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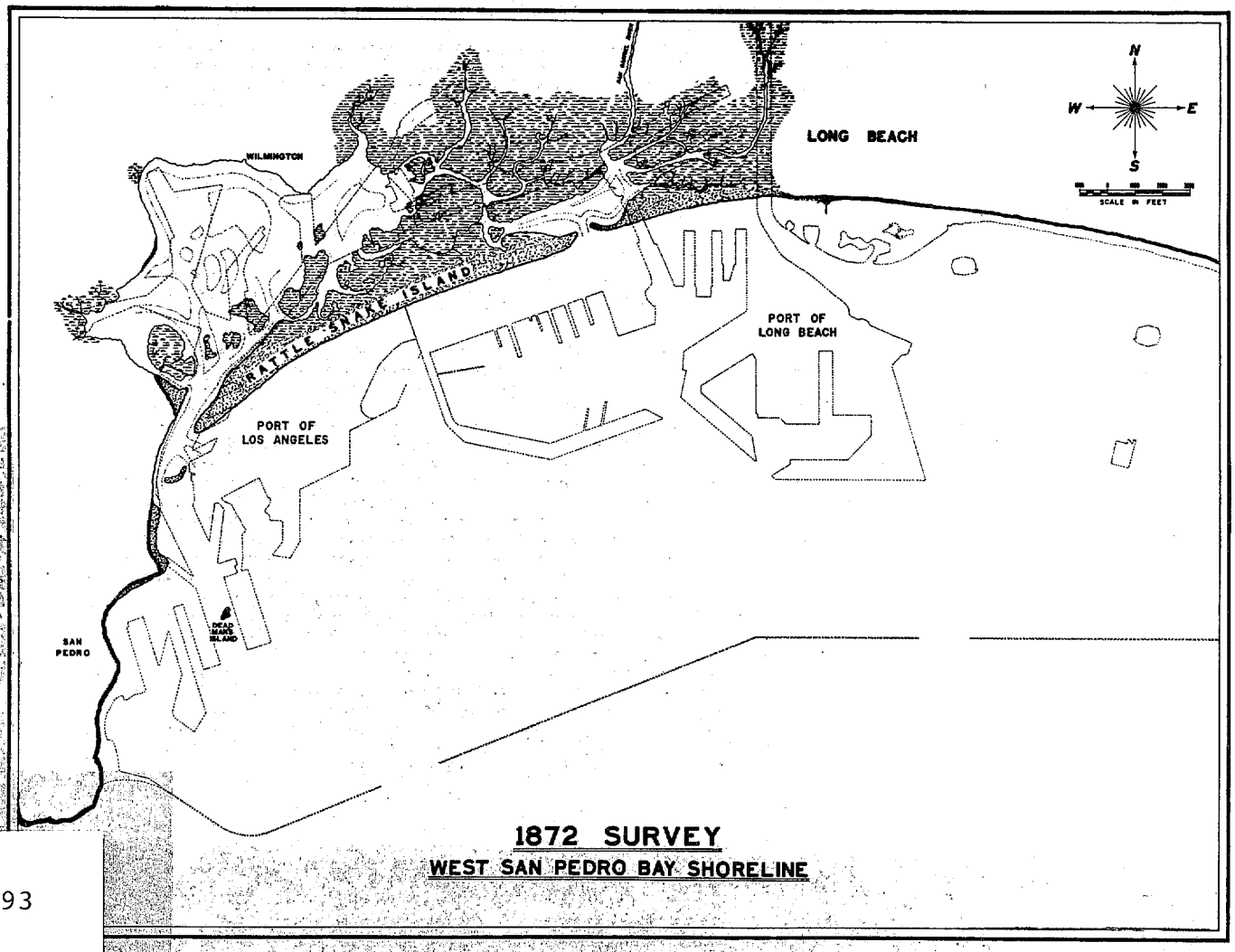
THE URBAN HARBOR ENVIRONMENT



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PROCEEDINGS OF THE FIRST

SOUTHERN CALIFORNIA OCEAN STUDIES CONSORTIUM

SYMPOSIUM

THE URBAN HARBOR ENVIRONMENT

Edited by

J.N. Baskin, M.D. Dailey, S.N. Murray and E. Segal

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*Symposium speaker

INTRODUCTION

COASTAL ZONE
INFORMATION CENTER
MAR 1979

The Southern California Ocean Studies Consortium (SCOSC) chose the theme "Urban Harbor Environment" for its first symposium because of the timely and important nature of the topic. The symposium was held at the University Union, California State University, Long Beach on April 16, 1977. The urban harbor is currently an area of controversy since the needs of parties representing commercial shipping, recreational boating, water front construction and public beach space collide in community shoreline planning. Through our six State university campuses, we seek to carry out an active role in identifying, publicizing, and solving marine-related problems in the Los Angeles basin. Nearly every marine community within this region has been faced with major planning decisions concerning the harbor environment.

We structured the symposium to present broad coverage of the urban harbor environment. To this end we invited individuals with expertise in various disciplines from harbor administration and planning to environmental sciences. Our intent was to treat these topics to lend continuity to subject matter, thought and discussion.

It is our hope that the information presented in this symposium has functioned to provide perspective and to broaden our view of the urban harbor environment and to lend insight into existing and future problems of concern to all parties with an interest in this environment.

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SUMMARY OF THE PROCEEDINGS

This symposium covers an exceptionally broad range of topics on the subject of the Urban Harbor Environment, from special aspects of land ownership to the life styles of fishes and worms.

The historical perspective is set by Donald B. Bright. He discusses, in both general and specific terms, guidelines for the incorporation of the undefinable "public interest" in harbor master planning. He outlines the planning elements and the areas where data are needed to reconcile public and commercial interests. That the interests of all lie together, in the maintenance of an environment where men can continue to live, rather than just survive, is impressed upon us by a vivid quotation from an 1885 letter from the chief of the Duwamish Indians to President Franklin Pierce.

Lindell L. Marsh provides an insight into the legal aspects of marina and harbor development, and the attorney's role in that process. He examines in specific detail the intricacies of land ownership. The unique difficulties of determining such ownership in the constantly changing tideland environment, with the complexities of the old Mexican land grants, is illustrated in an historical context. He recommends retaining locally weighted decision-making and private property institutions in the planning process, while incorporating regional and statewide concerns. The preferred mechanisms for reconciliation of these interests is the specific plan, as authorized by the State Government Code. It is also increasingly appropriate for governmental agencies to have a major role in the design process.

Margarita McCoy discusses the planning of land use. She finds that the Coastal Commission's activities have been "at best, ineffective..." Five steps of the planning process are given:

1. Systems analysis (collection and analysis of information).

2. Goals definition (the political problem of finding out what we want).

3. Evaluation of alternative means (figuring out how to get what we want).

4. Plan formulation (goals, means and rules of implementation are put together).

5. Implementation and feedback (planners recommend procedural changes to keep goals intact).

The operation of these five steps by the California Coastal Commission Local Coastal Program Regulations, and the effect of these regulations on urban coastal planning, is assessed. It is concluded that the cities must play a greater role in the planning of developed areas.

Dorothy F. Soule, in her discussion of environmental sciences and harbor planning, points out that there is much to be gained through broad academic, industry, and governmental cooperation in harbor studies. Data bases for analysis and impact projections can be more readily accomplished with each group working together rather than independently. She proposes that regardless of the desirability of a given project, at least there will be a data base upon which to make decisions, and that these decisions may be influenced by available environmental information.

Biological aspects of the urban harbor environment are discussed in four papers. Rimmon C. Fay and James A. Vallee bring together a large amount of original data and many observations on 16 Southern California harbors. These harbors are compared with "natural" estuaries using five physical parameters (water surface area, shoreline, depth, volume, tidal volume change) and data from various sources on numbers of species found in each area. They conclude that shallow embayments and substantial tidal exchange are important for the development of large and diverse populations of marine organisms. When comparing harbors with natural areas, the presence of multiple substrates, increased circulation and more sedimentary bottoms does not result in greater numbers of species per unit area in harbors. They further conclude that water circulation is of principal importance in providing diversity and standing crop of organisms in harbors. None of the cases they consider show harbors to have improved the "habitat function" as compared with natural areas.

Alan J. Mearns and David R. Young summarize studies relevant to understanding effects of man's activity on some chemical and biological conditions along our Southern California coast. They explore coastal discharge sites in detail and indicate which pollutants appear to have the greatest biological effects. Data are given on the distribution of pollutants, and this is correlated with the kinds and amounts of organisms found (especially benthic infauna) and the distribution of diseased animals. Although DDT and PCB's are still present in Southern California coastal waters, some discharge control is beginning to assist in biological recovery in outer coastal areas. Harbors appear to provide their own sources of PCB's and trace metals and vessel related activities appear to be the specific source. The relationship between trace element inputs and biological changes is uncertain. The increased production of tolerant species appears to be the major effect

where organically rich solids are discharged, with resultant decrease in benthic infaunal diversity. It is suggested that the magnitude of biological effects and the mass emission rates of solids in wastewaters need to be quantified.

Donald J. Reish presents his ideas on the Los Angeles-Long Beach Harbors biological environment based on 25 years of research on the organisms, especially the polychaete worms. Based on the use of pollution indicator organisms and other data, he reviews the conditions in the harbor since the early 1950's. He points out the dramatic reduction in pollution and the recovery of the benthic biological community that has occurred since the initiation of the pollution abatement program in 1968. He considers benthic biological conditions, as shown especially by indicator organisms, the best measure of the "health" of the harbor aquatic environment, and is optimistic about its future. He points out, however, that the terrestrial environment needs improvement.

John S. Stephens, Jr., is also optimistic in his discussion of original investigations of the fish populations and their habitats in King Harbor and Los Angeles-Long Beach Harbors. In contrast to the conclusions of Fay and Vallee, Stephens suggests that harbor facilities (especially breakwaters) are more productive environments than similar substrate areas in Southern California. Also, harbors here supplement or replace natural areas as nurseries for juvenile fishes.

Although no participant in the symposium ventured to define the "public interest", Mearns and Young give a view of the public's expectation. "...reasonable access to an uncluttered sea, strict adherence to high standards for public health, adequate management of harvestable resources and protection of the underlying ecosystem." The contributors to this symposium present a reasonably optimistic picture that this expectation may well soon be met, at least for the aquatic environment of our Southern California urban harbors.

HARBOR MASTER PLANNING AND PUBLIC INTEREST

by
Donald B. Bright

INTRODUCTION AND HISTORICAL CONCERNS

Planning can be defined as the devising of a scheme for doing, making or arranging. Often, planning is viewed solely as futuristic. But, planning cannot be accomplished in a void. It must be founded on what has happened in the past, as well as what is wanted for the future. Therefore, let me set the stage for the consideration of harbor master planning by providing a brief historical overview of man's interest in the sea and commerce.

The philosophy of "down to the sea in ships" began with the Phoenicians as they pursued and developed new trade routes. But even the adventurous Phoenicians were restricted in their travels by the belief that the world was flat and the oceans could not be circumnavigated. The age of European exploration perhaps represents the next phase. It flourished in the fifteenth and sixteenth centuries when adventurous navigators set out to discover new wealth on land despite the then widespread opinion that if one adventured too far he was certain to fall off the edge of the sea into the unknown. This period included the voyage to America by Columbus whose view of the sea was representative of that time, i.e., a vast, endless and untested but challengeable obstacle to his pursuits. Later periods were marked by active efforts to acquire knowledge about the ocean. Major oceanographic expeditions such as the Challenger and the Fram provided the vehicles for scientific inquiry followed more recently by such ships as the Seadragon, the Glomar Challenger and locally, the Velero IV. Today man has come to the realization that with the large utilization of the ocean for recreation, commerce and as a dumping ground, that it has suffered from his hand; it is not endless, it is limited just like the land in its ability to absorb traffic and perturbation. Scientific studies have documented the degree and at times the nature of ocean degradation and have clearly indicated the need to protect, preserve, enhance and restore its resources. However, this difficult task must be accomplished in balance with commerce and world trade. Perhaps, the harbor environment presents the greatest challenge in meeting this goal for it is an intense focal point of man's marine activities. To accomplish these ends, considerable effort must be placed in the planning process.

PLANNING, REGULATION AND THE PUBLIC INTEREST

Planning and control has been a prime goal of man since his very beginning. Controls, such as cultivation and altered

1) Proposed land and water uses.

2) Projected design and location of port land and water areas.

3) Estimate of the effects of development on the marine environment.

4) Listing of projects which will require Coastal Commission review after approval of the Port Master Plan, such as oil refineries, storage transmission and processing facilities, for example, for LNG and crude oil.

5) Provisions for public hearings and participation.

How can decisions be reached that give fair treatment to public interest and still leave the ports with the needed flexibility to continue growth and efficient operation? Obviously, for the process to be successful, several important planning elements must be employed. These include:

1) Establishment of a set of goals and objectives to provide guidance in decision making so as to insure compatible, but flexible port development.

2) Concern for developing plans which are sensitive to changing marketing and operational trends.

3) Prioritization of use of harbor lands for maritime purposes which minimize the impact on limited coastal resources.

4) Incorporation of state-of-the-art technology to maximize the use of existing facilities.

5) Creation of guidelines for the provision of buffer areas between port industrial complexes and adjacent communities based on recreational, open space, public access, and other public interest concerns.

Additionally, the availability of a current and accurate data bank defining environmental conditions and commercial and recreational facilities and operations is needed. These data must include:

1) Environmental conditions, such as air and water quality, distribution and abundance of harbor biota, water movements and seismic conditions.

2) Oil production, including the number, location and capacities of wells, tanks, pipelines and processing plants.

3) Storage and transfer of dry (e.g., soda ash, petroleum coke, coal) and petroleum (e.g., crude oil, gasoline, jet fuel) bulk.

4) Cargo-handling techniques, and the location and number of dry docks and port operation and support facilities, such as tugs and shiphandlers.

5) Present and planned recreational, governmental and research facilities and the availability of utilities such as telephone, water and electrical power.

6) Distribution of open space including aquatic and greenbelt areas, highway corridors and recreational terrain.

Ports also must develop safety criteria to account for seismic risk and expanded operational efforts.

There must be a process for incorporation of the diversity of public interests. Therefore, the process of public input must be flexible and responsive but, not such as to be abused by the chronic complainer who has limited and vested-interest vision on a given topic. For harbors, the public is mostly concerned about oil spills, LNG explosions, air pollution induced by port operations, reduced water quality from shipping operations, impact on view by port development, dredging and filling of harbor areas; ship safety, including conflicts between recreational and commercial boating also must be treated.

Initially, it might appear that harbor master planning is not compatible with the public interest. Often, in the past, the result has been conflict, confrontation, confusion and unnecessary rhetoric. Yet, within a framework of openness and the willingness to discuss issues prior to implementation, this incompatibility can be reduced or dissipated. With this goal in mind, we must consider three points which have been forged out of the "heat" generated by recent conflicts between planning and environmental concerns. Firstly, the environmental movement (ecoethics) is based on a practical precept, i.e., that environmental quality has diminished while simultaneously its value has increased to the public. Secondly, the future protection of the environment will be costly and that government, as the public's trustee must provide for environmental protection. Finally, govenmental agencies must broaden their view so as to achieve a realistic balance between the absolute development

ethic and the absolute conservation ethic. Based on these assumptions and provided we move towards productive resolution of conflicts, we can predict that in the future bureaucracy will increase while the public will hold increasingly tenacious positions for better, more efficient procedures and viable public participation. Also, properly trained professionals will increasingly address applied problems and bridge the gap between academic pronouncements, bureaucratic dicta and public temperament. The government and the public will participate in the decision-making process, but with a goal of solving problems, not creating new ones and realize that progress is not synonymous with either development or conservation.

CONCLUSIONS

In conclusion, we must pursue courses in harbor master planning and in the representation of public interest that instill responsibility in all participants. This sense of responsibility is subtly but clearly expressed in a statement made by Chief Sealth of the Duwamish Indians in an 1885 letter to President Franklin Pierce (National Archives, Correspondence of President Franklin Pierce). This statement, placed in context 122 years later, remains incisive and disturbingly appropriate. It reads:

> We know that the white man does not understand our ways. One portion of the land is the same to him as the next, for he is a stranger who comes in the night and takes from the land whatever he needs. The earth is not his brother, but his enemy, and when he has conquered it, he moves on. He leaves his father's graves, and his children's birthright is forgotten. The sight of your cities pains the eyes of the red man. But perhaps it is because the red man is a savage and does not understand.
>
> It matters little where we pass the rest of our days; they are not many. A few more hours, a few more winters, and none of the children of the great tribes that once lived on this earth, or that roamed in small bands in the woods, will be left to mourn the graves of a people once as powerful and hopeful as yours.
>
> The whites, too, shall pass - perhaps sooner than other tribes. Continue to contaminate your bed, and you will one night suffocate in your own waste. When the buffalo are all slaughtered, the wild horses all tamed, the secret corners of the forest heavy with the scent of many men, and the view of the ripe hills blotted by talking wires, where is the thicket? Gone. Where is the eagle? Gone. And what is it to say goodbye to the swift and the hunt, and the end of living and the beginning of

> survival? We might understand if we knew what it was that the white man dreams, what hopes he describes to his children on the long winter nights, what visions he burns into their minds, so they will wish for tomorrow. But we are savages. The white man's dreams are hidden from us.

Now is the time to determine our goals for today and tomorrow. We must cease the processes of making decisions on the goals of yesterday; "old wine in new flasks" is not the answer.

LEGAL ASPECTS OF MARINA AND HARBOR DEVELOPMENT IN THE CALIFORNIA COASTAL ZONE

by
Lindell L. Marsh

THE ROLE OF THE ATTORNEY IN THE DEVELOPMENT PROCESS

From a legal standpoint, marina and harbor developments in the California Coastal zone are extremely complex and reflect the coming together of two major and diverse physical systems, ocean and land. Nowhere are the number of conflicting and overlapping jurisdictions greater, the interests involved more diverse, and the public and private sectors more intertwined. My purpose in these brief remarks is to provide a general appreciation for the law and the role of the attorney with respect to marina and harbor developments.

Normally, the development process has been heavily centered in the private sector with the developer promulgating the plan of development subject to relatively limited governmental regulatory review and approval. In the coastal zone, however, the interests that may have some effect on the governmental approval of the development proposal are so numerous and complex that a different model or view of the process is appropriate. In such cases it is many times more effective to view the process as one in which the developer's role is that of project initiator and orchestrator and the public provides major design input.

Accordingly, a major component of this design process is the developer's understanding and appreciation of the role of each of the various agencies and interest groups that will be involved. The attorney must have not only an appreciation of the legal limits of the various institutional authorities but also must be sensitive to their underlying interests and concerns. He must work together with the development team to articulate a process which accords each separate interest its appropriate place in the whole.

From this broad overview of the attorney's role in the development process, I would like to discuss some of the specific legal considerations normally reviewed with a client when we are first engaged.

SPECIFIC AREAS OF INQUIRY

The initial discussions with a client include a consideration of the development process in general and then, normally, more specific attention to two areas of inquiry: legal title, and the regulatory permit process.

Title

Particularly in California, questions of title are normally resolved by securing for the developer a policy of title insurance. At the outset, the prospective title insurer customarily provides to the developer a preliminary title report describing the state of title which, when approved by the developer, is then incorporated into the policy.

Particularly at the land-sea interface, the determination of the state of title may become extremely difficult. This is because there are several unique title concepts and principles which relate to such areas, including the following:

1. Tidelands and Submerged-Lands. Generally, tidelands, i.e., those lands between the ordinary high water mark and the ordinary low water mark of the Pacific Ocean, belong to the State as an incident of its sovereignty. Based on a legal concept with its roots in Roman law, the state holds these lands in trust for the public for fishery, navigation and commerce. While it was determined in 1947 that the submerged-lands beyond these tidelands belonged to the United States, those submerged-lands were conveyed by the United States to the individual states.

At the outset one might ask how the boundaries of these tidelands and submerged-lands are determined? Obviously the line of the water on the land changes from moment to moment and from year to year. One need only observe Manhattan Beach before and after a major storm to know how drastic this change can be. In addition, each day there are two unequal high tides on the West Coast. Where is the ordinary high water mark?

Based on past decisions and statutes, generally the ordinary high water mark is set at the height of the average of certain high tides over a period of time. The period of time used has been 18.6 years, which corresponds with certain major cycles of the moon and the sun.

While there is some suggestion that the height of the run of the waters on the beach was used under Mexican law and that this rule should be applied to lands covered by Mexican rancho grants, the height used is that of the intersection of the plane of the ocean and the land at time of such average tides.

In determining the average high tides, which tides are used? The daily high tide? The higher high tide only? The spring tides? There is a conflict of authority as to whether the "neap tides" should be used or all of the high tides. The old cases in California used the neap tides although from a reading of those cases, it appears that the courts loosely used the term as synonymous with "usual" or "normal" tides and were unaware of a more specific

definition. With the increase in the value of coastal lands, a vertical difference in height of 0.3 m (1 ft.) may result in a change in the horizontal boundary of 6 to in excess of 30 m. The better rule is probably the use of all high tides. In part this is because historical data regarding the average of all high tides has been accumulated and is available, while data relating to neap tides would be extremely expensive and time consuming to determine.

What about the effect of artificial changes in the water interface, resulting, for example, from the construction of a groin or pier? Generally the courts have held that such modifications do not change the boundary but, in effect, fix it at its location in the last natural condition of the area. Obviously a question is raised as to the equity of this principle when the cause of the artificial condition, the State, is also the primary beneficiary. There is some authority to the effect that in this situation the rule would be different.

During the latter part of the 19th century and the early part of this century, the State purportedly conveyed substantial portions of the tidelands and submerged-lands along the California coast to private interests. In 1913, in an historic decision, it was determined that except in rare cases the transactions generally conveyed only the naked legal title to the lands subject to an easement in the public for commerce, navigation and fishery. Accordingly, even though the private owner of tidelands can trace his title to a State patent, the title may continue to be subject to the interests of the State. This rule of law has been modified somewhat where the owner can show that based on certain equitable principles that it would be unfair to permit the State to now assert its interest.

2. Federal Lands. Under the terms of the Treaty of Guadalupe Hidalgo of 1848, which settled the Mexican American War, the United States acquired title to all of the lands in California. It agreed however, to honor Mexican private property interests. These interests included, of course, all of the Mexican and Spanish ranchos which comprised a significant portion of the coastal lands of Southern California. Pursuant to the terms of that treaty, the Federal government established a commission to hear and determine the validity of various claims and to issue patents confirming these interests. The significance of a rancho grant and confirmatory patent is that if lands, even tidelands and submerged-lands, were included within a rancho patent, the Federal and State governments would have no proprietary claim to them.

This becomes extremely important with respect to wetlands where tidal sloughs may extend far into the property. In this case, it must be determined whether the rancho boundary crossed

the tidal inlet at its mouth or meandered the sinuous sloughs. Mission Street in San Francisco, for example, was the subject of a litigation on this point which was finally decided by the Supreme Court of the United States. It was held that the pueblo grant covering San Francisco crossed Mission Creek at its mouth and that the creek was within the land-sea pueblo grant. San Pedro Bay, which in its natural state did not present the definitive boundary that it presents today, was the subject of similar litigation in which the California Supreme Court drew the boundary line of the Rancho San Pedro across the mouth of the Los Angeles River. If lands were outside of the rancho, then they remained the property of the United States and subject to conveyance, by homestead patent for example, to private interests.

In addition, to make matters more complex, the Federal government authorized the State to segregate and sell into private ownership, swamp and overflowed lands within the State, which were extremely difficult to distinguish from tidelands. The procedures for dealing with swamp and overflowed lands were entirely different from tidelands and submerged-lands which resulted in a number of procedural errors which go to the validity of the conveyances of these lands.

In summary, the location of historic boundaries is an extremely complex and difficult process. This difficulty is exacerbated by the fact that this property was historically considered of little value, and accordingly, in many cases surveys were carelessly prepared or were simply copied from past surveys, usually with several drafting errors which distorted the actual boundaries. Further, historic documents are frequently difficult to locate and may involve investigations in Washington, Sacramento, San Francisco and libraries such as the Bancroft Library in Berkeley and the Huntington Library in Southern California.

Normally, when substantial questions regarding title boundaries have been introduced, we recommend that a surveyor or engineer with special expertise in this area be engaged to work under the supervision of counsel to review all of the information available and to provide us with their opinion as to the line which best represents the location of boundary in question. From the procedural viewpoint, we make sure that the opinion of this engineer will be accepted by the appropriate State and Federal govenmental agencies.

3. Tidelands grants. In some cases, the State has conveyed its interest in certain tidelands and submerged-lands to local governmental agencies for administration. For example, grants of tidelands and submerged-lands have been made to the San Diego Unified Port District, the cities of Huntington Beach, Long Beach, Los Angeles, Eureka and Orange County. In such cases, the developer must work with both State and local agencies in resolving the questions

relating to boundaries.

4. Boundary line agreements and land exchanges. In cases where title problems, such as those I have discussed above, exist, the developer may seek a boundary line agreement with the State establishing the location of the boundary in question. This may be incorporated into a settlement agreement whereby various disputes regarding title are resolved. In some cases a land exchange may be appropriate. The land exchange permits the developer and the State to each consolidate its land holdings into manageable parcels. Such a settlement is an extremely complex undertaking and is subject to a number of judicial and statutory requirements which are beyond the scope of our present discussion. Further, the areas involved are in many cases the subject of oil and gas leases and interests which further complicate the undertaking.

5. Public dedication by law of coastal access. Historically, the law has recognized the unique character of the land-sea/water interface as evidenced by the development of the tidelands trust for fishery, navigation and commerce which I have previously mentioned. Recently, the courts have articulated this concern in the form of certain presumptions based on use of accessways and beach areas by members of the public regarding the dedication by private landowners of lands and interests to the public in order to provide public access to and use of the coast and the ocean. This issue goes to the title of the property and must be addressed as part of the investigation of title.

6. Leases. In some cases, the site of the proposed development is not in private ownership and a lease or general permit must be obtained from the governmental agency having jurisdiction. Generally, as discussed above, tidelands and submerged-lands are owned by the State and are administered by the State Lands Commission. In some cases, where the lands have been granted to a local agency, the developer must obtain a lease or permit from that agency. In such cases the developer should carefully review the terms of the specific grant. This is because the grant may be terminated on certain conditions and there is some question as to whether the State, upon such termination, would take back the title to the tidelands subject to the lease to the developer. In answer to this concern, specific legislation has been adopted which establishes a procedure for the approval of the lease by the State Lands Commission whereupon, in the event of such a termination, the State will take the tidelands subject to the lease.

Regulatory Authority

Historically, marina and harbor developments have generally

required a number of governmental agency permits; however, in the last ten years, there has been a proliferation of additional required permits and far more demanding procedures with respect thereto. Historically, the permission and approval of the U.S. Army Corps of Engineers, the State Lands Commission and the local agencies have been required. More recently, however, the list of agencies involved has expanded substantially. The Corps of Engineers has permit authority for the dredging and filling of navigable waters. The Coast Guard is very much involved in developments that involve shipping and specifically have permit authority with respect to bridges over navigable waters. Regional and State administrative agencies, such as the State and Regional Coastal Conservation Commissions, have been established to regulate coastal development. The Federal Bureau of Sport Fisheries and the California Department of Fish and Game have become increasingly involved in the permit process, although technically a permit is not required from these agencies. In some cases, the State Water Resources Board and the Regional Water Quality Control Boards have become involved as well as the regional and State Air Quality Boards. In certain instances with respect to air quality, the Environmental Protection Agency of the Federal government may become involved. The California Energy Conservation and Development Commission has, and will increasingly have, an important role to play in the siting of energy facilities. The California Department of Public Parks and Recreation, the California Department of Transportation and the California Department of Navigation and Ocean Development may also have a role in certain cases.

There are a number of proposals which have been promulgated to deal with the proliferation of required permits. These proposals take into consideration the recent problems related to the proposed Dow Chemical Company facility on the Sacramento River, certain experiments to coordinate permit processing regarding dredging and filling conducted by the San Francisco Bay Conservation and Development Commission and certain statewide procedures established in Washington and Oregon. These proposals specifically contemplate certain consolidated and concurrent applications and hearings, standardization of criteria, coordination of time periods for review and in some cases, the reconciliation of conflicts between agencies.

Generally, these proposals reflect a consensus that certain regional and statewide interests have not been but should be taken into consideration in the planning of the coast. Generally, there also appears to be a concern that in acknowledging State and regional interests, local concerns will be overwhelmed and our long-established private property institutions will be adversely affected.

It is my opinion that we need to creatively develop mechanisms to permit the incorporation of regional and statewide concerns

into the planning process while at the same time retaining the locally weighted decision-making process, which is the level where most affected interests are normally represented, and the private property institutions which provide for a diversity of decision-making and action initiation which cannot be matched by government.

One of my favorite mechanisms for the reconciliation of these interests is the specific plan as authorized by the State Government Code. The specific plan can be established with respect to a specific area and may evidence and incorporate all of the programs, regulations, and policies of the local governmental agency relating to that area. It may also evidence a reconciliation with state, regional and private interests as well as, perhaps, federal interest. Limited attempts at developing such specific plans have occurred. A plan was developed with respect to Marina del Rey, under the direction of the USC Institute of Marine and Coastal Studies and Ms. Margarita McCoy. The City of Carlsbad also has successfully employed this approach with respect to the Agua Hedionda Lagoon, as well as other areas of the City. The advantage of the specific plan is that it sets out, in a comprehensive fashion, a consensus of the interests with respect to a particular area. It is not subject to the fragmentation which normally characterizes land-use regulatory schemes. It is my belief that the use of this mechanism, which is not substantially dissimilar in concept from the certification approach for local coastal programs under the Coastal Act, will substantially increase in the future.

THE PROCESS

I believe it is increasingly appropriate with respect to certain types of development to view the governmental agencies as having major roles in the design process. Certainly, the developer has ideas and requirements which must be incorporated in the development if it is to succeed, however, a major part of his role is increasingly that of orchestrator of the design process as a whole. At the outset of the project, in connection with the selection of the development team, the developer is best advised to approach the governmental agencies which will be involved and to establish their roles in the process. This liaison and appreciation of the relative roles of all interests must then be maintained in balance throughout the project's life.

A good example of this approach is the SOHIO project in Long Beach. It is my understanding that at an early date, SOHIO approached the Office of Planning and Research and obtained their assistance in coordinating an on-going involvement of the appropriate governmental agencies in the design and review of the project. While such a process cannot assure the developer that all conflicts will be avoided, I believe that it will predictably reduce them. Of course, projects of a smaller nature

than the SOHIO project will not always require such extensive coordination.

CONCLUSION

In these brief remarks, I have attempted to provide an insight into the legal aspects of marina and harbor development and the attorneys role in that process. The process in many cases is best characterized as one in which the developer has the role of initiator and orchestrator, utilizing a team of specialized consultants and working cooperatively with a variety of public and private interests to develop a concensus regarding the development which is to occur.

PLANNING LAND USE IN URBAN COASTAL AREAS

by
Margarita McCoy

THE ROLE OF CITIES IN CALIFORNIA COASTAL PLANNING

In 1972, when California began its coastal planning effort, the emphasis was on the undeveloped, "unspoiled" rural coastal zone. An analysis of the first elements of the Plan revealed that the needs of cities, except as the origin of pollution, were almost ignored. This was not surprising: the California Coastal Conservation Act of 1972 had its roots in the environmental movement which sought to right the balance between the works of man and his natural environment. Understandably, then, the first approach of the coastal planners was reminiscent of the Jeffersonian philosophy of antiurbanism, in which cities are seen only as a necessary evil. It was not long, however, before successive events hammered home the defects of this approach.

By 1976, when the California Coastal Plan was completed, a severe economic recession reminded us of the vital role that the coastal zone, and particularly the urban coastal zone, plays in the economic health of California. As a result, adjustment and compromise of the original values of the Coastal Plan were necessary before the Plan was approved for enactment by the California legislature.

Currently, the energy crisis is making new demands on California coastal land use. Offshore oil drilling, expanded energy facilities, LNG (liquid natural gas) terminals and other coastal-dependent energy needs, threaten more compromise to the original intent of coastal protection. The energy crisis is, in all likelihood, only the first of the natural resource pipers waiting to be paid, so that we can look forward to a series of such threats to planned coastal land-use.

How then will it be possible to implement our Coastal Plan so that its original goals -- protection and restoration of natural coastal resources -- can be met while at the same time absorbing the demands that each new crisis will make on land uses in our coastal zone? Public policies now being developed point to our existing cities as the vital areas which hold the answers to both the long-term preservation of the natural coastal environment and the immediate strategies necessary for crisis planning.

Within SB 1277 (the California Coastal Act of 1976) and within the forthcoming State policy paper, "An Urban Development Strategy for the State of California," a key concept is urban containment. This means not only the containment of urban activities within existing urban limit lines, but the designation of coastal cities

as the proper containers for growth, change and development that will be necessary for our economic health and social welfare. Within the coastal area, the result will be a reduction of pressures for development in rural areas and an intensification of those pressures in urban areas.

Thus, the role of cities has assumed its proper importance in coastal planning. While protection of natural resources remains the major goal for implementation of the Coastal Plan in undeveloped areas, the coastal planning challenge for the future has clearly come to rest on the local coastal plan elements of our cities.

MEETING THE CHALLENGE OF URBAN COASTAL PLANNING

Containment is an appealing tidy solution which addresses, in one broad-brush policy, a whole range of answers to existing problems: the containment of urban sprawl, the preservation of open land including prime agricultural soils and the revitalization of our coastal cities which, like other cities in the nation, are showing symptoms of central decay. It is also, of course, the gist of the sermon on rational land use which planners have been preaching for years, always to empty pews. There may be a chance that this time someone is listening. The rising costs of new single family houses which are the residential mode for urban fringe areas, the rising costs of commuting and the proposed governmental incentives may combine to make containment an enforceable policy. At least, the odds are better now than they have ever been before.

The odds would be even higher if we could be assured that our land use plans for urban coastal areas could meet these challenges. Currently, the only suggestions for the cities from the macroscale policy designers is a series of buzz words: "in-fill,"which means developing urban land that was skipped over in previous development; "recycling," which means clearing land in deteriorated city areas and starting fresh; and "rehabilitation," which means improving old structures and neighborhoods so that they meet modern standards of comfort, convenience and attractiveness. These are all valid activities in city land-use planning, but the real trick, one which we do not appear to have mastered, lies in creating the social, economic, and political conditions in which these physical measures, in-fill, recycling and rehabilitation, result in cities that are good to live in, productive to work in and fun to play in.

The requirements for city coastal planning from the microscale policy designers, the Coastal Commissions, are considerably less than helpful. Our Commissions appear to be styling themselves, in their guidelines and directives to city planners, to be a junior-sized HUD, multiplying the letters of the law past all comprehension while the spirit of the law, the goals of the

Coastal Act and the understanding of urban containment are lost in the forms and filings and criteria for evaluation and review. I do not minimize the difficulties inherent in the current situation: municipal governments are being required to relinquish a significant claim to local land use regulation, heretofore almost sacrosanct to home rule, back to the State. We could discuss the trends and precedents for this action, we could show the minimal impacts on local governments in relation to the larger shifts of authority originally contemplated by the Coastal Plan but, in the final analysis, the sources of friction are great. Unfortunately, the means the Coastal Commissions have chosen to counter these frictions so that productive urban coastal plans can be achieved are, at best, ineffective and, at worst, counter-productive.

The remainder of this paper will be devoted to discussion of the major issues involved in urban coastal land-use planning, the means chosen to address these issues, and some alternative means to which, I believe, coastal cities ought to give serious consideration. The classical planning process will be used as the framework for the discussion.

THE PLANNING PROCESS: THE STEPS INVOLVED

An essential core of activity has long been recognized as a necessary basis for evolving any plan. Although the process has, and should have, a myriad of permutations and idiosyncracies as applied to the varying needs of different municipalities with differing problems, it is usually reduced to these five steps: (1) systems analysis, (2) goals definition, (3) evaluation of alternative means, (4) plan formulation, (5) implementation and feedback.

Systems analysis. In common terms, systems analysis is the collection and analysis of information relative to the planning area including populations of residents, workers and users, spatial allocation of activities, measures of density and intensity of land use, socioeconomic indicators of growth, stasis and decline. Systems analysis tells us where we are now.

Goals definition. Defining goals is the effort to find out where we want to be in the future in relation to our findings from systems analysis, the present reality. Goals definition is probably the most difficult part of the process. It is an exercise in adjusting values, in negotiating conflicting objectives of our pluralistic society: it is, essentially, a political problem. The danger here is that the defined goals will be the judgments of a small number of technicians, including planners, and decision makers rather than the will of the Plan's clients who are all those people who will be affected by the forthcoming plan. Citizen participation is the only means we have developed to ensure a democratization of the planning process in defining

goals. As presently constituted, it is a weak "reed" on which to lean.

Evaluation of alternative means. This step measures the gap between the findings of systems analysis and goals definition and considers the means of accomplishing the changes between what we've got and what we want. Here the knowledge of the specialists in urban finance, sociology, technological infrastructure, natural sciences and a host of other fields can be coordinated to produce expert and often innovative solutions to the problems we have defined. The evaluations of these alternative solutions will depend, for their criteria, on explicit conditions as they are perceived in each community. The final choice between alternatives should be that of the duly constituted political decision makers.

Plan formulation. Here, the goals, the means chosen to achieve the goals, and the rules necessary to implement them are made into a final plan. There cannot be a single best plan in any public sector planning effort. Politics is the art of compromise, and so is land-use planning. Optimization is possible only in plans made for single sectors of society, suboptimization must result when the disparate objective of societal groups are brought together in a single plan. My own test of this truth when working in the field is to look around to see if there is any group of participants in the planning process who appear to be totally content. If there is, I know that our process has failed: one group is anticipating a disproportionate share of benefits while other groups, somehow overlooked or ignored in our process, will be shouldering more than their share of the costs of change.

Implementation and feedback. This final step is the one in which the greatest "slip 'twixt the cup and the lip" can be anticipated. This is the common slip between the intent of the State's legislation and the guidelines and regulations by which that legislation is administered and enforced. In the case of land-use plans, the planners must be involved in implementations and feedback so that they can see how the plan is working, and to recommend amendments to policy so that goals remain intact while the means for achieving them are improved by the lessons of experience.

CALIFORNIA COASTAL COMMISSION: LOCAL PROGRAM REGULATIONS AND THEIR EFFECTS ON URBAN PLANNING

Let us now review the California Coastal Commission's Local Coastal Program Regulations as issued on January 27 and revised on March 23, 1977, in order to assess their effect on urban coastal planning.

Systems analysis. All cities on the California coast and

most ports have already completed their General Plans. This means that they have already acquired an expensive storehouse of information and analyzed it for use in their plans. It means, also, that their planners have a heightened understanding of the part that their particular coastal strip plays in the general welfare of the city's residents and users.

The Local Coastal Program Regulations demand information in a Work Program designed to serve only the needs of coastal protection. In an effort toward parity and comparability of all local plans, the California Coastal Commission has not sufficiently recognized the varying purposes and needs to be served by different kinds of coastal communities. A single method for data analysis was required for all local coastal plans in the first draft of the Regulations. This method is only recommended in the revised draft. This recommended method is appropriate and useful for small, isolated communities but, speaking from personal experience, it loses validity when applied to communities as parts of large and complex metropolitan areas.

Coastal cities would be well advised to use their existing information in individually designed methods which will serve the needs of the Coastal Commissions but also serve their own needs. The intent of the Coastal Act must, of course, be reflected in the chosen method, but the vital part an urban coastal strip plays in making the coastal city a good place to live, a productive place to work and a fun place to play in will also have to be understood if cities are to fulfill their container function. Adjusting information to serve both these purposes will require negotiation between the coastal commissions and the cities but, until the role of cities is better understood in coastal planning, the burden will rest mainly with the cities.

Goals definition. There is a major difference between this step in the usual planning process and in urban coastal planning: the cities will not be defining their own goals for their coastal areas, for these goals have already been stated in the California Coastal Act. Rather, cities will bear the responsibility for adapting their own goals and objectives as defined in their general plans in response to coastal mandates.

The "Guidelines for Local Coastal Programs" rely heavily on citizen participation for an effective local coastal planning process. Unless citizens are instructed carefully in both the goals of the Coastal Plan and the goals of their own cities, their testimony cannot be pertinent to the issues of goal adaptation.

Gilbert Ferguson, President of California Council for Environmental and Economic Balance, has said, "The new politics is numbers and unity. If you haven't got a vocal, vote-casting, letter-

writing constituency behind you, forget it, you're doomed to failure" (Turpin, 1977). While I don't often find myself in agreement with Mr. Ferguson, I cannot argue with his statement. If you believe that a port activity requires expansion or an additional energy facility is required to support urban coastal-dependent commerce, go down to the beach next 4th of July and count the votes that will be cast against you. The great majority of the beach goers will oppose your plan not because, as Mr. Ferguson goes on to suggest, that we are vulnerable to rule by rabble, but because those citizens are informed about the benefits of the beach and uninformed about the real effects of your project, or the consequences of denying it. Citizens have had little opportunity to assess these trade-offs and less opportunity to enter into significant debate on the eventual outcome. Citizen participation as a ritual will not improve our situation, it will only increase the frustration and skepticism which adds to the growing public distrust of its government. I would urge, therefore, that despite the failure of the local coastal regulations to address these issues, the cities themselves begin to improve the process of citizen participation. A broad base of citizen understanding and support cannot fail to improve our urban coastal plans from both local and State perspectives. While the public interest is a difficult concept to define, I know of no better way of serving it than involving the public in the decisions made in its interest.

Evaluation of alternative means and plan formulation. These steps have been grouped since they are not yet treated in detail in the regulations. The Commissions suggest that local planners may wish to present alternative coastal plans for approval by the Commission. As noted earlier, the final choice between alternatives is properly the function of the elected officials responsible for decisions within their jurisdictions. In undeveloped coastal areas where the goal of preservation of the natural environment is paramount, this decision between alternatives may properly be given to the coastal commissions. In our coastal cities, however, the goals of environmental preservation must be related to other goals of urban living, working and recreational needs. Here the responsibility is not only to preserve but also to use the coastal zone to serve the needs of urban living within containment. These responsibilities fall to city officials and any choice between alternatives should be theirs.

The cities' coastal plans, as presented to the Commissions, should, therefore, be in final formulation. In this form they will represent the necessary coordination between the general plan for the city as a whole and its coastal element.

A major omission from the existing framework, however, is the recognition of regional coordination for effective coastal

planning. This, after all, was the purpose of the 1972 Coastal Conservation Act. Local governments, answering only to local constituencies, were seen to be incapable of meeting regional coastal needs, and the State and Regional Coastal Commissions were created to address these issues.

The Commissions have not yet been able to hammer out their policies to implement regional plans through permit decisions. The means presented to achieve regional coordination now appear in two provisions: first, that local governments should notify their neighbor governments of hearings on local coastal plan proposals, and, second, that areas of more than local significance be given special attention by the Commissions. The first provision is ineffective since local governments cannot coordinate their plans for regional benefit merely by attending one another's hearings. The second provision is amorphous in application to our coastal cities, since each of them, including their ports, can be shown to be of more than local significance to the State's welfare and economy.

In the face of the failure of the Commissions to achieve policy for regional resource allocations among local communities through permits and other processes, some alternative means to this end must be found. Subregional planning, a model by which overlapping local jurisdictions within the metropolitan coastal zone could be coordinated for regional planning was tested and found promising. This, or some other model should be reinstituted for testing in order to move past the governmental boundary obstructions to rational and effective regional coastal planning, the stated objective of all those people who voted for Proposition 20 in 1972.

Implementation and feedback. Zoning is the most well known of all the means for planning implementation. It has serious limitations, which are equally well known, but, despite this, it is the only method for implementation specifically mentioned in the Local Coastal Program Regulations.

Cities would be well advised to consider implementing other possible actions to support zoning. Used alone, a zoning ordinance is generally meant to provide guidance for a relatively short time span of only five to ten years (Goodman and Freund, 1968). During that time, zoning can be empirically shown to respond very poorly to both the requirements for permanence and the need for planned flexibility. Devices, such as capital budgeting for planned acquisition, community redevelopment areas, conservation easements and others, must be supplements to zoning if cities are to have the tools they need for effective implementation. One special tool, the Specific Plan (California Conservation and Planning Code, 1972), deserves mention here. Although still little known, the Specific Plan shows great promise for meeting many of the needs of both local and subregional coastal planning.

Currently, the City of Rancho Palos Verdes is producing a specific plan for its coastal zone which may become a model of excellence for local coastal plans.

Finally, it must be remembered that no one should expect a plan and its administration to get it all right the first time, which is why the last word of the process is "feedback."

Feedback and review are essential to making a plan work, and plan amendment may also be a necessary part of the process. There is no apparent reason why local coastal plans should prove an exception to this rule. Cities must not be viewed as hedging on their agreements when they seek amendments to their original coastal plans from the Coastal Commission. Considering the role they must play in meeting the future crises of our coast, urban coastal land-use planning will need all the help it can get.

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IMPACT OF NEARSHORE DEVELOPMENT ON OPEN COASTAL RESOURCES

by
Alan J. Mearns and David R. Young

INTRODUCTION

The harbors and marinas of southern California are part of a unique and complex marine province known as the Southern California Bight. As with the harbors, outer coastal areas are receiving heavy public and industrial use. Annually, nearly 180,000 metric tons of commercial fish are harvested primarily within a 50 km radius of the Los Angeles area; at least another two million fish are taken by party boats. Annually the area receives 1.4 billion m^3 of municipal wastewaters and 7.7 billion m^3 of recycled and warmed seawater. These immense uses are matched by improbable expectations: the public expects reasonable access to an uncluttered sea, strict adherence to high standards for public health, adequate management of harvestable resources and protection of the underlying ecosystem.

The Southern California Coastal Water Research Project (SCCWRP) is one of several governmental and private institutions that have been studying man's impacts on the marine environment. During the past several years SCCWRP has devoted much of its research effort towards an understanding of the ecology of the Bight's nearshore coastal waters. Much of the research has focused on an assessment of all possible sources of chemical contaminants and on biological effects of the large municipal sewage outfalls which discharge in deep water a few miles off the coast. A number of these discharges are located adjacent to entrances of harbors and marinas. This clustering of urban facilities makes diagnosis of effects both difficult and challenging. However, the diagnosis is nonetheless necessary if we are to properly assess present problems and develop responsive management schemes.

The purpose of this paper is to summarize recent studies which we believe are relevant to understanding the combined and separate effects of coastal and harbor activities on chemical and biological conditions along the coast of southern California. Our chemical summary updates earlier reports on contamination along the coast and in harbors (SCCWRP, 1973; Young et al., 1973, 1974, 1975; Young and Heesen, 1974), and presents new data on the coastal distribution of trace metals, chlorinated hydrocarbons and biological accumulation of some trace contaminants. Our comments on biological effects focus on the now well studied soft bottom communities at open coastal discharge sites. Previous studies, including monitoring surveys, have generally centered around descriptions of the faunal complexities at individual waste discharge sites. In this paper, we explore (1) the biological similarities among large and small coastal discharge sites, particularly those which show promise as management tools and (2) which pollutants appear to be most important in causing the kinds of effects observed around most sewage discharge sites.

COASTAL-HARBOR DISTRIBUTIONS OF TRACE CONTAMINANTS

By definition most trace chemicals occur in extremely low concentrations in seawater, even at discharge sites (i.e., a few parts per billion to parts per trillion). Most are attached to particulates and suspended material (Rohatgi and Chen, 1975) and in this form can be concentrated in the digestive glands of shellfish. Since shellfish are both potential seafood items as well as efficient pollutant concentrators, we have undertaken numerous analyses of the digestive glands and other tissues of widely distributed shellfish to assess coastal pollutant distributions. In most of our studies, replicate collections of mussels (Mytilus californianus and M. edulis) were taken from a wide variety of island, coastal, harbor, and other marine sites and subjected to detailed chemical analyses. The Bight surveys were conducted for chlorinated hydrocarbons and trace metals in 1971 (SCCWRP, 1973; Alexander and Young, 1976) and again in 1974 (Young and Szpila, 1975; Eganhouse and Young, 1976). Additional time-series samples have been taken onshore at Palos Verdes since 1971 from caged mussels attached to buoys off Palos Verdes, Orange County and in Santa Monica Bay during 1975 and 1976. Harbor collections, including nearby coastal stations, also were made in 1974 as part of a program to examine the pollution potential of these regions.

Chlorinated hydrocarbons. DDT and the polychlorinated biphenyls (PCB's) are major contaminants in southern California coastal waters (Young et al., 1976; McDermott et al., 1976. Our studies focused on several isomers of DDT, Dieldrin, and PCB 1242 and 1254 in inputs as well as in mussels, sediments, bottom fish and other invertebrates. Recently, we also have quantified chlorinated benzenes (dichloro-, trichloro-, and hexachlorobenzene) in wastewaters (Young and Heesen, 1976) and in fish.

There has been a clear gradient of increasing DDT concentrations approaching the Palos Verdes Peninsula from the north, south and offshore, (Fig. 1). Concentrations measured in soft tissues of 1971 mussels by B. De Lappe and R. Risebrough (U. California, Berkeley) covered a range of two orders-of-magnitude (SCCWRP, 1973). The dominating cause was the Los Angeles County municipal outfalls located off Palos Verdes Peninsula. Source control beginning in 1970 has been extremely effective in reducing this input but the overall gradient still persists (Young and Szpila, 1975).

This pattern of increasing concentrations approaching Palos Verdes was evident in harbor mussels during our 1974 study of San Diego, Newport and Los Angeles-Long Beach (San Pedro) harbors (Young and Heesen, 1974). An inputs survey conducted as a part of this study indicated negligible amounts of DDT entered Newport and San Diego Harbors via the five major routes studied (wastewaters, direct industrial discharges, surface runoff, aerial

fallout and anti-fouling paints). However, because of the large contribution of stormwater in the Los Angeles River, surface runoff was a dominant source within San Pedro Harbor (about 100 kg/yr in 1973). This input, however, can be tempered with a rate of 3,200 kg entering the coastal shelf from the nearby Palos Verdes discharges in 1973 (Young and Heesen, 1974). Furthermore, San Pedro Harbor mussels taken from near the breakwater yielded higher values than those inside the harbor. Moderate levels of DDT occurred in Newport Harbor mussels but were probably due to both low level coastal input and the slow flushing nature of this harbor. Direct measurements of water flowing past the entrances to all three harbors revealed extremely low levels (0.2 to 18.0 pptr) but geographic patterns of high and low values were similar to those seen in the 1971 coastal mussel survey.

The accumulation of DDT isomers in local populations of three coastal fishes is now well documented (Duke and Wilson, 1971; Young et al., 1976). Bottomfish off Palos Verdes continue to show the highest levels along the coast and the flesh of many still exceed the federal limit of 5 ppm wet weight.

As mentioned above, source control has markedly reduced DDT inputs to the coastal ecosystem. As a result, levels have decreased markedly in pelagic fishes offshore which has led to lower levels in pelicans and their eggs as well as increased reproductive rates and survival of fledglings (Anderson et al, 1975). However, local conditions still pose a potential health hazard. During the past year, for example, we measured DDT levels as high as 400 ppm wet weight in brain tissues from marine birds that died in captivity at the Los Angeles Zoo. The birds had been fed for up to 1.5 years on a diet of fish caught off Palos Verdes by a San Pedro fish company. Symptoms of death were similar to those documented for chlorinated hydrocarbon poisoning in other animals and the levels found in tissues were about the same.

PCB's show coastal and harbor distributions that are markedly different from DDT, thus indicating different sources. In mussels from open coastal sites, PCB concentrations are generally higher near urban areas. However, mussels from some harbors and harbor entrances have produced even higher levels. For example, median PCB 1254 concentrations of 300 and 380 ppb, were found in San Diego Harbor and near the entrance to Port Hueneme respectively as compared with 150 ppb in San Pedro Harbor. The San Diego and Port Hueneme anchorages are two of the largest naval depots in southern California. Past use of PCB's in hydraulic fluids, lubricants and paints may well have caused this contamination (Nisbet and Sarofim, 1972). We have not attempted to document use of hydraulic fluids and lubricants in these and the other harbors, however, vessel paints may have been important sources of PCB's (Young et al., 1974).

High levels of PCB's in harbor mussels also appear to be related to contaminated harbor sediments. Excluding one of 17 data points, we found a correlation (significant at the 90 percent level) between PCB 1254 levels in the San Pedro Harbor mussels and in nearby sediment levels reported by Chen and Lu (1974). There was no evidence of a corresponding correlation for DDT in the harbor, although offshore, sediments remain important sources.

Surveys of market crabs (Cancer anthonyi) and mussels indicate that PCB levels in these animals from the outer coast are low but widespread. Specimens near coastal outfalls containing concentrations 10-100 times those from coastal and island control sites. However, none exceed the FDA limits of 5 ppm (McDermott et al., 1976). Archlor 1254 is the dominant form in nearly all organisms studied while municipal wastewaters are dominated by Archlor 1242. This indicates that organisms are selectively concentrating the higher chlorinated compounds.

From 1972-75, inputs of PCB's in municipal sewage have decreased but there has been no complimentary decrease in concentrations of PCB's in bottom-living flatfish offshore (Young and McDermott, 1976). It appears that factors other than inputs now dominate uptake in contaminated areas offshore. As with DDT (Young and McDermott, 1976) sediments may be the source of this biological contamination. A fin erosion disease (Mearns and Sherwood, 1974, 1977) continues to affect Dover sole (Microstomus pacificus) along the Palos Verdes Peninsula and both DDT and PCB's occur in significantly higher concentrations in livers of diseased fish than in apparently unaffected fish (McDermott et al., 1977). Laboratory experiments confirmed that the fish could accumulate high muscle and liver concentrations of chlorinated hydrocarbons from contaminated sediments (Sherwood and Mearns, 1977).

Numerous other synthetic organic chemicals are produced and used locally. These probably are discharged and no doubt will be found in local coastal organisms in the near future. In our laboratory we have found that chlorinated benzenes occur in municipal effluents at concentrations at least ten times those of DDT residues and PCB's. One of these compounds, para-dichlorobenzene, is a potent mitotic poison (Biesel, 1958). Low molecular weight chlorinated hydrocarbons are also present at even higher levels in these wastewaters. The occurrence of these compounds definitely affects interpretation of present standards for total identifiable chlorinated hydrocarbons (TICH).

Other hydrocarbons. Petroleum hydrocarbons can enter the ocean from a variety of sources other than petroleum related activities. A major source in southern California may be in the greases and oils discharged in municipal wastewaters. For example, during the water year 1971-72 nearly 65,000 metric tons of

hexane extractable materials were discharged by five of the largest treatment plants while surface runoff and direct industrial wastes carried 4,000 and 2,000 metric tons respectively (SCCWRP, 1973; Young, 1975). Unfortunately, we do not yet know how much of this material is in fact from petroleum wastes.

Some of the known petroleum hydrocarbons are potent carcinogens. In 1975 we measured benzo(a)pyrene (BaP) in mussels from island, coastal and a few harbor locations (Dunn and Young, 1976). Levels were near the detection limit, ranging from 0.1 to 8.2 ppb wet weight in whole soft tissues. Concentrations from most coastal sites were similar to or below open ocean levels reported for British Columbia by Dunn and Stich (1975) and were 10 to 1000 times lower than in poorly flushed areas of Vancouver Harbor. Peak concentrations in southern California occurred in mussels taken near entrances to several harbors. The measurable levels found at Seal Beach, the west Long Beach breakwater and off Oceanside may well have originated from creosoted pilings adjacent to some of these locations. Measurements inside these harbors are probably warranted, and may reveal levels rivaling those in Vancouver harbor. However, Dunn and Young (1976) concluded that the local coastal data run counter to previous suggestions that BaP is widely distributed in marine organisms.

Trace metals. As with synthetic and petroleum hydrocarbons, trace metal contamination also occurs in our nearshore coastal waters with a variety of sources of varying importance indicated. Unlike the synthetic hydrocarbons, however, the trace metals occur naturally, often in high concentrations in marine sediments and in particular marine organisms.

The large scale distributions of three trace metals in Mytilus californianus have been summarized (Figs. 2a - 2d). For lead, no coastal point sources are particularly evident, but coastal levels (18.0 ± 9.0 ppm) are about double those at the inner islands (11.0 ± 0.9 ppm). This pattern is most likely due to aerial fallout (Alexander and Young, 1976).

Chromium (Fig. 2b), however, fits a more classic point source pattern, emanating from the Los Angeles urban area and passing up the coast and out to sea toward Santa Barbara Island. Although the high value at Gaviota may be a result of minor industrial input, the pattern suggests that large municipal outfalls are important sources. Copper (Fig. 2c) also shows this "urban" point source pattern, with elevated levels outside the Los Angeles-Long Beach harbors. The pattern for zinc (Fig. 2d) shows no clearcut regional difference; higher values may not be associated with wastewater discharges. For the other metals, evidence of harbor and coastal discharge sources are indicated for mercury (Eganhouse and Young, 1976) and silver (Alexander and Young, 1976), coastal discharges for chromium, and no obvious pattern for nickel (Alexander and Young, 1976).

Some of these large scale patterns (or lack of them) are reflected within the three largest harbors. Elevated cadmium concentrations (above typical coastal values) have been detected in mussel digestive gland tissues at several harbor stations, especially within Newport and San Diego Harbors. Silver and copper also demonstrate elevated levels at some stations within these harbors (Fig. 2). These increases are probably associated with vessel repainting operations (Young et al., 1974). One of the most striking harbor-related patterns in mussels is the depression of titanium and vanadium concentrations, relative to outside coastal stations (Fig. 4).

Seawater measurements for dissolved metals confirm some of these trends. Cadmium, copper (both organic and ionic forms) and zinc show elevated levels in Newport Harbor (Young et al., unpublished data). Although the concentrations of most metals are extremely low (0.05 to 22.0 ppb) and well below known toxic concentrations, the higher harbor copper concentrations (3.3 and 8.8 ppb) approach the 10.0 ppb reported to cause abnormal development in sea urchin embryos (Okubo and Okubo, 1962).

BIOLOGICAL EFFECTS OF OPEN COASTAL DISCHARGES

Trace chemicals and nutrients in coastal waters may or may not cause detrimental responses even when accumulated by marine organisms. Nevertheless, anything man adds to or changes in the sea will affect some organisms and more than a scientist's opinion is required to judge whether the change is detrimental or beneficial. Demonstrating ecological changes in a highly urbanized coastal area is now relatively easy, but confirming cause and effect relationships requires sophisticated and thoughtful field approaches.

General ecological changes that have been measured at several offshore discharge sites include a decrease in variety and diversity of coastal shelf invertebrates and an increased abundance of tolerant invertebrates and many fishes (Mearns, 1974; Smith and Greene, 1976; Greene, 1976 a, b; Mearns and Greene, 1976; Allen and Voglin, 1976). These changes are reflected in alterations in the structure of rocky bottom (Grigg and Kiwala, 1970) as well as soft bottom communities. Fortunately such changes are reversible at some coastal sites when discharges are terminated (Smith, 1974).

To document these changes we and our colleagues have relied, in part, on some of the continuous biological monitoring surveys conducted at discharge sites by both public and private agencies. Nearly 1000 bottom samples and 150 trawl samples have been taken yearly at the five major discharge sites. Many of the bottom samples, taken by one of several grab devices, were analyzed for trace metals and chlorinated hydrocarbons; total organic nitrogen, carbon, BOD, COD, pH, eH, sulfide, color and odor were recorded at some of the sites. Animals retained on

0.5 or 1.0 mm mesh screens were sorted, identified, weighed and counted. Trawl-caught animals were sorted in the field, identified, counted, measured, inspected for diseases and weighed.

In the past, the imposing data base resulting from these surveys has been largely ignored by scientists because of variations in gear and gear-use procedures as well as questionable sampling and taxonomic expertise. However, during the past four years SCCWRP undertook a number of studies to help alleviate these problems. Several chemical intercalibration studies were made among agencies (Young et al., 1976). Efficiencies of various sizes and types of otter trawls used on this coast were measured (Mearns and Stubbs, 1974) and the results tested in the field (Mearns and Greene, 1974). Grab and other sediment sampling devices were loaned by cooperating agencies and compared under actual field conditions (Word,1975a, 1976). Finally, in 1973, a taxonomic intercalibration program was initiated at SCCWRP; biologists from many local and state-wide agencies continue to meet bi-monthly, to compare and confirm species identification, to acquaint each other with up-to-date information on new species and new ways of identifying old ones and to publish and disseminate the findings and taxonomic corrections (Word, 1975b; Word et al., 1976). As a result, we believe much of the southern California coastal monitoring data obtained since 1974-1975 is qualitatively comparable, and with judicious adjustments for gear differences and changes, quantitatively comparable. As an additional check, however, the Project initiated some of its own trawl surveys at Point Loma (Voglin, 1975), Laguna-Dana Point (Mearns and Word, 1975) and at the major Los Angeles-Orange County outfall sites (Mearns and Greene, 1974). Two benthic infaunal surveys were also conducted off Orange County in 1975 (Greene,1976a,b).

Responses of the benthic infauna. In 1976, we assembled, checked and summarized data from the 1974 and 1975 benthic monitoring programs to re-examine both the kind and the extent of biological conditions at the five major discharge sites.

The 1974-75 sampling conditions and kinds of responses observed at each site are summarized (Tables 1 and 2) for biomass, abundance (number of animals/m^2) and diversity.

The values for each of the five characteristics chosen for this comparison differed markedly with survey area (Table 1). Biomass was low at the Oxnard and Point Loma outfall sites, moderate at Orange County and in Santa Monica Bay, and high at Palos Verdes. Individual samples produced values as low as 5 g/m^2 and as high as 2,000 g/m^2. Abundance showed somewhat similar (but less dramatic) trends ranging from a low of about 1,300 animals/m^2 at Point Loma to about 4,800 animals/m^2 in Santa Monica Bay.

Diversity, as indicated by three distinct measurements was generally high where biomass and abundance were low. For example, the average Oxnard sample (which was low in biomass and moderate

in abundance) contained about 52 species, had a diversity index of 3.3 (H') and a richness index (D) of about 24. In contrast, samples from Santa Monica Bay and Palos Verdes (which had high values for biomass and abundance) had about one-half the number of species per sample (27 and 18, respectively) and one-half to two-thirds the diversity (2.2 and 2.0, respectively) and richness (12 and 8, respectively).

At the depth range of 55 to 65 m (Table 2), these general trends remain, but there are some notable differences. The differences between high and low average values for biomass are increased, with Palos Verdes now showing the highest abundance. Trends in species number, diversity, and richness are not substantially changed, however.

The changes in abundance, biomass and diversity are reflected in the composition and community structure of the benthic infauna. For example, using data from an earlier synoptic benthic survey by the Los Angeles County Sanitation District, Smith and Greene (1976) identified some 12 different categories (site groups) of communities along the Palos Verdes shelf. The site groups showed a progression of change with proximity to the outfalls. Of greater importance, Smith and Greene were able to use the biological patterns to help identify and separate the most important physical and chemical factors. For example, despite the steep gradients of trace metals, DDT and other pollutants, depth and sediment coarseness accounted for much of the variation in community structure. This was followed, in order of importance, by waste-water-related factors with highest correlation for sulfide, eH and nitrogen. These results supported a prior mathematical analysis of the same data (Greene, 1975). The earlier analysis was equally revealing because it also implicated DDT but not mercury in sediment as an important factor.

The results of the studies reviewed above suggest that biostimulation (i.e., increased production of tolerant species) is the major response now being measured at these discharge sites. Such responses are not unexpected when we consider the high mass emission rates of organically rich total suspended solids being discharged (2,000 to 131,000 metric tons per year, Table 1). At least a portion of these solids do fall out in the vicinity of the outfalls (estimates range from 10-20% of the total emissions). In fact, one might expect rather definite quantitative relationships between the amount of solids discharged and the magnitudes of biological effects (e.g., low diversity, high biomass). However, inspection of Tables 1 and 2 indicate that low diversity and high abundance and biomass are only cursorily related to effluent solids concentrations (ranging from 85 to 278 mg/l, Table 1). Much stronger relationships appear when mass emission rates of suspended solids are compared to the range of values for diversity and biomass (Table 3). Suspended solids mass emission rates significantly correlate

directly with biomass (r = - 0.975) and inversely with Brillouin diversity (r = - 0.960) and richness (r = 0.856). Equally important is the fact that biomass is inversely correlated with diversity (r = - 0.997) and richness (r = - 0.931), that mass emission rates of suspended solids are poorly correlated with abundance (r = 0.365) and number of species (r = - 0.721), and that compared to suspended solids the wastewater flows (mgd) show still less correlation with biological variables. These kinds of comparative relationships among discharges should be further exploited since they could provide the kind of biological criteria that are needed for responsive management of some of these discharges. Moreover, since effects of high biological oxygen demand (BOD) as expressed by major depressions in dissolved oxygen levels in the water column have not been found at these outfall sites, it would seem more appropriate to focus new emission controls directly on the effects of solids themselves. At present considerable management effort is being devoted to meet federal BOD standards. While suspended organic waste solids can exert a considerable oxygen demand it appears that in open coastal waters this effect is insignificant compared to its direct effects on the benthic environment.

The biostimulatory effects of some of these discharges create an additional problem which is rarely appreciated; they override our ability to assign effects to trace element contamination. Observation of such effects requires studies at sites where biostimulation does not occur or is minimized. This may be nearly impossible to find since even the presence of an outfall structure itself increases abundances of fishes and invertebrates (Allen et al., 1976). Greene (1976c) found that previously toxic reducing sediments (producing H_2S) were sufficient to eliminate all but the most tolerant species of molluscs, polychaetes and echiuroids in the impacted area off Palos Verdes. Due to improvements in treatment and perhaps source control of refinery wastes, H_2S production in sediments off Palos Verdes is now largely eliminated and may be an historical phenomenon by the end of 1977. Diversity and biomass have increased markedly and rapidly in this area since 1973.

The Orange County discharge has also caused increased infaunal abundance and biomass, and a slight decrease in diversity but, unlike Palos Verdes, no build-up of organic material in bottom sediments (Greene, 1976b). This suggests that a balance has been struck between solids input and utilization at this site. More importantly, abandonment of a previous outfall site at Orange County has resulted in biological recovery (decreased abundance and biomass, increased diversity) most of which occurred within 8-12 mos after termination of 15 yrs of discharge (Smith, 1974; Greene, 1976b).

Responses of benthic fish. Bottom fish also appear to be more abundant near the larger discharge sites than away from them,

but their densities appear to be only about two to four times higher at Palos Verdes and in southern San Pedro Bay than in areas to the north and south (Allen and Voglin, 1976). However, unlike the benthic infauna, bottom fish populations have not shown a marked decrease in variety or diversity at Palos Verdes and southern San Pedro Bay as compared with areas 80-160 km (50-100 miles) to the north and south. Some fishes, such as California tongue-fish (Symphurus atricarda) and Pacific sanddabs (Citharichthys sordidus) are clearly less abundant than elsewhere while others such as Dover sole (Microstomus pacificus) are one to two orders-of-magnitude more abundant than elsewhere (Sherwood and Mearns, 1977). As with the infauna, changes in community composition have been detected (Mearns, 1974) and the data from these trawl studies has lead to a model for predicting fish community structure patterns (Allen, personal communication).

The most significant effects discovered in local fish populations is a fin erosion disease. The disease (or diseases) affected at least 33 of 151 species that were examined in over 900 otter trawl samples taken through 1975 (Mearns and Sherwood, 1977). The disease epicenter is the Palos Verdes Shelf where nearly one-half of the Dover sole and one-third of the rex sole (Glyptocephalus zachirus) are affected.

The disease is not caused by any known pathogen (Sherwood and Kim, 1975). As indicated above, it is associated with high liver levels of chlorinated hydrocarbons (Sherwood and Mearns, 1977) and changes in concentration of calcium, sodium, and possibly chromium and copper in other tissues.

Finally, the high liver chlorinated hydrocarbon levels supports other evidence suggesting that diseased Dover sole, off the Orange County discharge site, were in fact migrants from Palos Verdes (McDermott et al., 1977). It is likely that at least some diseased and contaminated fish from Palos Verdes are capable of migrating to other urban coastal areas.

The fin erosion disease is not related to a tumor disease which also affects populations of young Dover sole (and other pleuronectid flatfish) off Mexico and northern California, Oregon, Washington, British Columbia and Alaska (Mearns and Sherwood, 1977). Present evidence suggests this disease is not increased near wastewater discharge sites.

ACKNOWLEDGEMENTS

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Table 1. Summary of benthic biological sampling conditions and survey statistics (mean ± SE) at five southern California wastewater discharge sites; summers of 1974 and 1975. (Modified from Mearns and Greene, 1976.)

Region	Oxnard	Santa Monica Bay	Palos Verdes	Orange* County	Point Loma
Discharge depth (m)	16	60 & 100	60 & 65	56	61
1975 flow (mgd)	9.5	349	341	175	109
1975 total suspended solids: metric tons/year	2,181	110,180	130,966	33,396	18,725
mg/l	166	229**	278	138	125
No. benthic stations (replicates)	19(3)	23(4)	40(4)	35(1-3)	18(3)
Grab device	Shipek	Shipek	Shipek	Van Veen	Petersen
Biomass (g/m^2)	9.3 ± 1.3	141 ± 24	439 ± 80	62 ± 7.6	20.2 ± 2.6
Abundance ($10^3/m^2$)	3.6 ± 0.3	4.8 ± 1.1	4.0 ± 0.6	4.3 ± 0.4	1.3 ± 0.1
Species (no./sample)	52 ± 2.4	27 ± 2.0	18 ± 1.3	58 ± 2.0	42 ± 1.9
Diversity (H')	3.3 ± 0.1	2.2 ± 0.2	2.0 ± 0.1	2.7 ± 0.1	2.9 ± 0.1
Richness (D)	24 ± 0.8	12 ± 0.9	7.9 ± 0.5	22 ± 0.7	19 ± 1.1

* Survey conducted by the Coastal Water Research Project (Greene, 1976)

** Flow-weighted average for effluent (85 mg/l) and sludge (10,300 mg/l)

Table 2. Summary of sampling statistics (mean ± SE) from surveys of benthic stations located between 55 and 60 meters at five southern California discharge sites; summers 1974 and 1975. (Modified from Mearns and Greene, 1976.)

Region	Oxnard	Santa Monica Bay	Palos Verdes	Orange County	Point Loma
Biomass (g/m^2)	12 ± 4.0	153 ± 42	918 ± 213	69 ± 15	28 ± 2.9
Abundance ($10^3/m^2$)	3.1 ± 0.5	4.0 ± 0.6	6.6 ± 1.2	5.7 ± 0.7	1.5 ± 0.1
Species (no./sample)	48 ± 4.3	24 ± 1.8	21 ± 1.3	64 ± 3.7	42 ± 1.8
Diversity (H')	3.4 ± 0.1	2.2 ± 0.1	1.8 ± 0.1	2.7 ± 0.2	3.0 ± 0.2
Richness (D)	23 ± 1.4	11 ± 0.9	8.4 ± 0.5	23 ± 1.5	19 ± 0.9

Table 3. Matrix of correlation coefficients (r) for wastewater flows (mgd), suspended solids mass emission rates and five biological measurements of the infauna. Data from single semi-annual benthic surveys at five major wastewater discharge sites (see Table 1); df = 3.

	Log Flow mgd	Log Suspended Solids Mt/yr.	Log Biomass g/m^2	Abundance No./m^2	No Species per Sample	Brillouin[1] Diversity H'	Richness[2] D_g
Log flow, mgd	-	0.983**	0.918*	0.271	-0.614	-0.895**	-0.769
Log suspended solids, Mt/yr.		-	0.975**	0.365	-0.721	-0.960**	-0.856
Log biomass g/m^2			-	0.417	-0.811	-0.997**	-0.931*
Abundance, no. per sample				-	-0.182	-0.465	-0.304
No. species per sample					-	0.829	-0.965**
Brillouin Diversity H'						-	0.945
Richness, D_g							-

[1] Brillouin Index, $H = \sum_{i=1}^{s} n_i/N \ \ln n_i/N$ and;

[2] Gleason Index (richness) $D_g = (s-1)/\log_{10}N$.

Where s = number of species in a sample, n_1 is the number of individuals of the ith species and N is the total number of individuals in the sample.

* p = 0.05, r = 0.878

** p = 0.01, r = 0.959; all correlations with * or ** also have t-tests significant at p = 0.05 or greater.

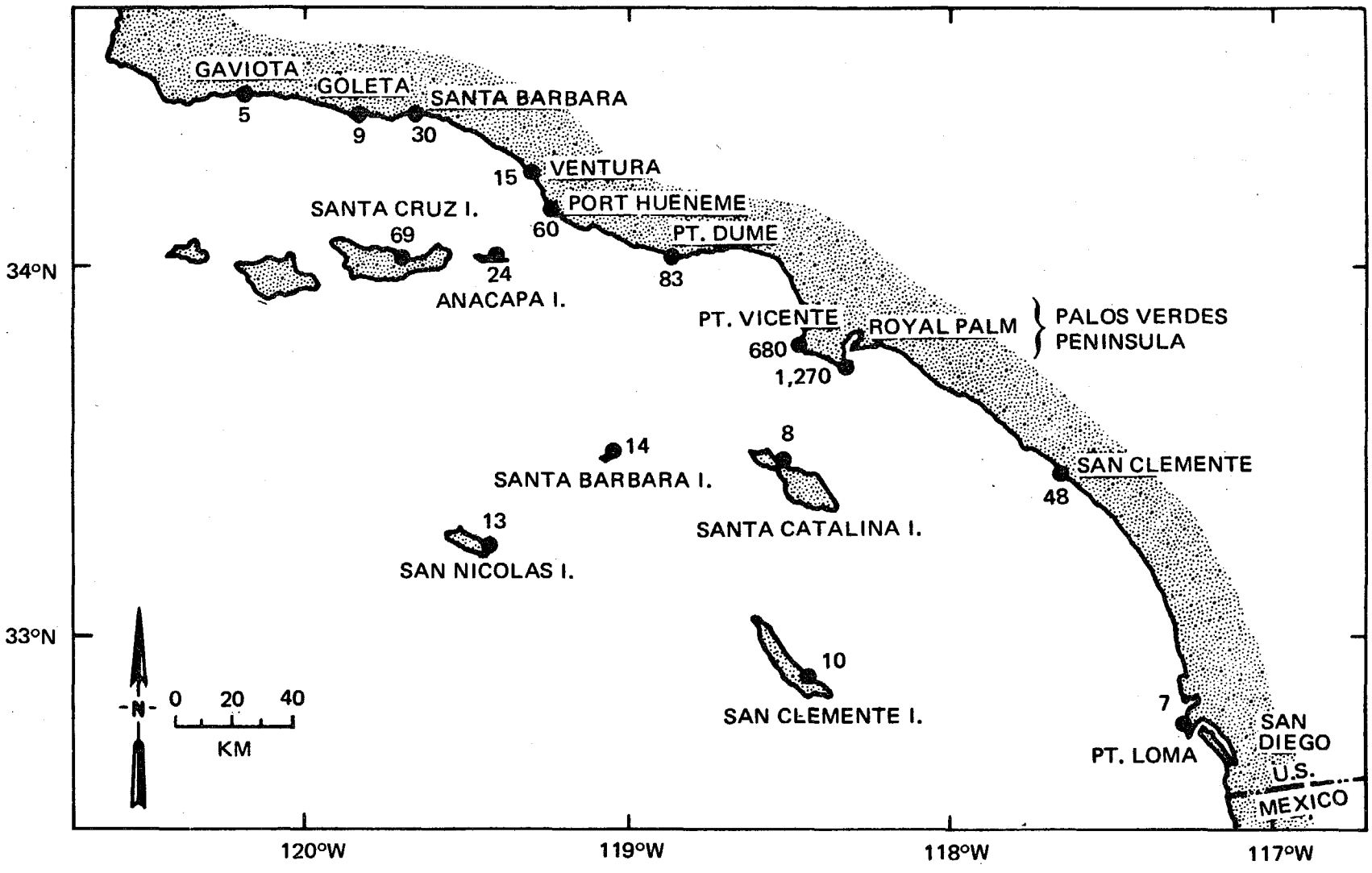

Figure 1. Mussel collection stations in the Southern California Bight. Concentrations of total DDT (ppb, wet weight) in whole soft tissues of the intertidal mussel, Mytilus californianus collected during summer, 1974. From Young and Szpila,1975.

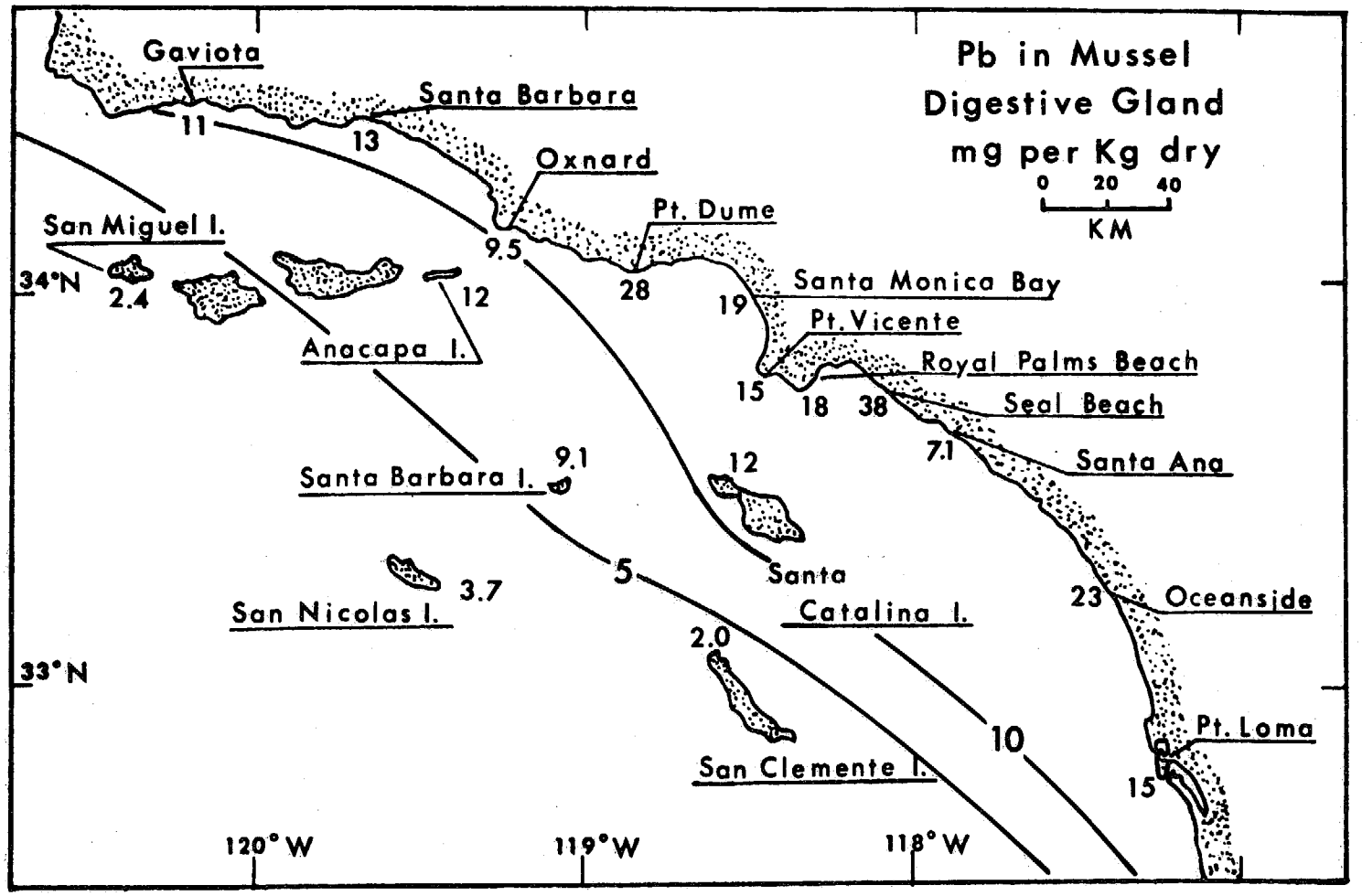

Figure 2a. Concentrations (ppm, dry weight) of lead in digestive gland tissue samples of Mytilus californianus, 1971. After Alexander and Young, 1976.

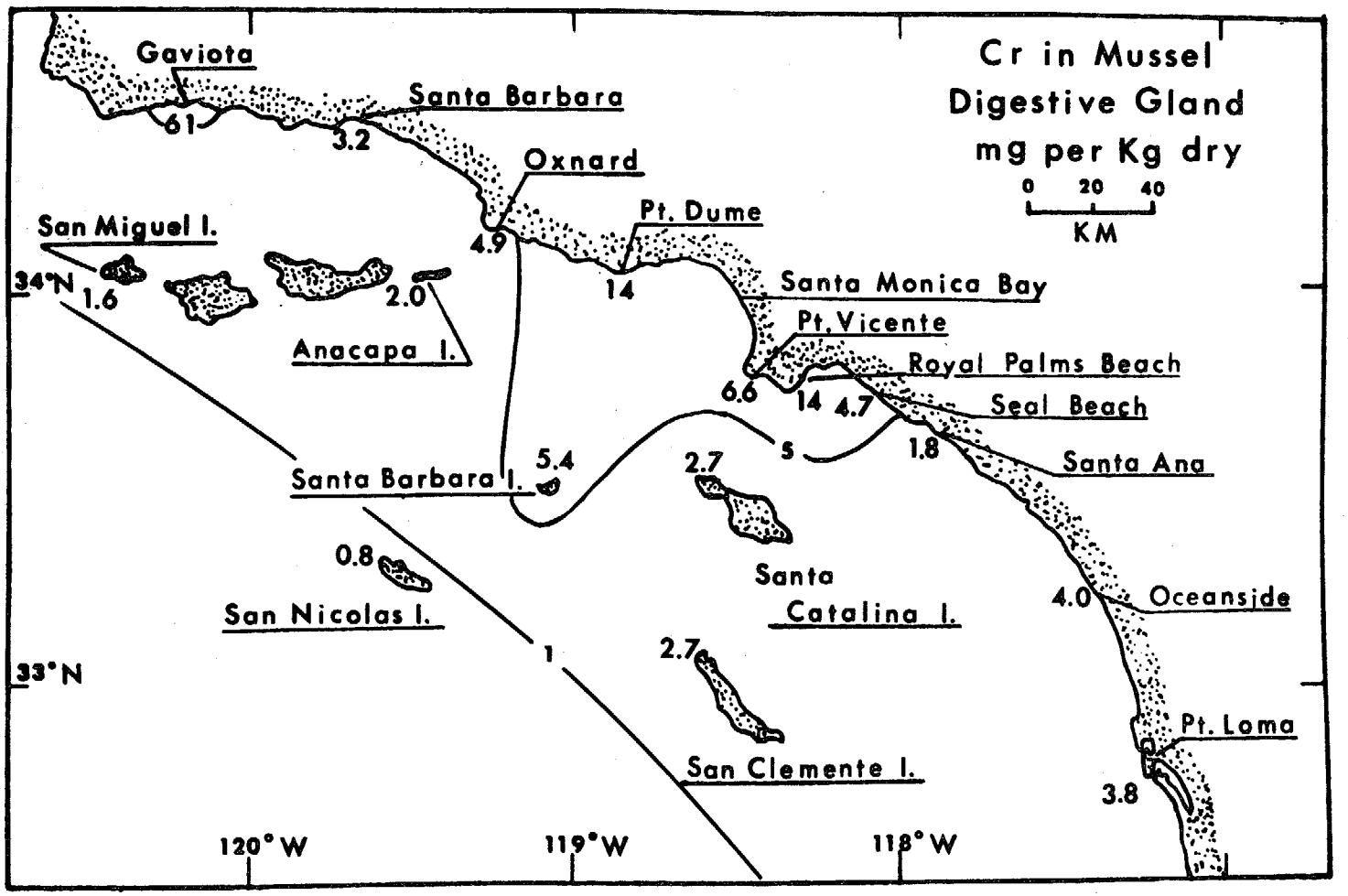

Figure 2b. Concentrations (ppm, dry weight) of chromium in digestive gland tissue samples of Mytilus californianus, 1971. After Alexander Young, 1976.

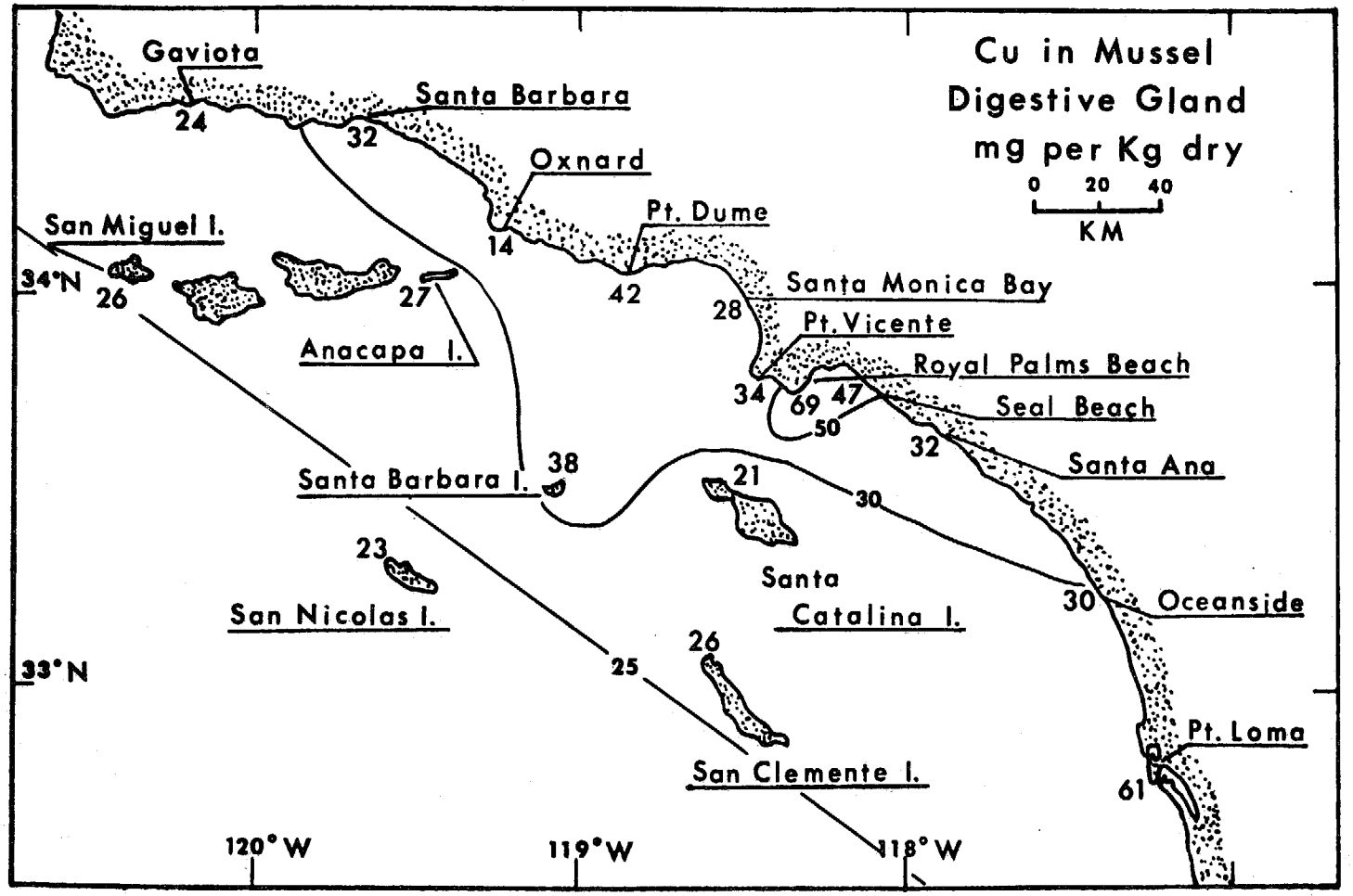

Figure 2c. Concentrations (ppm, dry weight) of copper in digestive gland tissue samples of Mytilus californianus, 1971. After Alexander and Young, 1976.

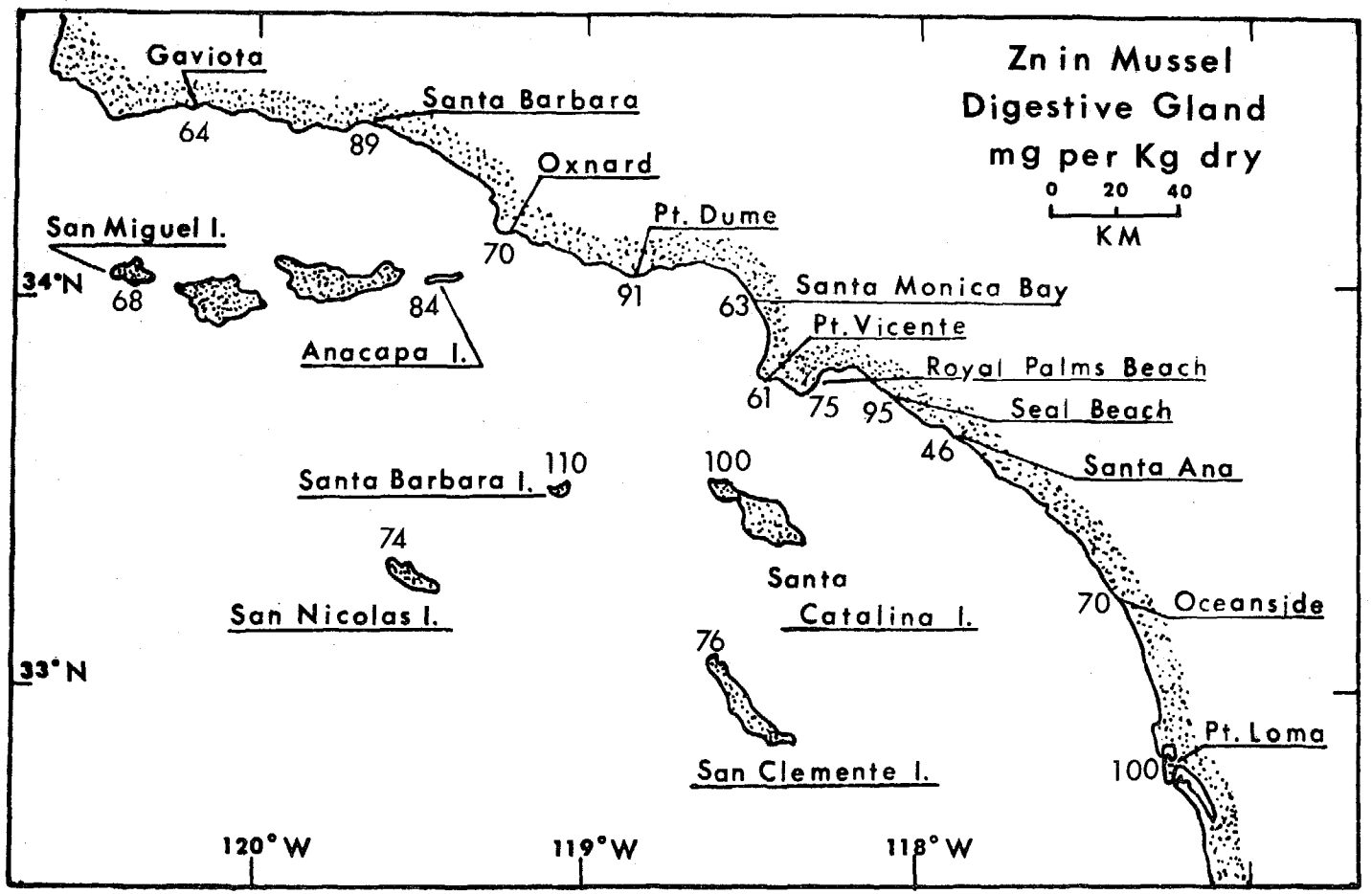

Figure 2d. Concentrations (ppm, dry weight) of zinc in digestive gland tissue samples of Mytilus californianus, 1971. After Alexander and Young, 1976.

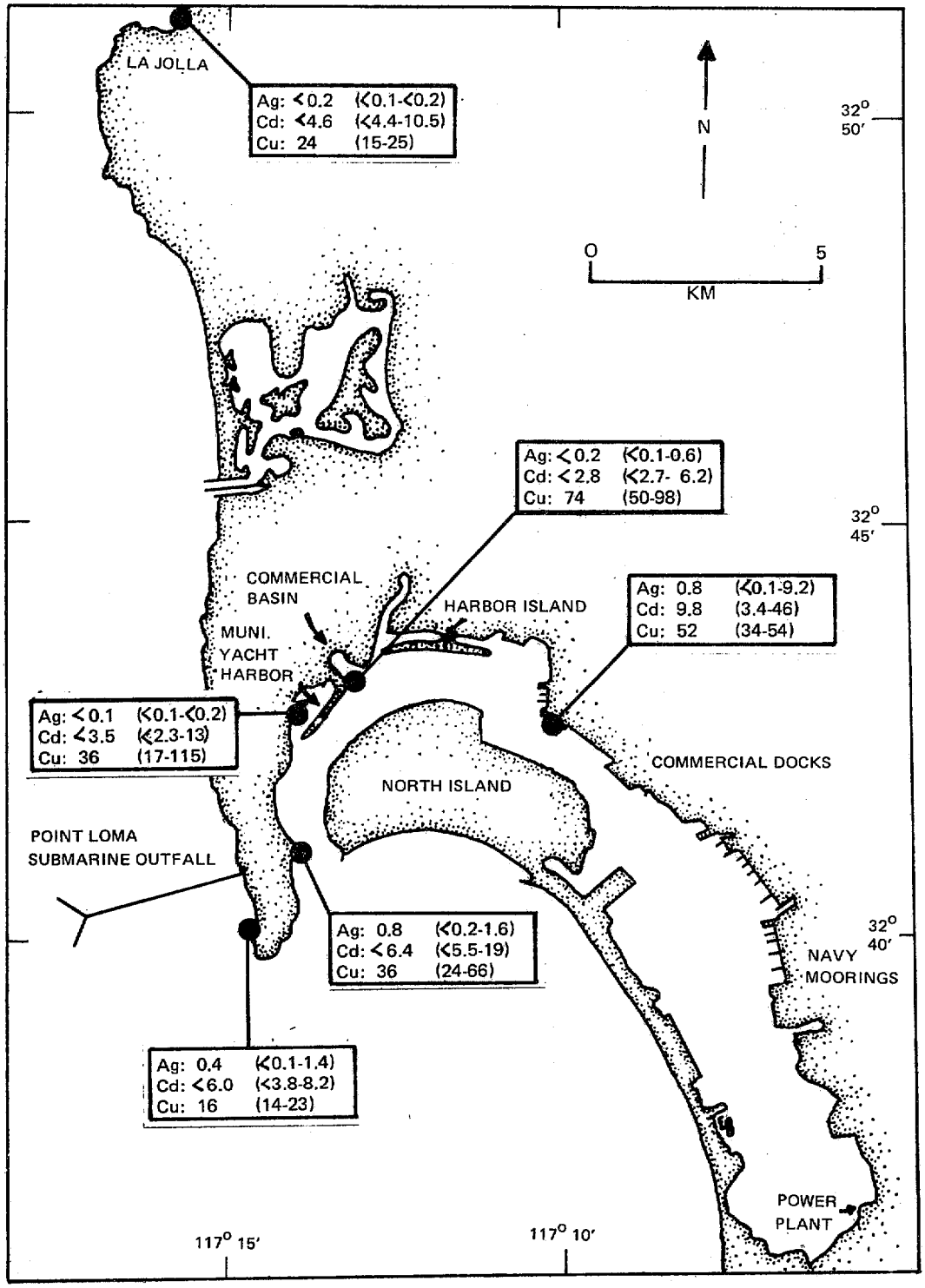

Figure 3. Concentrations, median (range) of silver, cadmium, and copper in digestive glands of intertidal mussels, Mytilus edulis, from in and around San Diego Harbor, Jan. 1974 ppm, dry weight. From Young et al., 1975.

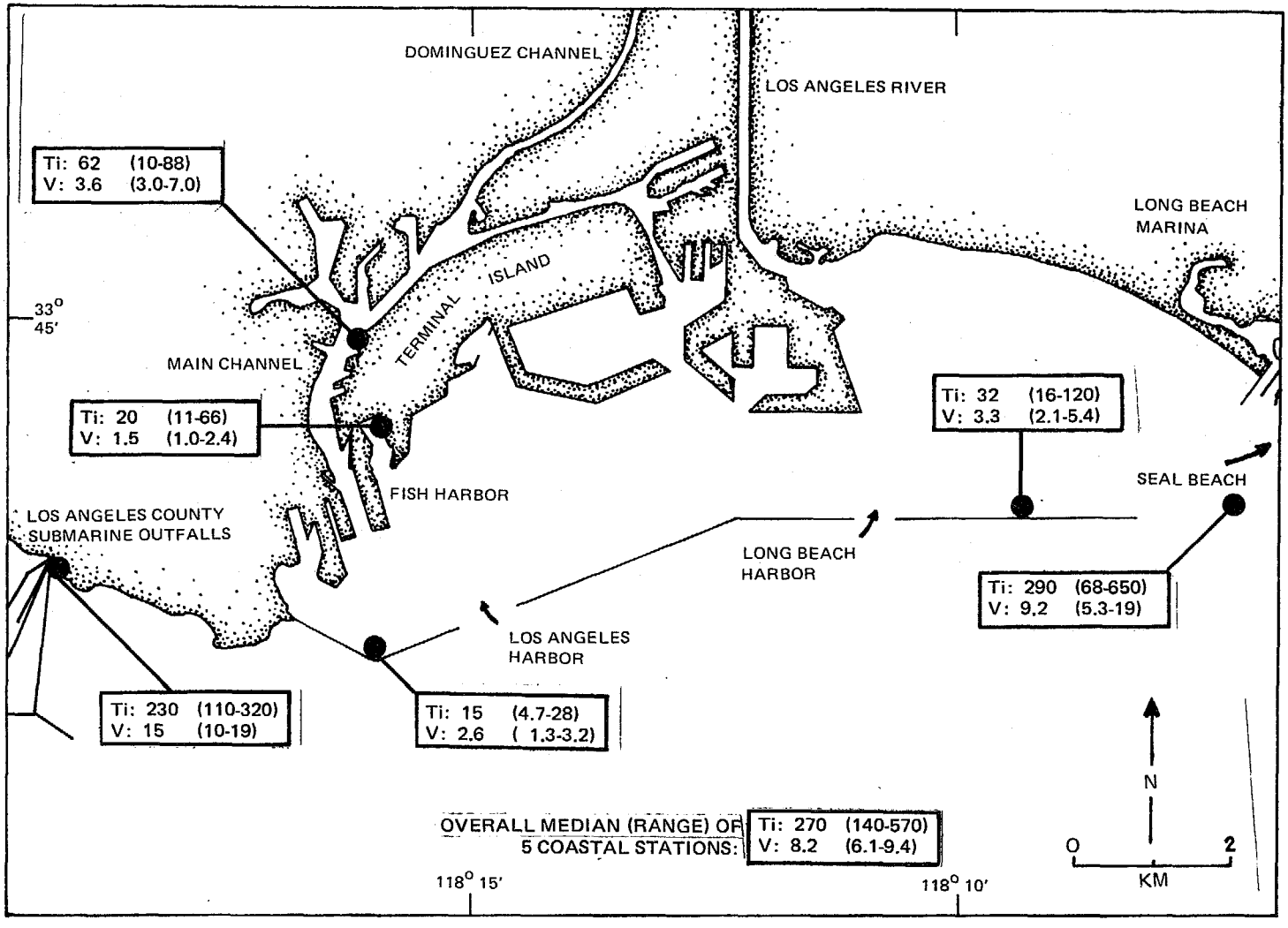

Figure 4. Concentrations, median (range) of titanium and vanadium in digestive glands of intertidal mussels, Mytilus edulis, from in and around San Pedro Harbor, Jan., 1974 (ppm, dry weight). From Young et al., 1975.

BREAKWATERS AND HARBORS AS PRODUCTIVE HABITATS FOR FISH POPULATIONS- WHY ARE FISHES ATTRACTED TO URBAN COMPLEXES?

by
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California has a coastline of approximately 1609 km. Much of this coastline north of Point Conception is undeveloped, with the exception of its major bays and estuaries, Monterey, San Francisco, Bodega and Humboldt. South of Point Conception there is only one large protected embayment (San Diego) though a limited number of estuaries are present. Here urbanization is much more extensive. Horn and Allen (1976) list 13 bays and estuaries on the California Coast. The mean surface area and standard deviation of the seven "bays" in Southern California calculated from their data is 846 ± 1,543 ha while the mean area of the six northern bays is 23,316 ± 52,102 ha. In both areas one bay is much larger than the rest, San Diego in the south (4,287 ha) and San Francisco to the north (129,555 ha). If these large bays are excluded, the southern mean (N = 6) is 272.8 ± 312 ha and the northern (N = 5) is 2,068 ± 2,697 ha. These figures emphasize the fact that available bay or estuarine habitat is extremely limited in Southern California. In fact, Horn and Allen's data on the distribution of bay or estuarine obligate species demonstrate this difference because the southern bays have very few obligate species ($\bar{x}$ = 1.14, SD = 2.27), while northern bays ($\bar{x}$ = 7.80, SD = 7.49) all have obligate species.

A great deal of ecological emphasis has been placed in the past on the importance of estuaries as nurseries for marine fishes (Odum, 1961). Because few accessible estuaries are present in Southern California, it seemed probable that local fish populations may rely little on such nursery areas. Of course, Odum's (1961) analysis omits today's "new embayments," the harbors, artifically constructed or modified habitats developed to serve the dense coastally oriented population of Southern California. Many harbors are present within the Southern California Bight, i.e., Santa Barbara, Ventura, Hueneme, Santa Monica, Marina del Rey, King Harbor, Los Angeles-Long Beach Harbor, Huntington Harbor, Newport Harbor, Oceanside, and the variety of complexes in Mission and San Diego Bays. The construction of harbors produces a modified bay-like environment, often with relatively deep water, dredged channels and a variety of newly placed rocky groins and breakwaters. Such areas, especially the protected rocky environment of the leeward side of a breakwater, become immediately habitable and unique environments for shallow, sublittoral fishes.

Since 1965, a major emphasis of Occidental College's VANTUNA Research Group has centered around fish populations in harbor facilities. During this period we have examined fish faunas and interrelationships at Newport Bay, Los Angeles-Long Beach

Harbors, King Harbor and Santa Monica Harbor, though most of our work has been at Los Angeles Harbor and King Harbor. In both of these sites, we have been impressed by the relatively high density and variety of fishes.

Much of the Los Angeles Harbor data was taken utilizing Occidental's VANTUNA otter trawling program (Stephens et al., 1973; Stephens et al., 1974). The otter trawl is a piece of equipment that is biased toward benthic organisms of the soft substrate and works best in turbid waters. By contrast, the King Harbor study is largely a diver-transect study which requires relatively clear water and is biased toward the less cryptic species and those not showing a diver avoidance response (Chapman et al., 1975).

Comparative trawling data for Los Angeles Harbor and San Pedro Bay are given in Table 1. These data are compared using only collections from the same depth range (approximately 5-25 m) and those made with the same collection techniques during 1971-73. A comparison of the 14 dominant species (by numbers) in each area are expressed as percent of total catch over this period.

Wilcoxon signed rank test of the paired rankings from Table 1 do not indicate a significant difference between the rankings ($T = 20.5$, $n = 9$). There are, however, certain suggestive differences. Engraulis mordax (northern anchovy) and Genyonemus lineatus (white croaker) are far more available in trawl collections within Los Angeles Harbor than in San Pedro Bay. Likewise, the rank positions of Citharichthys stigmaeus (speckled sanddab) and Symphurus atricauda (California tonguefish) are reversed in the two areas.

The dominance of G. lineatus within the harbor most likely reflects nutrient enrichment. The patterns of distribution of this fish shows it is most abundant near the fish cannery or sewage discharges (Fig. 1 and 2), a fact that suggests that G. lineatus may be utilizing energy resources associated with effluent discharges.

Most of the E. mordax, taken by this study were young fish. They are more broadly distributed in the outer harbor (i.e., no peaks found in distributional data). It is possible that nutrient enrichment along with the calm, stable conditions of this area favor it as a site for growth and maturation of young anchovies.

The difference in the distribution of C. stigmaeus and S. atricauda may reflect different substrate and feeding preferences. Citharichthys stigmaeus appears to prefer sandy substrate and cool water (11 C) (Helly, 1974; Ehrlich et al. in press). Los Angeles Harbor has limited area of sandy substrate,

located primarily adjacent to harbor entrances, and much of the harbor water may be warmer than the temperature preferred by this species. Symphurus atricauda seems to prefer mud bottom. We have not as yet tested its thermal preference, but Jim Allen of Southern California Coastal Water Research Project (pers. comm.) has indicated that it differs from C. stigmaeus in its feeding habits. Citharichthys stigmaeus is a visual, diurnal feeder, while S. atricauda uses primarily other senses and could feed successfully in the turbid water commonly found within the harbor.

From the standpoint of numerical abundance, the data indicate that for the years of this study (1971-73) the abundance of fishes as estimated by otter trawl samples was significantly higher within the harbor than in San Pedro Bay. The San Pedro shallow water data included 34 trawl samples containing a total of 8,697 fish of 43 species, an average of 256 fish and 11.5 species per trawl. By contrast the Los Angeles Harbor study (76 trawl samples) yielded a total of 57,647 fish of 65 species, averaging 738.5 fish and 10 species per trawl. These data suggest that Los Angeles Harbor is an extremely productive soft substrate environment for fishes and that the abundance of certain species, especially G. lineatus, reflect nutrient enrichment.

Our King Harbor work (Stephens, unpublished data) supported by Southern California Edison's Research and Development Division, was an attempt to quantify our previous observations which indicated that the breakwater population of fishes was extremely dense and diverse. All data were collected by timed diver surveys at specific substrate depths. The surveys were taken independently by two divers for five minutes and their observations were combined to form one set of data (Terry and Stephens, 1976). Duplicate transects were run for each station. For horizontal substrates such as sand-mud bottoms, the diver records fishes laterally within 3 m so that the transect covers a path 6 m wide and between 50 and 100 m long, depending on fish density. Maximum area covered, therefore, equals about 600 m^2 or about one-sixth of the area calculated to be covered by our 10 min otter trawl samples. Our soft substrate transects averaged seven species and 234.6 individuals near the harbor entrance (sandy) and 5.6 species and 50 individuals from the inner harbor transects (mud). Considerable variation was present in both abundance and species richness, primarily reflecting seasonality and fish movement. The dominant fishes in this study were Citharichthys stigmaeus, Cymatogaster aggregata (shiner surfperch) and Phanerodon furcatus (white surfperch). These fishes ranked in abundance (Table 1) in the top seven in the Los Angeles Harbor study and in the top four in the San Pedro Bay survey. The two most important species missing in King Harbor were G. lineatus and S. atricauda, the former is a species known to avoid divers and the latter has never been observed in King Harbor. Generally, it would appear that the abundance of fishes from unstable substrates in King Harbor is

quite similar to that seen in our study of San Pedro Bay, but fewer species are regularly present.

An interesting comparison of diver and trawl data collecting techniques can be made. An average of 141 fish were observed based on 28 soft substrate diver transects in King Harbor. If we standardize these data to the approximate area of an otter trawl transect (X 6), the estimated number of fishes per diver transect is 846. This number is considerably higher than that averaged by otter trawl collections. However, data collected by SCCWRP indicate that otter trawl efficiency is probably not over 30%; therefore, the standardized figure (30% of 846 = 253 fish) for King Harbor is almost identical to that generated by our trawling studies in San Pedro Bay. It may be that the two methods are quite comparable.

So far we have presented data that suggest that harbor facilities are productive environments, comparable to other similar substrate areas on our coast. In some instances harbors are extremely productive for certain species (e.g., G. lineatus). The artificial habitat areas of harbors, especially breakwaters and jetties, provide an additional community base which appears to be well utilized. It is well known that hard substrate (stable) areas are limited in the ocean and that the addition of artificial "reefs" serve to attract fish populations. In Southern California, Turner et al. (1969) have described such habitats. Because they must not represent a hazard to shipping, artificial reefs are usually low relief structures at a depth below 18 m. By contrast, a breakwater is a high relief habitat which provides vertical coverage including the littoral and sublittoral zones. Further, a breakwater modifies water movement, currents, and temperatures in an area. The seaward side of a breakwater represents an unprotected rocky shore while the leeward side is usually well protected.

For the last three years, we have conducted a large number of diver studies of Southern California rocky shore areas. All of the study areas (Table 2) are relatively high relief (e.g., breakwaters) though Palos Verdes includes low relief reefs. The averages represent a summation of all transects in each area from all depths. The mean number of fish and species recorded from the leeward side of the King Harbor breakwater are significantly higher than those from non-King Harbor habitats when compared using a "T" test ($p = .005$). Another estimate of diversity at each station is gathered from non-quantitative but time-limited diver surveys. Using this technique the results (Table 3) show a much greater difference between the number of species observed at King Harbor and the other areas, and this difference is also statistically significant ($p = .005$).

King Harbor breakwater has an extremely diverse and abundant fish fauna with about twice the number of species found in a

natural rocky shore or around Los Angeles and Santa Monica breakwaters. If we compare only breakwater habitats, King Harbor's breakwater is deeper (mean depth 11 m) than Santa Monica's (mean depth 8 m), and the latter breakwater is barely visible at high tide while King Harbor's breakwater extends well above the high tide mark. By contrast, Los Angeles Harbor's breakwater is both deeper (18 m) and larger than King Harbor's. Size differences, therefore, probably do not account for the differences observed between these areas as fish habitats. The only major difference we have noted between the breakwaters is a difference in the leeward thermal environments. The breakwater at King Harbor has a regular thermocline present during most of the year and includes temperature conditions suitable for a variety of fishes. The temperature differences are due to the position of the breakwater, adjacent to Redondo Submarine Canyon and perhaps to the presence of an electrical generating warm water discharge within the harbor mouth. By contrast, at Santa Monica breakwater we have never observed a thermocline, and there is little difference (1-3 C) between surface and bottom waters. Figure 3 illustrates thermal conditions at King Harbor breakwater during 1975-76. The diversity of fishes at King Harbor reflects the presence of both cold and warm water preferring fishes in the same area.

It is interesting to note that the "canyon-effluent" association at King Harbor appears to enhance fish populations there during both summer and winter. In the summer, circulation of the outer harbor brings cold upwelling from the canyon into the harbor mouth, while in the winter when surface water temperatures have cooled, the effluent water may help to maintain a slightly higher temperature in surface waters of the outer harbor than at adjacent areas. The high number of Pacific bonita (Sarda chiliensis) known to be present occasionally in King Harbor correlated well with periods when harbor surface water temperatures are slightly warmer than the winter-cooled adjacent surface waters.

We have now collected considerable thermal preference data (Stephens, unpublished data) that indicate the importance of thermal differences to our local marine fishes. These data support our contention that the fishes living around the breakwater in King Harbor are selecting different thermal regimes and that the thermal diversity of the area probably accounts for the increase in number of species found there.

Another important aspect of the leeward side of a breakwater is that contained shallow waters are warmed rapidly by insolation so that as one proceeds inward from a harbor mouth surface waters tend to be relatively warm, a situation paralleling that of a natural bay or estuary. There is a tendency for most young fish to prefer warmer water. Norris (1963) described a change in temperature preference with growth in Girella nigricans (opaleye). This tendency has been documented in Atherinidae (silversides)

(Ehrlich, pers. comm.) and Embiotocidae (surfperch) (Terry and Stephens, 1976). Ehrlich (pers. comm.) has related the temperature limits in young Atherinidae to thermal responses in protein and lipid utilization. Fishes grow faster in warmer waters and growth enhances their chance for survival. A large proportion of the fishes observed seasonally in harbors are juvenile fishes. At King Harbor when the number of adult fishes is divided by the number of immatures, the ratio varies from 1.46 at the harbor entrance where large adults are numerous, to 0.20 around a rock jetty situated near the back of the outer harbor. This latter preponderance of young fishes in the harbor reflects both their preference for warmer waters and the avoidance of warm waters by most adults. For many species, especially rockfishes, adults are rarely seen within the harbor, but juveniles make up a large proportion of the fish population. Harbors, therefore, do serve as nursery areas for many juvenile fishes, and although this is probably not an obligate relationship, it certainly is a major factor in explaining the large fish populations inhabiting these areas.

In summary the numerous harbors in Southern California supplement or replace the few estuaries as nursery areas for juvenile fishes. They supply calm, often nutrient rich waters, with a variety of substrates, all of which, provided ecological conditions remain suitable, supply habitat for fishes. Further, it is suggested that because of their special physical conditions these areas may produce larger or more diverse fish populations than those occurring in "natural" environments, and our evidence suggests that this is presently the case both in Los Angeles Harbor and King Harbor. We recognize that harbors are structures designed for ships, not fish, but suggest that as fishes will make use of them, and as sportfishing is an important recreational and economic activity in Southern California, it would be interesting to engineer new construction in ways that would further enhance our local fish populations.

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Table 1. A comparison of the 14 numerically dominant species in each area expressed as percent of total catch over the period 1971-1973. Number in parentheses is percent less 25,487 juvenile Genyonemus lineatus collected Summer 1973.

Species	San Pedro Bay	L.A. Harbor
Citharichthys stigmaeus	39.5	6.5 (11.6)
Symphurus atricauda	22.2	8.9 (15.9)
Phanerodon furcatus	9.8	3.6 (6.6)
Cymatogaster aggregata	7.7	3.7 (6.7)
Engraulis mordax	6.4	17.1 (30.7)
Seriphus politus	4.9	3.8 (6.8)
Genyonemus lineatus	3.3	52.4 (14.6)
Pleuronichthys verticalis	2.7	0.5 (0.9)
Pleuronichthys decurrens	0.9	0.1 (0.3)
Parophrys vetulus	0.8	>0.1 (0.1)
Porichthys notatus	0.4	0.7 (1.4)
Embiotoca jacksoni	0.4	0.1 (0.2)
Sebastes miniatus	>0.1	0.6 (1.1)
Lepidogobius lepidus	---	0.7 (1.3)

Table 2. Number of species and fish per transect at five rocky shore localities.

Area	Number species per transect ±	S.D.	Number fish per transect ±	S.D.	Number transect
King Harbor Breakwater (leeward)	13.3	3.0	282.0	120.0	225
King Harbor Breakwater (seaward)	11.8	1.3	342.0	150.0	150
Santa Monica Breakwater	10.5	1.6	162.0	90.0	15
Catalina kelp bed	10.6	2.6	157.0	70.0	22
Palos Verdes	8.0	1.5	90.0	75.0	108

Table 3. Number of species of fish observed by divers in area surveys.

Area	$\bar{x}$ number of species	S.D.	N
King Harbor Breakwater (leeward)	47.0	6.8	17
Santa Monica Breakwater (leeward)	23.0	5.7	2
Palos Verdes	17.0	5.8	9
Los Angeles Harbor Breakwater (leeward)	28.0	-	1

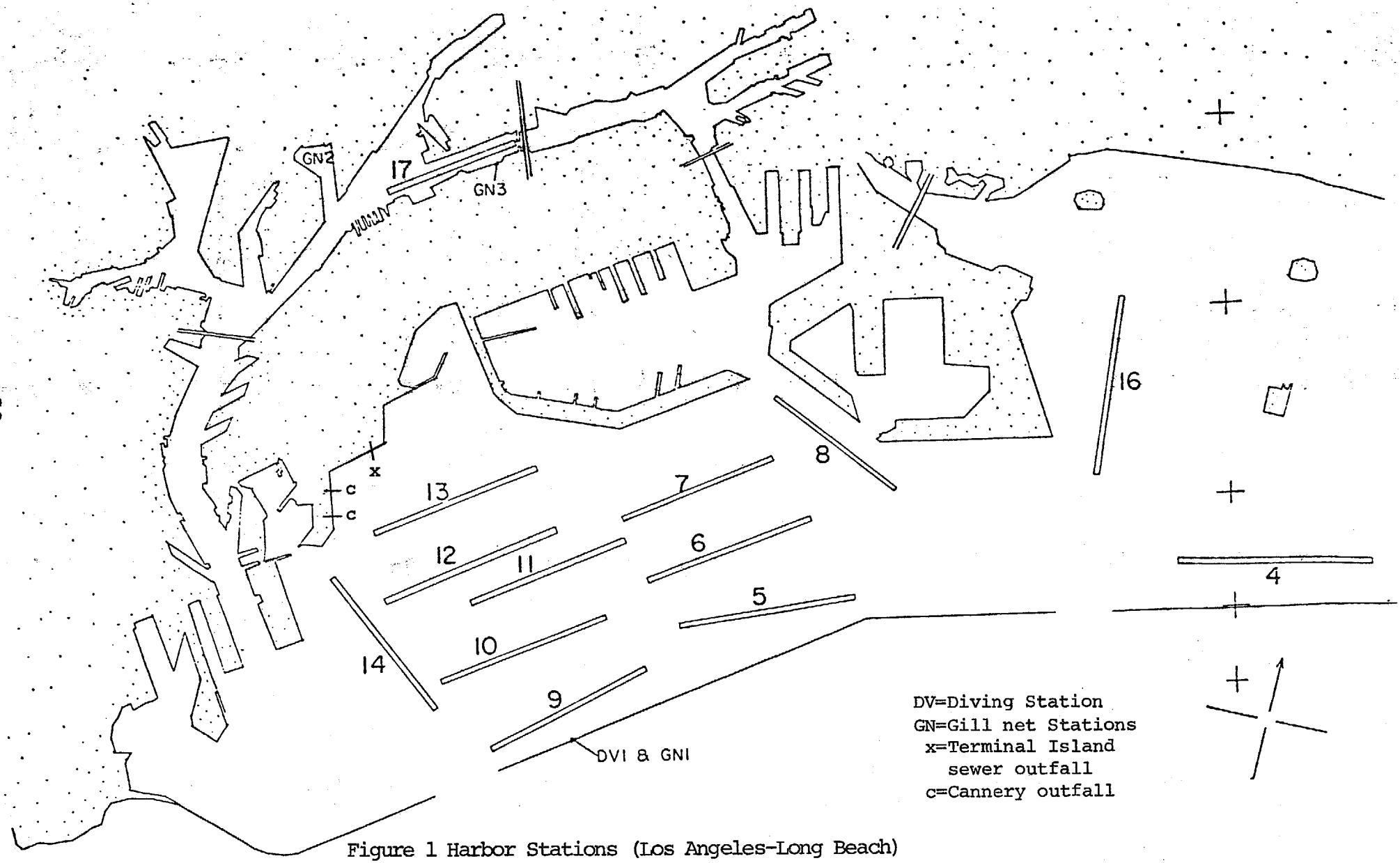

Figure 1 Harbor Stations (Los Angeles-Long Beach)

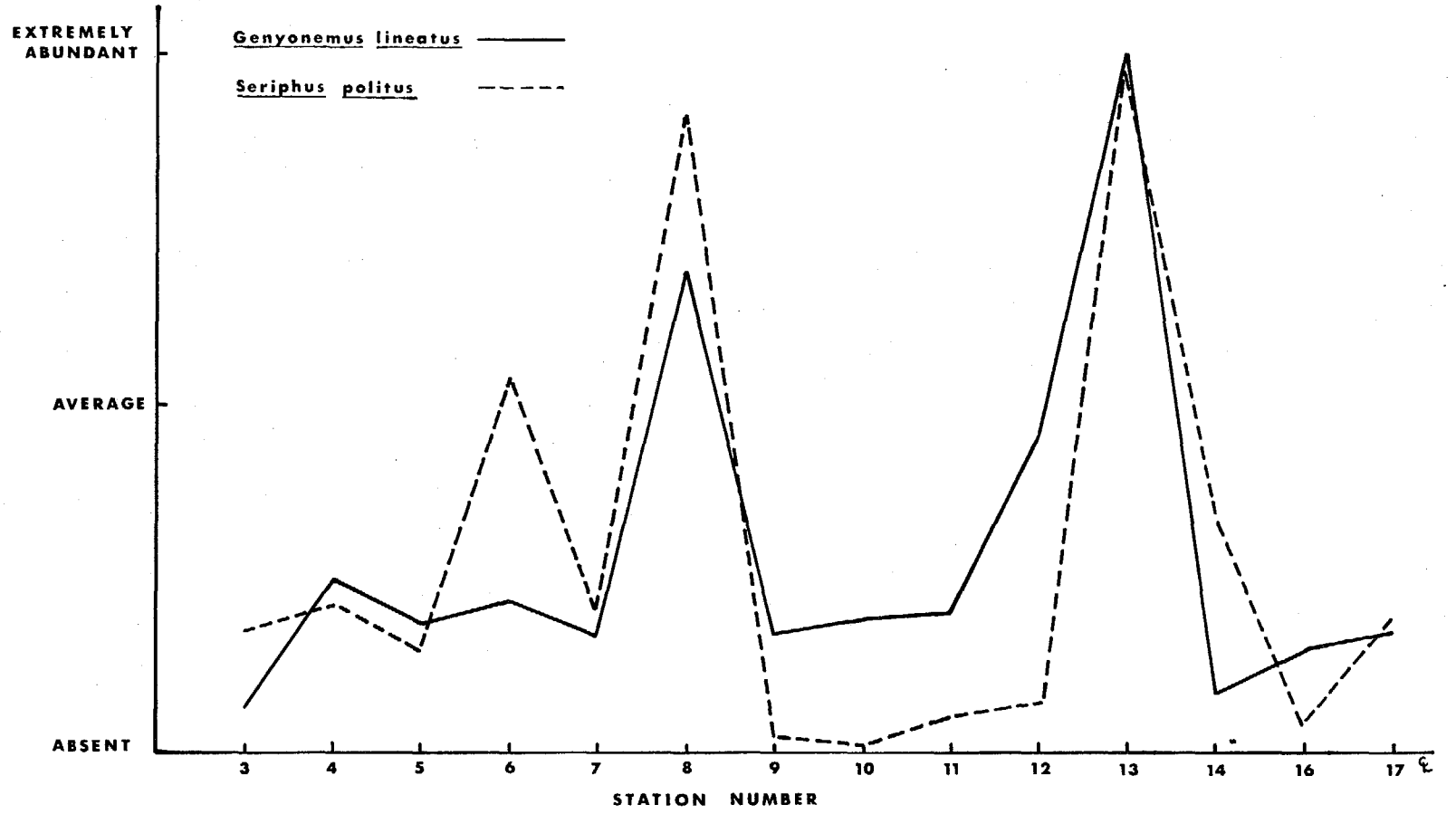

Figure 2. Differences in relative abundance of croakers with station (from Stephens et al., 1974).

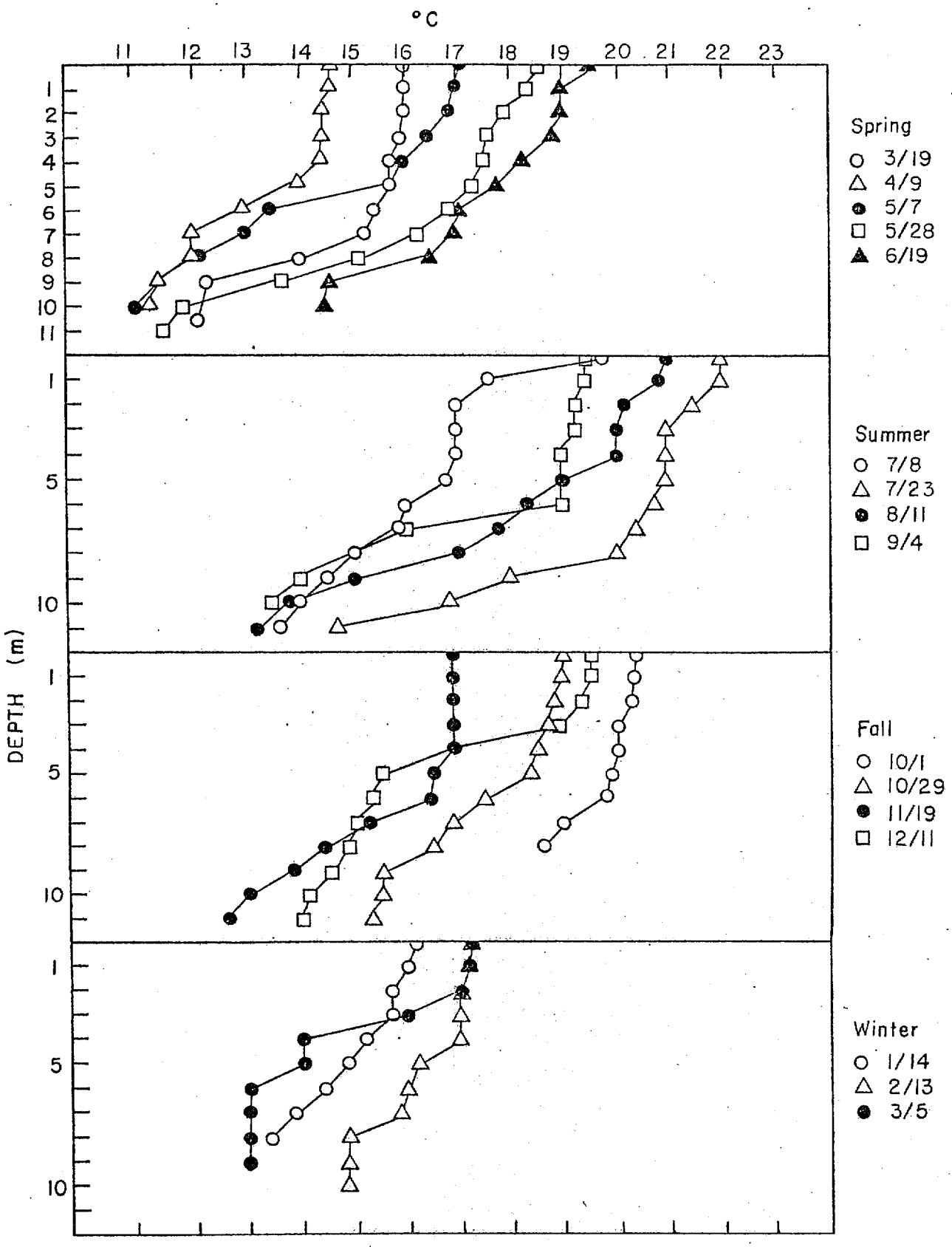

Figure 3. Bathythermal profiles from the leeward side of the breakwater, King Harbor, California, 1975-76.

SOME BIOLOGICAL COMPONENTS OF MARINE HARBORS AND BAYS OF SOUTHERN CALIFORNIA

by
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Southern California is a semi-arid environment subject to wide variations in rainfall (e.g., Long Beach annual average 33 cm, range 10-61 cm; Kimura, 1974). The coastline trends from east to west and is protected from the predominant wind and swell patterns to some extent by Point Conception and the Channel Islands. Transverse mountain ranges border the southern California coastal plain to the north and reach elevations in excess of 2,000 m (Salitore, 1974). These ranges receive three to four times more precipitation per year than the adjacent low lands (Department of Commerce, 1962). Originally, seasonal streams crossed the lowlands. These streams varied considerably in volume and in their course to the sea; thus much of the land adjacent to the ocean was flood plain (Coastal Wetlands Program Staff, 1976). Along the coast, littoral and aeolian transport of sands formed dunes and bars which resulted in extensive areas of sea level marshland that had both diverse fresh water and marine components. As a result of the semi-arid climate and highly seasonal rainfall, however, coastal wetlands in Southern California do not contain a continuous gradient from fresh to sea water throughout the year. Often, in fact, hypersaline conditions develop during dry periods when high rates of evaporation occur, thus resulting in a physically harsh estuarine environment (Emery and Stevenson, 1957).

Today, the original $\sim$ 10,500 hectares (26,000 acres) of Southern California coastal wetlands have been reduced by an estimated 75% as a result of human uses which impact on the capacity of these environments for the sustenance of an estuarine biota (Hendrickson, 1976).

While records of the original biota of southern California coastal wetlands and bays are incomplete, the available evidence suggests that these regions once supported a highly diverse and productive biota comparable to similar temperate habitats. The types of evidence to support this conclusion include: 1) paleontological descriptions of the various sedimentary layers found at the mouths of coastal streams in the vicinity of coastal wetlands (Warme, 1969, 1971); 2) archaeological evidence from kitchen middens of coastal indians (Kroeber, 1976; Landberg, 1965); 3) the records and observations of early whalers and hunters (Scammon, 1874); 4) the records and observations of fisheries workers (Follett, 1976; Goode, 1887); 5) the records and observations of ornithologists (Grinnell, 1915; Bloeker, 1943).

Aboriginal peoples employed crude techniques to capture

game, thus relatively large populations of these organisms were probably necessary to support their subsistence level culture. Similarly, large populations of marine mammals and sea and shore birds required even larger populations of fishes, invertebrates and grasses. It is clear that present population levels of marine organisms are insufficient to sustain either large numbers of predatory fish, mammals and birds or a subsistence level of thousands of aboriginal people.

Today with reduced areas of coastal wetlands, the intensity of human demands upon the remaining areas have increased. Among these demands are the need for additional maritime commerce and recreational boating. Even so, the construction of every harbor on the coastline has in part been justified in economic terms. It has also been argued that if coastal wetlands were to be altered by dredging and filling operations, the resultant harbor would be as good as, if not a better marine habitat than the original area of coastal wetland. If this argument is valid, the available evidence should sustain it.

The purpose of this paper is to provide a comparative analysis of the phyla and species of organisms now living in coastal harbors with the biota of existing "natural" estuarine habitats.

For the purpose of this analysis, five physical parameters of the harbors will be considered (Table 1). These include total surface water area which has been estimated from coast and geodetic survey maps with the aid of a planimeter, the length and nature of the shoreline (sand, bulkhead, rip-rap, wharf and piling), depth and estimated tidal flushing. These parameters will be considered in conjunction with the number of reported species of coelenterates, sponges, benthic macro-mollusks, arthropods, echinoderms, ascidians, teleost and elasmobranch fishes, and benthic algae (Table 2). Biological data have been derived from numerous sources and from personal observations made over more than 20 years by the senior author.

ANNOTATED OBSERVATIONS AND COMMENTS

Santa Barbara Harbor. Sited and formed as it is, the harbor breakwater serves as an efficient device for the capture of sediments moving along the shoreline from west to east. The accumulating sediments are continuously dredged to keep the harbor open for vessels. In biological terms, the harbor is unremarkable for the development of most benthic species of invertebrates, fishes, or algae.

Ventura Marina and Ventura Keys. This area is remarkable for the siting of the breakwater, sand capture, and shoaling problems at the entrance. This is a relatively young harbor complex with a poorly developed marine biota. The harbor was severly damaged in 1969 when the Santa Clara River broke into it during flood conditions.

Channel Islands Harbor and Mandalay Bay. Shoaling problems exist on the west and north sides. A substantial growth of Macrocystis (giant kelp) distinguised the entrance to this harbor in 1972; however, this alga is now less abundant. Recent infestation by juvenile sea urchins, Strongylocentrotus spp., dates from the start of the use of the harbor for the off-loading of sea urchins for the export industry. The Mandalay Bay harbor is unusual in that a constant flow of water passes through the harbor to the Mandalay Steam Plant of the Southern California Edison Company (SCE).

Port Hueneme. It was recently dredged to a depth of about 12 m to serve as an active port of maritime commerce; this site also accommodates a number of U.S. Navy Vessels. Observations were not made on the Navy side of the harbor.

Mugu Lagoon. Three sections of the lagoon are structurally distinguishable. The two westerly portions have suffered from restriction in circulation, and therefore presumably have poor water quality. The south-easterly portion is essentially unaltered. It has been investigated by a number of marine biologists including the MacGinities and more recently by Dr. K. MacDonald. Thanks to the interest of the Navy in this lagoon and the work of Dr. MacDonald, an impressive number of species has been reported here.

Marina del Rey. Development of this marina is characterized by bulk-head construction and channels of about 3.7 m in depth below mean lower low water (MLLW). Water quality appears to be poor, as indicated by periods of zero dissolved oxygen (D.O.) and a poorly developed biota, which lacks many perennial species.

King Harbor Marina. This is principally of rip-rap design with some bulk-head components. It is another marina with constant cooling water in-flow and discharge by SCE. Large numbers of fishes may be found in the harbor on an extended seasonal basis. The fishes are mainly found in the vicinity of the hot water discharge where they appear to be attracted by the warm water and possibly to some extent by the presence of dead plankton which has been released with the cooling water discharge of the power plant. Some of the fishes may feed on this dead plankton. Artificial circulation of water appears to preclude the development of anaerobic conditions during periods of red tides. The biota of the harbor remains productive although lower than other areas (e.g., Mugu Lagoon, Mission Bay). (See also paper by J. Stephens in this symposium.)

Los Angeles-Long Beach Port Complex. Gross configuration of the port complex was developed about 1937 with the construction of the Federal Breakwater. This configuration has never been completed however, because dredging, construction, and alteration of the shoreline and tributary streams (Dominguez Channel and the Los Angeles River) continues. In addition to gross physical alteration, severe problems of water quality have developed and

continue to exist in the port complex. These include chemical pollution by toxins (e.g., copper, mercury, lead, arsenic, DDT), petroleum spills, cannery wastes, domestic and industrial sewage wastes, storm run-off, and thermal discharges. However, the waters of the port complex support a varied and in some places highly productive marine biota. Periods of low D.O. are still encountered in association with refinery, cannery waste, and sewage discharges and occasional blooms of red tide organisms. Wide variations in the abundance of native and introduced species occurs from year to year and no large perennial populations of anything other than clams, sea anemones, tunicates or sea urchins have been observed by the authors. Even the sea urchins have failed to sustain high numbers on the Federal Breakwater, presumably due to low algal abundance.

Alamitos Bay and Colorado Lagoon. This facility was originally constructed with a mix of rip-rap, bulk-head, and sandy shoreline. Recent and proposed construction is of the type which will expand the length of bulk-head configuration. Extensively studied by Reish and his co-workers, the bay has had a fairly high diversity and an abundant biota. This was severly disrupted by a heavy siege of red tide in 1973 that eliminated climax communities found in the area of the north channels. The calculation of the number of species as a function of water area (Table 2) is probably too high by a factor of about 2 because it is based upon data collected prior to 1973 and represents more of an abundance of marine life than is true of the harbor now even with the continuous flow of water through the complex to the SCE power plant on the San Gabriel River.

Anaheim Bay. Originally an extensive coastal wetland occupied most of the shoreline from Palos Verdes to Newport Bay. Three rivers (Los Angeles, San Gabriel, and Santa Ana) and several creeks crossed this area and their stream beds meandered from year to year. Today, Anaheim Bay remains as a vestige of this system. This area has been extensively studied by the faculty and students of the California State University at Long Beach. A formal description of the area was published as Fish Bulletin 165 by the California Department of Fish and Game (Lane and Hill, 1975).

Huntington Harbor and Sunset Bay. Predominately bulk-head construction throughout Huntington Harbor results in extended periods of low or zero D.O. and periodic fish kills. In addition, the bulk-head construction provides limited niches for marine organisms and thus a relatively poor index of species per unit area is observed.

Newport Bay. Once the professional domain of the MacGinities and the site of some classical studies of the biota of protected waters of southern California, this bay has experienced a continuing decline in the diversity and abundance of marine life over the past 25 years. This decline parallels an increased

input of environmentally hazardous materials into the coastal ecosystem in general along with increased urban and agricultural run-off, increased siltation, increased boat traffic in the Bay and the addition of some bulkhead type canals on the west end of the complex. This bay is unusual in that a large portion of the complex remains in a nearly natural configuration (Upper Newport Bay).

Dana Point Marina. Construction of this harbor facility destroyed what was once one of the most productive and diversified tide-pool areas on the southern California coastline. Nothing formerly typical of the tide-pool area now appears to flourish in the harbor, and the present biota is characterized by a low diversity of species and low specific abundance.

Oceanside Marina-Camp Pendleton Boat Basin. This area is subject to excessive shoaling, resulting in severe shoreline erosion downstream. This has been credited to the U.S. Marine Corps and the construction of the Camp Pendleton Boat Basin. Be that as it may, in terms of marine biota making use of the Oceanside Marina, it is small.

Mission Bay and San Diego River Flood Control Channel. Development of the Mission Bay Complex occurred stepwise over a period of more than 50 years. The last major step ended in 1961 when the total water area was expanded to some $\sim$ 1000 hectares (2500 acres). In this case, the number of species observed as a function of the total water area is somewhat misleading because large areas may be dominated by Zostera (eel grass) and the rip-rap is well colonized by benthic algae. The importance of the rich flora is essential to understanding the complexity and abundance of animal life in this complex aquatic system.

San Diego Bay. Possibly comparable to the port complex of San Pedro Bay, for reasons not entirely obvious, San Diego Bay has a relatively low diversity and standing crop of biota. It may be that water quality is a serious problem limiting the abundance of marine life in the bay. However, since about 1964, sewage wastes have no longer flowed into the bay from the City of San Diego. Even so, it is not nearly as diverse or abundant in marine life as is the nearby Mission Bay even though it is of comparable total area.

DISCUSSION

While the data are still preliminary due to the unavailability of extensive distributional and quantitative data, certain trends are evident. The relatively high ratios of numbers of species per hectare of water surface noted for Mugu Lagoon, Anaheim Bay and Upper Newport Bay suggest the importance of shallow embayments and substantial tidal exchanges to the development of large and diverse populations of marine organisms. When a harbor is compared with a natural bay or lagoon, the

greater number of species present in the harbor does not appear to be proportional to the presence of additional substrates (bulk-head, rip-rap, pilings, and floats). Further, if a comparison between the harbors and the natural bays is conducted for those species which are found in or on sedimentary bottoms, it is evident that soft bottom communities do not develop more extensively in harbors than in natural bays.

The importance of tidal exchange can be emphasized by noting the multiple of the number of species present times the estimated percent flushing per tidal cycle. This approach still applies when considering the Channel Islands Marina, King Harbor, and Alamitos Bay for in these instances, natural tidal flushing is increased by the circulation of water through these marinas for cooling purposes in adjacent electrical generating stations. In these cases, the presence of multiple substrates and increased circulation does not result in proportionately increased numbers of species per unit area compared with the natural bays (Mugu Lagoon, Anaheim Bay, and Upper Newport Bay).

Several criteria must be applied in estimating the quality of a harbor as habitat. Among these are the extent of water circulation, the configuration of the habitat, the types and amount of substrate present, and water quality. Based upon these preliminary comparisons, it appears that water circulation is of principal importance in harbor design with respect to biological considerations, i.e., diversity and standing crop. How this factor is to be applied in harbor design and operation remains to be determined. In no case considered here have the harbors been shown to improve the habitat function as compared with natural bays and estuaries. If this conclusion can be verified by additional data and observations, it could have considerable importance in the design of harbors, and marinas to improve their functional capacity as marine habitats.

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Table 1. Physical data pertaining to the habitats studied.

Location	Water Area acres (hectares)	Shoreline miles (km)	Depth feet (m)	Water Area/Shoreline ratio acres/miles (hectares/km)	Volume (at MLLW) acre feet ($m^3 \times 10^3$)	Tidal Volume Change** acre feet ($m^3 \times 10^3$)	% of vol. changed
MARINA OR HARBOR							
Santa Barbara Harbor [o]	51.5 (20.8)	0.9 (1.4)	12 (3.7)	57.2 (14.9)	618.0 (770)	236.9 (291)	38
Ventura Keys Marina and Ventura Marina +	156.2 (63.2)	5.3 (8.5)	11 (3.4)	29.5 (7.4)	1718.2 (2,149)	718.5 (885)	42
Channel Islands Harbor+	193.8 (78.4)	8.4 (13.5)	12 (3.7)	23.0 (5.8)	2325.6 (2,901)	891.5 (1,098)	38
Port Hueneme+	68.9 (27.9)	2.0 (3.2)	35 (10.7)	34.5 (8.7)	2411.5 (2,985)	316.9 (391)	13
Marina Del Rey*	422.8 (171.1)	9.0 (14.5)	12 (3.7)	47.0 (11.8)	5073.6 (6,331)	1944.9 (2,395)	38
King Harbor+	111.2 (45.0)	3.1 (5.0)	20 (6.1)	35.9 (9)	2224.0 (2,745)	511.5 (630)	23
San Pedro Bay[o] (plus Los Angeles and Long Beach)	15,405.5 (6234.6)	67.1 (108.0)	40 (12.2)	229.6 (57.7)	61,6220.0 (760,621)	70,865.3 (87,284)	12
Alamitos Bay[o]	429.8 (173.9)	13.0 (20.9)	15 (4.6)	33.1 (8.3)	6447.0 (7,999)	1,977.1 (2,435)	31
Anaheim Bay[o](West of Pacific Coast Highway)	86.2 (34.9)	2.0 (3.2)	30 (9.2)	43.1 (10.9)	2586.0 (3,211)	396.5 (489)	15
Huntington Harbor and Sunset Bay*	241.2 (97.6)	14.4 (23.2)	10 (3.1)	16.8 (4.2)	2412.0 (3,025)	1,109.5 (1,366)	46
Lower Newport Bay[o]	835.2 (338.0)	18.0 (29.0)	14 (4.3)	46.4 (11.7)	11,692.8 (14,534)	3,841.9 (4,732)	33
Dana Point Harbor+	167.0 (67.6)	4.6 (7.4)	16 (4.9)	36.3 (9.1)	2,672.0 (3,312)	768.2 (946)	29
Camp Pendleton Boat Basin and Oceanside Harbor+	212.6 (86.0)	4.6 (7.4)	15 (4.6)	46.2 (11.6)	3,189.0 (3,956)	978.0 (1,204)	31
Mission Bay [o]	2,147.0 (868.9)	22.0 (35.4)	10 (3.1)	97.6 (24.5)	21,470.0 (26,936),	9,876.2 (12,165)	46
San Diego Bay [o]	11,040.0 (4467.9)	44.1 (71.0)	25 (7.6)	250.3 (62.9)	276,000.0 (339,560)	50,784.0 (62,551)	18
LAGOON OR ESTUARY : at low tide							
Mugu Lagoon (East arm)	52 (21.0)	5.7 (9.2)	4 (1.2)	9.1 (2.3)	208 (252)	488 (602)	235
Anaheim Bay (East of Pacific Coast Highway)	50 (20.2)	7.7 (12.4)	3.5(1.1)	6.5 (1.6)	175 (222)	414 (511)	237
Upper Newport Bay	170 (68.8)	5.1 (8.2)	3.5(1.1)	33.3 (8.4)	595 (757)	2105 (2,593)	354

[o] Mixture of sand, bulkhead, rip-rap

* Bulkhead dominates

+ Rip-rap dominates

** Average tidal change = 4.6' (1.4 m), except for Mugu Lagoon where it is 2.3' (0.7 m) due to entrance sill

Table 2. An analysis of the number of species of selected taxonomic groups found in the habitats studied.

Location	Porifera	Coelenterata	Mollusca	Arthropoda	Echinodermata	Ascidiacea	Vertebrata (fish)	Algae	Total no. of species	No. spp./ acre water	(No. spp./ hectare water)	No. spp. x % flushing
MARINA OR HARBOR												
Santa Barbara Harbor (S. Anderson, pers. comm.)	8	14	43	28	6	8	26	9	142	2.8	(6.8)	54.0
Ventura Keys Marina and Ventura Marina (Henningson, Durham, and Richardson, Inc.,1974)	1	3	10	5	0	2	4	3	28	0.2	(0.4)	11.8
Channel Islands Harbor (authors)	7	14	51	14	8	11	12	14	131	0.7	(1.7)	49.8 (135.0)*
Port Hueneme (authors)	7	12	23	9	8	10	12	11	92	1.3	(3.3)	12.0
Marina Del Rey (authors)	3	3	13	11	2	4	15	5	56	0.1	(0.3)	21.3
King Harbor (authors; Duffy, 1969)	6	13	74	28	16	9	71	27	244	2.2	(5.4)	56.1 (219.6)*
San Pedro Bay (Los Angeles and Long Beach Harbors) (authors; Hurst, 1976)	10	22	121	43	22	15	130	31	394	0.03	(0.06)	47.4
Alamitos Bay (authors; Reish, 1968)	4	10	65	32	10	9	28	16	174	0.4	(1.0)	53.9 (134.0)*
Huntington Harbor and Sunset Bay (Hardy, 1970;Moorhouse, 1974)	2	9	60	28	4	8	27	13	151	0.6	(1.5)	69.5
Dana Point Harbor (authors)	4	4	17	6	7	10	10	10	68	0.4	(1.0)	19.7
Oceanside Harbor (authors; Russ Bellmer, pers. comm.)	4	8	32	39	5	7	41	12	148	0.7	(1.7)	45.9
Mission Bay (authors; Lo-Chai Chen, pers. comm.)	9	18	101	32	20	18	42	22	262	0.1	(0.3)	120.5
San Diego Bay (authors; Browning and Speth, 1973)	6	5	43	28	0	8	41	16	147	0.01	(0.03)	26.5
LAGOON OR ESTUARY:												
Mugu Lagoon (MacDonald,1976)	0	4	94	26	7	0	25	4	160	3.1	(7.6)	360.0
Anaheim Bay (East of Pacific Coast Highway) (Reish et al., 1975; Klingbeil et al., 1975; Lane, 1975)	2	2	23	27	0	3	45	6	108	2.2	(5.3)	256.0
Upper Newport Bay (Frey et al., 1970)	9	11	74	31	6	6	61	18	216	1.3	(3.1)	764.6

*Includes flushing resulting from water flow through power plants

ENVIRONMENTAL SCIENCES AND HARBOR PLANNING

by
Dorothy F. Soule

After the interesting and challenging remarks of today's sessions we must still return to the thesis that the major problem ecologically in the world today is the one that we all recognize -- that there are too many people, in too small a space, causing too much pollution and too much demand on resources. Where resources still exist, they are often not located where the people want or need them. Conversely, we often find that there are fewer people in the areas where the resources are. Associated with the problem of transportation systems for relocating the resources are the attendant impacts on the environment, on other resources and on people.

A great deal has been said about the depletion of our local environment. Some of the numbers are, of course, very real in terms of decline in some fish species, abalone and lobster populations, for example. I would tend to disagree with Dr. Fay, however, in his statement that if we were to revert to the primitive level of population here, the sea would be unable to sustain it. If the population were reduced to 2,000 people, not catastrophically but by choice, I would venture to guess that by the next very high tide there would be an array of shellfish along the shore. There are also urchins and starfish on the breakwaters; in the harbor there are many fish, seals, even an occasional albacore, and innumerable benthic polychaetes. The polychaetes are so abundant that fish are able to feed by the "lawnmower" technique. One of the fish canning industry men maintains that those are not lesions on some of the sewer trout, they are bed sores from the fish resting so close together. In fact, at the turn of the century when Los Angeles Harbor consisted only of the waters within the Cabrillo breakwater, ichthyologists at USC were able to capture approximately 28 species of fish. Dr. John S. Stephens, of Occidental College and D. W. Chamberlain, formerly at USC, collected somewhere around 130 species in 1973-74 using an otter trawl. Very few of the latter species are the same as those caught earlier because construction of the breakwaters caused current velocities to slow and created a soft sediment trap, so that the species groups that feed and live in the area are altered.

This is not to say that we can not, or have not, eroded our environment and that we do not need to plan to protect and enhance it in the future. We need to plan ahead, and we need to plan together using novel and possibly radical approaches. I think we have made considerable progress in the planning process in the last seven years since the advent

of environmental legislation.

It is entirely possible that those of us who have resided at USC for a good many years as marine biologists would never have known the engineering faculty at USC nor the management and staffs of the two Ports, the Coast Guard and Corps of Engineers. It's possible that we would not have known and worked with urban planners such as Margarita McCoy, who formerly taught at USC. The scientists call her a soft scientist, which may not be correct terminology, but we probably would not have met except for the new planning modes. With the coming of the requirements of environmental law, people of diverse disciplines have come together, and I think we have achieved a great deal in terms of preserving the environment, and also in opening avenues for the public to be heard.

Many citizens have concerns about the environment that they are not able to pursue in the same manner that we may as scientists. They may have vague fears that they cannot control what is happening around them, or recognize the consequences of some plan. The larger the population, the less the feeling that they are able to influence their environment or control their political situation.

Our laws, by the nature of their origins, are unfortunately not rapidly responsive to the changes in knowledge and changes in the wishes of the public. Rapid response is the antithesis of the legislative process. At first our environmental laws led us, but they now lag far behind us, because there was no significant feedback provision written into them. We find now that environmental laws were constructed more for convenience in enforcement than for consideration of local or regional environmental quality. For example, the original levels of trace metal standards were picked because they were below the detectable limits of the existing methods; therefore when any positive reading occurred you knew you had exceeded some mythical background level. The lawyers wished to make one rule for all water discharges because then the agencies wouldn't have to look at the receiving waters -- take measurements or count fish and worms -- in order to determine whether or not an effluent was "polluting." If there is any one thing the law needs today, it is revision by legislators to provide for input of new knowledge in a constructive fashion. Certainly the laws should not vacillate, nor should they be weakened, but they can and must be responsive to advancing knowledge.

And what about the public input? Many of you at this symposium have sat through a number of hearings in the last 5 yrs. I look around the room and I see a number of familiar faces of people who have spent considerably more time than I have at public hearings. Sometimes we hear from

experts from a variety of fields who hold conflicting views. The economist, scientist, planner or industrialist has his public, or institutional responsibility as well as his personal feelings, which may be in conflict. While the public worries about a project and feels inadequate to evaluate information, we are really a sophisticated society compared with primitive societies. While we sometimes hear some very comical input at public hearings, they generally reflect the real concerns of an educated people who nevertheless feel insecure about their future environment.

By comparison, what of primitive people, who do not realize that some impact is building until it is too late and the axe has fallen? Let us look for a few moments at impacts and demands in some problem areas in the Pacific Ocean Basin associated with development, transportation and delivery of resources (Fig. 1).

For example, several years ago we did some research in Papua, New Guinea, where the Stone Age culture is still very much in existence. The mountains of New Guinea are mineral-rich and the natives are nutrient-poor. The people cannot understand the confrontation with "development" for their experience with the twentieth century has largely been limited to the "cargo culture" and a few tourists (Sorenson, 1977). If proposed resource extraction projects are carried out in New Guinea the river basins and harbors on which they depend for food will die. If a proposed giant dam and bauxite mill are constructed on the Strickland River, the mangroves and much of the fauna of the Gulf of Papua will probably be destroyed.

Other, more developed, civilizations have problems, too. Sydney, Australia had one of the most polluted harbors I've seen, with nothing living along one particular area which had been an industrial dump for many years. Other branches of the estuary fortunately are not polluted and can be used for swimming and boating. The famous opera house stands on harbor landfill but they didn't worry about water circulation because the current is several knots there. Australia also has 1600 km (1000 miles) of remote coral reefs along its eastern coast and in the northern straits. Industry wants to exploit the Great Barrier Reef by exploring for oil and minerals and by mining lime for fertilizer so that sugar cane can be grown where cane has never been grown before. These developments would damage or destroy the irreplaceable shallow water reef areas that not only protect the long coast from erosion but also serve as nursery grounds for the teeming fish life along the coast (Clare, 1971).

At Singapore, on trade routes that bring the resources from under-developed lands to consumer countries, islands in the enormous harbor complex are used to tranship petroleum,

LNG and LPG. A major mode of transportation for much of the harbor is by lighter, however, and those of you who are acquainted with LASH terminals would hardly recognize the term applied to the small sampan-like lighters there. Many parts of the harbor cannot accommodate deep draft vessels. Okinawa, along the Pacific Basin rim, has a supertanker terminal at Kim Bay. During the typhoon season supertankers are forced to put to sea away from the docks because ships cannot stay tied up when the winds reach 80 km/h (50 m/h). When the terminal was built out on an island in the bay it seemed like a good idea to isolate it, except that it was built on mud-flats where important shellfish beds and small boat fishing for that area of Okinawa occurred. In order to get across the mud flats a causeway was built; the causeway effectively blocked the flushing and circulation and killed off most of the shellfish. The terminal solved the social impact by putting the local fishermen on the payroll. The boats might have been able to go farther afield, but where would they find new fishing grounds?

There's been talk in the newspapers recently of Palau as a site for the world's largest supertanker port. Palau includes hundreds of islands and reefs. The port might be located on the Island of Babelthaup, an area that is primarily a dense mangrove swamp, or on the Kossol Reefs. Mangrove swamps are essential to the life cycles of many of the marine crustaceans and to the endemic mangrove crabs. Palauans now boat into the swamps and bring out crabs to ship to Guam as one of the few things they can do to earn a living. The tanker port location would be separated from the only island with major habitation, the Island of Koror. The beautiful Palauan chain of islands is surrounded by coral reefs (Faulkner, 1974), which are even now depleted of marine life in some areas because of the impact of the increased population on seafood supplies. And yet the native population is not at all prepared to cope with the impact of modern superport facilities and the associated commerce; they would almost certainly be relegated to the most menial tasks. However, port advocates feel that this might be better than no tasks at all, for the islands probably cannot be self-supporting for present populations. The islands are limestone and not at all fertile because the heavy rains percolate right through the ground into the sea. The only significant industry was a small Van Camp fishing plant. But Palauans go to sea when they feel like it, and many seem not to be particularly concerned about how they will be supported, since they've been ruled or cared for by some one else for more than 100 yrs.

Again, in contrast to areas with low populations and simple life styles where impact of resource development and logistic support are yet to come, one sees Tokyo as the epitome of the consumer society; highly industrialized, with attendant air and water pollution and extreme population pressure. The

tendency has been to export pollution to underdeveloped countries by processing at the remote site of resource extraction. Until recently Japan has accepted health hazards and death risks, such as mercury contamination of fish and severe air pollution, as part of the cost of their society. Dr. Bright has alluded to the willingness of the Japanese to accept the risk of thousands of deaths due to an LNG explosion in place of the possible death of millions from a severe air pollution attack.

A mid-Pacific city, Honolulu, is one you may recognize with coastal problems from people pressure. With tourism as the principal industry, they have overbuilt, channelized their intense rainfall, filled their lagoons with mud and killed off much of the coral and inshore biota. Sand is barged in from Molokai, since Waikiki was originally a swamp. The population pressure and earlier lack of concern for their limited coastal environment have depleted the shores and nearby reefs of fish and shellfish.

Returning to the southern California coast, we recognize that our area was in the resource development phase for many years, and is now slated to function more and more in the transshipping role for the rest of the nation. Depletion of non-living resources locally has been accompanied by depletion of living resources, due to population and pollution pressures, and perhaps to natural phenomena as well.

The University of Southern California has been involved in marine science since the early 1900's and at one time operated the old Venice Marine Lab and a little sloop called the Anton Dohrn out of Venice. In the 1930's-1950's the RV Velero III and IV made many cruises along the Eastern Pacific, from Colombia and the Galapagos Islands to Washington State, collecting marine organisms. In 1970, when environmental legislation began to affect industry and the public as it related to the Los Angeles-Long Beach Harbor area, we received a number of calls asking whether we had a data base, or could develop one that would enable public agencies and industries to comply with the environmental requirements. We were at the "What's an EIR?", "Where do we get the data?" stage. We looked for data on the harbor, being certain that in a sophisticated, developed society like ours, all this information would surely be in someone's files. It turned out that for too many years those who took data had treated them as proprietary, or the data were gathered only according to the single interest of one or two investigators with limited resources, who were unable to mount any kind of a harbor-wide study that would involve more than their particular research emphasis. And so we were faced with the fact that a data base had to be developed and quickly.

At the same time we ran into a common academic sentiment

that it was not right for a scientist to dirty his hands in the market place, that the only ethical way to proceed with research was to get money from NSF or a similar agency. If funding was provided, one went and did one's research on some tropical island or wherever, and whether it related to any real life problem was up to someone else. It was virtually impossible for non-scientists, such as planners, to find or use the erudite publications when they finally reached the world five or so years later. A number of us felt that this was not the proper way to proceed in an overstressed world and if we were not willing to <u>try</u> to translate our sciences into assessing impacts and making suggestions for planning improvements and mitigation, then we had no right to criticize the engineer or the civil servant planner who must make a decision that day, that week, that month.

Three of us at USC (Mikihiko Oguri, John Soule and I) began to organize a series of projects for coordinated base-line data gathering and research. We did find that in Los Angeles Harbor there had been a long history of effort by members of the group that became the Regional Water Quality Control Board and by the two Ports, particularly Mr. Carol Wakeman and Larry Whiteneck of the Port of Los Angeles, and Bob Hoffmaster of the Port of Long Beach, to improve harbor water quality. While for many years the harbor had been treated as a sewer, a liquid railroad track, and a convenience to fill, dig, and otherwise push around, the people who worked there were sometimes actually made sick by their environment because of the sulfide fumes when the waters were anoxic. It was the early efforts of some of these local people that actually pushed the State toward water quality enforcement.

We recognized, then, that there was a tradition of local cooperative effort which could be built upon. We felt that the need to develop a data base was urgent, with all the port planning that was ahead, from 1971 on. There was no single agency standing in the wings ready to provide the funding which would be required to mount a multi-million dollar study of everything from the air to the air-sea interface, through the water column to the bottom sediments. We thought that if we gathered together those who might have a need for the data, we could get our data base established. Therefore, with the cooperation of the Ports and the Southern California Gas Company, we began our work. Shortly thereafter we received assistance from the Federal Sea Grant Program. This program has as its main theme the development of applied sciences to meet existing and future needs. Later we were joined by the U.S. Army Corps of Engineers in a major harbor-wide study, and the tuna industry began serious investigations with us of the effects of cannery wastes on the ecosystem. Other industries joined in, as their immediate needs could be met.

Recognizing that the harbor was a wetlands at the turn of the century, and that our harbor was part of that wetlands, we must also realize that it had long since ceased to be a part of the true wetlands, as can be seen from Figure 2. The historic channels of the Los Angeles River sometimes came down the present-day course; sometimes the San Gabriel River shifted over and came down this channel also, and sometimes the Los Angeles River meandered over and went out via the present Ballona Creek area into Santa Monica Bay. We still have the natural mountain basin watershed which drains in part into the harbor through channels and storm drains along the north, but in the 1920's the Los Angeles River was permanently diverted and channelized to prevent debris from coming down the main harbor channel. Earlier, Rattlesnake Island, which was extended by landfill to become Terminal Island, was connected along the south and east side of the channel by a very slender series of sandbars. Deadman's Island partially blocked the western entrance to the channel. The alterations were done long ago, when much of the coast was empty, so that there was no onus whatever attached to changes in the land and water configuration. In fact, the few nearby residents wanted the mudflats eliminated because of the stench from sulfide fumes.

In an active harbor some things happen that are unforeseen, and some are not supposed to happen, but people do have accidents. When accidents such as oil spills occur, cleanup efforts may be made and sometimes the consequences of the cleanup are worse than the accident was in the first place. Some accidents are, more accurately, due to carelessness; a little oil is spilled here and there or wastes dumped and holds washed. Sometimes phytoplankton take advantage of this and find whatever is in the water to be so nourishing that they produce intense blooms, forming the so-called red tides, green tides and white tides. These, too, may lead to unpleasant odors.

For perhaps 20 yrs engineers and planners have been designing harbor landfill projects, until we came to the Master Plan to end all Master Plans, one which would fill virtually the entire harbor. Dr. John Stephens said there was no impact from the Plans on the marine environment because there was no marine environment left! However, recognizing that much of the harbor <u>is</u> too shallow for modern day commerce and industry, and recognizing that the delivery systems have changed radically from small boats and small ships to large boats, containerized cargo, bulk cargo and various other systems, it is clear that this second busiest harbor in the United States has to progress. The question is, how much more land do the Ports need, and how should they progress?

We recognize that the first priority on the Los Angeles main channel relates to the fact that the channel is shallow

and that much of the terminal area in the inner harbor will not be usable by modern shipping if the channel is not dredged. Part of the outer Los Angeles Harbor is also shallow and receives sewage and cannery wastes so that reduction of circulation by filling there would cause degradation of water quality. In Long Beach, the Pier J development in the 1960's radically changed the circulation of the harbor but did not seem to degrade the water quality as far as we could determine. But if the general plan were carried out we recognized that decreased circulation could be a great problem. The various plans can undergo and have undergone considerable evolution since they were first proposed and before the first phase of development occurs. We hoped to furnish some solid information and prediction so that modifications could be made in the plans before any irrevocable development would be undertaken.

For our first local cooperative effort, no one had data on circulation, and we had a notion that if everybody would contribute what they had in the way of boats and people, we would be able to survey the currents and get some information. Drogues were built in the Los Angeles Harbor Department's shop; boats were mustered from both Ports, and from USC. About 100 people helped follow the drogues for 24 h, doing sighting compass readings every 30 min. In our first computer venture we mapped the over-all Los Angeles-Long Beach Harbor circulation patterns. The Army Corps of Engineers subsequently used that study to verify their physical model built in Vicksburg, Mississippi at the Waterways Experiment Station. So, things can be done with little money and lots of local cooperation if you're naive enough not to know that they can't be done. Thus the genesis of Harbors Environmental Projects at the Allan Hancock Foundation, USC.

Next our staff carried out dye studies of the cannery waste outfalls which were not very pretty and sometimes didn't smell too nice, so people assumed that the waste was a BAD THING. We began to suspect that perhaps it was not such a BAD THING when we saw how many fish were being caught nearby. We made inexpensive midwater samplers to suspend above areas where the bottom might be too silty or polluted for larvae to settle out. We hung the samplers on buoys and changed them monthly.

We took the harbor's temperature, salinity, oxygen, and pH; we measured turbidity, light transmittance, nutrients, microbials, primary productivity and phytoplankton pigments. We identified and counted the zooplankton; we took box cores and Campbell grabs of the bottom and sifted the muds. Dr. Don Reish of CSULB helped us to identify the resident organisms and compare results with his 1950's data taken when pollution was at a maximum. We carried out 2 yrs of weekly bird surveys, with help from Dr. Bill Hardy's students, then at Occidental College. There were over a hundred species; the harbor is a very important resting area and not just for seagulls.

Dr. Dee Chamberlain, now with ARCO, began our fish studies at USC. Earlier at this meeting John Stephens of Occidental College showed graphics of the distribution of fishes that his people discovered, during studies for us. About 130 species were identified from the outer harbors. Anchovies were also a very controversial subject when we began. People said that if anything is done in the harbor all the anchovies would be killed off because that's where all the anchovies are. It was even said that there was an endemic species of anchovy in the harbor. Dr. Gary Brewer at USC found that the anchovies spawn primarily outside the harbor and the eggs are carried into the warmer harbor waters. After hatching, anchovies spend the first year of their lives in the warmer water and then tend to swim seaward to cooler waters. The harbor is an important nursery ground for anchovies, but does not contain an endemic anchovy species.

Dr. Ken Chen, in Environmental Engineering at USC, has done hundreds of sediment and water chemistry analyses for us, and J. J. Lee, in Coastal Engineering, has helped with mathematical analysis of currents, circulation, and transport.

Dr. Damian Juge at Immaculate Heart College carried out microbiological surveys, working along with our people. Later Dr. Jay Kim of California State University, Long Beach, helped us evaluate the data. Dr. Jim Foxworthy at Loyola helped with the dye studies. Several hundred people including some SCOSC investigators, have now helped our Harbors Environmental Projects in building an effective, multidisciplinary data base.

We have also carried on special experimental studies to determine, for example what impacts thermal changes such as cooling by an LNG plant might have on representative organisms. We suspended polluted sediments and unpolluted sediments in columns of water to find out whether heavy metals and pesticides would leach out into the waters, to learn whether dredging would seriously affect the biota. We discovered that when we simulated putting fine harbor mud up into the water column it seemed to take more metals out of the water than it released into them. These studies reduced our fear of the impact of localized dredging considerably. There are still many questions to be answered on food web effects, however.

We turned to computer mapping of our parameters through the help of John McDonald, a USC geographer, and found that this showed us general patterns of the harbor that we had not even been aware of. For example, we found a very high annual average BOD near the mouth of the Los Angeles River. We anticipated that this would occur near the cannery and sewer outfalls but we didn't expect it at the river mouth. BOD levels can be compared with data on light transmittance patterns and other parameters such as the incidence of phosphate, one of the nutrients, and with the bacterial counts. We hadn't realized the

extent of the impact of the river on the harbor, on primary productivity and on the distribution of invertebrate fauna. Computer analysis techniques worked out by Nick Condap, Dr. Bob Smith, and Clyde Henry at USC have broken new ground in relating these multiple parameters to the living resources.

The new information base can be used to aid in projecting impacts; the SOHIO Terminal project, being supervised by Dr. Don Bright, illustrates this. The original plan called for a large landfill near Queens Gate, but we predicted an impaired circulation and this was tested on the Corps of Engineers physical model of the harbor in Vicksburg, Mississippi. The configuration was substantially modified, after the tests, to a trestle and small breakwater, and this was verified by mathematical modeling. It was then concluded that the new design would not affect general harbor circulation and would perhaps enhance micro-circulation at the breakwater. This, in turn, would enhance the flora and fauna at the site.

Not all problems and conflicting needs can be as easily solved as this one, but it is clear that without an environmental data base, decisions cannot be influenced by environmental considerations. Such studies must be continued, in an effort to keep the data base current.

The widespread base of participation by local scientists has made this harbor probably the best known in the world. Twelve volumes of scientific papers have now been published by Harbors Environmental Projects, as Marine Studies of San Pedro Bay, California (Soule and Oguri, 1972-1976). The data base has been used directly in environmental impact documents on over 2 billion dollars in capital projects. Whether one approves of a given project or not, at least there is now some actual environmental basis for making decisions. In our next "generation" of efforts, perhaps we can move on to designing projects in such a way that we will continue to improve and enhance the marine environment.

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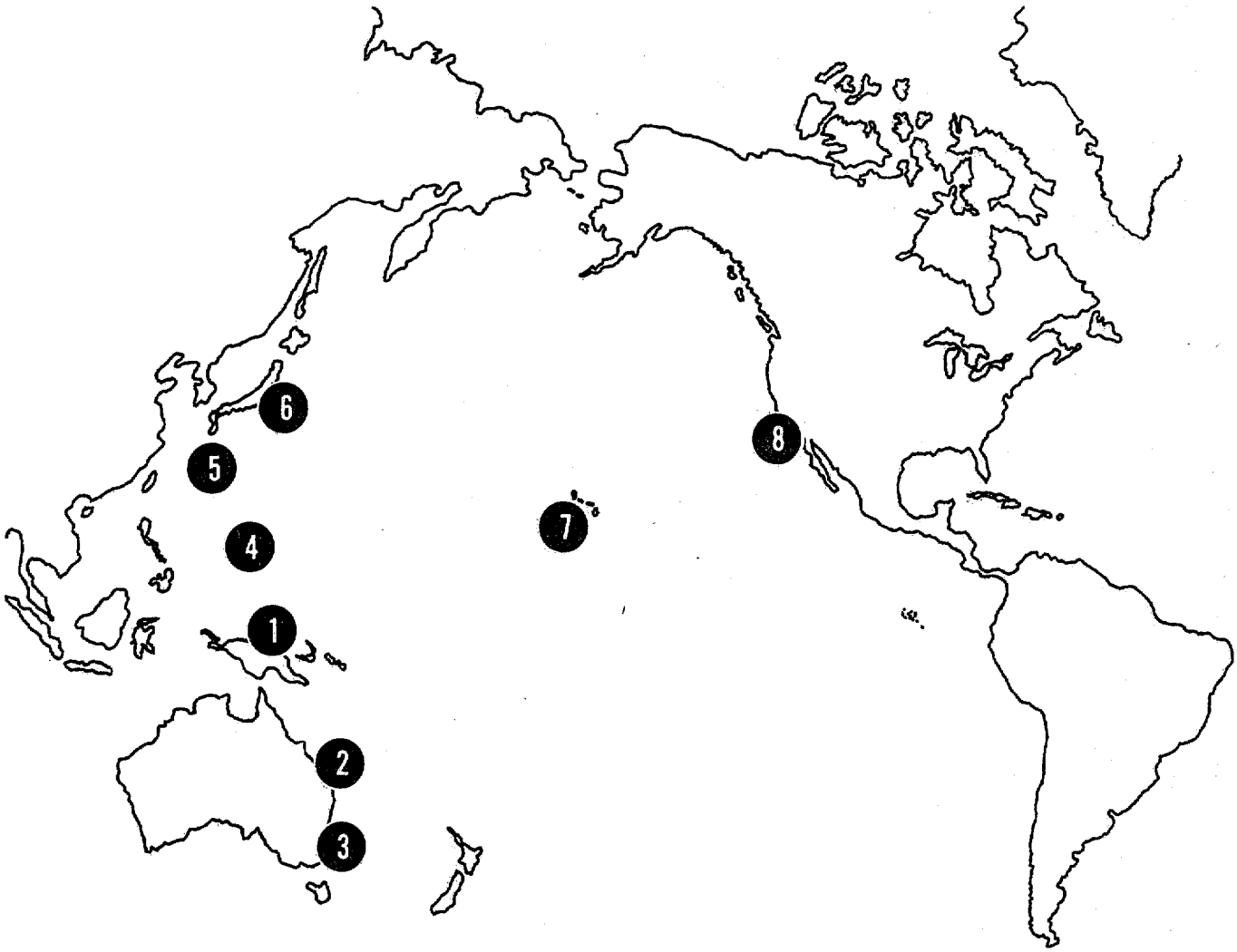

1 - Papua New Guinea
2 - Great Barrier Reef
3 - Sidney
4 - Palau
5 - Okinawa
6 - Tokyo
7 - Honolulu
8 - Los Angeles

Figure 1. The Pacific Ocean Basin.

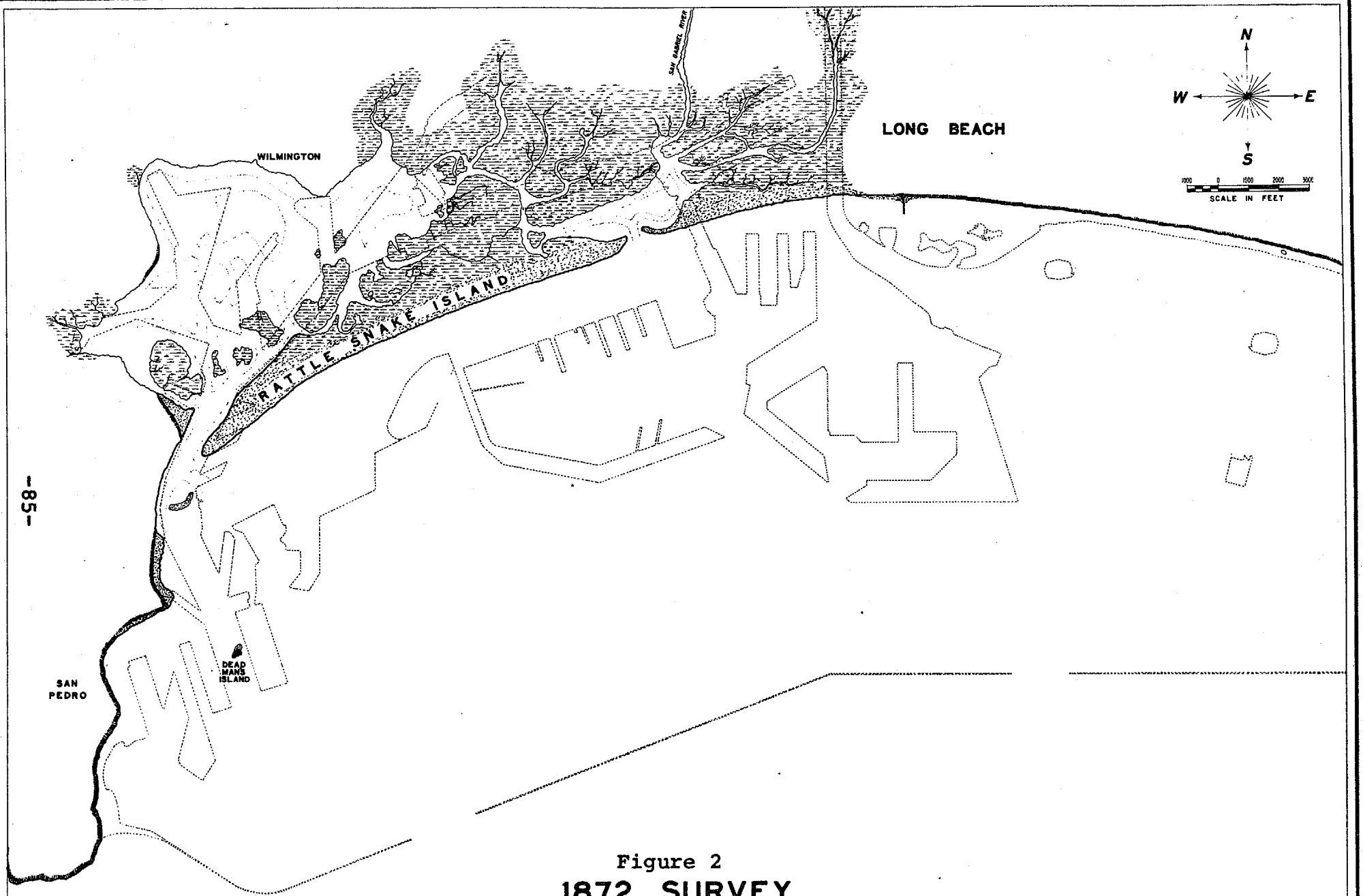

Figure 2

1872 SURVEY

WEST SAN PEDRO BAY SHORELINE

Courtesy Long Beach Harbor Department

HD 8-68-7
P SMONGESKY 2-4-72

PERSONAL REFLECTIONS OF 25 YEARS OF BIOLOGICAL INVESTIGATIONS IN LOS ANGELES - LONG BEACH HARBORS

by
Donald J. Reish

INTRODUCTION

The primary purpose of this paper is to present my personal reflections on the biological environment of Los Angeles - Long Beach Harbor as gathered over the past 25 yrs. One of the advantages of age is the perspective acquired with the passage of time. This perspective is especially apropos when considering the changes which have occurred in the marine environment of the harbor area these past 25 yrs. We have witnessed the period when essentially no one was concerned about these waters, through a period when pollution abatement was initiated, to one in which environmental-socio-economic factors are considered in depth before changes or construction takes place. It is probably safe to assume that such a change in public attitude concerning environmental matters taking place in such a short period of time has never been paralleled in the history of mankind.

As so often happens during the formative years of one's life, my interest in the biological environment of the Los Angeles-Long Beach Harbor began quite casually. My first view of the harbor was in September, 1949, and the specific site was that seen from the end of slip 5 in Los Angeles Harbor. It was my first experience in seeing the effects of industrial pollution.

However, and unfortunately the sight of oil slicks and dead fish on the water did not particularly affect me emotionally or intellectually. As a typical person of the time, including biologists, I accepted such conditions as a way of life.

My first participation in biological research in the harbor began in 1950 as a part of a team interested in the interrelationships of marine wood borers and marine fouling. Dr. John L. Mohr, University of Southern California, assembled together a group of USC graduate students, including myself, with personnel from the Los Angeles Harbor Department and private enterprise. Thus a loosely formed group, the Southern California Marine Wood Borers Council was formed; a group which lasted about 2 yrs. The primary purpose of this organization was to conduct a survey of the wood boring isopods, amphipods, and pelecypods plus fouling organisms at 13 localities in the Los Angeles - Long Beach Harbor. This survey was completed and many of the results were later published. I was concerned with which species of polychaetes settled on the test blocks as well as which polychaetes fed upon the wood-boring isopod Limnoria. My first publication (Reish,

1952) on the biology of the harbors dealt with the polychaete predators of Limnoria. As this study was nearing completion, the State of California through its Regional Water Pollution Control Boards (now the Regional Water Quality Control Boards) initiated biological investigations in many of the more important protected marine waters of the State. The Los Angeles Regional Board through the California Department of Fish and Game funded the USC group to determine the benthic biological conditions in Los Angeles - Long Beach Harbors. A survey was made in August, 1951 and the results published (Anon., 1952). The importance of polychaetes in assessing water quality was noted in this study which then formed the basis of a grant from the United States Public Health Service to study the relationship in greater detail. Three extensive surveys were made in 1954 which substantiated the importance of polychaetes as indicators of varying degrees of water quality (Reish, 1959). While the relationship of polychaetes to marine pollution had been noted previously in the literature (Wilhelmi; 1916, Blegvad, 1932), the importance of this animal group in such studies was firmly established in the Reish 1959 publication and related studies in the 1950's (Anon., 1952; Filice, 1954; Reish and Winter, 1954; Reish, 1955).

ENVIRONMENTAL CONDITIONS 1951-1968

The first comprehensive investigation of the environmental conditions in Los Angeles-Long Beach Harbor was made in 1951 (Anon., 1952) and included analyses of the water, sediment, and benthic biological conditions. However, prior to this date, water analyses were made which consisted of dissolved oxygen, sulfide, and temperature measurements. There seems to be little doubt that the water quality was at a low point during 1940 due to the numerous reports of conjunctivitis among the fish cannery workers caused by emission of hydrogen sulfide from the water (Anon., 1952).

On the basis of the 1951, 1954, 1955 and 1967-68 surveys as well as repeated observations by the author, a determination was made that the environmental conditions were similar during the 1951-1968 period. The June 1954 survey may be used to construct a representative description for conditions in Los Angeles-Long Beach Harbor during this 17 yr period. Measurements taken at 55 stations included dissolved oxygen, temperature, pH, organic carbon contents of sediments, and identification of macroscopic benthic invertebrates (Reish, 1959). Five distinct zones were present based on the presence, or absence, of polychaete species. These five zones are given in Table 1 and are characterized as follows:

In general, the polluted and very polluted zones were present within the majority of the blind-ending slips or basin of the inner harbor area. Similar conditions were noted within Fish Harbor and at the Terminal Island sewer outfall. The healthy

zone was present in the outer harbor and in the main channels of the two harbors. The semi-healthy zones were observed at intermediate areas. Therefore, the cleaner the area, the greater the number of species present and the higher the dissolved oxygen and pH content and the lower the organic carbon content of the sediments.

While at this time it was thought that the benthic organisms were the most useful as indicators of varying degrees of water quality it was found that an additional indicator could be found by studying the species of polychaetes associated with the fouling organisms attached to floating boat docks. Not only the presence or absence of species but also the number of individuals and their body lengths. In a monthly survey over a period of a year Crippen and Reish (1969) found greater polychaete diversity and an increase in the size of those species found at stations with the cleaner water. A summary of the biological, chemical and physical characteristics of five selected stations in Los Angeles Harbor is presented in Table 2. Both quantitive and qualitative differences were noted. So dramatic were these differences from outer to inner Los Angeles Harbor that it was possible to demonstrate the effects of pollution on biota to classes or groups in the field as well as in the classroom.

POLLUTION ABATEMENT 1968-1970

Dramatic changes occurred in the harbor area as a result of the initiation of the pollution abatement program by the Los Angeles Regional Water Quality Control Board on February 21, 1968. A directive was issued on this date which required the oil refineries to either cease to empty their wastes into the harbor or eliminate the oxygen depleting factor from their discharge. The last company to comply with this order did so on September 25, 1970. Biological conditions, as indicated by the organisms on the boat floats, were similar in April 1970 to what had been noted earlier. However, during the summer of 1970 marked changes in the biota occurred. An extensive benthic and boat float investigation was made in October, 1970. Dissolved oxygen readings ranged from 3.8 to 5.2 where previously they had been 0 to 1.5 mg/l. A total of 13 species of organisms, including Mytilus edulis (bay mussel) were observed on the boat floats where previously only oligochaetes and blue green algae were noted (Reish, 1971). Capitella capitata, the pollution indicating polychaete which had been a dominant species at several stations, disappeared as an inhabitant of the boat float community. Similar biotic changes were noted in the benthic fauna. Polychaetes, including C. capitata, pelecypods, crustaceans, and additional groups were represented where previously no macroscopic life had been taken.

The rate of recovery of the East Basin area of Los Angeles Harbor proved to be rapid indeed once the oxygen depleting substances of refinery wastes were removed from the environment.

The previously large, very polluted zone, with its lack of benthic organisms located in many of the slips of inner harbor, disappeared. These results were even more remarkable when one considers that Los Angeles - Long Beach Harbor is the first major industrial port in the world which has embarked on a successful pollution abatement program. The results obtained here should serve as notice that not only is it possible to improve an industrial harbor but that improvement is rapid once the source of pollution is removed. Also this should serve notice to the most pessimistic conservationist that at least some forms of pollution are not irreversible.

ENVIRONMENTAL CONDITIONS IN THE 1970's

Concurrent with the pollution abatement in Los Angeles - Long Beach Harbor, the environmental movement began both here and elsewhere. The spin-offs from this movement, which were of importance to the harbor area, were the requirement of environmental impact reports prior to any construction or change and the requirement of monitoring existing discharges. These requirements have resulted in extensive studies of all aspects of the harbor environment (see the Allan Hancock Foundation, 1976). Parameters are now being measured which were previously not considered important. Techniques have become more sophisticated with data now being analyzed by computers. Expenditures for environmental studies in the harbor, which were probably less than $50,000 per year in the 1950's are today now, undoubtedly over one million dollars per year.

The benthic biological conditions, which probably represent the single best measurement of environmental conditions in Los Angeles - Long Beach Harbors in the 1970's are summarized pictorially (Fig. 6.3 in Allan Hancock Foundation, 1976). The very polluted zone with its absence of benthic life is no longer present. The polluted zone is confined to Consolidated Slip and Fish Harbor areas of Los Angeles Harbor. The semi-healthy zones extend throughout the main channels of the inner harbor and into some of the basins and slips. Benthic conditions in the outer harbor are similar for both times except that additional organisms have come into the outer harbor in recent years which has resulted in the formation of two different assemblages of animals.

We can see by comparing the results of the benthic surveys of 1950's with those of the 1970's that environmental conditions, as measured by benthic organisms, have improved markedly as a result of the pollution abatement program. Since this represents the first major industrial harbor of the world which has initiated pollution abatement, and in which we have witnessed dramatic results, I believe it is important that these findings be widely circulated to indicate that improvements in environmental quality can be seen in a short period of time. It can

be surmised from published and unpublished data, as well as from my own personal observations, that the environmental conditions of Los Angeles - Long Beach Harbor are better today than they have been for decades.

PROTECTION OF WATER QUALITY IN LOS ANGELES - LONG BEACH HARBORS IN THE FUTURE

While water quality has improved in the harbors in recent years, we cannot assume that conditions will remain the same or improve; constant vigilance is required. It is important to recognize that modifications in one area of the harbor can affect other areas. Too often environmental impact reports consider only the immediate area of the project. Perhaps one of the most far-reaching alterations of the outer harbor involves the construction of additional basins, channels and land-fill areas which can limit water circulation around Terminal Island and the basins and slips in the inner harbor. For example, during the initial planning of the proposed SOHIO docking site in outer Long Beach Harbor, it was discovered that the construction of a land-fill facility would alter the entire water circulation pattern in both outer harbors. However, by placing the docking facility on pilings, the inhibition of water movement would be minimal. This change was then made in the plans.

Environmental impact reports are generally written over a short period of time and are typically based on existing data. If new data are collected, then they are usually obtained over a limited period of time, e.g., 3 mo. The occurrence and distribution of marine organisms are frequently governed by yearly cycles. Important biological considerations are therefore overlooked in short-term environmental impact reports.

The structure of the harbors is constantly changing creating a continual need for environmental data. Because of its commercial and recreational importance, I would like to propose the establishment of a single body which would, on a continuing basis, be concerned with the collecting of biological, chemical geological and physical harbor data. This body should be permanent and given adequate funding, presumably from companies requesting environmental data. Whenever an environmental impact report is required for an alteration of an area, a company could come to the body for data. These data would provide both long and short-term information and the decision as to whether or not the contemplated alteration would have an adverse affect on the harbors would have a firmer scientific basis. This approach seems more logical and scientific than the present one, which at times is highly short-sited and inefficient. For example, four different environmental impact reports were being written at the same time for the West Basin area of Los Angeles Harbor. Samples were taken for each of these studies in order to enumerate the benthic fauna present. One wonders what the impact of sampling was on

the environment of West Basin!

Finally, I would like to consider another environment of the harbors; I refer here to the terrestrial portion. Much of the harbor area is unsightly and in need of cleanup, these areas breed more of the same. Beautification is urgently needed. Only small, isolated areas of both harbors have been cleaned and their appearance improved. In some instances, I have observed the same rusting equipment stored in vacant yards for the past 25 yrs. So unsightly are some of the terrestrial areas, that it leads one to conclude that conditions on land are worse than they ever were in the water. The Los Angeles - Long Beach Harbor has an important influence on the economy of the Los Angeles Basin and beyond. It seems to me that there should be sufficient funds to beautify this area.

In conclusion, although water quality in the harbor has improved, we need to continue to keep a watchful eye so that the waters do not degrade once again. We must also consider how we can achieve a better understanding of the harbor environment in order to make wiser decisions in the future.

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Table 1. Summary of June, 1954 biological, chemical and physical characteristics of the 5 ecologic zones of Los Angeles-Long Beach Harbors

ZONE CHARACTERISTIC	Healthy Bottom	Semi-Healthy Bottom I	Semi-Healthy Bottom II	Polluted Bottom	Very Polluted Bottom
Dominant species of polychaete	*Tharyx parvus*, *Cossura candida*, *Nereis procera*	*Polydora (C.) paucibranchiata* *Dorvillea articulata*	*Cirriformia luxuriosa*	*Capitella capitata*	No animals
Number of animal species (Aver.)	10	7	7	5	0
Dissolved oxygen in mg/l 6 m depth (median)	6.0	3.2	3.2	3.5	2.2
pH (median) 6 m depth	7.8	7.4	7.6	7.6	7.5
Substrate	7.2	7.2	7.2	7.3	7.1
Organic carbon of substrate (%) (median)	2.5	2.0	2.7	2.7	3.4

Table 2. Summary of the biological, chemical and physical characteristics of 5 selected stations in Los Angeles Harbor October 1966-January 1968*

ZONE CHARACTERISTIC	LA7	LA26	LA39	LA54	LA50
Number of Polychaete Species	30	19	17	5	0
Dominant Polychaetes	Cirriformia luxuriosa	Cirriformia luxuriosa	Capitella capitata	Capitella capitata	None
	Cirratulus cirratus	Polydora limicola	Boccardia proboscidea	Polydora ligni	
	Halosydna johnsoni	Ophiodromus pugettensis	Syllides sp	Hydroides norvegica	
	Hydroides norvegica	Hydroides norvegica	Polydora limicola	Polydora limicola	
		Capitella capitata	Ophiodromus pugettensis		
		Ctenodrilus serratus	Stauronereis rudolphi		
Other Dominant Organisms	Mytilus edulis	Mytilus edulis	Phoronis sp	Oligochaete	Oligochaete
	Balanus spp	Hiatella arctica	Hiatella arctica		
	Ciona intestinalis	Bugula sp			
Dissolved oxygen (mg/l, mean)	4 0	2 3	2 6	1 5	0 1
Turbidity (mg/l, mean)	2 7	4 4	4 7	5 6	6 7

*Data modified from Crippen and Reish, 1969, stations arranged from outer to inner harbor, left to right