvae have not been determined, but some research is underway in this field.

## Physical Effects

Intake and discharge structures are potentially hazardous to aquatic life. Warm water serves as an attractant to fish, crabs and possibly other species. The accumulation of fish and subsequent entrapment in the intake structure has been a problem in some plants.

Proper design of these intake structures, including intake velocities low enough to permit escapement, can help to alleviate this problem. Long discharge canals which serve as attractants to fish and crabs also have contributed to sizable mortalities.

These kills have been presumed to result from the combination of increased temperature and excessive chlorination at the generating station. While such isolated incidents are dramatic locally, they do not appear to be a necessary result of power plant operation in surface waters.

Heated water is less dense than the ambient water and thus tends to rise to the surface where cooling involving conduction, radiation, and evaporation to the atmosphere take place. Normally there is a density stratification in estuaries and in deep lakes in the summer. The addition of heat can intensify their stratification. Oxygenation of the lower layer is dependent mostly upon mixing with the upper layer. In stratified lakes, this normally takes place in the spring and fall turnovers. Intensification of lengthening of the stratification could retard oxygenation judicious placement of intakes can improve circulation and prevent anaerobic conditions in the hypolimnion of lakes.

## IV. NATURAL GAS AS A HIGHER ORDER FUEL

Oil and gas industry experts estimate the United States has a 20-150 year supply of natural gas remaining. Such a wide variance in estimates is accounted for by such variable factors as population growth, per capita usage, and the rate of discovery of new fields. These same sources also estimate that over 50% of the United States' petroleum reserves lie under the coastal zones of Texas and Louisiana, the bulk of which is in Louisiana.

Natural gas is the principal fuel used in power plants in Texas and has been used for many years although fuel oil was used extensively in some of the smaller early plants and is used as a stand-by fuel in a number of plants today. Within the next ten years at least three coal fueled plants will be put into service in Texas principally because of the location of the coal deposits in relation to the major load centers in North Texas, i.e., the Dallas-Fort Worth area. These plants will be built at the mine site thereby virtually eliminating the cost of transportation which has made the use of coal prohibitive in Texas up until now. As progress is made toward the more efficient transmission of high voltages, it is possible to expect that suitable deposits in other parts of the State might be utilized. At the present time, however, it is still more economical to transport the fuel to a plant site located relatively close to the load center than it is to transmit power the same distance.

A question arises as to whether some attention should not be given to the idea of preserving our natural gas resources as a higher order fuel, particularly if they are determined to be fairly limited.

Both the electric utility and the petro-chemical industries use tremendous quantities of natural gas and are increasing their consumption at a rapid rate when other sources of energy are available. Perhaps the time has come when the heavy industrial user is going to have to take into consideration not only economics when selecting a fuel but also whether this fuel is the proper one from a conservation of fuels standpoint.

It may be that someday priorities of use will be placed on certain fuels. If this happens then it would be logical that natural gas, which is clean burning, easy to handle, and transport would be given one of the highest priorities and might eventually be limited to home and commercial use.

## V. COST OF TRANSMITTING ELECTRIC POWER

Because of the great cost of transporting electric power in large amounts over distances of several hundred miles, electric utilities generally locate their generating plants as near as possible to the electrical load centers to obtain a greater service reliability. In view of this it is more expensive to locate generation in large centralized generating stations, then transmit the power over several hundred miles to the load centers. An example of this is illustrated in the cost tabulation for a 500 KV transmission line of 200 miles length (Appendix H).

If a large centralized power plant was located along the Gulf Coast to produce power for Gulf States Utilities, Houston Lighting & Power, and Central Power & Light, then an average transmission distance might be about 200 miles. For approximately each 500 megawatts of generation one 500 KV transmission line would be required. On this basis, a 5000 megawatt plant would require ten 500 KV lines of 200 miles length each. The cost of these lines would be about two-hundred million dollars ($200,000,000). The carrying cost and the cost of losses would be about 0.71 mills per killowatt hour. This would increase the cost of the delivered power by about 32 per cent.

Another factor which must be considered in locating power plants remotely from the load centers is the effect on reliability. Regardless of how well the transmission lines are designed, built, and provided with elaborate protective features, they are still subject to outages caused by hurricanes, lightning, airplane crashes, and sabotage. It should, therfore, be remembered that under these conditions the reliability of service is not as great as it would be if the power plants were located nearer the load centers.

## VI. HURRICANE PROTECTION AND DISASTER PLANNING

The frequency of hurricanes along the Texas Coast is a very strong consideration in the planning and design of outdoor facilities by those companies operating in the Coastal Zone. On the average, a hurricane can be expected to strike somewhere along the Texas Coast once every two years with winds ranging from 80 mph to in excess of 150 mph. Obviously special efforts must be taken to insure that all outside plant and equipment be able to withstand the effects of wind and rising water with a minimum of damage and loss of service.

Underground distribution and transmission is the most desirable method of insuring system reliability; however, it is impractical in many instances because of high installation costs and the technical problems associated with the underground transmission of high voltages. Breakthroughs are being made on both fronts, and it is expected that within the foreseeable future, underground distribution and some transmission could become quite practical. High installation costs result from the costs of labor and equipment required to bury the cable; a major factor is the type of terrain in which the cable is being buried. As the terrain becomes more rugged and rocky, costs rise accordingly, but this is not so much of a problem in the Coastal Zone since the ground lends itself readily to trenching and ditching.

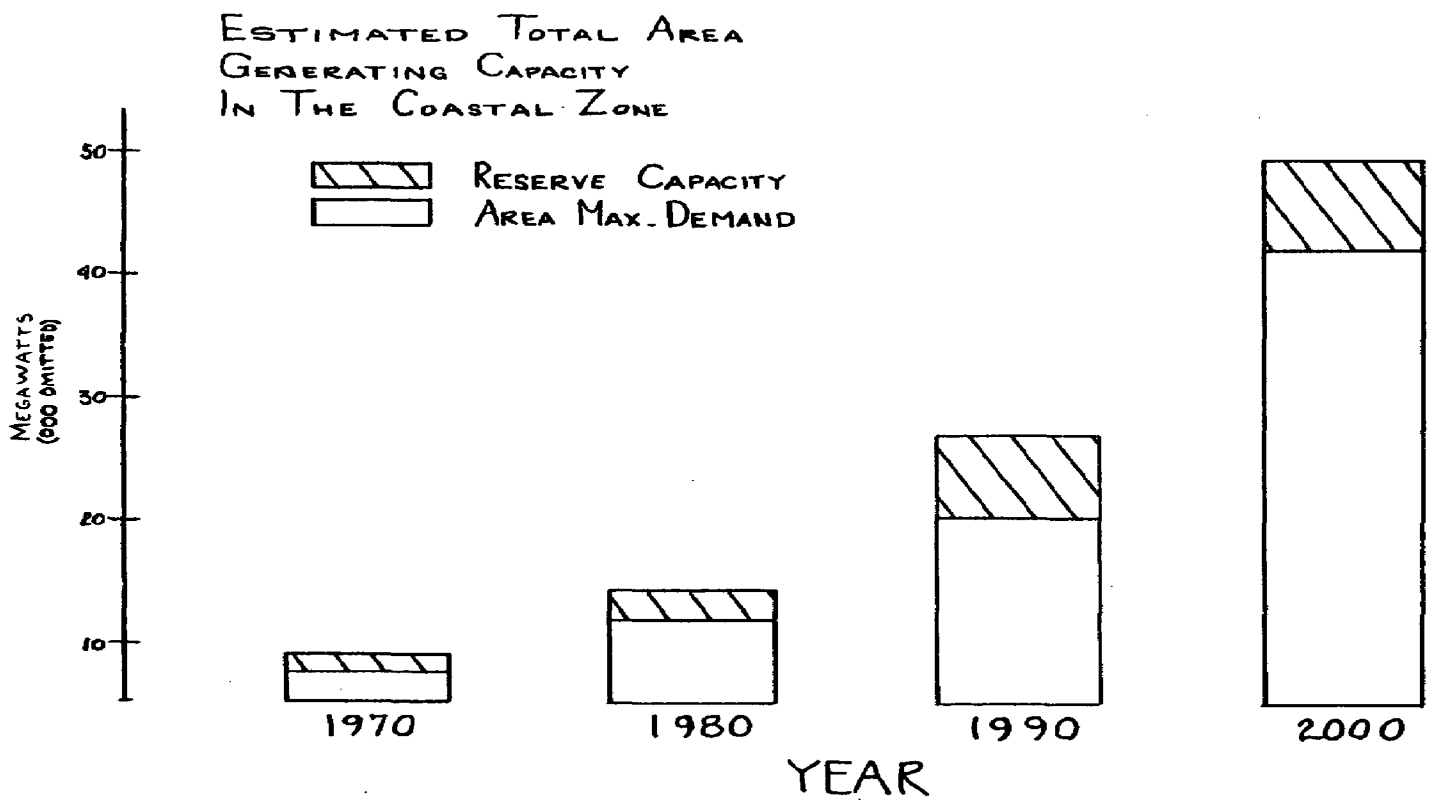
The principal technical problems are the difficulty of dissipating the tremendous amounts of heat energy which build up on and around high voltage conductors, and the interference of the magnetic fields which each conductor sets up. In an overhead line these problems are easily solved through design of the towers which provide the separation needed to maintain the integrity of each field, and the surrounding atmosphere acts as a coolant for the conductor.

Several research programs are underway at the present time and progress being made toward the development of a suitable underground cable for some of the lower transmission voltages. However, the state of the art is still far from successful development of the extra high voltages (345 KV and above).

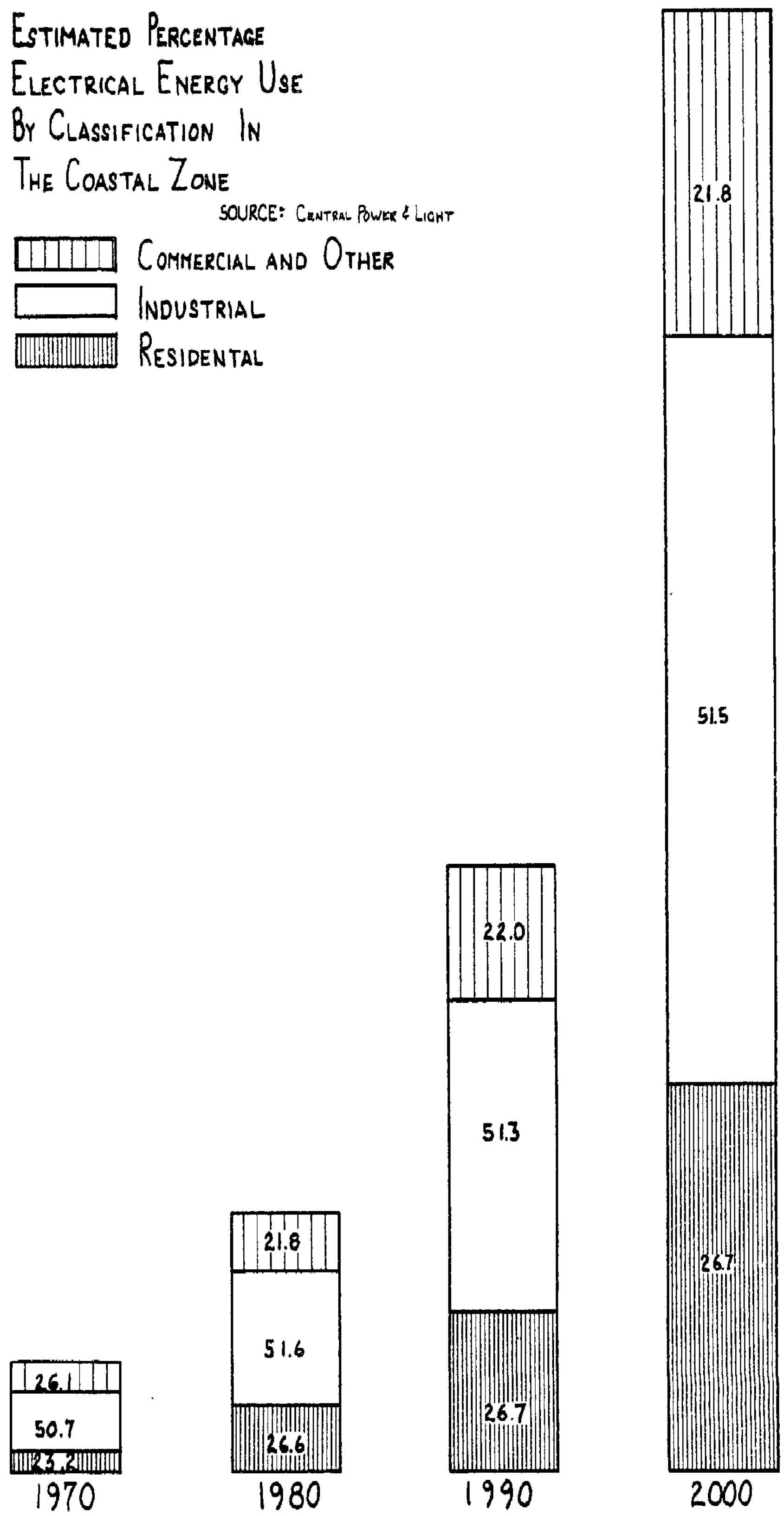
Like other large industries with heavy investments in plant and equipment, the electric utilities operate on a self-insured basis for outside plant and equipment because of the prohibitive expense of such an insurance premium. Through accelerated depreciation methods, casualty loss regulations, and investment tax credits, all of which are deductions to taxable income, the federal government, in effect, acts as a partial insurer to the electric utilities. It should be pointed out that all of these methods are available to any business concern of comparable size.

As a result of experience and careful planning the companies operating in the coastal zone in cooperation with the other investor-owned companies in Texas have developed comprehensive disaster plans to meet all types of catastrophies including civil disturbances. These disaster plans are periodically updated and reviewed to enable the companies to be prepared for any type of disaster should it occur with or without warning. Agreements have been reached with other investor-owned companies throughout the State for these companies to provide men, material, and equipment to restore service to any devastated coastal area as quickly as humanly possible. Many of these plans have been in effect long enough for them to have been tested under actual disaster conditions, and they have proved their merit.

Key personnel and their backup men keep in their possession at home and at work a copy of the disaster manual which contains very specific instructions with alternatives should any of the directives prove to be unfeasible or unneeded. These personnal almost without exception know their duties and those of other key personnel with whom they would need to work without reference to the disaster manual.




SOURCE: Central Power & Light



ESTIMATED PERCENTAGE
ELECTRICAL ENERGY USE
BY CLASSIFICATION IN
THE COASTAL ZONE
SOURCE: CENTRAL POWER & LIGHT
COMMERCIAL AND OTHER
INDUSTRIAL
RESIDENTAL
26.1
50.7
23.2
1970
21.8
51.6
26.6
1980
22.0
51.3
26.7
1990
21.8
51.5
26.7
2000

## BIBLIOGRAPHY


Energy Policy Staff, Office of Science and Technology, Executive Office of the President, Electric Power and the Environment, U. S. Government Printing Office, August, 1970, 70 pp.

Electric Reliability Council of Texas, Response to Federal Power Commission Order No. 383-2 (Docket R-362), April 1, 1971.

Central Power and Light Company, Energy and Power 1970-2000 A.D. Environmental Management Report for Coastal and Marine Resources, December, 1970.

Southern Governor's Conference, Nuclear Power in the South A Report of the Southern Governor's Task Force for Nuclear Power Policy, September, 1970.

Blomeke, J. O., (ed.), "Considerations Related to the Siting of Fuel Reprocessing Plants and Their Associated Waste Management Facilities," ORNL-CF-68-5-33 Rev., August 14, 1968.

Goodner, C. F., "Pricing, Purchasing, and Managing Transportation of Radioactive Materials," Proceedings Second International Symposium on Packaging and Transportation of Radioactive Materials, CONF-681001, 1968.

McDaniels, J. D., "Total Shipping Requirements," Proceedings of the Conference on Transportation of Nuclear Spent Fuel, Atlanta, Ga., Southern Interstate Nuclear Board, Feb. 5-6, 1970.

Peterson, R. W., and C. W. Smith, "Shipping Container Design and Transportation," *ibid.*

Mayer, M., "A Compilation of Air Pollutant Emission Factors for Combustion Processes, Gasoline Evaporation, and Selected Industrial Processes," Cincinnati, Ohio, U. S. Department of Health, Education and Welfare, Public Health Service, Div. of Air Pollution, May, 1965.

Smith, W. S., "Atmospheric Emissions from Fuel Oil Combustion," Public Health Service Publication No. 999-AP-2, Cincinnati, Ohio, U. S. Department of Health, Education and Welfare, Public Health Service, Div. of Air Pollution, November, 1962.

Eisenbud, M., and H. G. Petrow, "Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuels," *Science* 144:3616, Apr. 17, 1964, p.p. 288-289.

"Nuclear Power Plants in Maryland," Report by the Governors' Task Force on Nuclear Power Plants, William W. Eaton, Chairman, December, 1969.

Office of Science and Technology, Report of the Energy Policy Staff, "Considerations Affecting Steam Power Plant Site Selection," GPO 0-325-261, 1968.

Pritchard, D. W., Appendix D in "Nuclear Power Plants in Maryland," Report to the Governors' Task Force on Nuclear Power Plants, December, 1969.

Clark, J. R., "Thermal Pollution and Aquatic Life," *Scientific American,* 20:3, pp. 19-27.

Drew, H. R., and J. E. Tilton, "Thermal Requirements to Protect Aquatic Life," paper presented at the 42nd annual conference of the Water Pollution Control Federation, Oct. 5-10, 1969.

Martino, P. A., and J. M. Marchello, "Using Waste Heat for Fish Farming," *Ocean Industry,* pp. 36-39.

Issacs, John D., and Walter R. Schmitt, "Stimulation of Marine Productivity with Waste Heat and Mechanical Power," *Journal Cons. Int. Explor. Mer.* 33(1): pp. 20-29.

Federal Power Commission 1969 Staff Study, "Selected Materials on Environmental Effects of Producing Electric Power," Joint Commission on Atomic Energy.

Hynes, H. B. N., "The Biology of Polluted Waters," Liverpool Press, 1963, 202 pp.

Federal Water Pollution Control Commission, U. S. Department of Interior, "Industrial Waste Guide on Thermal Pollution," 1968, 112 pp.

Mihursky, J. A., and V. S. Kennedy, "Water Temperature Criteria to Protect Aquatic Life," in "A Symposium on Water Quality Criteria to Protect Aquatic Life," American Fisheries Society Spec. Publication No. 4, 1967, pp. 20-32.

Federal Water Pollution Control Administration, U. S. Department of Interior, "Temperature and Aquatic Life," Lab. Invest. Serv. No. 6 of Tech. Advisory and Investigations Branch, 1967, 151 pp.

Gunter, G., "Temperature," Chapter 8 in "Treatise and Marine Ecology and Paleoecology, I" (Joel W. Hedgpeth, ed.), Geological Society of America, Mim. 67, 1957, pp. 159-184.

Brett, J. R., "Thermal Requirements of Fish--Three Decades of Study--1940-1970," In. Biol. Problems in Water Pollution 1959 Seminar, Trans. PHS Tech. Rep. W 60-3 (Robt. A. Taft Eng. Center, Cincinnati, Ohio), pp. 110-117.

Butler, P. A. "Reaction of Some Estuarine Mollusca to Environmental Factors," in "Biological Problems in Water Pollutions," (C. M. Tarzwell, ed.), third seminar, Public Health Service Pub. N. 999-WP-25, 1965, pp. 92-104.

Jensen, L. D., R. M. Davies, A. S. Brooks, and C. D. Meyers, "The Effects of Elevated Temperatures Upon Aquatic Invertebrates," Edison Electric Inst. Publication No. 69-900, 1969, 232 pp.

Shelford, V. E., "Laboratory and Field Ecology," Williams and Wilhine Co., Baltimore, 1929.

Brett, J. R., "Some Lethal Temperature Relations of Algonquin Park Fishes," University of Toronto Studies, Biol. Ser. No. 52, 1944, pp. 1-49.

Maryland Dept. of Water Resources, "Report of the Thermal Research Advisory Committee," 1969.

Rosenburg, W. H., "A Study of the Effects of Thermal Pollution on *Crassostrea virginica* (Gmelin) in the Patuxent River Estuary, November 1966-1967," Final Report, Sub-project No. 3-23R-2, U. S. Dept. of Interior, Bureau of Commercial Fisheries, 1968.

Patrick, R., Academy of Natural Sciences of Philadelphia, Dept. of Limnology, "Patuxent River, Maryland, Statistical Studies of Oysters and Associated Organisms," 1968.

Cory, R. L., and J. W. Nauman, "Marine Fouling and Thermal Additions in the Upper Estuary of the Patuxent River," Patuxent Thermal Studies, Supplemental Report, U. S. Geological Survey, Washington, D. C., 1969.

Warriner, J. E., and M. L. Brehmer, "The Effects of Thermal Effluents on Marine Organisms," *Int. Journal of Air and Water Pollution*, 10:277-289, 1966.

Coutant, C. C., "The Effect of a Heated Water Effluent Upon the Macroinvertebrate Riffle Fauna of the Delaware River," *Proc. Penna. Acad. Sci.*, XXXVI pp. 58-71, 1962.

Morgan, R., *et al*, "Phytoplankton Studies," Patuxent Thermal Studies, Supplementary Report, Natural Resources Inst. Ref. No. 69-6, University of Maryland, 1969.

Bauer, O. N., "The Influence of Environmental Factors on Reproduction of Fish Parasites," from Voprosy Ekologii (Izdatelstvo Kievskogo Universiteta), 3: pp. 132-141, 1959.

## APPENDICES

APPENDIX A

WATER QUALITY CRITERIA FOR MARINE AND ESTUARINE ORGANISMS
ENVIRONMENTAL PROTECTION AGENCY - WATER QUALITY OFFICE*

The statement of the FWQA Committee on Water Quality Criteria regarding marine and estuarine organisms is given here in its entirety:

> *"Temperature requirements of marine and estuarine organisms in the biota of a given region may vary widely. Therefore, if we are to maintain temperatures favorable to the biota, all important species, including the most sensitive, must be protected. It has been found that organisms in the intertidal zone vary considerably in their ability to withstand high temperatures.*
>
> *"Those in the uppermost areas of the tidal zone generally can withstand higher temperatures than those in the lower portions of the tidal zone, and these, in turn, generally can withstand higher temperatures than the same species of animals living in the subtidal zones. In addition, when considering the coastline as a whole, we must recognize that there are various races within a given species which may vary considerably in their environmental requirements, or in their ability to withstand extreme conditions.*
>
> *"In our marine waters, there is a great mixture of species. Species typical of higher latitudes are found with species that are more abundant farther south. Tropical or subtropical species generally will spawn in the summer months. Species from the higher latitudes require low water temperature for spawning and the development of the young. Thus, they usually spawn in the winter months and temperatures at that time are critical. Any warming of the water during the cold weather or winter period could be disastrous from the standpoint of the elimination of the more northerly species. In some instances, a rise in winter temperatures of only 2 or 3°F might be sufficient to prevent spawning and, thus, eliminate these species from the biota.*

*Ed. Note: These criteria are presently under revision by EPA. What changes may be made are not known at this time. However, there are indications that certain standards may be left up to the regional offices. This would be especially desirable for thermal standards since conditions vary widely across the United States.

*"In the Northern portions of the country there is generally a great range in natural temperatures. In Southern areas, as we approach the tropics, we find smaller overall temperature ranges. In the tropics or subtropics, optimum temperatures for many forms are only a few degrees lower than maximum lethal temperatures. Great care should be exercised, therefore, to prevent harmful increases in maximum summer temperatures in tropical areas.*

*"In general, temperatures in the marine waters do not change as rapidly nor do they have the overall range from extreme to extreme as they do in fresh waters. Marine and estuarine fishes, therefore, are less tolerant of temperature variation. They can accommodate somewhat, but overall temperature range and rate of change are even more important here than they are in fresh waters.*

*"It has been observed that when surface water temperatures over the Georges Bank increased from 46 to 60°F, the larval fish died at 65°F. It has been found that species in subtropical and tropical environments are living at temperatures that are only a few degrees less than their lethal temperatures. In the most Northern forms, extensive variations in seasonal temperatures are a necessity for orderly development and growth. Spawning and development frequently occur at lower temperatures and the sexual products ripen on rising temperatures after a period of low temperatures. Temperatures above or below the optimum range may delay or speed up development. They may inhibit swimming ability and the effectiveness of food utilization may be decreased with increasing temperatures in the upper viable range. Fishes and other forms are also more susceptible to parasites and diseases at temperatures outside their optimum range.*

*"In regard to rapid changes in temperature, it has been found that a drop in temperature from 58 to 43°F kills sardines. Tolerable temperature mimina vary with the population and its past temperature history. Kills have occurred off the Texas coast at 40°F, whereas kills of the same species have occurred off Bermuda at a drop to 59°F. Many kills have occurred in nature due to unusually low temperatures. Kills also occur due to natural high temperatures. Yellowtail*

*flounder and whiting larvae died when they drifted from an area of 44°F to one of 64°F. It has been reported that 61°F is best for the developing of mackerel, but 70°F is too high. These are merely illustrations of what might happen to species occurring in inshore waters.*

*"It is apparent from the foregoing that data are very sparse on temperature requirements of marine and estuarine species. It is very difficult, therefore, to attempt to suggest temperature requirements for marine and estuarine forms. The difficulty is compounded by the great extent of the nation's shorelines, the differing natural temperature variations from north to south, and the geographic overlapping of species native to different latitudes. Consideration must be given to maximum allowable temperatures for both the summer period and winter period.*

*"In attempting to establish permissible levels of temperature increase in receiving waters due to heated waste discharges, precautions must be taken to prevent:*

*"a. Excessive incremental increases above background values even though such incremental increases lie below maximum limits.*

*"b. Exceeding maximum natural background limits.*

*"Such precautions are necessary to prevent gradual net increases in background temperatures due to the continuously increasing volumes of heated wastes being discharged into receiving waters.*

*"The discharge of heated wastes into estuaries and other tidal tributaries must be managed so that no barrier to the movement or migration of fish and other aquatic life is created."*

These criteria realize that, if the marine or estuarine areas are to receive thermal wastes, there will be an unavoidable zone of mixing. Consequently, recommendations were made by the committee regarding zones of passage for drifting or migrating species. Here is the statement:

*"Any barrier to migration and the free movement of the aquatic biota can be harmful in a number of ways. Such barriers block the spawning migration of anadromous and catadromus species. Many resident species make local*

*migrations for spawning and other purposes and any barrier can be detrimental to their continued existence. The natural tidal movement in estuaries and downstream movement of planktonic organisms of aquatic invertebrates in flowing fresh waters are important factors in the re-population of areas and the general economy of the water. Any chemical or thermal barrier destroys this valuable source of food and creates unfavorable conditions below or above it.*

*"It is essential that adequate passageways be provided at all times for the movement or drift of the biota. Water quality criteria favorable to the aquatic community must be maintained at all times in these passageways. It is recognized, however, that certain areas of mixing are unavoidable.*

*"These create harmful polluted areas and for this reason it is essential that they be limited in width and length and be provided only for mixing. The passage zone must provide favorable conditions and must be in a continuous stretch bordered by the same bank for a considerable distance to allow safe and adequate passage up and down the stream, reservoir, lake or estuary for free-floating and drift organisms.*

*"The width of the zone and the volume of flow in it will depend on the character and size of the stream or estuary. Area, depth, and volume of flow must be sufficient to provide a usable and desirable passageway for fish and other aquatic organisms. Further, the cross-sectional area and volume of flow in the passageway will largely determine the percentage of survival of drift organisms. Therefore, the passageway should contain preferably 75% of the cross-section area and/or volume of flow of the stream or estuary. It is evident that where there are several mixing areas close together they should all be on the same side so the passageway is continuous. Concentrations of waste materials in passageways should meet the requirements for the water.*

*"The shape and size of mixing areas will vary with the location, size, character, and use of the receiving water and should be established by proper administrative authority. From the standpoint of the welfare of the aquatic life resource, however, such areas should be as small as possible and be provided for mixing only. Mixing should be*

*accomplished as quickly as possible through the use of devices which insure that the waste is mixed with the allocated dilution water in the smallest possible area.*

*"At the border of this area, the water quality must meet the water quality requirements for that area. If, upon complete mixing with the available dilution water, these requirements are not met, the waste must be pretreated so they will be met. For the protection of aquatic life resources, mixing areas must not be used for, or considered as, a substitute for waste treatment, or as an extension of, or substitute for, a waste treatment facility."*

Admittedly, it is difficult to describe how these zones are to be delineated, but the principle should be adhered to keeping in mind that swimming species normally may swim at certain preferred depths and may have the capacity to avoid unfavorable temperatures, while drifting organisms are subject to currents and their innate flotation characteristics.

The Committee on Water Quality Criteria made a number of recommendations as to the allowable temperature increase and maximum temperatures for receiving water for both fresh and marine waters. It should be noted that since the Committee on Water Quality Criteria reviewed and examined scientific data for the purpose of formulating recommendations, a considerable quantity of field and laboratory data relating to thermal tolerances and ecological impact of heated discharges has been reported in technical literature. It is obvious that much could be gained through an evaluation of these data by a second committee for the purpose of updating these recommendations.

## Fresh Waters

*Recommendation for warm waters:* To maintain a well-rounded population of warm-water fishes, the following restrictions on temperature extremes and temperature increases are recommended:

1. During any month of the year; heat should not be added to a stream in excess of the amount that will raise the temperature of the water (at the expected minimum daily flow for that month) more than 5°F. In lakes and reservoirs, the temperatures of the epilimnion, in those areas where important organisms are most likely to be adversely affected, should not be raised more than 3°F about that which existed before the addition of heat of artificial origin. The increase should be based on the monthly average of the maximum daily temperature.

Unless a special study shows that a discharge of a heated effluent into the hypolimnion or pumping water from the hypolimnion (for discharging back into the same water body) will be desirable, such practice is not recommended.

2. The normal daily and seasonal temperature variations that were present before the addition of heat, due to other than natural causes, should be maintained.

3. The recommended maximum temperatures that are not to be exceeded for various species of warm-water fish are given in Appendix C.

*Recommendation for cold waters:* Because of the large number of trout and salmon waters which have been destroyed, or made marginal or nonproductive, the remaining trout and salmon waters must be protected if this resource is to be preserved:

1. Inland trout streams, headwaters of salmon streams, trout and salmon lakes and reservoirs, and the hypolimnion of lakes and reservoirs containing salmonids should not be warmed. No heated effluents should be discharged in the vicinity of spawning areas.

For other types and reaches of cold-water streams, reservoirs, and lakes, the following restrictions are recommended.

2. During any month of the year, heat should not be added to a stream in excess of the amount that will raise the temperature of the water more than 5°F (based on the minimum expected low for that month). In lakes and reservoirs, the temperature of the epilimnion should not be raised more than 3°F by the addition of heat of artificial origin.

3. The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes should be maintained.

4. The recommended maximum temperatures that are not to be exceeded for various species of cold water fish are given in Appendix C.

Note.--For streams, total added heat (in BTUs) might be specified as an allowable increase in temperature of the minimum daily flow expected for the month or period in question. This would allow addition of a constant amount of heat throughout the period. Approached in this way for all periods of the year, seasonal variation would be maintained. For lakes the situation is more complex and cannot be specified in simple terms.

## Marine Waters

*Recommendation:* In view of the requirements for the well-being and production of marine organisms, it is concluded that the discharge of any heated waste into any coastal or estuarine waters should be closely managed. Monthly means of the maximum daily temperatures recorded at the site in question and before the addition of any heat of artificial origin should not be raised by more than 4°F during the fall, winter, and spring (September through May), or by more than 1.5°F during the summer (June through August). North of Long Island and in the waters of the Pacific Northwest (north of California), summer limits apply July through September, and fall, winter, and spring limits apply October through June. The rate of temperature change should not exceed 1°F per hour except when due to natural phenomena.

Suggested temperatures are to prevail outside of established mixing zones as discussed in the section on zones of passage.

# APPENDIX B

## CRITERIA FOR MAINTENANCE OF WATER QUALITY OF THE ENVIRONMENTAL PROTECTION ADMINISTRATION WATER QUALITY OFFICE

The Federal Water Quality Administration has adopted a set of criteria for the maintenance of water quality, including thermal and radioactivity aspects. Each state is to establish its own water quality standards (which must be approved by FWQA) and the legal means of enforcing these standards.

The following pertinent paragraphs are taken from the report of the Federal Water Quality Administration Committee on Water Quality Criteria:

> *"In arriving at suitable temperature criteria, the problem is to estimate how far the natural temperature may be exceeded without adverse effects. Whatever requirements are suggested, a seasonal cycle must be retained, the changes in temperature must be gradual, and the temperature reached must not be so high or so low as to damage or alter the composition of the desired population.*
>
> *"In view of the many variables, it seems obvious that no single temperature requirement can be applied to the United States as a whole, or even to one state; the requirements must be closely related to each body of water and its population. To do this, a temperature increment based on the natural water temperature is more appropriate than an unvarying number. Using an increment requires, however, that we have information on the natural temperature conditions of the water in question, and the size of the increment that can be tolerated by the desired species."*

## APPENDIX C

### RECOMMENDED MAXIMUM TEMPERATURES FOR FRESH-WATER FISH

(Provisional maximum temperatures recommended as compatible with the well-being of various species of fish and their associated biota)(a)

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93° F: Growth of catfish, gar, white or yellow bass, spotted bass, buffalo, carpsucker, threadfin shad, and gizzard shad.

90° F: Growth of largemouth bass, drum, bluegill, and crappie.

84° F: Growth of pike, perch, walleye, smallmouth bass, and sauger.

80° F: Spawning and egg development of catfish, buffalo, threadfin shad, and gizzard shad.

75° F: Spawning and egg development of largemouth bass, white, yellow, and spotted bass.

68° F: Growth or migration routes of salmonids and for egg development of perch and smallmouth bass.

55° F: Spawning and egg development of salmon and trout (other than lake trout).

48° F: Spawning and egg development of lake trout, walleye, northern pike, sauger, and Atlantic salmon.

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Note - Recommended temperatures for other species, not listed above, may be established if and when necessary information becomes available.

(a) As determined by the Federal Water Quality Administration Committee on Water Quality Criteria.

## APPENDIX D

### PREFERRED TEMPERATURE AND TOLERANCE LIMITS OF SELECTED FISH[a]

| Name of Fish | Preferred Range Field | Preferred Range Lab | Upper[c] Lethal Limit | FWQA Criteria | Spawning Criteria |
|---|---|---|---|---|---|
| Pacific Salmon | 52-55.5 | 55.5-57.5 | 77 | 68 | 54.5 |
| Lake Trout | b | 52.5-54 | 77 | 68 | 48 |
| Winter Flounder | 53-58 | b | 77 | b | b |
| Brook Trout | 57-60.5 | 55-67 | 77 | 68 | 55 |
| Brown Trout | b | 53.5-64 | 78 | 68 | 54.5 |
| Tautog | 55.5-62 | b | 86 | b | b |
| Greenfish | b | 74-76 | 88 | b | b |
| Silverside | 71-73 | b | 88 | b | b |
| Yellow Perch | 67.5-70 | 70-75 | 90 | 84 | 68 |
| Atlantic Salmon | 57-61 | b | 92 | 68 | 48 |
| Bluegill | b | 89-91 | 94 | b | b |
| Striped Bass | 55.5-61 | 64-72 | 94 | b | b |
| Largemouth Bass | 82-86 | 86-90 | 96 | 92 | 76 |
| Gizzard Shad | 73-74.5 | b | 97.5 | 94 | 79.5 |
| Goldfish | b | 82-84 | 106 | b | b |

[a]Adapted from Clark, 1969.[103]

[b]No data given.

[c]Determined by laboratory testing.

APPENDIX E-1

POWER PLANT SITES AND INSTALLED GENERATING CAPACITY
AS OF DECEMBER 31, 1970

Houston Lighting and Power Company

| Station | Location | Unit No. | Capability MW | Type |
|---|---|---|---|---|
| Cedar Bayou | Baytown | 1 | 750.0 | Steam Fossil-Fuel |
| W. A. Parish | NE Ft. Bend Co. | 1 | 177.0 | Steam Fossil-Fuel |
| W. A. Parish | NE Ft. Bend Co. | 2 | 177.0 | Steam Fossil-Fuel |
| W. A. Parish | NE Ft. Bend Co. | 3 | 278.0 | Steam Fossil-Fuel |
| W. A. Parish | NE Ft. Bend Co. | 4 | 565.0 | Steam Fossil-Fuel |
| W. A. Parish | NE Ft. Bend Co. | GT-1 | 14.0 | Gas Turbine |
| P. H. Robinson | Bacliff | 1 | 481.0 | Steam Fossil-Fuel |
| P. H. Robinson | Bacliff | 2 | 481.0 | Steam Fossil-Fuel |
| P. H. Robinson | Bacliff | 3 | 565.0 | Steam Fossil-Fuel |
| P. H. Robinson | Bacliff | GT-1 | 14.0 | Gas Turbine |
| Sam Bertron | Channelview | 1 | 177.0 | Steam Fossil-Fuel |
| Sam Bertron | Channelview | 2 | 177.0 | Steam Fossil-Fuel |
| Sam Bertron | Channelview | 3 | 235.0 | Steam Fossil-Fuel |
| Sam Bertron | Channelview | GT-1 | 27.0 | Gas Turbine |
| Sam Bertron | Channelview | GT-2 | 14.0 | Gas Turbine |
| Webster | Webster | 1 | 112.0 | Steam Fossil-Fuel |
| Webster | Webster | 2 | 112.0 | Steam Fossil-Fuel |
| Webster | Webster | 3 | 375.0 | Steam Fossil-Fuel |
| Webster | Webster | GT-1 | 14.0 | Gas Turbine |
| Greens Bayou | E Harris Co. | 1 | 72.0 | Steam Fossil-Fuel |
| Greens Bayou | E Harris Co. | 2 | 72.0 | Steam Fossil-Fuel |
| Greens Bayou | E Harris Co. | 3 | 112.0 | Steam Fossil-Fuel |
| Greens Bayou | E Harris Co. | 4 | 112.0 | Steam Fossil-Fuel |

APPENDIX E-2

POWER PLANT SITES AND INSTALLED GENERATING CAPACITY
AS OF DECEMBER 31, 1970

Houston Lighting and Power Comany, Continued

| Station | Location | Unit No. | Capability MW | Type |
|---|---|---|---|---|
| Hiram Clark | SW Harris Co. | 1 | 44.0 | Steam Fossil-Fuel |
| Hiram Clark | SW Harris Co. | 2 | 44.0 | Steam Fossil-Fuel |
| Hiram Clark | SW Harris Co. | 3 | 82.0 | Steam Fossil-Fuel |
| Hiram Clark | SW Harris Co. | 4 | 82.0 | Steam Fossil-Fuel |
| Hiram Clark | SW Harris Co. | GT-1 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-2 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-2 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-3 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-4 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-5 | 14.0 | Gas Turbine |
| Hiram Clark | SW Harris Co. | GT-6 | 14.0 | Gas Turbine |
| Deep Water | Houston | HP | 61.0 | Steam Fossil-Fuel |
| Deep Water | Houston | 7 | 177.0 | Steam Fossil-Fuel |
| Gable Street | Houston | 6 | 26.0 | Steam Fossil-Fuel |
| Gable Street | Houston | 7 | 36.0 | Steam Fossil-Fuel |
| Champion | Houston | 1 | 6.0 | Steam Fossil-Fuel |
| Champion | Houston | 2 | 4.0 | Steam Fossil-Fuel |
| Champion | Houston | 3 | 12.0 | Steam Fossil-Fuel |
| T. H. Wharton | NW Harris Co. | 1 | 71.0 | Steam Fossil-Fuel |
| T. H. Wharton | NW Harris Co. | 2 | 234.0 | Steam Fossil-Fuel |
| T. H. Wharton | NW Harris Co. | GT-1 | 14.0 | Gas Turbine |

APPENDIX E-3

POWER PLANT SITES AND INSTALLED GENERATING CAPACITY
AS OF DECEMBER 31, 1970

Central Power and Light Company

| Station | Location | Unit No. | Capability MW | Type |
|---|---|---|---|---|
| Nueces Bay | Corpus Christi | 3 | 17.0 | Steam Fossil-Fuel |
| Nueces Bay | Corpus Christi | 4 | 17.0 | Steam Fossil-Fuel |
| Nueces Bay | Corpus Christi | 5 | 35.0 | Steam Fossil-Fuel |
| Nueces Bay | Corpus Christi | 6 | 175.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 1 | 5.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 2 | 6.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 3 | 10.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 4 | 27.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 5 | 27.0 | Steam Fossil-Fuel |
| La Palma | San Benito | 6 | 150.0 | Steam Fossil-Fuel |
| Victoria | Victoria | 3 | 37.0 | Steam Fossil-Fuel |
| Victoria | Victoria | 4 | 73.0 | Steam Fossil-Fuel |
| Victoria | Victoria | 5 | 170.0 | Steam Fossil-Fuel |
| Victoria | Victoria | 6 | 240.0 | Steam Fossil-Fuel |
| Lon Hill | Corpus Christi | 1 | 72.0 | Steam Fossil-Fuel |
| Lon Hill | Corpus Christi | 2 | 70.0 | Steam Fossil-Fuel |
| Lon Hill | Corpus Christi | 3 | 163.0 | Steam Fossil-Fuel |
| Lon Hill | Corpus Christi | 4 | 240.0 | Steam Fossil-Fuel |
| J. L. Bates | | 1 | 73.0 | Steam Fossil-Fuel |
| J. L. Bates | | 2 | 111.0 | Steam Fossil-Fuel |

APPENDIX E-4

POWER PLANT SITES AND INSTALLED GENERATING CAPACITY
AS OF DECEMBER 31, 1970

Gulf States Utilities Company

| Station | Location | Unit No. | Capability MW | Type |
|---|---|---|---|---|
| Neches | Beaumont | All | 427.0 | Steam Fossil-Fuel |
| Sabine | Port Arthur | All | 890.0 | Steam Fossil-Fuel |
| Lewis Creek | Conroe | All | 265.0 | Steam Fossil-Fuel |

PUB--City of Brownsville

| | | | | |
|---|---|---|---|---|
| Si Ray | Brownsville | 4 | 6.0 | Steam Fossil-Fuel |
| Si Ray | Brownsville | 5 | 24.0 | Steam Fossil-Fuel |
| Si Ray | Brownsville | 6 | 23.0 | Steam Fossil-Fuel |
| Si Ray | Brownsville | 7 | 15.0 | Gas Turbine |

Source: Electric Reliability Council of Texas for all except Gulf States Utilities. GSU data supplied by the company.

APPENDIX F

PLANNED GENERATING CAPACITY RESOURCES
IN THE COASTAL ZONE

| Ownership Company | Station | Capability MW | In-Service Date | Type |
|---|---|---|---|---|
| CP&L | E. S. Joslin | 240.0 | 5/71 | Steam-Fossil |
| HL&P | Cedar Bayou #2 | 750.0 | 11/71 | Steam-Fossil |
| GSU | Lewis Creek #2 | 265.0 | 12/71 | Steam-Fossil |
| CP&L | Nueces Bay #87 | 325.0 | 3/72 | Steam-Fossil |
| HL&P | Greens Bayou #5 | 425.0 | 3/73 | Steam-Fossil |
| HL&P | Unassigned | 300.0 | 3/73 | Gas Turbine |
| HL&P | P. H. Robinson #4 | 750.0 | 11/73 | Steam-Fossil |
| CP&L | La Palma #1&2 (ret.) | - 11.0 | 12/73 | Steam-Fossil |
| GSU | Sabine | 580.0 | 12/73 | Steam-Fossil |
| CP&L | Barney Davis #1 | 325.0 | 1/74 | Steam-Fossil |
| HL&P | Cedar Bayou #3 | 750.0 | 11/74 | Steam-Fossil |
| CP&L | Nueces Bay #3&4 (ret.) | - 34.0 | 12/74 | Steam-Fossil |
| CP&L | Unassigned | 450.0 | 1/75 | Steam-Fossil |
| Brnsvl. | Si Ray #8 | 20.0 | 1/75 | Gas Turbine |
| CP&L | Unassigned | 160.0 | 1/76 | Steam-Fossil |
| HL&P | Unassigned | 750.0 | 11/76 | Steam-Fossil |
| CP&L | Unassigned | 450.0 | 1/77 | Steam-Fossil |
| HL&P | Unassigned | 750.0 | 11/77 | Steam-Fossil |
| CP&L | La Palma #3 (ret.) | - 10.0 | 12/77 | |
| CP&L | Unassigned | 520.0 | 1/78 | Steam-Fossil |
| Brnsvl. | Si Ray #9 | 40.0 | 1/78 | Steam-Fossil |
| HL&P | Unassigned | 750.0 | 11/78 | Steam-Fossil |
| HL&P | Unassigned | 750.0 | 11/79 | Steam-Fossil |
| CP&L | Unassigned | 520.0 | 1/80 | Steam-Fossil |
| HL&P | Unassigned | 750.0 | 11/80 | Steam-Fossil |

APPENDIX G

*COOLING WATER REQUIREMENTS*

*FOR STEAM ELECTRIC PLANTS**

The use of water for the dissipation of heat is a necessary part of the thermodynamic cycle of all modern steam electric power plants. Its value for this purpose lies in its high specific heat, its general abundance and its ability to consume heat in the evaporation process.

In the modern power plant, whether nuclear or fossil fueled, steam from the boiler flows through the turbine giving up energy to the turbine roter and cooling in the process. At the exhaust of the turbine, the steam must be condensed and returned to the boiler. This is accomplished in the condenser using cooling water and in the process the cooling water is increased in temperature. Although some water is also used in other processes in the power plant, particularly for boiler make-up, the quantities are not significant in comparison with the condensing use. The increase in the temperature of the water flowing through the condenser depends upon the design of the condenser, but it is usually between 15 and 25 degrees F.

For a given rate of heat removal, the temperature rise in the cooling water is inversely proportional to the amount of water pumped through the condenser. The size of the condenser and the amount of water circulated can be varied substantially. The design values are selected on the basis of a complex economic analysis which takes into account many factors such as the cost of fuel, the cost of money, expected operating schedules, water temperature, meteorological data and site conditions, all being part of the optimization process in plant design which will result in a plant with the lowest cost product. The range in water flow rates for modern plants is probably from about 30 to 50 gallons per kilowatt hour generated, the lower rate being associated with very efficient plants and the higher rate being that of the larger commercial nuclear plants now in operation.

Power plant efficiencies are expressed in terms of the plant heat rate, which is the BTU input required to generate each net kilowatt hour at the terminals of the plant generator. A "perfect" plant would have a heat rate of 3413 BTU/kwh meaning that each BTU entering the fuel was converted into electricity. At present the best that can be achieved is a heat rate of about 8600 BTU/kwh which

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**H. R. Drew, Director of Research, Texas Electric Service Company, Prepared for ASCE Conference on Research Needs in Civil Engineering Aspects of Power, Pullman, Washington, September 13, 1968.*

is equivalent to an efficiency of about 40%. There are many older plants with much higher heat rates and the national average heat rate is about 10,300 BTU/kwh.

Most of the loss of energy in the power plant occurs in the heat which must be dissipated in the cooling process. In nuclear plants this amounts for almost the entire loss. In fossil fueled plants between 10% and 15% of the heat entering with the fuel is lost in the boiler, the rest being lost in the cooling process. In the "average" United States plant, of the 10,300 BTU/kwh entering in the fuel, possibly 8800 BTU would reach the turbine. Of this, 3413 BTU leaves as electricity and the balance, about 5400 BTU is removed in the condenser. If this were a nuclear plant, the heat removed in the condenser would be about 7000 BTU per kilowatt hour. This is indeed typical of the first generation of nuclear plants. In the latest, most efficient supercritical fossil-fueled units, on the other hand, the heat removal in the condenser may be as low as 3600 BTU/kwh. Thus the range of heat removal rates in the condensers of large modern plants is between about 4000 and 7000 BTU per kilowatt hour generated.

The heat added to the water as it flows through the condenser must be dissipated to the environment in some way. Where the cooling water is returned to a natural watercourse, reservoir, bay or other water body, this dissipation is accomplished by evaporation, radiation, conduction, and advection. If the heat is dissipated in a wet-type cooling tower, it is almost entirely by the evaporation of water. In a dry-type cooling tower, the heat dissipation is almost entirely by conduction and convection.

It is desirable to make a distinction between the terms "consumption" and "use" as applied to water. As noted, the removal of heat in the condenser requires the circulation of large quantities of water, but except for its increase in temperature this water is unchanged in quality and is therfore still useable for other purposes. If the heat that is added, however, is dissipated partly by evaporation, the evaporated water cannot be reused and must be considered as having been permanently consumed, except in those cases where the evaporated water would not have been useable anyway; i.e., in the case of a plant located on the ocean or a cooling tower plant using sewage effluent.

Studies made by the U. S. Geological Survey on several reservoirs in the West have made it possible to determine how the heat which is added to a reservoir is dissipated. A pioneering study[1] at Lake Colorado City, Texas, in 1954-55 utilizing energy budget and mass transfer analyses demonstrated that the increase in evaporation from the lake was directly proportional to the amount of heat added to the lake by the power plant on it and that 58% of

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[1]*U. S. Geological Survey,* *The Effect of the Addition of Heat from a Power Plant on the Thermal Structure and Evaporation of Lake Colorado City, Texas, Professional Paper 272-B, (1959).*

the energy added to the lake by the plant was utilized to increase evaporation while 25% was conducted to the air above the reservoir, 3% was carried away by the evaporated water and 14% was radiated to the atmosphere.

The results of the Lake Colorado City study are strictly applicable only to that location. The percentage of the heat added to a reservoir which is dissipated by evaporation varies with meteorological conditions, particularly wind speed, air temperature and humidity. However, another study[2] permits an estimation of the increase in evaporation which would occur in other locations by making adjustments based upon the air temperature and wind speed measured at the nearest weather station. The following table was prepared using the foregoing study to illustrate the percentage of heat used in evaporation at different locations in the United States.

| | Mean Temp. °F | Mean Wind Speed* mph | Percent of Heat Added That is Utilized to Increase Evaporation |
|---|---|---|---|
| Phoenix, Arizona | 69.0 | 3.3 | 46 |
| Sacramento, Calif. | 60.4 | 6.2 | 49 |
| Denver, Colorado | 49.5 | 6.7 | 42 |
| Atlanta, Georgia | 61.4 | 6.6 | 50 |
| Chicago, Illinois | 50.8 | 7.3 | 43 |
| Topeka, Kansas | 54.9 | 7.9 | 49 |
| Syracuse, New York | 48.0 | 7.0 | 42 |
| Portland, Oregon | 52.9 | 5.4 | 44 |
| San Antonio, Texas | 68.7 | 6.4 | 55 |
| Washington, D. C. | 57.0 | 6.8 | 48 |
| | | | Average = 46.8 |

* corrected to 2 meter speed

If 47% of the heat added to a reservoir is dissipated by evaporation and evaporation takes place at the rate of 1061 BTU per pound of water (57°F), the amount of water evaporated will be approximately 50 gallons per million BTU of heat added to the lake.

The dissipation of heat from a lake is entirely a surface phenomenon and therefore the amount of surface area available is a critical factor in the use of lakes for cooling. As a general rule, about one acre of lake surface is required for each megawatt of generating capacity using the lake for cooling.

There is little information available as to the amount of water consumed due to heat which is added to flowing rivers. Heat

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[2]*Harbeck, G. E., Jr., Estimating Forced Evaporation from Cooling Ponds, Journal of the Power Division, Proceedings of the American Society of Civil Engineers, Vol. 90 No. PO 3, October, 1964.*

dissipation from a river involves some phenomena that are different from those which occur in ponds and reservoirs and the writer has been unable to obtain the results of any studies which would furnish a basis for making an estimate in the short time alloted for the preparation of this paper. The most reasonable approach seems to be to assume that the percentage of the heat added to a river which is utilized to increase evaporation is the same as that for a reservoir, recognizing that this assumption has a high probability of error. Hopefully, studies now taking place or proposed will give a better basis in the near future and meanwhile the approximation should be adequate for the purpose of this paper.

Wet-type cooling towers dissipate approximately 90% of their heat load by evaporation. In addition, systems using wet-type cooling towers require a continuous waste of water in order to prevent a build-up of dissolved solids in the circulating water system due to the loss of water by evaporation. The amount of this blowdown varies, being dependent upon the salt content of the makeup water and the permissible concentration (from considerations of corrosion and scaling) in the circulating water system. For the generalized case, the total water consumption in the tower is equal to $En/(n-1)$ where n is the ratio of the concentration of the water maintained in the cooling tower system to the concentration of the makeup water and E is the amount of water evaporated by the tower. A concentration ratio of 5, which is probably more-or-less typical, results in a total water requirement approximately 25% greater than that needed to replace the evaporation loss alone.

Assuming that the typical cooling tower dissipates heat at the rate of 1061 BTU per pound of water evaporated, that 10% of the heat is dissipated by non-evaporative processes and that makeup is 1.25 times the amount evaporated, the net amount of water required for the typical wet-type cooling tower is approximately 140 gallons per million BTU of heat dissipated.

Dry-type cooling towers being very expensive are little used, the largest being at a 120 mw unit in Rugeley, England. Because the heat is dissipated directly to air by conduction and convection rather than by evaporation as in a wet-type cooling tower, much more air must be moved through the dry-type tower and the available heat transfer surface must be very great. Both of these factors increase greatly the power requirements of these towers. In addition, the minimum cooling temperatures achievable in dry-type towers are limited by the dry bulb rather than the wet bulb air temperature with the result that higher turbine exhaust temperatures must be accepted. In the warmer parts of the country this places a severe penalty upon the efficiency and capability of the power plant. Because of their substantially greater cost it is unlikely that dry-type towers will be used to any great extent in this country in the near future and they are not considered as a factor in determining the water use estimates in this paper.

By combining the foregoing estimates of water consumption rates with the ranges in heat rejection and circulating water flow, a range of estimated water requirements by type of plant can be given. As noted previously, these are subject to major error in some cases due to a lack of adequate knowledge of some phenomena that occur in cooling.

(1) For smaller, less efficient fossil fueled plants and for the currently operating nuclear units, the amount of heat rejected can be as high as 7000 BTU per kilowatt hour generated and the amount of water required to be circulated through the condenser for the removal of heat is about 50 gallons per kilowatt hour generated. The amount of water actually consumed is about 0.35 gallons per kilowatt hour in plants located on lakes or rivers and 0.98 gallons per kilowatt hour in plants using wet-type cooling towers.

(2) Large modern highly efficient plants and eventually nuclear plants will typically reject heat at rates as low as 4000 BTU per kilowatt hour generated and will require the circulation of about 30 gallons per kilowat hour generated. The actual water consumed will be as low as 0.20 gallons per kilowatt hour in plants located on lakes or rivers and 0.56 gallons per kilowatt hour in plants using wet-type cooling towers.

(3) Most plants operate between the above ranges. The "average" fossil fueled unit would reject heat at a rate of 5300 BTU per kilowatt hour generated and would consume between 0.27 (lake or river) and 0.75 (wet-type tower) gallons per kilowatt hour.

Power plant efficiencies are still being improved, although for fossil fueled plants the improvement is at a slower rate than has prevailed in the last 25 years. The thermal efficiency of the current generation of nuclear power plants is poorer than the fossil fueled plants because of the limitations imposed on permissible temperatures in the nuclear fuel core, which in turn limits steam temperatures. This should be considered as a temporary condition. In the light water types we can expect continuing improvement in thermal efficiency as research and engineering develop improved materials and cooling methods in the core. In addition, some types, such as the high temperature gas cooled reactors, are capable of producing the same steam conditions as in modern fossil fueled plants. The HTGR plant being planned in Fort St. Vrain, Colorado, for instance will have a thermal efficiency of about 39%. Liquid metal cooled fast breeder reactors now being developed in this country and abroad are also likely to achieve temperature conditions equivalent to modern fossil fueled plants. All in all, it is likely within the next ten or fifteen years that new nuclear plants will be capable of achieving at least as good thermal efficiencies as fossil fueled plants so that their heat rejection rates will become nearly as low.

A number of other energy conversion methods which could increase the efficiency of power generation substantially above that which is possible in present day steam electric plants are being actively investigated although none is likely to come into general use for many years. Notable are magnetohydrodynamic, electrogasdynamic and thermionic methods. Although any of these might operate as separate power plants, they are more likely to be used at first as topping devices installed ahead of the boiler in the fuel cycle, in effect making it possible to utilize some of the energy in the fuel at higher temperatures before it enters the conventional steam-electric cycle. Magnetohydrodynamic generation has been demonstrated on a laboratory scale and a 32,000 kw demonstration unit has been constructed. Active investigation of electrogasdynamic generation is more recent and the unsolved problems are greater. Thermionic generation will probably be used only in conjunction with nuclear plants.

The development of fuel cells which convert chemical energy directly into electrical energy is receiving great emphasis in this country, with millions of dollars being spent annually. It is entirely possible that a fuel cell capable of operating continuously and reliably on hydrocarbon fuels and air will be developed within the next decade or so, but it is not certain that these devices ever can be built cheaply enough to substitute for central station power.

Ultimately, the use of controlled thermonuclear (fusion) reactions for the generation of electric power is likely to be accomplished, with the resulting benefit of making useable for fuel the almost unlimited supply of deuterium (heavy hydrogen). Fusion power plants may have the potential of converting all or a part of the fusion energy directly into electricity without going through the conventional steam cycle. Such plants are unlikely before the year 2000 however.

Because of the substantial savings in fuel cost which are possible, methods for increasing the efficiency of power plants are likely to come into general use as they become economic. The advantage of being able to reduce the amount of waste heat that must be rejected from the power plant is an additional incentive. It is noteworthy that a small increase in plant efficiency can result in a substantial reduction in the amount of heat rejected. As an extreme example, if plant efficiency could be increased from 40% to 60%, the amount of heat rejected would be reduced from 5200 to 2300 BTU per kilowatt hour generated.

However, even though the amount of water consumed in the generation of electric energy may decline in the future as plant efficiencies are improved, the amount of electrical energy being used per person in the United States is likely to continue to increase. The net result will probably be a gradual increase in the amount of water consumed per person for power generation.

In a study prepared in 1965 for the Texas Water Commission[3] the writer concluded that the future consumption of water for power generation in gallons per day per capita would show a net increase amounting to slightly less than 1% per year. If water quality considerations force greater use of wet-type cooling towers, this estimate could be too low.

In a recent article, Di Luzio[4] estimates that in the year 2000 the amount of heat to be rejected to rivers from thermal power plants will be 7,140 trillion BTU. If all of this heat were dissipated in wet-type cooling towers, the approximate amount of water consumed would be 1 trillion gallons as compared to 357 billion gallons using rivers. This increased water consumption would be particularly significant in the more arid parts of the country but as our use of water resources continues to grow, the importance of conserving water becomes a nationwide concern.

When one recognizes that plants using cooling towers cost substantially more to build and to operate, in addition to consuming more water, it becomes apparent that the selection of water temperature limits must give due weight to these hidden penalties. The ability of lakes and rivers to dissipate heat is very valuable and the substitutes are very costly. To ignore this in the selection of water temperature limits would be a disservice to the water and power using public which pays the bills.

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[3] *Drew, H. R., A Projection of Per Capita Water Use for Electric Power Generation in Texas, May 15, 1965.*

[4] *Di Luzio, Frank C., "Water Use and Thermal Pollution," Power Engineering, June, 1968.*

## SOURCES OF CONDENSING WATER SUPPLY

| | Year 1966 | | New Plants Ordered (1966-67) | |
|---|---|---|---|---|
| | Net generation billions of kwh | Percent of total | Installed capacity mw | Percent of total |
| | 1. | 2. | 3. | 4. |
| Rivers | 504.4 | 55 | 8172 | 29 |
| Lakes | 164.2 | 18 | 8251 | 29 |
| Cooling Towers | 96.9 | 11 | 6971 | 25 |
| Brackish | 99.3 | 11 | 2432 | 9 |
| Salt Water | 44.2 | 5 | 2224 | 8 |
| | 909.0 | | 28,050 | |

Derived from FPC data and industry sources. Column 1 figures are for 531 U. S. plants representing 79.3 percent of total energy production of 1,147 billion kwh in 1966.

APPENDIX H

RECORDED INCIDENTS OF THERMAL FISH KILLS

| Date | State | Stream or Lake | Nearest town or county | Degree of severity | Number of fish |
|---|---|---|---|---|---|
| Aug. 6-8, 1962 | Pennsylvania | Raystown Branch, Junita | Saxton | Heavy | 3,441 |
| Aug. 11, 1962 | Missouri | Discharges canal to Montross Lake | Ladue | Heavy | Several thousand |
| Sept. 7, 1963 | Illinois | Rock River | Rockford | Light | |
| May 28, 1964 | Texas | Unnamed stream | Victoria | Light | |
| Aug. 19, 1965 | Pennsylvania | Schuylkill River | Reading | Moderate | 1,000 |
| Aug. 20, 1965 | Ohio | Greater Miami River | Montgomery County | | 11,250 |
| Jan. 19-22, 1966 | Ohio | Ohio River | Toronto | Light | 200 |
| Sept. 2, 1967 | Pennsylvania | Schuylkill River | Philadelphia | Heavy | 50,000 |
| Jan. 1, 1967 | Ohio | Sandusky River | Sandusky County | | 300,385 |
| Jan. 17, 1967 | Ohio | Sandusky River | Erie County | | 78,750 |
| Jan. 1, 1968 | Nebraska | Lake Hastings | Hastings | Moderate | 5,000 |
| Jan. 2, 1968 | Ohio | Sandusky River | Sandusky County | | 250,585 |

APPENDIX H

RECORDED INCIDENTS OF THERMAL FISH KILLS, Continued

| Date | State | Stream or Lake | Nearest town or county | Degree of severity | Number of fish |
|---|---|---|---|---|---|
| March 1, 1968 | Utah | Price River | Castlegate | Heavy | 150 |
| July 1968 | Massachusetts | Cape Cod Canal | Sandwich | Moderate | |
| Aug. 22, 1968 | Massachusetts | Cape Cod Canal | Sandwich | Moderate | |
| Dec. 16, 1968 | West Virginia | Ohio River | New Cumberland | Light | 9,500 |
| Dec. 24, 1968 | Ohio | Sandusky River | Sandusky County | | 3,000 |
| June 30, 1969 | Florida | Biscayne Bay | Miami | | |

APPENDIX I

INCREMENTAL COST PER KWH DELIVERED

FOR 200 MILES OF 500 KV TRANSMISSION LINE

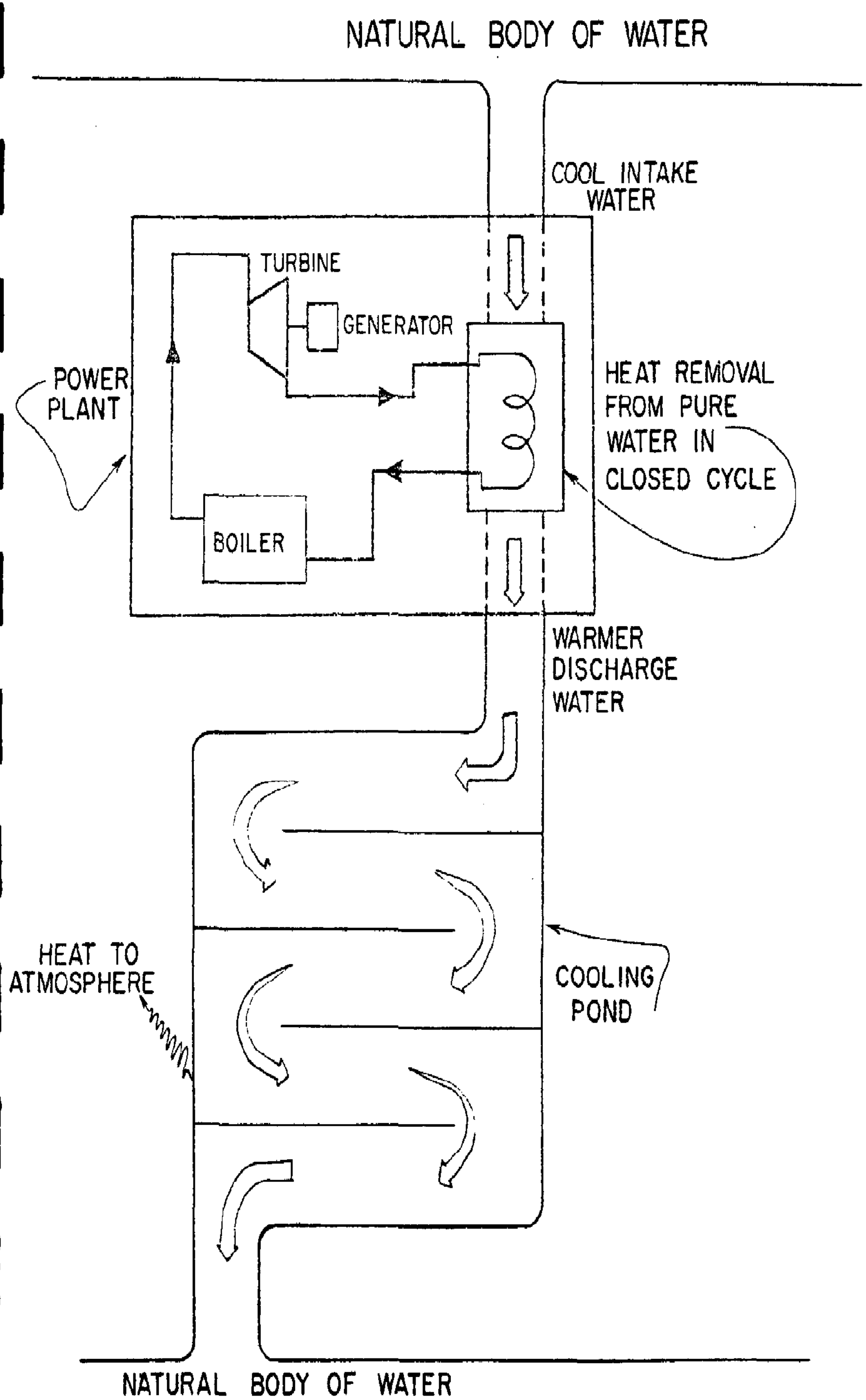
Assume 500 KV transmission line cost at $100,000 per mile. Losses on transmission line from hi-side of power plant step-up transformer to hi-side of bulk substation step-down transformer to be about 0.50% more than would occur if power plant was located adjacent to load center. The average load of the 500 KV line is assumed to be 500 MW. Also, assume cost of power plant at $100/KW and fuel cost at 2.2 mills/Kwhr.

Cost of transmission line:

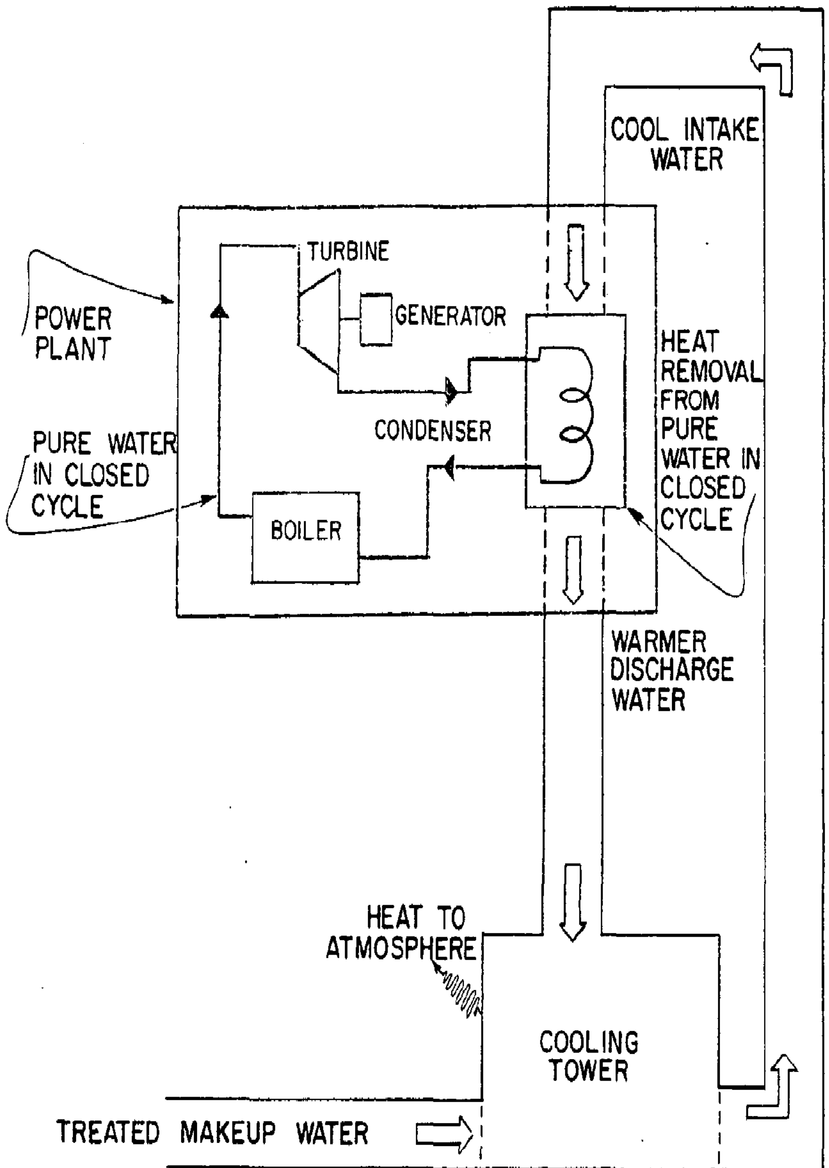
| | | | |
|---|---|---|---|
| | 200 miles at $100,000 per mile | .......... | $20,000,000 |
| (A) | Annual charge at 15% | .......... | 3,000,000 |
| | Cost of power plant capability for losses | | |
| | 2,500 KW at $100 per KW | .......... | 250,000 |
| (B) | Annual charge at 15% | .......... | 37,500 |
| (C) | Fuel for losses | | |
| | 2500 KW x 8760 hrs. x $0.0022 | .......... | 48,200 |
| | Total Cost = (A) + (B) + (C) | .......... | 3,085,700 |
| | Total energy delivered: | | |
| | 500,000 KW x 8760 x 0.995 | .......... | 4,360,000,000 Kwhr |
| | Cost per Kwhr delivered per 100 miles line: | | |
| | $3,085,700/4,360,000,000 | .......... | 0.71 mills per Kwhr |

APPENDIX J

TYPES OF COOLING SYSTEMS FOR
STEAM ELECTRIC PLANTS IN COASTAL ZONE

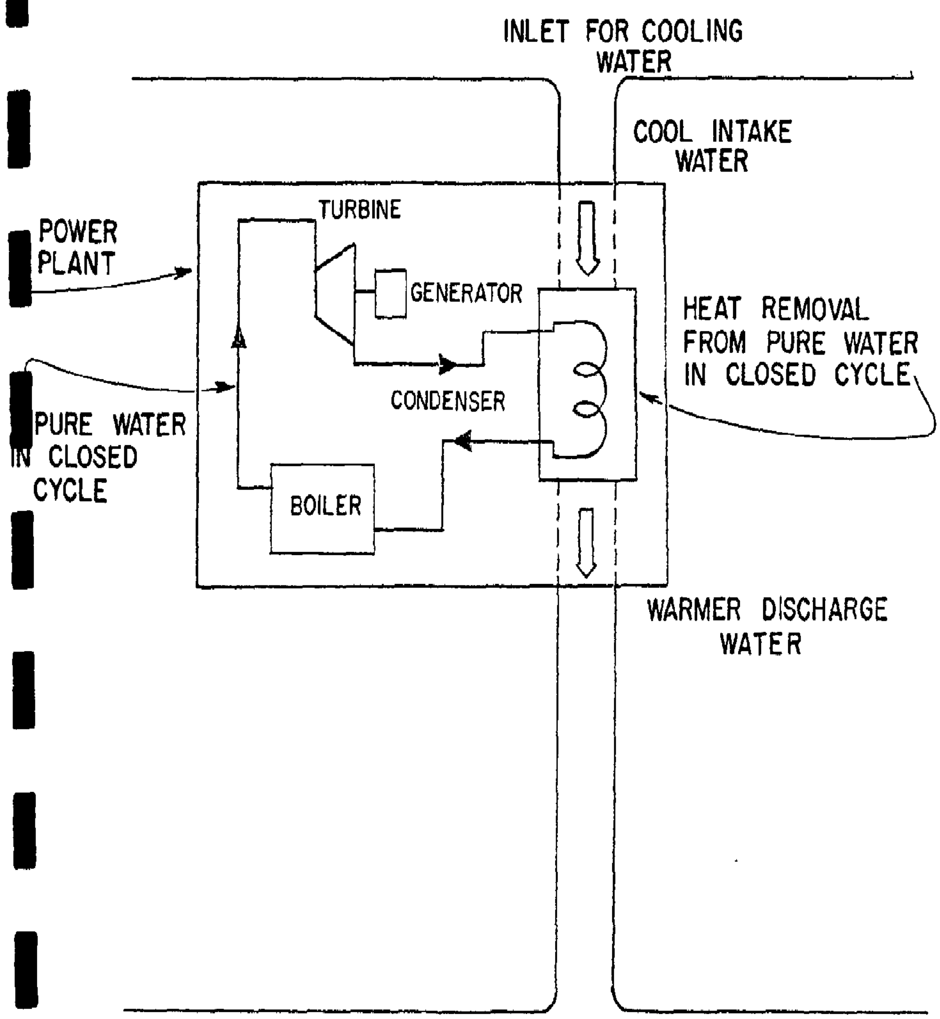



## COOLING POND




# COOLING TOWER

NATURAL BODY OF WATER




NATURAL BODY OF WATER

# ONCE THROUGH

APPENDIX K

COMPARATIVE COSTS FOR CONDENSER AND COOLING WATER SYSTEMS

(800 mw net generation)

INVESTMENT COST
(in thousands of $)

| Cooling Water System | Condenser and Auxiliaries | Cooling Towers and Basin | Pumps and Conduits | Cooling Tower Makeup System | Cooling Lake | Total Investment |
|---|---|---|---|---|---|---|
| FOSSIL FUEL UNIT | | | | | | |
| Ocean | 1,600 | - | 3,300 | - | - | 4,900 |
| River | 1,700 | - | 3,300 | - | - | 5,000 |
| Cooling Lake | 1,500 | - | 2,700 | - | 2,600 | 6,800 |
| Mechanical Draft Wet Tower | 1,900 | 1,700 | 1,600 | 1,200* | - | 6,400 |
| Natural Draft Wet Tower | 1,900 | 4,200 | 1,700 | 1,200* | - | 9,000 |
| Mechanical Draft Dry Tower | 1,100 | 12,200 | 2,100 | - | - | 15,400 |
| Natural Draft Dry Tower | 1,100 | 28,000 | 2,100 | - | - | 31,200 |
| NUCLEAR FUEL UNIT | | | | | | |
| Ocean | 2,400 | - | 4,800 | - | - | 7,200 |
| River | 2,600 | - | 4,800 | - | - | 7,400 |
| Cooling Lake | 2,300 | - | 3,900 | - | 3,400 | 9,600 |
| Mechanical Draft Wet Tower | 2,800 | 2,600 | 2,400 | 1,600** | - | 9,400 |
| Natural Draft Wet Tower | 2,800 | 7,100 | 2,500 | 1,600** | - | 14,000 |
| Mechanical Draft Dry Tower | 1,700 | 19,300 | 3,400 | - | - | 24,400 |
| Natural Draft Dry Tower | 1,700 | 45,000 | 3,400 | - | - | 50,100 |

*Includes $700,000 for tower water makeup pretreatment system
**Includes $800,000 for tower water makeup pretreatment system

APPENDIX K CONTINUED

CAPITAL COSTS

| Cooling Water System | Condenser and Cooling Water System (thousands of $) | Auxiliary Power Requirements (kw) | Incremental Cost for Auxiliary Power (thousands of $) | Total Comparative Capital Cost (thousands of $) | Unit Cost ($/kw) |
|---|---|---|---|---|---|
| FOSSIL FUEL UNIT | | | (1) | | |
| Ocean | 4,900 | 3,000 | 300 | 5,200 | 6.50 |
| River | 5,000 | 3,400 | 340 | 5,340 | 6.68 |
| Cooling Lake | 6,800 | 3,400 | 340 | 7,140 | 8.93 |
| Mechanical Draft Wet Tower | 6,400 | 8,600 | 860 | 7,260 | 9.08 |
| Natural Draft Wet Tower | 9,000 | 7,000 | 700 | 9,700 | 12.13 |
| Mechanical Draft Dry Tower | 15,400 | 24,300 | 2,430 | 17,830 | 22.29 |
| Natural Draft Dry Tower | 31,200 | 7,300 | 730 | 31,930 | 39.91 |
| NUCLEAR FUEL UNIT | | | (2) | | |
| Ocean | 7,200 | 4,600 | 690 | 7,890 | 9.86 |
| River | 7,400 | 5,200 | 780 | 8,180 | 10.23 |
| Cooling Lake | 9,600 | 5,200 | 780 | 10,380 | 12.98 |
| Mechanical Draft Wet Tower | 9,400 | 13,200 | 1,980 | 11,380 | 14.23 |
| Natural Draft Wet Tower | 14,000 | 10,600 | 1,590 | 15,590 | 19.49 |
| Mechanical Draft Dry Tower | 24,400 | 38,400 | 5,760 | 30,160 | 37.70 |
| Natural Draft Dry Tower | 50,100 | 11,600 | 1,740 | 51,840 | 64.80 |

(1) $100/kw
(2) $150/kw

| | FUEL COST | | PARTIAL PRODUCTION COSTS (with alternative condensing and cooling water systems) | | | | |
|---|---|---|---|---|---|---|---|
| Cooling Water System | Net Plant Full Load Heat Rate Btu/kwh | Fuel Cost Mills/kwh (1) | Fixed Charges@ 15%(thousands of $)Annual | mills/net kwh (1) | Fuel Cost Mills/net kwh | Comparative Partial Production Cost Mills/net kwh | Differential Partial Production Cost Mills/net kwh |
| FOSSIL FUEL UNIT | | | | | | | |
| Ocean | 9,106 | 2.73 | 780 | 0.14 | 2.73 | 2.87 | Base |
| River | 9,110 | 2.73 | 801 | 0.14 | 2.73 | 2.87 | 0.00 |
| Cooling Lake | 9,128 | 2.74 | 1,071 | 0.19 | 2.74 | 2.93 | 0.06 |
| Mechanical Draft Wet Tower | 9,187 | 2.76 | 1,089 | 0.19 | 2.76 | 2.95 | 0.08 |
| Natural Draft Wet Tower | 9,171 | 2.75 | 1,455 | 0.26 | 2.75 | 3.01 | 0.14 |
| Mechanical Draft Dry Tower | 10,217 | 3.07 | 2,675 | 0.48 | 3.07 | 3.55 | 0.68 |
| Natural Draft Dry Tower | 10,014 | 3.00 | 4,790 | 0.85 | 3.00 | 3.85 | 0.98 |
| NUCLEAR FUEL UNIT | | | | | | | |
| Ocean | 10,364 | (2) 1.55 | 1,184 | (1) 0.21 | 1.55 | 1.76 | Base |
| River | 10,369 | 1.56 | 1,227 | 0.22 | 1.56 | 1.78 | 0.02 |
| Cooling Lake | 10,388 | 1.56 | 1,557 | 0.28 | 1.56 | 1.84 | 0.08 |
| Mechanical Draft Wet Tower | 10,445 | 1.57 | 1,707 | 0.30 | 1.57 | 1.87 | 0.11 |
| Natural Draft Wet Tower | 10,427 | 1.56 | 2,339 | 0.42 | 1.56 | 1.98 | 0.22 |
| Mechanical Draft Dry Tower | 12,167 | 1.83 | 4,524 | 0.81 | 1.83 | 2.64 | 0.88 |
| Natural Draft Dry Tower | 11,954 | 1.79 | 7,776 | 1.39 | 1.79 | 3.18 | 1.42 |

(1) Fossil fuel cost
\$0.30 per million Btu
(2) Nuclear fuel cost
\$0.15 per million Btu

(1) Based on full load operation at 80% annual capacity factor(5606 x $10^6$ net kwh per year).

# APPENDIX L

## SALT WATER COOLING TOWER APPLICATION

## BY ELECTRIC UTILITIES ON THE GULF COAST

Based on the results of a survey of the existing technology of salt water cooling towers and on the operating experience of a limited number of units, a salt water cooling tower system of the magnitude required for the size of generating units being installed by electric utilities could have consequences on the environment that would be totally unacceptable. Salt water cooling towers can be built to give satisfactory service for certain requirements and in certain locations notably in the smaller sizes and applications not subject to potential environmental problems.

The installations now in service on salt water are 20 to 100 times smaller than what would be required for the size of generating units being installed by electric utilities. Substantial additional research and development is required to develop the necessary information before an acceptable cooling tower system can be specified for a large power plant using salt water.

A. Areas of Sufficient Experiences

1. The thermodynamic performance of towers can be predicted with a degree of confidence that assures proper hear rejection capability.
2. Mechanical draft towers are modular in construction and thereby capacity can be achieved by adding cells. There is extensive experience in the utility industry with the large size double-flow towers with multiple cells. The largest tower facility in salt water service is only 5 cells in size. Electric utility generating units will normally require about 100 cells of similar size.

3. To accommodate the normal electric utility generating unit, six hyperbolic towers would be required of the largest size that the suppliers are currently prepared to offer. There is demonstrated design, construction, and operating experience with towers almost as large in fresh water service. It should be noted that these 500 ft. towers would probably present a potential interference to the operations of airports within several miles.

4. Cooling tower suppliers are prepared to submit conventional, fixed price bids for salt water equipment. Regarding the relative economics, of mechanical draft towers and hyperbolic towers, it is the general opinion of knowledgeable people in the cooling tower industry that the climatic conditions along the Gulf Coast favors mechanical draft towers. With respect to dry towers, they are not now feasible.

B. Areas of Minimum Experience

1. The materials of construction currently selected by the suppliers of both mechanical draft and hyperbolic towers appear to be suitable for salt water service. However, with the exception of the metals, none of these materials has been in use in warm salt water for sufficiently long enough periods of time to be assured their real lifetime is adequate. In particular, there is a question regarding the serviceable lifetime of the treated wood.

2. The cooling tower suppliers are unanimous in saying that except for hyperbolic towers they can furnish equipment that will meet hurricane criterion of 140 mph winds. However, it should be noted that their general experience has been to

design to lower wind loadings. With possibly one exception, there are no large towers of the types discussed that have been designed and constructed to 140 mph criteria. However, it is believed that the suppliers can suitably meet this requirement with an appropriate design and development program.

3. All of the operating salt water towers on which definitive information has been obtained use some type of water treatment to inhibit or minimize marine growth in the towers. Some type of treatment would probably be required for towers located on the Gulf Coast, however, it is not possible at this time to properly appraise this situation. It is concluded that a suitable engineering solution can be reached on this point during the time period of other research and development.

C. Area of Inadequate Experience

Drift represents an outstanding problem area. Simply defined, drift refers to the water carried up the stack in fine droplets and released to the atmosphere. In salt water cooling towers these droplets contain salt. The problems are: (1) how much salt comes out of the cooling towers, (2) what is the size of the area over which this salt is deposited, and (3) what effect does the salt have upon the surrounding environment, including plant and animal life, and soil and structures of the area. The cooling tower suppliers are willing to guarantee a maximum limit of drift from their equipment; however, the industry possesses no accurate standard method for experimentally measuring drift, and therefore present drift guarantees are probably not too meaningful, particularly at low values. The significant problem is that even operating within the guaranteed drift values for

APPENDIX L CONTINUED

currently operating towers, the amount of salt coming out of cooling towers used for electric utility generating units is calculated to be from 20 to 400 tons per day depending on meteorological conditions and area deposition rates are potentially prohibitively high. Prior to building a salt water cooling tower as large as that required for the subject units substantial research, development, and prototype testing will be required. There is no such research development and testing being carried out at this time, or even contemplated. It is judged that a program to do this job would require a minimum of 4 years and several million dollars.

# FINANCIAL INSTITUTIONS IN THE COASTAL ZONE

Prepared by

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BANK OF THE SOUTHWEST

October 1970

for

COASTAL RESOURCES MANAGEMENT PROGRAM

INTERAGENCY NATURAL RESOURCES COUNCIL

DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

*TABLE OF CONTENTS*

# FINANCIAL INSTITUTIONS IN THE COASTAL ZONE

## *INTRODUCTION*

Financial institutions have probably contributed more to the growth of the Texas-Gulf Coast than any one other kind of organization. Moreover, as they have contributed to industrial, commercial and residential development in the Texas-Gulf Coast, these activities have in turn contributed, in an upward cycle, to the growth of financial institutions. This relationship has held true in the past and will continue to hold true in the future.

The subject of this discussion will be the past growth of the Texas-Gulf Coast and the part financial institutions have played in it, and the future growth of the Texas-Gulf Coast and the importance financial institutions can expect to have in it. Financial institutions include not only commercial banks, but also savings and loan associations, credit unions, insurance companies, and any other organization which lends money. Because commercial banks, however, by virtue of their taking demand deposits and making more different kinds of loans than either insurance companies or savings and loan associations, enjoy a more direct relationship to the economy, this discussion will be confined to commercial banks.

For purposes of this discussion, the Texas-Gulf Coast is defined as the 17 counties which border the coast: Aransas, Brazoria, Calhoun, Cameron, Chambers, Galveston, Harris, Jackson, Jefferson, Kenedy, Kleberg, Matagorda, Nueces, Orange, Refugio, San Patricio and Willacy. This area is shown in Figure 1.

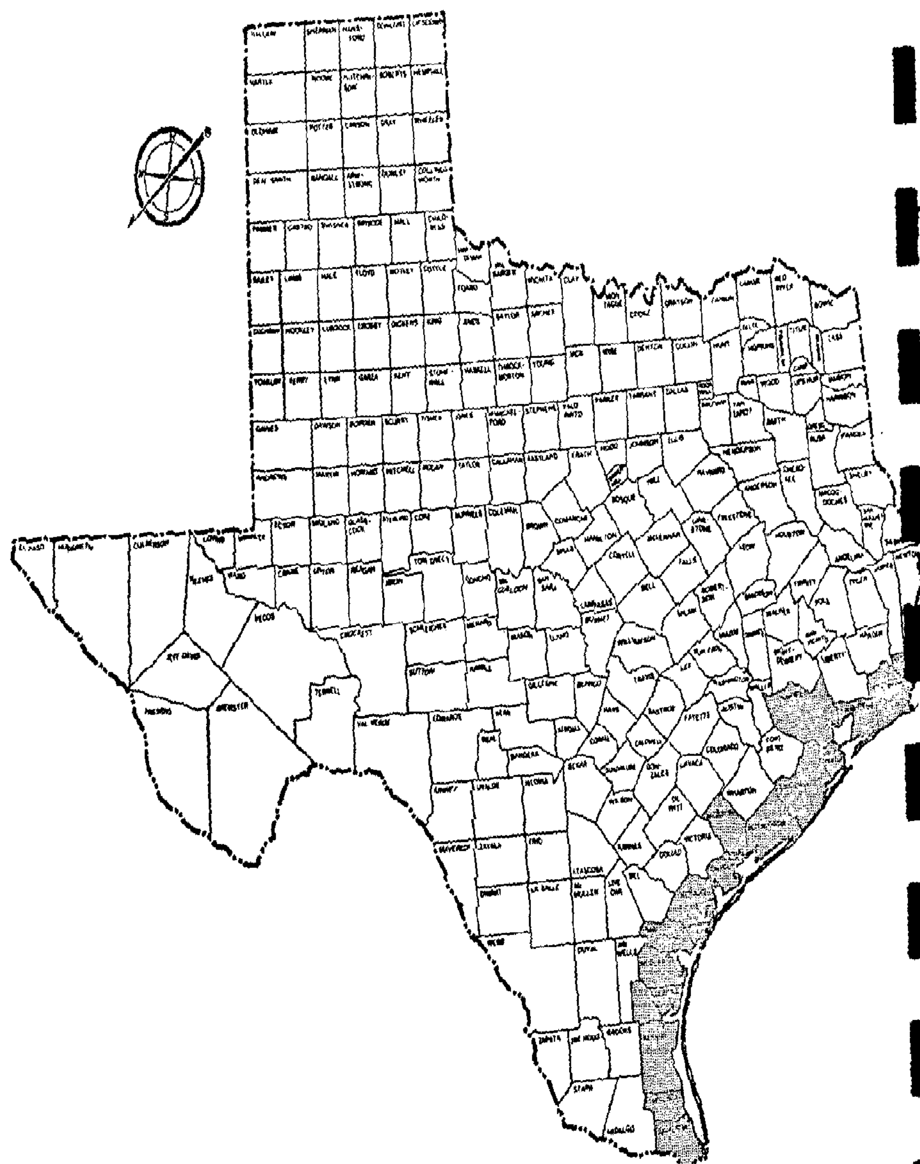
### *PRESENT ACTIVITIES*

Table I gives for each of the 17 counties of the Texas-Gulf Coast the number of banks and accounts and the amount of deposits as of June, 1966, and June, 1968, and the percent change over that period. *The total number of accounts in the Texas-Gulf Coast increased by 14.1%. Total deposits increased by 21%,* from 4.9 billion dollars in 1966 to nearly six billion dollars in 1968. *Demand deposits increased by 22%, but savings deposits decreased by 6.8%.*

There were 180 banks in the Texas-Gulf Coast in 1966, and 184 in 1968. Nearly half, however, were found in Harris

FIGURE 1

TEXAS-GULF COAST
COUNTIES



TEXAS

Scale of Miles

## TABLE I

NUMBER OF ACCOUNTS AND AMOUNT OF DEPOSITS, ACCORDING TO TYPE OF DEPOSIT, ALL COMMERCIAL BANKS
GROUPED BY COUNTY
JUNE 29,1968 AND JUNE 30,1966

| COUNTY | | --NUMBER OF-- BANKS | BANKING OFFICES | ---TOTAL--- NUMBER OF ACCOUNTS | ---AMOUNT OF DEPOSITS (IN THOUSANDS OF DOLLARS)--- TOTAL DEPOSITS | DEMAND IPC | SAVINGS | OTHER TIME IPC | STATES & POL SUBDIVISIONS |
|---|---|---|---|---|---|---|---|---|---|
| ARANSAS | 1968 | 1 | 1 | 4,294 | 6,196 | 3,275 | 321 | 1,237 | 1,027 |
| | 1966 | 1 | 1 | 3,626 | 4,978 | 3,070 | 224 | 513 | 989 |
| | % CHANGE | 0.0 | 0.0 | 18.4 | 24.5 | 6.7 | 43.3 | 141.1 | 3.8 |
| BRAZORIA | 1968 | 14 | 14 | 76,596 | 121,399 | 46,903 | 19,127 | 21,946 | 27,772 |
| | 1966 | 14 | 14 | 62,924 | 86,538 | 40,939 | 20,115 | 5,345 | 15,822 |
| | % CHANGE | 0.0 | 0.0 | 21.7 | 40.3 | 14.6 | -4.9 | 310.6 | 75.5 |
| CALHOUN | 1968 | 2 | 3 | 15,643 | 31,291 | 9,348 | 1,838 | 11,304 | 6,546 |
| | 1966 | 2 | 3 | 13,681 | 25,907 | 7,688 | 1,914 | 7,642 | 6,183 |
| | % CHANGE | 0.0 | 0.0 | 14.3 | 20.8 | 21.6 | -4.0 | 47.9 | 5.9 |
| CAMERON | 1968 | 9 | 9 | 82,176 | 142,080 | 56,706 | 19,911 | 42,498 | 14,715 |
| | 1966 | 9 | 9 | 67,974 | 104,329 | 46,237 | 21,260 | 15,540 | 14,254 |
| | % CHANGE | 0.0 | 0.0 | 20.9 | 36.2 | 22.6 | -6.3 | 173.5 | 3.2 |
| CHAMBERS | 1968 | 2 | 2 | 7,523 | 11,746 | 4,763 | 1,925 | 3,378 | 1,647 |
| | 1966 | 2 | 2 | 6,708 | 9,698 | 4,023 | 1,610 | 2,183 | 1,648 |
| | % CHANGE | 0.0 | 0.0 | 12.1 | 21.1 | 18.4 | 19.6 | 54.7 | -0.1 |
| GALVESTON | 1968 | 14 | 14 | 132,268 | 238,622 | 89,219 | 52,772 | 34,163 | 41,822 |
| | 1966 | 13 | 13 | 104,247 | 200,142 | 77,696 | 53,097 | 6,835 | 38,290 |
| | % CHANGE | 7.7 | 7.7 | 26.9 | 19.2 | 14.8 | -0.6 | 399.8 | 9.2 |
| HARRIS | 1968 | 87 | 89 | 1,272,048 | 4,406,081 | 2,022,264 | 552,026 | 863,572 | 356,942 |
| | 1966 | 86 | 88 | 1,122,439 | 3,650,176 | 1,621,235 | 605,039 | 484,115 | 345,168 |
| | % CHANGE | 1.2 | 1.1 | 13.3 | 20.7 | 24.7 | -8.8 | 78.4 | 3.4 |
| JACKSON | 1968 | 3 | 3 | 11,470 | 22,375 | 8,359 | 3,695 | 5,973 | 3,942 |
| | 1966 | 3 | 3 | 10,982 | 19,681 | 7,915 | 4,047 | 3,095 | 4,321 |
| | % CHANGE | 0.0 | 0.0 | 4.4 | 13.7 | 5.6 | -8.7 | 93.0 | -8.8 |
| JEFFERSON | 1968 | 13 | 14 | 182,743 | 414,541 | 187,468 | 89,956 | 68,356 | 51,153 |
| | 1966 | 13 | 14 | 168,709 | 357,570 | 152,765 | 90,063 | 37,605 | 43,219 |
| | % CHANGE | 0.0 | 0.0 | 8.3 | 15.9 | 22.7 | -0.1 | 81.8 | 18.4 |

NUMBER OF ACCOUNTS AND AMOUNT OF DEPOSITS, ACCORDING TO TYPE OF DEPOSIT, ALL COMMERCIAL BANKS
GROUPED BY COUNTY
JUNE 29,1968 AND JUNE 30,1966

| COUNTY | | NUMBER OF BANKS | NUMBER OF BANKING OFFICES | TOTAL NUMBER OF ACCOUNTS | AMOUNT OF DEPOSITS (IN THOUSANDS OF DOLLARS) TOTAL DEPOSITS | DEMAND IPC | SAVINGS | OTHER TIME IPC | STATES & POL SUBDIVISIONS |
|---|---|---|---|---|---|---|---|---|---|
| KLEBERG | 1968 | 3 | 4 | 13,525 | 27,055 | 14,801 | 3,181 | 3,833 | 4,596 |
| | 1965 | 3 | 4 | 14,427 | 26,315 | 15,319 | 2,396 | 2,375 | 4,912 |
| | % CHANGE | 0.0 | 0.0 | -6.3 | 2.8 | -3.4 | 32.8 | 61.4 | -6.4 |
| MATAGORDA | 1968 | 3 | 4 | 20,734 | 42,179 | 19,773 | 4,597 | 9,266 | 6,528 |
| | 1966 | 3 | 4 | 17,577 | 33,915 | 19,763 | 4,478 | 4,112 | 4,254 |
| | % CHANGE | 0.0 | 0.0 | 18.0 | 24.4 | 0.1 | 2.7 | 125.3 | 53.5 |
| NUECES | 1968 | 16 | 19 | 137,312 | 333,383 | 145,906 | 37,970 | 63,223 | 39,453 |
| | 1966 | 15 | 17 | 118,972 | 264,565 | 134,634 | 41,334 | 24,816 | 40,731 |
| | % CHANGE | 6.7 | 11.8 | 15.4 | 26.0 | 8.4 | -8.1 | 154.8 | -3.1 |
| ORANGE | 1968 | 5 | 5 | 39,203 | 60,516 | 26,813 | 16,263 | 4,726 | 8,757 |
| | 1966 | 5 | 5 | 35,224 | 60,730 | 26,247 | 16,018 | 8,157 | 7,310 |
| | % CHANGE | 0.0 | 0.0 | 11.3 | -0.4 | 2.2 | 1.5 | -42.1 | 19.8 |
| REFUGIO | 1968 | 2 | 2 | 4,700 | 13,330 | 10,538 | 0 | 1,045 | 1,484 |
| | 1966 | 2 | 2 | 4,803 | 12,561 | 10,574 | 0 | 206 | 1,276 |
| | % CHANGE | 0.0 | 0.0 | -2.1 | 6.1 | -0.3 | 0.0 | 407.3 | 16.3 |
| SAN PATRICIO | 1968 | 8 | 8 | 23,147 | 38,044 | 19,417 | 2,901 | 7,670 | 6,507 |
| | 1966 | 8 | 8 | 20,621 | 27,471 | 16,456 | 2,890 | 2,146 | 5,094 |
| | % CHANGE | 0.0 | 0.0 | 12.2 | 38.5 | 18.0 | 0.4 | 257.4 | 27.7 |
| WILLACY | 1968 | 2 | 2 | 9,498 | 18,380 | 6,576 | 2,907 | 3,685 | 3,245 |
| | 1966 | 2 | 2 | 8,223 | 12,734 | 4,813 | 3,168 | 1,305 | 2,821 |
| | % CHANGE | 0.0 | 0.0 | 15.3 | 44.3 | 36.6 | -8.2 | 182.4 | 15.0 |
| TOTAL | 1968 | 183 | 192 | 2,028,536 | 5,921,022 | 2,668,859 | 809,067 | 1,144,638 | 575,109 |
| | 1966 | 180 | 188 | 1,777,511 | 4,892,352 | 2,186,309 | 867,429 | 605,477 | 535,303 |
| | % CHANGE | 1.6 | 2.1 | 14.1 | 21.0 | 22.0 | -6.8 | 89.0 | 7.4 |

County. At present there are 186 banks in the Texas-Gulf Coast; 113 of them, or more than half, are found in Harris County. Kenedy County has no banks.

As of December, 1970, 43 bank charter applications were pending in the Texas-Gulf Coast; of them, 34 were proposed for Harris County.

The Federal Deposit Insurance Corporation has divided the state into 28 statistical areas which cover from one to 24 counties. The 17 counties of the Texas-Gulf Coast, as shown in Figure 2, are included in seven of the F.D.I.C. areas, as follows:

Area 03 - Kenedy, Kleberg
Area 11 - Aransas, Refugio
Area 14 - Brazoria, Calhoun, Chambers, Harris, Jackson Matagorda
Area 15 - Cameron, Willacy
Area 19 - Galveston
Area 23 - Nueces, San Patricio
Area 24 - Jefferson, Orange

The following Tables II through VI gives figures for F.D.I.C. insured commercial banks in the State and in the seven areas which include Texas-Gulf Coast counties. Only insured commercial banks are represented here.

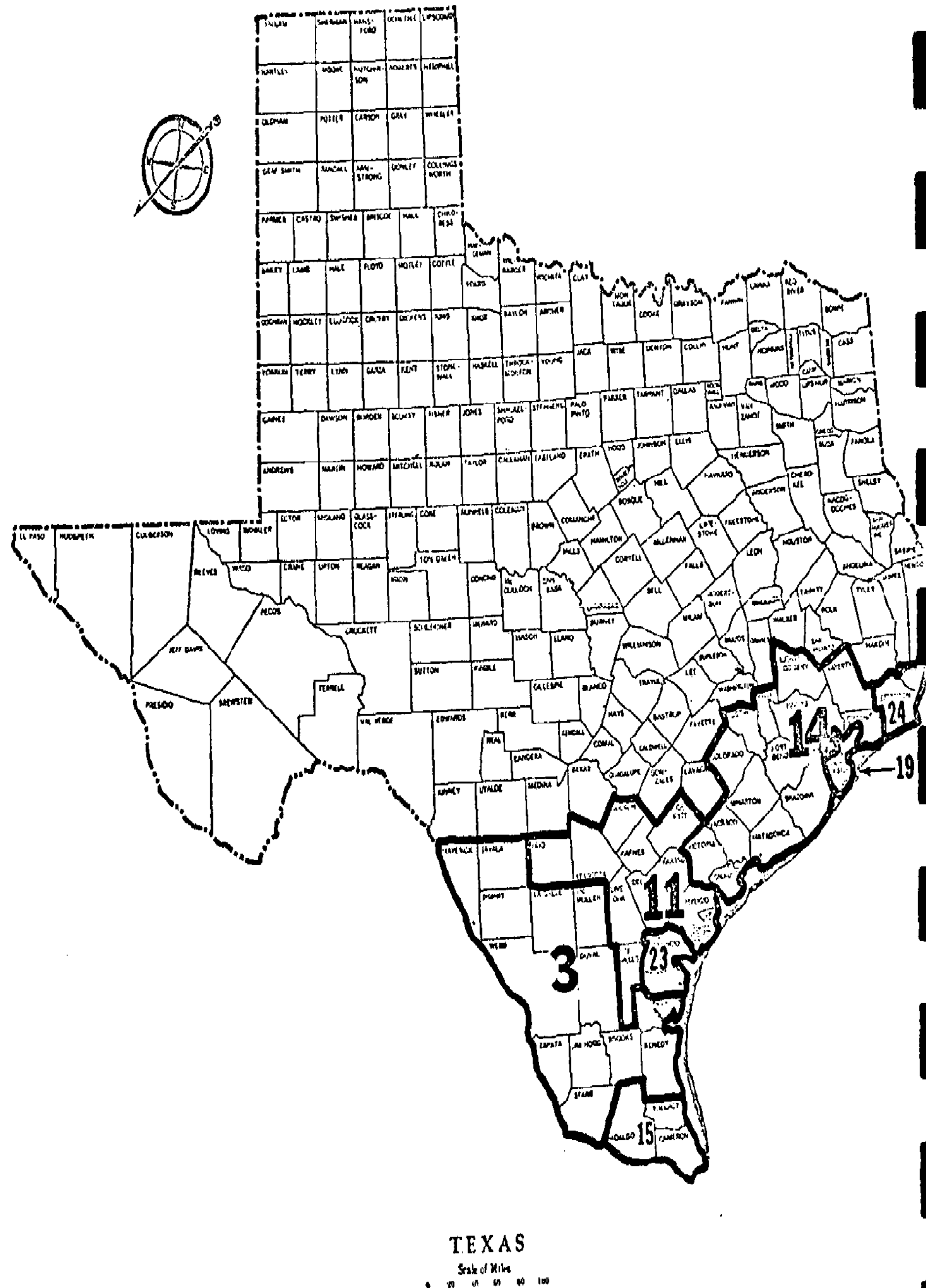
Table II gives assets, liabilities and capital accounts for December, 1968, and December, 1969, and the percent change over that period. Table III gives selected balance sheet ratios for a breakdown of assets and total deposits as of December 31, 1969. Table IV gives income and expenses for December, 1968, and December, 1969, and the percent change over that period. Table V gives income and expenses as a percentage of total operating revenue as of December 31, 1969. Table VI gives selected operating ratios for a breakdown of rates of return, percentages of total assets, percentages of capital accounts and special ratios for 1969.

*ANALYSIS AND PROJECTIONS*

In order to determine the past, current, and future growth of the Texas-Gulf Coast counties, economic characteristics have been studied for selected years during the 1950-1960 and 1960-1970 ten-year periods. *Economic indicators are statistical, and projections based on them are therefore statistical.* The periods were chosen to show past and recent performance and rate of growth; alternate years within these periods were used when possible to give close points for graphical projection into the future. The economic characteristics used were *population, economic index,* and *bank deposits.*

FIGURE 2

SEVEN F.D.I.C. AREAS
COVERING
TEXAS-GULF COAST COUNTIES



## TABLE II

ASSETS, LIABILITIES AND CAPITAL ACCOUNTS
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | BANKS IN STATE DEC. 1968 | BANKS IN STATE DEC. 1969 | % CHANGE 68-69 | BANKS IN AREA 03 DEC. 1968 | BANKS IN AREA 03 DEC. 1969 | % CHANGE 68-69 | BANKS IN AREA 11 DEC. 1968 | BANKS IN AREA 11 DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL ASSETS | 26,717,446 | 27,829,859 | 4.1 | 196,221 | 212,129 | 8.1 | 240,516 | 261,766 | 8.8 |
| CASH AND DUE FROM BANKS | 5,422,731 | 5,481,495 | 1.0 | 31,961 | 32,127 | .5 | 38,497 | 41,323 | 7.3 |
| INVESTMENTS | 6,918,757 | 6,502,604 | 6.0- | 72,335 | 71,905 | 1.2- | 91,035 | 90,151 | .9- |
| U.S. TREASURY SECURITIES---# | 3,141,769 | 2,501,306 | 20.3- | 31,233 | 27,433 | 12.1- | 47,672 | 42,550 | 10.7- |
| SECURITIES OF OTHER U.S. - GOVERNMENT AGENCIES---# | 710,304 | 624,596 | 12.0- | 8,640 | 7,278 | 15.7- | 12,314 | 11,525 | 6.4- |
| OBLIGATION OF STATES, ETC.-# | 2,955,817 | 3,172,288 | 7.3 | 32,101 | 35,024 | 9.1 | 29,849 | 35,259 | 18.1 |
| OTHER SECURITES---# | 110,867 | 99,378 | 10.3- | 861 | 2,170 | 152.0 | 1,200 | 817 | 31.9- |
| TRADING ACCOUNT SECURITIES | # | 105,036 | # | # | # | # | # | # | # |
| LOANS AND DISCOUNTS | 13,647,002 | 14,910,000 | 9.2 | 87,245 | 102,993 | 18.0 | 107,552 | 126,847 | 17.9 |
| RESIDENTIAL REAL ESTATE | 671,424 | 686,112 | 2.1 | 11,305 | 12,703 | 12.3 | 7,002 | 8,137 | 16.2 |
| 1- TO 4-FAMILY PROPERITIES | # | 624,884 | # | # | 12,649 | # | # | 7,592 | # |
| MULTIFAMILY PROPERTIES | # | 61,228 | # | # | 54 | # | # | 545 | # |
| OTHER REAL ESTATE | 947,442 | 1,082,373 | 14.2 | 9,397 | 12,365 | 31.5 | 11,205 | 12,495 | 11.5 |
| COMMERCIAL AND INDUSTRIAL | 5,607,602 | 6,074,548 | 8.3 | 27,252 | 31,565 | 15.8 | 28,114 | 35,684 | 26.9 |
| AGRICULTURAL | 720,513 | 804,984 | 11.7 | 8,826 | 7,255 | 17.7- | 22,308 | 25,200 | 12.9 |
| FOR CARRYING SECURITIES | 775,026 | 882,019 | 13.8 | 344 | 569 | 71.2 | 1,971 | 1,745 | 11.4- |
| TO INDIVIDUALS TO PURCHASE - AUTOMOBILES | 1,640,951 | 1,771,373 | 7.9 | 12,760 | 15,333 | 20.1 | 11,462 | 11,738 | 2.4 |
| TO INDIVS. FOR CREDIT CARDS | 24,665 | 83,970 | 240.4 | | | | | | |
| OTHER LOANS TO INDIVIDUALS | 1,779,016 | 1,943,850 | 9.2 | 13,659 | 15,603 | 14.2 | 17,162 | 18,114 | 5.5 |
| ALL OTHER LOANS | 1,480,363 | 1,580,771 | 6.7 | 3,702 | 7,580 | 104.7 | 8,328 | 13,734 | 64.9 |
| FIXED ASSETS | 530,198 | 622,134 | 17.3 | 3,107 | 3,741 | 20.4 | 3,204 | 3,199 | .1- |
| OTHER ASSETS | 198,758 | 313,626 | 57.7 | 1,073 | 1,363 | 27.0 | 228 | 246 | 7.8 |
| TOTAL LIABILITIES | 24,551,041 | 25,454,697 | 3.6 | 180,142 | 194,093 | 7.7 | 216,723 | 235,529 | 8.6 |
| TOTAL DEPOSITS | 23,445,849 | 23,721,775 | 1.1 | 177,064 | 189,584 | 7.0 | 214,803 | 233,123 | 8.5 |
| TOTAL DEMAND | 13,922,078 | 14,267,834 | 2.4 | 104,675 | 108,276 | 3.4 | 139,915 | 145,277 | 3.8 |
| TOTAL TIME AND SAVINGS | 9,523,771 | 9,453,941 | .7- | 72,389 | 81,308 | 12.3 | 74,888 | 87,846 | 17.3 |
| DEMAND DEPOSITS, IPC | 10,347,514 | 10,567,997 | 2.1 | 74,728 | 79,575 | 6.4 | 118,479 | 121,810 | 2.8 |
| SAVINGS DEPOSITS | 3,041,022 | 2,939,377 | 3.3- | 17,662 | 17,947 | 1.6 | 33,287 | 30,920 | 7.1- |
| OTHER TIME DEPOSITS, IPC | 4,965,485 | 4,976,989 | .2 | 43,497 | 51,703 | 18.8 | 32,207 | 46,385 | 44.0 |
| DEPOSITS OF STATES, ETC. | 2,401,522 | 2,294,183 | 4.4- | 35,044 | 33,341 | 4.8- | 26,796 | 28,668 | 6.9 |
| DEPOSITS OF U.S. GOVERNMENT | 214,450 | 311,621 | 45.3 | 1,587 | 1,354 | 14.6- | 1,440 | 2,104 | 46.1 |
| DEPOSITS OF COMMERCIAL BANKS | 2,151,321 | 2,255,575 | 4.8 | 2,826 | 3,296 | 16.6 | 1,722 | 1,904 | 10.5 |
| OTHER LIABILITIES | 1,092,017 | 1,732,922 | 58.6 | 3,078 | 4,509 | 46.4 | 1,920 | 2,406 | 25.3 |
| TOTAL RESERVES ON LOANS AND - SECURITIES---# | 226,294 | 261,800 | 24.5 | 1,208 | 3,026 | 150.4 | 1,533 | 1,707 | 11.3 |
| TOTAL CAPITAL ACCOUNTS | 1,940,111 | 2,093,362 | 7.8 | 14,671 | 15,010 | .9 | 22,260 | 24,530 | 10.1 |
| NUMBER OF BANKS | 1,142 | 1,157 | | 19 | 19 | | 38 | 38 | |

# SEE EXPLANATORY NOTES

SOURCE- REPORTS OF CONDITION
DEC. 1968 AND DEC. 1969

ASSETS, LIABILITIES AND CAPITAL ACCOUNTS
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | ---BANKS IN AREA 14----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | ----BANKS IN AREA 15----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | ---BANKS IN AREA 19----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL ASSETS | 6,452,704 | 6,843,998 | 6.0 | 384,949 | 405,909 | 5.4 | 267,771 | 271,044 | 1.2 |
| CASH AND DUE FROM BANKS | 1,457,057 | 1,579,035 | 8.3 | 57,179 | 68,249 | 19.3 | 37,387 | 42,071 | 12.5 |
| INVESTMENTS | 1,524,721 | 1,394,619 | 8.5- | 127,862 | 116,367 | 8.9- | 91,244 | 88,271 | 3.2- |
| U.S. TREASURY SECURITIES---# | 692,596 | 464,107 | 32.9- | 53,731 | 43,087 | 19.8- | 30,529 | 28,156 | 7.7- |
| SECURITIES OF OTHER U.S. - GOVERNMENT AGENCIES---# | 134,174 | 111,745 | 16.7- | 30,372 | 23,953 | 21.1- | 19,813 | 17,791 | 10.2- |
| OBLIGATION OF STATES, ETC.-# | 657,855 | 775,836 | 17.9 | 42,231 | 48,278 | 14.3 | 39,127 | 41,471 | 5.9 |
| OTHER SECURITES---# | 40,096 | 30,526 | 23.8- | 1,528 | 1,049 | 31.3- | 1,775 | 853 | 51.9- |
| TRADING ACCOUNT SECURITIES | # | 12,405 | # | # | | # | # | | # |
| LOANS AND DISCOUNTS | 3,263,096 | 3,616,410 | 10.8 | 188,328 | 208,302 | 10.6 | 129,267 | 129,870 | .4 |
| RESIDENTIAL REAL ESTATE | 207,739 | 192,456 | 7.3- | 8,353 | 6,932 | 17.0- | 11,416 | 11,408 | |
| 1- TO 4-FAMILY PROPERTIES | # | 172,566 | # | # | 6,629 | # | # | 10,472 | # |
| MULTIFAMILY PROPERTIES | # | 19,890 | # | # | 303 | # | # | 936 | # |
| OTHER REAL ESTATE | 232,865 | 285,465 | 22.5 | 14,209 | 19,846 | 39.6 | 11,548 | 13,912 | 20.4 |
| COMMERCIAL AND INDUSTRIAL | 1,516,117 | 1,722,495 | 13.6 | 78,537 | 86,681 | 10.3 | 37,775 | 36,914 | 2.2- |
| AGRICULTURAL | 47,935 | 51,778 | 8.0 | 13,188 | 13,906 | 5.4 | 445 | 407 | 8.5- |
| FOR CARRYING SECURITIES | 192,784 | 253,986 | 31.7 | 9,299 | 8,935 | 3.9- | 5,055 | 3,510 | 30.5- |
| TO INDIVIDUALS TO PURCHASE - AUTOMOBILES | 298,111 | 311,764 | 4.5 | 24,456 | 30,296 | 23.8 | 20,907 | 21,948 | 4.9 |
| TO INDIVS. FOR CREDIT CARDS | 1,128 | 16,437 | 999.9 | | | | 173 | | 100.0- |
| OTHER LOANS TO INDIVIDUALS | 382,879 | 438,038 | 14.4 | 27,862 | 28,581 | 2.5 | 28,938 | 27,949 | 3.4- |
| ALL OTHER LOANS | 383,538 | 343,991 | 10.3- | 12,424 | 13,125 | 5.6 | 13,010 | 13,822 | 6.2 |
| FIXED ASSETS | 140,967 | 166,019 | 17.7 | 8,473 | 9,084 | 7.2 | 8,540 | 9,098 | 6.5 |
| OTHER ASSETS | 66,863 | 87,915 | 31.4 | 3,107 | 3,907 | 25.7 | 1,333 | 1,734 | 30.0 |
| TOTAL LIABILITIES | 5,908,864 | 6,237,967 | 5.5 | 356,755 | 374,525 | 4.9 | 243,182 | 244,697 | .6 |
| TOTAL DEPOSITS | 5,709,578 | 5,851,506 | 2.4 | 351,917 | 365,662 | 3.9 | 239,361 | 240,075 | .2 |
| TOTAL DEMAND | 3,556,697 | 3,731,165 | 4.9 | 190,268 | 193,462 | 1.6 | 118,927 | 122,609 | 3.0 |
| TOTAL TIME AND SAVINGS | 2,152,881 | 2,120,341 | 1.5- | 161,649 | 172,200 | 6.5 | 120,434 | 117,466 | 2.4- |
| DEMAND DEPOSITS, IPC | 2,632,232 | 2,694,916 | 2.3 | 143,616 | 147,169 | 2.4 | 93,275 | 96,305 | 3.2 |
| SAVINGS DEPOSITS | 623,033 | 641,803 | 3.0 | 47,588 | 49,128 | 3.2 | 51,651 | 54,453 | 5.4 |
| OTHER TIME DEPOSITS, IPC | 1,190,718 | 1,148,283 | 3.5- | 83,866 | 90,718 | 8.1 | 38,998 | 39,490 | 1.2 |
| DEPOSITS OF STATES, ETC. | 502,500 | 504,673 | .4- | 56,582 | 56,259 | .5- | 42,730 | 34,608 | 19.0- |
| DEPOSITS OF U.S. GOVERNMENT | 48,632 | 80,741 | 66.0 | 3,117 | 4,000 | 28.3 | 1,666 | 2,868 | 72.1 |
| DEPOSITS OF COMMERCIAL BANKS | 615,261 | 673,283 | 9.4 | 11,703 | 11,509 | 1.6- | 7,909 | 9,530 | 20.4 |
| OTHER LIABILITIES | 191,990 | 386,461 | 101.2 | 4,828 | 8,863 | 83.5 | 3,821 | 4,622 | 20.9 |
| TOTAL RESERVES ON LOANS AND - SECURITIES---# | 45,486 | 57,051 | 25.4 | 5,293 | 5,580 | -5.4 | 1,851 | 2,643 | 42.7 |
| TOTAL CAPITAL ACCOUNTS | 498,354 | 548,980 | 10.1 | 22,901 | 25,804 | 12.6 | 22,738 | 23,704 | 4.2 |
| NUMBER OF BANKS | 152 | 158 | | 27 | 27 | | 13 | 13 | |

# SEE EXPLANATORY NOTES

SOURCE- REPORTS OF CONDITION
DEC. 1968 AND DEC. 1969

ASSETS, LIABILITIES AND CAPITAL ACCOUNTS
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | BANKS IN AREA 23 DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | BANKS IN AREA 24 DEC. 1968 | DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|
| TOTAL ASSETS | 456,523 | 469,803 | 2.9 | 571,761 | 590,428 | 3.2 |
| CASH AND DUE FROM BANKS | 85,618 | 93,949 | 9.7 | 91,927 | 92,309 | .4 |
| INVESTMENTS | 120,679 | 115,602 | 4.2- | 158,269 | 160,606 | 1.4 |
| U.S. TREASURY SECURITIES---# | 67,080 | 56,975 | 15.0- | 72,417 | 70,654 | 2.4- |
| SECURITIES OF OTHER U.S. - GOVERNMENT AGENCIES---# | 12,058 | 10,954 | 9.1- | 21,444 | 15,430 | 28.0- |
| OBLIGATION OF STATES, ETC.-# | 40,139 | 46,068 | 14.7 | 59,955 | 67,489 | 12.5 |
| OTHER SECURITES---# | 1,402 | 1,605 | 14.4 | 4,453 | 7,033 | 57.9 |
| TRADING ACCOUNT SECURITIES | # | | # | # | | # |
| LOANS AND DISCOUNTS | 235,506 | 244,348 | 3.7 | 306,636 | 321,697 | 4.9 |
| RESIDENTIAL REAL ESTATE | 6,597 | 6,115 | 7.3- | 30,400 | 32,094 | 5.5 |
| 1- TO 4-FAMILY PROPERITIES | # | 5,086 | # | # | 29,093 | # |
| MULTIFAMILY PROPERTIES | # | 1,029 | # | # | 3,001 | # |
| OTHER REAL ESTATE | 10,482 | 11,158 | 6.4 | 30,268 | 29,989 | .9- |
| COMMERCIAL AND INDUSTRIAL | 103,424 | 114,298 | 10.5 | 102,217 | 100,988 | 1.2- |
| AGRICULTURAL | 9,957 | 9,394 | 5.6- | 2,606 | 3,896 | 49.5 |
| FOR CARRYING SECURITIES | 13,958 | 8,813 | 36.8- | 13,588 | 5,648 | 58.4- |
| TO INDIVIDUALS TO PURCHASE - AUTOMOBILES | 34,766 | 35,161 | 1.1 | 53,574 | 58,109 | 8.4 |
| TO INDIVS. FOR CREDIT CARDS | 21 | 695 | 999.9 | 1,457 | 5,227 | 258.7 |
| OTHER LOANS TO INDIVIDUALS | 31,322 | 31,533 | .6 | 44,273 | 50,044 | 13.0 |
| ALL OTHER LOANS | 24,979 | 27,181 | 8.8 | 28,253 | 35,702 | 26.3 |
| FIXED ASSETS | 10,367 | 11,155 | 7.6 | 11,554 | 11,160 | 3.4- |
| OTHER ASSETS | 4,353 | 4,749 | 9.0 | 3,375 | 4,656 | 37.9 |
| TOTAL LIABILITIES | 414,645 | 423,554 | 2.1 | 526,940 | 542,270 | 2.9 |
| TOTAL DEPOSITS | 403,496 | 413,398 | 2.4 | 517,900 | 526,618 | 1.6 |
| TOTAL DEMAND | 243,201 | 258,333 | 6.2 | 275,577 | 284,775 | 3.3 |
| TOTAL TIME AND SAVINGS | 160,295 | 155,065 | 3.2- | 242,323 | 241,843 | .1- |
| DEMAND DEPOSITS, IPC | 200,570 | 204,222 | 1.8 | 221,266 | 230,383 | 4.1 |
| SAVINGS DEPOSITS | 41,602 | 39,067 | 6.0- | 103,220 | 100,112 | 3.0- |
| OTHER TIME DEPOSITS, IPC | 81,536 | 85,683 | 5.0 | 86,845 | 91,993 | 5.9 |
| DEPOSITS OF STATES, ETC. | 58,272 | 53,469 | 8.2- | 74,607 | 68,942 | 7.5- |
| DEPOSITS OF U.S. GOVERNMENT | 2,645 | 4,389 | 65.9 | 5,124 | 5,420 | 5.7 |
| DEPOSITS OF COMMERCIAL BANKS | 14,617 | 21,328 | 45.9 | 22,440 | 25,258 | 12.5 |
| OTHER LIABILITIES | 11,169 | 10,156 | 9.0- | 9,040 | 15,652 | 73.1 |
| TOTAL RESERVES ON LOANS AND - SECURITIES---# | 4,974 | 5,117 | 2.8 | 4,651 | 5,251 | 12.9 |
| TOTAL CAPITAL ACCOUNTS | 36,904 | 41,132 | 11.4 | 40,170 | 42,907 | 6.8 |
| NUMBER OF BANKS | 24 | 24 | | 18 | 18 | |

# SEE EXPLANATORY NOTES

SOURCE- REPORTS OF CONDITION
DEC. 1968 AND DEC. 1969

# TABLE III

SELECTED BALANCE SHEET RATIOS
OF INSURED COMMERCIAL BANKS
DECEMBER 31, 1969

| | BANKS IN STATE: ALL BANKS | BANKS WITH TOTAL DEPOSITS (IN MILLIONS): UNDER 5 | 5-10 | 10-25 | 25-100 | OVER 100 | ALL BANKS IN AREA 03 | ALL BANKS IN AREA 11 | ALL BANKS IN AREA 14 | ALL BANKS IN AREA 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| PERCENTAGE OF ASSETS | | | | | | | | | | |
| CASH AND DUE FROM BANKS | 17.3 | 18.7 | 16.4 | 16.1 | 16.5 | 22.6 | 16.0 | 16.8 | 17.7 | 15.2 |
| U.S. TREASURY SECURITIES | 13.2 | 17.3 | 12.0 | 10.6 | 8.7 | 8.4 | 14.2 | 18.4 | 10.0 | 13.9 |
| SECURITIES OF OTHER U.S. - GOVERNMENT AGENCIES | 4.6 | 5.4 | 4.9 | 4.1 | 3.2 | .7 | 5.4 | 4.5 | 3.9 | 7.9 |
| OBLIGATIONS OF STATES, ETC. | 10.1 | 6.2 | 11.0 | 13.4 | 13.4 | 9.8 | 13.6 | 11.4 | 11.3 | 9.9 |
| OTHER SECURITIES | .4 | .4 | .3 | .4 | .4 | .8 | .3 | .3 | .5 | .3 |
| LOANS AND DISCOUNTS | 51.9 | 49.9 | 52.8 | 52.8 | 54.3 | 53.7 | 48.2 | 47.2 | 53.6 | 49.8 |
| COMMERCIAL AND INDUSTRIAL | 15.2 | 12.0 | 14.8 | 16.6 | 21.7 | 22.7 | 13.1 | 10.9 | 18.1 | 19.0 |
| AGRICULTURAL | 8.1 | 11.3 | 8.6 | 5.5 | 1.5 | 1.6 | 7.1 | 11.6 | 2.7 | 4.6 |
| REAL ESTATE | 6.8 | 5.6 | 7.0 | 7.8 | 8.3 | 5.4 | 7.4 | 7.8 | 8.3 | 6.4 |
| TO INDIVIDUALS | 16.2 | 14.9 | 17.1 | 17.0 | 17.3 | 12.5 | 16.7 | 12.5 | 16.8 | 13.5 |
| OTHER | 5.5 | 5.4 | 5.1 | 5.5 | 5.3 | 11.2 | 3.9 | 4.5 | 7.6 | 6.3 |
| FIXED ASSETS | 1.8 | 1.5 | 1.9 | 1.8 | 2.3 | 2.3 | 1.8 | 1.2 | 2.2 | 2.1 |
| OTHER ASSETS | .4 | .2 | .4 | .5 | .9 | 1.4 | .4 | .1 | .7 | .9 |
| TOTAL CAPITAL ACCOUNTS | 8.7 | 10.8 | 8.1 | 7.3 | 6.9 | 7.3 | 9.3 | 9.5 | 8.6 | 6.9 |
| PERCENTAGE OF TOTAL DEPOSITS | | | | | | | | | | |
| DEMAND | 59.3 | 65.6 | 56.6 | 54.6 | 54.1 | 63.2 | 62.2 | 65.7 | 57.9 | 52.5 |
| TIME AND SAVINGS | 40.6 | 34.3 | 43.3 | 45.3 | 45.8 | 36.7 | 37.8 | 34.3 | 42.1 | 47.5 |
| CASH ACCOUNTS | 19.5 | 21.4 | 16.2 | 17.8 | 18.5 | 26.6 | 18.2 | 10.8 | 20.0 | 16.9 |
| CASH, U.S. TREASURY AND - FEDERAL AGENCY SECURITIES | 39.6 | 47.3 | 37.1 | 34.2 | 31.9 | 37.2 | 40.4 | 44.7 | 35.7 | 40.9 |
| TOTAL LOANS | 52.4 | 56.9 | 58.9 | 58.6 | 60.9 | 63.3 | 54.5 | 52.8 | 60.4 | 55.3 |
| NUMBER OF BANKS | 1,157 | 419 | 309 | 278 | 120 | 31 | 19 | 38 | 158 | 27 |

SOURCE- REPORT OF CONDITION, DEC. 1969

SELECTED BALANCE SHEET RATIOS
OF INSURED COMMERCIAL BANKS
DECEMBER 31, 1969

| | ALL BANKS IN AREA 19 | ALL BANKS IN AREA 23 | ALL BANKS IN AREA 24 |
|---|---|---|---|
| PERCENTAGE OF ASSETS | | | |
| CASH AND DUE FROM BANKS | 14.5 | 19.0 | 16.4 |
| U.S. TREASURY SECURITIES | 9.5 | 13.7 | 11.0 |
| SECURITIES OF OTHER U.S. – GOVERNMENT AGENCIES | 6.6 | 4.5 | 2.8 |
| OBLIGATIONS OF STATES, ETC. | 10.8 | 8.1 | 10.9 |
| OTHER SECURITIES | .4 | .3 | .9 |
| LOANS AND DISCOUNTS | 54.6 | 51.1 | 55.2 |
| COMMERCIAL AND INDUSTRIAL | 16.4 | 18.6 | 16.6 |
| AGRICULTURAL | .2 | 4.2 | .3 |
| REAL ESTATE | 10.0 | 4.4 | 9.0 |
| TO INDIVIDUALS | 20.7 | 18.6 | 25.1 |
| OTHER | 7.3 | 5.3 | 4.3 |
| FIXED ASSETS | 3.1 | 2.5 | 2.0 |
| OTHER ASSETS | .5 | .8 | .7 |
| TOTAL CAPITAL ACCOUNTS | 8.3 | 9.7 | 8.0 |
| PERCENTAGE OF TOTAL DEPOSITS | | | |
| DEMAND | 49.3 | 60.0 | 54.4 |
| TIME AND SAVINGS | 50.7 | 40.0 | 45.6 |
| CASH ACCOUNTS | 16.3 | 21.7 | 18.5 |
| CASH, U.S. TREASURY AND – FEDERAL AGENCY SECURITIES | 34.3 | 42.5 | 34.0 |
| TOTAL LOANS | 61.1 | 58.5 | 62.0 |
| NUMBER OF BANKS | 13 | 24 | 18 |

SOURCE- REPORT OF CONDITION, DEC. 1969

# TABLE IV

INCOME AND EXPENSES
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | BANKS IN STATE DEC. 1968 | BANKS IN STATE DEC. 1969 | % CHANGE 68-69 | BANKS IN AREA 03 DEC. 1968 | BANKS IN AREA 03 DEC. 1969 | % CHANGE 68-69 | BANKS IN AREA 11 DEC. 1968 | BANKS IN AREA 11 DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL OPERATING REVENUE | 1,265,882.4 | 1,549,538.2 | 22.4 | 10,269.3 | 12,530.8 | 22.0 | 11,698.9 | 14,357.4 | 22.7 |
| INCOME ON LOANS | 868,714.8 | 1,100,349.0 | 26.6 | 6,457.6 | 8,214.1 | 27.2 | 7,135.4 | 8,985.2 | 25.9 |
| *INTEREST ON U.S. TREASURY - SECURITIES* | # | 133,844.1 | # | # | 1,452.9 | # | # | 2,270.9 | # |
| INTEREST ON SECURITIES OF - U.S. GOVT AGENCIES | # | 41,489.1 | # | # | 331.1 | # | # | 709.9 | # |
| INTEREST ON OBLIGATIONS OF - STATES, ETC. | # | 115,607.2 | # | # | 1,285.8 | # | # | 1,150.9 | # |
| INTEREST AND DIVIDENDS ON - OTHER SECURITIES | # | 5,541.3 | # | # | 195.6 | # | # | 49.7 | # |
| TRUST DEPARTMENT INCOME | 26,411.5 | 31,441.5 | 19.0 | 34.1 | 50.0 | 46.6 | 7.8 | 186.0 | 999.9 |
| SERVICE CHARGES ON DEPOSITS | 62,268.4 | 69,491.4 | 11.5 | 556.1 | 638.1 | 14.7 | 658.5 | 772.2 | 17.2 |
| ALL OTHER REVENUE | 38,959.6 | 51,774.6 | 32.8 | 305.3 | 362.2 | 18.6 | 206.1 | 232.6 | 12.8 |
| TOTAL OPERATING EXPENSE | 938,275.5 | 1,193,250.8 | 27.1 | 7,444.2 | 9,765.4 | 31.4 | 8,135.7 | 10,376.2 | 27.5 |
| SALARIES AND WAGES | 245,040.4 | 282,595.3 | 15.3 | 2,421.5 | 2,861.3 | 18.1 | 2,761.7 | 3,141.8 | 13.7 |
| *PENSIONS AND OTHER EMPLOYEE - BENEFITS* | 30,172.1 | 34,787.8 | 15.2 | 332.2 | 357.3 | 7.5 | 250.2 | 289.9 | 15.8 |
| INTEREST ON DEPOSITS | 391,807.1 | 443,246.7 | 13.1 | 2,811.9 | 3,539.7 | 25.8 | 2,990.9 | 3,677.6 | 22.9 |
| INTEREST ON BORROWED MONEY | 29,498.3 | 95,281.2 | 223.0 | 21.0 | 77.0 | 266.6 | 29.7 | 38.0 | 27.9 |
| INTEREST ON CAPITAL NOTES - AND DEBENTURES | # | 1,369.4 | # | # | | # | # | | # |
| NET OCCUPANCY EXPENSE | 44,941.5 | 45,540.2 | 1.3 | 481.9 | 572.5 | 18.8 | 460.7 | 455.2 | 1.1- |
| PROVISION FOR LOAN LOSSES | # | 45,492.1 | # | # | 387.8 | # | # | 587.1 | # |
| OTHER EXPENSES | 196,816.1 | 244,938.1 | 24.4 | 1,375.7 | 1,989.8 | 44.6 | 1,642.5 | 2,186.6 | 33.1 |
| CURRENT OPERATING EARNINGS | 327,606.9 | 356,287.4 | 8.7 | 2,825.1 | 2,745.4 | 2.8- | 3,563.2 | 3,981.2 | 11.7 |
| TAXES ON OPERATING EARNINGS | # | 108,353.2 | # | # | 564.7 | # | # | 1,144.7 | # |
| NET CURRENT OPERATING EARNINGS | # | 247,934.2 | # | # | 2,180.7 | # | # | 2,836.5 | # |
| NET PROFIT ON SECURITIES | # | 13,392.9- | # | # | 38.9- | # | # | 64.9- | # |
| *OTHER ADDITIONS OR DEDUCTIONS* | # | 2,617.9 | # | # | 35.2 | # | # | 16.7 | # |
| NET INCOME---# | 185,380.8 | 237,154.2 | 27.9 | 1,932.2 | 2,177.0 | 12.6 | 2,130.2 | 2,788.3 | 30.8 |
| DIVIDENDS PAID ON COMMON STOCK | 83,216.6 | 81,802.3 | 1.6- | 466.1 | 503.4 | 8.0 | 593.6 | 650.9 | 9.6 |
| ---MEMORANDUM--- PROVISION FOR INCOME TAXES | # | 83,375.6 | # | # | 466.9 | # | # | 905.2 | # |
| NUMBER OF BANKS | 1,142 | 1,157 | | 19 | 19 | | 38 | 38 | |

---#-SEE EXPLANATORY NOTES

SOURCE- REPORT OF INCOME AND DIVIDENDS 1968
AND REPORT OF INCOME 1969

INCOME AND EXPENSES
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | ----BANKS IN AREA 14----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | ----BANKS IN AREA 15----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | ---BANKS IN AREA 19----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|---|---|---|
| TOTAL OPERATING REVENUE | 290,082.8 | 362,710.8 | 25.0 | 20,296.0 | 23,914.2 | 17.8 | 14,489.9 | 16,307.0 | 12.5 |
| INCOME ON LOANS | 201,559.1 | 262,096.2 | 30.0 | 12,648.1 | 15,876.6 | 25.5 | 8,844.1 | 10,455.4 | 18.2 |
| INTEREST ON U.S. TREASURY - SECURITIES | # | 24,335.9 | # | # | 2,575.2 | # | # | 1,529.3 | # |
| INTEREST ON SECURITIES OF - U.S. GOVT AGENCIES | # | 7,573.1 | # | # | 1,617.3 | # | # | 1,063.6 | # |
| INTEREST ON OBLIGATIONS OF - STATES, ETC. | # | 29,423.3 | # | # | 1,704.7 | # | # | 1,291.6 | # |
| INTEREST AND DIVIDENDS ON - OTHER SECURITIES | # | 2,041.5 | # | # | 65.3 | # | # | 26.0 | # |
| TRUST DEPARTMENT INCOME | 7,086.2 | 8,600.4 | 21.3 | 71.2 | 108.5 | 52.3 | 626.8 | 605.3 | 3.4- |
| SERVICE CHARGES ON DEPOSITS | 13,703.0 | 15,270.7 | 11.4 | 1,115.5 | 1,286.5 | 15.3 | 910.5 | 981.2 | 7.7 |
| ALL OTHER REVENUE | 9,663.5 | 13,369.7 | 38.3 | 529.5 | 680.1 | 28.4 | 274.0 | 354.6 | 29.4 |
| TOTAL OPERATING EXPENSE | 207,728.3 | 267,068.8 | 28.5 | 15,786.9 | 18,877.9 | 19.5 | 11,732.1 | 13,432.7 | 14.4 |
| SALARIES AND WAGES | 52,336.6 | 60,340.7 | 15.2 | 4,338.3 | 4,672.1 | 12.2 | 3,001.1 | 3,339.4 | 11.2 |
| PENSIONS AND OTHER EMPLOYEE - BENEFITS | 5,534.5 | 6,728.8 | 21.5 | 390.7 | 501.8 | 28.4 | 333.2 | 365.9 | 9.8 |
| INTEREST ON DEPOSITS | 93,205.4 | 104,090.6 | 11.6 | 6,609.9 | 7,709.4 | 16.6 | 5,269.5 | 5,681.5 | 7.8 |
| INTEREST ON BORROWED MONEY | 4,168.2 | 21,288.7 | 410.7 | 115.1 | 111.0 | 3.5- | 46.6 | 79.9 | 71.4 |
| INTEREST ON CAPITAL NOTES - AND DEBENTURES | # | 216.3 | # | # | 50.0 | # | # | 8.1 | # |
| NET OCCUPANCY EXPENSE | 5,783.7 | 6,909.0 | 19.4 | 1,146.5 | 1,205.9 | 5.1 | 643.1 | 617.2 | 4.0- |
| PROVISION FOR LOAN LOSSES | # | 9,483.1 | # | # | 466.2 | # | # | 547.1 | # |
| OTHER EXPENSES | 46,699.9 | 58,011.6 | 24.2 | 3,185.9 | 3,961.5 | 24.3 | 2,438.6 | 2,793.6 | 14.5 |
| CURRENT OPERATING EARNINGS | 82,354.5 | 95,642.0 | 16.1 | 4,509.1 | 5,036.3 | 11.6 | 2,757.8 | 2,874.3 | 4.2 |
| TAXES ON OPERATING EARNINGS | # | 31,705.1 | # | # | 1,304.5 | # | # | 721.9 | # |
| NET CURRENT OPERATING EARNINGS | # | 63,936.9 | # | # | 3,731.8 | # | # | 2,152.4 | # |
| NET PROFIT ON SECURITIES | # | 1,531.3- | # | # | 80.4- | # | # | 4.5 | # |
| OTHER ADDITIONS OR DEDUCTIONS | # | 210.6 | # | # | 87.5- | # | # | 2.3- | # |
| NET INCOME---# | 49,258.8 | 62,616.2 | 27.1 | 2,736.5 | 3,563.9 | 30.2 | 1,868.5 | 2,154.6 | 15.3 |
| DIVIDENDS PAID ON COMMON STOCK | 21,130.3 | 21,704.9 | 2.7 | 997.7 | 1,035.5 | 3.7 | 680.0 | 779.1 | 14.5 |
| ---MEMORANDUM--- PROVISION FOR INCOME TAXES | # | 26,286.2 | # | # | 1,625.7 | # | # | 521.4 | # |
| NUMBER OF BANKS | 152 | 158 | | 27 | 27 | | 13 | 13 | |

# SEE EXPLANATORY NOTES

SOURCE- REPORT OF INCOME AND DIVIDENDS 1968
AND REPORT OF INCOME 1969

INCOME AND EXPENSES
OF INSURED COMMERCIAL BANKS
(DOLLAR AMOUNTS IN THOUSANDS)

| | ---BANKS IN AREA 23----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 | ----BANKS IN AREA 24----- DEC. 1968 | DEC. 1969 | % CHANGE 68-69 |
|---|---|---|---|---|---|---|
| TOTAL OPERATING REVENUE | 23,102.3 | 27,513.3 | 19.0 | 30,822.6 | 36,235.8 | 17.5 |
| INCOME ON LOANS | 15,382.3 | 19,019.4 | 23.6 | 20,084.3 | 24,405.5 | 21.5 |
| INTEREST ON U.S. TREASURY - SECURITIES | # | 3,200.6 | # | # | 3,416.6 | # |
| INTEREST ON SECURITIES OF - U.S. GOVT AGENCIES | # | 573.9 | # | # | 1,170.3 | # |
| INTEREST ON OBLIGATIONS OF - STATES, ETC. | # | 1,522.9 | # | # | 2,299.9 | # |
| INTEREST AND DIVIDENDS ON - OTHER SECURITIES | # | 157.2 | # | # | 179.4 | # |
| TRUST DEPARTMENT INCOME | 341.4 | 392.4 | 14.9 | 423.3 | 430.9 | 1.7 |
| SERVICE CHARGES ON DEPOSITS | 1,592.6 | 1,674.0 | 5.1 | 1,918.2 | 2,068.5 | 7.8 |
| ALL OTHER REVENUE | 617.9 | 972.9 | 57.4 | 1,587.4 | 2,264.7 | 42.6 |
| TOTAL OPERATING EXPENSE | 17,496.9 | 22,078.4 | 26.1 | 23,691.5 | 27,816.1 | 17.4 |
| SALARIES AND WAGES | 4,764.5 | 5,428.4 | 13.9 | 5,911.7 | 6,537.1 | 10.5 |
| PENSIONS AND OTHER EMPLOYEE - BENEFITS | 559.6 | 628.8 | 12.3 | 682.3 | 747.5 | 9.5 |
| INTEREST ON DEPOSITS | 7,204.7 | 7,912.5 | 9.8 | 10,106.8 | 11,705.4 | 15.8 |
| INTEREST ON BORROWED MONEY | 159.4 | 835.1 | 423.9 | 71.1 | 383.3 | 439.0 |
| INTEREST ON CAPITAL NOTES - AND DEBENTURES | # | | # | # | | # |
| NET OCCUPANCY EXPENSE | 1,133.9 | 1,219.1 | 7.5 | 1,994.1 | 1,915.3 | 3.9- |
| PROVISION FOR LOAN LOSSES | # | 1,194.6 | # | # | 1,047.8 | # |
| OTHER EXPENSES | 3,674.8 | 4,859.9 | 32.2 | 4,925.5 | 5,479.7 | 11.2 |
| CURRENT OPERATING EARNINGS | 5,605.4 | 5,434.9 | 3.0- | 7,131.1 | 8,419.7 | 18.0 |
| TAXES ON OPERATING EARNINGS | # | 1,609.5 | # | # | 2,947.2 | # |
| NET CURRENT OPERATING EARNINGS | # | 3,825.4 | # | # | 5,472.5 | # |
| NET PROFIT ON SECURITIES | # | 186.8- | # | # | 256.2- | # |
| OTHER ADDITIONS OR DEDUCTIONS | # | 41.3 | # | # | 126.4 | # |
| NET INCOME---# | 3,072.9 | 3,679.9 | 19.7 | 3,879.9 | 5,344.7 | 37.7 |
| DIVIDENDS PAID ON COMMON STOCK | 970.0 | 1,183.3 | 21.9 | 1,542.3 | 1,866.1 | 20.9 |
| ---MEMORANDUM--- PROVISION FOR INCOME TAXES | # | 1,419.3 | # | # | 2,388.3 | # |
| NUMBER OF BANKS | 24 | 24 | | 18 | 18 | |

# SEE EXPLANATORY NOTES

SOURCE- REPORT OF INCOME AND DIVIDENDS 1968
AND REPORT OF INCOME 1969

# TABLE V

INCOME AND EXPENSES
OF INSURED COMMERCIAL BANKS
DECEMBER 31, 1969

| PERCENTAGE OF TOTAL OPERATING REVENUE | BANKS IN STATE — BANKS WITH TOTAL DEPOSITS (IN MILLIONS) — ALL BANKS | UNDER 5 | 5-10 | 10-25 | 25-100 | OVER 100 | ALL BANKS IN AREA 03 | ALL BANKS IN AREA 11 | ALL BANKS IN AREA 14 | ALL BANKS IN AREA 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| INCOME | | | | | | | | | | |
| INCOME ON LOANS | 66.0 | 64.2 | 66.1 | 66.4 | 68.9 | 73.6 | 63.8 | 62.3 | 66.0 | 64.0 |
| INTEREST ON U.S. TREASURY - SECURITIES | 13.0 | 17.5 | 12.0 | 10.2 | 8.7 | 8.1 | 14.3 | 16.3 | 10.2 | 14.1 |
| INTEREST ON SECURITIES OF - U.S. GOVT AGENCIES | 4.9 | 5.6 | 5.0 | 4.7 | 3.6 | 1.2 | 4.0 | 4.8 | 4.4 | 7.9 |
| INTEREST ON OBLIGATIONS OF - STATES, ETC. | 6.1 | 3.9 | 6.7 | 7.8 | 8.2 | 7.1 | 8.8 | 6.9 | 7.0 | 5.8 |
| INTEREST AND DIVIDENDS ON - OTHER SECURITIES | .4 | .5 | .3 | .3 | .4 | .2 | .6 | .3 | .6 | .2 |
| TRUST DEPARTMENT INCOME | .2 | | | .2 | .8 | 3.4 | .1 | .3 | .2 | .2 |
| SERVICE CHARGES ON DEPOSITS | 6.0 | 4.9 | 6.7 | 7.4 | 5.9 | 2.2 | 6.1 | 5.3 | 7.5 | 5.4 |
| ALL OTHER REVENUE | 2.9 | 3.2 | 2.9 | 2.5 | 3.1 | 3.7 | 2.3 | 1.8 | 4.1 | 2.4 |
| EXPENSES | | | | | | | | | | |
| SALARIES | 23.9 | 28.7 | 23.0 | 21.0 | 18.8 | 16.7 | 24.6 | 24.5 | 21.0 | 21.2 |
| PENSIONS AND OTHER EMPLOYEE - BENEFITS | 2.0 | 1.7 | 2.0 | 2.1 | 2.3 | 2.4 | 2.6 | 1.8 | 1.8 | 1.9 |
| INTEREST ON DEPOSITS | 26.5 | 21.2 | 28.1 | 29.6 | 31.5 | 30.3 | 22.9 | 22.8 | 27.7 | 31.9 |
| INTEREST ON BORROWED MONEY | .4 | .1 | .1 | .3 | 1.0 | 7.6 | .3 | .1 | .8 | .4 |
| INTEREST ON CAPITAL NOTES - AND DEBENTURES | | | | | | .1 | | | | .1 |
| NET OCCUPANCY EXPENSE | 4.0 | 4.1 | 4.1 | 4.1 | 4.2 | 2.5 | 3.9 | 3.4 | 4.1 | 5.1 |
| PROVISION FOR LOAN LOSSES | 4.1 | 4.7 | 3.8 | 3.9 | 3.6 | 2.2 | 3.8 | 4.2 | 3.8 | 2.1 |
| OTHER EXPENSES | 17.0 | 17.5 | 17.2 | 16.8 | 15.9 | 14.8 | 17.1 | 16.2 | 17.9 | 16.6 |
| CURRENT OPERATING EARNINGS | 21.6 | 21.6 | 21.2 | 21.8 | 22.3 | 23.0 | 24.8 | 27.0 | 22.8 | 20.6 |
| TAXES ON OPERATING EARNINGS | 5.2 | 5.0 | 4.8 | 5.4 | 6.4 | 7.8 | 6.0 | 7.0 | 5.8 | 5.5 |
| NET CURRENT OPERATING EARNINGS | 16.3 | 16.6 | 16.4 | 16.3 | 15.9 | 15.2 | 18.7 | 20.0 | 16.9 | 15.2 |
| OTHER CHARGES AGAINST EARNINGS | .4- | .1- | .6- | .8- | .3- | .4- | .8 | .6- | .4- | .5- |
| NET INCOME | 15.8 | 16.4 | 15.7 | 15.5 | 15.6 | 14.8 | 19.6 | 19.3 | 16.5 | 14.7 |
| NUMBER OF BANKS | 1,140 | 404 | 309 | 277 | 119 | 31 | 19 | 38 | 152 | 27 |

SOURCE- REPORT OF INCOME 1969

INCOME AND EXPENSES
OF INSURED COMMERCIAL BANKS
DECEMBER 31, 1969

| PERCENTAGE OF TOTAL OPERATING REVENUE | ALL BANKS IN AREA 19 | ALL BANKS IN AREA 23 | ALL BANKS IN AREA 24 |
|---|---|---|---|
| INCOME | | | |
| INCOME ON LOANS | 66.4 | 65.7 | 67.8 |
| INTEREST ON U.S. TREASURY - SECURITIES | 9.1 | 12.0 | 8.9 |
| INTEREST ON SECURITIES OF - U.S. GOVT AGENCIES | 6.7 | 4.4 | 2.5 |
| INTEREST ON OBLIGATIONS OF - STATES, ETC. | 5.2 | 4.3 | 5.8 |
| INTEREST AND DIVIDENDS ON - OTHER SECURITIES | .1 | 1.2 | .6 |
| TRUST DEPARTMENT INCOME | 1.7 | .9 | .4 |
| SERVICE CHARGES ON DEPOSITS | 8.5 | 8.3 | 9.0 |
| ALL OTHER REVENUE | 2.4 | 3.2 | 4.8 |
| EXPENSES | | | |
| SALARIES | 22.0 | 23.1 | 20.4 |
| PENSIONS AND OTHER EMPLOYEE - BENEFITS | 2.0 | 2.0 | 1.8 |
| INTEREST ON DEPOSITS | 32.3 | 24.2 | 28.8 |
| INTEREST ON BORROWED MONEY | .2 | .9 | .4 |
| INTEREST ON CAPITAL NOTES - AND DEBENTURES | .1 | | |
| NET OCCUPANCY EXPENSE | 4.9 | 5.2 | 5.5 |
| PROVISION FOR LOAN LOSSES | 3.8 | 5.5 | 3.2 |
| OTHER EXPENSES | 17.9 | 19.8 | 17.1 |
| CURRENT OPERATING EARNINGS | 16.7 | 19.3 | 22.7 |
| TAXES ON OPERATING EARNINGS | 3.9 | 6.4 | 8.0 |
| NET CURRENT OPERATING EARNINGS | 12.8 | 12.8 | 14.7 |
| OTHER CHARGES AGAINST EARNINGS | | .2- | .4- |
| NET INCOME | 12.8 | 12.7 | 14.3 |
| NUMBER OF BANKS | 13 | 23 | 18 |

SOURCE- REPORT OF INCOME 1969

## TABLE VI

SELECTED OPERATING RATIOS
OF INSURED COMMERCIAL BANKS
1969

| | BANKS IN STATE: ALL BANKS | BANKS WITH TOTAL DEPOSITS (IN MILLIONS): UNDER 5 | 5-10 | 10-25 | 25-100 | OVER 100 | ALL BANKS IN AREA 03 | ALL BANKS IN AREA 11 | ALL BANKS IN AREA 14 | ALL BANKS IN AREA 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| RATE OF RETURN ON | | | | | | | | | | |
| LOANS | 8.11 | 8.20 | 8.12 | 8.18 | 7.79 | 7.55 | 8.92 | 7.80 | 8.01 | 8.25 |
| U.S. TREASURY SECURITIES | 5.29 | 5.38 | 5.32 | 5.28 | 5.15 | 4.66 | 5.42 | 5.18 | 5.27 | 5.57 |
| OBLIGATIONS OF STATES, ETC. | 3.41 | 3.14 | 3.40 | 3.64 | 3.70 | 3.73 | 3.85 | 3.48 | 3.55 | 3.40 |
| PERCENTAGE OF TOTAL ASSETS | | | | | | | | | | |
| OPERATING REVENUE | 6.21 | 6.14 | 6.32 | 6.37 | 6.04 | 5.42 | 6.45 | 5.81 | 6.31 | 6.28 |
| SALARIES AND WAGES | 1.48 | 1.74 | 1.45 | 1.34 | 1.14 | .91 | 1.60 | 1.42 | 1.32 | 1.34 |
| CURRENT OPERATING EARNINGS BEFORE TAXES | 1.33 | 1.30 | 1.32 | 1.38 | 1.34 | 1.23 | 1.51 | 1.59 | 1.43 | 1.28 |
| NET CURRENT OPERATING EARNINGS AFTER TAXES | 1.00 | 1.01 | 1.02 | 1.03 | .95 | .81 | 1.15 | 1.17 | 1.07 | .93 |
| NET INCOME | .97 | .99 | .97 | .98 | .93 | .79 | 1.20 | 1.13 | 1.04 | .90 |
| PERCENTAGE OF CAPITAL ACCOUNTS | | | | | | | | | | |
| CURRENT OPERATING EARNINGS BEFORE TAXES | 16.39 | 12.97 | 16.45 | 19.66 | 19.97 | 17.47 | 16.62 | 17.31 | 19.13 | 19.83 |
| NET CURRENT OPERATING EARNINGS AFTER TAXES | 12.39 | 10.03 | 12.68 | 14.79 | 14.29 | 11.55 | 12.90 | 12.50 | 14.31 | 14.65 |
| NET INCOME | 11.95 | 9.81 | 12.18 | 14.07 | 13.89 | 11.22 | 13.32 | 11.42 | 13.93 | 14.21 |
| DIVIDENDS PAID | 3.13 | 2.71 | 3.17 | 3.31 | 3.72 | 4.21 | 3.17 | 2.85 | 3.02 | 3.50 |
| SPECIAL RATIOS | | | | | | | | | | |
| SERVICE CHARGES/DEMAND DEPOSITS | .81 | .60 | .96 | 1.04 | .79 | .24 | .78 | .54 | .99 | .80 |
| INTEREST PAID/TIME DEPOSITS | 4.34 | 4.05 | 4.45 | 4.52 | 4.51 | 4.87 | 4.40 | 4.31 | 4.48 | 4.63 |
| LOANS RESERVES/LOANS | 1.35 | .96 | 1.33 | 1.68 | 1.76 | 1.95 | 1.11 | 1.06 | 1.27 | 2.55 |
| PROVISION FOR LOAN LOSSES/LOANS | .48 | .57 | .44 | .45 | .39 | .21 | .51 | .49 | .44 | .22 |
| NUMBER OF BANKS | 1,140 | 404 | 309 | 277 | 119 | 31 | 19 | 38 | 152 | 27 |

SOURCE- REPORT OF INCOME 1969 AND THE AVERAGE OF REPORTS OF CONDITION FROM DEC. 1968, JUNE 1969 AND DEC. 1969.

SELECTED OPERATING RATIOS
OF INSURED COMMERCIAL BANKS
1969

| | ALL BANKS IN AREA 19 | ALL BANKS IN AREA 23 | ALL BANKS IN AREA 24 |
|---|---|---|---|
| RATE OF RETURN ON | | | |
| LOANS | 8.33 | 8.54 | 8.43 |
| U.S. TREASURY SECURITIES | 5.79 | 5.36 | 5.18 |
| OBLIGATIONS OF STATES, ETC. | 2.39 | 3.15 | 3.65 |
| PERCENTAGE OF TOTAL ASSETS | | | |
| OPERATING REVENUE | 6.81 | 6.73 | 6.96 |
| SALARIES AND WAGES | 1.51 | 1.56 | 1.44 |
| CURRENT OPERATING EARNINGS BEFORE TAXES | 1.14 | 1.24 | 1.62 |
| NET CURRENT OPERATING EARNINGS AFTER TAXES | .88 | .82 | 1.04 |
| NET INCOME | .88 | .81 | 1.01 |
| PERCENTAGE OF CAPITAL ACCOUNTS | | | |
| CURRENT OPERATING EARNINGS BEFORE TAXES | 14.12 | 13.52 | 21.31 |
| NET CURRENT OPERATING EARNINGS AFTER TAXES | 10.80 | 8.92 | 13.84 |
| NET INCOME | 10.70 | 8.91 | 13.49 |
| DIVIDENDS PAID | 2.51 | 3.08 | 3.10 |
| SPECIAL RATIOS | | | |
| SERVICE CHARGES/DEMAND DEPOSITS | 1.41 | 1.25 | 1.35 |
| INTEREST PAID/TIME DEPOSITS | 4.73 | 4.39 | 4.62 |
| LOANS RESERVES/LOANS | 1.36 | 1.83 | 1.53 |
| PROVISION FOR LOAN LOSSES/LOANS | .43 | .66 | .39 |
| NUMBER OF BANKS | 13 | 23 | 18 |

SOURCE- REPORT OF INCOME 1969 AND THE AVERAGE OF REPORTS OF CONDITION FROM DEC. 1968, JUNE 1969 AND DEC. 1969.

Population figures for each county were gathered from the 1950 and 1960 U.S. Census of Population, and from estimates for 1970 and projections for 1980. The percent change was calculated for each year tabulated and for the overall period, 1950-1980. As shown in Table VII, the population of the Texas-Gulf Coast was 1,633,041 in 1950, and 2,311,300 in 1960, or an increase over that period of 41.5%. By 1970 it had increased by 23.2% to 2,839,429. Projections to 1990 were obtained from the Bureau of Business Research at The University of Texas at Austin. As shown in Table VIII, the population of the Texas-Gulf Coast is projected to reach 4,882,716 by 1990.

The economic index for each county, obtained from the Texas Education Agency, Austin, Texas *is based on the assessed county valuation, scholastic population, and income total*, and is determined by weighting these factors by 8%, 20%, and 72% respectively. The economic index of each county represents that county's percentage of the total economic activity of the state. It was tabulated for seven years within a period beginning with the 1952-1953 school year and ending with the 1969-1970 school year, and the percent change was calculated for each year tabulated and for the overall period, 1952-1953/1969-1970. As shown in Table IX, the economic index of the Texas-Gulf Coast was 24.265 in 1952-1953 and 32.015 in 1969-1970, or an *increase over that period of 31.9%*. Graphical projections were made to 1990. As shown in Table X, the economic index of the Texas-Gulf Coast is projected to be 36.293 in 1980, or an increase of 12.4% over 1970, and 39.981 in 1990, or an increase of 10.2% over 1980.

Bank deposits of each county were tabulated for five years within a period beginning with 1950 and ending with 1968. Again, the percent change was calculated for each year tabulated and for the overall period, 1950-1968. As shown in Table XI, bank deposits of the Texas-Gulf Coast increased by over 200% from 1950 to 1968. Projections to 1990 are shown in Table XII. Bank deposits of the Texas-Gulf Coast are projected to reach $13,078,000 by 1980, or an increase of 96.2% over 1970, and $25,146,000 by 1990, or an increase of 92.3% over 1980.

The figures given in Tables VII through XII allow for significant inferences to be made about the economic activity to be expected in the Texas-Gulf Coast in the future; the past performance and rate of growth of a county give an indication of what its future performance and rate of growth will be. If a county experiences a dramatic change in its economic base - if, for example, a major facility employing a large portion of the county's labor force opens or closes - the projections for that county will have to be re-evaluated. *If, however, development throughout the state continues at its current pace, the statistical projections given here will hold true.* They indicate the growth to be expected in each county in the Texas-Gulf Coast and can thus be used as tools for planning for future needs.

TABLE VII
POPULATION OF TEXAS-GULF COAST COUNTIES
(1950-1970)

| County | 1950 | 1960 | % Chg | 1970 | % Chg |
|---|---|---|---|---|---|
| Aransas | 4,252 | 7,006 | 64.8 | 7,865 | 12.3 |
| Brazoria | 46,549 | 76,204 | 63.7 | 106,230 | 39.4 |
| Calhoun | 9,222 | 16,592 | 79.9 | 17,052 | 2.8 |
| Cameron | 125,170 | 151,098 | 20.7 | 137,506 | -9.0 |
| Chambers | 7,871 | 10,379 | 31.9 | 12,010 | 15.7 |
| Galveston | 113,066 | 140,364 | 24.1 | 165,669 | 18.0 |
| Harris | 806,701 | 1,243,158 | 54.1 | 1,722,533 | 38.6 |
| Jackson | 12,916 | 14,040 | 8.7 | 12,597 | -11.3 |
| Jefferson | 195,083 | 245,659 | 25.9 | 242,719 | -1.2 |
| Kenedy | 632 | 884 | 39.9 | 769 | -13.0 |
| Kleberg | 21,991 | 30,052 | 36.7 | 32,172 | 7.1 |
| Matagorda | 21,559 | 25,744 | 19.4 | 27,630 | 7.3 |
| Nueces | 165,471 | 221,573 | 33.9 | 233,965 | 5.6 |
| Orange | 40,567 | 60,357 | 48.8 | 70,380 | 16.6 |
| Refugio | 10,113 | 10,975 | 8.5 | 9,089 | -7.2 |
| San Patricio | 35,842 | 45,021 | 25.6 | 44,445 | -1.3 |
| Willacy | 20,920 | 20,084 | -4.0 | 15,432 | -23.2 |
| TOTAL | 1,633,041 | 2,311,300 | 41.5 | 2,849,429 | 23.2 |

Source: U. S. Census of Population

TABLE VIII
PAST AND PROJECTED POPULATION OF TEXAS-GULF COAST COUNTIES
(1950-1990)

| County | 1950 | 1960 | % Chg | 1970 | % Chg | 1980 | % Chg | 1990 | % Chg | % Chg 1950-1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aransas | 4,252 | 7,006 | 64.8 | 8,468 | 20.9 | 9,300 | 9.8 | 11,312 | 21.6 | 166.0 |
| Brazoria | 46,549 | 65,204 | 63.7 | 106,230 | 39.4 | 180,600 | 48.5 | 253,274 | 40.2 | 444.1 |
| Calhoun | 9,222 | 16,592 | 79.9 | 17,052 | 2.8 | 32,505 | 31.0 | 39,640 | 22.0 | 329.8 |
| Cameron | 125,170 | 151,098 | 20.7 | 137,506 | -9.0 | 207,931 | 16.8 | 240,816 | 15.8 | 92.4 |
| Chambers | 7,871 | 10,379 | 31.9 | 12,010 | 15.7 | 14,442 | 20.2 | 17,284 | 19.7 | 119.6 |
| Galveston | 113,066 | 140,364 | 24.1 | 165,669 | 18.0 | 226,791 | 29.0 | 293,166 | 29.3 | 159.3 |
| Harris | 806,701 | 1,243,158 | 54.1 | 1,722,533 | 38.6 | 2,226,340 | 29.8 | 2,776,814 | 24.7 | 222.6 |
| Jackson | 12,916 | 14,040 | 8.7 | 12,597 | -11.3 | 18,470 | 46.6 | 20,922 | 13.3 | 62.0 |
| Jefferson | 195,083 | 245,659 | 25.9 | 242,719 | -1.2 | 359,655 | 23.9 | 453,892 | 26.2 | 132.7 |
| Kenedy | 632 | 884 | 39.9 | 665 | -24.8 | 710 | 6.8 | 708 | -0.3 | 12.0 |
| Kleberg | 21,991 | 30,052 | 36.7 | 32,172 | 7.4 | 41,779 | 20.8 | 51,629 | 23.6 | 134.8 |
| Matagorda | 21,559 | 25,744 | 19.4 | 27,630 | 7.3 | 36.380 | 20.4 | 44,216 | 21.5 | 105.1 |
| Nueces | 165,471 | 221,673 | 33.9 | 233,965 | 5.6 | 348,113 | 29.6 | 460,101 | 32.2 | 178.1 |
| Orange | 40,567 | 60,357 | 48.8 | 70,380 | 16.6 | 87,065 | 21.7 | 106,909 | 22.8 | 163.5 |
| Refugio | 10,113 | 10,975 | 8.5 | 9,089 | -7.2 | 10,453 | 15.0 | 10,788 | 3.2 | 6.7 |
| San Patricio | 35,842 | 45,021 | 25.6 | 50,634 | -1.3 | 59,949 | 18.3 | 72.966 | 21.7 | 103.6 |
| Willacy | 20,920 | 20,084 | -4.0 | 15,432 | -23.2 | 24,736 | 60.3 | 28,279 | 14.3 | 35.2 |
| TOTAL | 1,637,565 | 2,319,190 | 41.6 | 2,864,481 | 23.2 | 3,885,219 | 35.6 | 4,882,716 | 25.7 | 198.2 |

Source(1980 & 1990): Bureau of Business Research, The University of Texas at Austin

TABLE IX
ECONOMIC INDICES OF TEXAS-GULF COAST COUNTIES
(1952-1970)

| County | 1952-1953 | 1955-1956 | % Chg | 1960-1961 | % Chg | 1965-1966 | % Chg | 1967-1968 | 1968-1970 | % Chg | 1969-1970 | % Chg | % Chg 1952-53/1969-70 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aransas | .081 | .127 | 56.8 | .127 | - | .109 | -14.2 | .095 | .089 | -6.3 | .084 | -5.6 | 3.7 |
| Brazoria | 1.672 | 2.448 | 46.4 | 2.532 | 3.4 | 2.296 | 9.3 | 2.412 | 2.466 | 2.2 | 2.424 | -1.7 | 45.0 |
| Calhoun | .155 | .280 | 80.6 | .431 | 53.9 | .499 | 15.8 | .511 | .494 | -3.3 | .485 | -1.8 | 212.9 |
| Cameron | .877 | .888 | 1.3 | .768 | -13.5 | .687 | -10.5 | .661 | .649 | -1.8 | .626 | -3.5 | -28.6 |
| Chambers | .769 | .618 | -19.6 | .490 | -20.7 | .387 | -21.0 | .412 | .413 | 0.2 | .432 | 4.6 | -43.8 |
| Galveston | 1.707 | 2.038 | 19.4 | 1.888 | -7.4 | 1.948 | 3.2 | 2.028 | 2.046 | 0.9 | 2.026 | -1.0 | 18.7 |
| Harris | 10.304 | 12.973 | 25.9 | 14.251 | 9.9 | 14.852 | 4.2 | 15.489 | 15.993 | 3.3 | 16.467 | 3.0 | 59.8 |
| Jackson | .507 | .492 | -3.0 | .401 | -18.5 | .349 | -13.0 | .352 | .342 | -2.8 | .353 | 3.2 | -30.4 |
| Jefferson | 3.519 | 3.483 | -1.0 | 3.744 | 7.5 | 3.799 | 1.5 | 3.949 | 3.990 | 1.0 | 4.047 | 1.4 | 15.0 |
| Kenedy | .023 | .021 | -8.7 | .027 | 28.6 | .039 | 44.4 | .052 | .059 | 13.5 | .059 | - | 156.5 |
| Kleberg | .202 | .212 | 5.0 | .218 | 2.8 | .431 | 97.7 | .529 | .554 | 4.7 | .571 | 3.1 | 182.7 |
| Matagorda | .468 | .433 | -7.5 | .357 | -17.6 | .424 | 18.8 | .455 | .462 | 1.5 | .487 | 5.4 | 4.1 |
| Nueces | 2.035 | 2.186 | 7.4 | 2.298 | 5.1 | 2.017 | -12.2 | 2.028 | 2.032 | 0.2 | 1.996 | -1.8 | -1.9 |
| Orange | .404 | .747 | 84.9 | .819 | 9.6 | .884 | 7.9 | .910 | .937 | 3.0 | .930 | -0.7 | 130.2 |
| Refugio | .767 | .615 | -19.8 | .540 | -11.4 | .451 | -16.5 | .446 | .428 | -4.0 | .433 | 1.2 | -43.5 |
| San Patricio | .588 | .824 | 40.1 | .742 | -10.0 | .615 | -17.1 | .610 | .617 | 1.1 | .600 | -2.8 | 2.0 |
| Willacy | .291 | .272 | -6.5 | .220 | -18.4 | .152 | -20.9 | .148 | .149 | 0.7 | .138 | -7.4 | -52.6 |
| TOTAL | 24.369 | 28.657 | 17.6 | 26.853 | -6.3 | 29.939 | 11.5 | 31.087 | 31.720 | 2.0 | 32.158 | 1.4 | 32.0 |

TABLE X
PAST AND PROJECTED ECONOMIC INDICES OF TEXAS-GULF COAST COUNTIES
(1952-1990)

| County | 1952 | 1960 | % Chg | 1970 | % Chg | 1980 | % Chg | 1990 | % Chg | % Chg 1952-1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aransas | 0.081 | 0.127 | 56.8 | 0.084 | -33.9 | 0.066 | -21.4 | 0.040 | -39.4 | -50.6 |
| Brazoria | 1.672 | 2.532 | 51.4 | 2.500 | -1.3 | 2.725 | 9.0 | 3.000 | 10.1 | 79.4 |
| Calhoun | 0.155 | 0.431 | 178.1 | 0.490 | 13.7 | 0.591 | 20.6 | 0.680 | 15.1 | 338.7 |
| Cameron | 0.877 | 0.768 | -12.4 | 0.616 | -19.8 | 0.552 | -10.4 | 0.390 | -29.3 | -55.5 |
| Chambers | 0.769 | 0.490 | -36.3 | 0.460 | -6.1 | 0.680 | 47.8 | 0.800 | 17.6 | 4.0 |
| Galveston | 1.707 | 1.888 | 10.6 | 2.030 | 7.5 | 2.110 | 3.9 | 2.180 | 3.3 | 27.7 |
| Harris | 10.304 | 14.251 | 38.3 | 16.620 | 16.6 | 19.300 | 16.1 | 22.000 | 14.0 | 113.5 |
| Jackson | 0.507 | 0.401 | -20.9 | 0.340 | -15.2 | 0.301 | -11.5 | 0.270 | -10.3 | -46.7 |
| Jefferson | 3.519 | 3.744 | 6.4 | 4.050 | 8.2 | 4.400 | 8.6 | 4.750 | 8.0 | 35.0 |
| Kenedy | 0.023 | 0.021 | -8.7 | 0.060 | 185.7 | 0.082 | 36.7 | 0.110 | 34.1 | 378.3 |
| Kleberg | 0.202 | 0.218 | 7.9 | 0.600 | 175.2 | 0.870 | 45.0 | 0.980 | 12.6 | 385.1 |
| Matagorda | 0.468 | 0.357 | -23.7 | 0.490 | 37.3 | 0.602 | 22.9 | 0.718 | 19.3 | 53.4 |
| Nueces | 2.035 | 2.186 | 7.4 | 2.000 | -8.5 | 2.000 | - | 1.995 | -0.3 | -2.0 |
| Orange | 0.404 | 0.819 | 102.7 | 0.950 | 16.0 | 1.090 | 14.7 | 1.230 | 12.8 | 204.5 |
| Refugio | 0.767 | 0.540 | -29.6 | 0.420 | -22.2 | 0.400 | -4.8 | 0.370 | -7.5 | -51.8 |
| San Patricio | 0.588 | 0.742 | 26.2 | 0.595 | -19.8 | 0.562 | -5.5 | 0.538 | -4.3 | -8.5 |
| Willacy | 0.291 | 0.220 | -24.4 | 0.132 | -40.0 | 0.110 | -16.7 | 0.080 | -27.3 | -72.5 |
| TOTAL | 24.369 | 29.735 | 22.0 | 32.437 | 9.1 | 36.441 | 12.3 | 40.131 | 10.1 | 64.7 |

TABLE XI
BANK DEPOSITS OF TEXAS-GULF COAST COUNTIES
(1950-1968)
(000's)

| County | 12/30/50 | 12/31/59 | % Chg | 12/28/62 | 12/31/64 | 6/30/66 | % Chg | 6/29/68 | % Chg | % Chg 1950-1968 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aransas | $1,587 | $3,234 | 103.8 | $4,574 | $4,511 | $4,978 | 10.4 | $6,196 | 24.5 | 290.4 |
| Brazoria | 24,810 | 54,217 | 118.5 | 68,254 | 86,809 | 86,538 | 2.0 | 121,399 | 40.3 | 389.3 |
| Calhoun | 7,125 | 14,260 | 100.1 | 22,151 | 21,034 | 25,907 | 23.2 | 31,291 | 20.8 | 339.2 |
| Cameron | 58,696 | 77,874 | 32.7 | 85,713 | 93,530 | 104,329 | 11.5 | 142,080 | 36.2 | 142.1 |
| Chambers | 2,341 | 5,467 | 133.5 | 7,133 | 8,675 | 9,698 | 11.8 | 11,746 | 21.1 | 401.8 |
| Galveston | 132,607 | 156,602 | 18.1 | 169,275 | 184,922 | 200,142 | 8.2 | 238,622 | 19.2 | 79.9 |
| Harris | 1,375,442 | 2,320,454 | 68.7 | 3,002,119 | 3,494,205 | 3,650,176 | 4.5 | 4,406,081 | 20.7 | 220.3 |
| Jackson | 10,130 | 15,258 | 50.6 | 17,262 | 19,600 | 19,681 | 0.4 | 22,375 | 13.7 | 120.9 |
| Jefferson | 150,368 | 241,486 | 60.6 | 279,903 | 326,936 | 357,570 | 9.4 | 414,541 | 15.9 | 175.7 |
| Kleberg | 9,603 | 13,523 | 40.8 | 19,002 | 19,383 | 26,315 | 35.8 | 27,055 | 2.8 | 181.7 |
| Matagorda | 17,389 | 25,748 | 48.1 | 29,793 | 34,426 | 33,915 | -1.5 | 42,179 | 24.4 | 142.6 |
| Nueces | 118,999 | 164,128 | 37.9 | 189,080 | 223,617 | 264,565 | 18.3 | 333,383 | 26.0 | 180.2 |
| Orange | 20,545 | 34,205 | 66.5 | 44,848 | 54,607 | 60,730 | 11.2 | 60,516 | -0.4 | 194.6 |
| Refugio | 10,781 | 12,210 | 13.3 | 12,172 | 12,821 | 12,561 | -2.0 | 13,330 | 6.1 | 23.6 |
| San Patricio | 19,162 | 24,962 | 30.3 | 26,487 | 29,083 | 27,471 | -5.5 | 38,044 | 38.5 | 98.5 |
| Willacy | 9,988 | 12,087 | 28.9 | 12,123 | 13,609 | 12,734 | -6.4 | 18,380 | 44.3 | 84.0 |
| TOTAL | 1,969,573 | 3,175,715 | 61.2 | 3,989,889 | 4,627,768 | 4,897,310 | 5.8 | 5,927,218 | 21.0 | 200.9 |

TABLE XII
PAST AND PROJECTED BANK DEPOSITS OF TEXAS-GULF COAST COUNTIES
(1950-1990)
(000,000)

| County | 1950 | 1960 | % Chg | 1970 | % Chg | 1980 | % Chg | 1990 | % Chg | % Chg 1950-1990 |
|---|---|---|---|---|---|---|---|---|---|---|
| Aransas | $2 | $3 | 50.0 | $6 | 100.0 | $8 | 33.3 | $10 | 25.0 | 400.0 |
| Brazoria | 25 | 54 | 116.0 | 130 | 140.7 | 305 | 134.6 | 720 | 136.1 | 2,780.0 |
| Calhoun | 7 | 14 | 100.0 | 37 | 164.3 | 100 | 170.3 | 270 | 170.0 | 3,757.1 |
| Cameron | 59 | 78 | 32.2 | 157 | 101.3 | 330 | 110.2 | 670 | 103.0 | 1,035.6 |
| Chambers | 2 | 5 | 150.0 | 15 | 190.0 | 35 | 141.4 | 85 | 142.9 | 4,150.0 |
| Galveston | 133 | 157 | 18.0 | 243 | 54.8 | 350 | 44.0 | 495 | 41.4 | 272.2 |
| Harris | 1,375 | 2,320 | 68.7 | 5,000 | 115.5 | 9,800 | 96.0 | 19,000 | 93.9 | 1,281.8 |
| Jackson | 10 | 15 | 50.0 | 23 | 53.3 | 34 | 47.8 | 48 | 41.2 | 380.0 |
| Jefferson | 150 | 241 | 60.7 | 450 | 86.7 | 830 | 84.4 | 1,050 | 26.5 | 600.0 |
| Kleberg | 10 | 14 | 40.0 | 30 | 114.3 | 54 | 80.0 | 98 | 81.5 | 880.0 |
| Matagorda | 17 | 26 | 52.9 | 45 | 73.1 | 77 | 71.1 | 128 | 66.2 | 652.9 |
| Nueces | 119 | 164 | 37.8 | 385 | 134.8 | 910 | 136.4 | 2,150 | 136.3 | 1,706.7 |
| Orange | 21 | 34 | 61.9 | 78 | 129.4 | 155 | 98.7 | 300 | 93.5 | 1,328.6 |
| Refugio | 11 | 12 | 9.1 | 13 | 8.3 | 14 | 7.7 | 16 | 14.3 | 45.5 |
| San Patricio | 19 | 25 | 31.6 | 38 | 12.0 | 55 | 44.7 | 79 | 43.6 | 315.8 |
| Willacy | 10 | 12 | 20.0 | 16 | 33.3 | 21 | 31.3 | 27 | 28.6 | 170.0 |
| TOTAL | 1,970 | 3,174 | 61.1 | 6,666 | 110.0 | 13,078 | 96.2 | 25,146 | 92.3 | 1,176.4 |

# INTERAGENCY RELATIONS AFFECTING THE COASTAL ZONE

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Office of the Governor

October 1970

for

COASTAL RESOURCES MANAGEMENT PROGRAM

INTERAGENCY NATURAL RESOURCES COUNCIL

DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

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# INTERAGENCY RELATIONS AFFECTING THE COASTAL ZONE

## *I. INTRODUCTION*

The ultimate success of the Coastal Resources Management Program, as well as the success of the efforts to arrive at it, *clearly depends on the effective cooperation of the many State agencies involved.* Effective interagency cooperation depends on a positive and fully understood plan of action and full utilization of the State personnel, funding, and data involved. One of the most important functions to perform at this stage of the Program's development *is to delineate and specifically determine what the total State effort in the Coastal Zone now is.*

The following analysis of interagency relations presents the responsibilities and activities of the natural resources agencies of Texas State government and the coastal and marine programs that they are now undertaking. The next step will be to determine the flexible organizational format that will bring all of this managerial and technical competence together with the political and financial realities into implementing a purposeful, integrated, and truly effective management program.

*Unique Heritage*

Texas alone among the 37 states which have been added to the Union was a truly independent nation before its annexation. The Republic of Texas did not cede to the United States the ownership of the public land and minerals within its boundaries but specifically retained this right under the terms of the agreement between the Republic and the Union. *This fact of Texas independence places the State in an extraordinary position so far as its recognized jurisdiction to coastal and submerged lands bordering the Gulf of Mexico is concerned.* Thus, Texas has a unique heritage in claiming ownership of the State's tidelands up to 10½ miles from shore.

The State-owned bays, estuaries, beaches, and submerged lands of the Texas Gulf Coast, comprising over four million acres, are the property of the people of Texas and held in trust for them by the State. This bond carries with it a State responsibility to insure their optimum development and conservation through the proper management of these great natural resources.

*Resource Management*

The vast resources associated with the Texas Coastal Zone are contributing significantly to the prosperity and welfare of the people of the State. The potential of the wealth represented by the estuarine and marine waters, and by the submerged and continguous lands, has not been completely realized as of yet. Part of the reason is that these resources have not yet been fully inventoried and developed. Future realization of this potential may be precluded by the exploitation of one resource unnecessarily damaging or destroying another. This disasterous occurrence can be avoided by wise management.

If the most advantageous use or combination of uses is to be attained in managing our Coastal Zone resources, this must be identifiable. If the criteria used to identify the most advantageous mix is economic advantage in the *true sense - not short-term economic gain* - the value associated with each particular use must be discriminable. Further, it must be realized that the value of a particular resource is *not a constant but a variable* related to the quality of the resource, the need for the resource, and the demands presented to the utilization of the resource by conflicting users. In addition to identifying the optimum mix resource uses and processing the technical knowledge to correctly predict the level of demand one will present to another, the management procedures must be provided to properly manage them.

*The Coastal Resources Management Program has this purpose as its goal.* The Program will be a flexible framework to enable the development of our Coastal Zone resources to be done for the satisfaction of the collective needs of our society and its optimum relationship to the natural environment. The Program is founded on the principles that *the fundamental responsibility for the management and orderly development of these resources rests with the State* and the development must satisfy the values and needs of the citizens of Texas and of the United States.

The Program recognizes the vast social, economic and esthetic value of our Coastal Zone resources, the complexity of the environment and its problems, and the magnitude and difficulty of the Program's task at arriving at a politically, economically, and environmentally sound solution. The Program recognizes that implementation *must rely on existing functions as well as on potential capabilities of State and local governmental units and must safeguard the interests of both government and private citizens.* The Program also recognizes that *priorities do exist, they are not static, yet they must be observed* throughout the development and conduct of the preparation and implementation of a resources management program. Consequently, flexibility exercised by competent and responsible program management is a fundamental element of the total effort.

*Interagency Natural Resources Council*

In the management and development of the State's natural resources for the people of Texas, the administrative organizations involved and the intergovernmental relations necessarily connected with them are continually becoming more complex. Thus, numerous State, federal, and local agencies are concerned with many natural resources programs at varying degrees of intensity and responsibility and the related governmental activities often overlap one another.

The 60th Texas Legislature designated the Governor as the Chief Planning Officer of the State and authorized the creation by the Governor of interagency planning councils, chaired by the Governor, to foster the coordination of functional State planning and programs. This was done in *legislative recognition that the important need for effective cooperation* in the coordination of administrative planning and control would undoubtedly increase as the State continued to grow. Thus, the *Interagency Natural Resources Council* was created as the focal point to conduct State resource and environmental activities on a joint, cooperative basis.

The present members of the Council are:*

*General Land Office*
*Office of the Governor*
*Texas Air Control Board*
*Texas Department of Agriculture*
*Texas Highway Department*
*Texas Industrial Commission*
*Texas Parks and Wildlife Department*
*Texas Railroad Commission*
*Texas Soil and Water Conservation Board*
*Texas Water Development Board*
*Texas Water Quality Board*
*Texas Water Rights Commission*

The Council is the means that has been established to help coordinate the natural resources development of Texas and to undertake the Coastal Resources Management Program. This Program is aimed at determining the economic, cultural, and recreational contribution of the State's Coastal Zone under various levels and types of development and formulate the essentials of a system to manage the coastal and marine resources of Texas.

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*Texas A & M University and the University of Texas at Austin sit on the Council as ex-officio members.

*Enabling Legislation*

The *Joint Interim Committee to Study Texas Beaches*, as part of its total effort to foster conservation in the State's Coastal Zone, presented to the 61st Texas Legislature a concurrent resolution which upon enactment did initiate the Coastal Resources Management Program. A complementary bill, declaring a *moratorium on the sale or leasing of State-owned tidelands*, also was submitted by the Committee and subsequently passed.

The resolution, S.C.R. No. 38, states the following:

> *"Whereas, it is the declared policy of the State that such submerged lands, islands, estuaries, and estuarine areas shall be so managed and used as to...develop these...areas to further the growth and development of the State's and...*
>
> *"Whereas, a comprehensive study is necessary to prepare the way for constructive legislation for the present and future protection of the interests of the people of the State of Texas in such...areas; and...*
>
> *"Whereas, the United States government is now conducting similar studies...and is entitled to receive the full cooperation of the agencies of this State with respect to the...estuarine areas of this State's...*
>
> *"Now, therefore, be it resolved...that the following be accomplished:*
>
> *"Section 1. The Interagency Natural Resources Council, an interagency planning entity created under the authority of...Acts of the 60th Legislature...is authorized and directed to make a comprehensive study...of the State's submerged lands, beaches, islands, estuaries, and estuarine areas, including but without limitation, coastal marshlands, bays, sounds, seaward areas, and lagoons."*

S.C.R. No. 38 represents a milestone in helping to foster State interagency cooperation. There is no similar Texas precedent for such legislative encouragement of joint State program participation and coordination.

The complementary bill, S.B. No. 20, Art. 5415f, declared a moratorium on the sale or leasing of the surface estate of State-owned submerged lands, beaches, and islands under any existing laws of Texas pending receipt of the Interagency Natural Resources Council report as directed by the concurrent resolution. The 61st Texas Legislature, at Governor Preston Smith's request, *also appropriated funds* (100,000 dollars per year) to the Council to undertake the Program.

*Federal Action*

Congress has *not been inactive* in consideration of the present and future status of the nation's Coastal Zone. In 1966, the *Clean Water Restoration Act* directed the Secretary of the Interior to conduct a study of the country's estuarine systems to determine the present condition of pollution, to delineate pollution problems, and to evaluate the detrimental effects of pollution on productive coastal rises. With *P.L. 90-454* passed in 1968, Congress has stated that it is now its policy to maintain the responsibilities of the States in protecting, conserving, and restoring the nation's estuaries. Congress is now considering *S. 2802 which recognizes that the attainment of the maximum benefit from the country's Coastal Zone depends on a management partnership between the federal and the State governments.* Thus, it is certain that public and private pressure for the multiple use of the Texas Coastal Zone will increase. This challenge must be met and accepted by the State in connection with its recognized exercise of jurisdiction over this region and in consequence of the benefits resulting to the people of Texas from its development and protection. Certainly, if the State does not take positive, affirmative action, then the federal government most certainly will. Since our State brought her public coastal lands with her into the Union well over a century ago, and has retained them ever since, it most certainly does not seem logical that they should now be relinquished to external control.

*Conclusion*

The Interagency Natural Resources Council has recognized and decided that *Texas will not allow the State's initiative in determining the utilization of its coastal and marine resources to be preempted by third parties who will surely step into the vacuum created as a consequence of the State's inaction and do the job for us.* Thus, the Council, through Governor Smith's leadership and legislative authorization, has formulated a Texas effort for the orderly and prudent development of the State's Gulf Coast through the Coastal Resources Management Program. The goal will be to provide for the optimum benefit and welfare for the people of Texas by achieving a rationale balance between the economic development and conservation of the resources of the Texas Coastal Zone.

*OFFICE OF THE GOVERNOR*

The Governor is the Chief Executive Officer of the State. The unprecedented growth and changes in the economic and social conditions of the State are requiring the Governor's Office to offer the citizens of Texas a wider range and scope of services. Therefore, in recent years the Governor has, of necessity, adopted significantly increased and varied responsibilities.

Among reason's for the expansion of services by the Governor's Office are:

Accelerated efforts by the Governor to provide services to State agencies and local governments in response to increased demand for reliable information and direction from a single contact point within State government.

Emergence of a multitude of federal programs which require comprehensive coordination of State, regional, and local plans prior to expenditure of federal project funds such as required by the U. S. Bureau of the Budget.

Execution by the Governor of his statutory responsibilities as Chief Budgeting and Planning Officer of the State which require the direct participation of his Office in the fiscal and comprehensive planning process.

Renewed emphasis by the Federal Administration on State and local governments as the principal instruments of action on domestic problems - "New Federalism."

Administration by the Office of the Governor of a number of "pass-through" financial assistance programs which provide State of federal grant funds in support of local, regional, and State programs.

Passage of House Bill 276 of the 60th Legislature Session authorized creation of interagency planning councils, recognized the Governor as Chief Planning Officer, and directed creation of the Division of Planning Coordination within the Governor's Office. The Division serves as an information center, provides State program coordination and regional services, operates as State grants clearinghouse, furnishes information systems assistance, operates the input-output economic project, and is undertaking the Coastal Resources Management Program through the Interagency Natural Resources Council.

The 60th Legislature, to foster the coordination of State planning and related functional activities at all levels of operation, provided in H.B. 276 for the creation of interagency planning councils composed of administrative heads of the member State agencies. The Interagency

Natural Resources Council was created to give attention to the coordination necessary for the unified development of Texas water, recreation, and environmental quality programs. Underlying these actions was the conviction that State government must continue its primary responsibility for the management and development of the natural resources of Texas.

*Coastal Zone Activities*

The Interagency Natural Resources Council recognized early in its existence that the Texas Gulf Coast was tremendously rich in natural wealth and was and would be rapidly developed for industrial, residential, navigational, fishing, and recreational purposes. With this perspective in mind, the Council recognized the desirability of meshing together the planning efforts and field operations of the various member State agencies in regard to their activities along the Gulf Coast. The Council thus decided to design a cooperative framework for the formulation of standards, policies, and activities for the development of the natural resources of the State's Coastal Zone - the Coastal Resources Management Program.

The objective of the Coastal Resources Management Program is to identify the State's coastal resources and the most desirable means to utilize these resources by providing the techniques and methodology required to permit their optimum development and management to be realized.

The Program will include:

1. The economic value of industrial, commercial, residential, recreational, and tourist development and other various estuarine resource uses in each estuarine complex at present, at some specified date in the future, and at ultimate development.

2. An estimation of the demand at specified dates for each estuarine use in each estuarine complex, such as, cooling water needs, recreation value, and waste disposal potential.

3. A compilation of the best available data on the response of significant marine animals and their food chains to environmental conditions.

4. The precise geographical locations of areas unique with respect to some particular use value, such as scenic areas, marine animal nursery areas, and areas with high or low waste assimilation capacity.

5. Predictive models for environmental quality management for selected estuarine complexes and their various components.

6. A compilation and interpretation of State and federal statutes to determine the responsibilities of various governmental jurisdictions - local, State, and federal - and to discover areas of statutory deficiencies and needs.

7. Management concepts for the coordination of all governmental and private activities in estuarine areas.

8. Establishment of priorities for programs or projects designed to correct existing problems or prevent approaching problems.

9. A set of bound, indexed volumes enumerating the programs findings and conclusions.

It will be no simple matter to design the Coastal Resources Management Program to provide for the optimum management of our Coastal Zone resources and for Texas political leaders to legislate an overall policy for the development and use of these resources. The Program's design and execution will tax the ingenuity of the foremost authorities on water resources, marine ecology, waste treatment, sociology, economics, law, political science, systems analysis, and the other disciplines involved in the development and use of Coastal Zone resources.

*Cooperative Programs*

The Interagency Natural Resources Council works through its member State agencies with federal and local agencies. The Council works closely with the Federal Water Quality Administration, Department of Housing and Urban Development, and Bureau of Outdoor Recreation on its Coastal Resources Management Program.

*Statutory Authorization*

S.C.R. #38, 61st Texas Legislature

*Funding - FY 1971*

Management $100,000

*TEXAS PARKS AND WILDLIFE DEPARTMENT*

The Legislature created the Texas Parks and Wildlife Department in 1963, by merging the State Parks Board and the Game and Fish Commission. The merger came about as a proposed economic move to consolidate the two agencies which had similar functions and administrative structures and which could be appropriately integrated. The new Department initiated long-range policies and programs designed ultimately to provide the

State with modern parks and game management in keeping with public demand for outdoor recreation areas and the preservation of wildlife resources.

Increased appropriations by the Legislature have made possible the emerging development program. Added emphasis and financial support came with the enactment of the Land and Water Conservation Fund Act of 1965 (Public Law 88-578) providing financial assistance in the development of public outdoor recreational areas and facilities. State participation, authorized by the Legislature in 1965, designated the Texas Parks and Wildlife Department the State agency to cooperate with the federal government in administration of this Program. A Statewide Comprehensive Outdoor Recreation Plan (SCORP) approved in January, 1966, established eligibility to receive federal funds and has been maintained and updated in accordance with the State's needs.

The annual federal apportionment under this act is divided, according to the State plan, 60 per cent for State projects and 40 per cent for projects sponsored by local governments. Grant-in-aid funds match State-appropriated funds for State park acquisition and/or development. Assistance is provided local political subdivisions in the preparation and submission of applications for federal matching funds to acquire new land for park sites or to construct recreational facilities on locally owned land. Approved local projects receive continuing administration by the Department for the duration of each project. To date, $10 million has been provided under the Land and Water Conservation Fund.

Acquisition and development of new State parks was provided for by the adoption of a Constitutional Amendment on November 11, 1967, authorizing the issuance of $75 million in State general obligation bonds for this purpose. Enabling legislation passed by the 60th Legislature in 1967 also provided that these bonds would be retired from entrance or gate fees at existing and/or new State parks. Other than an initial sale of $5.75 million, no more park development bonds have been marketed because of the 4½% interest rate allowed on the bonds has priced them out of the market. Funds from the initial sale are committed to various park development projects and limited additional purchases and are matched by federal grant-in-aid funds.

Over 12,000,000 persons visited State parks in 1969. Investigations of potential sites continue, with areas of 1,000-2,000 acres, and water based areas considered particularly desirable, especially if accessible to major metropolitan centers. Further acquisition is dependent upon additional bond sales.

The Texas Parks and Wildlife Department is responsible for the enforcement of game and fish laws, water safety laws, and trespass laws. Responsibility for the planning and execution of the Department's game and fish management programs are delegated to the Wildlife Restoration and Inland Fisheries functions. Their objectives are as follows: manage and regulate wildlife resources in regulatory authority districts; determine game and fish restoration needs and possibilities; conduct programs of applied research on wildlife management areas, reservoirs, and privately-owned lands and carry out proven restoration practices on suitable areas.

These objectives are accomplished through projects carried out under the provisions of the Federal Aid in Wildlife and Fisheries Restoration Acts. Projects are approved by the Department of Interior which reimburses the State for 75 per cent of the funds expended on approved activities.

A marine fisheries program involves the management of marine resources of the Gulf Coast. With the dual objectives of research and management practices, the Texas Parks and Wildlife Department studies the common species of marine life in their ecological relationships to associated coastal and marine plants and animals. Included in these efforts are related problems such as control of industrial waste coming from oil fields, ships and sewage disposals. An inland fisheries program produces and distributes fish and conducts continuous biological experimentation to improve the crop.

In 1969, 2.4 million State hunting licenses were sold. Individuals also bought 1.4 million fishing licenses. Both types of licenses sold averaged a 18% increase in two years. Fish produced and distributed by 14 State hatcheries totaled 15.2 million.

The Texas Parks and Wildlife Department administers the provisions of State laws relating to the sale of sand, shell, gravel, and marl from the public waters and streams of the State. Before anyone can legally take such material from these waters, he must secure a permit from the Department to operate, post a surety bond, and file monthly reports of his activities together with payments for the material removed. The Department is required to make refunds to municipalities, counties, and the State Highway Department for sums paid to the State for the purchase of sand, shell, gravel used in road, street, and highway construction.

*Coastal Zone Activities*

The coastal fisheries program of the Department develops information on marine and commercial fisheries on which to base management practices for these fisheries and the Coastal Zone. This includes the development of data on ecological factors regulating shrimp migrations and the development of data on shrimp growth in various salinities. The Department also develops disease resistant oyster stocks. Fish in all bay systems are monitored, potential mid-water Gulf fish are determined and red snapper fishing grounds are plotted. Also included is a seafood marketing program.

The Department enforces game and fish plus water safety programs regulations in the Coastal Zone.

Park activities include the operation and maintenance of State parks and the development of State park recreational facilities. Acquisition of new park sites is currently being expanded. Six coastal State parks are now operated and maintained, plus a new State park site (1950 acres) has been acquired on Galveston Island.

The Statewide Comprehensive Outdoor Recreation Plan provides guidelines for the development of the State's outdoor recreation resources to include actions by all levels of government and the private sector. The Plan is a continuing analysis of outdoor recreation demands, supply, and needs. The next updated version of the Plan will provide a balanced action program to meet critical needs in the Coastal Zone and elsewhere throughout the State.

The Department operates a beach cleaning and maintenance grant-in-aid program. It has provided grants-in-aid to seven coastal political subdivisions for the cleaning and maintenance of the public beaches within their jurisdiction bordering the Gulf of Mexico.

*Cooperative Programs*

The Department works with the Bureau of Outdoor Recreation on the Statewide Comprehensive Outdoor Recreation Plan and on the acquisition and development of new recreational sites and facilities.

The Department also cooperates closely with the Bureau of Sport Fisheries and Wildlife, Bureau of Commercial Fisheries in fisheries research work, and with other related activities of the federal government under the provisions of the Fish and Wildlife Coordination Act of 1958. Under the provisions of the latter law, the Department reviews all federal developments in the Coastal Zone for their effects on fish and wildlife. The Department also exchanges data and information with other State agencies and institutions engaged in coastal research and management.

*Statutory Authorization*

Articles 6069, 6067a, 6070h, 6081s, 6068, and 5415d-1, V.A.C.S.

*Funding - FY 1971*

| | | |
|---|---|---|
| Studies | | $ 225,000 |
| Management | | 978,457 |
| Planning | | 40,000 |
| Regulation | | 545,000 |
| | Total | $1,788,457 |

*TEXAS WATER QUALITY BOARD*

Water pollution control laws in Texas date back to 1860 although no comprehensive Statewide coverage or control was visualized nor centralization effort undertaken until 1961. In that year, the 57th Texas Legislature, in response to public recognition of the rapidly increasing pollution of the State's streams, lakes, bays, and estuaries, enacted the Water Pollution Control Act. This was the first step in the evaluation of an effective policy and an administering State agency.

Earlier responsibility for water pollution control was vested solely in the State Department of Health. Limited activities operated primarily under the direction of environmental health personnel of the Department and the affiliated local health departments throughout the more populous cities and counties of the State.

The 1961 Act established a seven member board with authority to study conditions and consider corrective measures. Three of these members are appointed by the Governor, and the other four are the Executive Director of the Texas Water Development Board, the State Commissioner of Health, the Executive Director of the Parks and Wildlife Department and the Chairman of the Texas Railroad Commission. Board authority and operating funds remained limited. No funds were appropriated directly to the Board during the first two years of its existence. This left the major pollution control functions in the State Department of Health with the Water Pollution Control Board acting in an advisory capacity only. For the 1964-65 biennium, the State made small appropriations for operation of the Board and authorized the receipt of any monies transferred to it from any Federal or State agency.

The Legislature in 1965, appropriated more funds and authorized the Water Pollution Control Board to employ some personnel. This was in recognition of the increasing need for a more comprehensive water quality control program and the value of an independent agency to develop a Statewide program and coordinate the efforts of all State agencies involved. The Executive Secretary of the Board, supervisor of all pollution control activities, remained an employee of the State Department of Health. He acted in the dual capacity of Director of water pollution control for the Health Department and Executive Secretary to the Board of Water Pollution Control.

The Texas Water Quality Board came into existence in 1967 through the enactment of the Texas Water Quality Act. This succeeded the Texas Water Pollution Control Board. For 1968, in addition to general operating appropriations, $2 million was granted for areawide sewage disposal planning studies in major population centers of the State. In 1969, the Legislature appropriated an additional $400,000 for areawide planning for the biennium.

The Texas Water Quality Act expresses the State policy on water quality and water pollution control. It outlines a Statewide control system to coordinate all water quality control programs of various State agencies and local governments with those of the federal government. The statute created the Texas Water Quality Board as the State agency to administer these programs.

The Public Law 660 Grant Program provides governmental efforts for water pollution control at all levels. This is the federal sewage construction grant program administered by the Texas Water Quality Board. Municipalities and other public bodies with authority to construct, maintain, and operate sewage treatment works are eligible for grants. Since the beginning of this program, over 400 projects in Texas have been funded. This represents $50 million in federal funds and $150 million in local funds which have been tied into the areawide planning activities.

The establishment of a sound, basic program and essential organizational structures has been completed by the Texas Water Quality Board. Significant progress has been made in studying present and future needs in areawide sewage treatment facilities for every major populated region of the State. Field offices have been created and staffed. Strides have been made in obtaining effective quality management in major industry-municipal-fishing systems. As of May, 1969, there were on file 976 municipal and 1,298 industrial permits. Also, a self-reporting system was initiated in the spring of 1970; as of the present, it is still too soon to evaluate it's true effectiveness.

The rapid development of quality control measures focused attention on the need for legislative action to delineate further State responsibility for water pollution control. This was coupled with the urged demand for immediate corrective control measures. Several State agencies and departments were still engaged in water quality control. Corrective action in this matter was taken by the 61st Legislature which spelled out the fields of responsibility and enforcement jurisdiction for the Department of Health, Water Quality Board, Water Development Board, Texas Railroad Commission, and Parks and Wildlife Department. The offense of water pollution was given the provision for criminal prosecution of violators.

*Coastal Zone Activities*

The Texas Water Quality Board is undertaking coastal programs in six major areas of activity. A Coastal Water Quality Monitoring Program covers field tests of temperature, dissolved oxygen, turbidity, water surface characteristics, tide cycle information, and conductivity. *Sample collections are taken from 65 stations along the Texas Coast four* times per year. Samples are examined for B.O.D., ph, Chlorides, Ammonia Nitrogen, Nitrate Nitrogen, total and violatile suspended solids, total phosphates, sulphates, and fecal and total coliform bacterial density. This data is available as computer printout.

An inventory of return flows covers compilation of quantity and quality data on waste water returned to the environment. Compilation includes data generated by both waste discharges and the Texas Water Quality Board. The compilation is made on digital computer and available on computer printout.

One of the most significant undertakings of the Board is the Galveston Bay Project involving waste waters discharged into the Bay and including the Houston Ship Channel - the huge petro-chemical complex of that area (over 50 per cent of the nation's petro-chemical facilities). The Project is scheduled for completion in fiscal year 1973. It is a multi-disciplinary effort of the State of Texas to determine an optimum water quality management program for the Galveston Bay System, an intricate industry-municipal-fishing complex. The scope of the Galveston Bay Project far exceeds any previously undertaken effort of this type. Concepts and lessons learned here will be of great value when applied in other areas of Texas and the nation.

Three year studies are being made on the effects of heated effluents on the ecology of Texas estuaries. They are to determine the ecological effects of the discharge of heated effluents and the measures required over and above those presently in effect to control the ecological impact of the waste water. The Texas Water Quality Board has required these studies to be undertaken by various power companies who are constructing facilities along the coast. The studies when concluded will be available as a final report.

Regulation of waste water discharges to the coastal waters is being controlled and maintained through the process prescribed by law and the rules of the Texas Water Quality Board.

Comprehensive water quality management plans are being developed by the Board through grants awarded to local planning entities.

*Cooperative Programs*

The Texas Water Quality Board assisted the Federal Water Quality Administration in the "National Estuary Study." The Board's part in this project consisted of the gathering of data regarding water quality, sources of pollution, immediate pollution control needs, water quality standards, and information on current and past water quality surveys.

The Board is helping the Gulf Coast Waste Disposal Authority to originate a comprehensive water quality management program including the development of one or more regional waste water collection and treatment facilities in the area under its jurisdiction.

Grants are being made to the Environmental Sanitation Services Division of the Texas State Department of Health for the purpose of funding the Shellfish Sanitation Program in Texas. This Program largely consists of the surveillance of water quality in and around producing oyster reefs.

The Board is participating fully in the Coastal Resources Management Program of the Interagency Natural Resources Council of which it is a member.

*Statutory Authority*

Article 7621d-1, Sections 1.02, 3.01, 3.03, 3.18, 4.01, V.A.C.S.

*Funding - FY 1971*

| | | |
|---|---|---|
| Management | | $ 115,500 |
| Studies | | 250,000 |
| Regulation | | 587,000 |
| Planning | | 777,000 |
| | Total | $1,729,500 |

*TEXAS WATER DEVELOPMENT BOARD*

Texas has 275,416 square miles of land, much of which is underlaid with usable groundwater. There are about 3,700 streams in the State having a combined length of approximately 80,000 miles, and some 1,000 miles of coastline which includes the shorelines of numerous bays. The State has more than 150 major lakes and reservoirs, each with a capacity of 5,000 acre-feet or more.

The struggle in Texas for the conservation, development, and management of its water resources dates back to 1889. In that year, the Legislature patterned its statutory concepts and procedures on those of other arid western states. This was an attempt to establish a basis for orderly distribution and peaceful development of the State's limited water resources.

From 1889 to the present, the struggle, in the form of effective water legislation and constitutional amendments, has been continuous in keeping with changes in the population pattern and general economy of the State. Texas has gone from a sparsely settled land of dry farms and cattle ranges to the fourth most populous State with modern mechanized agriculture, including thousands of acres of irrigated farmland, thriving urban centers, and highly industrialized complexes.

In 1957, the State reacted to the multi-million dollar property loss resulting from rampant floods on all major streams and earlier extensive drought conditions that prevailed throughout Texas. Texas advanced the cause of conservation and development by adopting a constitutional amendment creating the Texas Water Development Fund. This action initiated a program of loan assistance to local political subdivisions to encourage the development of the State's water resources. The issuance of the State's first water development bonds to finance such programs was also authorized. In 1965, the Legislature increased the responsibilities of the Water Development Board by transferring to it all planning and water development functions previously vested in the Texas Water Commission.

The most significant achievement of the Texas Water Development Board was the completion of the Texas Water Plan which was released in November, 1968, and formally adopted by the Board in April, 1969. The Plan was the culmination of more than 10 years work on the part of the State. It was formulated through the simultaneous progress of activities in many program areas. This included detailed summaries relating to each river basin concerning historical, present, and projected water conditions plus the holding of 27 public hearings.

Programs undertaken by the Texas Water Development Board relating to the Plan included the completion of population and water requirements projections for all uses to the year 2020. Reconnaissance hydrologic analyses were completed which resulted in the development of a water balance by decades from the present to the year 2020. Design and cost studies and the preparation of an organizational and institutional format in which the Plan could be implemented were started.

An extremely sophisticated research program of system analysis was initiated by the Texas Water Development Board. Its objective was the devising of an ultimate tool for the effective operation and management of the complex facilities proposed in the Texas Water Plan. The first part of this system analysis research program was funded, in part, by the Office of Water Resources Research, United States Department of the Interior. It was completed in September, 1969. The second phase of this research is underway along with preliminary application to the Texas Water Plan of the results of last years research. All of these studies and their results will be reviewed and refined as progressive steps are taken to implement the Plan.

Following the release of the Plan, refinement studies began, directed toward its ultimate implementation. On August 5, 1969, an election to amend the Texas Constitution was held. Two proposals affecting water resources development were on the ballot. Amendment 6 would have made financing available for implementing the Texas Water Plan by lifting the 4% interest restriction imposed by the Texas Constitution on Texas Water Development bonds. Amendment 2 would have increased the constitutionally authorized amount of Texas Water Development bonds by authorizing the Texas Water Development Board, with approval of the Legislature, to issue $3.5 billion in bonds to pay the Texas share of the cost of implementing the Texas Water Plan. Both of those amendments were defeated.

Some of the major economic studies prepared by the Texas Water Development Board have been concerned with water resources benefit-cost calculations, cost allocation, and analysis of electric power production. A study of the importance of an alternative irrigation water supply to the West Texas economy has been completed. Evaluation of water-oriented recreation benefits and projections of population, employment, and municipal and industrial water requirements have been initiated. Each of these studies is being conducted on a continuing basis with revisions being made as new information becomes available.

The Texas Water Development Board is studying the potential of desalination. The objectives are the determination of the economic feasibility of desalting brackish and saline water resources and the role of desalting in the water resources planning activities of the State. A more detailed regional study has been completed examining the application of large-scale desalting in lieu of small individual desalt plants for nine Rio Grande Valley cities. An engineering-economic appraisal has been made of the variations of desalt plant capacities and processes for variable saline waters of West Texas.

Since September, 1965, the Texas Water Development Board has completed 44 reports on various aspects of water resources planning needs.

*COASTAL ZONE ACTIVITIES*

The Board is developing an overall bay data acquisition management program to assure that sufficient information will be available to determine that the necessary fresh-water inflows of suitable quality will be provided seasonally and at optimum geographic locations for maintenance of estuarine environments and levels of productivity. The Board must propose for legislative consideration alternative methods of financing the repayment of costs of water thus allocated to estuarine inflow. Such allocation of inflows is essential as soon as possible, due to full upstream water resources development that is predicted and necessary for Texas.

The Board is beginning to establish general hydraulic and water quality characteristics of the coastal bays and estuaries under the widely varying hydrologic conditions to which they are subjected.

A coastal data collection program assembles, compiles, and incorporates into basic data reports tide gage information and physical and water quality data. Data on plankton, benthic fauna, and other biological organisms which are not presently being gathered under any existing bio-assay program in the coastal estuaries is collected by the Board's staff.

As an integral part of intensified data collection in the estuarine systems, 11 new streamflow, precipitation, and water quality stations have been established by the Board on approximately 11 major rivers having estuaries. These are stations where data on inorganic chemical constituents, biochemical oxygen demand, dissolved oxygen, temperature, nitrogen and phosphorous, Ph, chlorinated hydrocarbon pesticides, and herbicides are now being collected. Additional parameters will include periodic data on minor elements, color, turbidity, suspended solids, and bottom sediment pesticide residues.

Development and verification of two-dimensional mathematical hydrodynamic and conservative salinity transport models for two bay systems are being completed by the Board. Such models are considered basic to all aspects of estuarine studies. The models will simulate spatial and temporal variations of tidal flows and amplitudes throughout the bay systems, thus defining the hydraulic patterns throughout the estuarine systems under varying conditions. A total of approximately 9 to 11 new tide gages are being installed for purposes of a high degree of model verification.

*Cooperative Programs*

The Texas Water Development Board is currently engaged in a cooperative program with the U. S. Geological Survey involving collection of chemical and physical data, on a reconnaissance level, in all estuarine systems of the Texas Coast except Galveston Bay which is being extensively studied under direction of the Texas Water Quality Board.

An order of priority with respect to the intensity of data collection in each principal coastal estuary has been established with the Texas Parks and Wildlife Department. This priority schedule coincides in many respects with on-going ecological and related studies in the estuaries by the Texas Parks and Wildlife Department.

Tide gage data is collected in cooperation with the U. S. Army Corps of Engineers, U. S. Coast and Geodetic Survey, and the U. S. Geological Survey.

*Statutory Authorization*

Article 8280-9, Section 21, V.A.C.S.

*Funding - FY 1971*

| | | |
|---|---|---|
| Studies | | $188,335 |
| Planning | | 11,676 |
| Management | | 75,000 |
| | Total | $275,011 |

*TEXAS WATER RIGHTS COMMISSION*

Acts of both man and nature influenced the course of development of water policy in Texas. Early conflict between cattle and agricultural interests led to the passage of an act in 1913 creating the Board of Water Engineers. This initiated the first real attempt at orderly development of water rights. Floods in 1913-17 resulted in the adoption of a constitutional amendment recognizing the State's legal rights to regulate the conservation of its natural resources. The amendment also authorized the Legislature to pass all appropriate laws to accomplish this purpose.

With the growth of cities and industries within the State, municipal and hydroelectric interests became competitive with those of the cattlemen and the irrigators. This led to the passage of the Wagstaff Act in 1931 which declared, in effect, that for a given supply of water domestic and municipal needs must be met first. Then industrial needs, irrigation, mining, hydroelectric power generation, navigation, and recreation were to follow in that order.

The passage of the Water Planning Act in 1957 vested the Board of Water Engineers with the primary function of administering water rights. In 1962, the Legislature changed the name of the Board of Water Engineers to the Texas Water Commission to depict more accurately its functions and responsibilities. This name was changed to the Texas Water Rights Commission in 1965 when the Legislature realigned the functions of the Texas Water Rights Commission and the Texas Water Development Board.

The Texas Water Rights Commission exercises continual supervision of the public waters of the State. Commission functions include permitting and regulating the use of water, enforcing laws relating to the use of water, and ascertaining that authorized structures are properly designed, constructed and operated to provide the greatest degree of public safety and conservation of the public water.

Applications for permits to appropriate public waters are carefully examined to insure that essential information is complete and accurate. Evaluation is made of the availability of appropriate water, the need for and beneficial use of the applied for water, the effect of the proposed project on prior appropriation, and the hydraulic and hydrological capabilities of the project. When structures are involved in the project, determination is made as to the adequacy of structural hydraulic and hydrologic design. This is followed by periodical inspections during construction to insure compliance with approved plans.

The regulatory function of the Texas Water Rights Commission include investigations and studies made to assure compliance with State water statutes and Commission rules. Inspection by a corps of qualified personnel is continuous with reports filed concerning structural and hydraulic aspects of existing projects. These also include findings on complaints and use of water in highway construction. Inspections and investigations continue with appropriate remedial action when this is indicated by the Commission.

Statutory obligations require that the Texas Water Rights Commission evaluate, approve, or disapprove petitions for the creation of multi-county water development districts. For underground water conservation districts, the Commission must also designate the boundaries of the underground reservoir before the district is created. It must also review the feasibility of projects planned by water control and improvement districts contemplating the issuance of bonds to defray construction or improvement costs.

The Commission is responsible for the adjudication and administration of water rights on streams or segments thereof. Investigations are made and basic data collected and evaluated in preparation for adjudication proceedings as scheduled. All findings are reduced to writing and the necessary plots prepared for illustration and records.

The Texas Water Rights Commission maintains interstate compact coordination among the various compact commissioners of interstate streams and other State and federal agencies. This is to insure that Texas' interests in interstate and boundary streams are adequately protected. The Commission also reviews federally-supported water resources projects for recommendations to the Governor as required by statute. Research and development of new procedures and techniques to provide more efficient water resources operations are continually carried on.

During the 1968-69 biennium, the Texas Water Rights Commission received 929 water use applications and 865 permits were issued. Some 2,000 inspections were made for compliance with State water statutes. Developments point to the creation of 100 additional water districts by the 62nd Legislature in 1971 requiring investigations and recommendations.

*Coastal Zone Activities*

The Texas Water Rights Commission studies on specific applications for coastal projects as part of its regular work on permitting use of public waters. The Commission will become more deeply involved in the adjudication of coastal water rights as the various governmental authorities make a more intense developmental effort in this field. This will relate to such questions as arising from water planning, navigation, and coastal economic development and its demand on fresh water.

*Cooperative Programs*

The Texas Water Rights Commission works closely with the Texas Water Development Board, Parks and Wildlife Department, Texas Water

Quality Board, Corps of Engineers, and the Bureau of Reclamation in development and management projects involving the coastal waters.

*Statutory Authorization*

Article 7477, V.A.C.S.

*Funding - FY 1971*

No specific figures available.

*TEXAS HIGHWAY DEPARTMENT*

The Texas Highway Department was created in 1917 by act of the 35th Texas Legislature. At first it administered a program of State and federal aid to countries which performed the actual construction and maintenance of a proposed connected system of State highways.

In 1924, the Legislature gave the Highway Department active control over the construction, maintenance and operation of the State highway system.

Direct responsibility continues for these functions in rural areas, together with further identical responsibility for urban highway sections and for farm to market roads.

With the advent of the Federal Aid Highway Act of 1956, the Texas Highway Department began construction of the State's portion of the vast 42,500-mile Interstate Highway System. Texas has the largest portion of the system - 3,166 miles, now 70 per cent complete. The entire system is to be completed in 1978.

The Highway Department is dedicated to building, maintaining and operating facilities that provide the best service to all Texans, both in urban and rural areas. The Texas highway system now includes almost 70 thousand miles of State maintained and designated highways.

Mileage is not the best measure of a highway system. What is significant is the kind of service it provides the traveling public. Does it provide convenient transportation in keeping with the flexibility of the motor vehicle as a mode of transportation? Is it a safe facility? Can it handle adequately the volumes of traffic that use it? These are tests of a modern highway network. Providing affirmative answers to these questions is the goal of the Highway Department.

The Department also supervises registration of all motor vehicles and issues certificates of title through county tax officers and makes audits of their records.

The Department also compiles and disseminates information about all phases of Highway Department activities. It also is responsible for conducting the collateral phase of the official State travel and tourist development program to stimulate recreational travel to and within Texas. The Department operates tourist information bureaus on key highways at borders of the State, plus visitor centers in the Capitol in Austin and at the Judge Roy Bean Museum in Langtry. The Department also publishes the official State highway map.

*Coastal Zone Activities*

The State-maintained highway network in Texas' coastal area is one of the most complex and sophisticated in the nation. This system of highways of all types serves deepwater, barge traffic and commercial fishing ports of importance. It provides for motor vehicle traffic in, through and between some of the most important population centers. It supports traffic to and from some of the largest concentrations of heavy industries and petrochemical complexes in the world. Further, the entire coastal region is one of the most important and popular tourist and recreational areas in the South and Southwest.

At present, the five Texas Highway Department districts fronting on the Gulf of Mexico, plus the Houston Urban Office, have some $275 million of the $815 million worth of State highway work under contract.

Current activities range from the construction of a high-level, $18.5 million freeway bridge over the Houston Ship Channel to park roads affording access to both ends of the Padre Island National Seashore.

The Highway Department operates free ferry services regularly at Port Aransas and between Galveston and the Bolivar Peninsula. Many major bridges - also toll free - take traffic easily and smoothly over other major waterways in the area. The Highway Department's only highway tunnel serves coastal area traffic between Baytown and Greater Houston.

Meanwhile, major construction and reconstruction projects are underway on Gulf Coast highways. A major reconstruction is underway on the Gulf Freeway (IH 45) between Houston and Galveston.

Other important coast-wise roads are being developed as traffic demands rise and as funds are available.

The pace of highway development in the great arc of the Texas Gulf Coast will not soon slacken. Proposals have been made for a bridge over Bolivar Roads connecting Galveston and the Bolivar Peninsula, with a 1968 estimated cost of $30 million.

The rapid urbanization is not going unnoticed, either. As in other major population centers, urban areas all up and down the Gulf Coast are the subject of continuing urban transportation studies. The Highway Department, in cooperation with local and federal governments, is taking a leading role in their development.

In fact, throughout all of the work of the Highway Department, there is close cooperation with all levels of government. The Highway Department recently assumed responsibility for the operation of formerly-owned county causeways and roads affording access to Padre Island, for example. All the Highway Department's work is of a partnership nature.

*Cooperative Programs*

The Highway Department cooperated with the Federal Highway Administration in funding Interstate and many U. S.- and State-numbered and farm to market and recreational roads. On all but the Interstate system, local governments cooperate with the State in the acquisition of right of way. Local governments participate in planning.

In addition the Highway Department cooperates with many other agencies in the development of coastal highways; for example, the U. S. Corps of Engineers, the Coast Guard, and the Texas Water Development Board in highway crossings of navigable waters.

In short, the Highway Department involvement in Coastal Texas is great and, because of the dynamic growth of the region, without doubt will continue to represent a major effort of the Department.

*Statutory Authorization*

Articles 6663-6666, 6669-6674, V.A.C.S.

*Funding - FY 1971*

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|---|---|
| Development | $12,596,000 |

*TEXAS AIR CONTROL BOARD*

The Texas Air Control Board was created in 1965 as a semi-autonomous arm of the State Department of Health. The Board is comprised of nine members, which include an engineer, a licensed physician, a representative from industry, one experienced in municipal government, an agricultural engineer, and the remaining four from the general public. All Board members are appointed by the Governor. The objective of the Texas Air Control Board as stated by statute, is "to safeguard the air resources of the State from pollution by controlling or abating air pollution consistent with the protection of the health and physical property of the people, and for the full industrial development of the State."

To accomplish this objective, the Board is empowered to develop a general plan for the control of air pollution by adopting and promulgating rules and regulations governing air pollution. The Board directs the activities of the Texas Air Control Program, which is administered by the State Department of Health, in investigating possible sources of air pollution, holding hearings on complaints for litigation through the Attorney General's Office, and in seeking compliance with its regulations.

The Air Control Program conducts studies and performs extensive research on air pollution throughout the State, collects and disseminates information, and cooperates with other governmental agencies interested in the control of pollution. Voluntary cooperation is encouraged through persuasion and consultation, but when necessary the Board issues such orders or determinations as may be necessary to control the air pollution. If the Board determines that a regulation is being disregarded or violated flagrantly, action for injunctive relief and/or fine is undertaken.

*Coastal Zone Activities*

Activities of the staff of the Texas Air Control Board in the Coastal Zone embrace 18 counties which are designated into the regions of Beaumont-Port Arthur, Houston-Galveston, and Corpus Christi. The Texas Air Sampling Network operates stations in the coastal area which monitor particulate matter, benzene solubles, nitrates, and sulfates, as well as recording the effects of sulfur dioxide, hydrogen sulfide, oxidants, and acid mists upon various materials. Extensive 30-day ambient air studies have been conducted in all of the large industrial metropolitan areas among the coast. Mobil air sampling laboratories have been assigned to monitor the quality of the air in these regions periodically, and a four-phase study has been conducted along the Houston Ship Channel to determine the location of air pollution sources.

*Cooperative Programs*

The Air Control Board staff is entirely composed of employees of the Texas State Health Department functioning as the Texas Air Control Program. The Air Control Program works closely with the National Air Pollution Control Administration in the continuous monitoring of the ambient air to determine the effectiveness of air pollution control efforts. Local programs have been encouraged in an effort to promote pollution control at the source level. Local agencies are now operating in Houston, Beaumont, Corpus Christi, Harris County, Galveston County and Jefferson County in the Coastal Zone. In many cases these programs have been successful in effecting or enforcing compliance with the Board's Regulations. Industry is encouraged by the Texas Air Control Board to achieve compliance on a voluntary basis through the Variance System. The Board has also cooperated with industry in the constant evaluation of pollutant loadings through source emission inventories and a computerized data-feedback system.

*Statutory Authorization*

Article 4477-5, V.A.C.S.

*Funding - FY 1971*

| | |
|---|---|
| Regulatory | $1,114,264 |

*TEXAS RAILROAD COMMISSION*

In 1891, the Texas Railroad Commission was created to regulate railroad rates and tariffs in the State and to prevent unjust discrimination. In 1917, legislation was enacted which, though dealing principally with pipelines as common carriers, designated the Railroad Commission as the agency to administer certain of its general provisions relating to the conservation of oil and gas. In 1919, broad regulatory and enforcement powers relating to oil and gas conservation were conferred upon the Commission and these activities have subsequently constituted its major concern.

The Gas Utilities Act, passed in 1920, gave the Commission authority over persons and companies engaged in producing, transporting, conveying, or distributing natural gas for domestic or other use. Legislation enacted in 1937 conferred regulatory powers over the liquified petroleum gas industry. The Motor Bus Law of 1927 and the Motor Carrier Law of 1929 extended the supervisory and regulatory authority of the Commission to commercial transportation over the State's highways.

The principal activity of the Railroad Commission concerns the supervision and enforcement of laws and rules related to the conservation and prevention of physical waste in the production of oil and gas, including regulation according to market demand. The Commission issues drilling permits and conducts safety inspections upon completion of each well. Allowables for each well are set in accordance with production factors, consumer's requirements for oil and gas, and conservation practices.

In 1965, the Railroad Commission was given authority to provide for the pooling of mineral interests into proration units for an oil or gas well under certain conditions. The Commission was made solely responsible for the control and disposition of waste, abatement, and prevention of water pollution resulting from oil and gas activities. This involved both surface and subsurface water which was to be protected from contamination associated with oil and gas exploration, development, or production. Permits were to be issued for the discharge of waste resulting from these activities. The plugging of wells to prevent water pollution was given increased importance with broader powers for enforcement of related laws and regulations given to the Commission.

*Coastal Zone Activities*

The Railroad Commission enforces regulatory and policing activities concerning the production of oil and gas from coastal waters. It conducts an extensive coastal mapping program for coastal wells and pipelines and has inaugrated an oil spill program to contain and disperse offshore oil discharges. The Commission undertakes safety inspections of offshore wells and production facilities and plugs leaking and abandoned wells with State funds.

*Cooperative Programs*

The Commission maintains a cooperative program with the Texas Water Quality Board and the Texas Parks and Wildlife Department concerning coastal oil pollution and mitigation of damage to wildlife areas and fisheries hatcheries and spawning grounds.

*Statutory Authorization*

Article 16, Section 59e, Texas Constitution, and Articles 6004, 6005, 6008, Section 6, 6029a, 6029b, 6046, 6066a, 6066b, 6066c, 7621d, Section 10c4, Article 7621b, Section 2a, V.A.C.S.

*Funding - FY 1971*

| | |
|---|---|
| Regulatory | $125,000 |

*TEXAS STATE DEPARTMENT OF HEALTH*

The Texas State Department of Health was created in 1879. The laws of Texas assessing to the Health Department specific responsibility for all matters pertaining to the health of Texas citizens. The Department provides local health services, preventive medical services, and special health services, and is responsible for solid waste pollution control.

The sanitary engineering activities of the Health Department have as their principal objective the creation of an environment free from health and sanitary hazards and favorable to securing the greatest possible reduction in preventable diseases. The Department is charged with making studies and investigations and collecting evidence in connection with the enforcement of safe water laws and other laws relating to sanitation. This includes the certification of the competancy of water and sewage plant operators. The Department certifies water used in interstate traffic and provides consulting services on health engineering problems to municipalities, county governments, and State agencies.

The Air Control Board of the Department monitors air pollution in the metropolitan areas of the State. Air sampling stations are maintained in representative areas of the State. Inspections and surveys are made of industries producing significant quantities of atmospheric pollutants.

The Health Department handled water pollution control activities for the State until passage of the Texas Water Quality Act of 1965 which transferred this function to the created Texas Water Quality Board.

*Coastal Zone Activities*

The Division of Marine Resources of the State Health Department is responsible for determining those State waters that are suitable to produce a safe, edible shellfish product. This responsibility calls for a rather specific knowledge of the Coastal Zone particularly in the matter of industrial, commercial, and private activities that could influence the character of the shellfish harvesting and seafood producing waters. To obtain this knowledge, the Texas Health Department gathers sanitary and bacteriological data from all major Texas bay areas. In order to maintain a close public health surveillance of approximately 1.3 million acres of Texas Coastal waters, the scope of such data extends from simple field tests to laboratory determinations for fecal coliform, chlorides, pesticides, radionuclides, and heavy materials.

*Cooperative Programs*

The Health Department carries out its program for shellfish sanitation regulation in cooperation with the Texas Water Quality Board and the Federal Food and Drug Administration. Cooperation with the Water Quality Board includes an advisory service regarding shellfish production as it relates to the water quality of Texas bays and estuaries. The relationship with the Federal Food and Drug Administration is through the National Shellfish Sanitation Program. As a result of the Texas Shellfish Program, the Food and Drug Administration approves the sale of Texas shellfish in interstate commerce.

*Statutory Authorization*

Articles 4450f and 4476-8, V.A.C.S.

*Funding - FY 1971*

Regulatory $99,006

*GENERAL LAND OFFICE*

The General Land Office was first created in 1836 under authorization of the Constitution of the Republic of Texas. Although the Office was originally charged with the principal duty of keeping the records and archives pertaining to land titles, within the last half-century it has become a business office and collection agency. In 1876, the Texas Constitution dedicated one-half of the then remaining public domain to the Permanent Free School Fund. In 1939, the residue of the public domain along with the mineral interest in river beds and the tidelands, including bays, inlets, and the marginal sea to the outer edge of the continental shelf.

In 1949, the Veterans Land Board was created as a new State agency. The employees of the agency were to be considered employees of the Land Office and much of its administrative work has been absorbed by the personnel and equipment of the Land Office.

The General Land Office performs field surveying required by statute relative to the public lands in which the State owns a mineral interest. The Office maintains files on field notes, plots, and maps filed or prepared in the agency. It constantly compiles new maps of counties, prepares plots of submerged areas offered for lease by the School Land Board, and prepares sketches and maps for the land leasing boards. Field notes returned to the Office on which patents or deeds of acquittance are to be issued are examined for approval.

The Office is charged with the duty and responsibility of keeping a register on survey lands dedicated to the Public Free School Fund and the Veteran's Land Board Fund, as well as on all surface and mineral leases, sales, and easements. The Spanish archives contain records of Spanish and Mexican titles deposited in the General Land Office. The Spanish translator is charged with the statutory duty of translating the instruments on file from Spanish into English.

The Office maintains information on drilling and exploration activities throughout the State and collects data pertaining to those areas where the State owns mineral interests. Current abstracts are kept of all original Texas land titles. At their disposal is files containing the original grants made at the time Texas became a sovereign State. Records of corrections in existing titles and patents and of new surveys and patents issued are maintained by the abstract compiler.

At the end of each fiscal year, the land records are compiled and printed as a supplemental abstract volume for the State agencies requiring its use and for the public. These are used by county officials for tax purposes as well as a means of determining the existence of lands within the counties. The Office handles legal matters relating to patenting of lands and boundary questions. The validity of claims under old land certificates which have not been patented for some reason are determined.

The General Land Office prepares patents issued by the State of Texas and deeds of acquittance by which the State grants titles to excess lands after payment of the price fixed by the School Land Board.

*Coastal Zone Activities*

The General Land Office is the Constitutional Manager of the millions of acres of beaches and submerged lands that are owned by the State.

*Cooperative Programs*

The General Land Office works with the Texas Parks and Wildlife Department, the Texas Railroad Commission, and the Corps of Engineers in the management and leasing of State-owned submerged lands and islands so as to achieve coastal resources conservation, navigation, and industrialization.

*Statutory Authorization*

Article VII, Section 2, Constitution, Articles 5251, 5339, 5353, 5415c, 5415e, 5421C-6, 8225, V.A.C.S.

*Funding - FY 1971*

Management $21,236

*TEXAS DEPARTMENT OF AGRICULTURE*

Originally set up for the organization of farmer's institutes over the State to promote interest in agricultural problems, the Texas Department of Agriculture has embraced to varying degrees research, education, and regulatory activities in its programs. Today the Department functions primarily as the State's agency for enforcement of agricultural laws and provides equal emphasis on service programs for Texas agriculture and Texas consumers. The Texas Department of Agriculture is, in fact, the major agency in Texas State government assigned responsibilities for consumer protection in such areas as weights and measures, packaging and labeling and marketing. In addition to its direct regulatory and service function, the Department of Agriculture serves as a clearinghouse for numerous agriculture-related problems and requests which are under the jurisdiction of other governmental agencies.

The specific responsibilities of the Department include enforcement of agricultural and plant quarantine laws. The Department regulates the sale and control of herbicides and insecticides. It administers the Commodity Referendum Act and regulates many other programs pertaining to agriculture in the coastal area.

In addition to the regulatory work of the Department a very in-depth market news program is expanding to provide vital marketing information. Publications are mailed daily from the Department concerning all aspects of Texas production and prices paid for the productions. A list of market services are available from the Commissioner's office.

Perhaps the greatest service to Texas agriculture is the newly formed program for the promotion of Texas agriculture products, known simply as the "TAP" program. This program has worked diligently to promote and identify Texas products to Texans and to the people of the world alike. The demand by production groups for the services of the Department in this particular program is tremendous.

To summarize the efforts of the Texas Department of Agriculture, one must say that the Department enforces the laws of Texas agriculture. It promotes the sale of Texas products. It serves all the people of the State as farmers, as processors, as retailers, and as consumers. The development of the Texas Coastal Zone is a real concern to the Texas Department of Agriculture and its Commissioner, John C. White.

*Coastal Zone Activities*

The Department does not have specific programs for the Gulf Coast area; however, the regular work of the Department requires its involvement in this region. The Coastal Zone produces some of the major Texas agriculture products. The use of the land in these areas is of a very great concern to the Commissioner of Agriculture.

*Cooperative Programs*

The Texas Department of Agriculture works closely with the U. S. Department of Agriculture and local farmer and agriculture organizations in promoting the use of Texas Agricultural Products.

*Statutory Authorization*

Article 47, V.A.C.S.

*Funding - FY 1971*

No specific figures available.

*TEXAS INDUSTRIAL COMMISSION*

The Texas Industrial Commission is the State's agency for attracting industry and encouraging the expansion of existing industry thereby creating jobs for Texans.

The Commission conducts the State's advertising programs, provides consultants to communities to help outline local industrial development programs, and operates a department for the export of Texas made products.

As an information center, the Commission, through advertising, direct contact, and follow-up inquiries, seeks to attract the favorable attention of prospective new industries to Texas. The Commission also serves as a computerized clearinghouse for community data which can be used effectively by corporate industrial location executives seeking plant sites.

The Commission is vitally interested in development using water transportation, both from the standpoint of new or existing industry and through the development of Texas ports, and their export potential.

*Coastal Zone Activities*

Interest of the Commission in Coastal Zone Development centers around the tremendous potential growth of the Gulf Coast area. Realizing the necessity of protecting the environment, the Commission has a direct influence on helping communities achieve a balanced economical as well as ecological environment.

*Cooperative Programs*

In complementing and coordinating private programs, the Commission is in frequent contact with top industrial development leaders in utility companies, banks, railroads, chambers of commerce, and others. Meetings are held with community and business development officials where the work of the Commission is explained and successful individual efforts discussed. The Commission works closely with smaller communities in assisting them to organize and attract industry.

*Statutory Authorization*

Article 5190½, V.A.C.S.

*Funding - FY 1971*

No specific figures available.

*TEXAS SOIL AND WATER CONSERVATION BOARD*

The Board is the coordinating agency for the Texas soil and water conservation districts under procedure specified by State law. There are 188 soil and water conservation districts in Texas comprising 99 per cent of the State's total land area.

Each soil and water conservation district constitutes a governmental subdivision of the State. The districts have various powers including the formulation of regulations governing use of lands within the area to conserve soil and soil resources and prevent or control soil erosion.

The Texas Soil and Water Conservation Board offers and provides assistance to the districts in the execution of programs and plans and in coordinating and securing private and intergovernmental cooperation. The Board has been designated by the Governor as the approval agency for applications to plan and carry out watershed protection and flood prevention programs on small watersheds of 250,000 acres or less.

*Coastal Zone Activities*

The Texas Soil and Water Conservation Board is now participating in a Type IV Coastal Basin Study of the U. S. Department of Agriculture involving coastal flood prevention, drainage, and irrigation.

*Cooperative Programs*

The Type IV Coastal Basin Study is being undertaken in cooperation with the U. S. Soil Conservation Service and the Texas Water Development Board.

*Statutory Authorization*

Article 165a-4, 165a-10, V.A.C.S.

*Funding - FY 1971*

No specific figures available.

# HISTORICAL AND CULTURAL FEATURES

Prepared by

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for

COASTAL RESOURCES MANAGEMENT PROGRAM

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DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

*CONTENTS*

# HISTORICAL AND CULTURAL HIGHLIGHTS OF THE TEXAS COASTAL ZONE

## I. *OVERVIEW*

That portion of Texas near the Gulf of Mexico exhibits diversity in its historical past as well as the cultural past and present. Since 1530 when Cabeza de Vaca earned himself the distinction of being the first white man to set foot on Texas soil, throughout Coronado's jaunt of 1541, Frenchman La Salle's venture, Austin's colonization effort, revolution, independence, statehood, Civil War, reconstruction, and the transition to industry, oil, and NASA, the coastal area has seen its share of significant happenings:

*Austin brought his first colonists*

*Sam Houston led the defeat of Santa Anna*

*The only battle of the Civil War fought in Texas was at Sabine Pass*

*Oil, gas, and other mineral resources were developed*

*The dredging of the Houston Ship Channel made the area a world port*

*The few remaining Whooping Cranes winter at Aransas Wildlife Refuge*

*The Astrodome ushered in a new dimension for "outdoor sports"*

*The Manned Spacecraft Center sent men forward to their first walk on the moon*

These, combined with many other attractions both tangible and intangible, make this area a truly significant historical and cultural resource of the State of Texas and one which should be preserved so that future generations of Texans may cherish and enjoy it.

In preparing a synoptic discussion of the cultural and/or historical characteristics of the region, many parties provided information. Most notable among these were the State Historical

Survey Committee and the Barker Library at the University of Texas at Austin. This short report dwells briefly on each major time period in Texas history, then locates many of the significant sites (as noted by the State Historical Survey Committee), and finally proposes a set of objectives as established by the Goals for Texas investigations.

## *II. FROM DISCOVERY TO COLONIZATION*

Early in the 16th century (1519) Spain's Alonso Alvarez de Pineda was commissioned by the governor of Jamaica to find the expected strait through America which was supposed to bring the riches of the Far East within Spain's grasp. It was also his task to explore further those lands already claimed by Ponce de Leon. Pineda mapped the entire Gulf Coast from Florida to Vera Cruz and recommended that a settlement be established near the mouth of the Rio Grande, but this was not done for some two hundred years.

Entering the interior of Texas for the first time, and once again representing Spain, were Alvar Nunez Cabeza de Vaca and three survivors of the Panfilo de Narvaez expedition which had been ship-wrecked six years earlier. After wandering through the heart of the State, they arrived at Culiacan, near the Gulf of California on May 18, 1536.

Excited by tales brought to Mexico by Cabeza de Vaca, Francisco Vasquez de Coronado left to explore this northern land. The expedition led only to disappointment, though, when instead of the Seven Cities of Cibola and the expected riches, Coronado found only wretched pueblos inhabited by unfriendly Indians. In early 1541 he set out for the promised land of Quivira, which supposedly lay to the east of his present location near Albuquerque. Once again his search ended only in disappointment and frustration when he finally found Quivira. It was nothing more than an area containing several Wichita Indian villages and the only metal visible was some copper jewelry.

Coronado traveled back to Mexico and reported to King Charles I that there was nothing significant enough in the area to justify being colonized by Spaniards.

During this same period of time, Hernando de Soto was exploring the area north of the Gulf of Mexico. After his death, Luis de Mascoso de Alvarado led the expedition toward Mexico. The group attempted to link up with Coronado, but when they failed to find him they returned to the Mississippi River area. There they built some crude boats and began floating downstream. They were forced ashore near Beaumont and reached the Spanish town of Panuco. Like Coronado, De Soto's men found nothing of much value in Texas.

In the 1600's, Spaniards began settling Texas from the West. A number of missions were established along the Rio Grande border of Southwestern Texas. Then, in 1659, a mission was established near Juarez at El Paso del Norte. "After the Indian revolt in New Mexico in 1680, the retreating Spaniards and friendly Indians established the mission pueblo of Corpus Christi de la Isleta a few miles east of El Paso where the village of Ysleta now is. This was the first permanent European settlement within the present boundaries of Texas."[1]

In 1683 Spaniards began settling eastward and a group of missions was established near the joining of the Rio Grande and Conchos Rivers. Father Nicolas Lopez was sent from New Mexico with a military escort commanded by Don Juan Domingues de Mendoza in order to Christianize the Indians.

It was at this time that reports began arriving which confirmed suspicions that the French were beginning to settle along the Gulf Coast in direct violation of Spanish claims.

The intruder turned out to be Robert Cavelier, sieur de La Salle. He had actually planned to settle along the mouth of the Mississippi River, but through error, found himself at what is now Matagorda Bay. There he established Fort St. Louis. La Salle made a six-month exploration of the area around Ft. St. Louis, and returned to the settlement with only eight of his original thirty men. Upon his arrival he discovered that not one of his original four ships was left. Also, crops had failed and the Karankawa Indians were harrassing those who had managed to survive. Furthermore, only 45 people were still alive in the fort. La Salle decided to seek the Mississippi River once again and seek help in Canada. He never reached his destination, however, as he was assassinated by one of his own men on March 20, 1687. Six survivors of the band eventually made their way to Canada and finally to France, but Louis XIV never saw fit to send aid to the stranded colonists.

If help had come, it would have been too late anyway, as the fort was soon destroyed and most of its inhabitants slain. Meanwhile the Spanish learned of the fort from captured French pirates and tried to find the settlement. After four attempts, Governor Alonso de Leon of Coahuila finally discovered the ruins of the ill-fated fort.

Even though fate had removed the French threat for the present, the Spanish realized that they would never be secure in the area

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[1]Richardson, Rupert N., Wallace, Ernest, Anderson, Adrian N., Texas the Lone Star State, (3rd ed., Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970), p.15.

until they took formal possession of it. So, when De Leon returned to Mexico he sent optimistic reports of the land of the Tejas to the viceroy. He was assisted in his pleas for a mission in this area by Father Damian Massanet, as on an earlier expedition into that area, Massanet had promised the Tejas chief that he would return.

The petition was approved and Father Massanet, three other priests, De Leon, and a military escort set out for the area in 1690. Thus, the first mission in the land of the Tejas - San Francisco de los Tejas was established.

Unfortunately, this mission also was doomed to failure. Father Massanet and De Leon returned to Mexico. In 1691, Domingo Teran de los Rios, governor of the province of Tejas and Coahuila led another expedition into the area. They discovered that the crops were failing, an epidemic had killed many Indians and one of the priests, and the Indians had gradually become hostile to the intruders.

Early in 1692 Teran departed, leaving behind only Massanet and a small guard, to return to Mexico in order to seek help. A relief expedition from Monclove brought supplies, but already it was too late to be of any value. Finally, even Father Massanet had to agree that the missions could not survive without support from presidios and settlements. Thus, the East Texas missions were abandoned.

During this period, France had been involved with internal difficulties and did not press her claim to the Mississippi Valley. In 1712, however, France granted the colony of Louisiana to Antoine Crozat as a commercial monopoly and La Mothe Cadillac became its first proprietary governor. In Europe, the grandson of Louis XIV of France had ascended the throne of Spain and the Spanish government gave tacit agreement to the French to settle in the Gulf area. BUT, there would be absolutely NO trading between the two areas. This is exactly what Crozat sought, and as he was readying an expedition, word arrived from Fray Francisco Hidalgo suggesting that perhaps the French would like to help establish a mission for the Tejas. Louis St. Denis was sent to try to initiate trade with the Spaniards, and he arrived on the Rio Grande at San Juan Bautista on July 18, 1714.

St. Denis and Hidalgo were immediately called to Mexico for explanations of the forbidden trade. St. Denis ended up marrying the granddaughter of the commander at San Juan Bautista and was to serve as a guide for soldiers and missionaries which New Spain (Mexico) was sending to the Tejas.

So, once again a French threat led to the establishment of missions in the land of the Tejas Indians. By the end of 1716, there were six Spanish missions from Neches to Los Adaes and within a few miles of the Red River.

In 1716, also, Martin de Alarcon was appointed governor of Coahiila and Texas and established the Villa de Bexar and Mission San Antonio de Valero in present-day San Antonio in 1718. The beginnings of this mission preceded the most successful mission system ever set up by any government in Texas.

With the Spanish occupation along the Gulf of Mexico a general program of expansion was initiated in nearly all of New Spain. The efforts were redoubled when there were threats from the French occupying areas both to the north and east of Texas; the English had settled in Georgia and by so doing, appeared as a threat to Spanish supremacy in Florida; Indian tribes were harrassing the frontier areas; and, last but not least, there were reports of precious metals to the north of San Antonio. The fast-moving Spanish occupation actually began about the year 1745 and continued spasmodically until the cession of Louisiana to Spain by France in 1762. Even though the Spanish held much territory in Texas, there were still vast areas left totally uninhabited from Tampico to the San Antonio River (Nuevo Santander) extending inland in some places for as much as 300 miles. Now, the Spanish leaders held fears that the unguarded area might be settled by the English. And already that area was also an asylum for Indian renegades and remnants of tribes.

In 1746 Jose de Escandon was given the dubious honor of settling the area and subduing the Indians. He spent two years exploring the area and making preparations and finally gathered more than 3000 soldiers and colonists at Queretaro. Between 1749 and 1755 he left 23 settlements, among the most important of which were Dolores and Laredo north of the Rio Grande.

Also established during that time by Escandon was current-day Goliad. It had first been established in 1726, but later had been moved to Victoria. Escandon had the Mission La Bahia del Espiritu Santo de Zuniga and Presidio Nuestra Senora de Loreto moved back to the San Antonio River at the present site of Goliad.

The Spanish had ambitious plans to establish missions in the area approximately 150 miles northeast of San Antonio along the San Gabriel River. With problems created by disease, indifferent Indians, and hostile Apaches, the mission enterprise of a series of three missions along San Xavier (San Gabriel) was finally abandoned. Other expansion-type missions suffered similar disasters and defeats, especially Indian trouble.

"Thus, Spain's efforts at expansion in Texas, except at Goliad and Laredo on the Rio Grande were failures. El Orcoquisac, placed at the mouth of the Trinity River to expel French intruders, may have been of some value, but it never developed into a civil settlement or even a mission center of any consequence. The mission efforts on the San Xavier and the San Saba ended in calamity, proving that Spains's chief pioneering institutions, the mission and the presidio, could not be made effective north of San Antonio."[2]

Near the end of the Seven Year's War in Europe, Spain entered the conflict on France's behalf. In so doing, at the Peace of Paris in 1763, she lost Florida but was allowed to keep western Louisiana which France had ceded to her in secret.

Louisiana had been an enormous burden on France, anyway, and it was no less so to Spain. The *aggressive English* were now Spain's new neighbors instead of the *tolerant French*. After the American Revolution Spain had the uneasy Anglos to worry about, too, and if that were not enough, there were internal difficulties in New Spain.

Jose de Galvez was sent to America on behalf of Charles III to carry out certain reforms there. Under this man, the Marques de Rubi was sent to explore the northern frontier. From 1767 until 1770 Rubi spent three years traveling in the Area and made exhaustive reports and recommendations which resulted in a *Regulation for the Presidios* on September 10, 1772.

Among other things, the regulations called for "(1) the abandonment of all missions and presidios except San Antonio and La Bahia, (2) the strengthening of San Antonio de Bexar by moving to it settlers from Los Ais and Los Adaes, and (3) the inauguration of a new Indian program calling for friendly relations with the northern tribes and a war of extermination against the Apaches. Thus Spain had determined not only to give up all attempts to occupy the country north of San Antonio but also to abandon the settlements in East Texas and the presidio and mission on the Trinity, no longer needed to prevent intrusions from the east."[3]

In 1800 Napolean entered upon a grandiose plan for reinstituting French influence in the North American continent and cajoled the king of Spain into transferring Louisiana once again to France. "Then, in 1803, realizing that it would be difficult to hold the province in the event of a war with Great Britain, he broke his pledge to Spain not to alienate it and sold it to the United States. Now Texas was once again on the border of New Spain, and an indefinite boundary separated it from the land-hungry Americans. To meet the new situation Spain adopted a three fold imperial policy: first, to hold the territory with its ancient boundaries unimpaired; second, to increase its garrisons and colonize the territory with loyal Spanish subjects; and third, to keep out Anglo-American intruders."[4]

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[2] Ibid., p. 26.

[3] Ibid., p. 30.

[4] Ibid., p. 33.

The Adams-De Onis, or Florida Purchase Treaty, signed in 1819 after the Napoleonic Wars aided Spain greatly in their efforts to enforce this policy. In accordance with the terms of the treaty, the United States was given Florida from Spain and gave up any claim to Texas that she MIGHT have had. Perhaps even more important, the Louisiana-Texas boundary was at last settled. It was established as "the west bank of the Salina from its mouth to the 32nd parallel, thence north to the Red River, along the south bank of that stream to the 100th meridian, thence north to the Arkansas River, along the south or west bank of that stream to its source, and thence northward to the 42nd parallel. The eastern boundary of Texas as determined by the agreement remains unchanged to this day."[5]

Even with all of the Spanish efforts to colonize Texas, at the time of the Adams-De Onis Treaty, the only permanent settlements were at San Antonio de Bexar, La Bahia (Goliad) and the pueblo of Nacogdoches. Still fearful of Anglo-American tresspassing, Spain once again undertook the task of populating the province. The entire population of Texas at that time has been estimated at 4,155[6] one fourth of whom were soldiers. "The efforts of officials to introduce foreigners were offset in great measure by the opposition of Nemesio Salcedo, commandant general of the Interior Provinces, who looked with suspicion on all immigrants from Louisiana, and stoutly forbade commercial relations with that country."[7]

Those who tried to do so anyway, among them a Louisiana trader by the name of Philip Nolan, were promptly put to death. Another martyr, Miguel Hidalgo, a priest, was killed for raising the banner of revolt against the harsh Spanish government.

Hidalgo's rebellion in 1810 was suppressed mainly because the upper classes of Mexico, the merchants, and the clergy would not join the movement. Nevertheless, his death planted the seeds of rebellion in the minds of many others. Subjects in New Spain were becoming increasingly dissatisfied with Spain, especially after Napoleon had taken Ferdinand VII prisoner and put Joseph Bonaparte on the Spanish throne.

So, with the end of the Eurpoean wars in 1819, the revolution in New Spain was continued under new leadership. In Spain, Ferdinand was reinstated and made to restore the liberal constitution of 1812. This constitution, under which, of course New

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[5] Ibid., p. 34.

[6] Ibid., p. 35.

[7] Ibid., p. 35.

Spain must also live, was viewed as a threat by the higher classes in Mexico and also infuriated the priests because of certain anti-clerical policies that it contained. Thus, "Old Spain had become too liberal for New Spain."[8] On February 24, 1821, the two factions in Mexico entered an agreement by which New Spain was declared an "independent, moderate, constitutional monarchy."[9] It also guaranteed the Catholic religion and proclaimed racial equality. In August, the last Spanish viceroy recognized Mexican independence. This final severing of ties with the mother country was to have far-reaching effects on subsequent Texas history.

## *III. COLONIZATION BY ANGLO-AMERICANS*

On December 23, 1820, Moses Austin sought permission from Governor Antonio de Martinez in San Antonio to establish an American colony consisting of 300 families in Texas. Austin had come from Missouri, which was once a part of Louisiana; thus, he was received as a former Spanish citizen and was given permission on January 17, 1821, to settle his families in Texas.

Shortly after Austin's return to Missouri he died, leaving the fulfillment of his commission to his son, Stephen F. Austin. Although he was only 27 years old at the time, the younger Austin was well-educated and already experienced in business and legal matters. In addition, he had served for five years in the Missouri Territory legislature and had held an appointment as a district judge in Arkansas. Finally, and perhaps most importantly, Stephen F. Austin was well acquainted with the type of people that lived in that area and that would more than likely comprise his group of colonists.

So, in 1821, the younger Austin went to San Antonio with a small party of men and was given permission from the governor to carry out his father's dream. News about Austin's arrangements out-distanced his travels, and when he returned to Natchitoches, Louisiana, he found almost a hundred letters from people seeking to make the move into Texas. After sending the schooner *Lively* ahead of him with essential cargo for establishing a colony, Austin returned to Texas by way of Nacogdoches where he met a group of waiting colonists. When Austin reached the Brazos River, he found eager colonists already establishing homesites. The *Lively*, missing its destination of the Colorado River mouth, had returned to Louisiana with its discouraged colonists.

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[8] Ibid., p. 38.

[9] Ibid., p. 38.

"The first settler to enter the colony, Andrew Robinson, crossed the Brazos River at the La Bahia Road crossing in November 1821. The ferry he operated marked the settlement of Washington-on-the-Brazos."[10]

After helping to settle his colonists, Austin returned to San Antonio in March 1822. It was at that late date that Governor Martinez gave him the unwelcomed news that officials in Monterey did not recognize the arrangement made with Moses Austin and the authority of Stephen Austin to carry them out. Martinez suggested that Austin travel to Mexico immediately to straighten matters out with the central government. After leaving Josiah Bell in charge of the colony, Austin left for Mexico.

The political situation in Mexico was, to say the least, one of confusion. Political power had changed hands twice, but finally, on April 14, 1823, almost a year after his arrival in Mexico City, Stephen F. Austin's colonization grant was approved.

In August 1823, Austin returned to his colony with Baron de Bastrop, the commissioner who would have the authority to grant land titles. Although the colony had suffered extensive hardships enough to convince some colonists to return to the United States, the promise of soon-to-be-issued land titles and setting up of local governing officials helped the morale of the group greatly.

The local governmental headquarters was set up on the Brazos River and subsequently named San Felipe de Austin. The 272 land grants that Bastrop issued extended from the Brazos, Colorado and Bernard Rivers all the way to the Texas Gulf Coast. "By the terms of the imperial law each family was to receive one *labor* (177 acres) if engaged in farming, and a *sitio* (a square league or about 4,428 acres) for stock raising. Of course, most of the colonists preferred to be classed as stock raisers, and only about 20 titles called for less than a *sitio*. Special grants were made to a few men as compensation for substantial improvements such as mills... Austin, as *empressario,* received about 22 *sitios*. The law required that land should be occupied and improved within two years after the receipt of the deed, that colonists must profess the Catholic religion, that for six years they would be exempt from the payment of tithes and duties on imports, and that children of slaves born in the empire would be free at the age of fourteen."[11]

The Imperial Colonization Law, under which Austin received permission to carry on in his father's behalf, was not a national program, but a special arrangement worked out to aid Stephen Austin.

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[10] Ibid., p. 48.

[11] Ibid., p. 50.

It was not until August 1824 that the Mexican Congress issued a law covering colonization. This law decreed that, with certain exceptions, the national government turned over the dealing of public lands to local governments. The exceptions included the amount of land that could be issued to an individual (no more than 11 *sitios*), areas in which foreigners could not settle (ten leagues of the coast and twenty leagues from an international boundary), no alien could receive a grant, and, finally, that until 1840 no foreigner would be prohibited entrance to the lands as a colonist.

It was the great success of the colonization activities which nearly spelled its doom. Without warning, on April 6, 1830, the Mexican government forbade further colonization efforts. Through reports of such men as General Manuel Mier y Teran, the Mexicans were brought to realize the very real threat that existed if such extensive Anglo-American activity were to continue. General Teran recommended settling more Mexicans, Swiss, Germans and soldiers in the areas already occupied by American colonists. The April 6, 1830 decree forbid citizens of foreign countries which shared boundaries with Mexico from colonizing Mexican territory. This decree, of course, effectively shut off the flow of Anglo-Americans into Mexican-held Texas. This seemed to spell disaster to the colonists. In April 1833, a convention was held in which the colonists drafted a petition designed to convince the Mexicans to repeal the law. Stephen Austin carried it to Mexico City and, effective May 1, 1834, the decree was duly repealed.

Numerous colonization projects were begun, among them, the Galveston Bay and Texas Land Company and the Nashville Company. Other colonies, those of James Power (a native-born Irishman) and James Hewetson of Monclova and of John McMullen and James McGloin sought to draw Europeans into the area.

Colonization legally ended when, by an act of the Congress of the Republic in June, 1837, it was stated that all *empresarios* ended on the day of the declaration of independence on March 2, 1836.

## *IV. THE INEVITABLE REVOLUTION*

There were a number of contributing causes to the final break with Mexico. The colonists that came to Texas been exposed to self-government; they considered Mexicans inferior and resented both the governmental authority and having Mexican troops quartered among them. They hated the fact that civil matters were, at best, secondary to military matters. Finally, they did not like the close connections between the church and the state. These traits lay in direct opposition to Mexican customs. Most citizens of New Spain were very used to being subjugated, especially after being held by Spain for 300 years. They did not understand their own constitution which the Anglos considered sadly lacking in many respects. Some of these differences in custom and tradition could only accent mistrust and suspicion. Mexican President Guerrero's proclamation of the emancipation of slavery in the colonies (September 15, 1829) and the decree of April 6, 1830 did little to cement friendly relations between the Mexicans and the Anglo-Americans.

Colonel John Davis Bradburn, a Kentuckian in Mexican service, who was commander at Anahuac, added immeasurably to the already strained relations between Mexico and Texas. The most serious of his numerous blunders was the imprisonment of William B. Travis and Pratick Jack after they had irritated him by implying that a force was coming from Louisiana to retrieve some slaves which Bradburn would not release. The extended imprisonment of the two men brought open resistance from the colonists. William H. Jack, Patrick's brother, first tried legal means to have his brother released, and, when that failed, urged colonists to join him in attacking Bradburn. On June 10, 1832, 160 colonists, including some from Brazoria, were outside Anahuac awaiting the arrival of a cannon.

Colonel Jose de las Piedras, Mexican commander at Nacogdoches, arrived with orders to settle the dispute peacefully. The prisoners were released to civil authorities for trial and Bradburn resigned his post. Thus, for the moment at least, pitched battle was avoided.

John Austin, one of the colonists from Brazoria who had lent his support at Anahuac, returned home, retrieved three cannons and some men from Brazoria, and started by boat down the Brazos River toward Anahuac. The boat was stopped by Mexican officials at Velasco and a bloody battle was fought in which the colonists emerged victorious.

This engagement did much to help fan the flame of resistance among the Anglos. They were resolved to rid all the settlements of Mexican soldiers. This they finally did succeed in doing.

Since, so far, the colonists had been so successful, they decided to press for some concessions from the Mexican government. On August 22, a letter was sent from San Felipe to all the districts requesting that delegates be sent to San Felipe on October 1, 1832 for a convention. Sixteen districts acknowledged by sending 58 delegates to the proceedings. Stephen F. Austin was elected president and various committees were set up to investigate topics and propose legislation. Even with the former problems with the Mexicans, the colonists professed loyalty to the new Mexican government headed by Santa Anna and the Mexican constitution.

"The convention placed the greatest emphasis on two requests made of the government at Mexico City: first, the repeal of that part of the act of April 6, 1830, prohibiting Anglo-American immigration; and, secondly, separation from Coahuila and admission of Texas to the Mexican confederation as a state. There was a lengthy and urgent memorial on each. The convention adjourned on October 6."[12]

For some obscure reason the petitions were never presented to the Mexican government. The governor reminded the Texans that the whole idea of the convention itself was in violation of Mexican laws and that Santa Anna would not look upon the convention favorably.

This information did not frighten the colonists in the least. And, in fact, on April 1, 1833, a second convention was held. Chairman of this convention was William H. Wharton, a radical member of one of the two factions of the Texas group. Much the same grievances were aired as at the first convention with the same two major requests of the Mexican government heading the list. And, it was at this second convention that a highly improper - at least in the eyes of the Mexican government - state constitution was drafted. To add insult to injury, the Texans petitioned the central government for approval.

Once again Stephen F. Austin was entrusted with pleading their cause in Mexico City. When he arrived there on July 18, Santa Anna was away, so he met with the Vice-President, Gomez Farias. On October 1, after much frustrating delay, Austin flatly told the Vice-President that if the government would not act, the state government would be set up WITHOUT its approval. On November 5 Austin finally had his long-awaited conference with Santa Anna. The only request that was not approved was the separation of Texas from Coahuila.

Austin left Mexico City on December 10th and on his way back to Texas he stopped at Saltillo on business. There, on January 3, 1834, he was placed under arrest for a letter written in the heat of passion stating that the Texans WOULD set up their own state government. It wasn't until July, 1835 that his release was finally secured.

In April of 1834, the formerly liberal Santa Anna set himself up a dictator after he could see that the army, the clergy, and wealthier classes would oppose any liberal reforms. Consequently, his vice president was exiled and congress was disbanded. October, 1835 saw the form of government change from a federalist system to a highly centralized system with the ruthless Santa Anna in sole command.

*The actual beginning of the revolution can be dated at October 2, 1835.* Mexican Colonel Ugartechea was sent to Gonzales in order to retrieve a 6 pounder cannon which had been loaned to Green DeWitt, the empresario, for defense against Indians. The Texans saw this as an attempt to keep them from resisting the military forces of

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[12]Ibid., p. 76.

Santa Anna and consequently hid the cannon. Runners were sent to secure aid for the Texans and the men were able to send the small Mexican force fleeing for San Antonio. Now the Revolution was officially underway.

A force under Captain George Collinsworth captured Goliad with its extensive supplies and the colonists headed for San Antonio. On December 5, a force of about 300 volunteers under Ben Milam drove Mexican General Cos and his army from the city, but allowed them to return to Mexico.

In March, 1836, James W. Fannin, Jr., with about 450 volunteers sought to aid the defenders of the Alamo who were being besieged by Santa Anna. He was never able to arrive there because of transportation problems. On March 13th and 14th, General Houston ordered him and his men to retreat to Victoria, since it was already too late to help those at the Alamo. After being delayed while waiting for some of his men who had been sent to Refugio to evacuate settlers, he finally began retreating on March 19th. In one of the best known events of the Texas Revolution, Fannin and his men were surrounded on an open prairie by superior Mexican forces, and the next day they surrendered as prisoners of war. A week later, on Palm Sunday, Fannin and his remaining 350 men were slain. News of the massacre aroused citizens of the United States sufficiently for them to send financial and moral support.

On March 6, 150 men defending the Alamo in San Antonio were also slain at the hands of Santa Anna. Among those men were William B. Travis, David Crockett and his "Tennessee boys," Jim Bowie, and James Bonham. Although their situation had been hopeless from the beginning, the delay caused to Santa Anna bought much-needed time for the struggling Texans. For these few precious days, those men paid with their lives.

Several days before that, on March 2, 1836, a Declaration of Independence was presented before a Texas governmental convention. It was adopeed on March 16th. The convention set itself up as the government of Texas, and Sam Houston was appointed commander in chief of land forces. As a last act, an *ad interim* government was set up on March 17th. David G. Burnet was elected president and Lorenzo de Zavala was elected as vice-president.

Houston had left the proceedings to go to the relief of the Alamo, but at Gonzales where he had stopped for reinforcements, he learned that their arrival was too late. When Houston learned of Santa Anna's army moving eastward, he decided to retreat.

With news of Houston's retreat toward San Felipe, civilians and soldiers alike also began to flee. The government had been moved first from Washington to Harrisburg (present-day Houston) and then to Galveston Island.

Santa Anna and his forces arrived at San Felipe, which Houston's men had burned in their retreat on April 7th. At Fort Bend, where he took over the ferry, he heard that the seat of governemnt had been moved to Harrisburg; he wasted no time in setting out to cover that short 30 mile expanse, but arrived too late to capture the Texas officials. He missed them once again at Morgan's Point, on the mainland overlooking Galveston Bay. At this point, on April 20th, he set up camp "with open country on his left flank, the San Jacinto River on his right, and Buffalo Bayou and Houston's army before him."[13]

Sam Houston and a force of some 900 men were situated near Lynch's Ferry where Buffalo Bayou and the San Jacinto Rivers joined. He did not have any official strategy in mind, but adopted a watch and wait policy toward the Mexican army. The opportunity for action came on April 21st during Mexican siesta time. "A rise in the terrain hid the Texans from view until they were within 200 yards of the flimsy Mexican barricades. The shape of the terrain, the Mexican habit of taking a siesta, and the utter contempt in which Santa Anna held the Anglo-American troops, afford the only explanation of one of the most astounding facts in all military history: an army was taken by surprise by a much smaller force advancing for a mile across a prairie in the middle of an April afternoon. Santa Anna had made his second mistake within 24 hours."[14]

The entire Battle of San Jacinto lasted for about 18 minutes, in which time 630 Mexicans were killed, 208 were wounded, and 730 were taken prisoner, including Santa Anna himself. Nine Texans were killed and 34 wounded.

## V. *FROM REPUBLIC TO STATEHOOD*

Along with the astounding victory, the Texans faced many problems and responsibilities. There were still about 2000 Mexican troops in Texas; Sam Houston was incapacitated by a shattered ankle; the army was as thoroughly disorganized by their stunning victory as their opponents were disorganized by defeat.

The initial problems confronting the government, then, were to establish order, strengthen the army and its supplies, and achieve Mexican recognition of Texas Independence.

Time itself was their biggest ally, for as people learned how total the victory at San Jacinto had been, peace and order were

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[13] Ibid., p. 96.

[14] Ibid., p. 98.

restored. Those who had fled their homes during Santa Anna's advancement returned rapidly. The government headquarters were moved from Galveston to Velasco and, on July 23, President Burnet called for a general election on the first Monday in September to establish a constitutional government.

In this election, "three major issues were to be decided: first, ratification of the constitution; second, the election of constitutional officers who would take office provided the voters approved the constitution; and third, whether the new government should seek annexation to the United States."[15]

The first president of the Republic of Texas was Sam Houston, who was elected by a majority of 80% of the votes cast. Ironically, of the three men who were running for the office, Stephen F. Austin received the fewest number of votes. There were several reasons for his gradual disfavor among the people of Texas. First of all was his initial opposition to the independence of Texas; he wanted only to support the Mexican constitution of 1824. Secondly, it was mainly through his efforts that the prisoner Santa Anna was saved from a firing squad and finally sent back to Mexico. And, thirdly, he was charged with not serving the Texas cause well in his trips to the United States. Houston, however, chose Austin as his Secretary of State and his other opponent for the presidency, Henry Smith, as Secretary of the Treasury. Two months later, though, Austin died and Robert A. Irion fulfilled the rest of his term in office. Another pioneer Texas leader, William H. Wharton was sent to Washington to represent the new-born Republic.

Some of the congress' first legislation included re-opening of land offices which had been closed at the beginning of the revolution. By using land as payment, the Republic was able to reimburse soldiers according to their lengths of service.

One of the infant Republic's major problems was the financing of its activities. Houston's expenses amounted to almost $2,000,000 during his term of office, but total income for the same period was far below that level. Income included tariffs on imports, port and tonnage fees, property taxes, poll taxes, business taxes and land fees. These still did not finance the expenditures. In fact, at one time the Republic was so poor that Henry Smith, the Treasury Secretary, was unable to carry on his business because of the absence of stationery and any money with which to purchase any!

So, legislation in 1837 authorized paper money issuance. The President would issue $650,000 worth of promissory notes payable within 12 months and including a 10% interest rate. These notes were widely circulated and suffered very little depreciation.

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[15] _Ibid._, p. 106.

During the next Presidential election, Vice-President Lamar was elected, since no President might succeed himself. During his term of office, public lands were set aside for educational purposes, the permanent capital was established and duly named Austin (October, 1839), bloody Indian wars were engaged in and the financial situation was so bad that paper money issued in the amount of $3,552,800 was only worth 10-15 cents per dollar.

The third election saw Sam Houston once again as President. Houston embarked on an austerity program designed to pull the struggling Republic out of its financial quagmire and had fairly positive results. So carefully were expenditures controlled that in three years the government only spent $500,000! He also instituted Indian policies that saw a number of treaties signed and the end to the Indian hostilities.

During these years the Republic saw phenomenal growth. Liberal land policies constitute the main reason for this rapidly expanding population. Homestead acts, preserving one's home from seizure for unpaid bills, also added to the populatiry of the region. And finally, contracts with foreign immigrants saw an influx of Europeans, especially Germans and some Czechs.

"In summary, the frontier line of settlement in 1846, when a state government replaced that of the Republic, extended from Corpus Christi to San Antonio on the Southwest, and thence northward through New Braunfels, Fredericksburg (settled in 1846), Austin, Belton, Waco, Dallas, and Collin County to Preston on the Red River near the present city of Dennison. The main reason for such a phenomenal extension of settlement, in the face of danger from Indian attacks and Mexican invasion was the liberal land policy of the Republic."[16]

From 1836 through 1839, Texas had actively sought first, recognition by the United States, and then, annexation. The Texans managed to achieve recognition by the end of Andrew Jackson's term of office. Annexation was quite another thing, though. There was so much opposition to it in the United States Congress that on January 23, 1839, Texas formally withdrew its offer of annexation. Then, finally, in October 1843, President John Tyler opened negotiations for annexation by treaty. The treaty was defeated both because it was an election year and because the question of slavery had alréady become an issue of conflict. Texas' annexation, in fact, became one of the campaign issues of the year. Annexation came before Congress once again on February 28, 1845 and the joint resolution was finally passed and was signed by President Tyler on March 1, 1845. Then, on October 13, 1845, the people of Texas approved both annexation and a new constitution. Congress accepted the constitution on December 29, 1845 and Texas officially became a state.

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[16]Ibid., pp. 122-123.

## *VI. FROM STATEHOOD TO THE CIVIL WAR*

On December 15, 1845, election of the new State officers took place. J. Pinckney Henderson was elected governor and Albert C. Horton was elected Lieutenant Governor. When the Texas received word that President Polk had signed the act admitting Texas to the Union, President Jones of the Republic called for the legislature to meet in Austin on February 16, 1846, and on February 19, the reins of government were officially passed from the President of the Republic of Texas to the State's first governor. At that same time, Sam Houston and Thomas J. Rusk were elected as the state's first senators.

As had been anticipated, Texas' annexation to the United States led directly to a war with Mexico. The Republic of Texas had established the Rio Grande as its boundary, but Mexico was unwilling to accept this boundary. President Polk ordered General Zachary Taylor to move into the area along the Rio Grande to enforce the Texas claims. Skirmishes on April 24, May 8, and May 9 resulted in the United States' declaration of war upon Mexico on May 13th. The war ended with the treaty of Guadalupe Hidalgo on February 2, 1848, by which terms Mexico recognized Texas independence and the Rio Grande boundary, and, for a payment of $15,000,000, ceded New Mexico and upper California to the United States. Thus, Mexico lost any claim to the area north and east of the Rio Grande.

The northwestern boundaries were not settled until 1850, however, due to claims and counter-claims within the United States. Included in the Compromise of 1850, however, was the final boundary establishment which is present today; territory beyond that boundary which was claimed by Texas, was included in the Territory of New Mexico, and Texas was paid $10,000,000 for the land.

Governor Elisha M. Pease's term of office from 1853 to 1857 saw a number of important events for the future of Texas take place. "The most important act of his administration was the school law of 1854. By its terms the state set aside $2,000,000 of the indemnity bonds which it had acquired from the United States in the settlement of 1850 as a permanent endowment for public schools. Income from the fund was distributed each year on a per capita basis to supplement the receipts from the one-tenth of the annual revenues which the constitution had reserved for the schools."[17] This law provided the foundation for public education in Texas.

From the political standpoint, Pease's administration was

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[17] Ibid., p. 143.

important because it was during that time that political parties were first in evidence in the state of Texas. Finally, it was during Pease's term of office that the enormous public debt was at last paid off.

In the 1857 election, Sam Houston was defeated by Hardin R. Runnels, largely due to the issues preceding the Civil War. Since many immigrants were from the deep south, they favored a states' rights candidate. But in the election of 1859, the faction supporting the Union solidified, and Sam Houston was elected governor on an independent ticket.

Once again, though, those more radical factions calling for secession of Texas from the Union were gaining ground, and on March 5, 1861, Texas formally joined the Confederate States of America and withdrew from the Union. On March 16, the same convention declared the office of the governor of Texas vacant and made Lt. Governor Edward Clark governor.

Although officially a part of the Confederacy, almost the only military activity directly related to the Civil War occurred in the area along the Gulf Coast. In July of 1861, a Federal blockade included Galveston Island; therefore, before a sizeable enemy force, Confederate troops were forced to evacuate the Island in October, 1862. John B. Magruder was determined to recover the island, though, so with 300 men he recaptured the island on January 1, 1863.

Other activity was engaged in along Sabine Pass. In September, 1862, it, also, had been captured by Federal troops and forced the Confederate soldiers out. On January 21, after their success at Galveston, Confederate forces decided to recapture that area, also. This they did successfully. A major Federal campaign was then instituted to retake Sabine Pass once again. "Four gunboats and 17 transports bearing about 1,500 troops for the initial landing attacked it on September 8, 1863. To meet this formidable force, Lieutenant Dick Dowling had two small gunboats and a garrison of 46 men! Yet he disabled and captured two enemy craft, took about 350 prisoners, and turned back the entire expedition. His victory was a severe blow to the morale of the North and augmented doubts about the efficiency of the Federal Navy."[18]

The Federal troops were much more successful in other areas along the Gulf Coast. By 1863 they had overtaken Brownsville, Corpus Christi, Aransas Pass, Indianola, and others, leaving ONLY Galveston and Sabine Pass in Confederate hands.

On August 6, 1866, newly elected governor G. W. Jones proclaimed

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[18] Ibid., p. 193.

the insurrection of Texas over. Reconstruction in Texas proved to be nearly disastrous. The main problem was that of labor. To many former slaves, freedom meant freedom from work. "Cotton, practically the only money crop, declined in value from 31 cents per pound in 1866, to 17 cents in 1870 and 13 cents in 1875. The total production of cotton declined from 431,000 bales in 1859 to an average of 343,000 bales for the years from 1866 to 1870, both inclusive."[19] When working for wages was replaced in large part by tennant farming and the sharecropping system was instituted, cotton production by the year 1873 reached 500,000 bales per year.

The growth in the cattle industry also helped spark new life into the Texas economy; hundreds of thousands of cattle made their way from southern and western ranges to northern markets.

Industrial growth, although quite slow initially, advanced steadily. Railroad mileage increased from 395 miles in 1865 to 1,650 in 1874.

"Economic losses through the war and reconstruction were soon overcome, but the damage to political institutions was more enduring. The people could not forget that radical Republicans in Congress had imposed on the South a harsh program designed, it seemed, more for political purposes than for the general welfare. Thus, the Republican Party in the state was all but destroyed by the reaction against the Davis administration, and a one-party political system consequently has prevailed for a century."[20]

In 1872, with the election of a Democratic legislature and election of Governor Coke in 1873, the Democratic Party held a firm grip on State politics and were determined to rid the State of the last vestiges of radical Republican rule.

One of the most far-reaching accomplishments during the decade from 1876-1886 concerns public education. Both higher education and the State public school system were begun in that same period. The Agricultural and Mechanical College (present-day Texas A & M) was established near Bryan as the first institution of higher learning in the State (1876). Then, in 1883, the main University of Texas at Austin was opened, with the Galveston Medical Branch following in 1887.

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[19] Ibid., p. 221.

[20] Ibid., p. 222.

## VII. *FROM AGRICULTURE TO COMMERCE*

The greatest asset in converting the largely agricultural area of Texas to a State of industrial importance was the expansion of the railroads. Rapid, cheap, and dependable transportation was needed to cover the vast expanse of land and the scattered communities within the State.

In addition to local seductions of the railroads by communities (e.g., for a time Fort Worth offered bonuses to railroads coming into that city), a State law in 1871 heavily subsidized railroad building in the State. The bulk of railroad construction in Texas was completed within 20 years, and in 1890, Texas had 8,710 miles of railroads. This rapid increase made it possible for Texas to have more miles of railroad than any other state by 1904.

The industrialization in 1870 was still confined to small community shops; but, within the next several decades, the movement gained momentum and manufacturing came into its own, although it still depended heavily on agriculture and natural resources. Into the 1880's "flour milling was the leading industry, ranking ahead of that of lumbering. Meanwhile, manufacture of products from cottonseed steadily increased in importance, ranking second in the State's industrial economy in 1900."[21] Meat packing plants also grew in importance. The first was established in Victoria in 1868; later, plants were established in Fort Worth, Dallas, San Antonio, El Paso, and Amarillo.

In the mineral sphere, oil, of course, was the primary natural resource to be exploited. Oil was discovered accidentally in Nacogdoches County in 1867, and the Gulf Coast region is especially rich in this commodity.

There were also industrial developments in coal, salt, iron ore, limestone, granite, and sulphur mining.

"Paralleling the emergence of a commercial economy in Texas was the rise of cities. In 1870 only 6.7 percent of the people lived in incorporated urban areas of 2,500 population or more. By 1900 urban incorporated centers contained 17.1 percent of the population; and by 1930 the figure had climbed to 41 percent."[22] This explosive population growth and concentration in urban areas was brought about largely through better transportation facilities and through the astounding growth in oil and oil-related industries.

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[21] Ibid., p. 280.

[22] Ibid., p. 285.

Politically, during this era, perhaps the best known figure is that of James Stehen Hogg. His public career began in 1886 as attorney general under Lawrence Sullivan Ross. His efforts were directed against unlawfully operating insurance companies. He was also instrumental in the passage of antitrust legislation and measures were undertaken to regulate railroads operating in Texas. It wasn't until Hogg had been elected governor that a commission to regulate railroads was finally set up (April, 1891).

In 1914, another of the most well-remembered of Texas' governors was elected. James E. Ferguson, who rose from grinding poverty to be the chief executive of the State, had great influence in Texas politics for a generation. His determination to help the tennant farmer and his great appeal to that group led to his victory in the election in 1914. In 1916, Ferguson was re-elected easily and undertook a continuation of a constructive legislative program.

In 1917, Ferguson's popularity began to wane as his problems with the University of Texas, which had begun in 1915, came to a head. In June, 1917, as an outgrowth of that argument, Governor Ferguson vetoed the entire appropriation for the University. The situation worsened, and on September 24, the governor was convicted on ten of the 21 charges that had been made against him in impeachment proceedings. The impeachment forbid him from holding office again in the state of Texas.

The end of the first world war brought many changes on a State, as well as a national level. "The depression of 1920 was short-lived, and Texas shared the general prosperity that soon returned. New plants were erected for the manufacture and processing of goods, land values doubled, millions were invested in public utilities, and thousands of new oil wells belched forth their black gold. The state highway system was constructed, destined to be used by an ever-increasing number of foreign and Texan-owned cars. New colleges were built, and thousands of youths crowded the old ones; the public school system grew larger and more creditable each year. Prices of farm commodities lagged behind those enjoyed by industry, but bountiful crops tended to offset the price handicap. Texas was prosperous during the 'mad decade,' and people paid no heed to timid prophets here and there who told them that ahead were lean years that would devour the fat ones"[23]

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[23]Ibid., p.318.

## VIII. SIGNIFICANT SITES AND SUGGESTED POLICIES

Along with statehood have come many privileges as well as many responsibilities. Texas has had in the past and continues to have some of the most sobering and challenging problems with which any state has had to cope and seek solutions.

As can readily be seen, many of the major historical events in Texas have occurred in the counties in the Coastal Resources Management Program. There are certain areas which are especially rich with respect to historical sites, monuments, and architecturally significant sites that have played a major role in the development of the State.

Consequently many of these areas have been designated as historically significant points of interest by the Texas State Historical Survey Committee in a continuing effort to locate and preserve these areas (See Figure 1.). These sites have been included as a task in the Coastal Resources Management Program for two reasons. First of all, they provide educational benefits to anyone who is interested in the colorful history of our State. Secondly, and not to be overlooked, many of these sites lend themselves to tourist attractions, and this activity, bringing visitors from widely separated areas can be very beneficial to the region from a financial standpoint.

With thirty-four historical sites marked with plaques by the Texas State Historical Survey Committee, Galveston County is able to claim the largest number of sites in the coastal area. Many of these sites are buildings of architectural importance, such as the Galveston County Courthouse and St. Mary's Cathedral. Others such as West Galveston Island, which provided sanctuary for the famous Jean Laffite, and a Karankawa Indian campsite, lend themselves easily to imaginary pictures of dashing pirates and cannabilistic Indians.

Of the thirty-five counties considered in the Coastal Resources Management Program, Harris County contains the second largest number of historically important sites. Some of the most famous of these include the San Jacinto Monument and Battleground, the Battleship *Texas*, Old Market Square, Lynch's Ferry, and the original Port of Houston. As for culturally significant sites, Houston's new Astrodome and Astrohall merit mention.

Scattered throughout the remainder of the area are such varied areas as cemetaries, which are important for local historical reasons, all the way to sites as the first sulphur mine in Texas, the first railroad line in the State, and sites of famous battles of the Texas Revolution, such as the Goliad Massacre.

From the preceding information, it should be obvious that historical and cultural sites must be taken into consideration

NUMBER OF HISTORICAL SITES IN EACH COUNTY

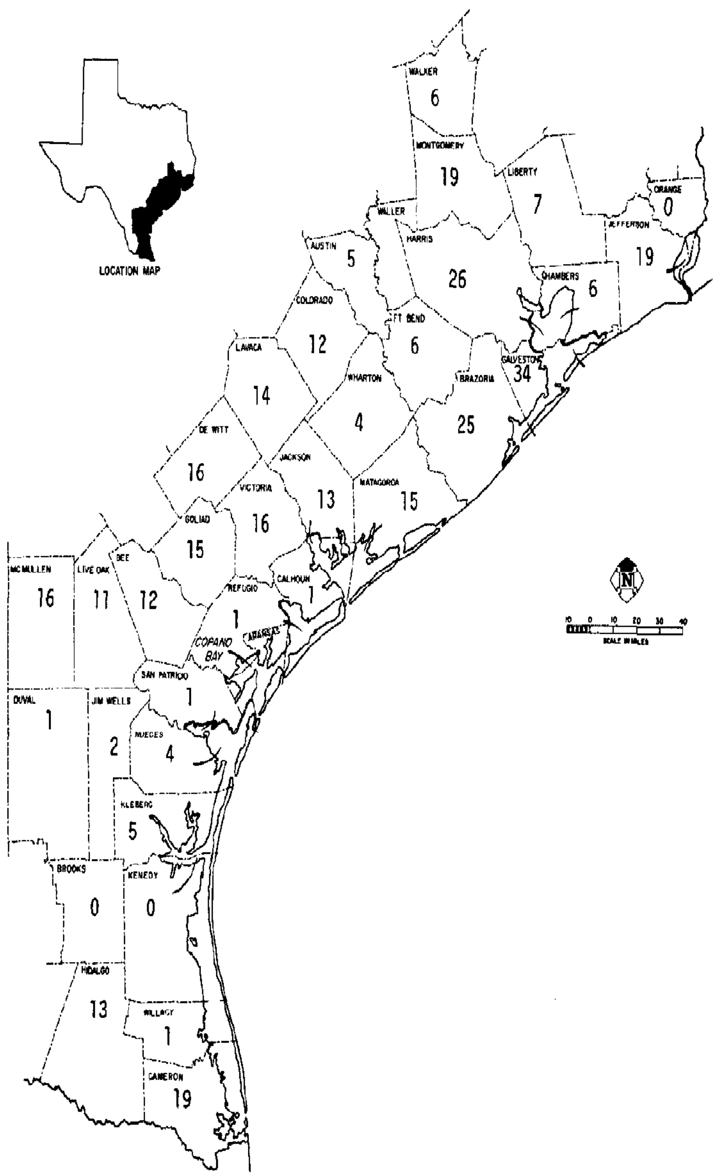


Figure 1

when planning for any land usage or developmental aspects along the Texas coast. The "Goals for Texas" program, a joint undertaking of the Office of the Governor and many local governmental entities plus countless private citizens, presented in its Phase II Report a set of objectives for the entire State. Those pertinent guidelines set down by that effort which relate to the State in general or to specific points within the Coastal Zone are given below.

SIX-YEAR GOALS

Develop State and local financing programs for the purchase and the renovation of buildings of historic and architectural value by developing a cooperative program with the State Historical Survey Committee, the Parks and Wildlife Department, local civic organizations, and governmental units.

Determine historic site acquisition methods which are to be employed and obtain the selected sites.

Increase public knowledge and appreciation of South Plains history by acquisition of historic and prehistoric sites.

Identify methods to publicly or privately acquire historic sites of statewide and regional significance and expand existing sites.

Acquire, preserve, and use local and county histories and records as resources for annual prehistory and historical celebrations.

Acquire and develop plans for preserving historical sites such as: Fort Concho, Fort McKavett, Old Fort Terrell, Fort Chadbourne, Fort Lancaster, Real Presidio de San Saba, Mission San Saba, Camp Elizabeth, Camp J. E. Johnston, and Camp San Saba.

Provide museums in Starr County, Zapata County, Jim Hogg County, and Webb County for the preservation and educational display of historical materials.

Cooperate with the State Historical Survey Committee, the Parks and Wildlife Department, and Highway Department in the development of a regional historic preservation plan.

Identify, acquire, and develop historical sites such as Pea Ridge site in Ward County, buildings in Fort Stockton, and the grounds at Horsehead Crossing.

Acquire and develop the Indian pictographs at Paint Rock as a State historical site.

TWO-YEAR GOALS

Analyze existing historic sites and determine remedial work required for those sites to be used as tourist attractions.

Identify and inventory buildings which portray local and Texas history and significant architectural design by encouraging local citizens to organize local historical societies or to work through civic clubs in cooperation with appropriate State agencies.

Provide for the preservation of sites of interest of local cities and organizations with the use of federal and State grants.

Preserve local, urban, and rural historical sites of interest through expanded planning.

Encourage a comprehensive historical site study that will be integrated into the program of site preservation as contrasted to acquisition and development of facilities for active recreation.

Initiate archeological excavations of those sites where historical records are incomplete.

Expand existing historic sites to incorporate all of the significant regional historic features.

Locate and identify historic and prehistoric sites of regional significance; and acquire for development the Comanche Canyon site in Lubbock as an area of historic interest and recreation opportunity.

Encourage the designation of all registered historic landmarks on Texas highway maps and related publications.

Establish a restoration and preservation program for historic sites and determine a sound method of management.

Survey, preserve, mark, restore, and interpret prehistoric sites and historic buildings, with special attention to band stands, courthouses, opera houses, and other buildings which can become attractions for the Texas Travel Trails.

Provide historical markers for all historical sites with permanent type plaques or stones containing descriptions.

Locate citizens who are qualified and interested in preserving recreational and historical sites and organize working committees.

## BIBLIOGRAPHY


Castaneda, Carlos E. (translator). The Mexican Side of the Texas Revolution. Dallas: P. L. Turner Company, 1925.

Clark, Joseph Lynn. A History of Texas, Land of Promise. Boston: D. C. Heath and Company, 1939.

Clark, Joseph Lynn, and Linder, Dorothy A. The Story of Texas. 2nd ed. Boston: Heath Company, 1963.

Clark, Joseph Lynn (with the collaboration of Elton M. Scott). The Texas Gulf Coast; its History and Development. New York: Lewis Historical Publishing Company, 1955.

Johnson, Frank W. A History of Texas and Texans. Chicago: The American Historical Society, 1914.

Jones, Anson. Memoranda and Official Correspondence Relating to the Republic of Texas, Its History and Annexation. D. Appleton and Company, 1859.

Molyneaux, Peter. The Romantic Story of Texas. Dallas: The Cordova Press, Inc., 1936.

Newton, Lewis W. and Gambrell, Herbert P. A Social and Political History of Texas. Dallas: Turner Company, 1935.

Richardson, Rupert N.; Wallace, Ernest; and Anderson, Adrian N. Texas - the Lone Star State. 3rd ed. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1970.

Wortham, Louis J. A History of Texas from Wilderness to Commonwealth. Fort Worth: Wortham-Molyneaux Company, 1924.

# MARINE AFFAIRS IN TEXAS

# A HIGHER EDUCATION REPORT

Prepared by

SEA GRANT PROGRAM

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for

COASTAL RESOURCES MANAGEMENT PROGRAM

INTERAGENCY NATURAL RESOURCES COUNCIL

DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

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# MARINE AFFAIRS IN TEXAS

# A HIGHER EDUCATION REPORT

## *I. INTRODUCTION*

A delineation of what constitutes marine affairs is essential to a discussion of marine education. For the purposes of this discussion the marine sphere will be considered to include:

> *the sea, the sea floor, and the land under the sea floor, the lands contiguous to the coast, the air above the sea, and any of man's industrial, commercial or recreational activities that occur because of his proximity to the sea and the land/water interface.*

A discussion of marine higher education requires some consideration of general higher education since the former is only one element of general higher education. This report attempts to bring out some pertinent elements in the development of American higher education in order to present a few comments on Texas marine education in proper context.

## *II. A PERSPECTIVE OVERVIEW OF AMERICAN HIGHER EDUCATION*

The American educational system is presently under scrutiny from several quarters. Educators, legislators, students and the public are very concerned about the form and content of the education available to the present generation of students. This is unusual only in its present intensity and some of its specific concerns. *The people of the United States have always placed great faith and hope in their unique form of public education.* Because of the close scrutiny inspired by this faith and hope, the system has remained responsive to public perception of national needs.

One of the early important changes in higher education in response to a societal need was the development of *land grant colleges* for the improvement of agriculture. This revolutionary (in its time) program focused on applied problems and introduced the concept of public service extension activities. It led to the establishment of field stations oriented toward experimentation relevant to regional problems (1).

Solutions to agricultural problems often required multidisciplinary cooperation. This cooperation continued over time because it was successful and because agricultural problems grew more complex. It will continue to be encouraged because of the need for food production to keep pace with increasing population.

Paralleling the development of the agricultural sciences was a *tendency, among engineers and scientists, toward discipline fragmentation* (1). As man's knowledge of his universe expanded, specialized disciplines emerged to cope with technological advances. This fragmentation of disciplines was part of the reason for very rapid expansions in technology that occurred. This fragmentation changed many aspects of the educational processes as more academic departments developed, concentrating on narrow aspects of technology. However, according to Berelson (1), past attempts to establish separate graduate colleges separate from undergraduate feeder institutions have failed. They failed at least partly because of the need for coherent broad-based undergraduate programs.

In the post-Sputnik era greater emphasis was placed on *mathematics, the sciences, and foreign languages* in secondary education as a result of the writings of such authorities as James B. Conant (2,3) and Hyman G. Rickover (9,10). The emphasis placed on quality, science-oriented, education by these authorities caused teachers, students, and parents to place great value on college education. *The increased demand thus created for education for all beyond high school has placed great strains upon our system of higher education.*

Perhaps more importantly, this emphasis is one of the factors that has created a *serious shortage of skilled craftsmen.* The same educational system that led to the high evaluation of a college education also led to the great technological advancement that required highly skilled technicians and craftsmen. Yet these craftsmen are in short supply because their value to society has been lost against the backdrop of the high value placed on the college diploma.

Furthermore, the rapid technological advancement appears to have been made to some extent at the cost of some degradation of the environment. Environmental improvement requires the *same kind* of multidisciplinary cooperation that was brought to bear on agricultural problems around the turn of the century (1).

In summary, it emerges clearly that the educational process is not merely a gathering together of a group of unrelated academic programs in an atmosphere of isolation. *Education involves academic programs, certainly, but it includes research, extension activities, field work, communication, information dissemination and central to it all, manpower development.*

While a knowledge of the content of the basic disciplines is important, education is no longer a matter of a few rigid curricula. These curricula must be kept flexible to suit the needs of the student. *Education should be relevant in that programs should be planned to meet problems that are emerging.*

Research and education in the decade of the 'Sixties were oriented toward economic and technological advancement and to the concurrent proposition that everyone should have a college education. Perhaps the emphasis for the 'Seventies and beyond still should be on technological advancement, but not at the cost of a spoiled environment; it should be on advancement with a *social conscience;* and it should be on a college education for all who want it and can profit by it, with a renewed emphasis on the social and economic value and worth of the skilled craftsman and the technician. This proposed new emphasis in education should begin at the elementary school level and extend through all levels of education including public-supported technician training programs and public service continuing education for adults.

## *III. MARINE RELATED HIGHER EDUCATION*

The ideas brought out in the preceding section were addressed to some of the philosophy and problems of general higher education. Much of the discussion relates as well to marine aspects of higher education. The purpose of this section of the report is to summarize some of the current thought on how best to present marine related education programs to interested students. At the outset it should be made clear that marine education like general education cannot exist alone, but must be integrated into the total educational system. *Marine education can no more stand separately than can the physical sciences or engineering or agriculture.* Thus the brief look at some of the elements of general higher education contained in the preceding pages has many direct applications to marine related higher education.

Marine related education is no more a gathering together of a group of unrelated academic programs in an atmosphere of isolation than is general education. Although some marine science programs are ideally suited for graduate study, all of marine science education can *not* be presented separately as a graduate level program. An appreciation of the marine environment begins at the elementary school level.

Marine higher education, just as does general education, involves research, extension activities, field work, communication of information and manpower development. As has been stated in Marine Science Affairs - Selecting Priority Programs (8, Chapter VII, p. 97):

> *During the coming decade, our ability to develop marine resources and wisely manage the marine environment will depend on the availability of trained manpower, facilities, and equipment to conduct programs of creative (pure and applied) research in the fields of marine science, engineering and related disciplines... legal, economic, medical, and sociological aspects of resource management, use, and conservation ... and marine commerce (in short, marine affairs).*

In another section of the same report it is stated that (8, p. 37)

> *Rational management decisions on the use of the coastal zone should be predicted on scientific information as to the unwanted and often unanticipated effects of man's activities on the coastal ecology... Monitoring capabilities to detect the changes already occurring in water quality are too limited to meet needs.*

In the so-called Stratton Report (2, Volume I, page I-44), the following recommendation is made:

> *... estuarine and coastal research centers (elsewhere called Coastal Zone Laboratories and referred to earlier in the present report as field stations) should develop appropriate training programs in their specialties; additional training programs for marine technicians should be created.*

*These training centers should supplement existing on-campus marine education programs, not supplant them.* These same centers could become extension centers in addition to their function as research centers and supplemental training centers.

In summary then, certain factors regarding marine related education emerge rather clearly. First, as in the case of other fields of study, students need to be introduced to marine related studies at an early stage of education, and some degree of exposure needs to be continued throughout the public school years. This exposure could be related to geoscience and/or conservation units of instruction. Vocational guidance programs also are needed.

On the college level, marine education should remain integrated with the standard, supportive curricula, and not separated. Woods Hole Oceanographic Institution and Scripps Institution of Oceanography both began as separate independent institutions devoted exclusively to oceanographic investigations and training. Both subsequently found it necessary to become affiliated with education institutions farther inland which possessed the full range of educational programs.

On the other hand, *field stations* situated along the coast and responsive to the special problems of a particular region are vitally important for research, on-site training and extension activities. These stations are analogous to the agricultural experiment stations, which dot the country-side. Such stations could serve a very useful purpose as extension centers, and as adult education and retraining centers as well.

Available evidence indicates a need for *more trained craftsmen and technicians* to support the viable and expanding marine activity on the Texas Coast (7,11). The areas of specialization of these technicians include oceanographic instrumentation, underwater welding, seafood processing and numerous others.

The point that marine education should be conducted in conjunction with other educational endeavors, and not be expected to stand alone in isolation from other academic units, has previously been made. Another facet of the problem of conducting meaningful and relevant marine education programs should be mentioned, namely the *management of such programs*. This problem was examined in a recent research study (12) whose purpose was to design an effective and efficient model for managing a Sea Grant Institutional Program. One of the major findings of the study was the importance of a unified management for such a marine activity. The multi-departmental, inter-disciplinary nature of marine programs require coordinative direction of a much greater degree than most other university programs. The high dollar level of expenditure for most comprehensive marine programs is also an important factor leading to a need for careful coordination of the activity.

In the following section of this report, a brief summary of the majority of the existing programs is given. *The summary highlights both the strengths and some of the weaknesses of existing marine programs in Texas educational institutions.* The survey first lists the state-supported senior colleges and universities followed by private university programs, and concludes with a summary of several technical institutes, junior colleges and other specialized activities.

## *IV. SUMMARY OF TEXAS MARINE EDUCATION PROGRAMS*

Several of the state supported institutions of higher education have marine related educational and research programs. Although the central focus of this report is on educational programs, some attention will be given to research programs since research is one of the cornerstones of higher education. For the purposes of this report, higher education will be defined as any form of education beyond the secondary school. It must be recognized, too, that leadership for public school curriculum change will often originate on the university campus, so ways and means of bringing about these curriculum changes will be discussed in the report as one function of higher education.

A report on marine related education programs was prepared as part of a 1968-69 study by the Industrial Economics Research Division (IERD) of the Texas Engineering Experiment Station of Texas A&M University (6). Some of the university marine science expenditure for the current academic year were cited by witnesses at the *Texas House of Representatives Interim Study Committee for a Texas Institution for Oceanography* hearings on education in College Station September 14 and 15 (7). In the IERD study it was reported that the state supported colleges listed on the following pages had marine science programs, supported at the indicated level of funding (1970 levels, where given, were from testimony at the hearings of the *House Interim Study Committee* *for a Texas Institution of Oceanography).* Some university, junior college, technical institute, and special marine education programs are not included in this summary, which was gleaned from the two sources cited above. Available time did not permit a complete, in-depth, inventory. Such an inventory should be conducted prior to initiation of a major marine education development program in Texas.

The expenditures given in the tables above are project expenditures and as such do not reflect funding for facilities maintenance or planned (or in progress) construction. Faculty instructional salaries are not included in the 1968-69 tabulation, except where faculty members have been given released time to conduct research, or where such salaries cover a part of the cost of guiding a graduate student research project. It should be noted that the expenditures for 1970-71 for the *University of Houston and the University of Texas System include environmental and/or water resources funds. Those for Texas A&M are for specific marine related activities only.* In the case of the 1970-71 tabulation, the funding lists all expenditures except those for facilities construction.

Facilities planned or available for marine science education and research are very important because of the need for expansion to take care of increasing enrollments. As was the case in research and teaching expenditures, illustrated by the tables above, the leading universities in the terms of facilities available, planned, and under construction are *Texas A&M University* and the *University of Texas at Austin.* Other universities have some facilities expenditures as well. These expenditures are given in the following narrative discussions.

## V. *PROGRAMS AND FACILITIES OF TEXAS A&M UNIVERSITY*

### *Oceanography Department*

The Department of Oceanography at Texas A&M University established in 1949 offers the M.S. and Ph.D. degrees in biological, chemical, geological, meteorological, and physical oceanography. The department is primarily engaged in graduate education and research. A total of 180 advanced degrees have been awarded since establishment of the department in 1949. Currently it has 95 graduate students enrolled and 26 faculty members. During the 1968-69 school year, seven M.S. degrees and seven Ph.D. degrees were granted in the department.

The department budget for the 1968-69 school year was $2,100,000. In support of its graduate academic program, the department conducts a broad program in basic research. Principal sources of support for the overall program of research include

TABLE I

| Institution | '68-69 Funding | '69-70 Funding |
|---|---|---|
| Texas A & M University | $2,865,724 | $4,350,000 |
| University of Texas at Austin | 1,026,402 | 4,300,000* |
| University of Houston | 713,498 | 360,000* (est.) |
| Texas Tech University | 37,000 | N/A* |
| Lamar State College of Technology | N/A* | N/A* |
| Texas A & I University | 40,000 | 40,000 |
| Southwest Texas State University | 23,000 | N/A* |

* The $4.3 million is for entire U. T. System and includes Water Resources funds.

*(est.) - The estimate of $360,000 was a verbally cited figure given to the Lemmon Committee.

*N/A - Not Available

In addition a few state-assisted community colleges-technical institutes reported expenditures for marine science programs. These were:

TABLE II

| Institution | '68-69 Funding | '70-71 Funding |
|---|---|---|
| Del Mar College | 110,800 (26 months) | 54,000 |
| Texas State Technical Institute (Waco) | 45,000 | 35,500 |
| Galveston College | 50,000 | -0- |

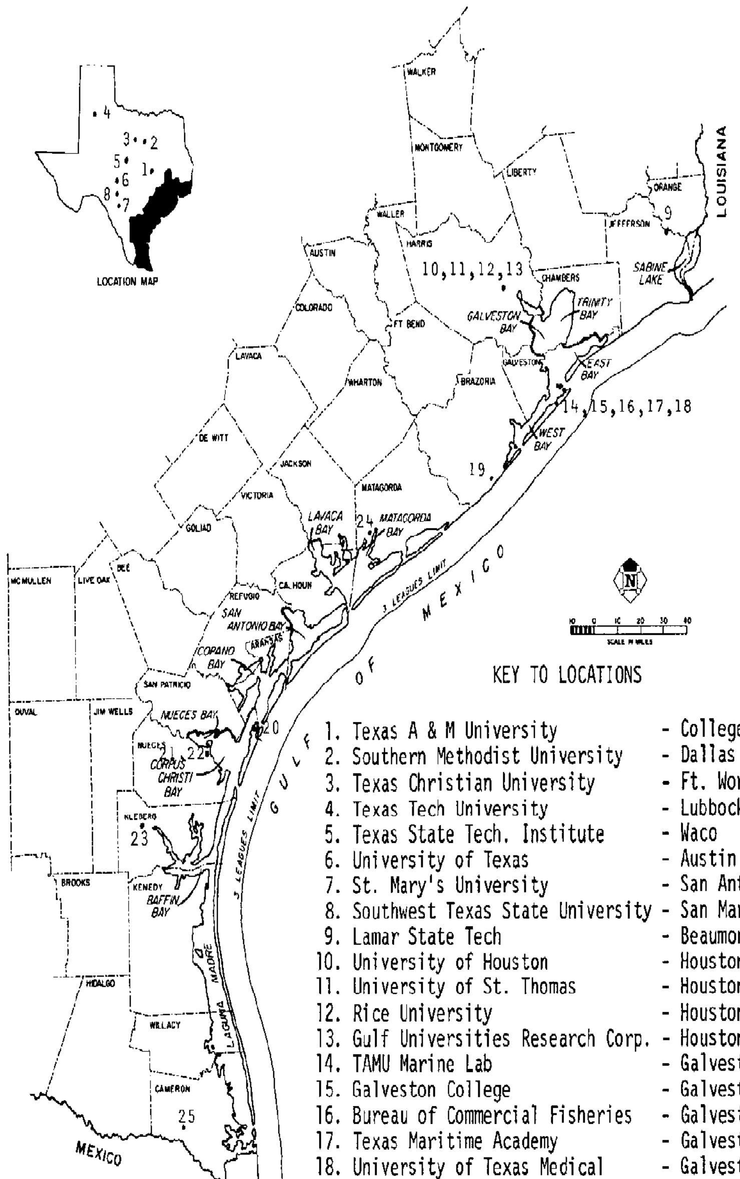
Other institutions in which marine activities have been initiated since the IERD report are:

TABLE III

| Institution | '70-71 Funding |
|---|---|
| Brazosport College | $18,000 |
| Texas State Technical Institute (Harlingen) | 20,000 |

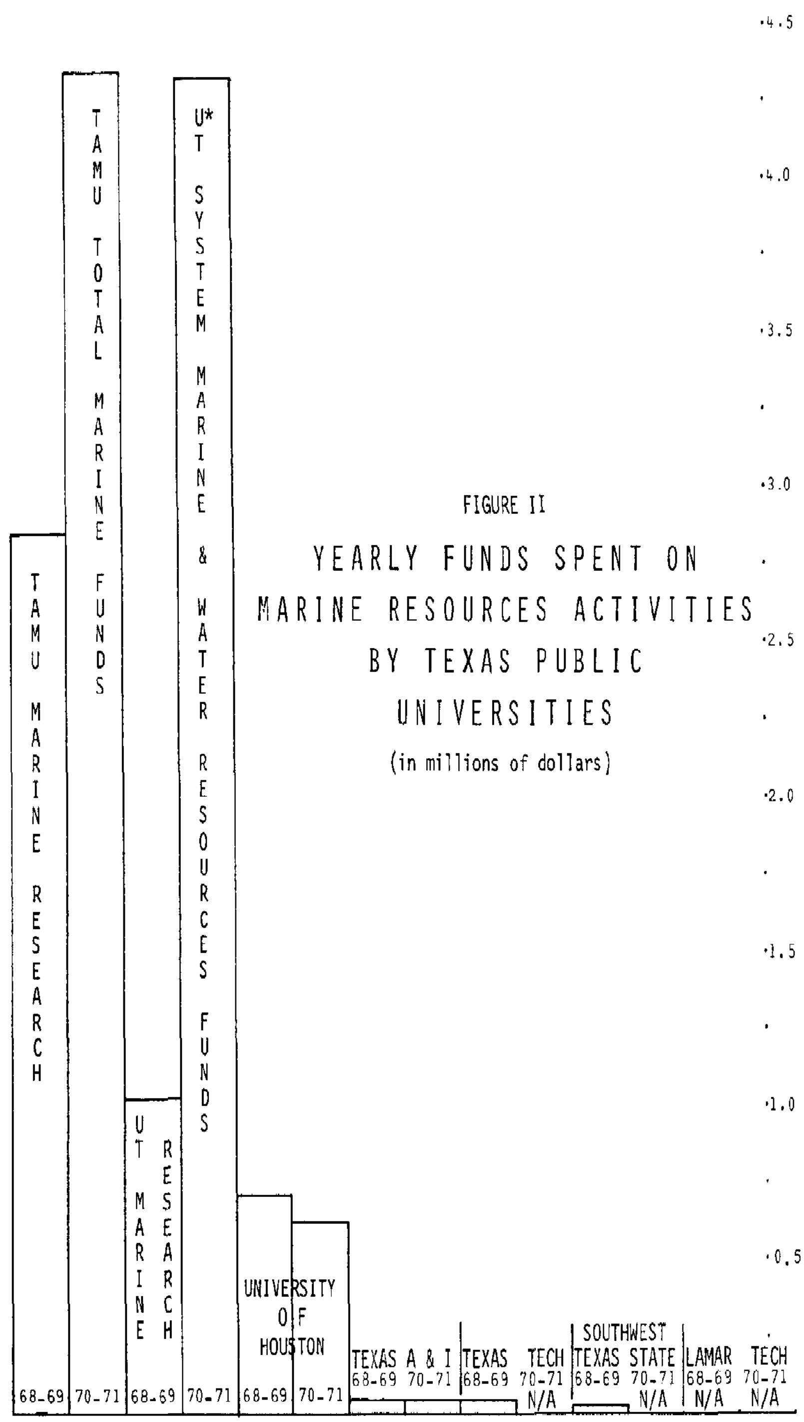
FIGURE I

# TEXAS MARINE EDUCATION AND RESEARCH PROGRAMS




KEY TO LOCATIONS

1. Texas A & M University - College Station
2. Southern Methodist University - Dallas
3. Texas Christian University - Ft. Worth
4. Texas Tech University - Lubbock
5. Texas State Tech. Institute - Waco
6. University of Texas - Austin
7. St. Mary's University - San Antonio
8. Southwest Texas State University - San Marcos
9. Lamar State Tech - Beaumont
10. University of Houston - Houston
11. University of St. Thomas - Houston
12. Rice University - Houston
13. Gulf Universities Research Corp. - Houston
14. TAMU Marine Lab - Galveston
15. Galveston College - Galveston
16. Bureau of Commercial Fisheries - Galveston
17. Texas Maritime Academy - Galveston
18. University of Texas Medical - Galveston
19. Brazosport Jr. College - Freeport
20. University of Texas Marine Lab - Port Aransas
21. University of Corpus Christi - Corpus Christi
22. Del Mar College - Corpus Christi
23. Texas A & I University - Kingsville
24. Texas Parks & Wildlife Lab - Palacios
25. Texas State Tech. Institute - Harlingen
26. Fitzgerald Lab T.T.I -




* Note that University of Texas funds include both marine and water resources funds

the Office of Naval Research, which contributed over $800,000 during the 1968-69 school year; the National Science Foundation, which contributed over $530,000; the United States Geological Survey; the Atomic Energy Commission; the U.S. Department of the Army; the National Aeronautics and Space Administration; various industry groups; and the University. The support from these organizations during the 1968-69 school year totaled an estimated $1,750,000.

Included in this figure is a $29,440 project being conducted in the Meteorology Department on the relations between sea surface temperature gradients and the structure of cloud systems associated with tropical disturbances. Although the Oceanography and Meteorology Departments are separate, considerable cooperation exists on research projects.

Also included in the Oceanography Department's research expenditures are several projects being conducted at the *Texas A&M Marine Laboratory in Galveston, Texas*. These projects total $91,298. The laboratory was established in 1944 and conducts research activities in many areas of marine estuarine biology.

Currently the Oceanography Department occupies parts of *three buildings* on the College Station campus. These have a combined floor space of 45,000 square feet. The Board of Directors of Texas A&M University has approved the construction of a new 14-story Oceanography-Meteorology Building and construction began in August 1970. The building is expected to cost approximately $8.1 million. An artist's conception of the proposed building is shown in Figure III.

The department's largest ship is the R/V Alaminos. It is the only oceangoing research vessel operated by an educational institution in the state. The 180-foot converted Army FS has displacement of 840 long tons and carries a crew of 17, with accomodations for 14 scientists. It has seven general laboratories and a central electronics lab where all data recording is conducted. A photograph of the R/V Alaminos is included as Figure IV.

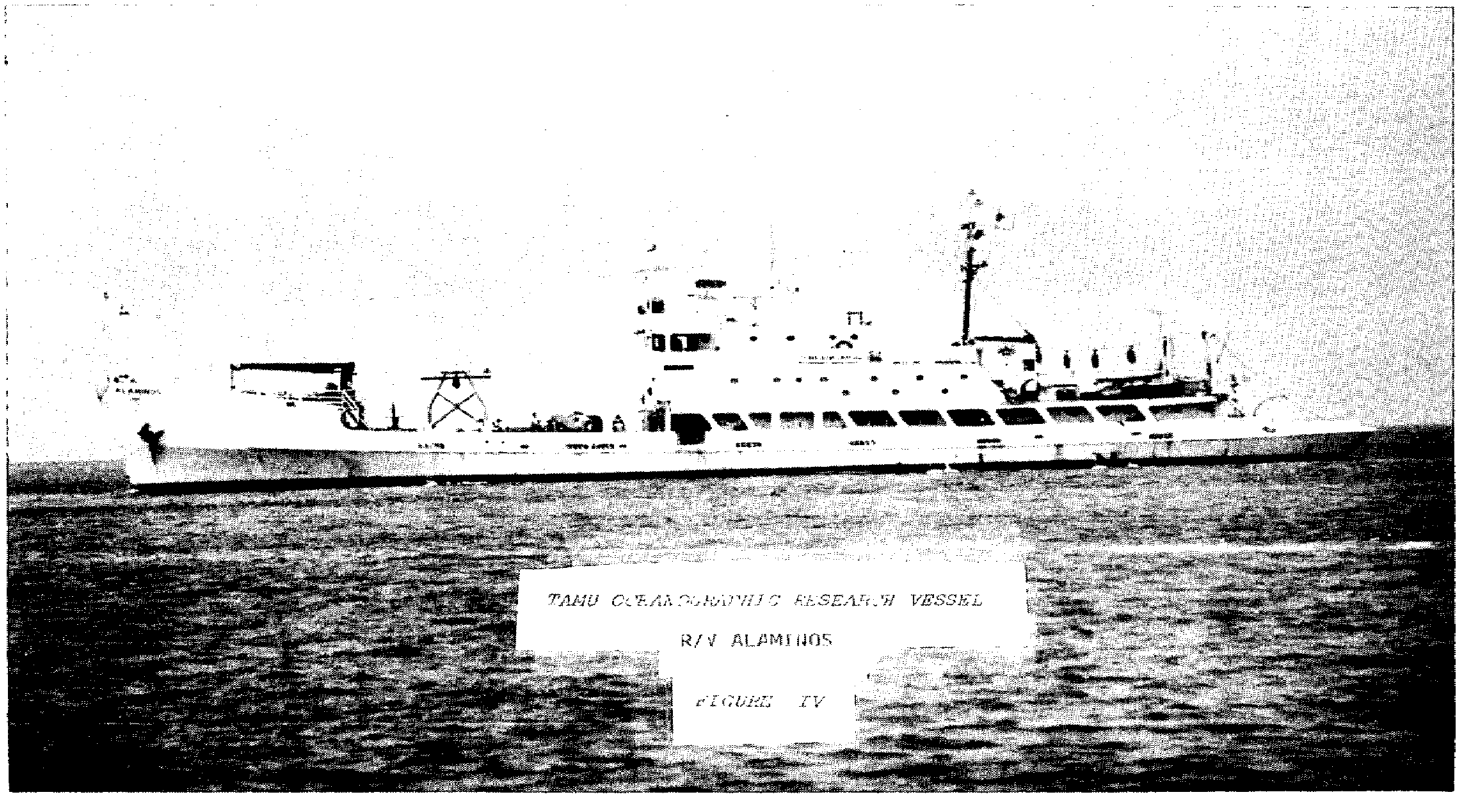
A second research vessel, the R/V Orca was recently acquired by Texas A&M University. The ship will be used for coastal research. Texas A&M University is also scheduled to receive two new oceanographic research vessels by the end of the 1970's under a special ship-building program proposed by the Navy. The first is scheduled for delivery in 1972.

*Sea Grant Program*

Texas A&M University is one of ten institutions in the United States that have received institutional grants from the

PROPOSED OCEANOGRAPHY-METEOROLOGY BUILDING
AT TEXAS A&M UNIVERSITY

*FIGURE III*



TAMU OCEANOGRAPHIC RESEARCH VESSEL

R/V ALAMINOS

FIGURE IV

National Science Foundation for a Sea Grant Program. The amount for the 1968-69 school year was $475,000. The institutional award for the university includes support for research projects, technician training, ocean engineering, advisory services, development of new subject matter, marine laboratory, and administration. An award of $750,000 was made for the second-year operations during the 1969-70 school year. The award for the 1970-71 school year is $1,166,000.

In the academic year of 1969-70 the Sea Grant Program had 47 projects. Of these, thirteen are *fisheries oriented,* ten are directed toward *engineering problems,* four are *technician training projects,* and five are *oriented toward advisory and information dissemination activities.* The remainder deal with such problems as marine and coastal law, resource management, marine acoustics, sediments and geochemistry, coastal tourism and land use, and pollution. In 1970-71, there are 54 projects, including fifteen in fisheries, twelve in engineering and equipment development, eleven in education and curriculum development, four in technician training, and six in advisory services. Others deal with pollution, sediments, and geochemistry, marine and coastal law, resource management and other areas similar to the 1969-70 program (see Figure V).

*Coastal and Ocean Engineering Division*

The Coastal and Ocean Engineering program is at the graduate level at present. The interdisciplinary program provides the basic course work leading to M.S., M. Eng., and Ph.D. degrees. Discussions are underway regarding the offering of a Baccalaureate degree in ocean engineering also. The graduate program is interdisciplinary in nature and flexible enough to satisfy the needs of individual students with a variety of backgrounds and career interests. Students with a Bachelor's or Master's degree in any area of science and engineering are eligible to enter this program. Eight new graduate courses were developed during the last three years. Three Master's degrees were awarded in 1967-68, three in 1968-69 and five Master's degrees and three Ph.D. degrees in 1969-70. There are currently twenty-one students enrolled in the Coastal and Ocean Engineering program.

Since research is an integral part of any successful graduate program a major effort has been made in attracting research grants and contracts. During the last three years research sponsorship was secured from the U. S. Army Corps of Engineers, N.A.S.A., Texas Water Rights Commission, Sea Grant Program, U. S. Coast Guard, Texas Engineering Experiment Station, and industry groups. Some twenty projects were conducted or are underway in Coastal and Ocean Engineering amounting to $320,000.

Concurrently with graduate program development a major effort was made to design and develop facilities. A new wing was added

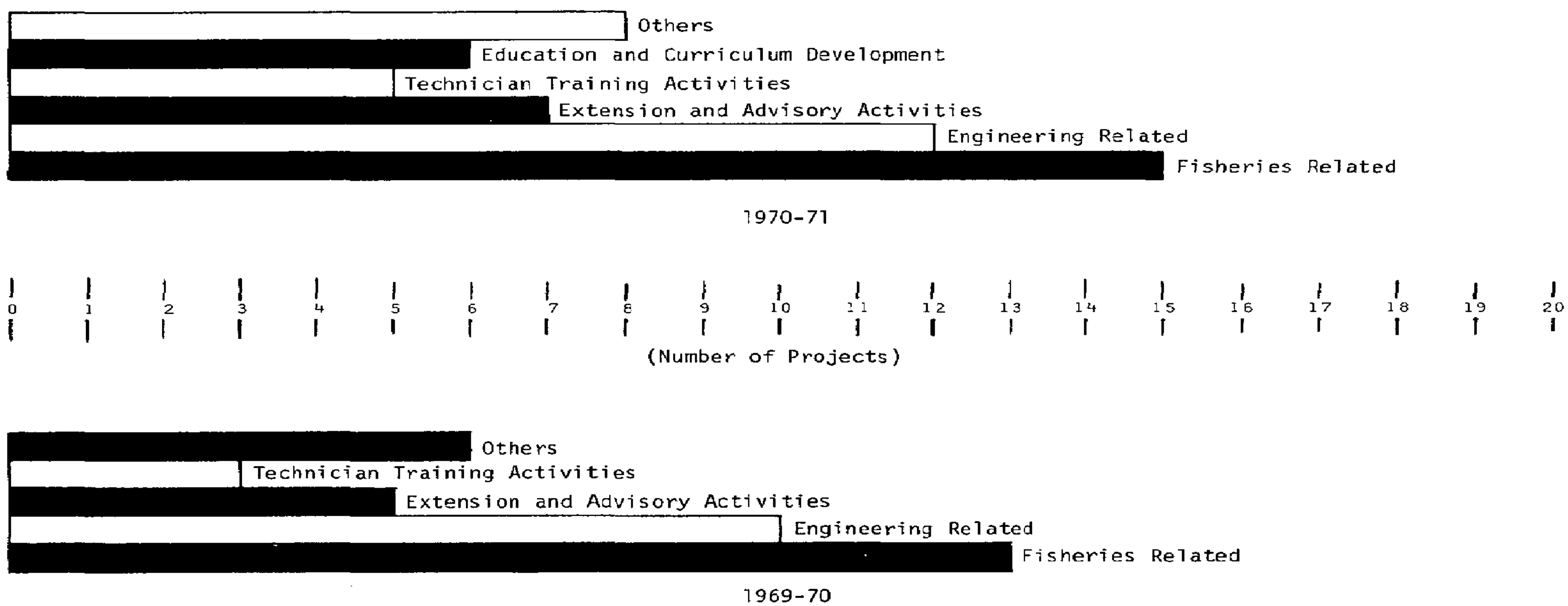



FIGURE V

DISTRIBUTION OF SEA GRANT PROJECTS

to the Hydromechanics Laboratories' Building and the old building was remodeled and now the division has exceptional facilities for research and testing. The facilities include four wave tanks or basins, large recirculating flumes and dredge pump test stands and slurry flow test pipelines. The expenditures totaled $300,000.

The program has alreadv begun planning work on the duplication of a major of the portion of the Texas Gulf Coast in its Coastal Engineering Laboratory at the Research Annex. When completed, the $2 million project will include large models (ranging up to 300 feet) of Galveston, Corpus Christi, Matagorda, San Antonio, Aransas, and Baffin Bays, Sabine Lake and Laguna Madre.

A "Coastal and Ocean Hydrodynamics" short course presented by the Division on August 4-15, 1969, was attended by 30 industrial and government engineers from throughout the nation. The course included such topics as prediction of mooring forces, hurricane and storm surge, dredging, and marine waste disposal, linear and non-linear wave theories, wave generation prediction and spectral analyses, and coastal model studies. The next short course titled Dredging Theory and Applications will be given on January 11-17, 1971.

*The University Marine Laboratory at Galveston*

Since its establishment in 1958, the Galveston Marine Laboratory has experienced a steady, but not rapid, growth in staff, funding and equipment. From the time of its establishment it has been located in one of the buildings of old Fort Crockett on Galveston Island. Present plans call for the Galveston Marine Laboratory to be moved to the Mitchell Campus on Pelican Island as soon as space there can be made available.

Early in its history the Laboratory was used as a base of operations for scientists preparing for cruises on the Oceanography Department research vessel, and as a research laboratory during the summer months. From this modest beginning, it has evolved into one of the most important seaside research laboratories in the Gulf of Mexico. Other universities than Texas A&M University have from time to time used these facilities on a cooperative basis, and indeed this type of usage is increasing markedly.

Beginning in 1964, some academic courses have been offered at the Laboratory. Originally, these courses were offered exclusively in the summer months. The educational offerings have been expanded however, such that at present, fourteen courses are being taught. These courses are still primarily summer courses, but present plans call for the expansion of the program to cover the entire academic year in order that a student may complete all or most of the requirements for the Master of Science degree at the Laboratory.

*Chemurgic Research Laboratory*

A fish protein concentrate (FPC) pilot research plant is now in operation at Texas A&M University. One of only a few FPC plants in the United States, it is located at the Texas A&M University Research Annex. The plant, jointly funded by the University's Chemurigc Research Laboratory and SWECO, was built at a cost of $150,000. SWECO is a Los Angeles based process equipment manufacturing firm.

Pacific hake from Washington State was chosen as the test fish because of its approval by the Food and Drug Administration. A maximum of 150 to 180 pounds of FPC can be produced in a day at the pilot plant during two four-hour cycles using 500 to 600 pounds of raw fish.

*Texas Maritime Academy*

The Texas Maritime Academy was established in 1962 and is an integral part of Texas A&M University. It is one of six major maritime academies in the nation and the only one on the Gulf Coast.

Two courses of study are offered - Marine Engineering and Marine Transportation. Upon graduation from the academy, graduates receive a B.S. degree in either Marine Transportation or Marine Engineering, a U. S. Coast Guard license as a Third Mate or Third Engineer, and a commission as Ensign, U. S. Naval Reserve or U. S. Coast Guard.

The Academy's budget during the 1968-69 school year was $1,816,513. The Galveston facilities include one building of white stucco, formerly a part of Fort Crockett, facing the Gulf of Mexico. The *Texas Clipper,* a converted ocean liner of 15,000 tons capable of 16 knots, is the Academy's training vessel. It is used to take the 190 plus students on an annual summer cruise. The 1969 Mediterranean cruise lasted 10 weeks and traveled 13,676 miles while visiting several foreign ports.

The construction of a new campus called the Mitchell Campus has been announced by Texas A&M University officials. Land for the 100-acre campus on Pelican Island was donated by Mr. George P. Mitchell, a Houston contractor and land developer. A $1 million grant from the Moody Foundation of Galveston will enable the immediate start of construction. A $597,000 contract has been awarded for construction of docking facilities at the new campus. The campus will eventually house the Texas Maritime Academy, Marine Laboratory, and other oceanographic installations.

*Water Resources Institute*

The institute was reorganized in 1964 when the name was changed from the Water Research and Information Center to the

Water Resources Institute. The scope of the institute program was broadened so that the organization could better serve the water research needs of Texas and complement the graduate and undergraduate academic programs in fields related to water resources at Texas A&M University.

The overall purpose of the Water Resources Institute is to promote and support research in water resources and to disseminate research information on water. The institute determines water resources research needs of Texas and carefully formulates a research program directed to these needs.

The institute research program now includes cooperative efforts with The University of Texas at Austin, the University of Houston, and Texas Tech University. Under the provisions of the "Cooperative Agreement for Water Resources Research Among Universities in Texas," which is a memorandum of agreement among the four universities, effective research programs have been developed. Representatives of each university meet to work out details of water research programs and establish priorities among research projects.

The research programs at Texas A&M University involves cooperative research with the six of the Colleges at Texas A&M University. These are the Colleges of Agriculture, Business Administration, Engineering, Geosciences, Liberal Arts, and Sciences. Efforts are continuing to provide opportunity for water resources research in any academic department which can contribute to the solution of the broad problems which exist in Texas. During FY 1968, a total of $200,724 was spent on 22 marine projects in the institute.

*Wildlife Science Department*

Texas A&M University is the only institution in Texas which offers an undergraduate curriculum in fisheries. The Department of Wildlife Science offers the B.S. and M.S. and Ph.D. degrees in fishery biology. Courses in fishery science are offered on the main campus during the regular school year as well as at the Texas A&M Marine Laboratory in Galveston during the summer months.

*Environmental Engineering & Environmental Science Division*

This division of the Civil Engineering Department is heavily involved in water quality studies in both fresh and salt water systems. The division offers specializations under the Civil Engineering Department at both the masters and doctoral level and also supports study and research in related science fields. The division operates a portable field laboratory at Barbour's Cut on upper Galveston Bay and the <u>R/V Excellence</u>, a fifty-five foot research vessel (a converted pleasure cruiser) in the Houston Ship Channel-Galveston Bay region. Negotiations are being conducted between the Texas A&M Sea Grant Program Director and Galveston Community College for the transfer of the fifty foot converted yacht Mariner to Texas A&M for use by the Environmental Engineering Division and the Sea Grant Program for technician training, research and familiarization cruises for summer institute high school teachers. Other Environmental Division activities are carried out on the College Station campus and in the city of Dallas Water Reclamation Center. Division activities related to estuarine systems are budgeted at approximately $200,000 per year.

## *VI. PROGRAMS AND FACILITIES OF THE UNIVERSITY OF TEXAS AT AUSTIN*

### *Environmental Health Engineering Laboratory*

The Environmental Health Engineering Laboratory, located at the Balcones Research Center, is engaged in some marine related research projects. During the 1968-69 school year, expenditures for all water quality related projects totaled $370,402. Source of funds includes U. S. Public Health Service, Federal Water Pollution Control Administration, Atomic Energy Commission, and the National Science Foundation.

Research activity of the eight-man staff includes graduate training in water supply and pollution control, transport of radionuclides in water, and interaction of nitrosylruthenium compounds with particulates in an aquatic environment.

### *Center for Research in Water Resources*

The Coordinating Board, Texas College and University System, and the Federal Water Pollution Control Administration awarded $55,000 to Texas A&M University, the University of Texas, and Texas Tech University for the development of a work plan of the Galveston Bay Water Quality Study Project.

Also, the Center has received grants from industries totaling $19,000 to conduct research on industrial water pollution problems.

### *College of Business Administration*

During the 1968-69 school year, the College of Business Administration received $50,000 from the Bureau of Commercial Fisheries for marine related research.

### *Bureau of Economic Geology*

The Bureau of Economic Geology is an organized research agency of The University of Texas at Austin and a component unit of the Division of Natural Resources and Environment; it also functions as a State agency. The Bureau was established in 1909 and is also recognized as the Texas State Geological Survey; its Director fills the position of State Geologist.

The Bureau is engaged in research and public service in Texas geology and natural resources. It carries on basic research to further the understanding of the geologic architecture of the State and of the natural earth processes that operate in Texas. The applied program is focused on earth resources, environmental and conservation problems, and engineering problems. The Bureau's effort in systematic geologic mapping is designed to produce geologic maps and special derivative maps at several scales and for several purposes. The Bureau also participates in other University research efforts in the fields of resources and earth sciences. The Bureau publishes major reports in The University of Texas Publication series; it also has its own series of Reports of Investigations, Geologic Quadrangle Maps, Guidebooks, Geological Circulars, Mineral Resource Circulars, and special publications. A complete list of approximately 565 items published to date is available on request.

Geologic and natural resource data developed by the Bureau of Economic Geology in the form of reports and maps are used by many State and Federal organizations in carrying out investigations in the public service. The Bureau cooperates on both a formal and an informal basis with various Federal, State, and local organizations.

The Bureau of Economic Geology staff presently consists of 13 full-time research personnel, with an accompanying clerical, administrative, cartographic, editorial, and technical staff. Total budget for 1970-71 is approximately $475,000, derived mainly through The University of Texas at Austin appropriations and in part from outside grants and contracts with certain Federal and State units. Approximately 20 percent of the total budget is utilized to support current ongoing research and mapping in the Texas Coastal Zone.

*Mechanical Engineering Department*

The Mechanical Engineering Department had several marine related research projects in force during the 1968-69 school year. These included research in the optimal number and location of offshore drilling platforms, nuclear dual-purpose desalination plant dynamics, and compression-extrusion freezing for desalting saline water.

*Institute of Marine Science, Port Aransas, Texas*

The Institute of Marine Science is a division of the graduate school of The University of Texas. M.A. and Ph.D. degree programs

PROPOSED UNIVERSITY OF TEXAS MARINE SCIENCE INSTITUTE BUILDING AT PORT ARANSAS

*FIGURE VI*

are offered in the fields of marine science, ecology, zoology, microbiology, geology, biology, and chemistry.

The budget during the 1968-69 school year was $587,000. The institute has seven full-time staff members. Six M.A. and two Ph.D. degrees were granted during the 1968-69 school year. There were 25 full-time students and 23 summer students enrolled during the 1968-69 school year.

Facilities include classrooms, library, constant temperature growth chambers, shops, garages, outdoor experimental ponds, 40-foot cruiser, several smaller boats, and related equipment.

A $3 million expansion of the institute has been approved by the Board of Regents. Nueces County and the federal government have made available a 50-acre tract of land south and west from the 11 acres now occupied by institute buildings. It is expected that the present seven-man academic staff will be enlarged to 18 to 24 members. The institute will then be able to accommodate 80 to 90 resident students as well as large numbers who will then be there for special courses and for short-term research.

The proposed University of Texas Marine Science Institute Building at Port Aransas is shown in Figure VI.

## *VII. OTHER MARINE RELATED EDUCATIONAL OR RESEARCH ACTIVITIES*

### *Programs and Facilities at Texas Tech University*

Texas Tech University does not have a major involvement in the marine field at this time. However, several areas of research currently underway indicate a strong interest in activities concerned with the marine environment.

A unique program is Texas Tech's new *International Center for Arid and Semi-Arid Land Studies* which will involve evaluation of the marine environment on arid and semi-arid processes and products.

Texas Tech, in cooperation with Texas A&M University and The University of Texas at Austin, has made a study of a plan for development of a comprehensive water quality management program for Galveston Bay.

In addition, Texas Tech has implemented a dune stabilization study on Padre Island in cooperation with the Gulf Universities Research Corporation. Sponsored and funded by the U. S. Army Corps of Engineers, the $37,000 study will identify various marsh and salt water resistant grasses which are effective in controlling the movement of sand dunes.

Researchers at Texas Tech are also participating in a three-year study of the submerged portion of the Rio Grande River delta.

Sponsored by the Gulf Universities Research Corporation, the project is in cooperation with the University of Houston, the Southwest Research Institute and the Westinghouse Ocean Research Laboratory.

*Programs and Facilities at The University of Houston*

Strong curricula in marine-oriented disciplines of geology, chemistry, physics, biology and engineering are being expanded into a marine program at The University of Houston. Courses in these fields offer preparation for all phases of oceanography. The scope of current research in the field of geology includes statistical measure of association of nearshore biostratigraphic projects conducted in the geology field totaling $13,500. In addition, the Chemistry Department reported 25 projects involving total expenditures of approximately $700,000 for the 1968-69 school year. The Biology and Mechanical Engineering Departments also conducted marine related research projects.

The largest departmental project within the university is the Geology Department's three-year investigation of the submarine portion of the Rio Grande River delta. This project is under the auspices of the *Gulf Universities Research Corporation and in partnership with Texas Tech University, the Southwest Research Institute,* and *the Westinghouse Ocean Research Laboratory.*

In testimony before the Interim Study Committee for a Texas Institution of Oceanography, representatives of the University of Houston discussed that institution's new *Marine and Environmental Council.* The Council surveyed the University's programs and recommended a new academic unit that is to be mission oriented and is to have a four fold emphasis: oceanographic, marine, coastal and urban. Two hundred thousand dollars in research funds were identified by the Council as channeled directly into marine research.

The University of *Houston College of Law* in cooperation with the Texas A&M University Sea Grant Program Office has initiated a project on the *law and the marine resources* of the Gulf of Mexico. The project aims at identifying and determining the needs, as well as priorities, of the legal-administrative framework relating to marine resources and the coastal zone of the Gulf, in order to initiate a coherent program in research, training, and the dissemination of information relevant to present and future developments. The University of Houston College of Law in cooperation with the Sea Grant Office of Texas A&M University, on May 17-18, 1970, held a workshop to discuss and evaluate the whole range of the legal-administrative framework relating to marine resources, in the context of present and future needs of training, research, and information. Based on this insight, the College of Law will initiate, during 1970-71, a program of instruction, begin extension services, and formulate a coherent plan of research. The funding for this project is in the amount of $37,500.

*Programs and Facilities at Southwest Texas State College*

The Biology Department of Southwest Texas State College expanded its curriculum to include a program in aquatic biology and added to its facilities an aquatic station in September 1967. The aquatic program permits an undergraduate student to pursue a course of study leading to the baccalaureate degree with emphasis in aquatic biology. An M.A. degree program with emphasis in aquatic biology is offered to qualified students holding a baccalaureate degree in biology, chemistry, mathematics, or physics.

In the 1968-69 school year, the Aquatic Station had a budget of $13,500, not including the salaries of its three full-time faculty members. The biology department had 18 full-time faculty members. During the 1968-69 school year, six B.S. and three M.A. degrees were granted in marine related studies. Expenditures for research projects during the same period totaled $23,000. Three of these projects were funded with state appropriations and one by the Texas Water Quality Board.

*Programs and Facilities at Texas A&I University*

The Department of Biology at Texas A&I University, with a $22,000 instructional budget and eight full-time faculty members, is engaged in marine related studies. During the 1968-69 school year, there were 11 research projects conducted with a total expenditure of $40,000. Five M.S. degrees were granted in marine related studies for the 1968-69 school year.

*Programs and Facilities at Lamar State College of Technology*

The Lamar State College of Technology Board of Regents has approved a new program to offer a B.S. degree in oceanographic technology. The program has been approved by the Coordinating Board, Texas College and University System. The program will involve the various departments of the science and engineering schools. The objectives will be to train oceanographic technologists for institutions, industries, and other organizations engaged in oceanographic investigations. Seventy-one students enrolled in the course for the 1970-71 academic year. Of these, seventeen are juniors who transferred from other institutions or other programs.

*Programs and Facilities at Southern Methodist University*

Each year at Southern Methodist from twenty-five to sixty students enroll in marine or marine related courses. Over the last few years sixty M.S. and Ph.D. degrees related to marine areas have been granted. Annually $35,000 is spent on marine research with $250,000 annual expenditures on marine related research. In the present year, eight faculty and a like number of students in science departments are conducting marine research, while over the entire university about twenty faculty and twenty students are so engaged.

*Programs and Facilities at Rice University*

Although Rice University does not have a recognized curriculum in marine activities, several of its scientists conduct marine related research. Since 1958, a total of 12 doctorate degrees have been granted within the Geology Department for research in marine geology and marine geophysics. Students in the Biology Department are concerned with the biochemistry and physiology of estuarine animals. The lack of deep water vessels has steered Rice's marine program toward shallow water sedimentology, along the northwest Gulf Coast.

*Baylor University*

Baylor University offers a small number of marine geology and marine biology courses. Three years ago the university initiated a geosciences secondary education certification program. There is presently an active CICAR project operated jointly with the University of Mexico City.

*Texas Christian University*

Several Texas Christian University scientists are conducting marine related research. Total expenditures for these projects are $95,000 under the TCU Research Foundation. The studies include how life in water can adapt to drastic environmental changes, ecology of a half square mile body of water near Wood Holes, the zoogeography and the taxonomy of marine ostracods, and the benthic fauna of the Heald-Sabine Banks area of the northwestern Gulf of Mexico.

No degree program in marine related studies is offered.

*University of Corpus Christi*

The University of Corpus Christi has a curriculum in Marine Science at the undergraduate level. During the 1968-69 school year, 40 students were enrolled. There are three full-time faculty members directing the program.

*St. Mary's University*

The Department of Geology at St. Mary's University plans to offer one course in Marine Geology in the 1969-70 school year as part of the Earth Sciences Teacher Preparation Program.

*The University of St. Thomas*

The Institute for Storm Research at the University of St. Thomas concentrates on the study of extreme weather phenomena. Five staff members teach part-time in the institute, and students completing the program are awarded the B.A. degree. A total of 13 research projects were reported with expenditures of $446,468 for the 1968-69 school year.

*Brazosport Junior College*

Under a cooperative agreement with the Texas A&M Sea Grant Program, the college has initiated a technician training program for boat operators. The technological developments during and since World War II have made available to marine use sophisticated equipment such as electrical devices for navigation, electrical fish finders, improved nets and deck gear for rapid handling of catch, newly developed processing methods, more efficient maintenance and care of equipment, and techniques of underwater operation.

The Brazosport project will undertake a study to plan and organize an educational program for marine technology. The study will include instructional aid, equipment, and facilities to supplement an established curriculum. Time will be given in the preparation of materials for the purpose of directing and guiding secondary school students into the fisheries program. Recruitment methods for the marine program will also be studied and established.

This initial year of study and planning is expected to be followed immediately by the implementation of a two-year Associate of Applied Science degree program in marine technology.

*Del Mar College*

Del Mar College, through its Technical Institute, is conducting a *marine technician project* in cooperation with the Southwest Research Institute. A project grant of $110,800 over a 26-month period was awarded by the Sea Grant Program of the National Science Foundation.

The project, started August 1, 1969, is oriented toward marine electronics. It will define marine electronics technician tasks and the required skills and educational background necessary for performance of work at sea and ashore as a basis for development of a two-year curriculum and course of study. A pilot program with an enrollment of 20 students will be conducted with both classroom and practical at-sea training. Basic classroom work will be conducted at Del Mar, with instructional assistance from specialists at Southwest Research Institute, which also will provide the sea experience. Three full-time faculty members at Del Mar and one Southwest Research Institute employee will provide the instruction.

Upon completion of the 120-hour, electronics-orineted program, the student will receive an Associate of Arts degree.

A new, somewhat more general program is now being offered in cooperation with the Texas A&M Sea Grant Program involving a seventy-five course hour program. This program is funded at the level of $36,000 and is oriented toward training Marine Biology and Marine Chemistry Technicians.

*Texas State Technical Institute - James Connally Campus*

The Connally Campus of TSTI has a program for the training of underwater welders. This is a cooperative program in cooperation with the Texas A&M Sea Grant Program. The training program is of fifteen weeks duration. The student's initial training is conducted in a special underwater facility located on campus. They then progress to nearby lakes and finally into the deep sea environment of the Gulf of Mexico. Training includes both "hard-hat" and SCUBA diving.

Students graduating from a two-year welding technology program offered on campus are considered to be ideal candidates for the program. Other candidates come from industry.

*Texas State Technical Institute - Harlingen Campus*

The purpose of this Rigman-Mate Training Course jointly sponsored by TSTI - Harlingen and the A&M Sea Grant Program is to train unskilled and semi-skilled adults for more highly skilled positions in the shrimping and fishing industry. Recent previous efforts to train migrant agricultural workers in this occupational field have not been greatly successful because of the *psychological and physiological problems inherent in adapting to life at sea.* Therefore, this program is oriented toward up-grading the skills of adults already involved in fishing. The course is designed to qualify a person as a rigman and enhance his opportunities to become a shrimp boat captain. The level of funding of the program is approximately $20,000 for the 1970-71 academic year.

*Fitzgerald Laboratories Technician Training Program*

This technician training program is conducted by a private corporation under contract from the federal government. The purpose of the program is to train and/or retrain unemployed and under employed adults as shrimp boat crew-men. The program is divided into two parts. In phase one the students are given classroom training in various phases of boat operation. The second phase consists of at-sea training under actual working conditions through a cooperative arrangement with area shrimp-boat captains. There are three training centers - at Freeport, Aransas Pass, and Brownsville.

*Gulf Universities Research Corporation*

The Gulf Universities Research Corporation (GURC) is a regional consortium of universities and industries from the states surrounding the Gulf of Mexico, plus the University of Mexico City. The purpose of the corporation is to unite the universities and industries into a group having sufficient resources and facilities to pursue detailed in depth studies of the chemistry, physics, geology, and biology of the Gulf of Mexico.

GURC recently received $100,000 from the National Science Foundation as a preliminary planning grant to precede Gulf of Mexico studies under the International Decade of Oceanography.

*Bureau of Commercial Fisheries Laboratory - Galveston*

The BCF Laboratory is operated by the Bureau to perform studies related to the fisheries of the western Gulf. These studies are primarily oriented toward the shrimp fishery since this is the major fish product of the region. The laboratory is currently involved in studying the feasibility of reproduction and spawning of shrimp in captivity.

*Texas Parks and Wildlife Laboratory - Palacios*

Researchers at this facility are studying the mariculture of various marine species, chiefly shrimp and oysters. The facility includes biological and chemical laboratories and a number of salt water ponds in which replicated mariculture studies are conducted.

The summaries given above indicate that the majority of the marine science programs in operation in Texas have very strong orientations toward marine biology. Only Texas A&M has a broadly-based, multi-disciplinary effort at present. This arises partly from the twenty year history of the departments of oceanography and meteorology. However, the other departments of the College of Geosciences; geology, geography, geophysics and the marine laboratory, contribute to this strength as well. The marine related programs that exist in seven of the eight colleges of the university are also contributing to the strength of the university in marine resource development. The existence of the Sea Grant Institutional Program serves to focus the activity of all these departmental efforts on the search for programatic mission-oriented solutions to problems of the coastal zone.

The summaries in the preceding pages may certainly not be exhaustive. Other colleges, junior colleges or specialized programs may exist that were not covered by the IERD survey, and that did not have witnesses to appear before the Interim Study

Committee. However, the coverage seems fairly complete in spite of the fact that the brief time available did not allow for the conduct of an up-to-date survey.

Certain facts seem to emerge clearly from the report. As is almost inevitable in any type of program, educational activities range from quite modest to imposing, and some areas of activity are well covered while others are almost bereft of effort. Panelists and discussion leaders at the Governor's Conference on Goals for Texas in the Coastal Zone and the Sea (5) seemed to echo many of the same sentiments. Many of the speakers spoke favorably of most of the major marine education programs of the State. However, on several occasions panelists cited specific areas in which insufficient effort was currently being expended. The conference proposed a number of actions to be taken, in its Conference Proceedings.

Educational recommendations for the future for development of the coastal zone of Texas and wise use of its resources are presented in the following pages. The recommendations represent a distillation of the expressed thoughts of many people who participated in such events as the Governor's Conference, Interim Study Committee hearings, educational, industrial, and other workshops conducted by the Texas A&M Sea Grant Program Office, "Stratton Commission" study panels, the studies of the National Council on Marine Resources and Engineering Development and a number of research studies.

## *VIII. RECOMMENDATIONS FOR THE FUTURE*

The State should initiate a vigorous campaign through the Legislature, the Governor's Planning Office and the Interagency Natural Resources Council to *inform the people of the State* of the value and importance of the natural resources of the Texas coast and the Gulf of Mexico. These resources must be *wisely* used; the coastal lands must be *wisely* developed. *Further, the people of the State must be educated as to the importance of the concepts of wise use and planned development.* The process of informing the public of the importance of these programs will be expensive. However, the programs themselves are even more expensive and may not be accepted by the public without a vigorous information campaign, regardless of their importance.

*What makes the marine educational program so expensive?* First is the need to develop and implement State supported *educational programs* at every level from kindergarten through postgraduate and adult-extension education. Second is the need to *improve the image of the craftsman/technician* and provide vocational-technical education for students not interested in a college degree. Third, and most important in view of cost, *is the need to provide adequate facilities* for education, training and research. An inadequate supply of ships, docks, sea-side facilities, research and educational laboratories and classrooms now exist to meet present demands. As future demand increases, additional expanded facilities will be required. *Because of the high initial cost of facilities such as these, it seems wisest to build upon and supplement existing facilities and programs rather than to build duplicate and/or complementary programs and facilities.*

The major percentage of the marine education and research funding presently comes from *federal* sources. As a rule, these federal programs are annual and not readily renewable and tend to be discontinuous. Therefore, the programs that result tend to be discontinuous as well, and tend not to be focused on solutions to regional or State problems. *A continuing support base of State funds is needed for at least the major facilities and programs in order to provide continuity of operation.* This does not mean a complete supplanting of federal funds, but rather a solid, continuing base on which to build sound, locally oriented programs. Examples of such major programs which should have this support are: the Texas State Technical Institute programs; the Del Mar College and Brazosport technician training programs; the Lamar State College Ocean Engineering Technology Program; the University of Houston Ocean Engineering programs; the Institute of Marine Science; the Bureau of Economic Geology and the Environmental Health Engineering Laboratory of the University of Texas; the Oceanography, Coastal and Ocean Engineering and Environmental Engineering programs, the Galveston Marine Laboratory, Moody Marine Institute and Texas Maritime Academy, and the Sea Grant Program of Texas A&M University to name but a few. Many of these have some State support, but should receive a *more solid base* of support to insure continuity of programming. Additional facilities will be required in the near future in most cases to provide for increased enrollment. To return to an earlier point, the process of educating the public to the wise use of the State's natural resources must begin at the earliest level in the educational process. In spite of the immense size of the State and the consequent size of its educational system, this education program should be statewide. The state has mountainous regions, deserts, high plains, forests, urban and rural regions. What happens to the soil and water in each of these regions ultimately is felt in the coastal zone, and in return, what happens in the coastal zone has a profound (and not perfectly understood) effect on the High Plains wheat farmer and the East Texas forester. The education of the public on the wise use of resources, if it is to take hold and grow, should begin with youth, and should continue through the entire educational process. It should be tailored to the differing perceptions of the student, wherever he may live.

It is the responsibility of the classroom teacher to motivate his students to want to know about environmental matters, marine science, and conservation of resources. It is the responsibility of the Regional Educational Services Centers and university faculty to provide help in assembling the materials and teaching units for the classroom teacher. Some of the necessary curricular materials and units are already available but others will need to be developed. Career selection materials are also needed for the use of public school counselors. These materials should stress not only careers requiring college preparation but technician and crafts opportunities as well. An effort must be made to provide meaningful retraining and work for the adult "drop-out" and the so-called hardcore unemployed whom the existing types of educational programs have tended to by-pass. These men and women are the legacy of our "college for everyone" attitude, and must not be overlooked.

## *IX. SUMMARY*

It can readily be seen that the majority of the commentary in the preceding pages is applicable to nearly all fields of educational endeavor, and need not be restricted to marine activities. However, the central focus of these remarks is on marine activities. In summation several actions may be recommended. The recommended actions are not necessarily in any priority order since all are of more or less equal importance to the future of marine activities in Texas. The first recommendation is, however, of critical importance and should be initiated immediately. The State should:

Conduct a thorough *inventory* of existing and planned marine programs in Texas educational institutions at all levels.

Develop an *earth science curriculum* for the public school level acceptable to the Texas Education Agency.

Develop public school level guidance and counseling materials with both college-bound and *crafts and technician information* in marine science.

Initiate and expand *summer programs* and field trips in marine science.

Create a *high school course in marine sciences* which might be used as a vehicle for making students aware of their environment.

Develop *junior college curricula in technician training*, individualized by the institution to serve the needs of local communities.

Develop *adult education programs* with a marine focus to train or re-train unemployed or under-employed adults.

Develop a *Marine Law Center*.

Develop *undergraduate courses in ocean science* which would provide a continuing interest for students.

Create *new programs* in marine related areas such as Coastal Zone Management and seafood processing.

Provide *increased support for facilities, equipment, and staff* for the teaching and research and extension functions at colleges and universities with *existing* marine programs.

Encourage greater *sharing* of facilities among institutions.

Provide for *more information* on marine resource development to be brought to the attention of the public.

Expand *extension services* to include the areas of marine resources.

Provide for a study of the job opportunities in Texas in marine resource fields.

Build up *existing* marine programs rather than create new programs based on self-interest groups.

Provide *long range planning* for marine resource use and development based on scientific knowledge.

These actions are essential to assure that existing marine programs become and remain responsive to the needs of the state. If Texas is to provide a well balanced marine education for present and future residents of the state, the voids outlined in this report must be filled, and existing major programs must be supported in their effort to forge ahead into imaginative new programs. If Texas is to be the leader in marine affairs that it could and should be, the time to advance is now.

*BIBLIOGRAPHY*


1. Berelson, B. Graduate Education in the United States, New York, McGraw-Hill Book Company, 1960, 346 pp.

2. Commission on Marine Science, Engineering and Resources, Panel Reports, Julius Stratton, Chairman, Three Volumes, U. S. Government Printing Office, February 1969.

3. Conant, J. R. The American High School Today, New York, McGraw-Hill Book Company, 1959, 150 pp.

4. __________, The Comprehensive High School, New York, McGraw-Hill Book Company, 1967, 95 pp.

5. Conference of the Governor of Texas on Goals for Texas in the Coastal Zone and the Sea, Honorable Preston Smith, Chairman, Houston, Texas, September 10-11, 1970.

6. Industrial Economics Research Division Staff Report, Marine Resources Activities in Texas, College Station, Texas, August 1969, 202 pp.

7. Interim Study Committee on Oceanography, Texas House of Representatives, 61st Legislature, Honorable Ray Lemmon, Chairman, 1969-70.

8. National Council on Marine Resources and Engineering Development, Marine Science Affairs - Selecting Priority Programs, U. S. Government Printing Office, April 1970.

9. Rickover, H. G. Education and Freedom, New York, Dutton Publishing Company, 1959, 256 pp.

10. __________, Swiss Schools and Ours, Why Theirs are Better, Boston, Massachusetts, Little, Brown & Company, 1962.

11. Sea Grant Workshop Reports

    Texas Marine Resources - The Industrial View, TAMU-SG-70-107, April 1970

    Texas Marine Resources - The Educational View, TAMU-SG-70-109, May 1970

    Texas Marine Resources - The Leisure View, TAMU-SG-70-110, June 1970

    Texas Marine Resources - The Legal Administrative View, TAMU-SG-70-112, July 1970

Texas Marine Resources - The Ports and Waterways View, TAMU-SG-70-114, August 1970

Texas Marine Resources - The Fisheries View, TAMU-SG-70-115, August 1970

12. Walsh, D. E. A Suggested Model for the Management of a Sea Grant Institutional Program, Sea Grant Technical Report TAMU-SG-70-213, College Station, Texas, May 1970, 139 pp.

# OCEANOGRAPHIC REPORT FOR

# COASTAL ZONE STUDY

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October 1970

for

COASTAL RESOURCES MANAGEMENT PROGRAM

INTERAGENCY NATURAL RESOURCES COUNCIL

DIVISION OF PLANNING COORDINATION

OFFICE OF THE GOVERNOR

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## *I. GENERAL DESCRIPTION OF THE GULF OF MEXICO*

Occupying a surface area of 619,000 square miles, the Gulf of Mexico is roughly two and one-thirds times the size of the State of Texas. Although almost entirely surrounded by land (of the United States, Mexico, and Cuba), the Gulf exhibits fully marine conditions; and, because of its small size, it provides a unique opportunity for studying a total marine system as a functional unit. For practical purposes, the Gulf may be divided into three zones: the *coastal zone, continental shelf,* and *offshore area* or *deep Gulf* (Figure 1). Although characterized by different properties and resource potentials, these three zones are intimately interrelated in the sense that they exchange water masses, nutrients, and living organisms.

### *Coastal Zone*

The coastal zone includes bays, estuaries, lagoons, and other shoreline features which are generally characterized by *shallow water, low but variable salinity,* and *reduced tidal action.* These areas often receive inflow from streams, on the one hand, and from the Gulf, on the other. Much sedimentary material is deposited here so that the bottoms tend to be quite muddy. *Such areas are normally zones of intense biological activity.* Bacteria and other decay organisms break down the organic material transported from elsewhere as well as the organic matter produced locally, especially in the salt marshes. Large populations of juvenile fish, crustaceans, and mollusks utilize these areas as nursery grounds and feed largely upon the nutrient-rich decaying organic matter of the shallow backwaters. *Thus, the production of most of the species of commercial importance (shrimp, crabs, oysters, menhaden, etc.) is tied closely with the water quality of the nursery areas.* Any activities which diminish the inflow of fresh water, reduce the extent of the salt marshes, or lower the quality of the estuarine waters are likely to decrease the populations and, hence, the potential harvest of the coastal marine biological resources.

### *Continental Shelf*

The continental shelf extends from the shoreline out to a depth of about 600 feet. Along the Texas coast it varies in *width from 40 to 120 miles.* The shelf receives water from land drainage (through the outfalls of streams, estuaries, etc.), from the open Gulf, and from neighboring portions of the shelf (by long-shore currents). *The environment of the shelf exhibits regular patterns of seasonal variation, but conditions may vary widely from year to year in response to water currents and weather*

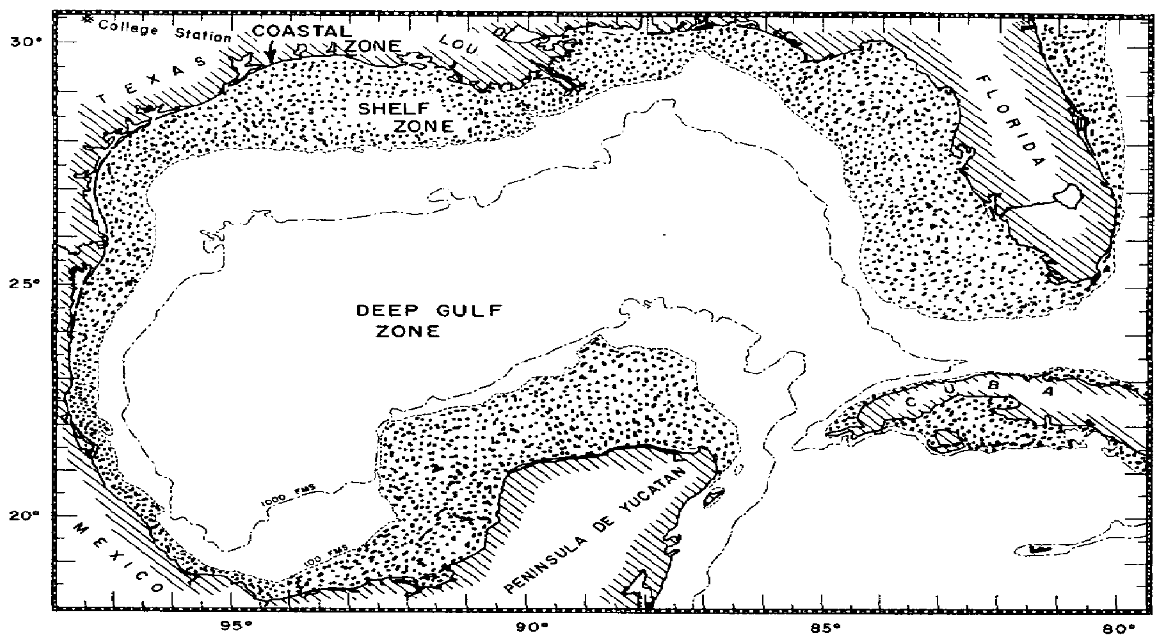


Figure 1. Map of the Gulf of Mexico showing the three zones.

*patterns*. Along the northern Gulf coast, the nearshore environments tend toward high mud content, whereas sand and shell bottoms increase with distance from shore. Consequently, nearshore waters contain much suspended matter and are highly turbid, while offshore waters have little suspended matter and are clear and deep blue. Along the outer edge of the continental shelf lie a *number of hills* which approach within a hundred feet of the surface. These hills support marvelous reefs of coral and carbonaceous algea which are populated by highly colored fishes and invertebrates of West Indian affinity.

### *Deep Gulf*

Beyond the edge of the continental shelf lies the bulk of the Gulf of Mexico covering a surface area of about 500,000 square miles and achieving a depth of 2 1/2 miles. *This area is characterized by clear water and low biological productivity, and the environment tends to be less variable than the shallower zones.* The deep Gulf is horizontally stratified. The surface water to a depth of about 150 feet is lighted and of relatively high temperature (approaching 90° F. at the surface in mid-summer), whereas the bottom water is totally devoid of light and exhibits yeararound temperatures only a few degrees above freezing. This stratification is reflected in the distribution of the chemical and biological components of the deep Gulf. All three zones of the Gulf of Mexico *probably contain exploitable quantities* of petroleum and other geochemical resources.

## *II. EXTERNAL INFLUENCES*

Although occupying a semi-enclosed basin, the Gulf of Mexico is strongly influenced by three major external factors:

*the Yucatan current,*

*drainage from land, and*

*atmospheric factors.*

These three influences determine, in large measure, the special characteristics of the Gulf and are chiefly responsible for the dynamic balance between the living and non-living components of the Gulf system.

### *Yucatan Current*

The Yucatan current annually brings approximately *200,000 cubic miles of water* into the Gulf of Mexico from the Caribbean Sea. This tropical water is distributed through both the surface and bottom layers of the Gulf and serves to keep the water os the Gulf of Mexico in circulation. Since the incoming waters are highly oxygenated, they maintain oxygen-rich conditions in the Gulf from top to bottom. *Without this constant flushing action, the Gulf of Mexico would tend to develop conditions of stagnation* (as occurs in the Black Sea and portions of the Mediterranean). The Yucatan current is also responsible for transporting tropical species so that the fauna and flora of the Gulf of Mexico are closely related to the Central American and West Indian biota. The Gulf is *drained* by currents passing into the Atlantic Ocean through the Straits of Florida.

*Land Drainage*

The Gulf of Mexico receives drainage from most of the United States lying between the Rocky Mountains and the Appalachians, as well as from eastern Mexico and a small portion of northern Cuba. *Nearly a million cubic feet per second of fresh water are normally discharged into the Gulf,* about three-quarters of which derives from the Mississippi-Atchafalaya River systems. Since the prevailing current along the ocntinental shelf of the northern Gulf is westerly, much of the sedimentary discharge of these streams is deposited along the Louisiana-Texas shelf areas. These streams drain most of the important agricultural lands and much of the highly industrialized portion of the United States so that the stream run-off (estimated to be about one-fourth of the total precipitation volume) brings into the Gulf enormous *quantities of fertilizers, pesticides, and other dissolved and suspended by-products of human activities.* Thus, the Texas coastal waters receive large amounts of domestic, agricultural, and industrial residues from the entire mid-section of the United States. The exact nature and extent of this pollution and its effect upon the coastal resources is *yet* to be determined.

*Atmospheric Factors*

The Gulf of Mexico is influenced by atmospheric conditions arising from the North American continental land mass (especially in the winter) and from the Caribbean area (especially during the summer). During the winter, cold, high-pressure Canadian air sweeps across the central plains bringing northern storms all the way to the Gulf, chilling the estuaries, and creating surface disturbances in the Gulf which send high rolling waves all the way to Yucatan. During the warmer months, tropical storms originating farther south sweep into the Gulf from the Caribbean. During the late summer, when the surface waters of the Gulf of Mexico achieve temperatures in excess of 85%F., they may provide the energy to transform tropical storms into hurricanes which strike the northern Gulf Coast with devastating force.

## *III. STATE OF OUR KNOWLEDGE OF THE GULF OF MEXICO*

Despite the extensive coastline and great economic potential *the Gulf of Mexico has not been the subject of intensive investigation until the past two decades*, and thus, even though a fair amount of pertinent information has been amassed in recent years, the system as a whole is only partially understood. This lack of knowledge is due to a combination of factors.

Serious marine investigation requires *adequate laboratory facilities on land* to process the marine data; to house collections of marine life, geological cores, and seawater samples; to study volumes of data on water current patterns and weather conditions; and to carry out a variety of chemical and physical analyses as well as laboratory experiments. It requires *sophisticated electronic environmental monitoring equipment*, a variety of types of collecting gear, remote sensing devices, radioisotope analysis facilities, etc. Most of all it requires a *team of well-trained scientists* to design and build the equipment, to carry out the observations and experiments, and to interpret the data. It depends, further, upon a *team of dedicated supporting personnel* to operate the ships in all kinds of weather, to participate in the heavy physical labor associated with the collection of data at sea, and to aid in the conduct of laboratory analysis.

Major marine work is, thus, a long-term endeavor of acquiring facilities, building teams, and obtaining stable sources of continuing funds. *It must be a goal of society, free from political whim, and untrammeled by trivia.* To the credit of the State of Texas these conditions are now being met, and the goals are being achieved at Texas A & M University.

Until recently, however, most of the Gulf work was carried out by *the heroic individual* who operated from totally inadequate shore facilities; who sampled from a skiff, bay-boat, or shrimp trawler; and whose efforts were limited largely to bays, estuaries, and other nearshore environments. The studies were poorly funded, limited in scope, and generally of little direct economic importance. *Most of the applied work was carried out under contract, and the results were buried in the files of Government agencies and private industry.*

The state of our knowledge of the Gulf of Mexico was summarized in 1954 in a large report by the U. S. Fish and Wildlife Service (*Gulf of Mexico, Its Origin, Waters, and Marine Life*. Ed. by P. S. Galtsoff. See References section). Providing for the first time a comprehensive view of the Gulf system, this volume dramatically illustrated the extreme diversity and complexity of the system, and at the same time it pointed to the great paucity of information, especially concerning the shelf and offshore areas of the Gulf.

Since publication of this volume much has been learned about the system. Coastal features have been studied by several Federal agencies, notably the Army Corps of Engineers, and significant reports are on file in their offices. During the 1950's the American Petroleum Institute sponsored an extensive series of investigations on the sedimentary environments of the northern Gulf coast, and these studies devoted considerable attention to the Texas coast. The U. S. Fish and Wildlife Service has conducted a series of exploratory fishery investigations on the deeper portions of the Texas shelf, the results of which are published primarily in the *Fishery Bulletins* and *Special Scientific Reports - Fisheries*. In addition, private industry has amassed a wealth of information concerning the potential mineral resources as well as the general surface and subsurface characteristics of the bays, estuaries, and continental shelf, but this information *is not generally available for public use*.

The most useful and most readily available information concerning the *offshore areas and the functioning Gulf system*, as a whole, has been amassed by and in cooperation with the Oceanography Department of Texas A&M University, and this information is available in the various publications and Reports of the Department (See Reference section.). These major studies fall into six categories, each of which is discussed briefly below.

*Biological Oceanography treats the composition, distribution, abundance, and life histories of the marine organisms.* Special efforts are being made to provide information on the abundance of marine production in relation to the physical and chemical environments of the Gulf. Studies are also underway on the effects of pesticides and other pollutants on marine species of economic importance.

*Chemical Oceanography attempts to define the organic and inorganic chemicals found in the Gulf and to relate these materials to the overall chemical cycles of the sea.* Both natural and man-made chemicals are under study, and efforts are being made to relate these to their sources of origin.

*Geological Oceanography concerns the origin, transport, distribution, and properties of sedimentary materials in the Gulf of Mexico.* It also attempts to describe the bottom surface features including slopes, canyons, salt domes, etc.

*Geophysical studies involve exploration of the physical properties of the sediments and crustal rocks underlying the Gulf of Mexico* and the surrounding basin and the interpretation of these structures in terms of the geological history of the region.

*Meteorlogical studies are concerned with energy exchange across the air-sea interface.* Involved is the investigation of wind-driven oceanic circulation and the effects of the oceanic system on weather phenomena, including the weather patterns on land as affected by oceanic disturbances.

*Physical Oceanography deals largely with circulation patterns, thermal structure, tides, and surface wave patterns of the Gulf.* Both meteorological and physical oceanography are being pursued at sea as well as through computer modeling experiments on land.

Studies listed above are being carried out in all three zones of the Gulf, the estuaries, the shelf, and the deep Gulf. Yet the task is one of some magnitude. For example, nearly *500 species* of fishes alone are already known from the Texas coast, and this figure represents less than half the types of fishes known from the entire Gulf. Add to this the thousands of types of tiny plants (algae) and invertebrates which inhabit the Gulf, and the diversity is staggering. Each type of organism displays its unique pattern of life in response to the currents, temperature, light, chemical factors, and other organisms, and each affects the environment in certain unique ways. There are, however, common denominators and overall patterns which can be discerned through careful study. *Efforts are already underway to understand the Gulf as a single functional system (in the ecological sense) through which chemicals and energy flow in regular pathways and at measurable rates.* Only through such basic knowledge can the resources of the Gulf be inventoried, managed, and utilized in a knowledgeable way.

## IV. *RESOURCES OF THE GULF*

*The Gulf of Mexico is a great regional asset.* Its *exploitable mineral resources* include petroleum, sulfur, and natural gas (of the subsurface formations), sand and shell (of the surface), as well as a variety of chemical elements extractable from the sea-water itself. *Biological resources* include a variety of fish, shrimp, crabs, and mollusks; and in 1969, the Gulf fisheries industry of the United States alone contributed a catch worth *152 million dollars* (about 30% of the total dollar value of the U. S. fisheries production that year). Many species which are not currently being utilized are potentially harvestable for direct human food, animal food, fertilizer, of FPC (fish protein concentrate). These include tunas, mackerel, pompano, deep-water shrimp, and a variety of smaller fish and crustacean species. Many of these forms are also available for potential commercial rearing ventures (mariculture). *The potential harvest of the Gulf biological resources is reflected in the fact that Cuba is building up a large and sophisticated fishery fleet.** In this connection, the *Russian* investigators have been intensively studying the fishery potential of the Gulf of Mexico (including the Texas coast) and *have recently published a book devoted entirely to this subject. While Texas debates the fishery potential, Cuban and Russian trawlers may be exploiting*

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**Undoubtedly with Russian support and backing* *the resources on the Texas coast.* In addition, it is known that *Japanese* long-line fishermen occasionally visit the Texas coast to harvest the tuna fishes of our shelf waters.

The Gulf of Mexico serves as a *transportation route* for marine shipping, and the availability of deep-water ports has fostered the development of much industry along the coast. The Gulf has been utilized as a *dumping site* for many of the solid wastes of civilization (including an arsenal of explosives) and as a *sump* for many of the liquid wastes. *As pressure is exerted to clean up the streams and the land of the nation, pressure will grow to use the Gulf as the final repository.*

Finally, the year-around mild climate of the Texas coast and the associated *recreational opportunities* have attracted many citizens who make use of the Gulf occasionally or indirectly. The coastal zone is visited by many citizens of the coastal and inland states. As California and Florida become saturated with humans seeking employment opportunities and retirement homes, the Texas coast will undoubtedly feel the effects of heavy population influx. While contributing to the economic base of the coastal areas, they *will exert further pressure* on the coastal and shelf zones of the Gulf itself.

It is clear that the conflicting uses of the Gulf resource must be brought into *proper perspective.* Yet it is already obvious that we are *exploiting and polluting an essentially unknown resource* and that the intensity of use and abuse will increase with greater human settlement and technological development. The Texas coast is already feeling the effect of oil pollution and of continental pesticide utilization, and *the question may legitimately be asked as to whether the biological resources of the Gulf will continue to be fit for human consumption or whether, indeed, they will even continue to exist as the toxic non-degradable wastes accumulate.* To those attempting to study the Gulf, the need for more detailed knowledge is as obvious as the need for planning.

*Within the immediate future, the main pressure will be directed to the estuaries and the shelf.* Yet one can not hope to understand either the estuaries or the shelf through superficial surveys of standing stocks or of pesticide analyses of occasional marine organisms. The resources of the Gulf are intimately interrelated; and to understand these relationships, *one must develop the theoretical framework upon which practical decisions may be based.* Of cardinal importance is the knowledge of the biological, chemical, and sedimentary characteristics of each water mass bathing the coast. With this knowledge as background, multi-disciplinary inventories will provide the base-lines against which pollution and exploitative effects may be measured.

## V. FILLING THE GAPS

Research supplies the basic data upon which planners and legislators must ultimately rely to reach appropriate decisions concerning multi-use resources. To bring the present discussion into the kind of focus necessary for planning and legislative decision-making there is set down below a series of concrete problems which merit immediate attention.

1. *Air-water interactions* - One of the most basic needs relates to the understanding of the complex water currents of the Gulf of Mexico, the factors which underlie them, and the ways in which the water currents interact with air patterns to produce the variable and often severe weather of the coastal zone. This knowledge is of fundamental importance in planning for shipping, agriculture, recreation, and dense human settlement in the coastal zone. Such knowledge also must underlie our understanding of the functional biological systems of the Gulf as well as the distribution and effects of coastal pollution, oil spills, etc.

2. *Inventory of mineral resources* - Since most of the information concerning the potential mineral resources of the Gulf is not available to the public some effort to survey these resources should be made by the State. The survey should give some attention to the subsurface deposits (oil, gas, sulfur, etc.) as well as the surface deposits of harvestable sand and shell. Associated with these investigations other studies should be carried out to determine methods of exploitation which would *cause the least damage* to the biological resources of the overlying water.

3. *Inventory of biological resources* - There is a strong and immediate need for a thorough inventory of the marine biological resources of the Texas shelf and adjacent waters. This study should be coupled with a detailed analysis of *how the ecological system actually works*. Such studies are necessary to lay the groundwork for wise management of the harvestable biological resources, *but they also are important in establishing the base-lines against which pollution damage may be assessed. Herein lies the URGENCY.*

4. *Survey of present extent of Gulf pollution* - There exists a desperate need to determine the extent to which the various areas of the Gulf are *already* damaged by pollution. On almost every oceanographic cruise the scientists encounter *oil slicks* on the surface. Cables, ropes, and equipment often come up oily. Bottom samples retrieve all manner of *human debris* from tin cans to metal gun

shell casings. Mounting evidence of *pesticide and heavy metal* pollution of the bays and estuaries suggests that the environment of the continental shelf may also be subject to pollution pressure, and it is of utmost importance to initiate an in-depth survey of pollution damage to the environment and ecosystem of the shelf zone.

5. *Studies to predict future dangers* - Investigations should be carried out in both the laboratory and the field to predict the effects of intensive coastal zone utilization and water resource modification on the Gulf system, and *particularly on the harvestable biological resources.* In order to complete their life cycles most of our commercially important fish and shellfish species require low salinity waters of high quality as well as estuarine bottoms which are constantly refertilized by the silt load derived from *normal* stream discharge. Construction of the Aswan dam in Egypt *has devastated* the fishery industry of the eastern Mediterranean, and it is *possible* that the State of Texas can accomplish the same result for its Gulf fishery if the coastal zone is deprived of its normal flow of nutrient-laden fresh water.

6. *Establishment of marine wildlife sanctuaries* - Up until the present time the living resources of the Gulf *have been taken for granted.* With intensive pressure from human coastal activities, however, the marine life will need help to survive. If survival of marine life is important to the well-being and happiness of the human population immediate steps should be taken to establish a series of marine and coastal wildlife sanctuaries where the marine organisms may exist in perpetuity. Such sanctuaries would be of considerable recreational value, but they would also serve as a source from which more devastated areas could be restocked.

   It is specifically recommended that *San Antonio Bay* and *Matagorda Island,* which are still in fairly primitive condition, be designated as a sanctuary to accompany and protect the birds and other wildlife of the Aransas Wildlife Refuge. It is also recommended that steps be taken to preserve Texas' only major living coral reef, the *Flower Gardens,* located on knolls at the outer edge of the continental shelf (about 120 miles southeast of Galveston). As the northernmost living coral reef of the western Atlantic these undersea gardens are of considerable scientific interest and of potential recreational value. *Unfortunately, this is also a convenient spot for ships to anchor while cleaning out their tanks before proceeding into the Port of Galveston.* Damage from anchors, garbage, and tank refuse is mounting.

7. *A synthesis of our knowledge of the Gulf* - Knowledge of the Gulf of Mexico is not readily available to the planner, legislator, industrialist, educator, sportsman, and general reader. Furthermore, even the oceanographer has a firm grasp of only the *limited* portion of the subject with which he is working. As an aid in future planning and as a service to the public, the State of Texas should authorize and finance an endeavor to provide a sourcebook on the Gulf of Mexico which is both authoritative and readable. The potential authors of this book *are already present* in the State.

*APPENDIX*

## MAJOR SOURCES OF REFERENCE LITERATURE CONCERNING THE GULF OF MEXICO

A. *General Sources* (containing a variety of types of information)

1. Books

Galtsoff, P. S. (Ed.) 1954. Gulf of Mexico, Its Origin, Waters, and Marine Life. U. S. Fish & Wildlife Service, Fishery Bulletin, 55. 604 pp.

Ladd, H. S. (Ed.) 1957. Treatise on Marine Ecology and Paleoecology. Geological Society of America Memoirs. 67, Part 1. Ecology. 1296 pp.

2. Journals

Deep Sea Research

Journal of Marine Research

Limnology and Oceanography

3. University Series

University of Miama (Florida)

- "Bulletin of Marine Science of the Gulf and Caribbean"

Louisiana State University

- Coastal Studies Institute - "Technical Report" Series

University of Texas

- "Contributions in Marine Science"

Texas A&M University - Department of Oceanography

- "Contributions in Oceanography"
- "Folio Series on the Gulf of Mexico" (Publ. by the American Geographical Society).
- "Technical Reports" Series
- "Texas A&M Oceanographic Studies" (Publ. by the Gulf Publishing Company, Houston, Texas).

B. *Journals Related to Specific Fields*

1. Biological

   U. S. Fish and Wildlife Service, Fishery Bulletins

   U. S. Fish and Wildlife Service, Special Scientific Reports - Fisheries

2. Chemical

   Geochimica et Cosmochimica Acta

3. Geological

   American Association of Petroleum Geologists, Bulletin

   Gulf Coast Association of Geological Societies, Transactions

   Journal of Geology

   Marine Geology

4. Physical and Geophysical

   American Geophysical Union, Transactions

   Journal of Geophysical Research

# THE MULTI-USER ZONE OF THE GULF OF MEXICO --ITS PROMISE AND PROBLEMS[1]

*Richard A. Geyer*[2]

## INTRODUCTION

There is an ever increasing intensification of the use of the coastal zone as the expanding population of the United States moves into this area. Currently, seventy percent of the Nation lives within an hour's drive of the sea coast, if the Great Lakes are included. A decent concern to preserve life's amenities, as well as economic considerations demand that more adequate provision be made for recreational use along the Nation's crowded coastal zone. It may come as a surprise that this emphasis on the recreational use of this zone should come so early in this discussion when one realizes the critical industrial uses that exist in this area as well. A comparison of recreational activity in coastal and offshore areas is summarized in Table 1. However, if the citizens of the highly congested urban areas along the sea coast do not have clean and attractive areas for recreational pursuits then many of the severe urban problems which face us today will never be solved completely and satisfactorily. In addition, private housing has exercised and will continue to exercise one of the greatest demands for available shore property. This is demonstrated, for example, in the Boca Ciega bay area off the West Coast of Florida. It has been transformed completely by housing developments and related activities in the past twenty years. The same applies to several areas along the Gulf Coast. But there are other needs that must be met. Traditionally heavy industry is located on the water's edge in seeking a cheap source of transportation for its finished products as well as ready access to raw material and a simple solution to waste disposal problems. Pollution abatement requirements have lessened somewhat the economic desirability of a waterfront industry location, but recent trends in

TABLE 1. A Comparative Summary of Recreational Activity in Coastal and Offshore Areas

| | Participants, millions | | Annual expenditures, millions of dollars | |
|---|---|---|---|---|
| Type of recreation | 1964 | 1975 | 1964 | 1975 |
| Swimming | 33.0 | 40.0 | $1,500 | $2,000 |
| Surfing | 1.0 | 4.0 | 50 | 200 |
| Skin Diving | 1.0 | 3.0 | 300 | 900 |
| Pleasure Boating | 9.6 | 14.0 | 650 | 1,000 |
| Sport Fishing | 8.2 | 16.0 | 760 | 1,300 |
| Total | 52.8 | 77.0 | $3,260 | $5,400 |

Source: Battelle Memorial Institute, *A Study of the U.S. Coast and Geodetic Survey's Products and Services as Related to Economic Activity in the U.S. Continental-Shelf Regions*, April 1966.

[1]Paper No. 70052 of the Water Resources Bulletin (Journal of the American Water Resources Association). Presented at the Fifth American Water Resources Conference, San Antonio, Texas, October, 1969. Discussions are open until six months from date of publication.

[2]Head, Department of Oceanography, Texas A&M University, College Station, Tex.

shipping have increased the demand for deep water frontage. Deep water access will be essential to the future competitiveness of steel and other U.S. industries processing large volumes of heavy raw material. Similarly, future shoreline development must provide adequately for additional transportation and power generating facilities. For almost a hundred years a vast network of piers, warehouses, and railroads was constructed about the perimeters of the Nation's ports, as seen in Figure 1. Today these facilities and housing to handle the type ship shown in Figure 2, as well as major offshore unloading facilities for deep draft tankers are shown in Figure 3. This transition will be extraordinarily difficult and will require considerable planning and coordination of public and private activities on an entirely new scale.

Electric power production has doubled approximately during every decade of this century. An increasing percentage of new power plants will use nuclear fuel; disposition of waste heat will become an increasing problem. An example of such a combined power and desalination plant designed for the Los Angeles area is shown in Figure 4. It is estimated that by 1980 the power industry will use for cooling one-fifth of the total fresh water run-off of the United States. Many more power plants will be located along the shore, thus competing not only for valuable land but warming the local waters posing a major threat to the regional ecological balance.

This is especially serious when we consider that seventy percent of the present U.S. commercial fishing effort takes place in coastal waters. Coastal and estuarine waters and marsh lands provide the nutrients, nursing areas, or spawning grounds for two-thirds of the world's entire fishery harvest. Seven of the ten most valuable species in American commercial fisheries spend all or important periods of their lives in estuarine waters; and at least 80 other commercially important species are dependent upon estuarian areas. Thus, not only thermal pollution but other types of pollution present an ever increasing threat, together with land fillings, dredging, dumping, and marsh draining operations to these areas. For example, eighty percent of the 300 square miles of tidal wetlands originally surrounding San Francisco Bay have been filled. Coming closer to home, 68,000 of the 828,000 prime acres of estuaries for the state of Texas or eight percent of this habitat has been lost. Of the other states bordering the Gulf, namely, Louisiana, Florida, and Mississippi, the percentages lost to date are 3, 8, and 2 percent respectively. Although one might say this compares favorably with the sixty-seven percent lost to California, and fifteen percent to New York and New Jersey, the impact on the fishing industry can be substantial when the pollution aspects as well are also considered.

Although aquaculture today as shown schematically in Figure 5 is of relatively minor importance in the coastal zone, its future in this area will continue to grow. As it does, the problems of conflicting use will increase; and estuarian areas leased for this purpose may be closed to sports fishermen and in some cases to navigation. A state wishing to emphasize the development of a major program in aquaculture may be compelled to limit its shore-side industrial development, or visa versa. Similarly, the conflict between competing objectives such as navigation, flood control and aquaculture is also a real one, as for example in the case of the Bonnet Carre Spillway located on the Mississippi River near New Orleans. Opening this spillway occasionally in the interests of flood control results in vast volumes of fresh water diluting the salinity of large areas to the extent that the oyster industry could be affected under certain conditions.

The expanding use of merchant as well as military shipping in the Coastal Zone, particularly the use of very large super tankers soon will require the designation of reserved fairways. The introduction of high speed hovercraft and hydrofoils will call for new safety measures, not to mention the burgeoning expansion of power boats and sailboats and their attendant marinas will be competing to an ever increasing degree in this zone.

## DEFINITION AND STATISTICS OF COASTAL ZONE COMPONENTS

The Coastal Zone is a region of transition between two environments--the land

Figure 1

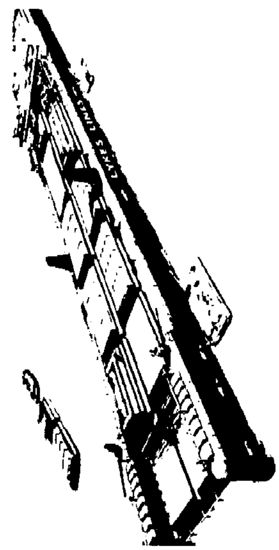

Figure 2

Figure 3

Figure 4

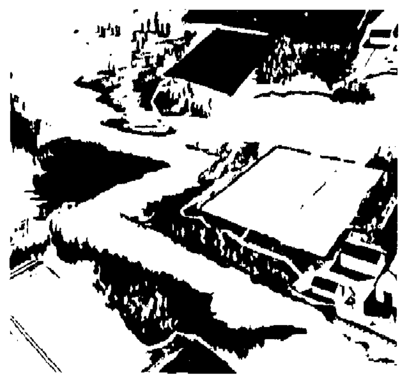

Figure 5

and the sea. It may be defined as that part of the land affected by its proximity to the sea. It includes a total of 1,631 statute miles along the Gulf Coast. The associated estuarine areas along the Gulf of Mexico include 3,838 square miles. This area is based on a definition of an *estuarian zone*, as an environmental system consisting of an estuary and those transitional areas consistently influenced or affected by water from an estuary, such as, but not limited to, salt marshes, coastal and intertidal areas, bays, harbors, lagoons, inshore waters and channels--as well as all or part of the mouth of a navigable or interstate river or stream or other body of water having unimpaired natural connections with open sea and within which the sea water is measurably diluted with fresh water derived from land drainage.

The total shoreline of the Gulf of Mexico includes 17,500 statute miles. Of this, some 4,000 miles have been categorized as recreation shoreline of which only 121 meet the criteria of public recreation shoreline. Of the slightly more than a thousand miles of recreation shoreline of the state of Texas, 301 miles are designated as beach, 421 bluffs, and 359 miles as marsh. For Louisiana with a comparable total shoreline 257 miles are designated as beach and the remainder of 819 as marsh. All but two miles of the entire 1,076 in Louisiana are privately owned. Of the total of 203 miles of shoreline for Mississippi, 134 are categorized as beach and 69 as marsh and 178 miles are privately owned.

The value of Louisiana fisheries in 1966 was approximately $100 million. In 1966, according to the Independent Petroleum Association of America, the value of crude oil, natural gas liquids, and natural gas at the well head, in Louisiana was slightly more than $3 billion and the petroleum industry paid almost half of the state's revenue.

Aquaculture is widely enjoyed in Asiatic countries and five percent of Japan's total fish catch comes from coastal areas having retention devices. Within the United States this is currently limited to development and pilot studies, but thriving commercial fresh water trout and catfish farms have developed recently. It is estimated that in the five-state southcentral region about 13,000,000 acres are suitable for conversion to catfish farms.

Port development expenditures in the United States from January 1, 1946 to December 31, 1965 in the Gulf Coast area totaled $385 million of which $199 million was for general cargo facilities and $186 million for specialized facilities. During this period the average size tanker in the world fleet increased from 15,000 dead weight tons to 27,000. However, the majority of new tankers building and planned are much larger with the largest one now operating of 312,000 tons was built in Japan. Similar increases in size for dry bulk and container carriers are also forecast. Tankers having a tonnage of 760,000 tons have been forecast for 1980 and the uppermost practical limit of a million tons based upon projected technology and experience is forecast for the period between 1990 and the year 2000. Bulk carrier tonnage of 185,000 tons are forecast for 1980 and 317,000 tons for 1990.

Since the River and Harbors Act was passed in 1826 the Federal Government has assisted in the development of over 500 commercial harbors, as well as assuming the responsibility for periodic dredging maintenance and navigational aids such as charting, channel markers, and buoys. This has resulted during this period of expenditures totaling $2.2 billion of which approximately three-quarters has been for deep draft harbors and channels. Deep draft being defined as an authorized depth of 30 feet or more for coastal harbors. The Gulf Coast participated in this expenditure in the amount of $182 million for construction and $123 million for maintenance. For harbors less than 30 feet the total expenditures for this area has been $43 million. Non-federal contributions for these activities totaled $3½ million for the shallow harbor class and $30 million for the deep.

Current funding by Federal agencies for activities relating to the Coastal Zone for the fiscal year averaged slightly more than $600 million. It involves such activities as fisheries, water pollution control, geologic surveys, national park services, Office of Saline Water, Bureau of Outdoor Recreation, Coast Guard, Corps of Engineers, ESSA, and so forth.

The suggested cost estimate for managing the Coastal Zone proposed by the President's Commission on Marine Resources is summarized in Table 2, for the next ten years in five-year increments. The total cost for the various categories including management and planning, land acquisition, scientific and engineering studies, including a Great Lakes restoration project, is estimated to be an average of $86 million annually for the first five years of the next decade, and $121 million per year for the next five years or a total of a little more than a billion dollars for the 1970 decade.

TABLE 2. Managing the Coastal Zone

(Incremental costs in millions of dollars)

| | Average annual costs | | Total 10-year costs |
|---|---|---|---|
| | 1971-75 | 1976-80 | |
| Management and Planning | $10 | $10 | $100 |
| Land Acquisition | 11 | 11 | 110 |
| Scientific and Engineering Studies | 50 | 80 | 650 |
| Operation of Coastal Laboratories | 10 | 20 | 150 |
| Estuarine Monitoring Equipment | 6 | 4 | 50 |
| Pollution Research | 4 | 2 | 30 |
| Coastal Engineering and Technology | 20 | 40 | 300 |
| Ecological Studies | 10 | 14 | 120 |
| National Project--Lake Restoration Project | 15 | 20 | 175 |
| Total, Managing the Coastal Zone | 86 | 121 | 1,035 |

## COASTAL ZONE MANAGEMENT--PROBLEMS AND THEIR POSSIBLE SOLUTION

Currently federal, state, and local governments including intrastate and municipal coastal and harbor authorities are funding coastal zone facilities through revenues derived by taxation of citizens and industries situated in this area. Consequently, they also share the responsibility to develop a plan for the coastal zone which reconciles, or if necessary, must make decisions to choose among competing interests and protect both long- and short-term values. Effective management to date has been thwarted by:

1. the variety of government jurisdictions from all categories involved,
2. the low priority afforded marine matters by state governments,
3. the diffusion of responsibilities among state agencies, and
4. the failure of state agencies to develop and implement long-range plans.

Until rather recently, navigation over which the Federal authority is preeminent has tended to dominate other uses of the coastal zone and perhaps for this reason states have been slow to assume their full responsibilities. In addition, the Federal role in the Coastal Zone has grown haphazardly and unfortunately with a minimum of coordination among the agencies responsible. For example, closely related functions are discharged by the U.S. Coast Guard, Army Corps of Engineers, Department of Housing and Urban Development, together with a number of bureaus of the Department of the Interior and several other Federal agencies. The Federal Government sponsors planning activities in certain coastal areas through River Basin commissions, which were established pursuant to Title II of the Water Resources Planning Act of 1965 and in certain others to regional commissions established under Title V of the Public Works and Economic Development Act.

Current coordination at the Federal level is the Committee on Multiple Use of the Coastal Zone of the Marine Council. It considers the broad aspects of coastal management and seeks effective and consistent Federal policies. In addition, the Water Resources Council, a Cabinet level coordinating and planning group analogous to the Marine Council, but chaired by the Secretary of the Interior also has an interest in the Coastal Zone. However, its work is primarily directed to inland waters, but neither committee is concerned with the detailed management of specific coastal areas. This diffusion and fragmentation of responsibility is reflected within state governments within which individual agencies deal directly with their counterparts at the Federal level. Too often states lack plans of their own based on an appraisal of all state interests and a lack of sound scientific knowledge in developing and maintaining their coastal resources. Frequently, in these cases states have tended only to react to Federal plans.

On a state government level, the states are frequently subjected to intense pressures from the county and municipal levels because coastal management often directly affects local responsibilities and interests. Hence, local knowledge frequently is necessary to reach rational management decisions at the state level. These decisions in turn should be reflected at the Federal level. Thus, making it necessary to reflect the interests of local governments in accommodating competitive needs.

The President's Commission on Marine Engineering and Resources has given considerable thought to the problem of Coastal Zone Management. It recognized the tremendous significance of this problem by designating a panel to study it specifically during its two-year tenure. In fact, of the many recommendations made by the Commission to accelerate the development of marine resources the closest program considered for the possible category of a crash program was that of Coastal Zone Management. This is necessary because of the rapidly accelerating rate at which existing coastal zone areas are being consumed for a variety of purposes, without any long-term planning or often recognizing the legitimate needs of competing uses both industrial and sociological. As a result of the studies of this Commission panel, as well as of the entire membership a number of specific recommendations have been made. Some of the major ones include:

1. A coastal management act be inacted to provide policies and objectives for the coastal zone, and authorize federal grants-in-aid to facilitate establishing state coastal zone authorities empowered to manage the coastal waters and its adjacent land.

2. Federal legislation to aid states to establish coastal zone authorities should not impose any particular form of organization. But it should require approval of each grant be contingent on showing that the proposed organization has the necessary powers to accomplish its purposes, has broad representation, and provide adequate opportunities to hear all viewpoints, before adopting or modifying its coastal development plans.

3. The land and water conservation fund be more fully utilized to acquire wet lands and potential coastal recreation lands. Enact legislation authorizing federal guarantees of state bonds for wetland acquisition when necessary to implement the coastal management plan.

4. All federal agencies providing grants-in-aid to states, or engaging in coastal activities should review all projects for consistency with plans by the state coastal zone authority.

5. Estuarine studies should be conducted by the Department of the Interior to identify areas to be set aside as sanctuaries to provide natural laboratories for ecological investigations.

6. Federal and state agencies with coastal zone responsibilities should provide more adequate support for scientific and engineering research on coastal problems. This includes making an inventory of the multiple resources in this area.

7. Universities affiliated with coastal laboratories should be encouraged to provide aid to state officials on coastal issues and for their training.

8. The National Oceanic and Atmospheric Agency in collaboration with the Department of Transportation, U.S. Army Corps of Engineers, and the Atomic Energy Commission should support feasibility and fundamental engineering studies relevant to the development of offshore terminals, storage facilities, and nuclear power plants.

9. Legislation be enacted to enable the AEC to consider environmental effects of projects under its licensing authority.

10. Rivers and Harbors Act of 1899 be amended to empower the U.S. Army Corps of Engineers to deny a permit in order to preserve important recreation, conservation, or esthetic values, or to prevent water pollution.

11. The FWPCA should give increased emphasis on research to identify specific pollutants and their effects. Immediate action by this agency aided by the National Oceanic and Atmospheric Agency should be taken to develop instrumentation and to detect and record pollution loads as part of an overall estuarian monitoring network.

12. Review enforcement procedures by federal agencies to strengthen enforcement of existing laws, and Presidential orders concerning pollution abatement.

13. Federal assistance should be given to states and localities adequate to permit the construction of waste treatment facilities at the rate already authorized by law.

The Commission recommended also that coastal zone policies should recognize the desirability to provide an outlet for the energy and innovative talent of individual entreprenures. Many ways exist in which these energies might be applied including not only for aquaculture projects but for underwater tourism. States should develop procedures to permit the leasing of offshore areas for new uses consistent with the overall plans of the state coastal zone authorities to develop these areas.

It was felt by some that underwater leases of this type might capture some of the excitement and public interest spurred by the Homestead Act of 1862. Such "sea-steads" might be offered for extended periods on attractive terms contingent upon the useful development of the marine tract so that it would still safeguard necessary navigation, fishing, and other uses of the superjacent waters, and would also be integrated for the overall plan for the development of the Coastal Zone. In this connection, it should be emphasized that oil, gas, and mineral rights could not be conveyed through a seastead plan.

Estimated costs of the various facets necessary for a comprehensive, efficient, and successful plan to manage the Coastal Zone were summarized in Table 2. It is not too soon to start implementing the many recommendations made by the Commission for the Coastal Zone of the United States, which is the Nation's most valuable geographic feature if it is to be developed in an optimum manner for all concerned. Yet it must be done in a manner compatible for the best short- and long-term interests of the diversified segments of the industrial and sociological components of our society. Otherwise it will not be possible to cope successfully with the myriad of problems involved in this area which holds for our nation so much promise, as well as unfortunately problems. Hopefully, the latter will not be insurmountable if the entire Nation is to derive the maximum benefit from this area.