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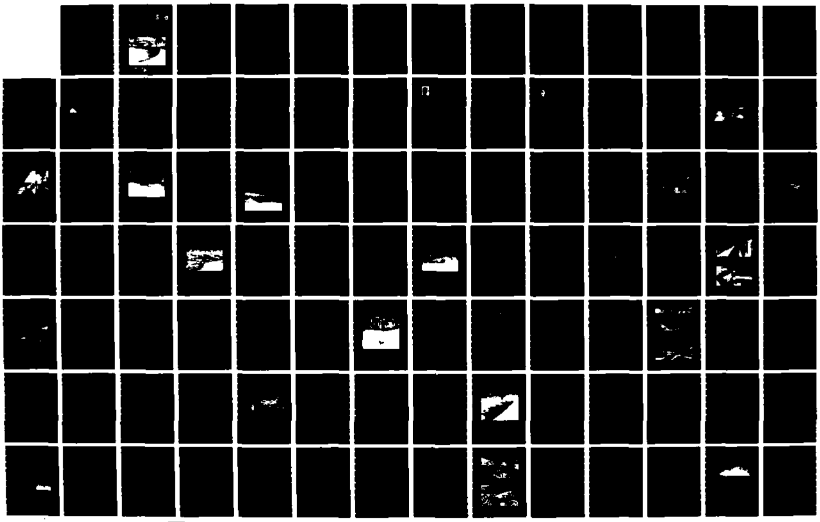

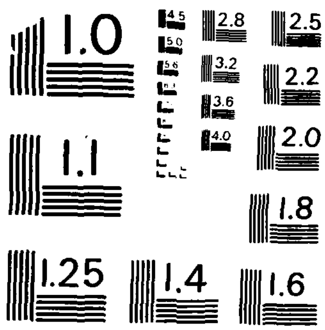

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U.S. Army
Corps of Engineers
Los Angeles District

Oral History of Coastal Engineering Activities in Southern California

1930 — 1981

January 1986

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Report covers development of coastal projects by Corps of Engineers from Morro Bay to the Mexican Border. Content is narrative with excellent historical photography and is based on taped interviews with four prominent coastal engineers whose careers span from 1930-1981. Interviews with William Herron, Omar Lillevang, Kenneth Peele and James Dunham were transcribed and then edited for clarity and reader interest.

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AN ORAL HISTORY OF COASTAL ENGINEERING ACTIVITIES IN SOUTHERN CALIFORNIA

1930-1981

QUALITY INSPECTED 1

Prepared for

U.S. Army Corps of Engineers
Los Angeles District

January 1986

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Preface

These personal reminiscences by four coastal engineers cover the span of coastal activities in southern California from 1930 to 1981. The four "oral historians" and their years of active participation in southern California projects are:

- Kenneth Peel, Corps of Engineers from 1930-1981.
- Omar Lillevang, Consultant from 1937-1981.
- James Dunham, Corps of Engineers and Consultant from 1935-1981.
- William Herron, Corps of Engineers from 1940-1981.

Their statements also refer many times to the following men and their years of participation: D. E. Hughes, Corps of Engineers from 1890-1930; Harry McOuat, 1920-1958; Colonel Charles Leeds, 1925-1968; and R.O. Eaton, 1930-1960. Although Hughes, McOuat, Leeds, and Eaton are now deceased, their knowledge, concepts, and experiences were passed on to the four of us who provided the following narrations. We are grateful for the assistance and encouragement they gave us in continuing their efforts to serve the boaters and beach users of southern California.

I have edited the statements herein only to the extent of organizing the comments geographically and eliminating extraneous comments concerning personal experiences and concepts that do not appear in the literature. I hope these recollections will fill some of the voids created in our records when the area office of the Corps of Engineers in San Pedro Harbor was completely destroyed by fire in 1940. Many valuable records covering the period 1890 to 1940 and much valuable information concerning construction and design and coastal fortifications were lost.

This unfortunate event makes the following personal narrations even more valuable.

I apologize for not including substantial contributions from the universities. Many engineers and scientists made major contributions in developing the "State of the Art" during this time, including M. P. O'Brien, Joe Johnson, Robert Wiegel, John Isaacs, Willard Bascom, Walter Monk, Doug Inman, Francis Shepard, Dr. Knapp, Vito Vanoni, and Fredric Raichlen. Unfortunately, the scope of this oral history does not permit including their contributions.

Lastly, I would like to express my thanks to the Corps of Engineers, Los Angeles District, for the opportunity to record this "oral history." The support of the Coastal Resources Branch and the Los Angeles District's Planning Division has made it possible for this part of history to be preserved.

William Herron

William Herron

Foreword

This volume of "oral history" presents the personal narratives of four men who have done much from 1930 to 1981 to improve and protect the southern California coast from the encroachment of both men and sea. These four men are Kenneth Peel, Omar Lillevang, James Dunham, and William Herron.

Each man comes across in his narration as a professional engineer in the best sense of the word: he used his talents and training to add to the quality of life for those who come into contact with the southern coast of California. It is of no small interest that each man's narration reflects how often he went about his work--constructing breakwaters, digging channels, dredging harbors, rerouting rivers--intuitively, especially in the "early days" when "wave diagrams" and "wave modeling machines" were in their infancy, or did not exist at all.

Individually, these four engineers narrate but a fraction of their highly interesting, informative, and sometimes humorous coastal engineering work from Morro Bay to Imperial Beach. Collectively, however, their narration spans 51 years and constitutes a wealth of knowledge and experience that, had it not been documented by one of them, William Herron, would have been lost forever.

As we travel down the coast of southern California with them, we learn how they struggle to find cost-effective and workable means to accommodate the force of the sea to the benefit of man. Always ready to give credit where it is due, they freely tell us that their engineering successes were not due solely because of their own hard work, study, and inventiveness. Their successful breakwater, quay, and harbor construction work was also a product of the knowledge and experience handed down to them by their mentors in the field and office.

It is fitting that the U.S. Army Corps of Engineers, Los Angeles District, should publish this volume, as each of these four men was directly, or indirectly connected with the District at one time or another during his professional life. This history's publication is also timely, in that it was written during the 1984-85 period that Congress has officially designated as "The Year of the Ocean."

What better way than publishing this report for the U.S. Army Corps of Engineers to acknowledge the dedication and professionalism exhibited by these four men (and the thousands of others like them) who, working together, and alone, have made southern California's coast more usable by man, but no less beautiful.

D. FRED BUTLER
Colonel, Corps of Engineers
District Engineer

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1 Introduction

Initially, the following narratives had been edited by Mr. Herron only to the extent indicated in his "Preface." The Corps has subsequently corrected any misspellings and omissions of punctuation that invariably occur when transcribing taped narrative into typewritten text.

In addition to his own, Mr. Herron supplies us with each man's involvement with coastal projects falling within six counties: San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego, the southwesternmost county in the United States.

This resulted in four individual narrative records organized geographically (from north to south), but not chronologically. They have now been given a greater degree of geographical organization by grouping together, for example, each of the four narratives concerning Morro Bay. This arrangement gives the reader the benefit of juxtaposition of viewpoint concerning the same project, and it also makes it possible for the reader to infer with a fair degree of accuracy their chronological involvement as well.

Some degree of narrative repetitiveness has resulted from this attempt to give the reader the "big picture" for each site all at once by the way of this grouping; but something has been gained, too, and that is the immediacy of their different perspectives on the same engineering project tackled at different points in time. Collectively presenting this wealth of individually recalled detail, both technical and personal in nature, gives each project's recollection a "wholeness" it might otherwise lack.

All four narratives have also been given a more categorical arrangement. Doing so involved segregating from the "usual" harbor and breakwater projects those that were of a larger scope or were not necessarily tied to any one project site. As a result, material has been grouped into separate chapters that address each man's education and engineering background and his work on coastal studies, coastal powerplant projects, and research and development.

To help the reader identify who is speaking on which subject, the narrator's name has been placed each time after the project's name or location, as the case may be, in the notation "As remembered by. . . ."

2 Educational and Coastal Project Engineering Background of Contributing Narrators

KENNETH A. PEEL (Corps of Engineers, 1930-1981)

After graduation from Oregon State University, I went to work for the San Francisco District, Corps of Engineers in June 1930 and spent 2 years in the District. I worked in Eureka, on dredging work in Alameda, on Oakland Harbor, and on constructing the breakwater at Monterey. From Monterey I went to the Los Angeles District where I worked on the detached breakwater in Los Angeles Harbor.

Starting in 1932, I spent 5 years on the detached breakwater at Los Angeles-Long Beach Harbor, and in building, as a WPA project, the first section on the jetties at the mouth of Ballona Creek. In 1937, I went into the District Office with the Planning and Reports Branch, River and Harbor Section, in drafting, designing, and planning of the small boat harbors and deep-draft harbors for preliminary examinations and surveys. In 1951, I spent almost a year with the Beach Erosion Board in charge of drafting the first edition of the Technical Report No. 4 on the planning and design of shore protective structures.

From there, I was assigned to the Division Office in San Francisco in the Planning and Reports Branch but specialized in river and harbor work, ending up as Chief of the Planning and Reports Branch.

In 1962, I went to the Mediterranean Division to finish the plans and specifications for the Banana Port in Chisimaio, Somali Republic, East Africa, and to construct it.

I retired from the Corps of Engineers in September 1965 and in 1966 went to work for Stanley Consultants on the planning, construction, and oceanography reports of projects mostly in the Caribbean, Naussauin, the Bahamas, and St. Johns Harbor in Antigua; in the planning and design of four ports in the Dominican Republic, and a study of the regimen of Kingston Bay in Jamaica.

OMAR LILLEVANG (Consultant, 1937-1981)

I was enrolled as a Civil Engineer student at the University of California, Berkeley, in the Class of 1937; and during that era at the University, Bachelor of Science candidates in civil engineering and some of the other branches of engineering were required to do a relatively simple thesis which might be a library style or it might be research based. Research at Bachelor's level was fairly simple. In all senior projects at Berkeley in those days, one usually teamed up with another man, whether it was in courses in design detail of bridges, dams, or other structures or on a survey party for training. My partner was Roger W. Brant who had grown up in Santa Barbara. When we had to select a thesis subject at the beginning of our senior year, we really didn't know what we wanted to do. Both of us were in the optional courses dealing with irrigation and drainage, and both of us were there because we were interested in getting as much structural engineering education as we could, in addition to the basic structural courses that were given to all seniors in civil engineering.

The other curricula that had structural emphasis were in irrigation; dealing with hydraulic structures, dams, canals, flumes, diversion structures, pump stations, and things of that sort. So both of us had gravitated there because of our interest in structures. Obviously then, we also got a very thorough inundation in the hydraulics program as it existed in the civil engineering curriculum at that time. Parenthetically one might say that was virtually to the total exclusion of what was then new and just becoming stylish--the emphasis among many educators--in fluid mechanics. There was fluid mechanics emphasis at Berkeley but it was in the department of mechanical engineering and some faculty abrasion existed--some "egos" perhaps--that amounted to jousting between the two departments. The civil engineering students then picked up the fluid mechanics aspect of things only by osmosis or by pressures when they had to take the hydraulics laboratory courses.

Roger Brant came back one afternoon and said that, in looking at the bulletin boards trying to find a thesis subject he had found that a Professor M. P. O'Brien, who was the director of the hydraulics laboratory then and, I believe, an associate professor of mechanical engineering, had posted as one of the subjects that could be carried out under his sponsorship, an investigation of sand movement and deposition at Santa Barbara Harbor. Roger, being from Santa Barbara, immediately spotted this and it sparked his interest to talk to Professor O'Brien, or one of his associates, who might have been Dick Folsom, and came back to me and said "it sounds like an interesting thing to do. He wants to build a model and see whether or not the model could reproduce what has been happening at Santa Barbara; and if it can, to see whether or not the model will predict what eventually will happen if nothing is done."

It sounded interesting to me too, but that was as much preparation as either one of us had for coastal engineering questions. Of course this threw us under the supervision of a man who is known throughout the world for his early contributions to this field. We did undertake that as a Bachelor's thesis effort and we were joined in it by an Army engineering officer, William W. Lapsley, Jr., who was there to get his Master's degree, at that time 2nd Lt., Corps of Engineers.

Lapsly took the output on the performance of the model and interpreted it at Master's level with the thesis on the same study. This was in 1936 and 1937. Lapsley has been credited in writings by, I think, Dean O'Brien and perhaps by Joe Johnson, with having prepared the first published work using wave refraction diagrams. And Lapsley, under the guidance of Professor Johnson and his associates on the faculty, did in fact do crest-type wave refractions studies of Santa Barbara channel and their initial purpose was for us to decide how to orient our wave maker to the model in order to produce what was judged to be representative wave directions for that model to experience.

Parenthetically, I should say that Lt. Lapsley went through a career with the Corps and I think never got close to coastal engineering other than serving as Division Engineer at Portland. But at Division Engineering level, he hardly had a chance to practice coastal engineering and he retired as a Major General.

The Santa Barbara model was small. It was built to determine whether or not very small, inexpensive, and simple models could be used beneficially for reliable prediction purposes in coastal problems. Added to it in progress of the work was another model at Santa Monica Harbor, which was also built and operated and reported upon by both Lapsley and Brant as well as myself, in two separate theses, one jointly authored by Brant and Lillevang, and other one by W. W. Lapsley, Jr.

This then was my introduction to coastal engineering and it excited my interest. When I got out of school, I spent the first 4 months as a topographic survey rodman--more mountain goat than man--working for the California Division of Highways, now called Caltran. This was in the Point Mugu area of Ventura and Los Angeles counties. After that I went to work as Junior Engineer, the only engineer employee other than the general manager, of a storm water and water distribution district in Coachella Valley. While there, I was contacted by a consulting firm in Los Angeles, which then was called Quinton Code and Hill - Leeds and Barnard. I went to work for them and was there for 25 years, except for the hiatus while I was in the United States Navy Civil Engineer Corps, during World War II. Charles Tyson Leeds, Sr., the Leeds of that partnership name, was a West Point graduate, Class of 1903, and had been District Engineer at Los Angeles as a 1st Lieutenant and then Captain about 1910, when it was found that he had active tuberculosis. The Army sent him to Fort Bayard in Silver City, New Mexico, to serve as post engineer in a bathrobe until they arrested the disease. Then they retired him medically and he established a partnership with Wilford K. Bernard, in Los Angeles, in the same building where he had served as District Engineer.

Leeds and Barnard and Quinton Code and Hill, two firms that had earned a very good reputation in Los Angeles region, merged in 1930--that's the reason for the involved name. They tried to use a fictitious name but nobody would forget the individual men and they went back to using all of their names because they found them professionally valuable to use, even though cumbersome.

Colonel Leeds, with his introduction to coastal engineering as District Engineer in the early days of the development of Los Angeles Harbor, attacked that area of practice as well as general engineering. He was also strongly related to water resources practice with his partner Bernard. By the time I went to work for the firm in August of 1938, I would judge that Colonel Leeds might be spending 30 percent of his time on sea coast and harbor matters and the balance on water resources construction, project development, and such. His partners in the firm, who were all water resources experts, made no pretentions of activity in sea coast or harbor matters; however, John Jewett, who eventually became a partner in the firm, did give him some staff support prior to the time that I went to work there.

Because of my interest at Berkeley which Colonel Leeds had known about, it turned out I was the only member of the staff with some introduction to at least a vocabulary of sea coast and harbor matters; so when staff support was required, I logically was the staff person who supported Colonel Leeds.

By the time World War II was over, Colonel Leeds was devoting one-half time to sea coast and harbor matters; and as I came back from service, I believe I probably shared about the same proportion of my time between sea coast and harbor matters supporting him and his partners in general water resources matters. By about 1960, both of us were devoting all of our time to sea coast and harbor matters with the exception of a small interruption now and then on something else.

Colonel Leeds' health began to fail but he remained mentally active and busy in the practice until his death. The last 4 or 5 years he worked on a "work awhile, rest awhile" basis in an office we equipped in his home and we shuttled dictation tapes, reference documents, and my person back and forth between his home in Pasadena and the office, and in that way, he was valuable and productive for his clients and for his own sense of fulfillment until his death. When he died, I assumed all of the burden that he was doing--became a Vice President of the firm and remained in that status until January 1, 1964, when I established my own business.

It has been virtually entirely in sea coast and harbor matters. Not necessarily because I eschewed the other kind of work but because the demand was such that I could be fully occupied with it and have enjoyed that occupation.

In considering projects that I worked on, I think it is fair to say that "projects" have to mean even looking at something that has been proposed or has aroused somebody's interest as an investor or as a public agent, or as a layman, or citizen, or with whatever reason, that never got built.

Projects, then, in the sense of examining a coastal problem, don't mean that they went to fruition. If we were going to talk about only those, compared with the time that it would take to talk about all of the things that have been considered or advocated and rejected either on a basis of couldn't get the money, couldn't get the political support, or that it was just simply good sense to abandon the idea.

The discussion here, as I understand it, just about incorporates the boundaries of the Los Angeles District of the Corps of Engineers. My involvement in those areas has been sometimes as a very young engineer and sometimes as one more mature than he likes to admit and at varying levels, therefore, of responsibility. But even as a youngster, I watched with great interest and was fortunate in that Colonel Leeds, my mentor, was one who freely discussed his views and his basis of making decisions or advice to clients. This was unique in my experience among the people I've worked for or with, in that he had no hesitancy whatsoever in having his clients realize that I was taking a part in the project or study, and sometimes a part on which he relied strongly. More of us ought to sponsor the future careers of young engineers by admitting that "somebody coming along may one day be just as good as I am." That wouldn't be too hard, perhaps, but too many try to conceal the fact that the youngsters have capability.

JAMES DUNHAM (Corps of Engineers, 1935-1981)

I was tranferred to southern California about the end of August in 1935, and at this time the big push was on flood control. I didn't get into coastal work until about 3 or 4 years later at the request of Dick Eaton because we had just been assigned the job of obtaining, for the Beach Erosion Board, the data and local input on the Santa Barbara study. This was about 1939, I believe, because I had just been reassigned from the field office on flood control construction into the report writing section.

Participation with the State of California. From 1954 through 1957, I was in private practice not related to the coast of California. Meanwhile the State had passed a law setting up a Small Craft Harbor Division under the Department of Natural Resources. I was asked to go up there as the Division Engineer of this new division. The Division Engineer was just the engineer for the division, and worked under an administrative head. But it fell on my lot to recruit the engineering staff and train it for the work that we were to do. Now the concept of this State Division was to loan money to cities and counties to build small craft harbors at an extremely low interest rate. It started out at 3 percent, using money collected by the State for fuel taxes on boats. Now people who buy fuel in California for their boats, if they document their buys, can recover that tax money. The only ones who ask to recover are the commercial interests. In 1958-60, California was receiving about 3 or 4 million dollars a year in unclaimed boat fuel tax. So they began building up a fund right away for small craft harbor loans. It was the Division's job to look over potential harbor sites as requested and first grant loans for studies to determine engineering feasibility and economic justification. If they were economically justified, the Division then made construction loans.

We had very little to do with actually going out and determining where harbors should be built, as we were supposed to wait for cities and counties to come to us with requests, which they did in short order. We had requests for 10 or 15 studies, and the studies were to be done, not by us, but by professional engineering consultants. One of the first consultants hired to make such a study was Moffatt and Nichol Engineers. That firm was to study the feasibility of a small craft harbor at Oneonta Lagoon just south of Imperial Beach.

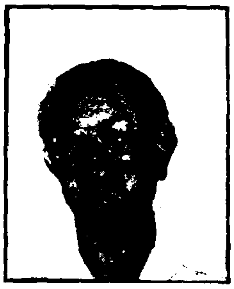
During the following 2 years, about 10 of the reports were completed and one of them was on the Avalon project at Catalina Island which I later participated in with Moffatt and Nichol, although the Avalon feasibility study had been done by Koebig and Koebig.

One of the most promising studies was done for San Leandro, and that was one of the first construction loans granted and was the beginning of a number of them. A small craft harbor was built at Blythe on the Colorado River; another near Needles on the Colorado River; and several small facilities were built in various lakes around the State. A launching ramp and a boat basin were built at Eagle Lake in Northern California. We looked at some potential harbors in Clear Lake; and although I don't think anything was ever developed there by the State, local interests developed some on their own.

There were a number of small craft harbor studies around the San Francisco Bay area, but very few in southern California. The main reason for this was that almost any place in southern California that was a good harbor site had already been developed, and there were very few new sites being considered. However, some southern California harbors that already been constructed needed additional money for further development. I believe one of those was the Oceanside small craft harbor, and a State loan was approved for that. The State is still working in that area helping them, not only with the harbor but with the beach erosion problems.

My work with the State lasted only 2-1/2 years; however, by that time, it was pretty well a going concern and loans were being made for various small craft facilities and launching ramps throughout the State.

WILLIAM J. HERRON (Corps of Engineers, 1940-1981)



I graduated from the University of California at Berkeley in 1939, and my first engineering experience on the coastline of southern California started in October 1940, when I became an inspector on a hopper dredge, building a section of the offshore breakwater in Los Angeles-Long Beach Harbor. This section was called "6000-foot Navy section." I continued in various field jobs in the Los Angeles Harbor area until January of 1943, when I left the area and worked on the Pan American Highway and later went into the Army.

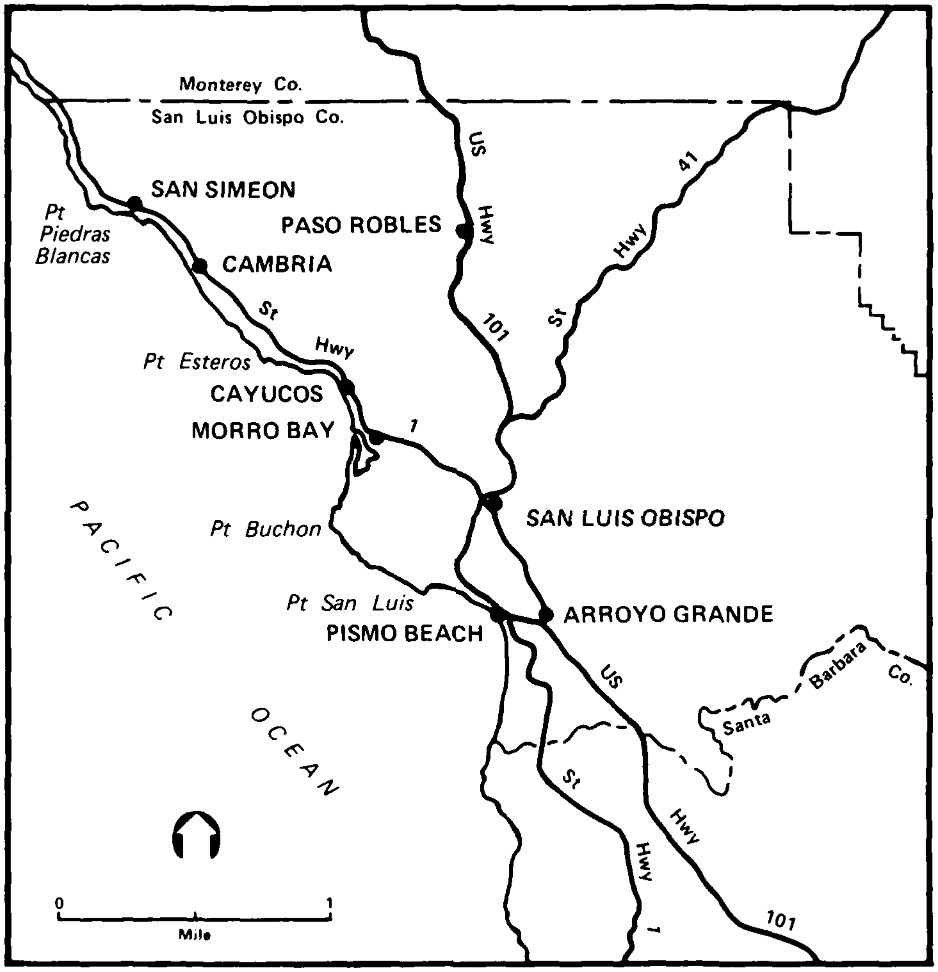
I returned to southern California in July 1946; and at that time joined the Beach Erosion Board, now known as the Coastal Engineering Research Center, and headed up a field research party for the Beach Erosion Board covering any or all parts of the United States. I continued with that group, in the field, until January of 1949, when I moved into the office as Assistant Chief of the Engineering Division under J. V. Hall. I maintained that position covering various projects in the United States, including some in southern California until 1954, when I returned to the Los Angeles District.

On my return to the Los Angeles District, I took over as head of the Beach Erosion Control Section replacing Jim Dunham and working under the direction of Mr. McOuat. I continued with the Los Angeles District moving on up eventually to Chief of the Coastal Engineering Branch until my retirement in 1970.

From 1970 to 1978, I was in private employment with Moffatt and Nichol Engineers, again working on various projects up and down the coast of southern California and in other parts of the United States and the world.

Since I left Moffatt and Nichol in 1978, I have been doing part-time consulting work—much of it in southern California—so that brings us up to 1981.

San Luis Obispo County



3 San Luis Obispo County

MORRO BAY

As remembered by KENNETH A. PEEL

The Morro Bay breakwater was constructed by the Los Angeles District in the 1940s with Naval funds to provide a base for small patrol vessels. I did the original design and wrote the original reports. Bill Dunbar was up there as project engineer and the first section of the breakwater was built as a hired labor, government plant project.

We considered on which side of Morro Rock the channel should be located but we were not making wave diagrams then as they had not come into existence. Historically, there had been an entrance on the north side of the rock, but it was very unstable and the records showed that the entrance would be north of the channel for awhile, then that would fill up with sand coming downcoast and it would shift over to the south side of the rock and the channel would be on the south side for awhile. It always seemed in the old days, when we had navigation in there, the channel was more or less on the north side.

The fishing boats were using the south side when we built the project. The channel was pretty well stabilized on the south side because, under the WPA in the 1930s, they had built a stone seawall connecting the rock with the land--and that was a fact accomplished.

It would have been a case of take it out and do too much changing, so we left it and designed the breakwater to extend on out from the rock. We soon found out when we started that

Morro Bay Prior to Construction

the sand started moving upcoast there into its lee coming upcoast rather than down like it was supposed to. But the extension of the breakwater apparently was creating an eddy of some sort out there and affecting the local wave movement so that the sand was moving upcoast, and we added a south breakwater to maintain the harbor. Then we started getting a slight amount of erosion downcoast but not severe. Our biggest trouble was with the oyster people who maintained that our dredging was roiling the water up so it was covering over their oysters. About that time I heard from a Stanford professor who had an interest in it. We got a long lecture on the lives and loves of an oyster, but we couldn't find any evidence of damage to their oyster beds from dredging.

We had taken the waste rock from the quarry at Morro Rock to the City of Morro Bay and built a retaining wall to pump the dredging material in behind. While there has been a lot of money spent on construction of the harbor and a lot of cost to maintain the breakwaters, I doubt very much if the cost of the harbor comes near the value of the land that was created and the structures that are now built on it. It was built originally as a Navy harbor for naval harbor patrol craft, but it hasn't been used as such very much, just a commercial fishing harbor.

There was not a real wave height analysis made during design. We put in the same design as we had used in Long Beach and it was inadequate. Then, we concreted the top and that proved inadequate. I am not sure, but I think that it was repaired the last time with Riverside rock and with flatter slopes.

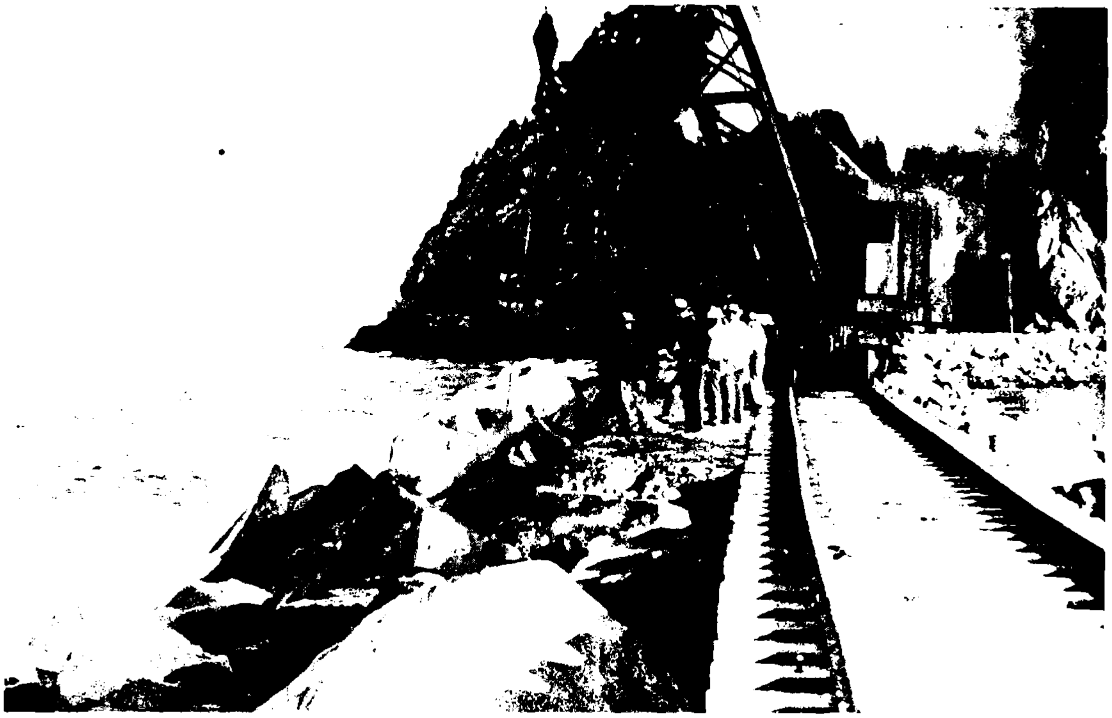
The second breakwater, as I recall, was designed and placed inside the one extending from Morro Rock, so that it acted somewhat as a wave trip for the new breakwater and that helped protect it.

I stop by there everytime we drive south but I imagine it has been 10 years since I last saw it.

As remembered by JAMES DUNHAM

In about 1961-62 we were asked by the county (which had control over the area at the time) to do a study of feasibility of harbor expansion of Morro Bay. By this time, of course, the outer breakwater had been built and Morro Bay was being used as a commercial harbor, primarily by fishing interests.

We made the study and noted that a considerable amount of dredging would be required. It seemed to be an ideal location of a marina, having a harbor entrance already and only the



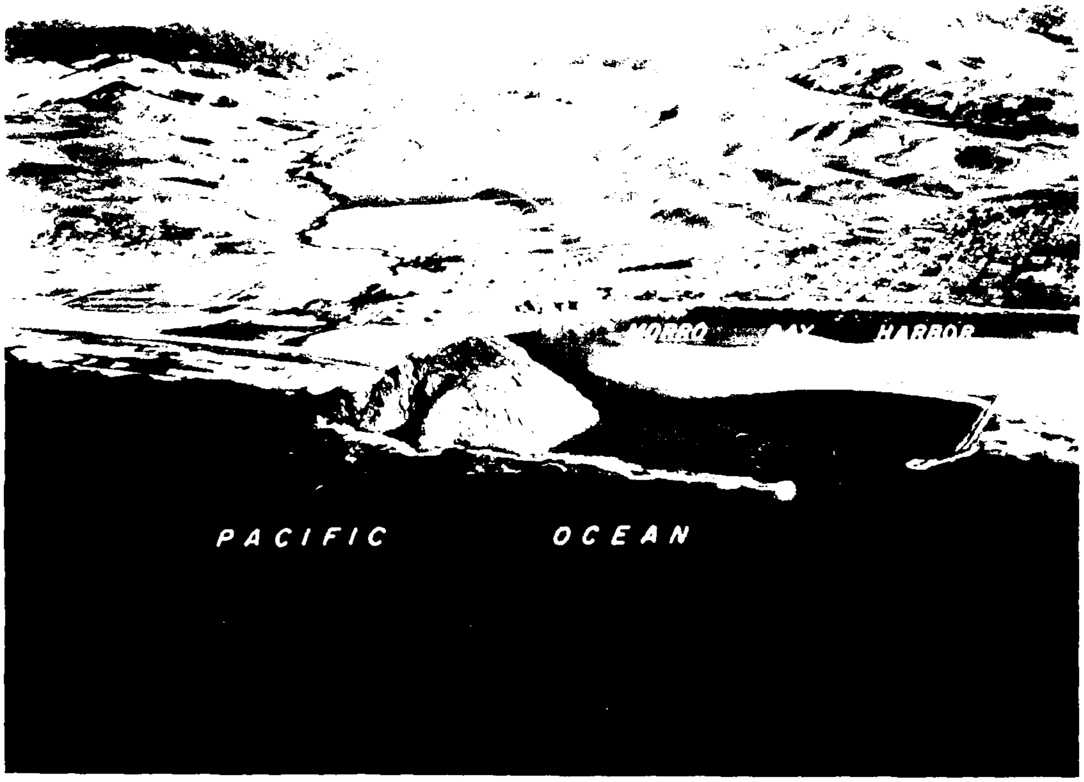
Start of North Breakwater Harbor Construction (1942) dredging involved. However, the difficulty was the remoteness of Morro Bay from any large centers of population and the fact that the amount of dredging that would be required necessitated that it be a large marina before feasibility could be established. It turned out that the feasibility, as such, was impossible. We did show a plan for dredging the entire bay and subdividing it into a marina area and a nature preserve that would actually be an improvement on nature; a number of tidal islands would be built that would separate the marina area from the natural part of the bay. We thought that this was an excellant plan and would satisfy many of the environmentalists in the area who were clamoring to maintain the naturalness of the area. However, this never came to pass, because the feasibility was not there and the facilities were not built. That was about the extent of our work at Morro Bay.

As remembered by ***WILLIAM J. HERRON***

Kenny Peel handled the initial construction of this project in about 1943, and it was probably the last breakwater project in the United States that was designed and built without having a clearcut analysis of wave heights and their effects on the structure. One of the points this brings out, which has been a burden to coastal engineering for generations, is that you cannot copy a project from one area and move it to another. Morro Bay was a hurried Wartime project and the breakwater design was simply a copy of that successfully designed and used for the Los Angeles-Long Beach Harbor. However, the basalt rock used in the Morro Bay original breakwater only weighed 154 pounds a cubic foot as compared to the 165- to 175-pound rock used at Los Angeles Harbor. Also Morro Bay is out from behind the shelter of the offshore islands and Point Conception and exposed to waves to as high as 30 feet. So the breakwater was soon severely damaged and by 1953, 10 years after construction, it was a shambles with large areas knocked down to almost mean sea level elevation.

Another problem was, of course, no model study was made, which was typical in those days. Also, the navigation channels were laid out keeping in mind purely the convenience of boats; and even later when alignments did not want to stay within the hard lines drawn on paper, we found it was not possible to get approval from OCE to change these lines. As a result, within almost a period of months after doing maintenance dredging on one of these channels, nature would take over and move the channel outside the project lines to where it wished, which was a channel still easily navigated by boats.

We also first got a true appreciation of the possible effects of wind blown sand in this area, as the large sand spit that encloses the Morro Bay in its natural state produces a great



Morro Bay Harbor as Completed

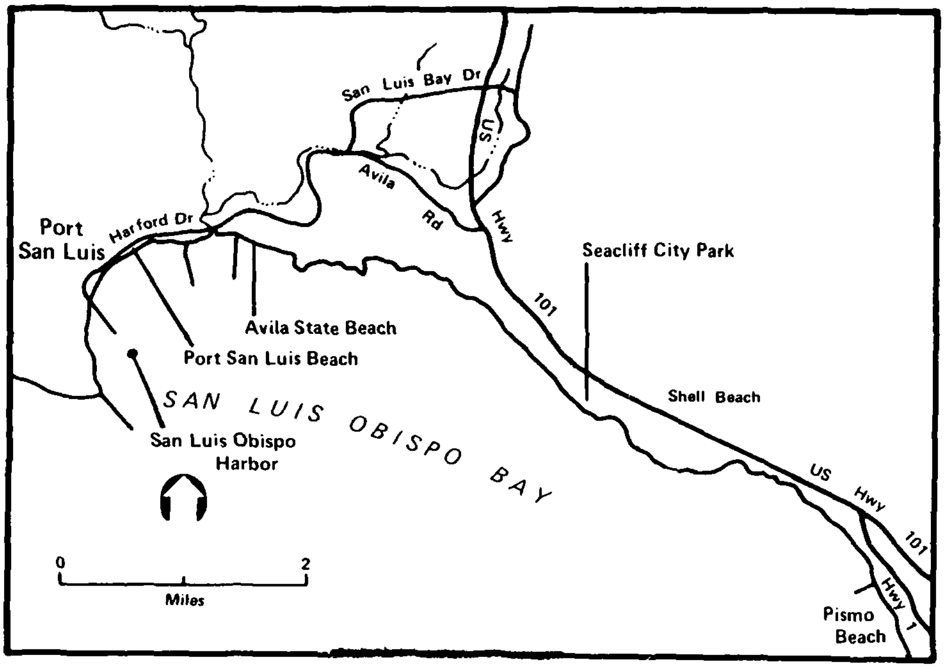
deal of wind blown sand, and there is question that this has accelerated the maintenance dredging requirements of the interior channels.

Also, of interest at Morro Bay is that, in the rebuilding of the breakwater in 1957, we were one of the first targets of the environmentalists. The large monolith known as Morro Rock was used as a source of rock for the original construction and we used it in 1957 for core rock. We realized by then that this material was not of sufficient density to use as armour. Actually, it was the last time we intended to use that rock for core because the quarry face was becoming too large, too high, and too dangerous to operate. But, the Sierra Club and other groups became, probably properly, incensed at further defacing this natural rock monolith and actually went to Congress and I believe, through a Senate bill, got a special bill passed by Congress that the Federal Government would no longer use Morro Rock as a quarry source.

The Corps completely rebuilt the breakwater in 1964, going into a wave analysis and coming up with much larger and denser cap rock. An interesting feature of this breakwater rehabilitation was that, about this time, there had been serious damage to the end structures of several different Corps of Engineers breakwaters and the Chief of Engineers' office came out with a pretty stern edict that we would provide more substantial end sections. To respond to this at Morro Bay, we decided to build a reinforced concrete head on the north breakwater. But the only way to build that was first to build a substantial ring breakwater of rock rubble, and then in the wave-protected water inside of this, we built a large reinforced concrete head using railroad rails for reinforcing steel. Our local concept was that as long as this rock rubble laid back against the reinforced concrete and prevented scouring of the sand which forms the base for the whole breakwater, the monolithic head might stand up. Apparently, to date, this is true. What will happen to this head if that toe rock is allowed to deteriorate, we will wait and see.

Another interesting aspect of Morro Bay was that, while there were two large gaps in the original breakwater where sections had been knocked down to about mean lower tide level, it still worked substantially as a breakwater and protected the interior waters. So this again is one of the advantages of the rock rubble structure and its flexibility—it will sustain a great deal of deterioration before it loses its effectiveness.

PORT SAN LUIS



Port San Luis Area

PORT SAN LUIS

As remembered by KENNETH A. PEEL

This breakwater was constructed at the start of the century. We repaired the breakwater while I was there in 1936. We took stone out of Riverside and loaded it on barges at Los Angeles Harbor. These were towed around Point Conception to the job site. The rock was placed from a floating crane. I took my family up to San Luis Obispo and we spent the whole summer there camping in their campground in a tent, and Barbara was just a little kid and she played along the beach. We rebuilt the entire breakwater from shore out to the end—restored it. And so far as I know, nothing has happened to it since.

We lost three or four barges coming up from the south and others were delayed by rough weather. They turned over. During those periods you would be out of rock for a week and we would play baseball with the Avila town team. We had a real nice vacation.

As far as the beach goes, I have been there fairly recently and there doesn't seem to be much difference between what it is now and what it was then.

As remembered by OMAR LILLEVANG

At Avila Beach, it has been an ambition of local people for many, many years to establish a harbor, and to that end a public agency was formed called Port San Luis Harbor District. Port San Luis Harbor District has wanted to build on some bare beginnings of shelter that have existed since near the turn of the century, and which, I think, was built during the time that Colonel Leeds was District Engineer at Los Angeles. It consists of a small breakwater and there was an oil loading station from piers and fishing operation, all of which are wide open to southeasterly storms. This had led local interests into the hope that they could build a combined harbor for relatively small commercial vessels and for pleasure craft.

That harbor district has been through a large number of consulting engineers. The first one they hired wrote a rather thick report describing what a poor idea it was to do anything at all, and then when they fired him came up with a plan of what to do. The names don't really matter. It may have been an injudicious report—whether or not it had merit, I don't know. Then, I believe in about 1962 or 1963, I came in about third in an echelon of people who were trying to get something done in order to satisfy the voters that their existence was worthwhile. The only thing that could be responsibly designed exceeded the financial capabilities, so my plan was rejected and nothing of lesser scope would have been professionally reponsible in my view, so I removed myself from that engagement. Others have picked it up since, including Moffatt and Nichol who have done some yeoman work for them, brought them to the threshold of success with a very well thought out plan, got support from the voters with funding, and were then cancelled out by regulatory agencies.

It is a project where a harbor could be used with great benefit. Nearest to it is Morro Bay, which has some severe problems of shoaling in the entrance and exceptionally heavy seas. It is about 12-14 sea miles away--the two together, even if both of them were fully successful and accessible, would be excellent for the region and used, I am sure, but its in the doldrums up there. I don't recall that there were any really significant influences on coastal processes on Avila Bay from the San Luis Harbor District plan. The Bay is land-locked, probably not much sand coming into it other than from the streams that drain into it or the bluffs that surround it. It was simply a harbor program.

As remembered by WILLIAM J. HERRON

Moving on downcoast from Morro Bay, the next Corps of Engineers project is San Luis Obispo Harbor and this has more of an economical and political history than engineering. The original breakwater is one of the oldest structures in the southern California district; starting back even before 1900. However, the secondary project was to build a smaller, tighter harbor well inside the outer breakwater, which is really built on a rock reef and provides outer protection from the north-west and westerly storms. The original design, which was approved by Congress, was to be a combined deep water commercial harbor and small craft port. But, when we got to the design memorandum stage, the greatest point of interest to me was that we started analyzing the long period of wave action in this harbor and we found there were many periods of very severe seiching action with periods of 120 seconds and more. By modifying a standard wave gauge, we were able to take measurements of these. Some of these seich actions lasted as long as 20 hours. This would have been a very difficult place to have designed a proper boat basin and dockage for large, deep water ships that would cope with this seich action. Not only that, the area is severely affected by tsunami waves in case of earthquakes, such as those in Alaska or in South America. Drawdown of as much as 13 feet has been observed. The economics of the area had changed by the time of the design memorandum, and a deep water commercial harbor was no longer economically justified, so we did not have to face up to a final design decision on how to properly deal with the seich and tsunami actions on a large ship.

I think this harbor has been designed and re-designed about six times. The Corps of Engineers and the Port San Luis Harbor District had a complete small craft harbor designed in about 1964 or 1965. However, when the Port District went to the people for a bond election for financing their share of the harbor, the bonding was defeated and the project had to be dropped. It was again re-designed in the 1970s and was to be financed by both the Federal Government and the Port itself, largely through loans from the State Small Craft Harbor Department. We bumped into the powerful environmental movement that was going through southern California in the 1970s, and strong objections were brought to construction of this harbor; largely on the possible impact of bringing too many people into this rather rural area.

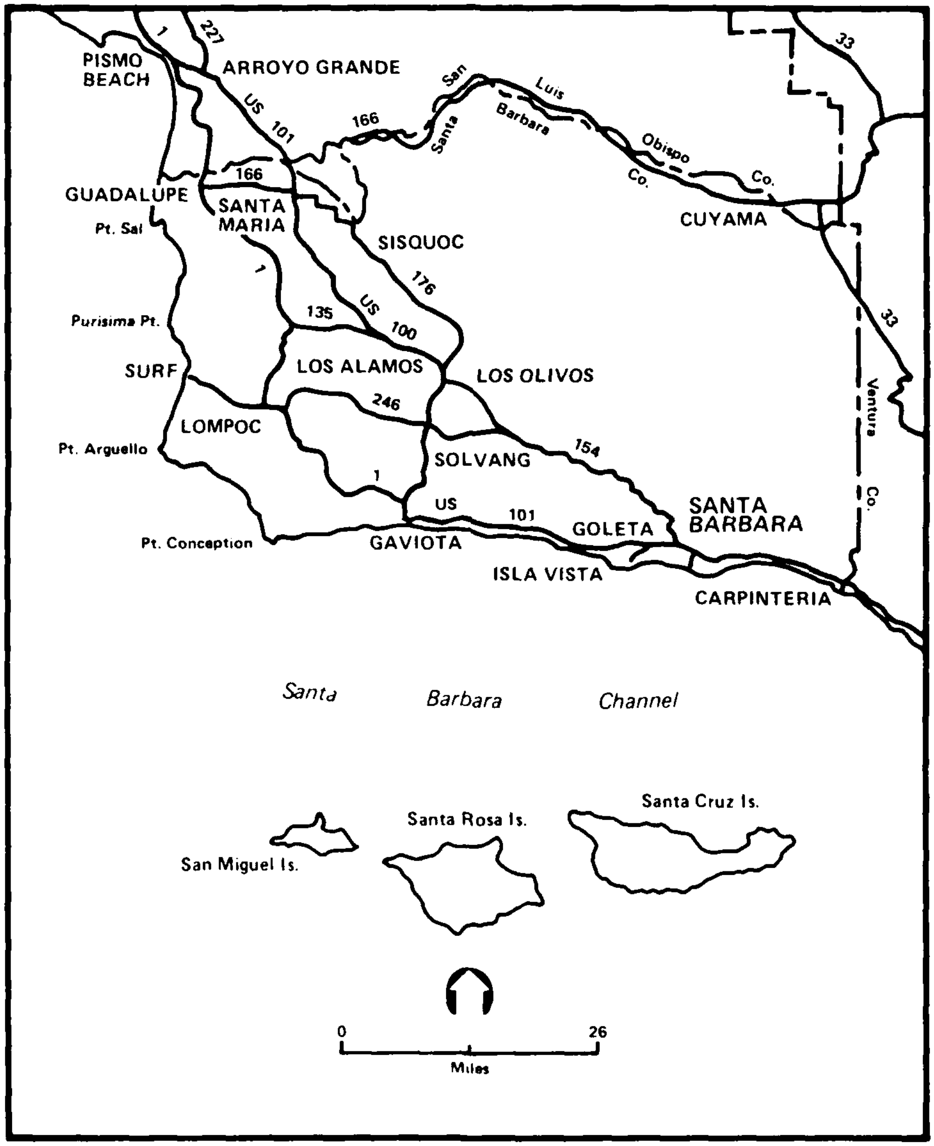
I did develop one point of interest, which I note has been picked up by some of the environmentalists, particularly the Fish and Game people. Environmentally, a rock rubble breakwater has pluses as well as minuses. We were able to develop, by a somewhat mathematical relationship between the area of sand bottom covered by a rock rubble structure and the new area of rock surface made available for marine growth to attach itself to, both plants and animals. In addition, hundreds even thousands of caves additionally provide for other types of plant life as well as a security area for the laying of eggs and the raising of young fish - shell fish and so on. This is a benefit which the environmentalists themselves failed to recognize at that time.

PISMO BEACH

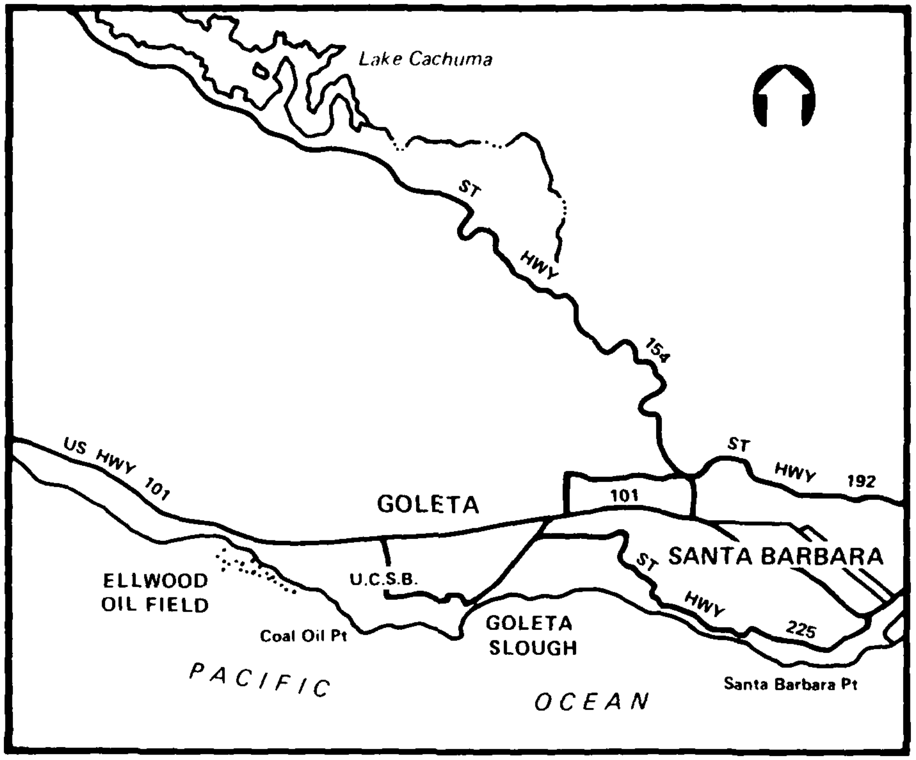
As remembered by OMAR LILLEVANG

Coming down the coast a little bit farther to Pismo Beach, I was involved there with the Attorney General of the State of California as technical advisor and potential expert witness to the condemnation action which was simply being used to tidy up a sea coast State park and close some real estate gaps. Pismo Beach is a sandy beach, a very wide, very gradual slope with fine grain material; sort of a location which has been a resort largely for people from the San Joaquin Valley for many, many years. The beach that was in dispute there was immediately adjoining a pier. I remember that, when the thing went to trial, I sat in the motel room and the Attorney General would come back and tell me, at lunch or in the evening each day, how things were going and particularly how Prof. Robert Wiegal was testifying for the other side. Because Wiegal was giving as good testimony as we needed, it wasn't necessary to put me on the witness stand. My involvement there was one of identifying what usefulness the beach could have to a landowner and what it might represent in terms of a constructible facility at a given price - all of which would then reflect upon the price that the State would be required by the court to pay in the condemnation proceedings. As I say, I never went on the witness stand but I did devote many, many hours of study to the problems there. Wiegal did it all for us. Why subject myself to cross-examination if the other guy's testimony is just fine?

Santa Barbara County



ELLWOOD/GOLETA SLOUGH

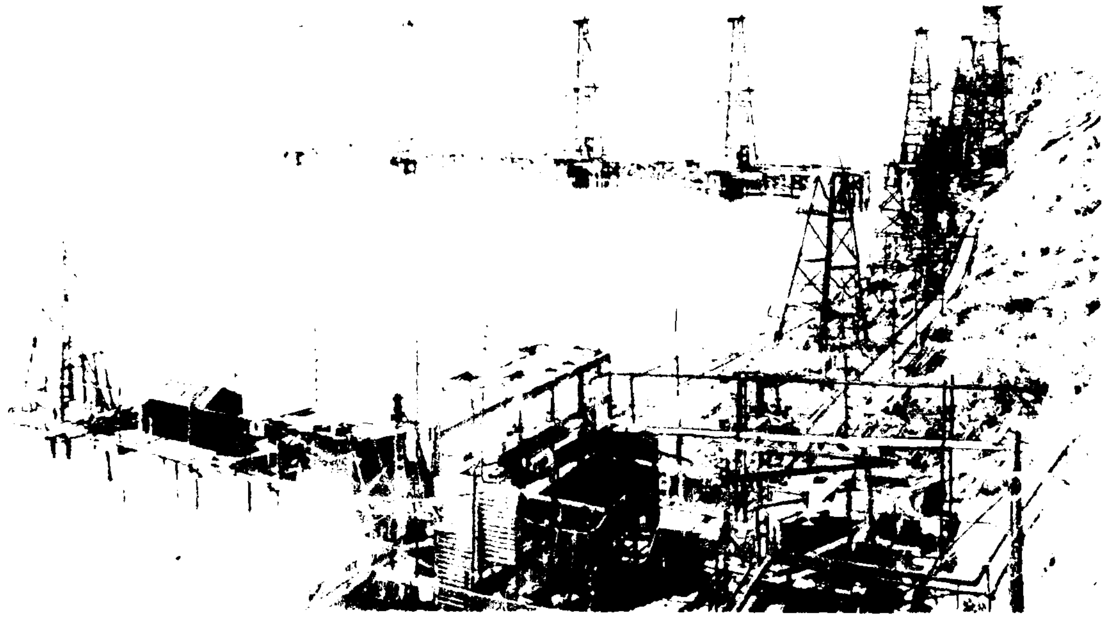


4 Santa Barbara County

ELLWOOD

As remembered by OMAR *LILLEVANG*

Moving down the coast to Ellwood in Santa Barbara County, I remember a story that Colonel Leeds told me about. I wasn't involved in it because it was in the 1920s and I was still a grade school boy. He was retained by oil companies who were establishing drilling platforms or wanted to establish drilling platforms in submerged lands off Ellwood. Ellwood is a little bit west of the campus of the University of California at Santa Barbara and is famous nationally as being the place where the Japanese submarine put a couple of shells through a service station. One of the few physical attacks on the coast of the United States during World War II. The oil companies had drilling platforms there for many, many years, and some of the rusted snags of the steel piling can still be seen, though most of it has been removed. There was opposition by Upland owners to these proceedings and they did not want to see the oil towers established; it's not a new objection, in other words, not simply a matter of 70s and 80s. And the problem was how to get out there. It was solved by going up the State tidelands between high tide and low tide with sleds dragging all the equipment and power drivers so they could launch from the beach, by that means on public land, where they had a permit to operate and frustrate the Upland owners. These devices for exploiting publicly owned lands for any benefit that has a permit are not new.



Ellwood Oil Piers (1937)

GOLETA SLOUGH

As remembered by OMAR LILLEVANG

In about 1965 or 1966, a partnership, not a corporation, of four men the best known of whom was the actor Fess Parker, undertook a real estate development which would involve channels from the ocean to each buildable parcel on a series of channels that would be dredged in this old slough area near the Santa Barbara airport. From my experience with developers, the people were amazingly generous of their time and the dissipation of their profits. They began with intentions of being very thorough and spending money on doing things right. Then, when public agencies made additional requirements of them, which in so many instances were terribly time consuming and therefore also very expensive, they undertook them without a whimper and continued with the work of trying to bring this development to a conclusion. My part of the effort was an engagement to conceive, design, and describe for permit-granting entities the means by which an entrance could be established and maintained in such a way that intercepted littoral drift would be properly bypassed to avoid any undue or unacceptable erosion of the sea coast to the east. Santa Barbara county probably had developed some of the earliest sensitivities to the effects that shore structures could have on erosion of downcoast beaches because of some bitter experiences and some classic lawsuits that took place over the effects of Santa Barbara Harbor.

So, a concept for extending entrance jetties to protect a channel that was to be dredged was devised in a manner that suited a bypassing system that was a physical--by physical I mean mechanical--removal of accreted sand on the updrift side of the entrance and its transport to a pumping facility on the beach by bucket excavator operated by cable and restored to the littoral stream. The concept was exhaustively studied and presented and was endorsed as a mature scheme appropriate for installation and close observation by the several entities: the county of Santa Barbara at the top political level; its board of supervisors; down to its public works agency and planning agencies with their engineers and planners, all of whom relied to some extent, and rather to a considerable extent, upon the opinions of the Corps of Engineers concerning the appropriateness of the scheme.

Unfortunately, other criteria that had to be met relating to groundwater, contamination threats, airport clearance matters, and things like that, all of which ere well under way and headed toward sucess, caused the backers of these developers to withdraw their funding and the project was never built. A disappointment that an idea that had promise didn't get to be put into physical activity. Nevertheless, it was an interesting experience, not the least of which was working

Goleta Slough (1966)

with these men. Even with the horrible disappointment and considerable financial loss the failure of their program had, they took it in good temper and ended friends with one another. They swallowed their disappointment and went on with it. I think they were, and probably still are, entrepreneurs in the most admirable sense.

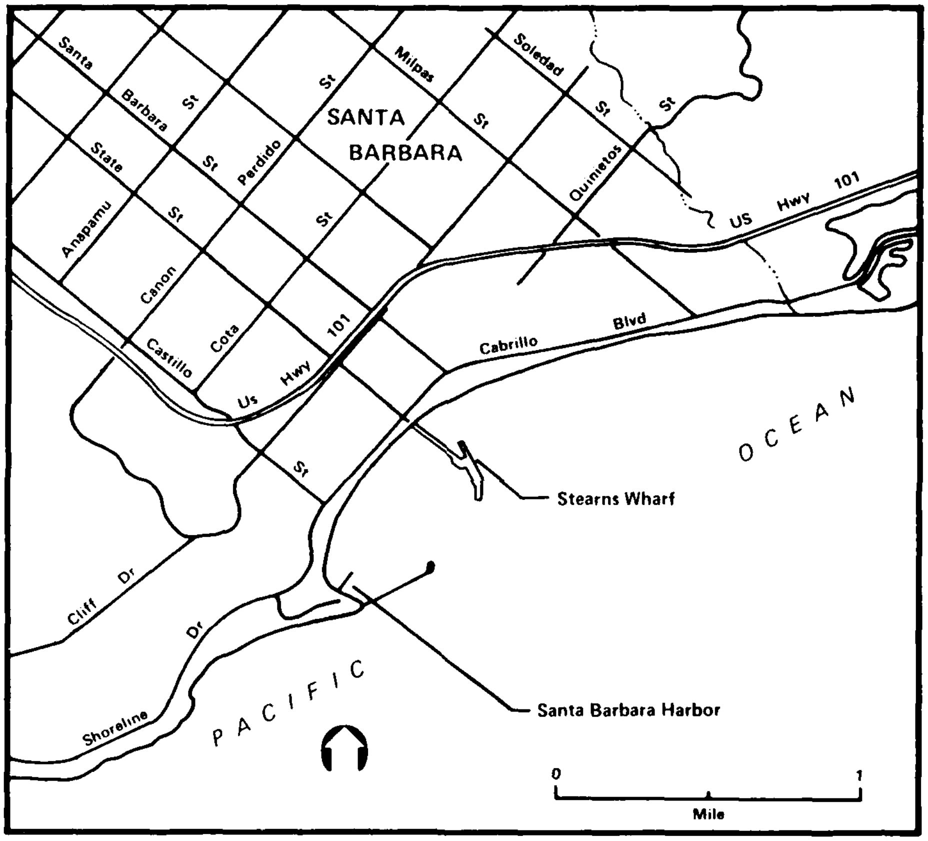
SANTA BARBARA

As remembered by KENNETH A. PEEL

My first job in southern California began in 1932 at the San Pedro Field Office, on the Los Angeles-Long Beach detached breakwater. During that period I came in contact with the Santa Barbara project, which had just been completed by the City of Santa Barbara. They had anticipated beach erosion problems and sand problems to the extent that they attempted to build a detached breakwater thinking that the sand would move right on through the harbor and go on down the coast without ever stopping there. That was when it first became apparent to most of us in the oceanographic and shore protection and harbor field that sand didn't move by long-shore currents per se, but by wave induced currents, and as soon as you interposed the structure to cut the wave action, you cut the wave's power to move sand and it stopped. Then the sand immediately started filling the harbor up, and they had to then connect the breakwater onto the shore to maintain the harbor at all. The net result the was instead of sand stopping inside the harbor the sand stopped upcoast from the harbor, and was impounded by the breakwater. That impoundment was accompanied by the continued movement of sand on down the coast below the harbor to the extent that the waves had the power to move the sand. This resulted in very severe beach erosion. This severe erosion went downcoast well below the Miramar Hotel and the Sandy Land area, and people started building groin fields to trap a little sand and to protect themeselves but in so doing, accentuated that continued erosion down the coast.

This progressive erosion continued until millions of dollars in shore land had been lost. The shore receded, as I remember, something like 500 to 600 feet back from the existing shoreline. Some houses were moved three and four times. The problem in Santa Barbara continued until a Congressionally authorized survey report and erosion study was made, which was the first in California.

A program was ultimately adopted by passing sand by dredging the harbor out and pumping it on the beaches downcoast. That effectively checked the erosion but it did not restore anything that had previously eroded because the amount of sand replaced in circulation was only sufficient to maintain the shoreline in the position at that time. While expensive, it was effective in correcting the erosion problem.


SANTA
BARBARA
Santa Barbara St
State St
Anapamu St
Canon Perdido St
Cota St
Milpas St
Soledad St
Quinientos St
Castillo
US Hwy 101
Cabrillo Blvd
Cliff Dr
Shoreline Dr
Stearns Wharf
Santa Barbara Harbor
PACIFIC
OCEAN
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SANTA BARBARA HARBOR
As remembered by OMAR LILLEVANG

In the model experiments of Santa Barbara Harbor itself that I worked on as a student, we modeled the breakwater in the sequence of geometrical arrangements that it had had in nature; and at that time of the thesis study, 1936, it only had about 6 years of performance experience. Already it had been observed that a shoal was extending off the tip of the breakwater and it had been observed that there was a small beach resting against the inside of the breakwater for its full length.

In our model we built the breakwater first of galvanized sheet iron which we bent into the dog-legged shape of the alignment it had in nature and we left a gap between the shoreline and the beginning of the shoreward leg of this dog leg alignment just as had been done in nature. The original designers had felt that would provide opportunity for currents to carry sand through and beyond and not interrupt its passage along the coast. They did recognize the presence of littoral drift. I don't believe that they had any concept of the quantity of material that was moving and they erred in their judgment that behind a sheltering structure there would be physical means for maintaining the transport of sand. Very quickly, as the thing was built, it was discovered in nature that the breakwater did have this sheltering aspect and they accumulated a good sized shoal in the gap that had been left. They hurriedly filled it in with rock and connected the breakwater to shore. The history, of course, is very full of the story of this accumulation. The accumulation then moved out on the shoreward side, building the beach seaward, then coming past the end of the breakwater again and the development of this shoal at the tip became a fact. Also, the small beach appeared inside the breakwater.

When we modelled the structure with sheet iron, we quickly found that we were getting a tip shoal at the end of the breakwater just as it had occurred in nature, but not with the same alignment or shape. It was trending almost in a continuing direction of the alignment of that seaward leg. This was not in accordance with nature. Because modelling is an art, at least as much as a science, one frequently grinds up lizards tails and adds bat wings and does things like that to see if one's intuition is correct--if that will make the model work as you would have expected. In our case, what we did was observe that the jet of water going off the end of this, as the waves impacted on and moved along the smooth sheet iron, was very strong in the direction that the sand was going and needed to be slowed down. So we coated the seaward side of the sheet iron with pebbles pasted to it. This had the effect of slowing this phenomenon down and we began to get a tip shoal that looked as it ought to.

Santa Barbara Harbor (1930)

Obviously, with the sheet iron barrier and virtually no overtopping, we didn't get the little beach inside. The theory that was the problem at the time, probably including the theory of our professor, was that a current was moving the sand from the tip down back along the inside of the breakwater and depositing it to make this beach. Because ours didn't do that, we didn't get "A's" on our thesis. Maybe there were other reasons too. It may not have been that good a job, but you know you prefer to find that reason as the reason that the Dean didn't want to give us an "A." About 4 or 5 years later, he and associates of Berkeley began reciting this model as evidence of the usefulness that small models had served because in the mean time it had been found that the little beach inside was coming, primarily due to transport of suspended sand, through the voids of the armor stone, foot by foot along the breakwater instead of the transport phenomenon around the end of the breakwater and along the inner side.

Since that time, I have had one or two occasions to be involved at the Santa Barbara breakwater. In one case, the Yacht Club wanted to build a new structure right by the root of the breakwater and the insurance industry questioned whether or not it could stay there. Everybody had been having a heck of a time even figuring out how to get rid of the sand, let alone worrying about whether or not the sea would remove it. So it was a fairly simple matter to write a letter of opinion that, properly founded on deep enough piling, the Yacht Club structure could be relied upon and would be, in my opinion, insurable. I sent them a bill for about a day's work and marked it "paid." One of the things I cherish in my files is a letter from the Yacht Club signed by every member of the Board of Directors thanking me for my help.

I can't recall, however, that it ever produced anything in terms of future business, but that's all right, who knows. Colonel Leeds always used to give me the Biblical injunction "that if one cast his bread on the water, eventually it would come back." You never know from whence or even that it came out of the same casting. The other was a matter of looking at the use of that the City of Santa Barbara elected to make out of what has sometimes been looked at as a detriment but is now being recognized as an asset: to keep the shoal of sand at the breakwater end as an inexpensive added extension of the breakwater to shelter new slips. Again, the insurance companies wanted to know whether or not new facilities behind the shelter could be insured. I examined the design and construction of some work that was done on the shoal, but I think that probably was the extent of my involvement. However, Colonel Leeds' involvement was farther back.

In the 1920s, and I have this report, and from my recollection it was around 1922 or 1923, Colonel Leeds performed comprehensive studies of the availability of sites for a small harbor to serve Santa Barbara. His report analyzed a proposed site at Goleta, but that would have been inside in the slough, much the same area that the airport now occupies and some of the area in which I was working in the little job for the actor and his partners. There were three proposed sites at Santa Barbara. One, the site of the harbor that was built; another, one just a little bit farther down at the foot of State street; and another one, at the lagoon, which is presently a wildlife refuge and park where the major public street turns in from the beach and goes back over to the Coast Highway.

Colonel Leeds' conclusion in that report was that the lagoon site at the south end of town was the most appropriate place for a harbor to develop and he was planning on dredging in there and constructing some jetties as an entrance regulator. His report did talk about littoral drift and that it had to be anticipated. Using the state of the art that existed at the time, he presented some concepts for doing it, all of which, as I recall, involved dredging, and said nevertheless, that the other one at Castilla Point where the actual harbor was subsequently built was feasible. He also discussed that at great length and discussed means by which the accumulating sand could be removed and restored.

I am not sure, at the phase of coastal engineering practice, how sensitive he was to beach losses due to accretion by harbors. He may have been very sensitive to it but I don't remember that aspect having been discussed by us. He was extremely sensitive to the need for managing much sand in order that the purpose for which the harbor was built could be assured, and he definitely intended that any sand that needed to be managed should go to the downdrift beaches. So, it would appear that he had a sensitivity to that aspect of beach balance at that time (1922).

The harbor design was actually carried out then by a man named Smith, I believe. Colonel Leeds used to refer to him as Steamboat Smith. A Major George Verill also participated. I guess Smith actually directed the building. These are a matter of history and my recollection is probably inaccurate.

As soon as they began having the problem with sand accumulation, and particularly the sand in the lee and through that open hole in the dog leg that Colonel Leeds had not approved of, he apparently provided some input back to the city, as one of many they went to, including the people who designed it, when it began to have the problems. But I believe his involvement after about 1930-31 and so forth was a matter of professional interest rather than engagement.

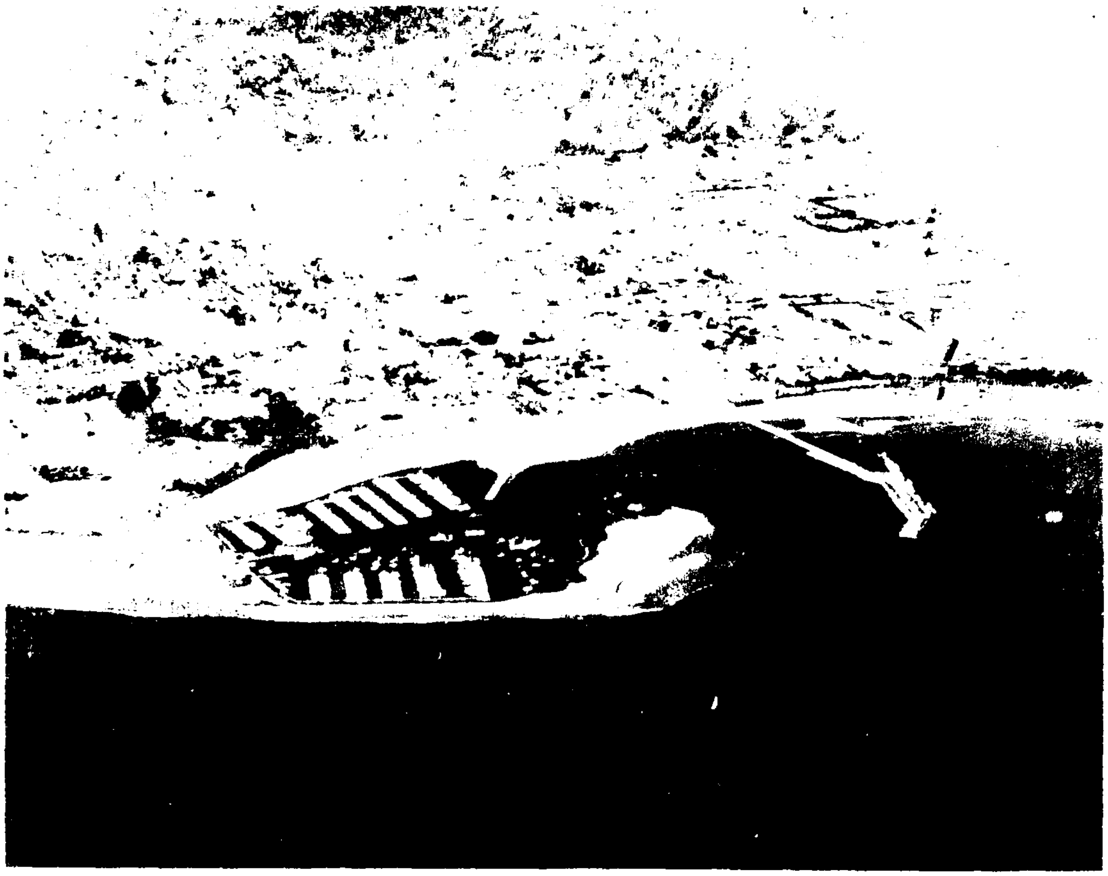
He had in the years earlier before the Santa Barbara breakwater was built, but probably while it was under discussion, served several property owners in the Montecito Beach area and had designed, and patented, in fact, a pre-cast concrete shape for groin building--it is described in the shore protection manual very briefly, I think. There is more that could be said about it; it had the merit of relatively quick construction and of ease of being removed, if necessary, and also quick performance. The building of that groin and several groins triggered some lawsuits by downstream owners that have interested me greatly because they presented, along with some other lawsuits later, over the effect of Santa Barbara Harbor, some anomalous, to a layman at least, applications of the principles of law. And the easier way to have a look at that would be to look into the proceedings of the conference in October 1965 that the ASCE carried on at Santa Barbara. I had a paper there that described these anomalies to the layman, and the subject of the paper I think was "groins and liability." Those I think are worth looking at. There is a long history of that and you can still find some remnants even of the groin that had to be removed, because they didn't remove it clear back into where it had been buried by beach sands, and pieces of it are still there.

As remembered by WILLIAM J. HERRON

As we move into the shelter of Point Conception, the characteristic southern California shoreline starts. Below Point Conception the area is semi-sheltered, both from the extension of Point Conception and the seven offshore islands generally known as the Santa Barbara Islands or the Offshore Islands. Roughly 50 percent of the wave energy from the offshore disturbances are intercepted by these islands and this very pronounced headland. So the shoreline from here to San Diego has quite different characteristics. The upper part of Santa Barbara County is of some coastal enginering interest as this was one of the first efforts, at least in the United States, to establish oil wells offshore. These were done during the later 1920s on a series of piers connected to the shoreline and were somewhat shallow wells.

There must have been close to a dozen of these piers installed along the shoreline and their efforts to prevent oil spills was not so energetic in those days and they did create many troublesome problems.

Moving on down to Santa Barbara Harbor, however, this is what we frequently called the "field laboratory" of the Corps of Engineers. The original harbor built in about 1928, and well described by Omar Lillevang, taught us that what we normally call "littoral current" is not a water current but a wave-induced current and when the wave energy is intercepted, sand



Completed Santa Barbara Harbor

is no longer going to move and the result is shoaling and interception of the sand with the resultant erosion on down shore. An early attempt at sand bypassing was tried in 1934, when the harbor was first re-dredged, using a Corps of Engineers hopper dredge. It was thought that, if this dredged material was put just offshore, the wave energies would transport it to the beach and it would move on down. The closest this type of dredge could get to the shoreline and discharge its sand cargo was a depth of about 18 feet, so several hundred thousand yards of sand were dumped at this point. However, it was too far outside the breaker line of waves in this area to be affected and, while it was closely watched for about 30 years, there was no evidence of this sand being transported into the beach and littoral zones to continue to supply on downcoast.

The harbor was originally built by the city. The maintenance dredging has now been taken over by the Corps of Engineers, and while in 1964, a study was made to enlarge the harbor and provide a more feasible sand bypass system, it was shot down by lack of funding by the local people. The bypass program which was established in 1934, and was one of the first to be established by the Corps of Engineers, was originally to come in with standard commercial dredging equipment every 2 years and completely dredge out the harbor trap and pump some 700,000 cubic yards of sand on down the coast.

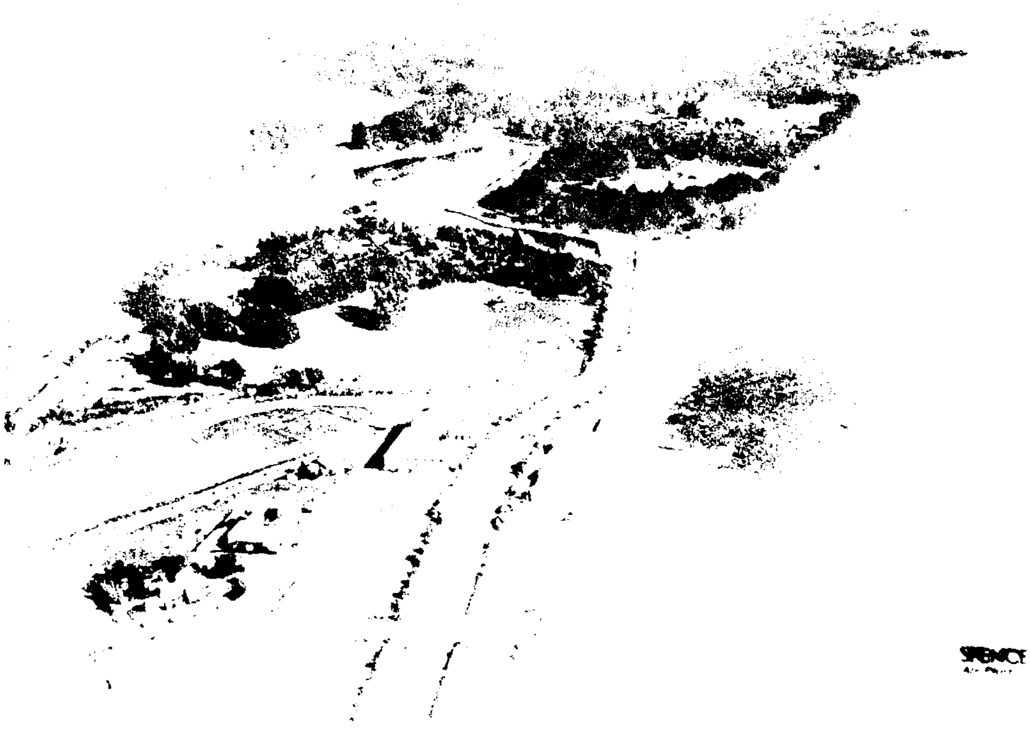
In about 1954, some of the people connected with the Santa Barbara City Harbor Department began to appreciate the partial wave protection that this sand spit was giving between dredging operations. So they took over the Corps of Engineers operation, put a smaller dredge in on a permanent basis, and simply trimmed this sand spit to provide additional protection to the harbor from the occasional storms from the southeast. This was fairly effective except for the one problem that is always faced when small government agencies try to get into the dredging business. A dredge is a complex piece of machinery and if it is not being used and operated by men well-trained in this game, it tends to deteriorate and not function properly. By the time the city gave up this operation in about 1970, this dredge was an almost useless piece of junk and had no resale value. The Corps of Engineers took the maintenance project back at the direction of Congress in about 1970, and they are now trying to follow the city procedure, except by using commercial dredges and establishing contracts on about a 3-year basis for continuous maintenance. This seems to have worked out fairly well.

The initial interference of the harbor breakwater with longshore sand movement in the 1928 and 1936 period also gave us some of our first indications of the time it takes for sand to travel along the coast. The harbor breakwater was completed in about 1928 or 1929. The sand bypass program was established in about 1936, but in the meantime a wave of erosion was moving downcoast with the littoral current, followed by the later bypassing efforts of the Corps. And in combination with severe storm, it appeared that it took about 8 years for this erosion impact to move 12 miles downcoast to the Summerland area, which was the last to show damage from the storm. I think now that this apparent movement of 12 miles in 8 years was a somewhat misleading conclusion and was probably, in part, caused by a series of rather severe storms between 1934 and 1936. Later studies have indicated that this sand will not normally move at the rate of a mile to a mile-and-a-half per year. This 12-mile stretch from Santa Barbara Harbor to Summerland is no longer subject to serious erosion, but in most areas the beaches did not recover their full width. It is a rather minimal coverage of sand and would not take much of a delayed sand bypass effort at Santa Barbara to create severe beach erosion problems downcoast from the harbor.

SANTA BARBARA BEACH EROSION
As remembered by JAMES DUNHAM

In about 1939, Dick Eaton had been pulled in from the field and with his knowledge in river and harbor work was asked to head up the acquisition of data on Santa Barbara and whatever else might come up on beach erosion. He needed someone to help him write the reports and gather the data. Although he was going to do most of the writing himself, he wanted somebody to do the leg work for him and so I was selected, probably by lot, because the River and Harbor Section did not have any spare report writers. I was writing reports on flood control, so they figured that I knew something about how to do it and I could be trained to do beach erosion work.

We started making trips to Santa Barbara, and the format that was set up for this work was that half of it was to be done by Santa Barbara County and half of it was to be done by the Corps. The county's contribution was primarily gathering data, doing the field survey work, and furnishing backup data on history of the area, photos, and what not. The Corps' work was to analyze the data submitted by them and—I forget exactly what all the input was—it amounted monetarily to about half the effort. We were asked by the Beach Erosion Board to not only submit the data but also to give our thoughts on why certain things had occurred and, from our local observation, what was the key to the erosion that was going on and what we thought of it, and they were to write up the final report. We did this and gathered the data, and I might say that the county did a very good job.



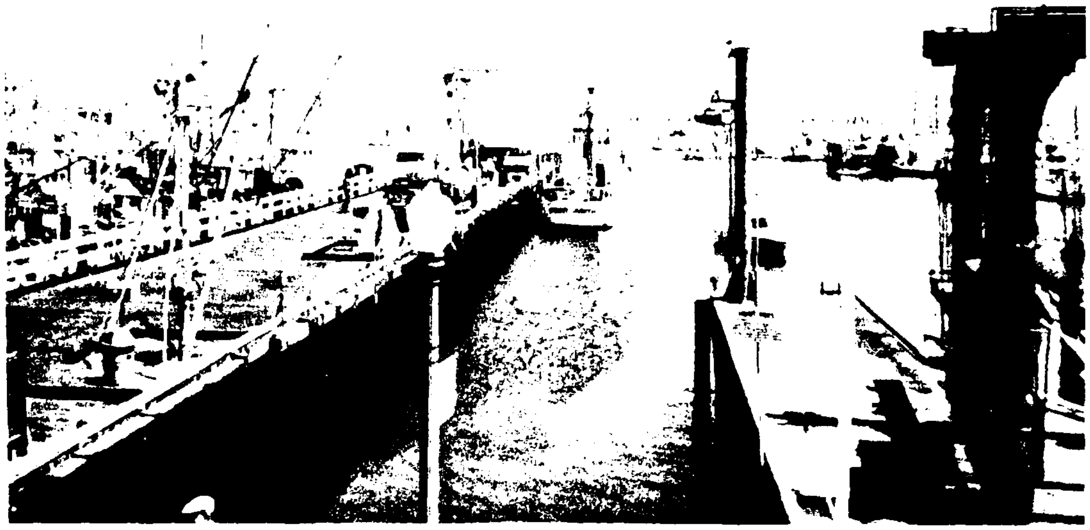
Post Harbor Downcoast Erosion

The man in charge of the work at that time was Wally Penfield. Although he didn't play a very active part in it, some of the people under him were very willing to help. Everyone was interested at the time as to why these things were happening and what to do about it. Well, our report was submitted and the Beach Erosion Board wrote a report based on it. The findings, as we all know now, were that the breakwater at Santa Barbara had intercepted the littoral drift and, as a result, the downcoast beaches eroded. Although an effort had been made to place the material that was being removed from the harbor in a downcoast area where it would get back to the beach (this was done by hopper dredge), the hopper dredge placed the material in a mound parallel to shore in about 20 feet of water--which was as close to shore as the hopper could get. This mound was monitored for the next few years; and by the time we got into the act, there were repetitive surveys to show that the mound was not moving. It remained almost exactly where it had been dumped; although its height had been reduced slightly, it was not getting ashore. So the decision was made on the next periodic dredging to use a hydraulic pipeline dredge and place the material along the shore.

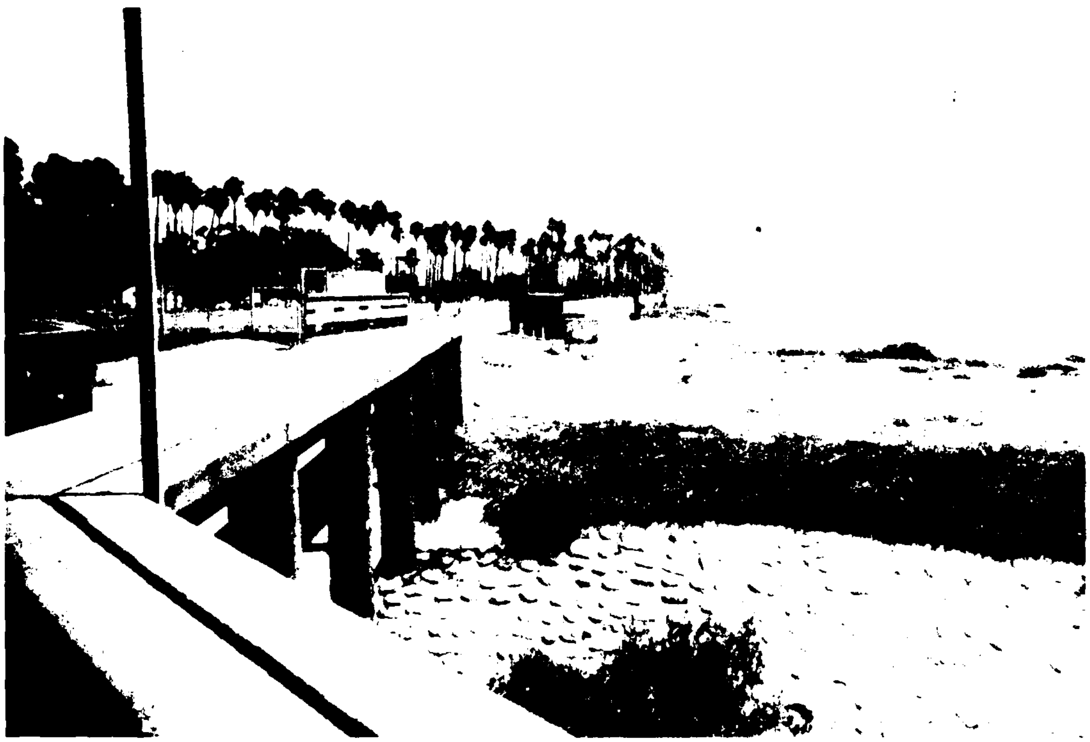
The first dredging was done about the time we were writing this report or preparing the material for it. It was thought at the time that it would be satisfactory to place the material along the beach about a 1000 feet and about 500 feet wide. Well, it turned out that this material didn't move fast enough from this relatively short and fat feeder beach. This was brought out in the Board's report, and subsequent periodic dredgings were distributed over about a half mile or so of beach. Then it began to work pretty well.

The report that the Beach Erosion Board wrote on this was put in a format they had adopted for other reports on the east coast. We reviewed the report; and by this time, we had been assigned two or three others. I forget the order in which they came but I believe the first one was the Long Beach City report, then the Coronado Beach erosion report, then Mission Beach in San Diego, and later Orange County. The same distribution of cost was to apply to each of these. These Beach Erosion Board reports were to be funded either in value of service or monetarily, half by local interests and half by the Federal Government.

On review of the Santa Barbara report, Dick Eaton suggested that it would save some time and make it easier for the Board if we submitted our reports in their format, backing them up with the field data. The Board was quite pleased with this, and they asked us to continue with it. Although the final reports were prepared by the Board itself, they mainly followed our original submittals, the Board merely modifying them in various ways.



From Upcoast End of Santa Barbara Harbor Looking Downcoast Toward Stearns Wharf (1985)



From Downcoast End of Santa Barbara Harbor Looking Downcoast Toward Feeder Beach (1985)

These several reports on beach erosion and means of correcting the problems were completed about 1941 or 1942, just before World War II. When I returned to the Los Angeles District after years of active duty in the ETO, I was put back in flood control. My primary work before the war was on flood control. Dick Eaton supervised all prewar beach erosion work (although he spent about a year at the Beach Erosion Board in 1940) while all the data were being gathered and work was being done. That was my training ground for what was to come later.

CARPENTERIA

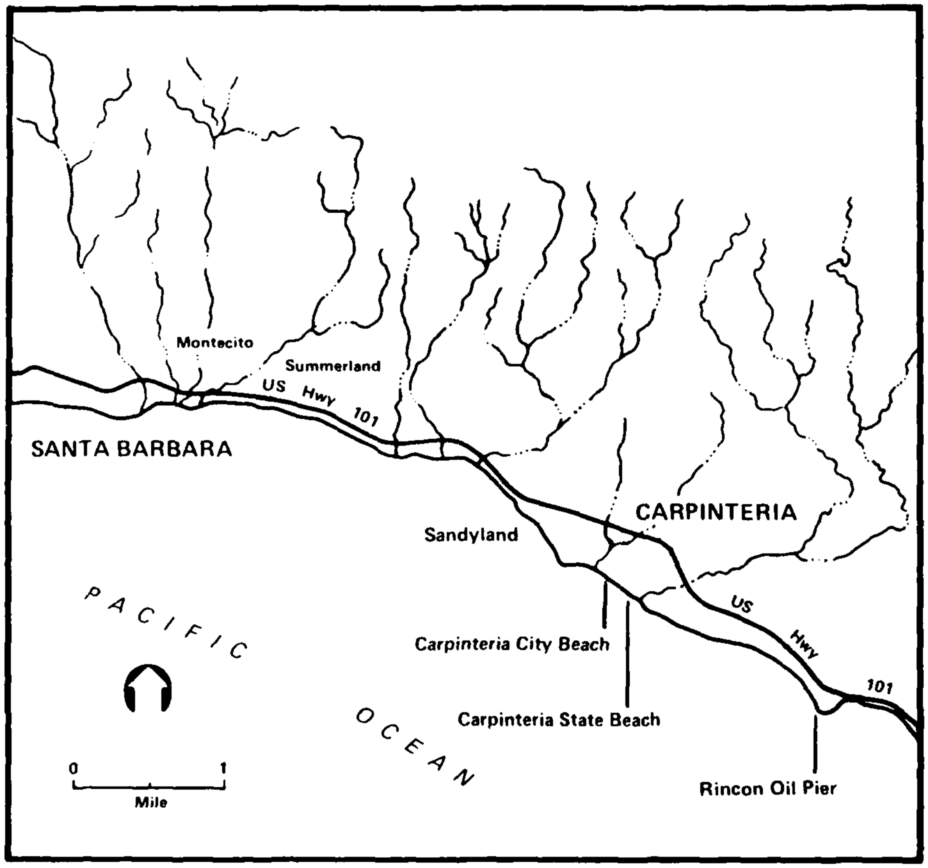
As remembered by OMAR LILLEVANG

My involvement was with the colony of landowners who have a private beach about a mile in length immediately adjoining the west city limits of Carpenteria. An engineer who spent most of his career in Santa Barbara, Wallace Penfield, a very savvy man and a person who understood the sea coast and its problems really quite well, was also an enthusiastic supporter of activities of the American Shore and Beach Preservation Association, and he was retained by these property owners. A greater part of them used these properties as vacation homes from their regularly established homes in Pasadena.

I had been retained to advise them on how to be sure that the sea would not take their homes away. They were worried about some erosion. They owned the slough behind their homes and vigorously kept it in a wild state as a buffer zone to maintain the privacy which wealthy people sometimes feel so strongly in need of. Penfield had devised a system of a quarry stone seawall for them but it didn't suit them too well. Everybody wanted to eat his cake and have it too, and it seemed like this seawall was too high and they couldn't sit on the front porch and watch the ocean as easily as they wanted to. But, neither did they want anything but full assurance that the sea would never take away that front porch. So, it was proposed that a second look be given to it and, of course, an expert is somebody from farther away, and they asked me to come up and have a look at what Penfield was talking about and doing. I met him and one of the residents, who was not from Pasadena, a man I am sure of very substantial means, a local businessman in Santa Barbara. But compared to the others economically, he was probably rather middle class. He met me and he shook me by the hand and his comment on the ego of his neighbors was, "Mr. Lillevang, I am glad to meet you," and he said, "I don't know if you are going to meet any of my neighbors or not. There are 30 of them, but 30 of them will tell you without hesitation that he is a better coastal engineer than you ever will be." That was an interesting comment. Actually, the strong opinions on coastal engineering matters are not reserved to the wealthy; Dean O'Brien had some interesting things to say about that at Mexico City back in the 60s.

Carpenteria Beach (1985)

CARPENTERIA/RINCON ISLAND

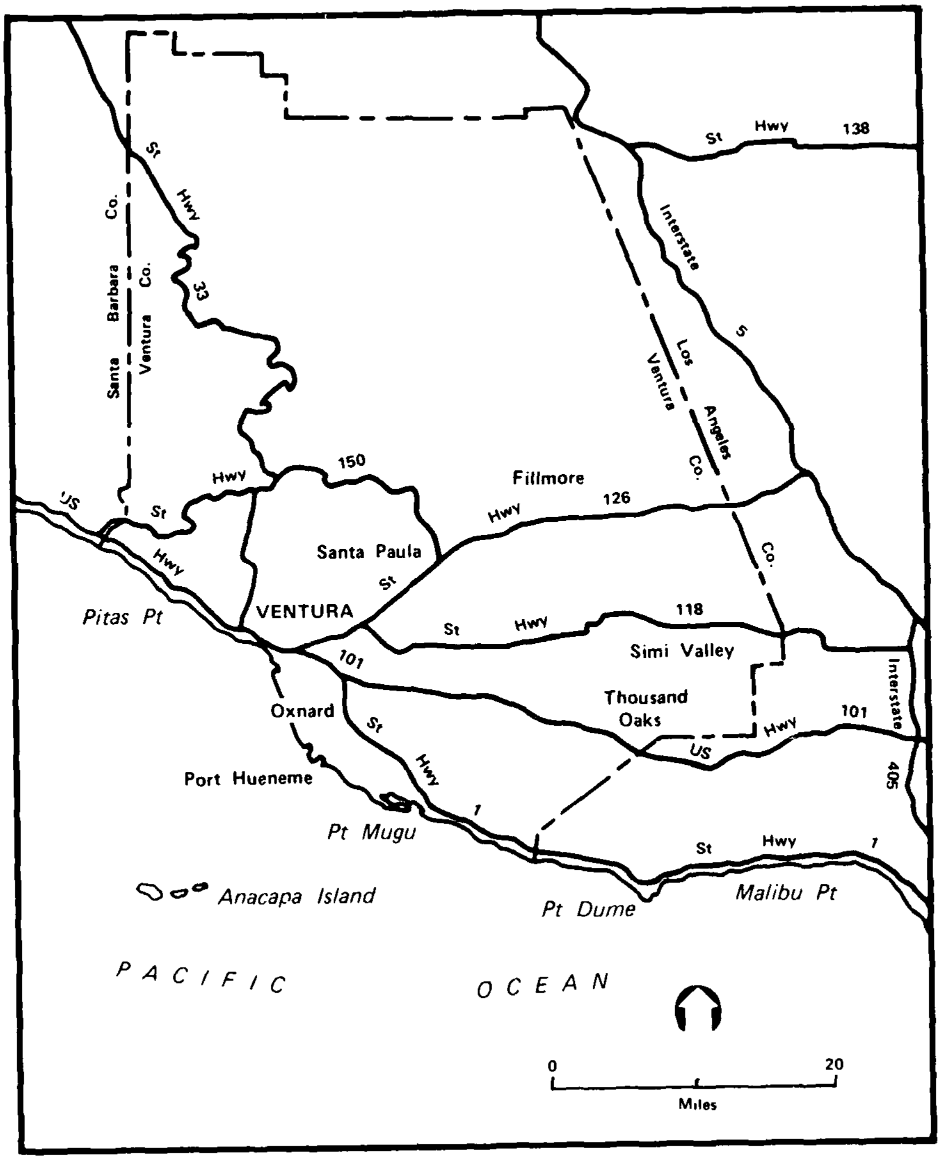


Again, it was a matter of how can one provide protection that is worthy of the investment that is not a false comfort, and still maintain all of the amenities that have made the place attractive to start with. Something did get built there, it was not my design, mine was just really advisory services.

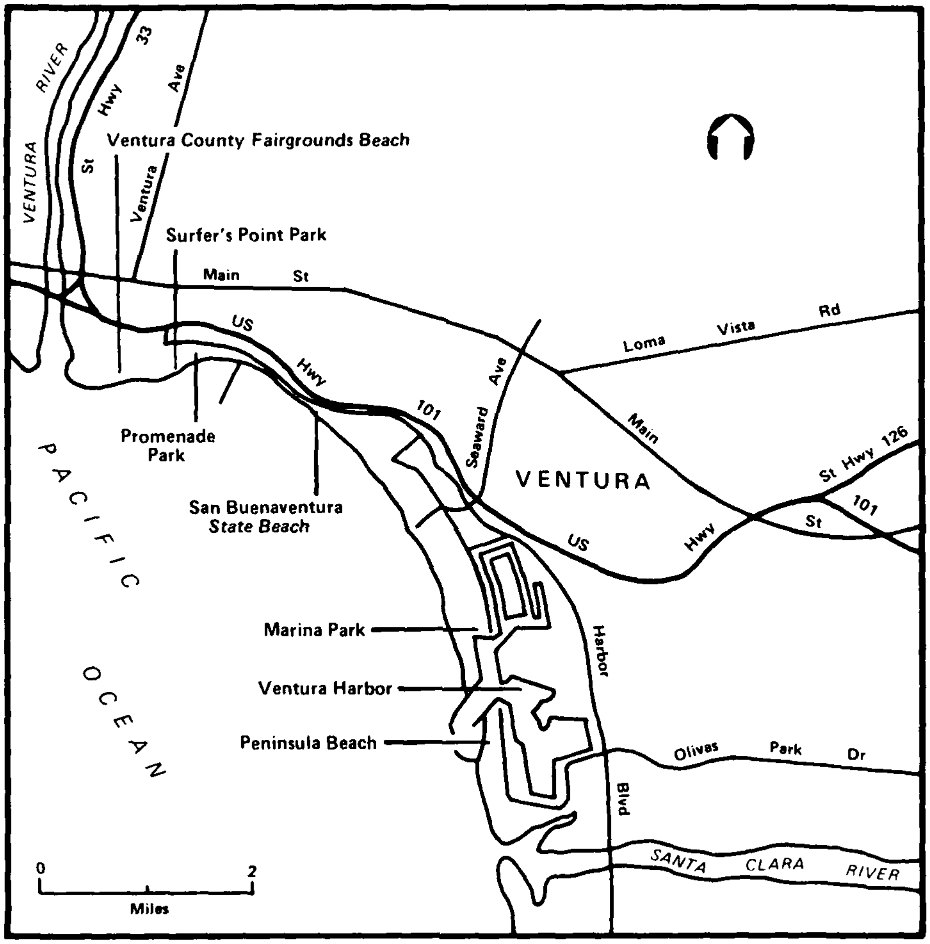
There was clearly a problem related to the maintenance of the estuary and to the slough area behind them. It was trapping sand when they opened the entrance physically with bulldozers and that invited sand to go in that might have continued to transport down the beach. The sand may or may not have gotten put back on the beach at the right time or the right place; it was a complex situation but like all of them being viewed as really a rather simple one by the owners.

Houses are still there so maybe they didn't even need the facility, but with what they were going to spend on it, it had to be a facility that could be depended upon. I don't know to what extent it ever had to function, so again it may be that they didn't need an insurance policy if they were never going to have an accident. Then a cheap insurance policy is all right, but if they were going to have one, they might have invested in something that gave a false sense of security. I haven't been familiar with it for years since the place is not accessible to the public. You get there only by invitation or by walking up the beach and I haven't done either one.

Ventura County



VENTURA PIERPONT GROINS / VENTURA HARBOR



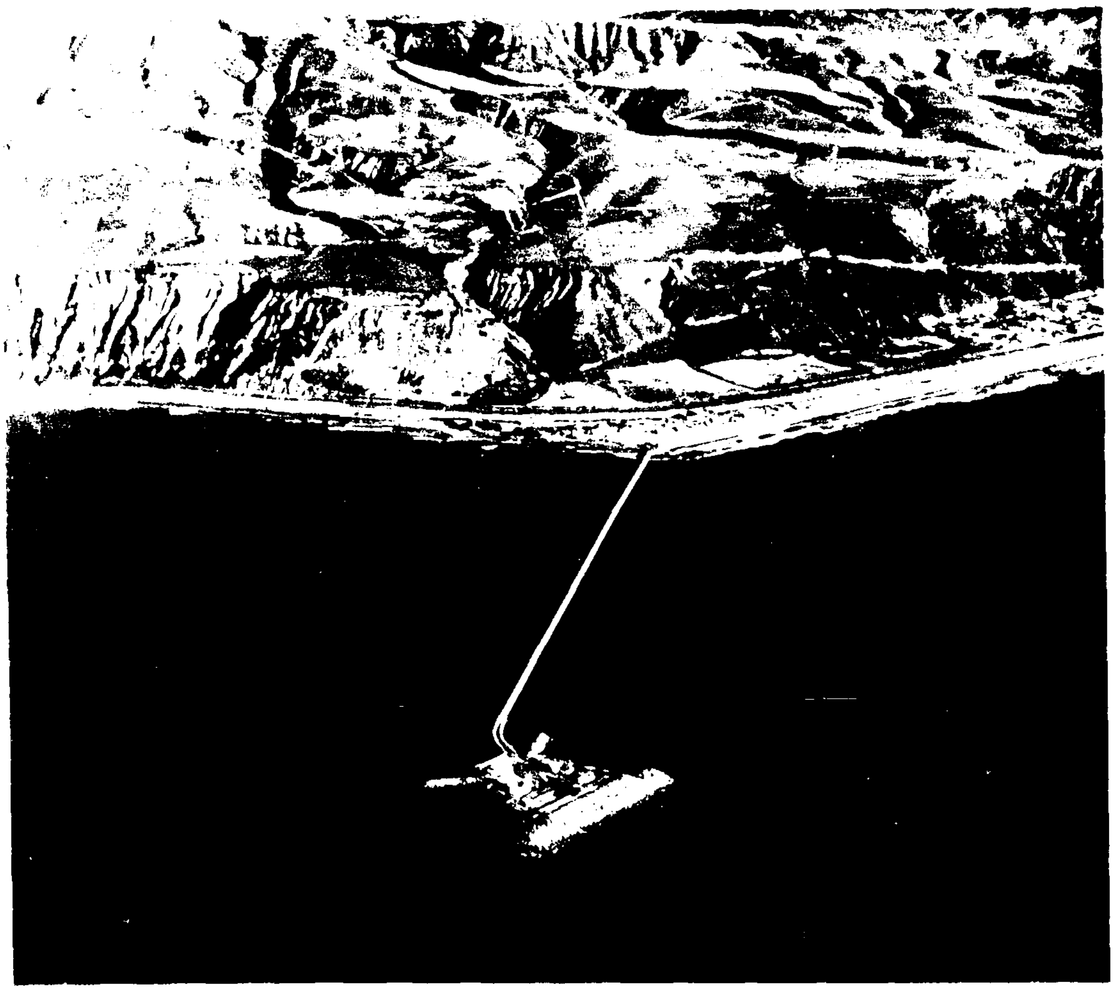
5 Ventura County

RINCON ISLAND
As remembered by WILLIAM J. HERRON

Moving to Ventura County, Rincon Island is about the first point of interest, largely because this was the first attempt on the coast of California to use the concrete shaped structures. The island was built by the Richfield Oil Company and the seaward rock face had an armour facing of tetrapods. The shape they had was designed by the French people. It is a very substantial seaward face to this island with the armour raised to an elevation of about 40 feet and I believe about 30-ton tetrapods were used. It probably is considerably over-designed, considering the effects of waves on lesser structures around it, but because these were operating oil wells using electric power, the demand was for 100 percent protection. Not too much was known at this stage about the effectiveness of the tetrapods, so it probably was a prudent design to say the least.

VENTURA PIERPONT GROINS
As remembered by WILLIAM J. HERRON

Moving on downcoast from Rincon Island and into the area of the Ventura River, we get into an interesting situation. The main supply of sand in this area is from the Ventura and the Santa Clara Rivers. They have very large drainage areas, but like all southern California streams, the sand supply to the shoreline is very sporadic—very large quantities during the major flood periods and then no supply for a large period of years in between. We first got an indication of this effect



Rincon Island (1962)

when there was very severe erosion of the shoreline between the Ventura and Santa Clara Rivers, accumulating to several million dollars' damage in about 1936.

The shoreline recovered after the 1938 floods, but again was beginning to erode in the 1950s to about the same point it had been in 1936. Then the project was developed to protect what is known as the Ventura Pierpont Beach with a series of groins. The design of these groins made use of our recently acquired knowledge of wave refraction characteristics and wave forecasting techniques, and a family of nine groins was actually based on a theoretical wave analysis to bring these waves ashore and an attempt to determine the alignment of the beach to the resultant energy of these waves throughout the year. The design was conservative and was the basis of designing the groin field in this area, but by taking into account the alignment shown by historical shoreline surveys of this area and building these groins in increments, we were able to slightly modify the shore alignment, and with careful analysis, seven groins were able to do the job that nine were originally intended to do.

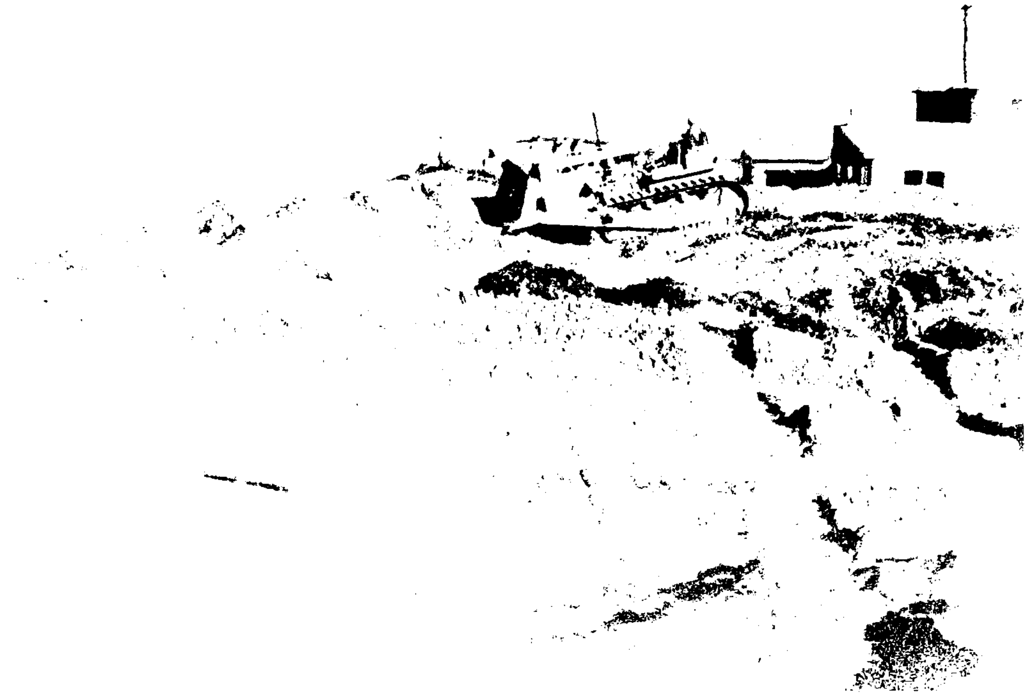
VENTURA HARBOR

As remembered by KENNETH A. PEEL

I had nothing to do with the present harbor design; in earlier years we did make a preliminary report for a commercial harbor, but it was unfavorable.

As remembered by JAMES DUNHAM

The first major construction loan was to the Ventura Marina (now known as Ventura Harbor). The State was approached, not to do a feasibility study on the Ventura Marina, but to join with the city in making an immediate loan for acquisition of the land area in which the harbor was to be built. This was a very interesting case because the State Division of Highways was building the coast freeway nearby and required about a million cubic yards of fill. They said that, if the city could get started soon enough, they would excavate the harbor for them at no cost. A contingent of local people went to the State capitol one day and presented their case, and they returned that same night with a check for $900,000, the amount required to buy the land. That was the beginning of the Ventura Marina, and although the State had little to do with the design of it, it enabled the city to get their marina built. That marina then was designed by John Blume and Associates. As I recall, funding of construction, other than basin excavation, was not by loan from the State's Small Craft Harbor Division but by a harbor district bond issue. However, I didn't get into its actual construction or the design.



[illegible] of Groin [illegible]

Completion of Ventura Pierpont Groin Field

Shortly after I joined Moffatt and Nichol Engineers, I had occasion to review the design of Ventura Marina at the request of a bonding agency. I noted that the plan made no provision for bypassing sand and called John Blume to advise him that I could not recommend that the bonding company join in on this to make the loan under his entrance plan. I arranged to meet with Blume at the site, and we discussed the problem for about 2 hours. However, he was adamant that the plan was satisfactory as existed and would not change it. The bonding company accepted my report and turned down the loan. I understand that it was eventually bonded by some firm on the west coast. However, the original bonding was to be backed only by harbor revenue, and when the city found that no one would buy them, they voted general obligation bonds, and on that basis they obtained their bonds without difficulty.

The lack of an adequate sand-bypassing system turned out to be the downfall of the plan. As I pointed out to them, they were soon in deep trouble with harbor shoaling and unable to maintain the entrance. The downcoast beaches were eroding and eventually it became necessary to build the offshore breakwater similar to what was done at Channel Island Harbor.

As remembered by WILLIAM J. HERRON

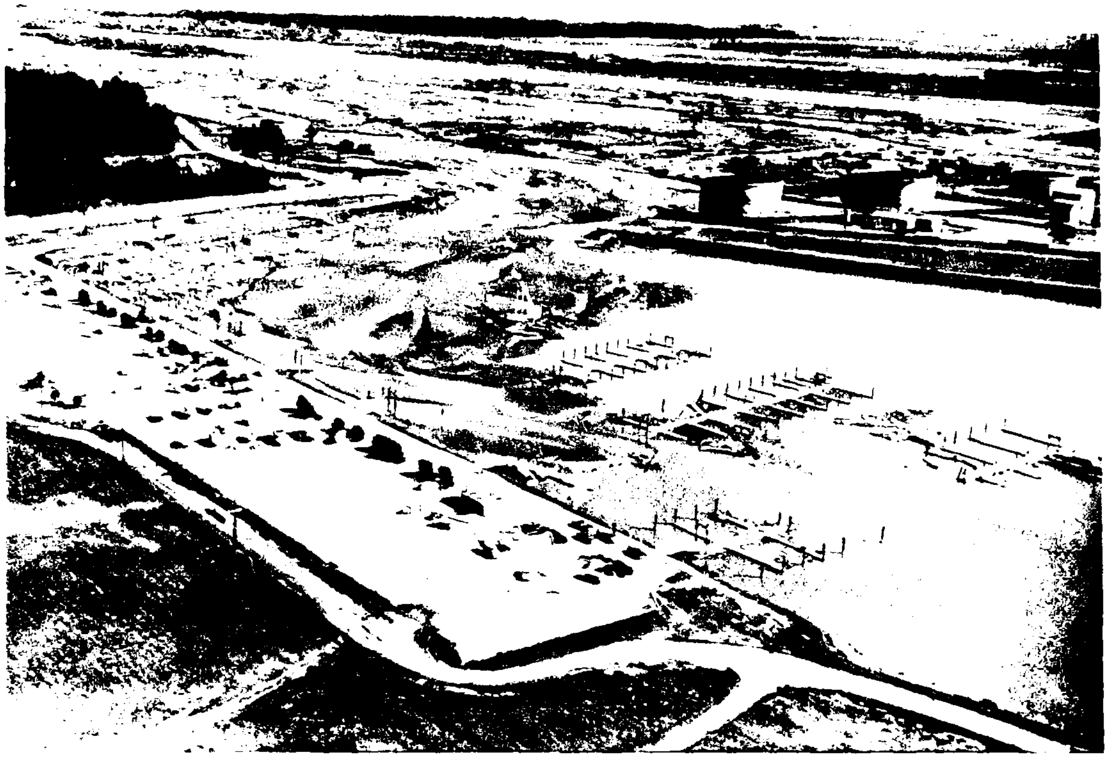
The problem, of course, with a groin field is how do you anchor the downdrift end of such a field? And in this case this was done because, in conjunction with the construction of the groins, planning was underway to build a harbor known as the Ventura Marina just above the Santa Clara River and this would form a downcoast anchor for this groin field. This has only been partially successful because, for what reason I do not know, the designer of the Ventura Marina adopted a very flat alignment for the north jetty which, instead of allowing the jetty to act like a groin, caused waves to be reflected upcoast from the north groin and created a confused wave pattern. There is still confusion as to the erosion and accretion patterns in the area of the most southern groin as it relates to the Ventura Marina. The Ventura Marina is one of the few harbor projects in southern California not originally designed by the Corps of Engineers. It was sponsored by a City Harbor District and was designed by a private engineering group and the original design was simply a pair of arrowhead jetties. This was, in part, discussed by Jim Dunham in his statement.

At that stage of design, I was in charge of permits for the Corps of Engineers and so we participated in the consideration of the design and construction of this harbor from the Corps of Engineers permit viewpoint. I was much concerned at this time, because we ran into several permit actions where the engineering was not always what we would consider adequate for proper recognition of wave forces and littoral transport activities. But the guidelines in those days for issuing Corps of Engineers permits was very narrow and our only consideration was the impact upon the "existing navigation" and the fact that it might create a new navigation problem was not considered as within our area of authority. This has now been corrected and the Corps now has a broader range of authority in this field. As I remember, during their permit stage, the designer had moved from his opposition to any type of sand-bypassing, as discussed by Dunham, to a consideration of 40,000 cubic yards per year. Through the permit discussions he did raise this estimate to 200,000 cubic yards per year, but never really developed a solid method on how to accomplish this bypass action. So, when the harbor was completed, there was no established procedure for the city to follow to maintain the harbor adequately.

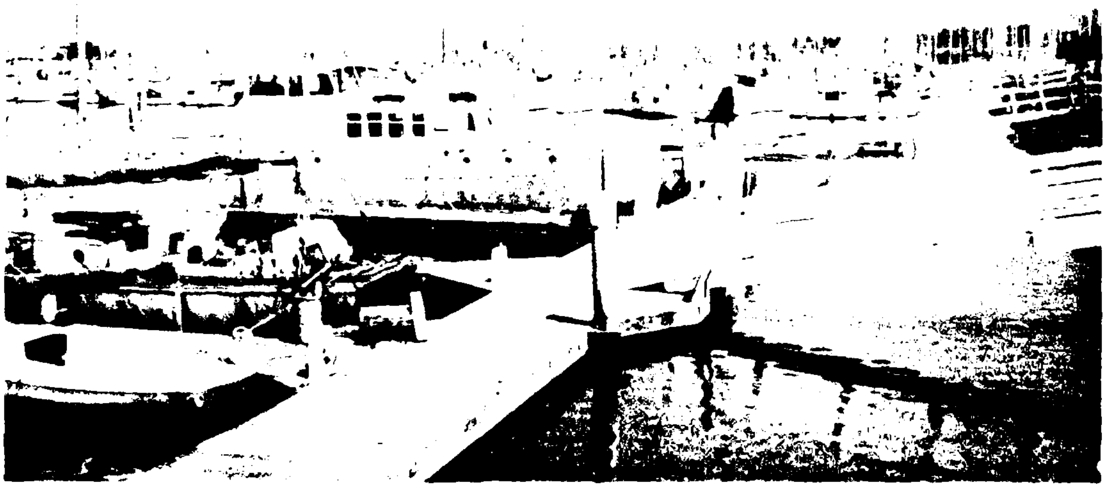
I think perhaps looking at historical coastal problems, another pertinent point illustrated at Ventura Harbor is the trap that is very easy for a designer to fall into. The original design of this harbor, which was really carefully considered and based on the knowledge of that time, and we were talking in the 1950s, was for a pair of simple arrowhead jetties. However, as they reached the final design and cost-estimating stage, it was realized that there was not adequate money to accomplish the original design, so the arrowhead jetties were shortened slightly. Then, when the job went to bid, again the lowest bid did not adequately fund the total length of these jetties, so the jetties were shortened again to come within the available funds. Unfortunately, neither the location nor the alignment of the jetties was not changed so this resulted in a pair of arrow-head jetties which not only had a wider entrance than originally planned but also terminated in shallower water than originally planned. So, almost before the harbor was finished, sand was coming around the north jetty and shoaling the navigation channel.

Perhaps it was fortunate that the shoaling problems at the entrance delayed full development of the interior harbor because this was at a period of time in southern California when there was a very heavy demand for berthing of recreational boats. In 1969, we had one of the most severe floods experienced on the Santa Clara River. The flood waters broke through some very light levies into the north floodplain area of the Santa Clara River, and then proceeded to discharge right through the partially occupied inner basin of the harbor and out the entrance.

All of the floats in the main basin were destroyed and many of the boats tied to the floats were destroyed; others were swept out to sea, and a very few were recovered. The basin was also filled with a mixture of sand and raw sewage as it broke the main sewer line from the City of Ventura to the treatment plant adjacent to the harbor.



Santa Clara River Flood Breakthrough Into Ventura Marina From Storms of 1969



Same Area, Now Known as Ventura Harbor (1985)

It is not clear whether this marina was really designed to take into account the possible major floods of the Santa Clara River. The harbor was immediately to the north of the river and obviously in line with the floodplain, but there is no indication in either direction as to whether that was considered. The only historical thing that might have influenced it was the 1938 flood which had breached its banks to the south and flooded the area to the south of the Santa Clara River rather than to the north.

Under Federal emergency laws, the Corps of Engineers was directed to dredge out the flooded portions of the harbor because of the pollution caused by the breaching of this main sewer line. They not only cleaned out the harbor but the material was used to build a very, very substantial levy between the harbor and the river, protecting the harbor from such type floods in the future and also protecting the city's sewage treatment plant.

At about this time, 1968, Congress directed the Corps of Engineers to take over the navigation features of this harbor and do a new study to determine how to protect the interior both from shoaling and severe wave action. The Corps came up with a concept very similar to the one that had been so successful at Channel Islands a few miles to the south. They did take into account the fact that, when there was a major flood on the Santa Clara River, the delta at the mouth of the river would extend upcoast and, perhaps, affect the entrance to the harbor, but they did not consider adequately the tremendous amount of sand that might be moved upcoast during flood discharge.

Even though the corrective offshore breakwater was built in about 1971, the shoreline still has not retreated to where it was before the 1969 flood. A substantial amount of that flood delta is still there. I might add actually that it is two deltas. The Corps of Engineers measurements indicated that some 14 million cubic yards of sediment were dumped into this delta as a result of the 1969 floods, but also in 1978 an additional 4 or 5 million cubic yards were dumped into the same area. Of course, as had been recognized in the studies, the material deposited at the mouth of the Ventura River moves very rapidly downcoast and joins the Santa Clara delta temporarily to further compound this effect.

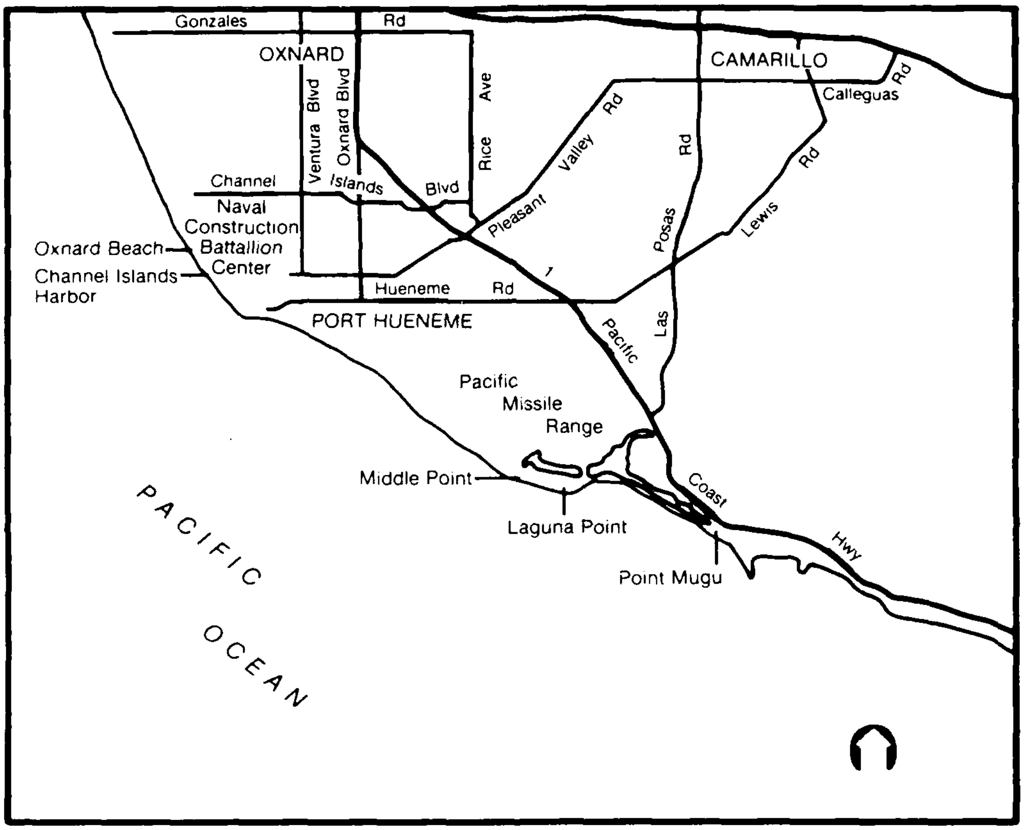
The Corps of Engineers study approached the sand bypassing problem by two methods; one based upon a general analysis of littoral supply in that area which was considered to average about 300,000 cubic yards per year coming from the Santa

Barbara shoreline, a long-term average of about 100,000 cubic yards per year from the Ventura River, and about 800,000 cubic yards from the Santa Clara River, for a total of about 1,200,000 cubic yards a year. Being that the harbor was upcoast from the Santa Clara River, it was considered that an annual average bypass of 400,000 cubic yards per year would adequately maintain this harbor and the adjacent beaches. This was further checked by using the approach developed by Dr. Inman of considering the resultant angle of wave attack and the wave energy versus sand movement, which checked out at about 400,000 cubic yards per year. So, the sand trap was designed to hold about 800,000 cubic yards of sand. The concept was to come in every 2 years and dredge the entire sand trap area, including the entrance channel, move the sand on downcoast below the Santa Clara River, and put it back on the beach so that it would continue to supply the downcoast beaches.

I am disturbed, when looking at the overall sand-bypass figures since 1971 when the breakwater was completed, to find that this program has really not been followed. Between 1971, the completion of the breakwater, and 1977, the average annual dredging has only amounted to about 300,000 cubic yards per year of pay yardage. This is probably somewhat in the order of 370,000 cubic yards per year when you take into account over-depth dredging and the daily introduction of littoral supply, which is not taken into account in pay estimates. But this is less than what was originally planned in the Corps of Engineers document for long term maintenance, and does not take into account the still remaining impact of the upcoast section of the deltas of the 1969 and 1978 storms.

The harbor is definitely not functioning properly. The entrance shoals very rapidly and there are very severe wave conditions in the entrance channel, and there have been two or more deaths by drowning caused by boats capsizing in this entrance channel since construction of the offshore breakwater in 1971. The harbor is under restudy, but I still must hold to a personal opinion that the dredging of the sand trap has not been adequate. If this were done, taking into account the still remaining effects of the 1969 and 1978 deltas, the plan might work without very expensive additional works. It might be said, in all fairness, that this plan was developed before the oil price rise of 1973, and the cost of dredging has probably tripled since conception of the original plan. The financing of this kind of bypass dredging is becoming more difficult every year.

OXNARD TO POINT MUGU



CHANNEL ISLANDS HARBOR
As remembered by KENNETH A. PEEL

Ventura County wanted the erosion of the beach downcoast from Port Hueneme stopped and they also wanted a new small craft harbor or marina.

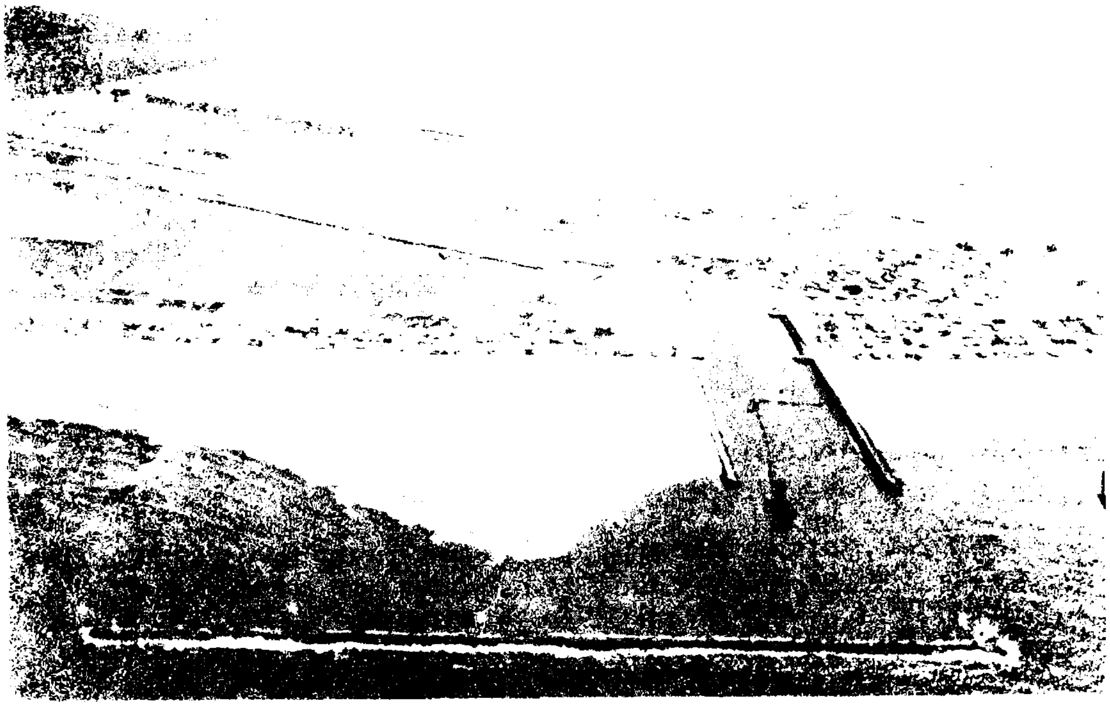
We combined both problems into one. We proposed to dredge the harbor, which was done, and build the entrance jetties with a sand trap breakwater going upcoast from the north jetty. That was with the idea that you could put a little dredge in behind and pump the material to bypass both the entrance to the new harbor and the Navy entrance. We were going to put in a submerged pipeline underneath the entrance to the Navy harbor and then bring it up and pump the drifting sand from the trap on downshore. That was about what was done and the sand trap worked. We could estimate, from the figures we had, the rate of the drift of littoral sand pretty accurately. We designed the sand trap to hold the material for at least 2 years between the dredging programs, and by combining that with the dredging from the new harbor, the erosion problem was corrected for quite awhile and then the harbor maintenance continued to make it permanent. This program also protected the base down at Point Mugu because they were starting to suffer next, and so the whole problem was fairly well whipped.

CHANNEL ISLANDS HARBOR — PORT HUENEME
As remembered by JAMES DUNHAM

My first visit to the general area was during my early days with the Los Angeles District, when we were asked around 1940-1941, I believe, to study the program.

The jetties were built around the 1940s, I believe. The jetties had to be built first, then the harbor was excavated behind it. I went up there with Mr. Bebout and Kenny Peel, as we had been asked by the Navy to take a look at the erosion that was going on and was threatening the Maritime School. We saw what was happening all right--the erosion was pretty severe, and we diagnosed it immediately as the cutoff of the supply of sand from the north by the Hueneme jetties. We recommended that, if they were to do any more harbor dredging, to place the material to the south of the jetties, to first revet the whole area to prevent loss of the Maritime School. This was done, and I believe there was some other arm of the harbor dredged out and the material was placed on the beach. It didn't last long, and continuous surveys were made then to document the rate of erosion and where it was going.

Within about 10 years after the harbor had been built, the downcoast shoreline was held by rock revetment for a distance of about one-half or three-quarters of a mile, just beyond

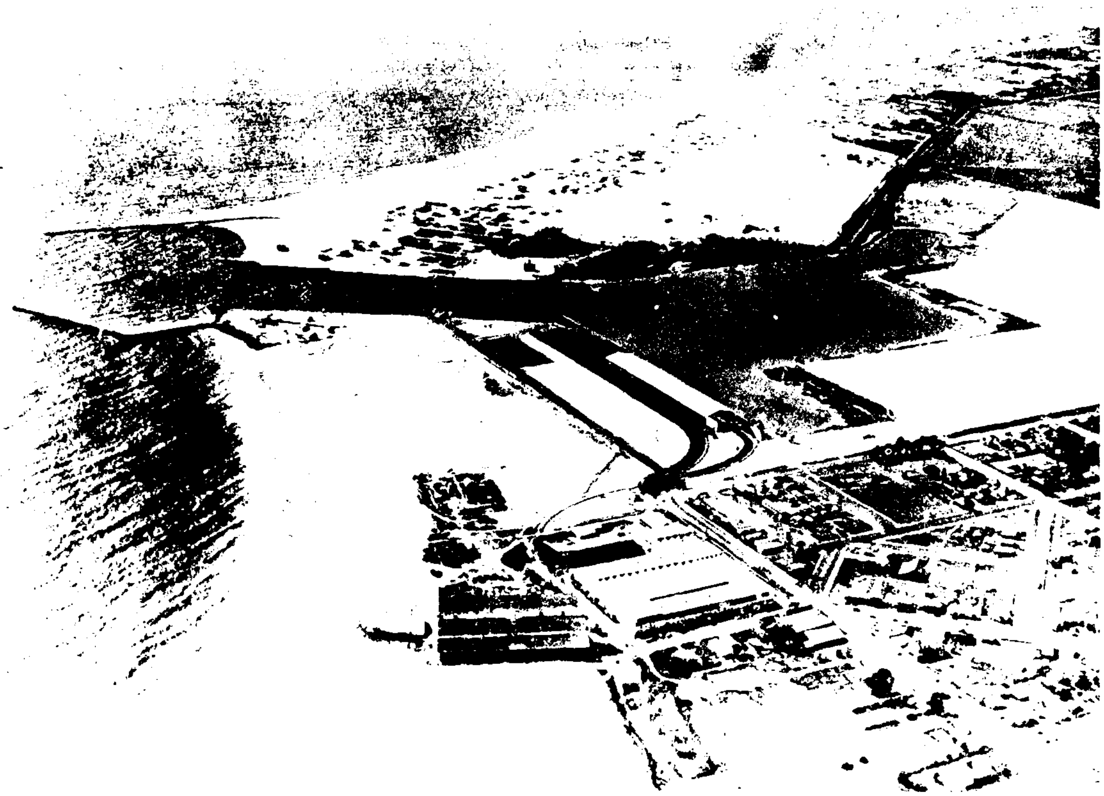


Channel Islands Harbor Before Dredging (1965) that it eroded, I believe, nearly 1000 feet inland and the erosion then tapered off down toward Mugu. At first, the main problem was to determine what could be done to halt the erosion within the City of Port Hueneme. Later, as erosion continued down the coast, the personnel at the Point Mugu Air Missile Test Center became concerned, especially when it began to erode toward and threatened to undermine their missile launching facilities along the beach. The Corps was asked to make a study of this and determine what best could be done. Because the erosion was caused by Federal structures, the Federal Government bore the cost of the study.

Recognizing that the best way to protect the eroding area would be to get sand on the downcoast beach again, we had the idea of combining a new small craft harbor with a Federal harbor and then bypassing the sand past both harbors to the downcoast beaches. That plan was recommended in the survey report, approved by local interests, and eventually built.

The entrance plan for that was the one that utilizes the offshore breakwater as a sand trap, and the basis for its design was taken from results of the Santa Monica breakwater. The Santa Monica breakwater had originally been built 2000 feet from shore—the bulge behind it came out about half way. We decided that this seemed like a good spot to put a sand-trap breakwater, and so the Channel Islands breakwater was put about 2000 feet offshore and was made about the same length as the Santa Monica breakwater, except that it was extended southward about 200 feet in order to give partial protection to the entrance to the harbor. This made it possible to shorten the north jetty and save some costs that way. It also enabled us for the first time to get an accurate measure of the rate of littoral drift in that area. We were all quite surprised when it turned out to be about twice or three times what we had expected.

In conjunction with developing the design, economic justification, funding, etc., for the two harbors' sand-bypass system, we also undertook an experimental field test. We saw this nice wide expanse of sand extending north of the Port Hueneme jetties—it was so wide and dry in fact that the sand was blowing up dunes that were so high it was possible to walk up them onto the roofs of the houses along the shore. In 1953, I suggested that a contract be let to dredge a lagoon behind the area by dredging an entrance from the harbor channel around the inner route of the north jetty. It was thought that the contractor might prefer to try to come in directly from sea, rather than going around the back end of the jetty. The main reason for leaving this option open was that there were a number of buried utility lines which the contractor would have to remove and maintain with overhead lines if he dredged behind the jetty.



Port Hueneme Harbor (1940)

We hoped in this manner to get about 2 million cubic yards out of the area for downcoast beach replenishment. When the dredge had cleaned out all the sand that was possible to get, the plan called for dredging a number of channels at the north end of the lagoon out to sea as far as the dredge could safely operate in the surf zone before the adjacent beach started collapsing. Then the dredge would retreat to the lagoon and take another seaward cut just downcoast and proceed in this manner until as much of the outer bar was removed as possible; then finally let the waves breach the rest of the bar so that littoral drift wouln't bypass the dredging area along an outer bar and leave the lagoon stranded. What we hoped for was that the shoreline would readjust to the dredged slope along the inside of the lagoon. Soon after this plan was developed, I retired from the Corps, and my replacement, Bill Herron, executed the plan.

As remembered by ***WILLIAM J. HERRON***

As we discuss Channel Islands Harbor, we need to consider it in conjunction with Port Hueneme. These two harbors are well documented and I think I might limit myself more to the discussion of one experimental part of this which is not that well documented. That was the attempt in 1953 and 1954 to dredge an intercepting lake just upcoast from Port Hueneme, as it existed at that time, and bypass the sand to the seriously eroding downcoast area. The plan was, as I remember, to take out 2 million cubic yards of sand and bypass it on downcoast. The bidding contractors were given the choice of either dredging their way around the inshore end of the north jetty and out into the beach or they could come in from the open sea. The general concept was to leave a protective beach berm, dredge a large lake area in the fillet of sand against the north jetty, and then as the last effort in moving out, use the dredge starting at the north end to breach this barrier beach and then continue to breach it downcoast.

The engineered concept was that on a large hydraulic dredge—and I am thinking in terms of 18- to 27-inch dredges—the cutter head is far enough out ahead of the barge of the dredge itself that the dredge would sit fairly steady in the quiet water while the cutter head would reach out into the surf and dig a channel ahead of the dredge. It would thus assist in the destruction of this berm and the ultimate movement of all the yardage downcoast. This did not work and we almost lost the dredge. Fortunately, one deep channel was created by the dredge but the barrier was disappearing faster than the dredge could keep up with it. At that stage the concept was cancelled and the dredge escaped in the one deep channel that was successfully dredged.

Unfortunately, while the barrier was destroyed it was only destroyed to about the 2-foot depth, so we did not get the cleancut fall back on the new inshore area of the lake that we anticipated and a great deal of sand continued to move along the berm and off the north tip of the Port Hueneme jetty into the submarine canyon where it was permanently lost. Also, it created some later design problems because it did not give us a true indication of the rate of littoral drift in this area, particularly to the north of the jetty. The figures were rather consistent south of the jetty; the erosion was in order of 1,200,000 cubic yards per year, but was not anticipated that it was nearly that severe on the upcoast side.

So the Channel Island Harbor, when it was designed, was anticipated to have an annual erosion rate of about 400,000 cubic yards per year. This was increased to about 700,000 in the design memorandum stage, but experience indicated that it is more in the order of a million to 1.2 million cubic yards per year. However, the construction of the Channel Islands Harbor with the entrapment of sand, and then the biennial bypassing of sand into the downcoast beaches, has been a very successful project although, of course, with the increased cost of energy, expensive. But it is more than justified by the 2000 or so slips created in Channel Islands Harbor to say nothing of the prevention of additional severe erosion downcoast from Port Hueneme.

An interesting sidelight of the sand bypassing efforts at Channel Islands and Port Hueneme was that, during one episode, we also did the first maintenance dredging of Port Hueneme Harbor since the end of World War II. The dredged material was placed on the beach, fortunately most of it in front of the seawall fronting the Navy property. To our embarrassment and concern about 3 months later, several young boys brought home some samples of 20- or 40-millimeter ammunition. This turned out to be live ammunition that had passed through the dredge line and dumped out onto the beach and nobody any the wiser until the sand eroded and exposed these rounds for the youngsters to pick up. Fortunately, nobody was hurt.

The Navy had another interest in this project beside Port Hueneme and that was the protection of some ammunition igloos that had been built on the beach about 8 or 9 miles south of Port Hueneme. These were nearly destroyed in the mid-1950s and as a portion of the dredging of the lake—a half million cubic yards of sand deposited directly at that point for immediate protection. At the start of the regular bypass program and construction of Channel Islands Harbor, 1961 to 1963, it was anticipated that this sand could be deposited immediately downcoast from Port Hueneme and that littoral drift would carry it southward and it would arrive at the igloos in time to continue protection of this area. This was again based on the old concept of about half a mile to a mile a year of mass transport. This turned out to not be so, and should have given us a clue that perhaps mass transport was even slower than we thought it was, because by about 1967, the igloos were again in serious danger of being eroded and undercut and emergency measures had to be taken.

With our assistance, the Navy designed and built a set of three groins in front of the igloos and partially filled them with sand. This protected the area in front of the igloos but the upcoast sand still had not arrived and so erosion started immediately below the new groins and threatened the access roadway. Then, instead of continuing the groin field, it was considered expedient to build a revetted wall from a few hundred feet to allow sand to bypass the groins and accumulate against the wall and this seems to have been the pattern in this part of the shoreline. Sand is moving through regularly but it has really not suceeded in rebuilding the beach.

The shoreline with the help of the groins has been stable but on occasion the downcoast revetment is exposed and has continued to serve its purpose. All these projects together have apparently succeeded in correcting the damage caused by the building of the Port Hueneme jetties to the lip of the submarine canyon.

PORT HUENEME

As remembered by KENNETH A. PEEL

Port Hueneme was completed by the Navy as a Construction Battalion Base. It started as a civilan harbor sponsored by the Oxnard Harbor District in 1940.

Colonel Leeds designed it and he planned on dumping a certain amount of material downcoast from the breakwater with the idea of using that to feed the beach. But he totally underestimated the rate at which it would recede out there. This is another place where a submarine canyon came in right to the mouth of the harbor, and the wave action would come in there and fan out so that it concentrated the wave action on both sides. The wave action on the upcoast side didn't hurt any because there was sand coming into it all the time.

It would, as far as I could see, stir up some sand but that would slough off into submarine canyon because the breakwater went right out to the edge of it. But it did build a huge fillet of beach sand upcoast from that. Downcoast, with the concentration of the wave energy hitting right into the old town of Port Hueneme, it just started cutting right back. It got back just about to where the Coast Guard had built a school on the fill that they had filled in with sand from dredging the harbor. The beach started to recede to where it

Port Hueneme Area (1929)

was threatening to take that school out. That was the time when General Kingman and I stopped to look at it, and we told them then "the only thing you can do to protect it temporarily is to build a substantial seawall in front of it. Now that is with the understanding that, wherever that seawall ends, erosion is going to start in again."

In the meantime, Colonel Leeds had recommended that they drive piling along the front of it—a permeable pile bulkhead. All that did was cut the beach out and let the piles dangle where the bulkhead had been built. But I think it had speeded up the erosion rather than slowed it down. Colonel Leeds didn't quite understand what he was doing there; and, of course, nobody else did either, I guess.

We recommended a stone seawall down in front. Well, that was built by the Navy and it did stop the erosion and stabilize the shoreline. But at the south end, they just extended the wall to where it protected all the Navy property, and the beach started cutting back again, back towards the center of town. That was when we were considering the need for a county small craft harbor, as well as how to protect the shore.

As remembered by OMAR LILLEVANG

My first involvement in the Oxnard—Port Hueneme area was in the Spring of 1939, when the construction of the harbor at Port Hueneme was getting started. I spent about 15 months in the area and my first home as a married man was there. My function on the staff of six—who were administered and supervised by and were the responsibility of Colonel Leeds and his partners, the designers of the harbor—was as his construction office engineer. However, it was not a white shirt and necktie kind of a job; one might be in the office for a day or so and then for 3 days out behind an instrument on a breakwater getting salt water all over everything, or in a boat taking soundings, which later got reduced at night or on weekends. It was an extremely interesting experience very early in my career. It included the construction of quarry stone breakwaters being built as a technical project rather than as a pile of rocks; dredging of an area inland that was not accessible by large dredges and had to be done by a small dredge and pilot cuts; and revetting of banks on a program that limited money. It also included building of wharfs with all the necessary pile driving; erection of transit sheds; construction of trackage; paving and grading walls; waste disposal; water supply; and a whole gambit of civil engineering that every harbor project under construction or design involves. It included the special aspects of sea coast and harbor engineering involved in the hydraulics of water motion; its deflection and interruptions; the special problems in excavation and fill construction involved in hydraulic transport by dredges; and the concerns over environmental impacts.

The plan for Port Hueneme had evolved over a number of years and Colonel Leeds had been the conceiver and was the designer. He assigned the details of preparing plans and specifications to the staff; two or three senior engineers carried the brunt of it. From the partnership standpoint, his partner, A.K. Bernard, who had succeeded the original Bernard, his brother, gave it such supervision as was required by a principal in the firm. I don't believe Bernard was deeply involved with the technical aspects of design. He was also the one who shuttled back and forth for the firm during construction, and the one I saw most. His contacts then were also liaison between the resident engineer, a man named Forrest S. Harvey, and the Harbor Administration and trustees.

The west breakwater at Port Hueneme is notorious for the manner in which it acts like a plough on a conveyor. It was extended out, in what was an excellent design concept as far as establishing a navigable channel is concerned, to terminate at the break of a steep walled submarine canyon, Hueneme Canyon. The walls of this canyon are so steep that divers reported inability to stand upright on them without sliding down. The jetties came and terminated at the edge of this canyon in the days before the involvement of submarine canyons in disposal of littoral drift was understood. Colonel Leeds did realize and said in his reports to the Harbor Board and to the predecessor, a private developer that had tried to get the thing built under Reconstruction Finance Corporation support, that there would be a sand problem that needed to be taken care of and that the property downcoast needed to be watched. I know he was not prepared for the magnitude of the problem. A beach on the downcoast side that was not protected receded about 700 feet in a relatively few numbers of years.

There are reports on the original design—I believe one might be able to get one in the library of Berylwood Investment Company, the headquarters of which is in Somas, California. That is the company that was a family, an agricultural and development entity of the Bard family. Mr. Richard Bard is the man I talked about who tried to get this harbor established as an RFC thing, a private harbor corporation. He was unsuccessful and was instrumental in the formation of Oxnard Harbor District so it could be pursued as a public program and who contributed the land, without cost or strings, on which the harbor was built. Although that company is a long time dead, its files may have those reports. I doubt that the Oxnard Harbor District has them, though its possible. If they have them, it's a question of knowing where they are. I know that during the war years when the Harbor District met only periodically to authorize payment of interest on bonds and had nothing to do with the harbor anymore, it having been taken over by the United States Navy, many of the records including maps and drawings were in literally a chicken coop near Somas that caught fire. The fire was quenched and I got and copied for the Leeds, Hill and Jewett's archives years ago prints of tracings of the high tide lines surveys that we made very rigorously and periodically on the beach during construction. They were water stained and damaged but were still legible for making prints. I don't know what got destroyed in that fire and what got salvaged, but that was an episode such as is not really uncommon in the history of projects. The biggest problem, of course, is the continuity of interest in keeping such things.

The jetty was built from land out. The stone for it was hauled from Catalina Island on flush deck barges. I believe they started trying to use a pocket barge for dumping a couple of loads but it was not successful and they went entirely to flush deck barges, wooden barges, that had been built by the contractor, then called Rohl-Connolly Company, to do work at Los Angeles Harbor.

The stone was loaded at the quarry in Catalina. Leeds, Hill and Jewett had two full-time inspectors at the quarry and the stone was hauled in multiple barge trains to Hueneme, a sea distance of about 60 miles. There the barges were anchored at fixed anchors offshore until they could come alongside the big old steam crane barge, which has been called "Red Rooster" and was transported from the barges by clam shell when it was core stone, and by orange peel when it was select pieces. The work was all done from the water. So, it was extended from the beach—wait a minute, memory is faulty—there was a gap left, they started along the trunk at various stations coming up and with it working toward the beach. They worked toward the beach and as they came closer, the velocity of the longshore current became stronger and stronger through that gap. The result was that we used something like 35 percent to 40 percent more rock getting through there than the previous estimates had assumed we would.

The erosion caused by littoral current concentrated into a smaller gap until finally the driving force to carry was inadequate to maintain the flow and began to accumulate sand on the seaward side and rather rapidly until the beach built out and began being lost into the submarine canyon. That loss then, of course, was the element that contributed to the progressive erosion on the downcoast side. Erosion, very severe, began to be telegraphed downcoast. Eventually a solution was asked for, primarily by Navy interests, who originally were slow to accept the idea that they were in long-term jeopardy, which was a bit subtle. People like the Corps of Engineers, Bill Herron, and his predecessors, could see the trends and understand what was happening, what the eventualities were. The Navy was a long time in accepting that and finally when they did, remedial measures were asked for—and that's another part of the story.

The civilian Hueneme Harbor went into business with a harbor manager hired from the middle west. He came out here confident that the west coast shipping operators and harbor managers didn't really know how to handle the International Longshoremen's Union. So, to teach them a lesson how things were done in the middle west, he ignored the International Longshoremen's Union and signed a contract for the Harbor District with an A. F. of L. waterfront union. The result was that the Longshoremen's Union immediately made that a hot cargo port and, from the day it was opened for business, no ships were willing to go in for fear of getting tied up with hot cargo and strike prohibitions. The harbor sat from 1940, its dedication date, until the first of 1942, virtually unused except for transshipment of cattle from Santa Cruz Island and the receiving of kelp from harvestors that were bringing it in and discharging it for processing into a food product.

The United States Navy took over the harbor in order to have a depot for the United States Navy CBs to support the construction program in the Pacific during World War II. At the end of World War II, after a short period, the Harbor District negotiated a lease for the original wharf from the Navy and went back into a limited commercial harbor operation on that wharf.

My next involvement at Hueneme was when that Harbor District then asked us to come back to determine (and I was the principal who did it), whether or not it was feasible for a civilian harbor operation of larger scope to function within Hueneme Harbor and use the harbor waters without impairing the assigned mission of the United States Navy.

The report that we worked up and which I submitted was used as a negotiating instrument with the Navy in order to successfully accomplish a recovery of ownership of land on the south side of Hueneme Harbor by the Harbor District.

They went into expansion designs and those expansions were built and it is really a thriving operation now, limited only by its size and the political acumen of its Board of Directors. Because they still have problems with the Federal agencies over customs services and over freight schedules for railroad and trucks coming into the harbor, they've got competitive problems with a juggernut in the political arena, i.e., the Long Beach and the Los Angeles Harbors. They are keeping their heads up and apparently it is profitable and working well in conjunction with the Navy.

I had nothing to do with the detail designs of the expansions. That was done by others.

POINT MUGU SLOUGHS

As remembered by OMAR LILLEVANG

During the time I was at Port Hueneme, and going back now to the 1939-1940, Colonel Leeds had been retained by what is still the largest law firm in Los Angeles--and one with a strong specialty in tidelands law--to provide technical services to them in a dispute that was going on between government agencies and several owners of land in what had been the Wilmington slough. The dispute over where tidelands boundaries would be placed was stimulated by the fact that oil had been discovered on land that, when originally established, had been thought of as having little, if any, value. Suddenly it had great value and where the tideland boundary could be placed was worthy of a considerable effort. In the meantime, before this dispute was stimulated by the oil values, there had been, of course, extensive tamperings by man's works with the location of high tide line as compared to the natural alignment of those sloughs. They no longer were recognizable as sloughs, and to provide himself with the means of illustrating to the court if the thing came to trial, what such a natural slough looked like and what its tidal regime might be like, Colonel Leeds made a determination that using an existing virtually untouched natural slough and tracking its tides for an extended period of time would be a useful bit of demonstration evidence. So he arranged for a cooperative tide survey in the sloughs of Point Mugu.

The Coast and Geodetic Survey supplied the tide recorders and agreed to interpret, file, and report on tide records taken in the slough and in the ocean if the Colonel would supply the installation and operation of those records. Being only 10 miles away at Port Hueneme, I was tapped to operate those recorders; and I did for 13 months, with daily calls 7 days a week to each of them. Three were in the lagoon and a fourth on a pier that was built in the ocean. That was before the Navy took Point Mugu. It was owned privately by some people who operated a fishing camp out near the entrance of the lagoon, and who had a rickety old pier that was not suitable for our purposes. We did put a tide recorder on the pier, however, and three of them inside various parts of the lagoon. The harbor assignment that I had did not allow me to take time out during the day to do this operation, so I got up at 3:15 every morning and left a warm bed and tended the tide gauges and got home to a 7 o'clock breakfast. I then went to work at the harbor about 7:30 a.m., and as on any construction job, was there until the work was finished at the end of the day or into the night. So it was a pretty rough go but this extra income from the tide gauge recordings paid for my bride's first appliances in a manner that we could not have afforded in 1939 any other way.

Port Mugu Sloughs (1966)

Continuing with the Mugu Lagoon Tide Survey as a cooperative venture with the Coast and Geodetic Survey, they did, in fact, take the 13 months of marigrams, that was 13 months on the lagoon recorders and 12 months on the ocean recorder. The reason the ocean recorder was 12 months was that the program included September 21,1939, when the most violent southern hurricane that has ever gotten as far north as southern California before turning inland, hit the Los Angeles, Orange, and Ventura Counties coast, and raised hell generally. It took out the pier at the little Mugu Fish Camp on which our tide recorder was and killed one of the partners in that Mugu camp operation who was skipper of their day boat. The boat broached in the surf when he was trying to bring his passengers in and beach the boat. All 40 aboard were drowned including the skipper. So, they were really on their uppers with their fishing shanties knocked galley west and their restaurant gone and their pier down. One of the plus aspects was that Colonel Leeds' client was so eager to continue with this program and get a full year of records that he paid for a brand new pier, which was built in short order. I believe the pier is still there. Obviously, it has been maintained several times but as a recreational facility for the Navy base now.

The tide data taken in the lagoon were extremely interesting, showing the long lag in the movement of waters in tortuous channels and the out-of-phase nature of the tide patterns farther back compared to what they were in the open sea.

After World War II, we were back there again and I was project engineer on an early contract for the Navy, after they had taken it over as Pacific Naval Air Missile Test Center Headquarters. Our job was three or fourfold. One was to make a very detailed topographic map of the site, at something like 50 feet to the inch with 1-foot-contour intervals of all terrain both above and below water.

It was a typical, tortuous, tidal slough with the channels from the air or on a map looking like a plate of spaghetti. Not really interwined but everything running every direction tortuously and then with the low marsh grass growing alongside. Somebody in our office, not versed in coastal matters, came up with the idea that it should be mapped like they had learned to map the reservoir for contents at Hoover Dam. It may be that somebody at the aerial survey firm that had done Hoover Dam was a part author of this idea. They flew over it with the idea that they would fly it once each hour on a major springtide ebb and take the waterline for contours. When they tried to model this thing in their stereo plotting devices, the operator went crazy because he couldn't establish a model with anything that looked to him like parallel planes. They came to me with, "What's the matter up there? Take the guy out in the field and see what's going on." I already had a pretty good idea but they hadn't asked the Colonel or me before they schemed this thing up. When I took him up and showed him that 3 hours after the peak of a higher high tide in the ocean, there was still an inland flow at a point a mile back, it was still strongly flooding there but it had been ebbing for 3 hours in the ocean, he began to understand his problem.

We then had to go and map this whole thing by plane table procedures and this is of interest in the coastal engineering aspects, in that, with these horrendously tortuous features that had to be faithfully mapped at 50 feet to the inch and 1-foot intervals, the question was how in the world could one find time to get enough rod shots on a field plane table operation in order to outline these things faithfully. We resolved that by using the aerial photos and blowing them up to plane table scale, and it was a very early use of mylar film as a plotting material. We laid it over the aerial photos--they were scale printed--and we were then able to map out the outline of these channels extremely well and take a lesser number of shots for elevation and get the whole thing done. Then, the next day, I got curious. I was looking at the C & GS smooth sheet for topography done in that area in the 1800s, and saw that it was done in meticulous detail in an area that couldn't have been worth 50 cents an acre to anybody. I wondered why the money had been imaginative (sic) or definitive. I couldn't believe they were and yet they looked so faithful that I decided to try it. I had that smooth sheet blown up to the scale of our scale-controlled aerial photo and printed on translucent-transparent, not just translucent-trends apparent plastic film, and laid it over the photo and it was absolutely astounding the closeness of fit. The old field surveyors in the earlier mid-1850s had mapped that thing with such care that we could have used the same year in order to outline the channels nearly 100 years later.

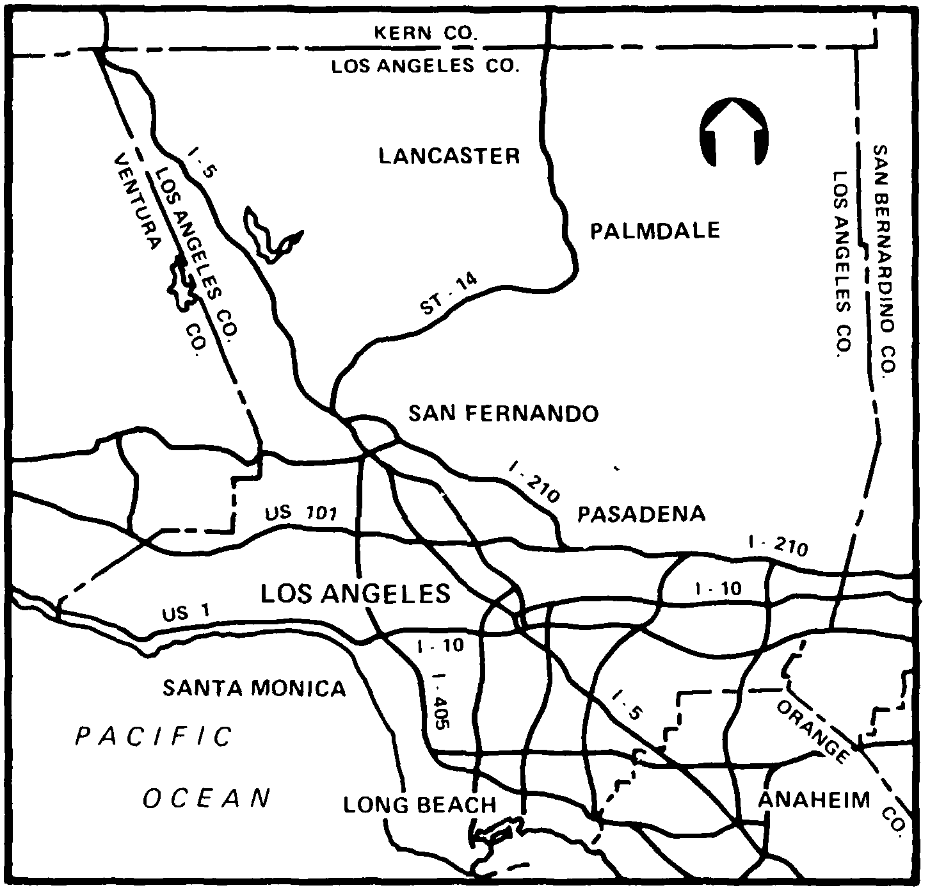
Besides the mapping, we were also called upon to do wash borings to determine the dredgeability for expansion of Naval facilities and to determine whether or not that which was dredged would make suitable fill for expansion of construction areas. We worked out designs of rerouting of the major streams that go through Calleguas Creek, which was occupying a lot of land on its meandering, that the Navy thought could better be used in a reasonable geometry of laying out the facility and prepared designs for rerouting that creek and for construction--and they have never been used.

Also there was a water supply question. At least one concealed water tank up on the hill behind Mugu stems back to those studies.

That, I think is about as much as I have to say about Lagoon Mugu except that the aerial photos taken on these 1-hour intervals in the aborted scheme to map by water level showed some very, very interesting flushing phenomena at the mouth, and when one plots the tide curve that was observed at the ocean pier and had been observed at tide staffs inside the lagoon during the progress of those aerial photos—mind you this is several years after the recording tide survey—so we were using staff observations by a man observing every 15 minutes rather than recorders. One can easily see the reason for the lag in time when you get the explosion of sediments coming out of an estuary at some point after the peak of the flood tide and during the major ebb from higher high to lower low.

We didn't get good surveys in the throat of it and that is unfortunate. The men were not equipped for it and the velocities were too high and, of course, they were highly ephemeral—in 15 and 20 minutes you would not have the same channel cross section. But having the pictures, the cloud of sediment they show is a long step toward illustrating for people who haven't direct knowledge how these estuaries clean themselves on ebb tides. I only wish that we had had enough pictures that we could have done a hydraulic analysis of it in terms of estuary mouth cross sections, but they were never taken.

Los Angeles County



6 Los Angeles County

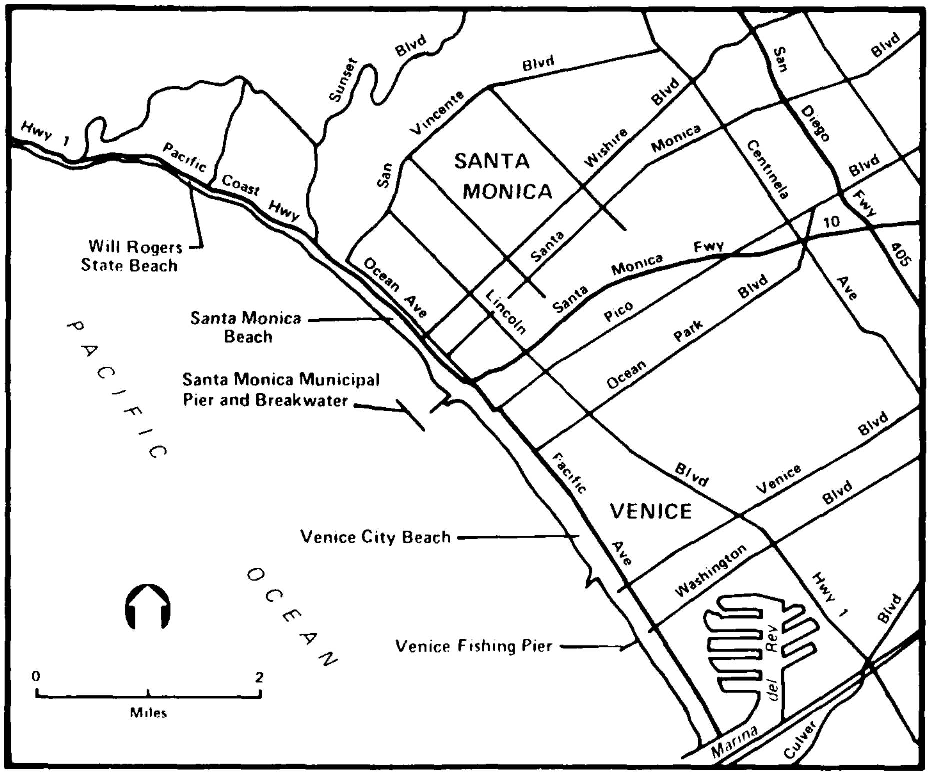
SANTA MONICA BAY

SANTA MONICA RAILROAD PIER

As remembered by OMAR LILLEVANG

Going to Santa Monica, because the Ballona Creek area reminds me of it, there was a celebrated dispute and contest at the turn of the century between interests as to where the deep draft harbor for southern California should be located. Collis P. Huntington, one of the early railroad barons, acquired interest in property in Santa Monica Bay not far from the present Sunset Boulevard terminus at the coast. He promoted and built the celebrated Long Wharf. This was a railroad bearing wharf that extended more than 4000 feet into Santa Monica Bay and was connected by tracks to Los Angeles. At that time the rails came down at the foot of the Santa Monica bluffs and turned inland at the present location at the end of the Santa Monica freeway. In fact, the curved tunnel for Santa Monica freeway discharging onto the beach fronting street is the alignment of the tunnel through which Mr. Huntington's rails went on their way to Los Angeles. He advocated the deep draft port for Los Angeles there; how he visualized growth and the need for surrounding marshalling and storage areas, I don't know, because the bluffs were a pretty good barrier to that. Nevertheless, he advocated an offshore breakwater and other facilities to make that the Los Angeles deep water port.

SANTA MONICA BAY



He was in contest with other interests who advocated San Pedro, and there was a third interest primarily related to the Atchison, Topeka, and Santa Fe Railroads that had interests at Ballona and were talking about that location as a deep water site for a port for Los Angeles. That one didn't seem to have as many advocates as did the San Pedro Bay and the Santa Monica Bay programs. It became a celebrated cause, politically. It was in the Senate and House of Representatives' proceedings extensively over the years from about 1892 into the early 1900s. It's one of the few fights that Mr. Huntington lost and a second government commission, which was headed by a Navy Admiral, finally concluded that San Pedro should be the Federal site for a deep draft harbor for southern California. That was reported in 1897 in a document called, "Report of Board To Locate a Deep Water Harbor at Port Los Angeles or at San Pedro." Port Los Angeles was Mr. Huntington's name for the Santa Monica Bay site.

That wharf stood there until sometime in the 1920s when it finally was demolished. Pacific Electric Railroad, one of the descendent Huntington companies, ran excursion trains from Los Angeles out there long after it ceased to function to serve freighters. But there was commerce over that wharf for a number of years and it was a dramatic visual landmark on the Santa Monica Bay coastline.

SANTA MONICA GROINS

As remembered by ***OMAR LILLEVANG***

Upcoast from Santa Monica, pretty close to where Sunset Boulevard comes to the sea, groins have been built from early days, but a remarkable series of groins were some that were conceived, built, and their behavior observed by an engineer appropriately described as remarkable named Wilkie Woodard. I never met Mr. Woodard but Colonel Leeds spoke with high approval of him. They had had much contact, collaborative in a sense. Mr. Woodward was chief engineer for Santa Monica Mountain Park Company, which owned a substantial part of a land grant called Rancho Boca de Santa Monica and he, I found since, went in and did some very fine recovery and re-establishment work on the rancho boundaries which had been established when the land was less valuable and really rather ill described. But, by this time, the Santa Monica Mountain Park Company had land of great potential and even of present high value for development.

Mr. Woodward did a lot of beautiful cadastral work in relocating or establishing the intent of original land grant surveys. But the thing I am talking about that

Old Groins Northern Los Angeles County Area

Mr. Woodward did was his interest in groins. I've got copies of correspondence indicating that even some of the highly respected experts on groins from the Long Island area regarded him as one of the United States best informed people about groins at that time.

He built this field of groins with a little pile driver. They were steel frames, rather light material. I never went out and actually looked closely at one but I remember driving the coast in 1939 and seeing them there and having Colonel Leeds remark about them as a relic of what had been there. They were in effect a light access pier out along which Mr. Woodard could go and remove or add flash boards, if you will, to a groin system, create openings for porosity or close them up for impermeability, change crest level, change slope, and then observe with surveys what happened. And he ran very careful high tideline surveys, and kept records of what he was doing and what happened. I have searched through the remaining archival files of Leeds, Hill & Jewett's material storage in San Francisco and I just simply can't find much of anything.

The City of Santa Monica and others brought action against Santa Monica Mountain Park Company over those groins, and others, asserting that they had an adverse influence on littoral processes in Santa Monica and in a compromise endorsed by the court, which I think terminated the lawsuit short of a judicial decision, there was a land exchange between the Santa Monica Mountain Park Company and public landholders - probably the State Division of Lands, but I am not confident about that. It included shortening of some and removal of others of those groins and Mr. Woodard apparently died not long after that because he disappeared from the scene. In fact, I am sure he died because the final report of a technical committee appointed by the court to consider all of this, and a committee that was made up by engineers and geologists representing all participants and interested parties, and of which Colonel Leeds was the Chairman, shows that the representative of the Santa Monica Mountain Park Company was Mr. Woodard to start with, but was replaced by somebody else upon his demise.

I don't know where those original records are. I found that CERC's library does have a copy of the final report of this court-appointed committee, but it doesn't have the technical data in it on behavior of groins that would be priceless if located.

I am still planning to go down through the phone book and contact everybody I can find in it, in the Santa Monica Bay region, whose name is Woodard and see if I can find out where they are. I have found the location of the corporate files of the successor in interest of Santa Monica Mountain Park Company. Those corporate files are just that, they don't have any technical data in them. The man who back-stopped Mr. Woodard and other generations of engineers to that company have died. His sons were not interested so if they had it, they did not keep it. I don't know what's become of it. But that was a very interesting area; some very good early work was done and it may be lost; thus far I haven't found it.

As remembered by WILLIAM J. HERRON

There had been a number of other groins built in this area, apparently back around 1925. These are of considerable interest because apparently the owners in those days learned in part how a groin works by watching some rock reefs along there and their ability to collect sand. Some real estate agent, turned engineer, decided this was a pretty good way to build real estate. So groins were created with the deliberate intent to increase the real estate holdings on the upcoast side. This was finally stopped in a couple of landmark lawsuits in the California courts, which made it illegal to artificially impound private land beyond the mean high tide line, and also made them subject to damage suits by their downcoast neighbors.

One of the groups of groins here that show in many of the text books is what is known as the Bel Air Club groins. I have not been able to find a design to date. They are concrete groins, sometime taking advantage of rock reefs and simply expanding on them, but they have worked exceedingly well in providing a stable beach with a greater width than originally existed. The surplus sand moves around and also over the tops of these groins to maintain a normal littoral sand movement downcoast of these groins. Somebody also experimented with steel sheet pile groins with removable boards or batons so that they could control the rate at which these beaches grew. Some of the steel piles from these groins are still in place and are badly corroded and extremely hazardous to bathers in this area.

SANTA MONICA BAY MASTER PLAN

As remembered by JAMES DUNHAM

Around 1948, the city and county had adopted a master plan for the entire stretch of beach along the Santa Monica Bay shoreline, extending from about Topanga Canyon to Malaga Cove. That master plan is included in the

Corps' Beach Erosion Control Study and we tried to conform to it as much as we could in what the Corps would recommend as the best means of correcting the erosion problems in the area.

SANTA MONICA BREAKWATER

As remembered by JAMES DUNHAM

The Santa Monica breakwater was built about 1933. I recall I was told that originally the Santa Monica breakwater was the first to be constructed of caissons. They were to be built in San Pedro, towed around to the site, and then placed on the bottom. When two of them were in place, the toe erosion started removing the material from underneath them and they started to fall seaward into the ocean. They gave up on the caisson approach and decided to make it a rock breakwater. But before they had it finished they ran out of funds, and that is why it was built to minimum dimensions and never brought to grade.

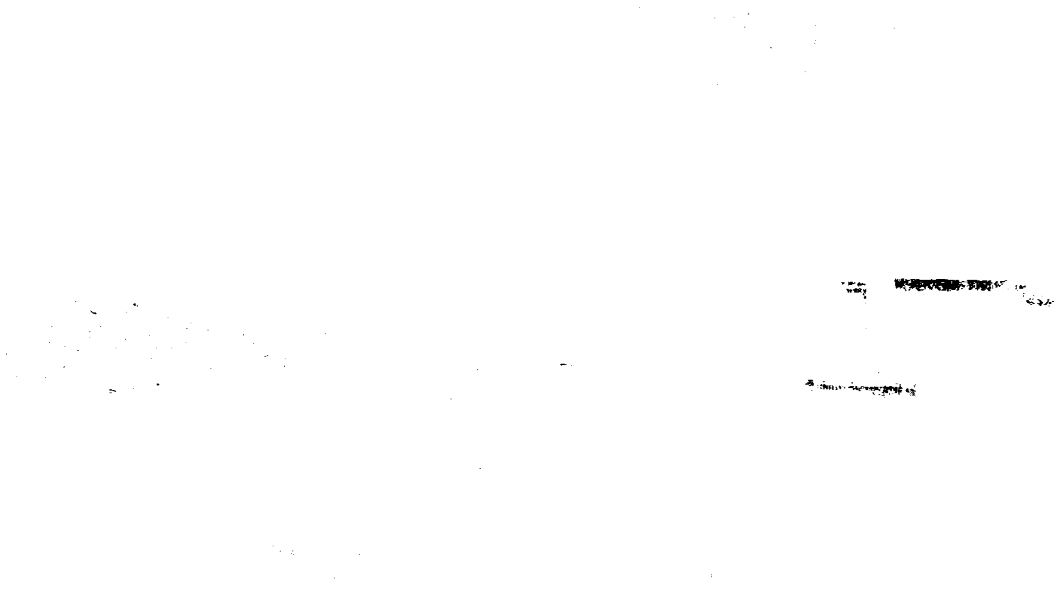
The Corps was not involved at all in the Santa Monica breakwater construction. Of course, we reviewed the effect that it had on the beach in the Corps' study.

As remembered by KENNETH A. PEEL

At about the same time as the Santa Barbara beach erosion in 1932-33, the harbor at Santa Monica was constructed with Santa Monica City bond funds. They planned a detached breakwater 2000 feet long, about 2000 feet offshore. It had been thought that sufficient wave action would occur to move the sand past this one also, but again it was demonstrated that this wasn't so. The sand in suspension, or sand in movement along the coast, with the littoral drift from north to south, proceeded to deposit in the lee of this breakwater and rapidly shoal it up and to build a beach fill toward the upcoast end of the breakwater.

The original breakwater design called for a series of concrete caissons filled with sand or gravel. I believe the Puget Sound Bridge and Dredging Company had the contract for the harbor construction. Who the designer of it was I don't know. I do know that when they completed two or three of those caissons in the dry docks, the first one was towed to Santa Monica and they sat it on the sand before putting it into its final position and the sand eroded out from under the end of it and it broke in two. At that time, Mr. Hughes took what little money there was left and redesigned the project to provide the random stone structure that replaced the caissons.

View Downcoast to Yacht Harbor-Ocean Park-Venice (1938)



Santa Monica Breakwater and Pier (1940)

He did that as a private individual, as a consultant for the City of Santa Monica. The inspector on the work was Dick Eaton.

Morrie King, the City Engineer of Santa Monica, may have the breakwater records. I don't believe he was the harbor engineer at that time, but I don't remember the man who was - I wasn't too mixed up with that, just proximity interest. The contract for construction was with Puget Sound and I understood they also did the design but I can't say for sure.

I think the Los Angeles District, more or less, developed the facts that an offshore breakwater caused erosion just as much as one connected to the shore did. In fact, it might even have been more effective. They were the first ones, I think, to start the idea that you could equate, through wave diagrams, the long-shore component of wave energy with sand movement where you had no way of actually measuring the rate of sand movement. You could get some idea of the problem. I think we pioneered that. We pioneered the use of wave diagrams in orienting harbor structures and we started developing wave heights, or design wave heights. I think the Los Angeles District pioneered these.

While Colonel Hunter was still there he sent me on a long trip down the east coast to see the small craft harbor, erosion projects, and beach development projects. M.E. Collins of the Division Office and I took about a month's trip, going from district to district, and when we finished it, I decided we had advanced further in small boat harbor development and shore protection on the Pacific coast than they had on the Atlantic coast.

At about the same time we were given seven or eight survey reports on small boat harbors. Practically the same year, we had hearings on beach erosion by the House Public Works Committee--subcommittee on public works--in an attempt to go over the beach erosion problems and the small craft harbor problem. This resulted in the authorization of the beach erosion program, and also the decision for Federal participation in the recreational boating program.

As remembered by OMAR LILLEVANG

My involvement with Santa Monica breakwater in early days was rather limited. While I was a senior at Berkeley in 1936-37, I think that earlier in this record I may have talked a little bit about what got me started in coastal engineering aspects of civil engineering was my doing a

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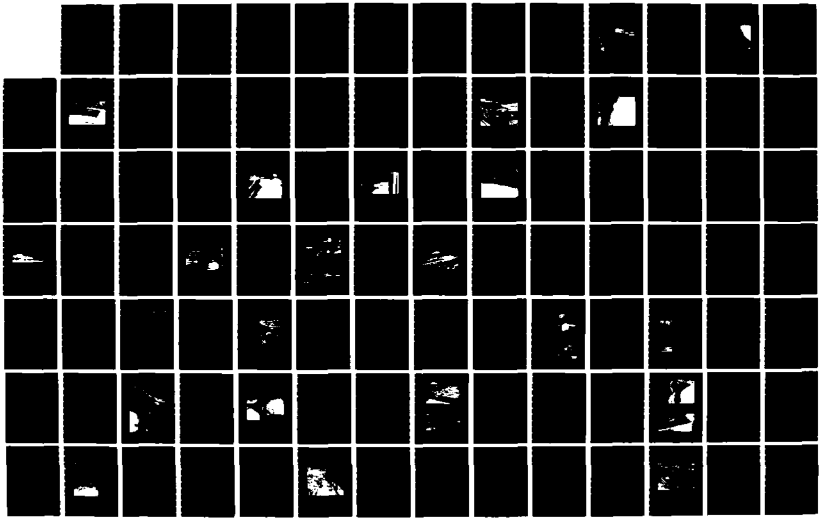
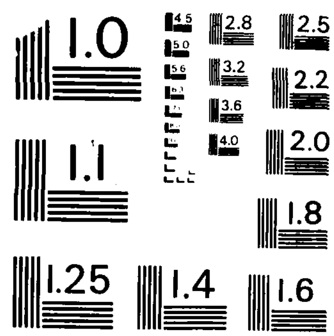




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

scale model study or two scale model studies along with two other men of two problem areas. One being Santa Barbara where we devoted most or our time, and the other was Santa Monica. We built a very small model of Santa Monica's shore and with Santa Monica breakwater on it, and molded the sea floor out of hard mortar except in the areas that we knew had been eroded since the breakwater was built. Those we did also in mortar but we molded them about an inch lower than the original profile had been before the breakwater was built and then we pumped waves in and observed whether or not in our model it would produce the kind of accretions behind the breakwater and erosions upcoast and downcoast from the breakwater that had been observed in nature. We did it rather well, considering the crudity of the model, and so my awareness of Santa Monica breakwater and of how it was affecting the sea coast began at a very early time, and therefore, I have watched it over the years and observed its disintegration. I had been aware for more than 20 years that the deterioration had gotten to where, if I had correct information at the time, it was difficult for anybody mooring his boat there to get marine insurance on it.

More recently I have looked into the history of its construction and knew something of some tugs of war that went on while it was in conceptual phase. Colonel Leeds told me some of this.

A consulting engineer in the area, who I believe was originally from Canada and whose name was Taggart Aston, was convinced that the way to build breakwaters was to do it with precast concrete elements that could be made in a graving dock and then floated, towed into position, and then sunk on a prepared bed, and you then virtually got instant protection. He made proposals, which I think were done as representing an interest of nearby landholders, and it might even have been the Santa Monica Mountain Park Company or one of its interrelated companies, to build a breakwater at Santa Monica using his precast caisson system. It was considered, according to news releases I have read, and was rejected, but not long after the City Engineers of Santa Monica prepared plans and specifications for something that had all the earmarks of Mr. Aston's scheme. They were let to contract and the pieces were of good size; I don't remember their dimensions now. They were built somewhere in the Los Angeles-Long Beach Harbor area and the first one was towed to Santa Monica to be sunk in place. But, as they got there and were preparing to arrange a bedding plane of quarry stone to sink it upon, the seas came up and dark was approaching and they dropped the thing to the sandy bottom and left it there overnight, intending to continue the next day. There were hinged steel doors on it, the hinges running horizontally so that those doors could be dropped down with the idea that they would reach out far enough from the base of the precast concrete structure to minimize erosion pits around the base of it. But for some reason or another, they didn't perform the intended function. It may not have been big enough; at any rate there were great big pits that were dug there overnight by the interaction of waves on this abrupt barrier of the caisson's sitting on the sandy bottom and the pits were unequal under the base of the caisson; and the next morning when they came out there, the thing had hogged over and had broken. Some way or another they removed the damaged caisson and abandoned the concept.

At that point, they hired Mr. David Hughes as a consultant to come in and analyze their options and he demonstrated to the satisfaction of the city that a quarry stone breakwater would be better and could be gotten on with rather promptly. This preceded the days of rational design of quarry stone mounds in the sea and it was, in fact, an intuitive and "experienced based" design for the size of the stones. Later I learned to my surprise that Richard Easton had been assigned by Mr. Hughes to act in a resident inspector function during construction of the Santa Monica breakwater. I had never heard that until about a year before Mr. Eaton's death. But the breakwater did get built with Catalina Island rock.

I think there was random placement rather than fitted and the intuitive sizing or slope of them missed the mark. They proved not to be adequate to resist the waves that came in there and the breakwater did deteriorate over the years and it is in an advanced degree of deterioration now. That is separate and distinct from what it has done to the shoreline in its shelter. The breakwater was conceived as a navigation facility in order to create an anchorage. Primarily what it created was virtually a tombolo; it never joined the breakwater, but it is a major bulge on the coast. It triggered tideland arguments that have benefited the purses of many lawyers and some engineers, and still continues to be an issue in legal proceedings over tidelands.

The City of Santa Monica, in the early days of this sand accumulation, apparently still with a concern that it created an anchorage area for them rather than seeing it as an asset to create more beach property, tried to dredge the accumulation. They did, in fact, put a dredge in a hole that was excavated in the accumulation with the intent that the dredge would remove it, break its way to the water to form a sand trap, and then transport sand downcoast where it could resume its travel along the coast under the impetus of waves. But it turned out that little dredge never could keep up with the accumulation. I remember seeing it sitting there in an isolated pond that couldn't maintain any connection with the sea, if it ever had one. That dredge was removed a number of years ago and I suppose it rests in a scrap pile somewhere if it wasn't shot at us by the Japanese during World War II.

Santa Monica has an interesting history of a structure that was built to create a harbor. Instead it caused beach accretion, the accretion being looked upon variously as an asset and a liability but in no way did it create a very useful navigation feature. It is not a safe anchorage and really never has been.

Further down the coast at the mouth of Ballona Creek there is another coastal engineering aspect that precedes Marina del Rey. I think it is one of the earliest sites for a wave model study in this country. I don't know who Colonel Leeds' client was, but the Colonel prevailed upon them to engage Professor Robert Knapp at Cal Tech to construct a model of the mouth of Ballona Creek and incorporated into it some works that had been attempted several times, abortively, to create an entrance into a little slough that was dredged immediately downcoast from the mouth of the creek. That model study was carried on and certain indications were noted and reported upon by Knapp; and then Vicksburg commissioned a parallel model study which reached rather different conclusions and interestingly that was one of the early baptisms in coastal engineering of our good friend, Joe Caldwell. Caldwell was the principal investigator at Vicksburg on that and wrote a report which I think stands in better position with the passing of time and the growth of technology as well as history of that location than did Knapp's study.

So there were two models done at the mouth of Ballona Creek. One by Knapp at Cal Tech and one by Caldwell at Vicksburg, and they are both part of the history of coastal engineering at Santa Monica Bay.

As remembered by WILLIAM J. HERRON

My next point of interest is the Santa Monica breakwater. This again is where we added a couple more pages to the text books because this was constructed around 1937. Based upon the happenings of the Santa Barbara breakwater, the concept at Santa Monica was to build a breakwater parallel to the beach along the 30-foot contour. They expected that this would provide shelter for boats and at the same time, allow the littoral sand to pass through. This was a fiasco for two reasons. First, the original design, rather than using rock which was in abundant supply, was to use concrete caissons filled with sand or gravel. The caissons were fabricated in a shipyard in Los Angeles Harbor and were to be floated around Palos Verdes into place, tipped up, secured, filled with sand and gravel, and thus would form a nice clean breakwater structure. Unfortunately, no consideration was taken of the deep sand base that exists in this area and shortly after the first two caissons were fabricated and brought into place and tipped up, the sand scoured out from underneath the foundations; the caissons cracked, tipped over, and broke up; and this plan had to be abandoned.

This caused another problem then, because a bond issue of, as I remember, $3,000,000 had been floated for this project. The city had to completely abandon the caisson design and go back to an absolute minimum cross-section of rock work to complete the breakwater and make it usable within their remaining funds. This was proceeded with, and even though this breakwater some 45 years later is still partially effective, it is severely damaged due to lack of maintenance and because of the steep slopes that were used to minimize the quantity of rock.

The effects on the beach were not at all as anticipated at the time of construction. Later, Dunham made some interesting studies as to the wave diffraction effects around both ends of a breakwater like this, which have been published. Actually, of course, the beach started to widen immediately at the northerly end as the littoral drift entered the wave shelter caused by the breakwater and a tombolo started to form. A similar one was formed at the lower end in much the same manner as happened with the diffraction around the uncompleted Redondo breakwater, which I will talk about later. The erosion effect immediately to the south of this breakwater for awhile was even greater than just the interference of the breakwater with downcoast littoral drift as it also temporarily included the diffraction effect. The apparent rate of littoral drift in this area is around 150,000 to 200,000 cubic yards per year. So there has been a considerable growth of beach behind the breakwater and a fillet of sand extending some 2 to 3 miles upcoast and has resulted in a very fine public bathing beach in the Santa Monica area. The erosion to the south almost caused the collapse of a five-story building before emergency sand bypassing was done to compensate for the loss of sand.

SANTA MONICA BAY FREEWAY PLAN
As remembered by WILLIAM J. HERRON

The first project of interest was never built but it was a very interesting study and much is available from the reports on it. Briefly, it was derived from an interest by the California Highway Department in building a new portion of freeway extending from Topanga Canyon to the vicinity of the Santa Monica breakwater. That area is quite thoroughly developed and the existing coast highway is backed by very high steep bluffs that are not stable and are continually exposed to slides. So, the hope was to go into the water and build a new freeway, and in conjunction with it, create new beaches, possibly additional marinas, and even quiet water swimming. Several studies were made and the most interesting, to me, was the first serious consideration of pushing a piece of shore seaward into existing depths of as much as 20 feet and deliberately creating a perched beach in which a beach with full surf and full littoral drift would be set between an artificial beach and a rock dike to reduce the amount of sand required to create this thing. Further details will come out of the study itself, but to me the most intriguing problem was that we developed means, partly through model studies, of determining what would happen landward of the submerged dike and on the perched beach and we felt confident we could accommodate the 200,000 cubic yards per year littoral drift. But the intriguing problem was: How do you guide this littoral drift from the natural sand beach onto the perched beach and then what do you do with it on the other end as it drops off into the natural water and natural slope area again?

The other area of interest in this general vicinity was what is normally known as the "State Highway Department groin field." This resulted from a tremendous slide of the cliffs shoreward of the coast highway. It was felt that the slide material was so unstable that rather than remove it, it was more desirable to detour the highway seaward several hundred feet.

This was a Highway Department project but the Corps of Engineers office provided a great deal of technical information and technical review of their completed design. It consisted of four groins with an artificial beach placed between them so as to not interfere with the normal movement of littoral sand. And, again part of the trick of this was not to create too severe erosion below the last groin. This was mainly done by an ordinary wave orthogon design, developing through considering perpendicular forces on a beach, the necessary spacing of the groins, from that the necessary length of the groins, and they were built.

Sand was imported from the El Segundo sand dunes in the vicinity of the Los Angeles International Airport and the beach between groins was filled. We had a little advantage because the downcoast groin butted on an area that was already a rock revetted area. The groin field itself in the upper areas worked fine. There is some lack of beach on the downcoast area for several hundred feet in which the wave energy is expended against the rock, but then the littoral drift picks up, and from there on down there has been no adverse effect of this groin field and the slide area still rests quietly.

VENICE PIER AND BREAKWATER

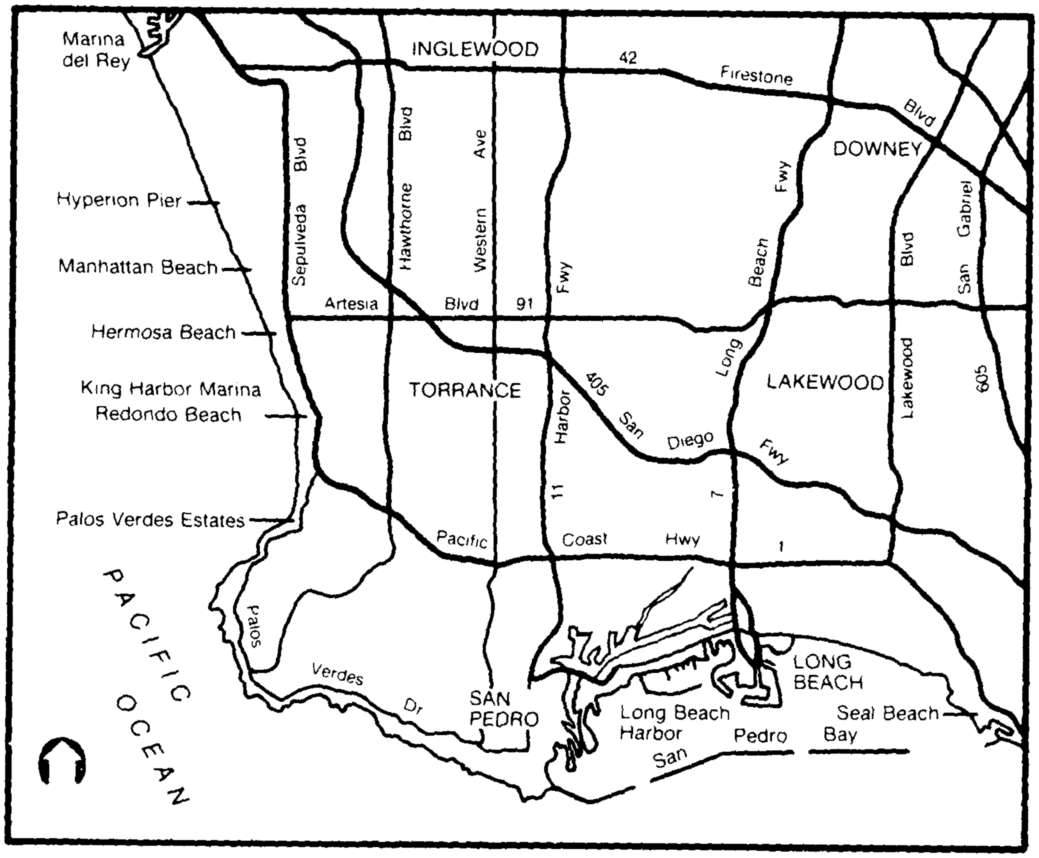
As remembered by JAMES DUNHAM

One of the things that caused the bulge at the Venice pier was a rock rubble breakwater that had been built 50 or 100 feet off the existing end of the pier. It was to allow boats to come in behind it and dock at the end of the pier. At the time it was built it was about 1200 feet from shore. It was about 600 feet long and parallel to the beach. That pier had been put in about 1900, and the breakwater, I think, about 1903. The bulge grew rather quickly and then it stabilized.

After 10 years there was no more advance of the bulge and apparently littoral drift was bypassing the area without any difficulty. Then, when the Hyperion sand dunes were leveled for the Hyperion Sewage Treatment Plant and the material placed along the shore, it built the beach out about 500 or 600 feet, and almost immediately a tombolo formed behind the Venice breakwater. The pier had been removed in the meantime, but the breakwater was still there. This gave us a clue as to what the relationship of breakwater length to distance from shore must be to prevent formation of a tombolo and to allow littoral drift to pass. Later on I was to use this relationship in designing a temporary breakwater for off-loading the tetrapods used in constructing Rincon Island. At that time the county insisted that the temporary off-loading structure must not intercept littoral drift because of the Santa Barbara Harbor experience.

This was the beginning of the development of the theory of crossing wave orthogonals behind breakwaters as a result of diffraction around their ends. I reasoned that sand would still be moving during the storms where the wave energy was reduced to a tenth of what it was at the point of incidence, or where the wave height would be about one-third of what it was at the point of incidence. If it were reduced any more than that, there would not be sufficient energy during storms to cause it to bypass sand.

MARINA DEL REY/MALAGA COVE



This has recently come up in a number of cases where it has been questioned why this should be so. The main reason is that the wave action that normally moves sand along the beach is caused by the normal low height breakers that occur almost daily, whereas the storm waves, with about 10 times the energy, can still transmit enough energy at the K = 0.3 crossing point to move sand past the point of obstruction.

I never did publish a paper on the particular point, but it has been questioned and reviewed. We used the same principle in the design of the Channel Islands breakwater, and the explanation is contained in the "Basis for Design" of that structure.

MARINA DEL REY HARBOR

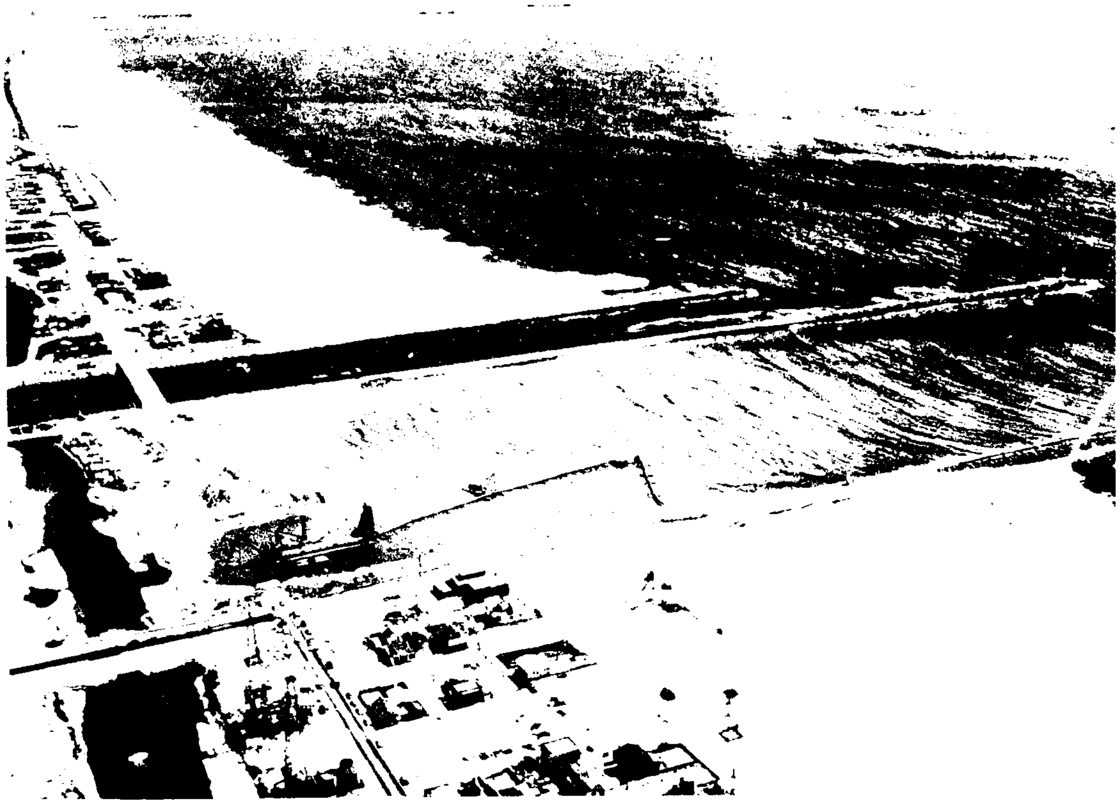
As remembered by KENNETH A. PEEL

At Marina del Rey, the harbor, as originally designed, is quite different than what exists today. The location was changed, the jettied channel widened from 700 to 1000 feet, and the rock rubble slopes at the basins changed to vertical walls. As originally constructed, large waves entered the entrance, caused a great deal of damage, and required later construction of the offshore breakwater, which is probably a good thing. The offshore breakwater that was built to protect the harbor entrance also intercepts the sand coming downcoast and keeps it out of the entrance to a considerable extent. It facilitates bypassing the sand. I don't know how many times, if any, they have actually dredged that sand trap to bypass the sand.

When we first put the jetties at the mouth of Ballona Creek, they were having a very serious erosion problem downcoast from that. A movie star had a big house right there on the beach and moved it two or three times.

As remembered by JAMES DUNHAM

The beach erosion aspect of studies for Marina del Rey and Redondo Harbors stems from the law, I forget what year it was, which stated that wherever a new harbor was to be constructed, the effects of the protective structures at the mouth of the harbor were to be studied and their possible effects on the beach to be determined for a distance of at least 10 miles on either side of the harbor. So, when we studied Marina del Rey Harbor, I prepared the shore effects study. It also fell my lot to design the entrance to Marina del Rey. Because the entrance was to be pointed directly offshore, it would be catching the brunt of the wave action that came in from



Marina Del Rey Construction—Entrance Channel (1960) the west. My first design, which I tried to hang onto, showed an overlapping north jetty--the reason for which was to intercept directly approaching waves. When this was first reviewed by the Beach Erosion Board, it was pointed out that a serious hazard would result from that overlap because, if a boater tried to enter the channel through this dogleg, he might be surf boarded onto the rocks by wave action. They insisted that the jetties extend straight out to sea and end with no curvature so that a vessel coming in during a storm or fog could line up on the channel markers and come in without having to make a turn.

This design was not at the existing location for the entrance, it was about a 1000 feet to the north. The entrance channel was to come in there and then the harbor would enlarge on either side. The design that the Corps had for the marina called for a series of basins in circular arrangements. All of the parameter would be revetted slope rather than a vertical wall. This, the Beach Erosion Board said, would be necessary in order to absorb the wave energy and prevent wave reflection troubles at the site. Of course, when they went to build it, the bulk of the expense was to be shouldered by the county. They hired a consultant, George Nicholson, who pointed out that it would save them money if they would move the entrance south alongside the Ballona Creek jetties, and have the three-jetty combination of creek outlet and harbor inlet. He also pointed out that considering the value of the land that would result from this project, they could ill afford to waste any of it in revetted slopes, and he designed vertical bulkheads throughout the marina. He did not think surging would be a problem, and died before the entrance was opened. Bill Herron tells the sequel to the marina story.

As remembered by WILLIAM J. HERRON

Another project in this general area was the construction of the Ballona Creek jetties and Marina del Rey. The Ballona Creek jetties resulted from a flood control project which straightened out the channel of Ballona Creek, and in this straightening moved the entrance about 1000 feet up the coast to its present location. In about 1936, a pair of jetties was extended beyond the surf zone and defined the ocean outlet of Ballona Creek but, of course, caused a severe interruption in the flow of longshore drift. For a period of time in the late 1930s, and probably on into World War II, there was severe erosion downcoast from these jetties that was not anticipated. The Marina del Rey jetties were constructed in about 1958-59 and consisted of an extension of the

Completion of Marina Del Rey Harbor (1962) north Ballona Creek jetty and the construction of a new navigation jetty, 1000 feet to the north. The general concept of design of these jetties was that, because of the alignment of the coast, they were extended almost directly into the prevailing winds. Because the marina was being designed to accommodate 6000 boats, and many of these were to be sail boats, a wide entrance was designed to permit the sail boats to have adequate tacking distance to work their way out to sea. This again, like too many of the old projects, was a matter of basing the design of one project upon knowledge gained from the other. The Newport jetties, which were about 760 feet apart and built in 1934-36, had worked very well. In turn, the Mission Bay jetties were constructed in the early 1950s about 960 feet apart and, with the delays caused by the Korean war, really had not had time to be properly wave tested before we proceeded with the Marina del Rey jetties.

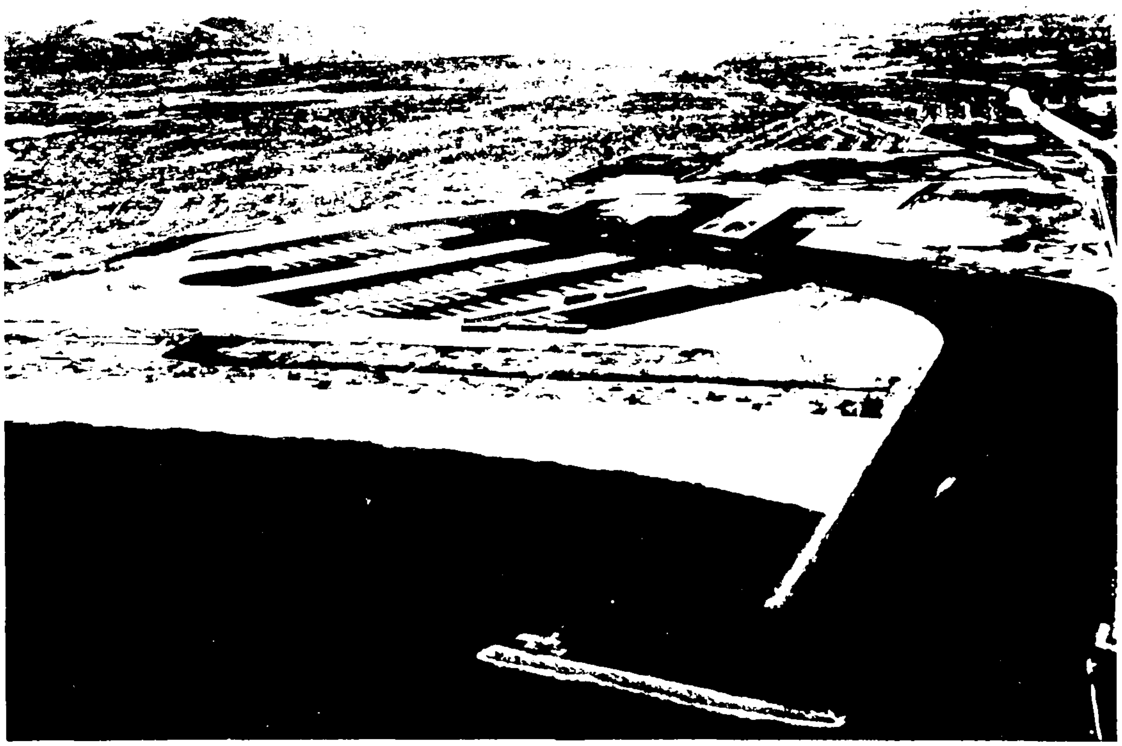
The original Marina del Rey, designed by the Corps of Engineers and as approved by Congress, called for a new pair of navigation jetties about 700 feet apart some 1000 feet north of the Ballona Creek jetties. The navigation channel was to be narrower than that presently existing and was to enter into a large stilling basin with a great deal of rock revetment which would absorb wave energy. However, there were some political problems because of City versus County ownership of this area, and a consulting engineer hired by the County presented an alternative design which was accepted by the Corps of Engineers and was the basis of the present layout of Marina del Rey. This included combining of the north jetty of Ballona Creek with the south jetty of the entrance channel, the 1000-foot-wide-channel, and the eight basins that presently exist.

I administered the dredging contract on this job, which consisted of a total of some 12,000,000 yards of dredging, of which 7,000,000 were the County's responsibility. They asked us to accept their funds and put it all in one large contract. The Ballona Creek channel also had a large set of tide gates, which supplied tidal water to the existing Venice canal project. I saw where we could take advantage of this and reduce cost considerably by having the commercial dredge dredge its way into the entrance btween the newly built jetties, and then replace the sand beach, and use the tidal gates to control and lower the water level. This enabled the County to go ahead and build their concrete vertical walls in the dry. This looked like a good idea, I still think it was, because it saved the County several hundred thousand dollars in the cost of constructing these bulkheads. However, it meant that we dredged almost the entire 12,000,000 yards without experiencing any of the effect of the ocean upon these interior basins. Because of the heavy pressure and need for additional slips, the County proceeded with their leasing program and permitted two of the lessees to go ahead and construct floats and other support structures in the first two basins that had been completed prior to the opening of the entrance channel. So, it was not until the dredging was almost completed and, as a last effort, the dredge removed the sand beach across the entrance channel, and dredged its way out to sea, that the full effects of wave action could be observed upon Marina del Rey.

The results became apparent very early in August of 1963. The marina received the residual of a South Pacific storm and we noted quite severe wave action inside the basin, particularly in Basins A and B where they were starting construction of slips. It was realized that something was wrong and we proceeded to start looking at this to see what corrective action could be taken. We decided, based on hydraulic model studies at WES, that this channel was just too wide to provide adequate shelter inside. An October storm put the finishing touches on our findings. There was severe damage to the existing slips, some were destroyed, and 12-foot waves were experienced inside the channel where the present Coast Guard station is. This resulted in a temporary shutdown of the harbor, a series of lawsuits, and a great deal of emergency work, to straighten out the situation.

We immediately went to a hydraulic model study of the entire harbor at Vicksburg and came up with two or three plans to correct this unacceptable wave action. One plan was to provide sufficient absorbing areas inside the harbor to absorb this energy before it reached the slips. Another plan was to construct an offshore breakwater across the entrance of sufficient length to prevent this wave energy from directly entering the harbor. The model work proceeded and it was determined that the solutions were about equal in cost except the absorbers inside would have required renegotiating a number of the County leases and would have been a very expensive process to the County, plus it would not have solved the problem of severe waves in the entrance which, incidentally, have also now been experienced in Mission Bay and are presently causing concern for their entrance.

We proceeded with the financing of this breakwater, which cost in the order of $4,000,000 and in the interim, at my suggestion, an interesting expedient protection was



Marina Del Rey Detached Breakwater Partially Completed (1965) undertaken. We knew that until there was major growth within the harbor, we did not have to provide for 6000 boat traffic. So, a pair of steel sheet pile interior jetties were designed and constructed by the County with an overlapping entrance to still the major wave action, and at the same time, leave a small (300-foot) entrance which the existing traffic could use. This worked out quite well and permitted further development of interior facilities while the offshore breakwater was being constructed. Upon completion of the offshore breakwater, these steel sheet pile jetties were removed.

An interesting offshoot of this problem was, of course, a series of major lawsuits, caused either from direct damage or from loss of income to the lessees inside. It had become obvious through the study that two design changes had contributed to this problem: one was the extreme width of these parallel jetties, and the second was the change of design of the interior basin walls to vertical concrete walls. The question that was continually being asked was: "Why was this not modeled before it was built?" I had just come into the Los Angeles District and was concerned with beach erosion studies at the time that this design was accepted by the Corps in 1956. In 1958, I took over and completed the project.

In review, it turned out that there were really three engineers basically responsible for this modified design of Marina del Rey. One was the consultant to the County, the second was the Corps of Engineers man in charge of coastal engineering, and the third was an engineer who represented the bonding company that floated this $14,000,000 bond issue. By the time that this became a political and legal football, all three of these gentlemen had died and I was left holding the bag. On review of available records, I could find no reason at all why a model study had <u>not</u> been made, or to what extent it had been seriously considered. But, I think it did provide a major contribution in that, from there on, model studies of these small craft harbors, where they really are built in one operation and don't have time to grow and be observed, set a Corps of Engineers policy that, as General Wilson put it, "You will have to prove to me why you will <u>not</u> model one of these harbors in the future."

Since construction of the offshore breakwater, there have been no major engineering problems at Marina del Rey, and, interestingly enough, the original findings of the shoreline studies and the construction of the Marina del Rey jetties were that it would provide an obstruction to littoral drift. This was partly the reason for putting 3,000,000 yards of the dredged excavation material on the beaches downcoast so as to anticipate the erosion caused by these extensive jetties. This beach fill was anticipated to support the downcoast beaches for about 20 years. The 20 years ended in 1982, but there appears to be no serious erosion of downcoast beaches at this time. I think some reconsideration is needed of the rates of littoral drift in the Marina del Rey to Redondo area, because we are not getting the losses now that were anticipated in this area when this design work was being done, back around 1950 to 1955.

The series of studies in the Santa Monica area brought out another interesting point. In nature, even with all of the artificial structures in the Santa Monica Bay area, the beach is a fairly uniform beach. But, the El Segundo pier, or Standard Oil loading pier as it is known, was constructed at El Segundo in the 1920s and it always experienced some rather severe wave conditions. This was not fully understood until the wave refraction studies were done in the late 1940s and early 1950s. From these it was found that it was probably the worst place to build a pier along the entire area. It is an area of wave concentration, under certain conditions, which can produce waves nearly twice the height of anywhere else along Santa Monica Bay. This was in part confirmed when the Corps of Engineers established an experimental wave gauge on the end of the pier, which operated from about 1948 to 1951, when there was a very severe storm, and the last gauge reading before the end of the pier and the gauge was destroyed, indicated 19-foot waves in that area. These large waves can cause real problems on structures but, because they are rather infrequent, they do not have much affect upon the configuration of the sandy beaches and the movement of littoral drift.

EL SEGUNDO PIER

As remembered by JAMES DUNHAM

The Beach Erosion Board loaned us a step-resistance wave gauge in 1948, and we put it out at the end of the El Segundo pier. We had a man from Standard Oil keeping track of it and changing the tapes.

I reviewed some of the tapes, and they showed 21-foot-high waves. I couldn't believe this, because no one had seen waves that high anywhere along the Pacific Coast. I asked the man to let me know the next time they were occurring and he did. I went down and I saw them with my own eyes. Not only that, but some of them were much higher breaking farther offshore. The waves were limited in height by the depth at which they were breaking and apparently waves up to about 30 or 35 feet were occurring in that area and nowhere else along the coast. Again, we went back to our refraction diagrams and I noticed that, as the waves from the west came in with periods up to about 15 seconds, which was about the longest period we had diagrammed at the time, there was considerable convergence but not enough to account for these waves. We then checked the periods on the tapes and we found that they were 17, 18, and 19 seconds - so we made refraction diagrams for those periods and we came up with K factors of about 7 or 8. This would account for the destruction of about 600 feet of the outer end of that pier in the 1920s and 1930s, beyond where we actually had the gauge. In this area, the outer end, the pier was lower as they figured they were out and beyond where any high waves would peak up and break, so they had lowered the height of the pier and it was washed out.

One of the things that was noticed in our studies (of Appendix 2 of the Corps of Engineers Beach Erosion Control Study) was that in certain areas there were bulges of beach wherever a number of pilings had been placed to support piers. Later on I had the opportunity, through work with the State of California, to review the records of this area back to the early 1900s, and we found that even before the Santa Monica breakwater was built, the shoreline at the base of the Santa Monica pier had moved out about 200 feet. The same thing had occurred a the base of the Venice pier. We reasoned that this must be the result of so much wave energy being taken out by turbulence caused by the piers.

As remembered by OMAR LILLEVANG

I understand that Jim Dunham has talked about some of the work that was done on the Standard Oil Company's pier at El Segundo. Perhaps he didn't mention another thing that was done at the same time but not related to the same problem. The City of Los Angeles had published plans for putting 17,000,000 cubic yards of dune sand on Santa Monica Bay beaches, widening them to some rather considerable degree as an intense recreational facility, but that was only providentially because it was a place to dispose of excavation for the Hyperion Activated Sludge Treatment Plan that was in the planning stages.

Standard Oil Company had two cooling water intakes at that location. One of them went out on the sea floor and had an elbow riser and came up to some level below water surface but off the sea floor. It was a steel pipe and that served a Butadyine synthetic rubber plant that had been built with Federal money during World War II. The other one was on a pile-supported pier that was also used by tugs and very small tankers and related to off-loading and on-loading of petroleum products or of crude oil for the refinery that was on land at that location. Standard Oil was worried for fear the sand from these fills would move down in littoral transport and damage their intake facility by either engulfing them or delivering suspended sediment to them that would be unacceptable in their cooling water process for their refinery. So, cooperatively, the City of Los Angeles and Leeds, Hill & Jewett for Standard Oil Company, with observation primarily by Jim Dunham who was with the Corps of Engineers then as their Beach Erosion Engineer, went into a series of studies to observe current direction and extent of suspended sand in the littoral zone.

A sand sampler operated by compressed gas had not been devised, I think, at the Beach Erosion Board, but whether or not any of them had been built for use elsewhere I don't known. But we borrowed, or Dunham borrowed, the machine shop drawings for them and Standard Oil Company had several of them made and the City of Los Angeles had one or two made. It was a device which could be lowered to any plane that was of interest, and at a moment that was appropriate, by operating a three-way pneumatic control valve, you could put pressure on a piston that would open the sampler momentarily and you turned the valve to a second position that would close it. And it would be free of any water; it was just an air pocket inside the thing when you opened it, and then you opened and let the water run, and closed it to hold it. So, over a period of about 14 months, men from each interest group went down there and we sampled suspended sand usually under wave crests as the waves moved toward the beach. These were taken at different locations and ended up with really a rather interesting profile of the distribution or the density of sediment suspension versus height from the bottom, but related to tide stage and to profile location and the bottom was profiled at the same time.

With 14 or more months of these data, we got a pretty good representation of changes through a year and of the extent to which sediment was carried off the bottom or quickly settled again as the wave went by. These data were, in fact, used in other studies as representatives and were actually the bases on which the appropriate profile for cooling water intakes for Edison Company at their pioneer twin pipe heat shock system at Redondo Beach were based. It turned out to be reliably applied and good data.

Meantime, Dunham was doing the work with his wave direction device with a Raley disc. He has talked about that and apparently he didn't comment on the suspended sand sampling program.

HYPERION BEACH FILL

As remembered by WILLIAM J. HERRON

To stay with subjects of engineering context, I think we have to jump in time a little bit and consider the filling of the Santa Monica Bay beaches by construction of the Hyperion Sewage Disposal Plant, which started in about 1947. Essentially, 14,000,000 cubic yards of sand were placed upon the beach from the southern Los Angeles City boundary in front of the Hyperion Sewer Plant northward for about 6 or 7 miles almost to the Santa Monica Pier. This quantity of sand was sufficient to widen the beach about 600 feet and to extend it northward to the Ocean Park Pier.

The widening of the beach up to the Ocean Park Pier nullified the damage caused by the construction of the Santa Monica breakwater and the resultant downcoast erosion, even though there has been no regular bypass program. From other studies that I made while with Moffatt & Nichol, it appears that presently there is a near-state of balance between wave energy leaking through the badly damaged breakwater and the quantities of littoral drift coming downshore. The beach behind the breakwater is no longer attempting to create tombolas out to the breakwater, but instead is stable or possibly slowly retreating and the next few years should be of interest as to whether that beach actually loses ground or not. There is not much in the way of recent surveys in the immediate area to confirm this point.

This widening of the beach by 600 feet over a distance of about 7 miles has been a tremendous boon to the beach users of Los Angeles County, but one problem was not anticipated. Most of this artificial beach has a very steep slope through the surf zone. Conjecture is that this is caused by the use of dune sand, which is a more uniform grain size than beach sand, and, perhaps, because the wind-blown dune sand does not have the angularity that beach sand normally has. Another possibility is the fact that the toe of the offshore beach fill was extended into depths of about 20 feet of water, so the chewing away of this beach to form an equilibrium profile has been considerably slower than was anticipated.

Along much of this beach during high tide, a rather dangerous surf is apt to occur. We did try to counteract this when we constructed Marina del Rey Harbor. We had about 3,000,000 cubic yards of sand available to place on the beaches to the south of Marina del Rey. I deliberately picked areas of dredging of rather fine sand and then, without a great deal of technical design, we simply required that this material be deposited at or near the top of the berm so that, in the discharge of this sand across the upper slopes, there would be as much mixing as possible with the existing coarse sands and a flatter slope would occur. This was done for several thousand feet south of Ballona Creek, and it did result in a much flatter and more desirable bathing beach in that area. The sand was placed in about 1962, and this flatter beach slope still exists; we have counteracted some of the adverse effects of the original Hyperion fill.

The possible loss of this fill from the beach has become somewhat confusing. Of the original 14,000,000 yards, at one time the beach area appeared to be losing about a million yards a year. There was some very noticeable loss of beach at the southern end. This is important to the City of Los Angeles because in the construction of this beach it was anchored on a rather long groin at the south City boundary, which was intended to maintain the beach and not let it all slip down into Manhattan and Hermosa. There have been two or three additional beach fills of this area since construction of the Hyperion fill, including the 3,000,000 yards from Marina del Rey and similar amounts from the construction of the powerplants near El Segundo. To some extent this has counterbalanced the losses below what we call the Los Angeles-El Segundo groin. There has been an appreciable widening of the beaches from the southern Los Angeles City boundary through Manhattan and Hermosa Beach to the Redondo breakwater. The result is that essentially the beach from the Redondo breakwater northwater to about Santa Monica Canyon is totally an artificial beach and much wider than it was 50 years ago in nature.

Another interesting aspect of the Hyperion fill was the impact on the beach at the old Venice pier. Originally, this pier extended into the ocean, and 50 or 100 feet offshore of the pier, a small parallel breakwater was constructed of rock simply to provide a small bit of shelter for the fishing boats and passenger boats to take on passengers from the pier. At the time of the widening of the beach by the Hyperion fill, the pier was removed, but the short rock breakwater was left. As long as the breakwater was 800 feet or so offshore, it had no visible affect on the shoreline, but with the shore pushed out some 600 feet, immediately a tombolo started forming and moved out to join the Venice breakwater. Dunham, in his

Area of Hyperion Outfall (1947)

studies of the Santa Monica breakwater and Santa Monica Bay, contributed to evolving the concept that if you want to build a parallel breakwater offshore without affecting the beach, it should be at least twice as far offshore as the length of the breakwater itself, and this has become a generally accepted rule in the design of such structures.

As remembered by JAMES DUNHAM

In regard to the 1947-48 Hyperion Beach fill, the successful bidder was Construction Aggregates, Inc., which had been doing a lot of work in the Great Lakes and on the East Coast, and they came up with the idea of using hydraulic giants to bring the dune sand down into pits. At the bottom of each pit they would place an eductor. This was their concept--I believe it had been used at a number of places where they had worked before, so they were quite familiar with it. They had a bunch of us from the Corps down there one day showing us how it worked. The heart of the whole operation was a mixing chamber. The hydraulic giants would feed dune sand into it, and when it was mixed with just the right amount of water to thoroughly fluidize it, it was sucked from there and pumped through 36-inch pipes onto the beach. It is of interest to note that the pumps that moved this material were those that had been taken from the hydraulic dredges that had built the Fort Peck Dam. They had dismantled the dredges and used just the pumps; there were four of them. They placed two in tandem to bring the water in from the ocean through the intake, and then two in tandem to pump the material on the beach. The eductors were moved around from point to point wherever it was most convenient to bring the dune sand down the slopes with the hydraulic giants. The lines themselves leading from the eductors to the central mixing chambers were 30-inch pipes, and the receiving mouth of each eductor was about 11 inches, which, of course, flared out to the 30-inch pipe diameter. The jet that shot the water into it was produced by about a 6-inch nozzle about a foot or so from the face of the receiving mouth. The sand fluidized by the monitors was sucked into the gap and entrained in the stream flowing through the 30-inch pipe. There was a Corps of Engineers mechanical engineer who wrote a paper on this operation. The entire operation was an eye opener for people on the Pacific Coast. As I recall, they bid that job at about 21 to 22¢ a cubic yard and I think their nearest competitor was well up in the 30 to 40¢ range.

El Segundo Beach (1947)

The beach fill took a lot steeper beach slope than they anticipated. Apparently that dune sand was coarser than the normal material on the beach, although no one at that time bothered to check grain size. In fact, little thought had been given to grain size in those days.

As remembered by KENNETH A. PEEL

Everybody was kind of fortunate along the Santa Monica Bay beach in that about that time Los Angeles County built its new sewage outfall, and as part of the program, they moved an awful lot of sand dune, which they pumped out onto the beach. They widened the entire beach by 500 to 600 feet. That provided sufficient sand to last for a good many years. I guess it is still there.

The Corps of Engineers officially had nothing to do with the Hyperion project except to give them a permit to deposit the materials on the beach; and everybody was very happy to do it. The means of dredging they used were the hydraulic giant monitors combined with eductors. I used to get out there about once a month to see how it was going. Also, further than that, the harbor at Marina del Rey and the harbor at Redondo Beach, I think, acted as long groins to retain a lot of the sand. Each one created its own erosion problem downcoast from it, but each, in turn, maintained the beaches upcoast from it. With a little bit of sand bypassing, they were able to maintain pretty fair beaches all the way along the bay.

It was in our work on the Redondo Beach Harbor that it first became apparent, to me anyway, that there should be a relationship between sand movement and, along the shore, wave energy; that is, the longshore component of wave energy. If a person could find enough traps where one could measure both the wave energy by wave diagrams and plotting it, and the measurement of the rate of sand trapped, you could equate, empirically at least, the relationship between wave energy and sand movement, and possibly with enough data, you could come up with the mathematical equation for computing rate of sand movement along the beach from the determination of the longshore component of wave energy. That idea didn't gain much credence for a long time, although I have recently seen in the American Society of Civil Engineer Bulletins an article or report by someone relating wave energy mathematically to littoral drift or sand movement. I imagine some day, if they haven't yet arrived at it, some mathematical estimates of sand movement on wave diagrams will be made. I think we did determine the overall direction of littoral drift from the wave diagrams. As to what to expect in the way of movement, you couldn't tell whether it was 200,000 yards a year or a million yards a year, but I have hopes that with enough empirical cases you might be able to come up with a quantity.

You never have enough data on the wave action. You can go back historically on weather diagrams--and much work was done on that during the war in the Pacific with the Japanese--on developing data on beaches, erosion problems, waves and wave diagrams, and what you can expect from weather patterns. With historical weather patterns, one can compute what the waves probably were. Then, in turn, one can take those and compute the directions of waves and intensity and the energy of the components. There is a historical collection of weather diagrams that's pretty fair but there would be much work involved in converting enough of that into wave diagrams. I think a historical record of wave diagrams is being accumulated. Incidentally, it is of interest that, at the El Segundo Pier of the Standard Oil Company, there may be 10- to 12-foot waves underneath, with certain wave characteristics just lapping up against the deck. If you look upcoast and downcoast, there will only be 1- and 2-foot waves. After World War II, when they started making the wave diagrams of Santa Monica Bay, we found out we could pinpoint just why that was. With about a 13- to 15-second wave coming in from one direction, I forget what, the wave orthogonals converged right at that one particular point. The Standard Oil Company picked the worst spot in Santa Monica Bay they could have found to build that pier. They could have gone 1000 feet upcoast or 1000 feet downcoast and had much better conditions. They couldn't have picked a worse spot than if that is what they had been looking for.

HYPERION BEACH FILL AND SEWER EFFLUENT OUTLET
As remembered by OMAR LILLEVANG

I've got another thing in this immediate area that I think is of interest. The City of Los Angeles was the principal defendant, but every other municipality and public district that were within the runoff water shed that Los Angeles is in were enjoined by the Superior Court of the State of California to build a sewage treatment facility at Hyperion that would deliver properly treated sewage to Santa Monica Bay, and this was to clear up a really scandalous sort of situation that existed there and had to be straightened out.

The various defendants were under very heavy penalties of daily fines if they did not meet the Court's schedule for correcting the health problems on the beaches. And so, they joined together and appointed the City of Los Angeles as the majority shareholder in the flow of sewage to that site to effect the solutions. They were to bill each of the defendants proportionately for his part of the flow, for the cost of engineering, and for the cost of construction.

Four of the defendants, who together added up to about 30 percent of the flow, retained our firm to audit each month, and in between times as judgment dictated, the performance of the City of Los Angeles Engineering Department and Administration; not out of a sense of suspicion that they would not do well, but rather with the consideration that very heavy penalties and the need for each public works director in these smaller cities to report to their governing council that things were going toward a solution. We looked at it as engineering auditors, which meant to determine whether or not the design, conclusions, the bidding policies, and the supervision of construction would bring it to a relief of the court injunction. It was my job to watch this, and it was during that time that 17 million cubic yards of dune sand was removed from the site and distributed along Santa Monica Bay to widen the beach. It was done hydraulically. They brought in hydraulic giants such as are used in the placer mining industry to sluice the dune sands down and the dunes rose, as I recall it, to an elevation of about 150 feet. They sluiced it down slope on the dune surfaces to a regenerating facility, which was, in fact, the property of and under the patents of, and operated by Construction Aggregates Corporation.

It was a dry land version of their reconstituting dredges that they've advertised successfully all over the country. This dry land dredge was built and the sluiced sand taken to it, mixed to a pumpable, transportable, mixture and delivered by pipeline from stationary pumps over a distance of about 7 miles, as I remember it, up the beach to the Santa Monica city limits. That was a way of creating a beach which was very interesting and which has been part of the literature.

Not as widely preserved in the literature was the construction of the outfall sewers for this project. Sewer outfalls a mile long, went out to about the 60-foot-depth curve, and were 10 feet in diameter. The inshore zone was a system of drive H piles; steel H piles close together within two sheet pile walls which kept the littoral sand and the breakers out. On those piles a concrete cap was poured; on that cap conventional ship-lap joint concrete pipe was laid and joined together; and then, with no sealing of those joints attempted, they were surrounded by a pour so that in cross-section that part of the sewer appeared to be a square hollow core which would be circular and 10 feet in diameter. What was overlooked was the surge effect on concrete at a point where water could flow back and forth under changes of pressure. Try as they would, they could not keep the alternating level in wave action from being transmitted to some degree inside the sheet pile walls. As they attempted to bring their underwater pour up around the pipe, there was a surging through these unsealed joints between the precast sections that carried cement and sand with it and left honeycombed pockets and a leaking path like one couldn't believe.

It was a monumental job to patch them because obviously where there was a sewage nuisance to be corrected, no leakage could be allowed. It meant going in with massive pumping and unwatering those pipes and then going from the inside and trying to pack them against the flow and pressure of the water, working against the normal way that one patches leaks.

I walked out under there and I confess I came close to having claustrophobia, but I didn't quite. It was my job to see what was going on and I did; and, of course, it was a valuable experience.

Seaward from that section, they laid precast 100-foot-long bell and spigot sections with rubber gaskets that were cast in Long Beach Harbor, close to where Mr. Hughes' Spruce Goose stood for so long. They were side launched into the Cerritos channel with bulkheads and towed by tug about 30 miles around Point Firman and Point Vicente to the Hyperion site. There, and this was in the water that was deeper, they had prepared abutment piers every 100 feet by again driving steel H piles and casting a cap on them with a recess to receive the bell ends of these pipes. They brought them over with the idea of flooding them and sinking them purely by hydraulic control into position for joining up and gasketing, and it didn't work. They had prior experience--the contractor did--with this technique but it was in the construction of the Posy tube under the Oakland estuary in quiet water--with tidal flows to be sure--but no waves.

The difference of the open coast and the estuary site for this kind of work was dramatic in terms of construction problems. They hadn't been recognized but they were soon discovered. The 100-foot-long sections were heavy; they had a natural frequency response which was close to common wave periods existing at the site; and they slewed around no matter how they ballasted or how they were held. They just simply could not be controlled. So, finally they gave up on the hydraulic method of managing them, sank them in position alongside the cap that they were to be placed upon, and then with cranes and other devices, brought them up into position and joined them for gasketing. They finished the job, but with a lot of trauma, and the leakage problem was one of the greatest embarrassments.

Some years later they converted that treatment plant from a high activated sludge plant with a 1-mile-long outfall to a primary treatment and clorination plant only. This then required that they had to go out something like 5 miles to about a 200-foot depth in order to get dilution in the rising water column of this less completely treated effluent, and to make use of the ocean as an element in the treatment process. That pipe was also 20 feet in diameter and was placed by a jackup barge built for the purpose. That jackup barge I think is still in the Long Beach area; it was the last time I was down there and saw it. It has been used for other work and for offshore drilling.

Alongside this 5-mile long, 10-foot-diameter liquid effluent line, a 7-mile long, 22-inch-diameter line was laid to dispose of sludge produced in the digestion process of the plant. They had to dispose of it this way, wasteful as it was, because they had attempted to market their sludge and found that, though it was a reasonably good and nutritious fertilizer, the fertilizer market was not ready, just overnight, to throw all other products and marketing systems aside and take this new one, and it was not a business success. So it had to be disposed of either by incineration or by disposal in deep waters.

They hired the Hancock Foundation at the University of Southern California to make a very comprehensive analysis of Santa Monica Bay as a receiving body and satisfied the Board of Health and the various cities and agencies who were contributors to the sewage plant that it was a safe, appropriate, and economical means of disposing of the sludge. So after complete digestion, in order to get maximum gas supplies out of it for running the treatment plant, it was to be disposed of in the 7-mile outfall. That 7 miles of steel pipe, lined and coated with the epoxy coatings, in the early days of the poxies, was welded together on the beach in 700-foot strings. It was rolled into place and towed out to sea and the 7 miles of pipe placement was done in 5 days. A very, very remarkable feat. It was done by a spectacular Texan whose outstanding characteristic, besides his ability to pull a job like this off, was his sensitivity to public relations. There were a lot of film and other coverages of it and the entrepreneur innovator contractor was to be found in virtually every picture. Sam Collins was his name. He's done this "towing out" work all over the world—sometimes with spectacular success. One or two countries, I am told, didn't want him back because of other problems that came up, but I know nothing of that and whether or not there are any grounds for it. But he certainly did a spectacular job here. It was beautifully planned, the equipment was new, good, and expensive, but when you can pull 7 miles of 22-inch epoxy-coated pipe to sea in 5 days, you've done something—and he did it!

REDONDO BEACH HARBOR (KING HARBOR)

As remembered by KENNETH A. PEEL

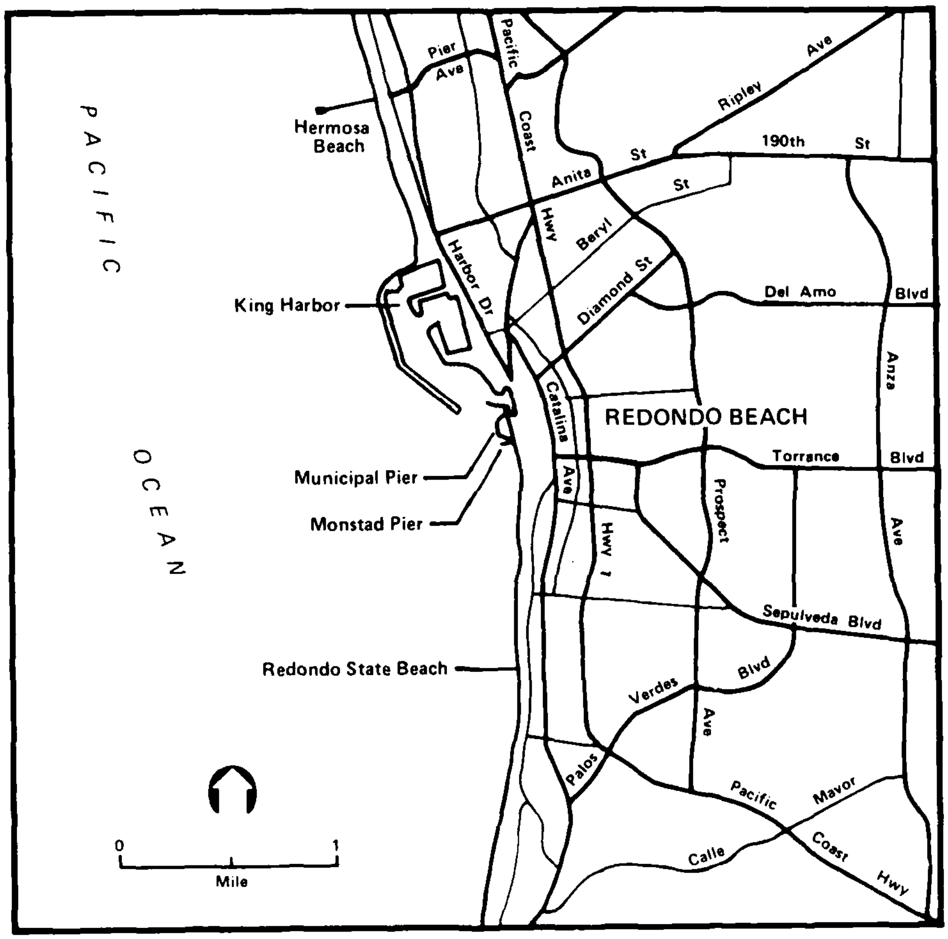
Redondo Beach Harbor was a study that I was more or less intimately connected with. At Redondo Beach, we were faced with not so much of an erosion problem downcoast because we ran right into the submarine canyon and the rocky headlands of the Palos Verdes peninsula.

At Redondo, the first breakwater was built by the local people. I think it was designed by Adolph Koebig. The harbor was pretty well fixed by the offshore canyon that came into the shore right there. The Corps of Engineers extended the north breakwater in about 1958, and added on the south breakwater north of the mouth of the submarine canyon.

We actually made studies of wave height and direction for all of our breakwaters after 1946.

About the time of our studies of beach erosion at Santa Monica Bay and our reports on Redondo Beach Harbor and Marina del Rey Harbor, we ran into an awful lot of opposition from the Shoreline Planning Association when Geoffrey Morgan was the president. It got so rough that I finally got together with Geoffrey Morgan and we had quite a long heart-to-heart talk in that we were both actually working for the same thing. We knew that the beach erosion problem was at that time and we were trying to combat it. At the same time we were trying to provide the harbors. I explained to him that the harbor design at Marina del Rey was going to include the sand trap and the cost of the project would include the cost of bypassing the littoral sand in the same manner as the project that had been adopted for dredging at Santa Monica Harbor and bypassing the sand. That finally satisfied him.

REDONDO BEACH HARBOR (KING HARBOR)



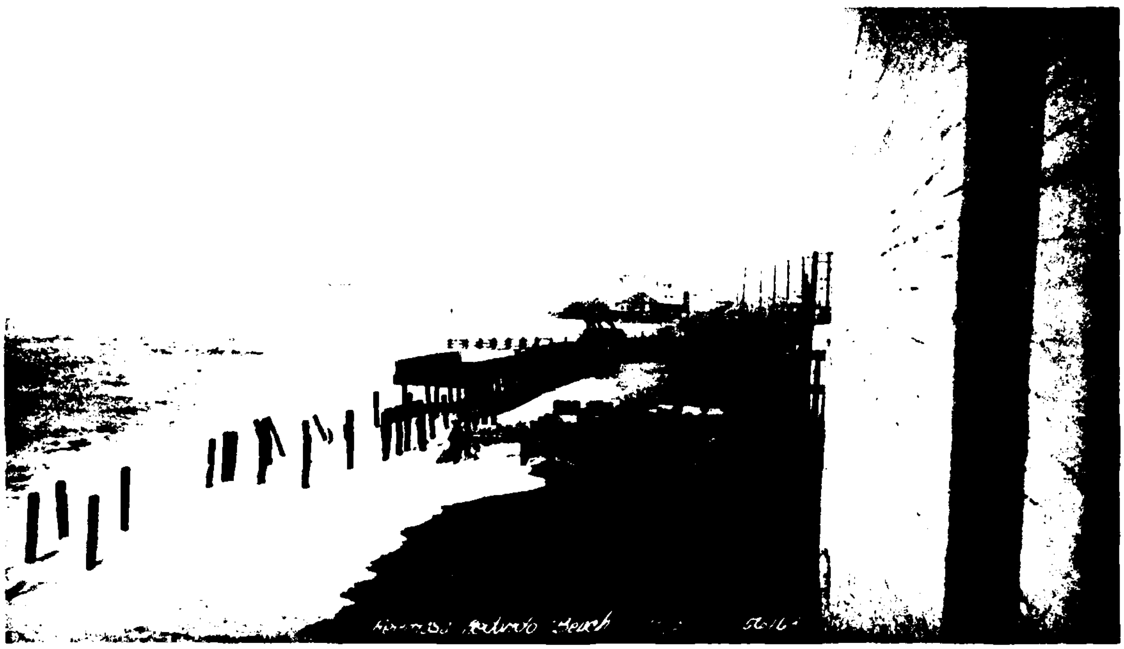
Original Construction Redondo Beach Harbor (King Harbor) (1939)

As remembered by JAMES DUNHAM

The Redondo Beach breakwater was designed for the city by Koebig & Koebig, and was intended to extend for some distance beyond where it ended, with completion in about 1939. They had run out of funds, I believe, and this was as far as they could go. Of course, as we all know, this was the beginning of severe erosion in the area just downcoast from the breakwater. Diffraction effects moved considerable sand from that area northward into the lee of the hook. Waves came in there higher than anyone had ever seen along the Pacific Coast and whenever a high wave episode at Redondo would occur, the news would be broadcast and people would go down there to see these huge waves breaking right on the beach.

We wondered why they should be so high in that particular area, and I went back to our refraction diagrams and noted that, for certain periods and directions, waves were converging as a result of turning over the north shoulder of the Redondo submarine canyon. We could show that, with a certain period and direction, we were getting shore area K factors in excess of two or three; not only that, but the offshore area had eroded to the extent that these high waves could come into within 100 yards or so of the beach before breaking, and that is why they were so obvious there and not at other places.

In considering the shore effects study for the design of Redondo Beach Harbor, it was quite obvious by this time that that breakwater needed to be extended to protect the beach area being eroded, and I came up with the design which brought it to the north edge of the submarine canyon. I reasoned that any sand that had got that far down the coast would not shoal the harbor but would drift off into the canyon. We didn't think that there was too much sand moving in that area because at that point the beach alignment was nearly due north and south, and the refraction diagram showed almost normal approach to the beach for the general run of waves. At that time we were measuring about 30,000 cubic yards a year accumulating in the fillet against the breakwater, but I had reason to believe that there was a lot more sand coming down the beach and then going out around the outside of the structure--this has been proven by surveys later. At any rate, we specified the largest armor stone that had been used in any breakwater of this type at that time, and we thought we had designed a pretty solid structure. However, construction funds did not become available until after I left the Corps.



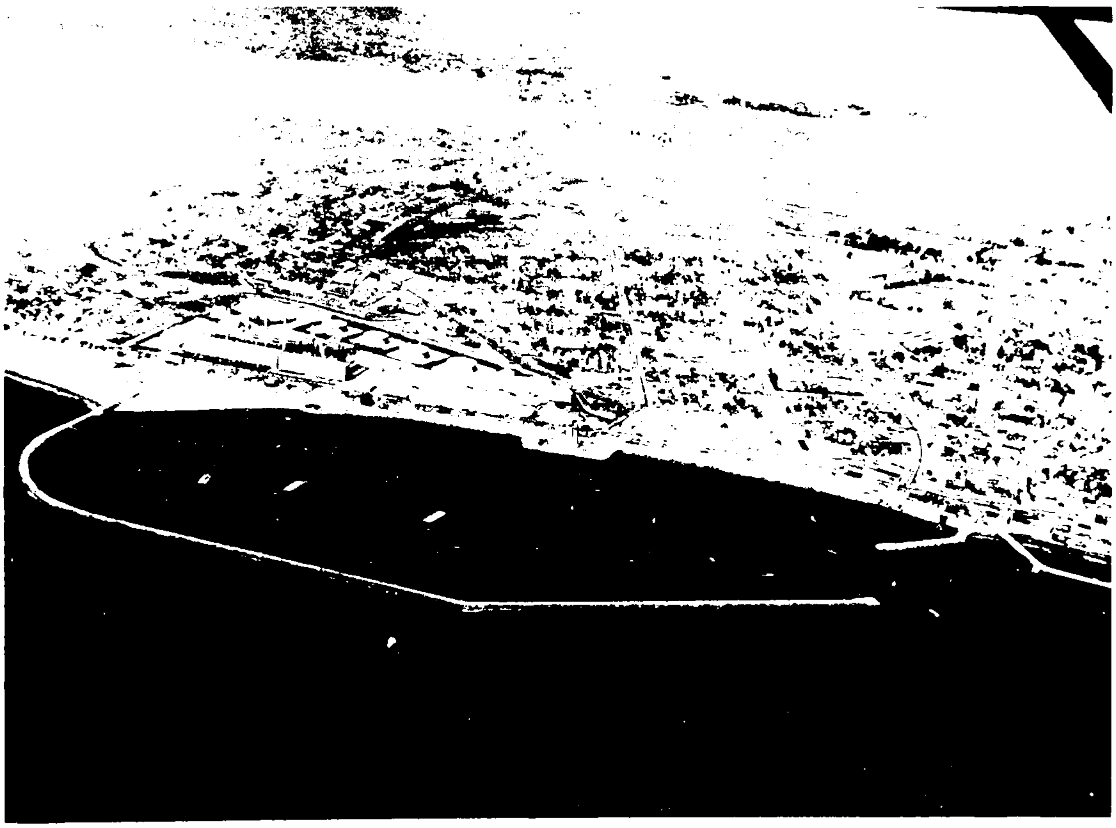
Hermosa/Redondo Beach (1945)

What we hadn't reckoned with is the results of our refraction studies, which showed that this was an area of high convergence and that there would be times when exceptionally high waves would come into the area. If we had designed for those waves at that time, we probably would have been the laughing stock of the area. No one up to that time had designed a breakwater in southern California calling for armor stone of more than about 10 or 12 tons, which is what we wound up with. Later, when the damage occurred and new stone-size formulas were in use, it was found that the design was considerably less than it should have been.

As remembered by WILLIAM J. HERRON

The next project of interest is the Redondo Beach Harbor. This was originally designed by Adolph Koebig in the 1930s, and construction was actually started in about 1937 by the City of Redondo, using money from a PWA grant. Unfortunately, this money was to come in two installments. Construction was started with the first installment and the breakwater was extended out from shore and curved to the south and had just about completed curvature, when they ran out of funds, and so did PWA. The second increment was not forthcoming, so the partially completed breakwater set for a number of years. With the hook on the end, it acted like a gigantic hooked groin. Sand was impounded on the upcoast side as might be expected, but the diffraction around the end of the breakwater also caused an upcoast movement of sand into the lee of the breakwater until that stabilized. For the first few years very severe erosion of the beaches downcoast from this partially completed breakwater was actually greater than the general rate of littoral drift in that area. The damage was considerable--several blocks of houses and structures were destroyed and a great deal of money was spent in emergency revetment, trying to stabilize this portion of the shoreline.

The design of the breakwater is interesting. From the early concepts, advantage was to be taken of the very steep submarine canyon that comes up to the piers at Redondo, and the intent was to extend this breakwater parallel to the coast, and create an entrance on the edge of the canyon where it would take advantage of the quiet water caused by the dispersion of wave energy at the head of the submarine canyon. The emergency revetment work ultimately stabilized the shoreline and it stayed in this condition until about 1958 when funds were finally obtained from the Federal government to extend and complete the breakwater system and reduce this problem.



Final Configuration of Breakwater and Jetty of Redondo Beach Harbor (King Harbor) (1958)

The breakwater was completed and, here again, we come back to the problem that was still being newly considered after World War II, of analyzing the design of these breakwaters based upon wave height.

A rather thorough wave refraction study was made of this area--and I do say rather thorough for that time when the methods were by hand and very cumbersome--but it was a complex area and the derived waves heights depended a great deal on the choice of wave direction and wave period in the design of the breakwater itself. The designers were also bucking the concept by the old timers, who were familiar with the local equipment and construction building techniques that, "it was not feasible, in the field, to extend the B rock and core rock above a -10-foot elevation because of turbulence caused by waves. Nor would the equipment handle more than about 10-ton rocks average size." We did force the design to about 13-ton rock, but still continued to raise the cap rock and B rock only to the -10-foot elevation. Again, probably based upon habit and the design from the Los Angeles-Long Beach Harbor breakwater, armor rock was only raised to an elevation of +14 feet, MLLW.

The breakwater was completed. The city proceeded to build three interior boat basins and operations were started. A severe storm hit the area in 1963, and these waves completely overtopped the breakwater. The result was that residual wave energy inside entered the basins, which had, I think, 400-foot-wide entrances, and caused considerable damage to the floats and some of the small craft that were inside of the basins. As a result of this destruction, the breakwater was redesigned and a very interesting model study was required to determine the most economical way of raising the core of this breakwater to about mean tide level and the upper structure to about +20-foot elevation along the section of breakwater required to protect the two entrance channels to the boat basins.

This work was done with one of the largest scale models that I am aware of. The Beach Erosion Board, now the Coastal Engineering Research Center, had recently completed their 600-foot wave tank. This was used for Redondo and the cross section was actually tested on a one-to-five scale. At this scale, we had to send field experienced men back to the Beach Erosion Board to help select model rock of the same general shape and characteristics as used in the field in southern California, and to ensure that it was placed in the same manner as in the field, and not hand placed like the models of smaller scale had been done.

It was fortunate that this type model study was made because the first cross section, based on analytical design, failed within just a few number of wave attacks and had to be completely redesigned at the model basin. However, the existing structure has been in place now about 18 years and has been through some rather severe storms without serious damage. We did succeed in raising the core material to about a +8 elevation, MLLW, and to raise the crest to +22. A political question was involved in this redesign, which resulted in us not raising the entire length of the breakwater but only extending the raised length southward sufficient to provide protection to the navigation channel and the entrance to the two boat basins that were part of the original Corps of Engineers project. The city attempted to get the higher structure built the entire length of the breakwater which, while it would provide some measure of shelter to the navigation channel, would primarily protect the city parking lot from overtopping during severe storms and is not necessarily a navigation project.

The city had also provided temporary protection to the boat basins after the 1963 storm by narrowing the 400-foot entrances with wooden sheet pile structures. These were replaced in 1976 with concrete sheet pile baffle walls.

It is also of interest that Redondo was the last project built under the revised Federal policy of 1936, which considered recreational harbors as subject to Federal aid as well as commercial harbors, and the Federal share of the breakwater cost was set at 100 percent in this harbor. In the succeeding construction at Marina Del Rey, the policy was changed and, because a recreational harbor has a regional benefit rather than national, the Federal cost was reduced to 50 percent, with the remaining being supplied by local agencies. That is now the national policy of the Federal government for recreational harbors.

REDONDO BEACH — MALAGA COVE SHORE PROTECTION
As remembered by WILLIAM J. HERRON

The final project in the Santa Monica Bay area is known as the Redondo Beach-Malaga Cove Shore Protection Project. This is the area between the submarine canyon and Palos Verdes hill and essentially is a beach compartment. It is of interest because the field studies and the wave refraction analysis show that, while this area is almost stable in alignment, it is subject to upcoast movement in the summer and downcoast movement in the winter; and, as a result, a certain amount of sand is spilled off into the submarine canyon lost to the system, and the beach gradually had narrowed. Probably, also because of urban development, some of the local littoral supply of sand has been lessened. As a result, a project was accomplished in 1969 and 1970 to widen this beach by about 300 feet and stabilize the northern end with a groin to prevent this intermittent spillage of sand into the submarine canyon.

This was an extremely interesting project because it was the first major attempt in California since 1934 to provide sand from an offshore deposit. Offshore explorations showed that sand in the 25-to 55-foot depths were essentially of beach sand characteristics and probably in previous centuries had been the location of the beach. The job was bid three ways and the objective was to put about 1.1 million cubic yards of sand on the beach. It was bid to either be supplied from an available sand gravel pit in the Palos Verdes hill or to be supplied by a sea going hopper dredge, or to be dredged by a standard commercial dredge with a pipeline directly through the surf zone to the shore. The low bid was the commercial pipeline operation by Shellmaker Corporation, with some major modifications of their dredges. Their concept was that they would be able to dredge and pump sand to the beach during wave action up to about 4 feet in height. Between 4 and 7 feet, they would lift their dredge intake from the bottom and just pump clean water, and then at 7 feet, they would have to cut their pipeline and tow the dredge into Redondo Harbor, which was less than 2 miles away. It was probably the immediate availability of this harbor for shelter, plus the generally quiet water at Redondo, that made this project so very possible. They also developed another new concept--they maintained just a minimum amount of floating pipeline behind the dredge and then immediately took the pipe to the bottom. They then carried the pipeline along the bottom through the surf zone and up on the beach. The discharge was moved up and down the beach to provide the 300-foot width as the deposit grew.

The project worked out quite well and was done for about $1.07 a yard under 1970 prices. The follow-on survey showed that there has been a very minimal loss of sand. Actually, the greatest loss of sand was due to the fact that, while the original design had been accepted to include this groin at the north end, in the final design work and the letting of contract, there was a reluctance at the Coastal Research Center to build this groin until "It was proven necessary in the field." So the dredging was done as a separate contract. The sand was placed on the beach and some 80,000 to 100,000 cubic yards of the sand at the northern end was lost into the submarine canyon before the review agencies were convinced that this groin was necessary. The groin was built as rapidly as possible and, as I said, since then this section of the beach has been quite stable and shows very little loss of shoreline once the equilibrium slopes had been established. This is the end of the discussion of Santa Monica Bay.

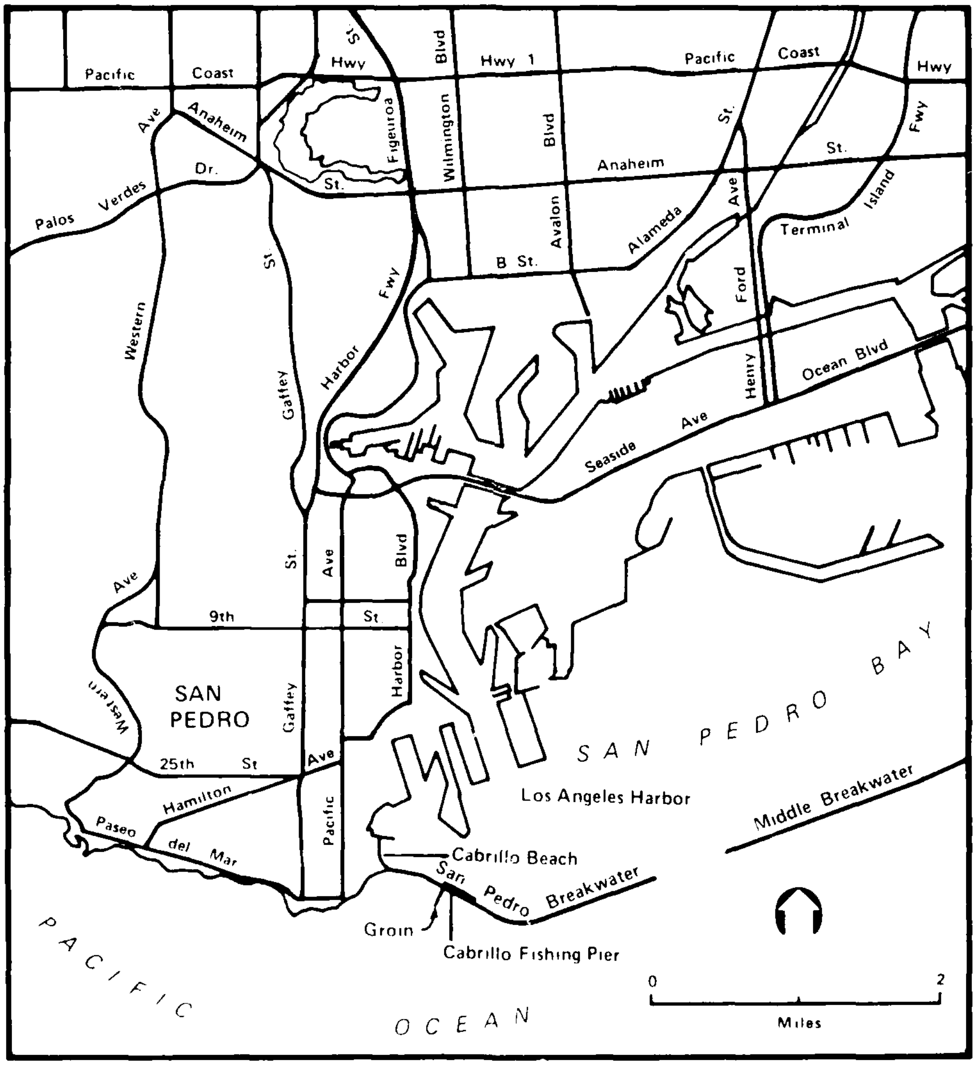
CABRILLO BEACH

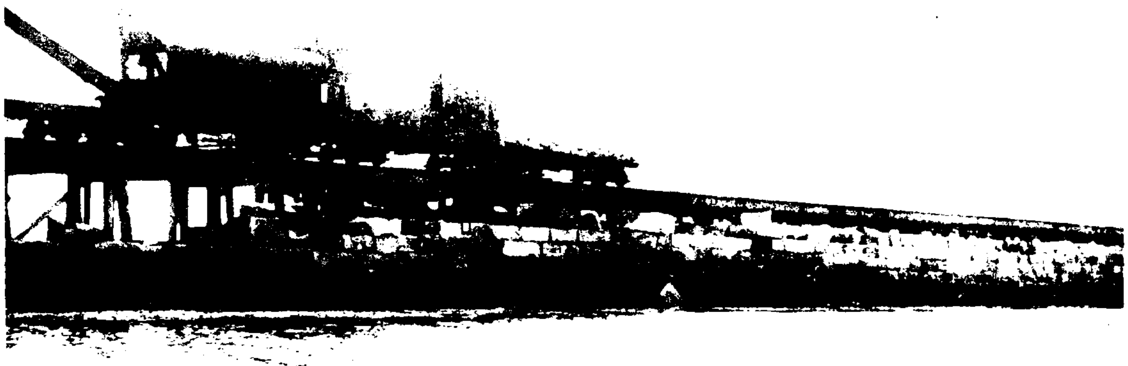
As remembered by JAMES DUNHAM

The Corps of Engineers' Beach Erosion Control Study included analysis of the loss of sand along Cabrillo Beach outside the breakwater. While studying the loss of this sand, we talked to some of the people at Berkeley. Of course, Morrough P. O'Brien, one of the first members of the Beach Erosion Board, was vitally interested in all this and was present at all the Board meetings. He suggested that it might be of interest to review a report that had been done in 1934 or 1935 by two young Corps of Engineers' officers who had studied under him for their Master's degree. One of those officers was Lieutenant Herb Gee (Colonel Gee organized the Florida engineering firm of Gee and Jensen after his retirement from the Corps.) O'Brien had suggested to them that they trace the wave approach of waves into the area, knowing generally where they were starting from and how they would arrive at Point Fermin. Although refraction diagramming had not been done prior to this time, the principles were known, and, under O'Brien's direction, these two officers had made a very creditable refraction diagram showing how the waves approached that area.

By the time we were doing the State Cooperative Studies, we were into refraction diagramming and using it very extensively. We not only proved that Herb Gee and his partner were right in the studies that they had made then, but we showed how waves from other directions would come in and what it was going to take to prevent the loss of the sand from Cabrillo Beach. That was the origin of the concept of a groin near the root of the San Pedro breakwater, which was ultimately built and has been quite successful in retaining the sand beach.

LOS ANGELES AND LONG BEACH HARBORS





Earliest Construction of San Pedro Breakwater Around 1900

LOS ANGELES AND LONG BEACH HARBORS

As remembered by OMAR LILLEVANG

Colonel Leeds, to whom I refer often, told me of the original construction of the San Pedro outer harbor breakwater, where those of us who had walked out there, and who hasn't, remember that for the goodly distance the breakwater's crest is one of flat, almost as if geometrically chipped or formed, blocks easy to walk on; no hopping from point to point except for tripping over a joint, you can go on there or ride a bicycle on it. He said that, in preparing specifications for that breakwater, an Army engineer officer paid the compliment that all of us have paid from time to time--and some of us have been complimented--by cribbing from the specification that he had in his reference file. One was for a breakwater that had been built on the New England coast and he had taken from the language of that reference specification, the descriptions of the stones and the way they had to be fitted, and came out describing a prismoidal shape to the stones and the requirement to be placed virtually in tiers much as you would cut stones. That was incorporated in this specification and, as the contract was let and the work proceeded, this officer, who was in a position of authority, resolutely set out to enforce that specification.

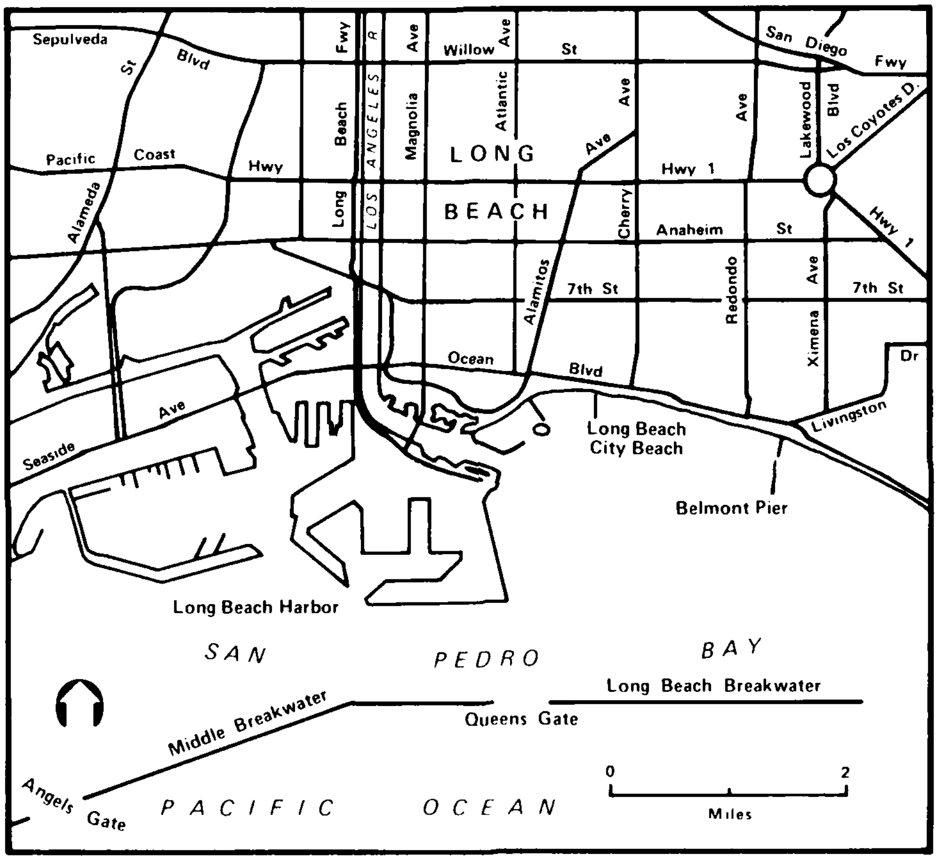
In spite of the fact that quarry stone in the Los Angeles region did not break out of quarries that way, it came out as rough geometry rubble; he forced the contractor to chip and fit and to create an New England style breakwater out of California quarry stone. He was so insistent and so persevering in this attitude of enforcement that he either brought the contractor into bankruptcy or to the verge of it--I think he said bankruptcy.

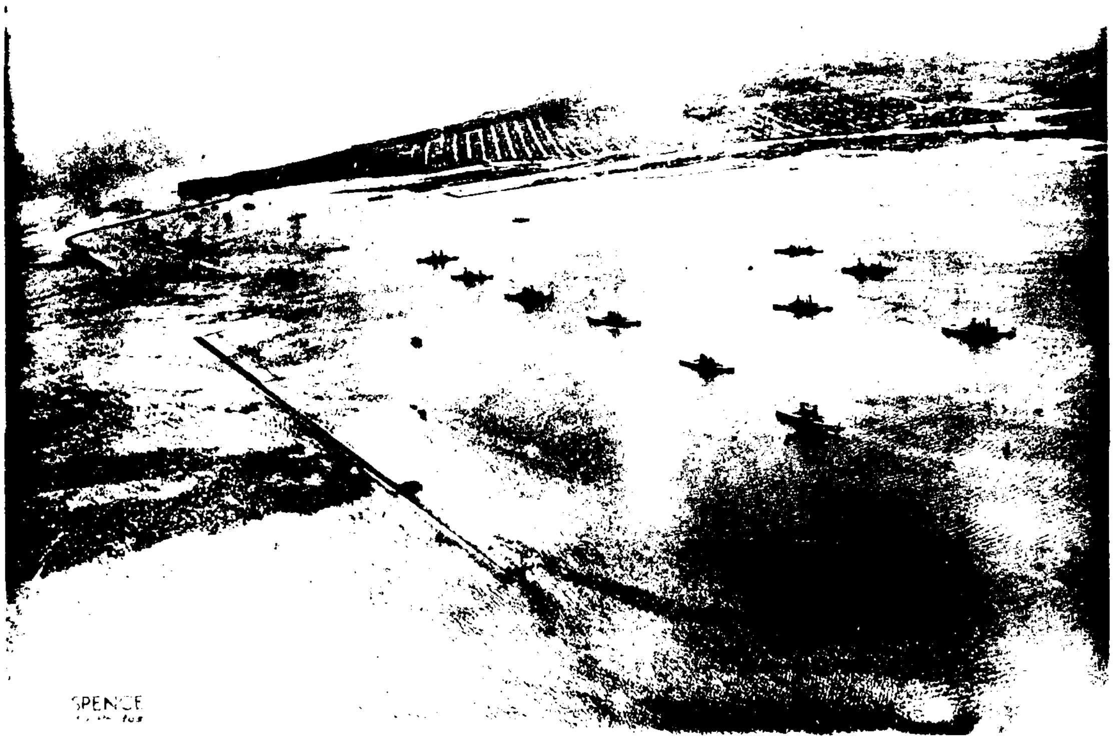
Subsequent contracts down there as those of us who have looked at it know, are more in the style of California breakwaters where the block quarry stones are put in place and, depending upon the specification, fitted together or placed randomly but to create a trapezoidal mound which is not easy to walk on but which is practical and appropriate for the kind of stone that we have here.

As remembered by KENNETH A. PEEL

We were building the first unit of the detached breakwater offshore when I joined the Los Angeles District in 1932.

LOS ANGELES AND LONG BEACH HARBORS





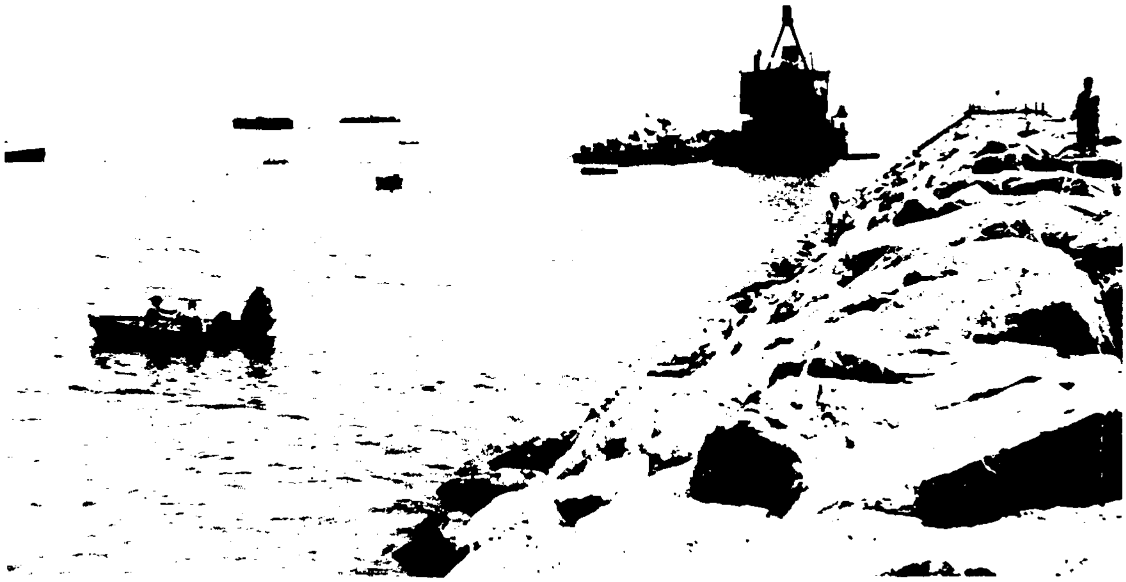
Middle Breakwater (1935) (Note Pacific Fleet)

I don't know if Mr. Hughes was responsible for the design of the San Pedro breakwater, but it was built with a stone base and a random stone core in the middle of that with armor on both sides of cut stone. The cut stone extended down to below low water. The stones on the outside weighed around 8 tons and stones on the inside were around 5 tons, or something like that. That was back around 1900 to 1905. I have never seen an actual design of that breakwater. It may not exist now as the Corps of Engineers has had too many file disposal programs and you have to fight to keep the records of anything that happened that long ago just for historical use. There might be copies of the plans and specifications some place back in the files--dead letter files.

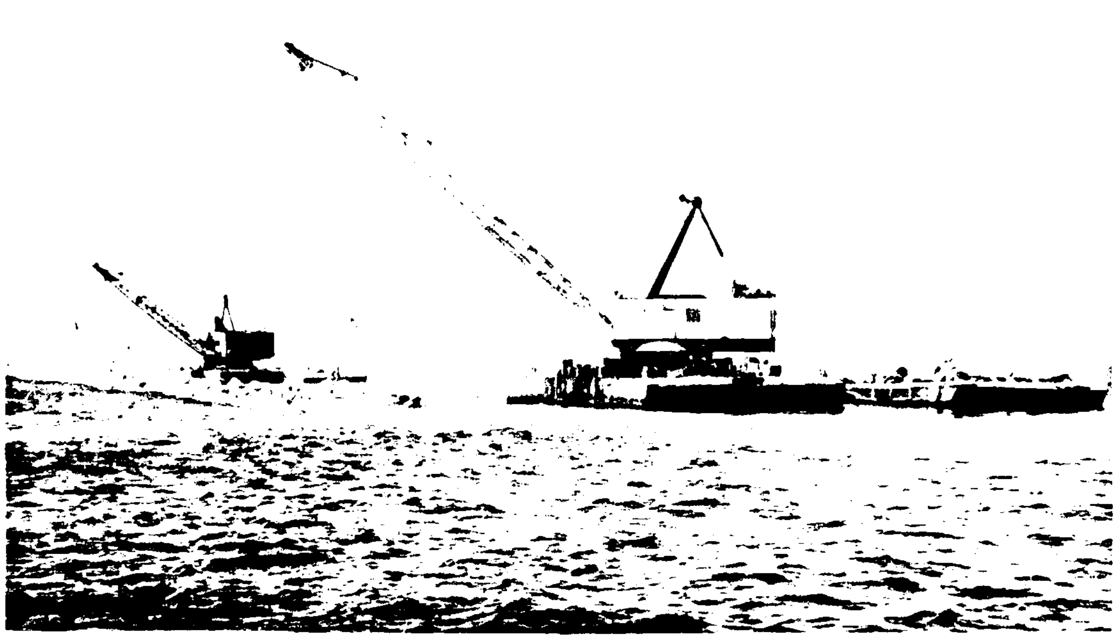
In about 1938, after the 12,000-foot detached breakwater section was completed, the design data was compiled by McOuat and published by the Los Angeles District. With regard to the detached breakwater, I am not sure who came up with the design for the clay core. But after we had had it about one-half built, one of the officers from the Division Office, the Division Engineer, came down and he said, "I will certainly be glad when you run out of that clay so we can start building breakwaters like they ought to be built." They proceeded to run through some model studies of that breakwater core and they came up with the idea that it had a factor safety of one. Now a factor safety of one means that it is just sitting there shaking. But he said because of the difference in costs he didn't dare recommend abandoning it, but he would certainly be glad when we were out of the stuff.

It served the purpose--it's been just as good as if had been all rock. It was a very solid clay, in fact, you could carve it. As Mr. Hughes said, he carved it when they were first considering it; he made a report on the stability of the core. He took a 1-1/2-inch cube that he carved out of it and he stood on it. Then he cut it down into a 1-inch cube and he stepped on it and crushed it, and so he computed the stability just like that.

One more important change was made on the 13,000 foot, or eastern, detached breakwater that was started in 1941. The final 1900 feet were a dog leg, turned inshore toward the Belmont Pier in Long Beach. By 1943, we were beginning to work up wave refraction diagrams and the wave diagrams showed that the few feet gained by straightening it out provided more protection along the shore and didn't cost any more because the water was about the same depth. By straightening it out, we protected more shoreline. There was no reason to turn it in; it accomplished nothing, and it prevented any future expansions of the harbor.



(Pre-1938) Construction on Middle Breakwater



Placing Armor Stone on Detached Breakwater of Los Angeles/Long Beach Harbor

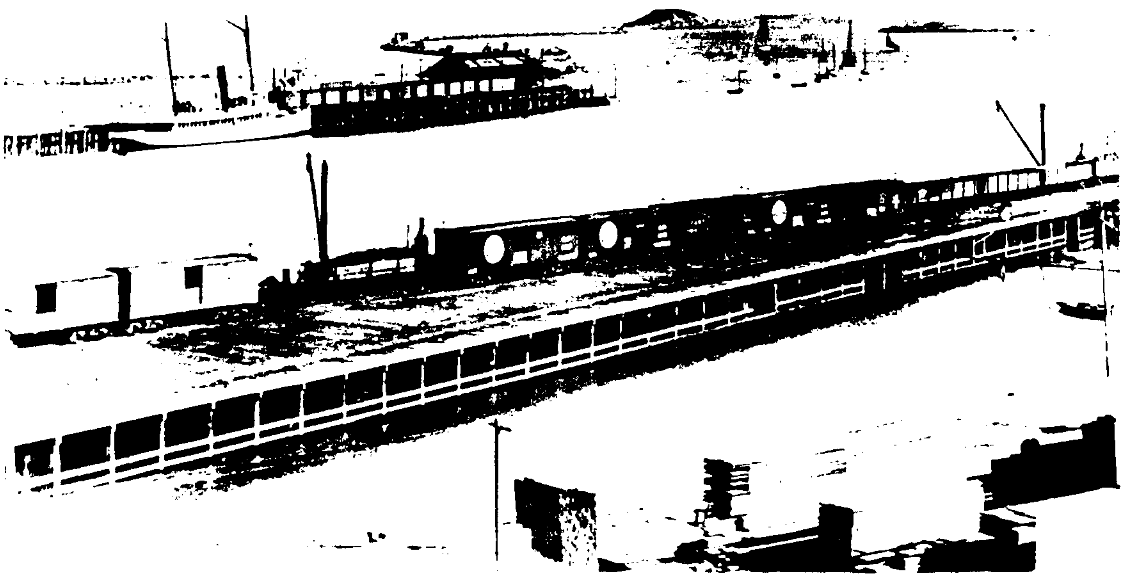
An interesting sidelight on that was that we met with the Division Engineer in the field office and convinced him that it was best to straighten the breakwater. By the time the Colonel got back to his Division Office in San Francisco, we had six loads of rock out on the extreme far end of that thing to anchor it down and make sure nobody changed their minds.

That almost backfired a bit because, when the breakwater job was shut down in 1943 as no longer needed for the war effort, we had that island out there by itself that was a little bit on the shoal side. But it at least achieved the objective and it almost forced construction to be resumed after the war.

The detached breakwater offshore also resulted in some downcoast erosion. It had been thought that the sand brought to the beaches by the Los Angeles River would be sufficient to maintain the beaches in front of Long Beach and Alamitos Bay but, with the construction to Long Beach Harbor and the offshore breakwater, most of the sand began to shoal east of the river mouth and the sand did not go downcoast. That resulted in considerable erosion along the Belmont Shore area. But there again, they began pumping sand on down the coast from the mouth of the Los Angeles River to maintain both the river channel and the downcoast beaches. The improvement of the harbor at Alamitos Bay also put some more material on the beach.

As remembered by WILLIAM J. HERRON

The initial development of the Los Angeles-Long Beach Harbor was in the San Pedro area where ships simply anchored behind the partial shelter provided by Point Fermin and eventually a barge channel developed back into the inner harbor of Wilmington. This resulted in one of the earliest of the Corps of Engineers projects in the southern California area. In 1878, a jetty, or dike, several thousand feet long was designed and constructed between Terminal Island and what was known as Deadman's Island, which no longer exists. The purpose of this jetty was to act as a tidal current control jetty and assist, through scouring, in maintaining the San Pedro-Wilmington channel. There is some question as to whether this effectively deepened the channel but it did appear, through future dredging projects, to help maintain the channel and, no question, it prevented the sandy beaches of Terminal Island from migrating into the channel during periods of upcoast drift. The San Pedro breakwater, completed in 1912, was the subject of great controversy which has been well covered in several reports on the political history of the battle between Los Angeles Harbor and Santa Monica Harbor, so I won't go into that.



Initial Development of Los Angeles/Long Beach Harbor (late 1800)

I have not yet been able to find a copy of the design document of the San Pedro breakwater but this 9000-foot breakwater was the start of the present Los Angeles-Long Beach commercial harbor setup and was completed just before the opening of the Panama Canal. It's an interesting breakwater because it is the only fitted stone masonry breakwater in the southern California area. The lower section, which we will at least show by cross-section, was rock rubble, built from a railway trestle but the top section is fitted granite blocks brought from one of the inland quarries. Suffice to say that two contractors went bankrupt and one committed suicide trying to build this expensive armor rock system. It has been a successful breakwater to the effect that, with about 70 years of service, the total maintenance cost for this breakwater to 1982 has been about $5000, all resulting from the 1939 hurricane, which is the only one that has ever directly crossed the Los Angeles Harbor area, in fact, that has crossed southern California. Another point in interest was that 50 years after the breakwater was built, when we had learned to understand wave refraction, a refraction analysis of this breakwater showed that most of it was in an area of wave divergence and not subject to the extreme wave action of some of the other portions of the San Pedro Bay area.

An interesting research project was also incorporated into this San Pedro section. Mr. D. Hughes was the civilian in charge at this time and he had a group of concrete test blocks placed under water on the breakwater. These have been recovered and cored by the Los Angeles Harbor Department at 10- or 20-year intervals and, to date, have shown no deterioration due to submergence in salt water.

The center breakwater, a 12,000-foot rock-rubble section, was designed and built in the mid-1930s. Suffice to say that, insofar as I know, this is the first breakwater which used a clay and sand core covered by rock-rubble construction. Also, there was no wave analysis, as such, in the design of this breakwater.

The design was based largely on experience with other breakwaters of similar types and a great amount of detailed analysis of slopes stability, but really from a static and not from a dynamic point of view. A portion of this 12,000-foot breakwater was severely damaged by the 1939 hurricane. If it had been simply restored, the repair bill would have probably been in the order of $200,000. However, it was felt that the outer slope stability was not secure and the entire 12,000-foot section was modified. What happened was the lower rubble, or B section from the natural bottom up to about -10-foot elevation was directly bottom dumped from barges and assumed a normal slope of about one vertical to one-and a-quarter horizontal. Then the cap rock from -10 to +14 was established on a one on one-and-one-half horizontal slope, so this provided a convex angle and weak point in the structure at the -10 foot depth. During the 1939 hurricane, either due to inaccuracy of the construction, or the hydrostatic uplift at the trough of the wave, the cap rock was literally pulled seaward. The entire 12,000-foot section was rebuilt with the B rock being brought seaward an additional 15 feet to provide a shelf for the flatter armor rock to rest on. This not only eliminated the convex point of weakness but it also made allowance for construction errors in the field.

Up to 1982, there has been nothing to approach the severity of the 1939 hurricane, but the section has held up well. The 13,000-foot eastern section, built in the 1940s to complete the entire breakwater system, was built to the same modified design. Again, these breakwaters were built without the knowledge we have today of dynamic wave forces. But follow-on refraction analysis, published in the old Beach Erosion Board Technical Manuals, shows that the area where the worst damage occurred was also an area of wave convergence. In part, that explains the damage, and it may not have been caused entirely by the weak point where the cap rock met the B rock.

Our improved knowledge of wave action in the early 1940s did result in a change in alignment of this breakwater. Originally, the 13,000-foot section was to extend eastward about 11,000 feet and then have a 1900-foot bend inshore to enclose the harbor. This would have prevented further expansion of the outer harbor area. During construction in 1942, it was decided to straighten this out, as wave refraction analysis showed that, because of the sweeping curvature of the shoreline, a straight line breakwater would provide just as much wave shelter to the inshore navigation feature as the bend, and would permit future extension of the breakwater by changing the alignment to parallel the coast and allow shelter for either additional navigation facilities or for the ongoing development of offshore oil facilities in this rich oil field.

I will not go much into the inner harbor designs except to comment on the fact that at the time of the original harbor design, when there was only the San Pedro breakwater, the concept of the inner channel, known as Cerritos Channel, connecting Long Beach and Los Angeles harbors behind Terminal island, was a good one because it provided a fast way for small boats, tugs, fire boats, etc., to get from one harbor to another without going into the exposed ocean. The completion of the offshore breakwaters made this channel somewhat redundant. It is very seldom used by the large commercial vessels, but mainly by the small craft in that area, and the tugs getting back and forth between Wilmington and Long Beach.

It did experience quite a problem in about 1964, I believe, when we felt the tsunami wave from the Chilean earthquake. This resulted in a tremendous seiching action in this channel and in over a million dollars in damage. Seich currents at the center point were estimated as high as 15 to 18 miles per hour, and, of course, one of the reasons for damage was the low-level Ford Avenue bridge which raked the super-structure off of at least several boats as they were swept through the channel.

I visited this area the next morning while the seiching action was still quite strong and we went first to the bridge connecting Long Beach and Terminal Island and there was no debris at this point. I then moved around to the area opposite West Basin and checked in that area and again there was no debris at that point, but in the center, a tremendous amount of debris was still sweeping back and forth due to the seich action with no resulting vertical movement. There probably would have been similar damage a few years later when the harbor was hit by the Alaskan earthquake, but the seiching action was much lower and all of the ancient and weakened piling systems had been destroyed by the earlier quake and replaced with new construction, so that the damage was minor from the Alaskan quake. It has become obvious that any severe seiching action will excite this section of channel due to the difference in phasing between the Long Beach entrance and the San Pedro entrance.

The groin built on outside of the San Pedro breakwater in about 1964 is an interesting structure because originally this area was a rocky headland with no littoral sand apparently moving in the area. This was evidenced by the heavy presence of kelp before the breakwater was constructed. Attempts were made to establish a beach in this area at least twice before the 1964 effort, but it was realized that the outer sand at certain times was being swept along the breakwater through the cap rock, which extending to a -10 had large voids in it, and was scattered back into the inner harbor.

So, as a result of the Corps of Engineers' Appendix II, Beach Erosion Control Study, a "Compartment Groin" was recommended, and in the 1960s built to contain sand between the groin and Point Fermin. A very large fill, resulting from deepening of the San Pedro entrance channel, was placed behind this groin. Two effects were achieved. The groin itself extended into deep water and had a very high core, so it acted as a no-sand bypass groin and sand was not going over it or around it. The sand fill itself was so massive that it acted as a real seal along the breakwater and apparently very little of this material has migrated into the inner channel, and the beach had remained quite stable.

The material was not as good as originally hoped for. It contained a certain amount of clay and a great amount of cobbles. The first result appeared bad because the area next to the groin was a cobble beach where the upper section was a sand beach, but this turned out quite well because surfers and bathers don't mix anyway and there was a very good surfing wave action adjacent to the groin. This, just by its nature, separated the surfers from the swimmers and prevented controversy. As the years passed, however, the cobbles shook down, the sand migrated and this entire beach now is a rather good sand beach and the project has been quite successful.

On the Long Beach side of the harbor there were several interesting projects. First, the City of Long Beach could not wait for the total construction of the outer breakwater system, so in 1928, they built their own breakwater. It was a 5000-foot rock rubble structure to enclose the Long Beach Harbor and provide it with local protection from the east and south. This was a rock rubble breakwater and extended outward from the alignment of the Los Angeles-Long Beach River and then curved back toward San Pedro. It is probably the longest buried breakwater in the world; because of the 5000-foot section, over 4000 feet is now buried within the various fills at Long Beach Harbor as they extended their port system.

It also showed a unique confirmation of wave refraction analysis because in the early 1930s one section suffered severe damage due to a storm. Later, with refraction analysis, this was confirmed to be an area of wave concentration. In addition, in discussing this with Dick Eaton before he died, he and Charley Vickers had to replace the navigation light at the end of this breakwater during some of the worst of this storm. He tells me that this is the first time he observed the severe "wrap around" effect that occurs as waves are diffracted around the end of the structure. This later was reconfirmed at Vicksburg and written up in the literature as a result of model studies of the Hawaiian breakwaters.

There were two World War II projects of interest in the Long Beach Harbor area. One was the construction by the Corps of Engineers of what was known as the Pier A Ammunition Dock. This was the first quay wall dock to be built in the southern California area. Due to the wartime scarcity of timber, it was decided to build this structure as a concrete and rock quay wall dock rather than timber. The design was probably more of a field solution than it was an office solution, as the basic concept was the base of the wall would be what is normally called a cyclopedian structure, in which we dumped barge loads of rock up to about 5 tons in size, and then almost by guess work attempted to fill the voids with concrete.

This quay wall was 1400 feet long and I think one of the reasons for its success was that it became almost a laminated structure. The rock placement was started at the eastward end and as soon as several hundred feet of rock were in place in the first layer, and I believe these were in about 10-foot lifts, the rock work continued and the concrete work followed behind it. I was office engineer on this job and as progress was plotted, we got a series of interwoven, almost laminated, types of structures.

This type of work carried forward for the entire 1400 feet, raising this cyclopedian section to a -10-foot elevation. Then from -10 upwards the quay wall was "formed" and filled with concrete to the final dock elevation. It was so successful that, while this wall was built in about 1942, I walked this section at a later date, when it had been subjected to at least 6 or 8 feet of subsidence, and I could not find a single crack in the whole structure; it subsided 6 to 8 feet as a monolithic structure. A commentary on cost and the impact of wartime schedules; this structure was built in about one-half the time it would normally take, and cost at least twice as much as such a structure would ordinarily cost, but this is the price you pay for hurry-up wartime structures.

The other structure of interest was the Long Beach Naval Base built on the face of Terminal Island. This was started even before we got into World War II. It was planned to be the largest naval base in southern California, with the nucleus being three large concrete graving docks--one capable of taking the largest of our aircraft carriers. It was originally thought that these docks could be built as they were, depending on the outer breakwater for protection. The gates were caisson gates that had to be floated into place and then sunk into matching sills where they could be lock-sealed and then the dry dock pumped out. It was found on the first set of gates that there was so much residual swell within the outer harbor area that it was just not feasible to use these caisson gates without being subject to considerable damage. So an emergency study was undertaken by the California Institute of Technology for the Navy to resolve this problem. The answer, through the use of a hydraulic model study and wave refraction diagrams, was to enclose the Navy base with secondary protection by a quay wall and to design the entrance so as to minimize wave action against the floating caisson gates. This resolved the problem and there have been no further wave problems there.

A different problem was that the Navy yard is very near the center of the subsidence area in Long Beach Harbor due to the extraction of oil. The entire Navy base has subsided some several feet. This subsidence very nearly resulted in these concrete graving docks rising out of the ground due to floatation. About the time the situation became critical, it was recognized and additional height and weight were added to the concrete walls and floor. The caisson gates also had to be modified and there was no further hazard from that problem.

This subsidence has now ceased due to repressuring of the oil field by the City of Long Beach and, in fact, the Navy base itself has now rebounded approximately 1 foot and will be subjected to some smaller rises in the future.

Moving over to the City of Long Beach proper, the area from the Los Angeles River to the San Gabriel River can hardly be recognized compared to what it was in the 1930s.

One of the events that occurred that had considerable impact on this beach was the 1938 flood. First, the flood built a tremendous delta at the mouth of the Los Angeles River at the western end of the City beach. In almost the same period, 1940 to 1943, the outer breakwater was extended about 8000 feet and this extension provided sufficient shelter to the western beach so that it was no longer subject to littoral drift. But, starting at about the Rainbow Pier, in the center of town, the littoral sand movement was resumed with no upcoast supply of sand, due to the cutoff of the river supply by flood control structures and the outer breakwater. So, the entire beach about 4 miles in length was stripped from the Rainbow Pier south through Belmont Shore to Alamitos Harbor and there was no high tide beach until after World War II.

In the 1948-49 period, however, two further events occurred. First, the outer breakwater was extended to its full length, as it exists today, and the entire Long Beach area is now in the shelter of the Los Angeles-Long Beach breakwater and is not subject to serious wave action. Based on this, the Corps of Engineers, under a flood control authority, moved in and completely dredged out the delta, in fact over-dredged, at the mouth of the Los Angeles River to provide for future floodflow and to rebuild the entire beach of Long Beach to a width of about 300 feet. This extended from the Rainbow Pier to about the Belmont Pier. At same period of time, the City of Long Beach initiated its first construction of the Long Beach Marina and was able to supply sufficient dredge sand from the marina to complete the beach widening project from Belmont Shore to the entrance to the Long Beach Marina.

These events went on from about 1948 to 1953. The beach has been relatively stable and there has been little lost sand since that period of time. However, it is not as attractive a beach as it was when they had open surf. Now there is almost no cleansing action due to surf or littoral drift, and the bottom has become rather murky.

The next project of interest combines the flood control structures of the San Gabriel River with the construction by the City of Long Beach of the Long Beach Marina. It is one of the few marinas in California that was not participated in by the Corps of Engineers. It was designed and built by the City of Long Beach with oil funds. However, just prior to, but really part of the Long Beach Marina action, the Corps of Engineers and the Los Angeles County Flood Control District completed the flood control works on the San Gabriel River; the river was separated from the marshlands that made up the original Long Beach Marina and provided its own jettied entrance. The Long Beach Marina jetties were combined with this, so, in the same manner as Marina del Rey, we now have a three-jettied entrance, with the navigation channel on the northside and the river on the southside. The Long Beach Marina was one of the very early attempts at modeling a marina before it was built. And while it was entirely a tidal model, it did provide a great deal of information on adequately designing the harbor and the entrance. Also, the extension of the Long Beach Marina jetties was one of the first attempts to place core rock above the -10-foot elevation, as had been the concept before. The core and B rock was successfully placed to about mean tide level and then the cap rock placed on top of that.

I don't believe Lillevang mentioned the powerplants in this area, but there are three powerplants here, which have taken advantage of the river-marina separation to avoid the expensive construction of salt-water-cooling intake and outlet pipes out into the ocean. They have tunneled under the San Gabriel River and draw their cooling water from the Long Beach Marina channel, take it underneath the river, up a canal, and through the powerplant, and then the hot water return is discharged into the river and gravity takes it back to the ocean. This has worked out quite well except that the warm water returned to the ocean at the west end of Seal Beach has become a very attractive breeding ground for Sting Rays, and each Spring lifeguards have to clean them out with explosives.

As remembered by JAMES DUNHAM

One of the 50-50 cost sharing studies was at Long Beach. When the middle breakwater was completed, it intercepted the drift that was being contributed by the Los Angeles River. Sand was no longer moving down along the coast but was collecting at the river mouth and the once beautiful, broad beach at Long Beach narrowed to the point where waves began to undermine the seawall. I recall taking pictures of the exposed piling under the seawall about 1940. We felt that unless something was done about it soon, the entire bluff from the Rainbow Pier to Belmont Shore would collapse. Subsidence in the vicinity of the Rainbow Pier due to oil extraction also contributed to this loss of beach.

Along the bluff area, and somewhere to the north of that, erosion was very severe. There was no beach left at all. Of course, we realized that the offshore breakwater was the cause of it, having prevented sand from the historic sources from reaching the area. The Beach Erosion Board's recommendation, which we had suggested, was that all this sand that had accumulated at the mouth of the Los Angeles River during recent floods be pumped down along the beach to protect the area. During and immediately after the war years, the Los Angeles-Long Beach breakwater was extended to its present terminus near Seal Beach, and relatively soon afterwards, the sand from the mouth of the Los Angeles River was pumped to the eroding beach along the Long Beach shore front. Now, 35 years later, the beach is still in good condition.

ALAMITOS BAY

As remembered by OMAR LILLEVANG

Colonel Leeds and I worked together, my working as a staff assistant to him, and in and around the mouth of Alamitos Bay when Southern California Edison Company first set out to construct what they now call their Alamitos Steam Station, which is on Cerritos Creek, above the rowing course--the Olympic rowing course--and above Alamitos Bay.

The site was one where Colonel Leeds had also been involved before I began working for him, which means it was before August of 1938. He had Dr. Knapp of Cal Tech do a model study of the mouth of the San Gabriel River, which was the same as the mouth of Alamitos Bay at the time. The river had not been separated from the bay. I think this work was done in the interest of the old Los Angeles utility, which was because of the presence of their steam electric generating station on the Seal Beach side of the mouth of the river and bay. They were concerned about how to maintain their intake of cooling water, which had been taken from that joint mouth channel, and now would be taken from Alamitos Bay through a siphon passing under the separated river channel and to the powerplant.

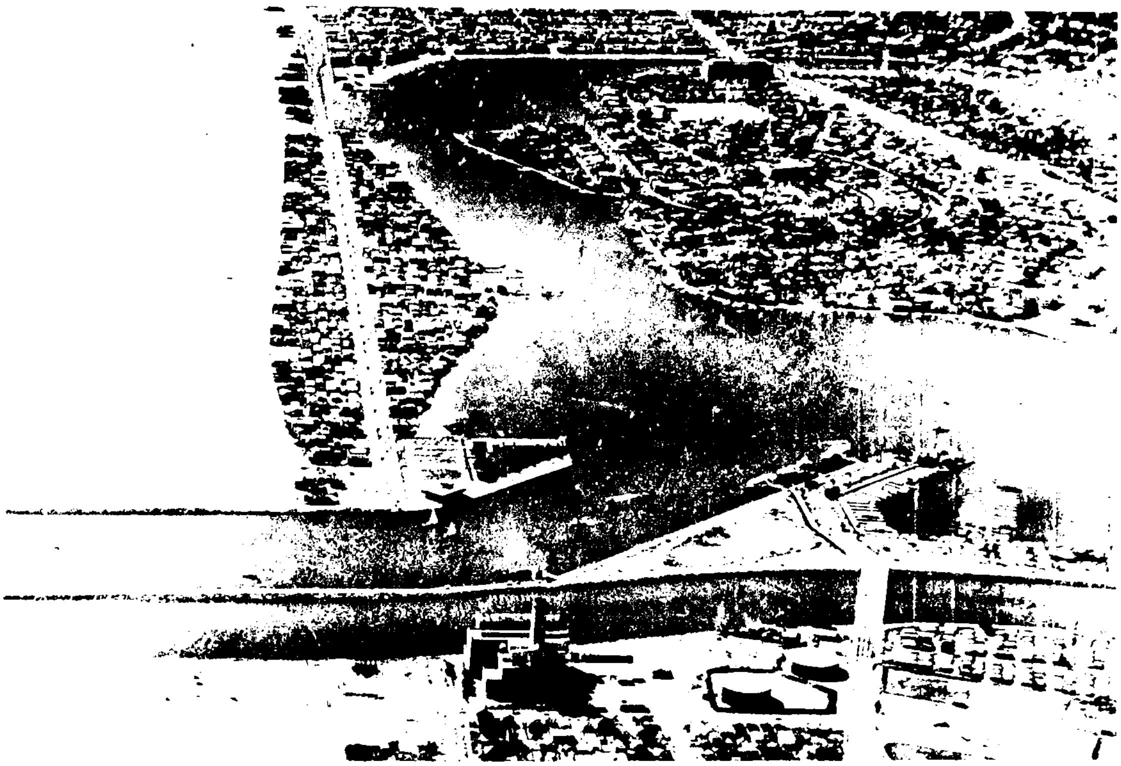
Well, I don't really have any knowledge of that model study, though I have a copy of it I believe somewhere in my library. But referring to the work where I was involved, we analyzed the tidal prisms and the flows of water, how the Edison Company's planned new plant would function, taking its cooling water through Alamitos Bay through the rowing course and up Cerritos Creek. Those intakes are a result of these studies, including a fairly long period of tide observations on a cooperative basis with the Coast and Geodetic Survey, and the cooling water supply was worked out as being a channel through the bay entrance, the bay waters, and Cerritos Creek, which was deepened up to the Edison Company's intake.

Alamitos Bay Area in 1921 and 19 Years Later

Later, and not very much later, we also worked with the Los Angeles Department of Water and Power in that area, as they evolved their plans for their Haines Steam Station, which is just across the San Gabriel river from Edison's Alamitos plant. It gets its water from Alamitos Bay also in a rather uncommon scheme; in that the intake itself is in the wall or bulkhead creating the basin border at the most northeasterly corner of the Alamitos Bay Marina.

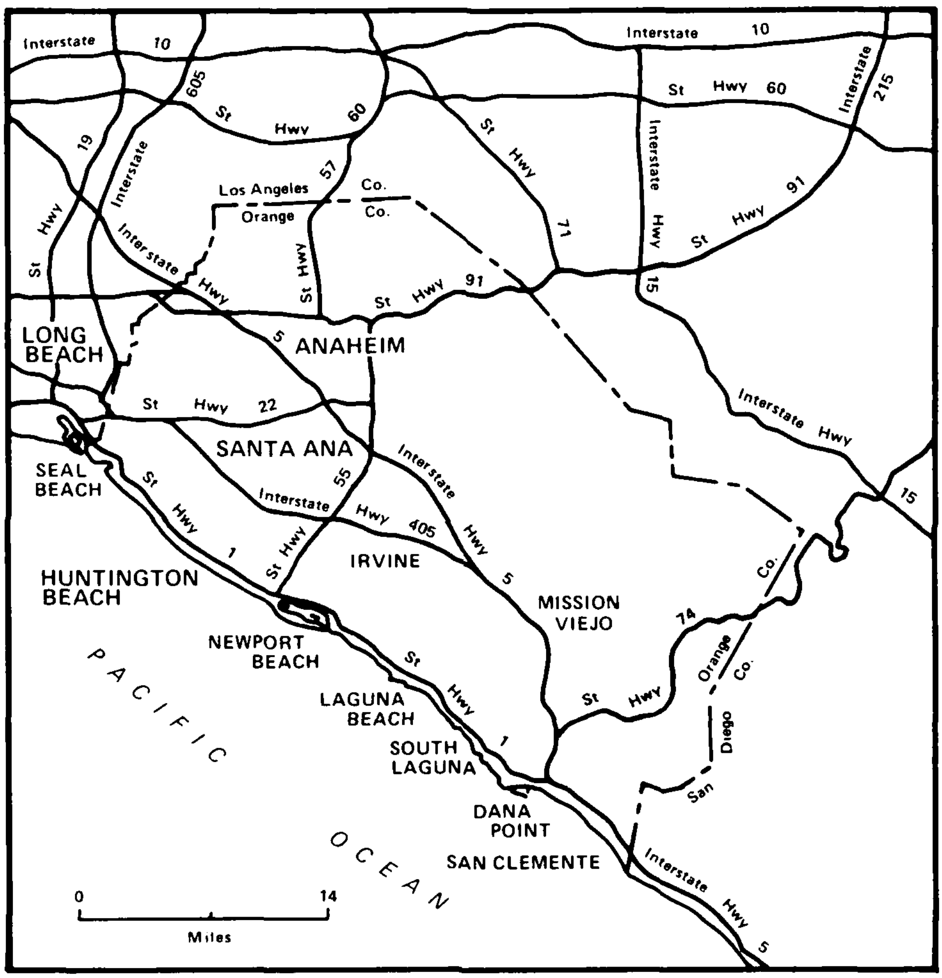
Almost no boatman mooring at slips in that area, nor maintenance people, nor even some of the harbor department nor the marine department personnel working in that marina know that the intake is there. It was devised so that the entrance velocities would be low enough to be subtle and hardly noticed. It functions well, it's all below water line, and unless one looks for and recognizes some checker plate covers that are on the perimeter walk back of the bulkheads, you would never suspect that it was there. Now that's not particularly unique but then those wall intakes go from there in seven parallel geometric concrete siphons under the San Gabriel River, cross to the other side and under the coast highway, and appear at an outlet structure. From that point, it flows about 2 miles farther up to the steam station in what really is a small river.

The problem of marine growth here could not be solved with hot water the way Edison Company had managed to solve theirs on the sea coast stations with two pipes. So, the seven barreled siphon was the answer for the flow they require. They only need about four barrels. The way they maintained them is to take one or several barrels out of service at a time for 2 weeks; totally close off the two ends so that there is no inflow of oxygenated sea water; and the marine organisms in juvenile stages that have attached themselves and begun their sedentary life on the walls of those conduits then become suffocated for lack of oxygen in the water and sluff and fall as readily moved detritus to the bottom. So, in rotation, two or three barrels of that seven-unit siphon are taken out of service, isolated from a supply of oxygenated water, and the oxygen then is consumed in the life processes of the animals. Once it's consumed, they can get no more and they suffocate. That seems to work extremely well.



Alamitos Bay (1964)

Orange County



7 Orange County

SEAL BEACH AND HUNTINGTON HARBOR

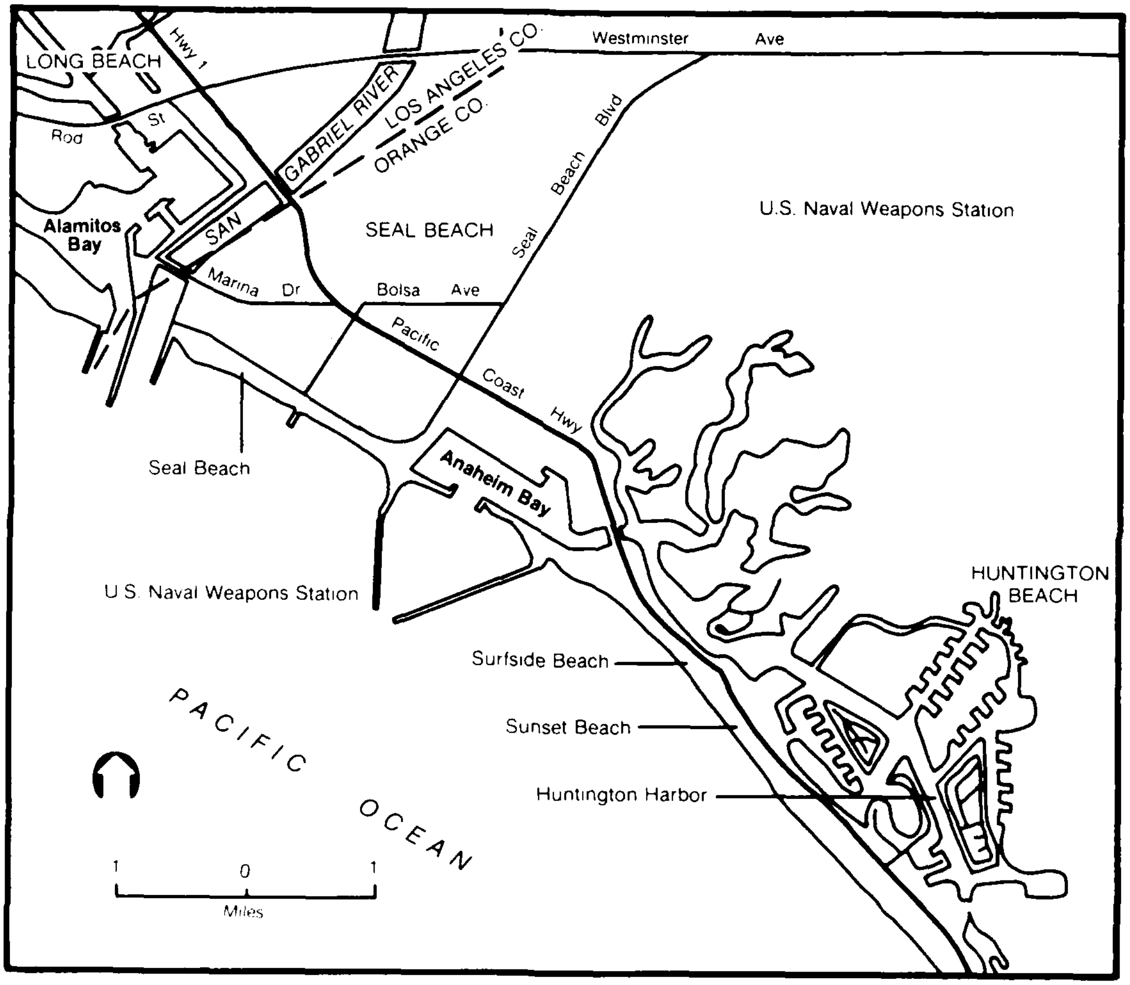
SEAL BEACH EROSION CONTROL

As remembered by JAMES DUNHAM

It is interesting to note what has happened to Seal Beach. I recall when I first went down to that area as a boy, there was a beach strand that extended almost without interruption from Long Beach all the way down to Huntington Beach and beyond, with just a slight indentation at Anaheim Bay. Anaheim Bay, of course, was originally the Anaheim Landing. There was just sufficient tidal prism effect to keep the bay mouth open, and vessels of real light draft could get in there and unload supplies. When the sand supply source was cut off, the beach began eroding, and to prevent this, the Seal Beach groin was built by the city at the north shore entrance to Anaheim Bay in 1939.

Very shortly thereafter, a fillet of sand built up against that groin and remained until the offshore breakwater was completed - I think about 1949 - and changed the wave regime. It cut off the waves from the west, and the waves from the south came in and started moving this fillet of sand from the south end back to the north end. About this time we were studying the effects 10 miles on either side of harbor construction work at Long Beach. We recommended that one way to handle this situation would be to build another leg of the offshore breakwater, because at that time Navy capital ships were

ALAMITOS BAY TO HUNTINGTON HARBOR



still in use. We thought the Navy might need the additional mooring area. Later, it turned out that the Navy showed no interest in extending the breakwater, so this was never done. We then recommended, and the Beach Erosion Board approved, construction of the middle groin along the pier in order to compartmentalize the Seal Beach strand into two halves. We knew the direction waves would come in and the sand that existed there would be contained within these two segments without being moved past either. The only trouble was that we knew that this wouldn't last forever because there was no source of supply for this area other than the San Gabriel River, and the San Gabriel River jetties shot the river material off to considerable depths into the water. We figured that at some time it would be necessary to move that sand and get it back on the Seal Beach strand.

We knew it would be necessary to replenish the beach sand periodically. It was done once when Anaheim Bay Harbor was dredged deeper. Some of the sand was placed to the north in accordance with our recommendations. That was about the end of my involvement with it. The central groin has been very effective in compartmentalizing the beach.

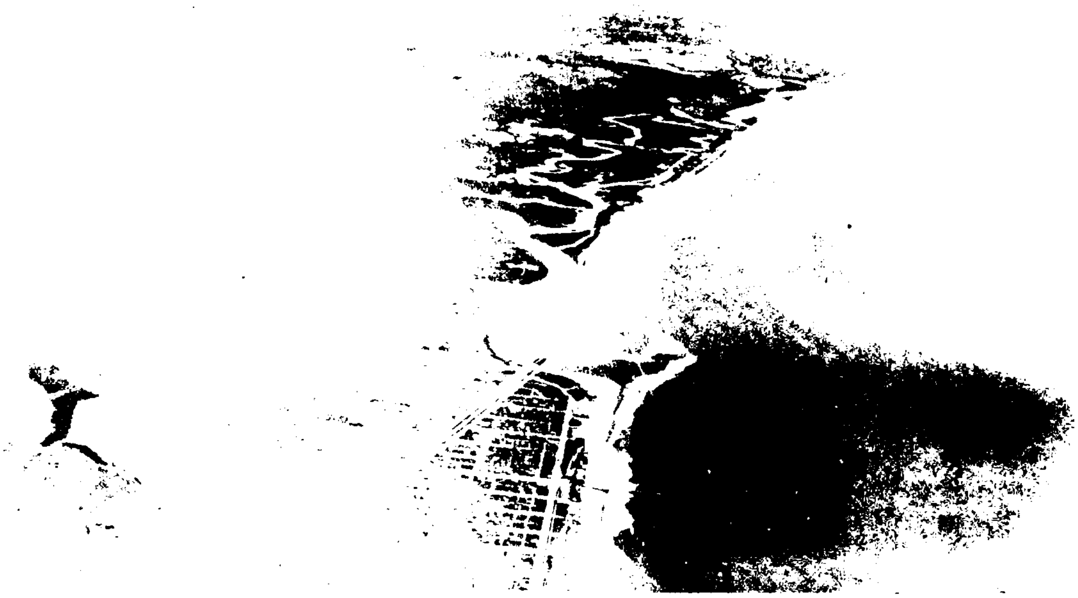
SEAL BEACH CITY

As remembered by WILLIAM J. HERRON

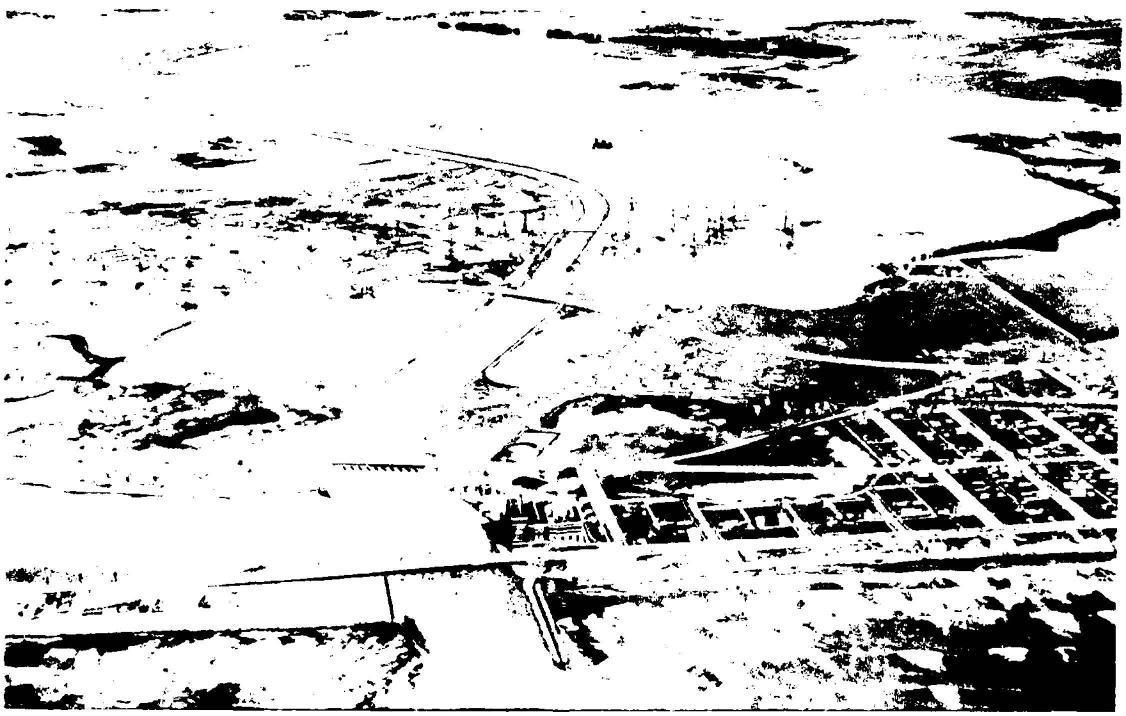
The Seal Beach problem became quite complicated. It had been a reasonably stable beach, about 1 mile in length, until the sand supply was denied to it by the construction of the flood control structures, particularly on the San Gabriel River.

In the early 1940s the beach was beginning to suffer loss of sand supply because the littoral drift was from west to east and the beach was beginning to move on down without replenishment. The city built a stub groin at the east end of the city, which partially solved their problem but, of course, simply transferred it to the adjacent Orange County beach community known as Surfside and Sunset Beach. This problem was just starting to become critical when, with the advent of World War II, the Navy decided to take over the Anaheim Bay area and construct an ammunition depot in support of the big Navy Repair Yard on Terminal Island.

The Navy proceeded to start with the short groin that the City of Seal Beach had built; they extended that and incorporated it into a pair of Arrowhead jetties; these extended out to about -22-foot depth. This, of course, completely trapped any sand to the west of the jetties.



Downcoast From San Gabriel River (1921)



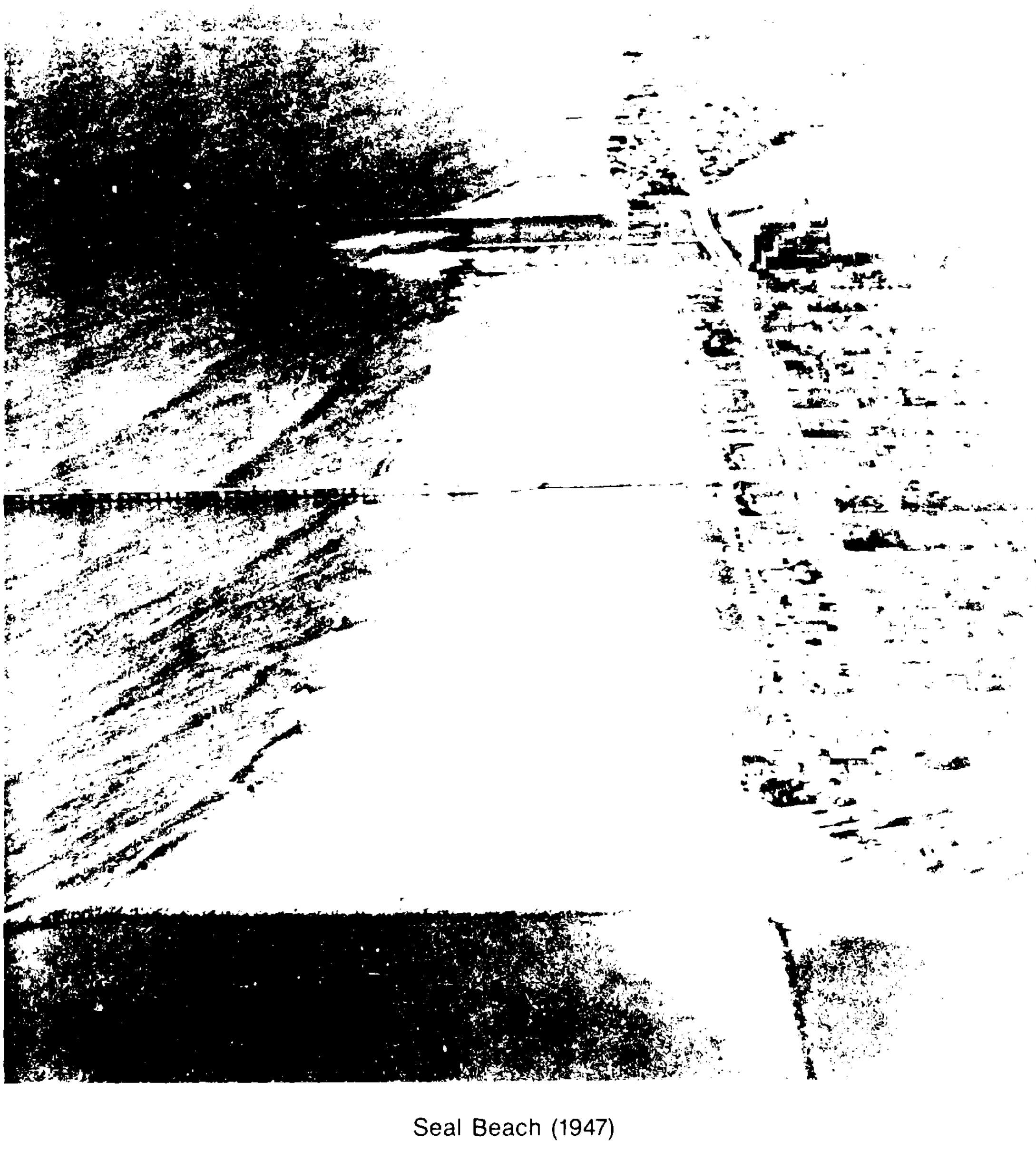
San Gabriel River Outlet (1933)

No great effect was noticed on Seal Beach until the extension of the outer breakwater was completed in 1948-49. But with the extension of the outer breakwater, and the cutoff by wave action from the westerly side, it was suddenly realized that the direction of littoral drift had changed in the Seal Beach area and was now carrying sand from east to west. As a result, the alignment of the beach fronting Seal Beach completely reversed itself with the erosion occurring at the east end and accretion at the west end to the extent of partially blocking the San Gabriel River. This resulted in hightide flooding of apartment houses at the east end of the beach and the city undertook one of the first cooperative beach erosion control projects in southern California. The solution was somewhat interesting.

By the late 1940s, the aforementioned projects had created a compartment beach between the jetties of the San Gabriel River and the Navy Weapon Station jetties. It was decided to build a long high groin at about mid-point of Seal Beach. This would compartmentalize the beach into two segments in which beach sand could be imported and stabilized so that there was no overtopping and flooding of the landslide structures. The groin here is interesting. This was about the time of the advent of the prestressed concrete sheet piling and a groin was designed of prestressed concrete sheet piles, taking advantage of the pier at about the mid-point of the beach to serve as a driving platform. The pier was checked out to determine if it could carry the weight of a pile driver and trucks. The groin was extended seaward along the west side of the pier, and carried out to about the -11-foot contour. This is a compartment groin. The top of the seaward end of the groin is at a +7 elevation and, as I said, carried out to the 11-foot depth. It was conceived as extending beyond the effect of littoral sand movement and would almost completely compartmentalize the two beaches.

A safety provision was put in the authorizing document to transfer 10,000 cubic yards a year of sand from one side to the other to maintain balanced beaches. The system has worked pretty well but it appears to me that the groin needs to be longer because there is a certain natural sorting of sand on, particularly, the east beach which gets more wave action, and, while the shoreside is pretty stable, the finer material is apparently slowly moving around the outer end of the groin and adding to the west beach.

We also ran into a problem in construction of the prestressed concrete sheet pile groin and I have still not really seen a solution. The sheet pile was driven



Seal Beach (1947)

and then heavy H-beams were used as walers to temporarily hold this structure. The cap was formed of concrete along and around the top edge of the concrete sheet pile and poured in place. With the flexibility of a prestressed concrete member, it appears that we just were not able to hold that structure firm enough, being subject to wave action, to allow the concrete to "set" in that cap and maintain complete bond with the connecting reinforcing steel. It was not long after construction when cracks began to appear in the cap and now sections have flaked off and it's obvious that, in many areas, there was not adequate bonding between the concrete and steel.

Later, we tried the same thing for a shorter groin at Capistrano Beach; and even there, we still had a little trouble, with the sheet pile being in movement while we were trying to pour this cap onto forms holding just the tops of them. I haven't seen an answer yet to this; and it is a problem.

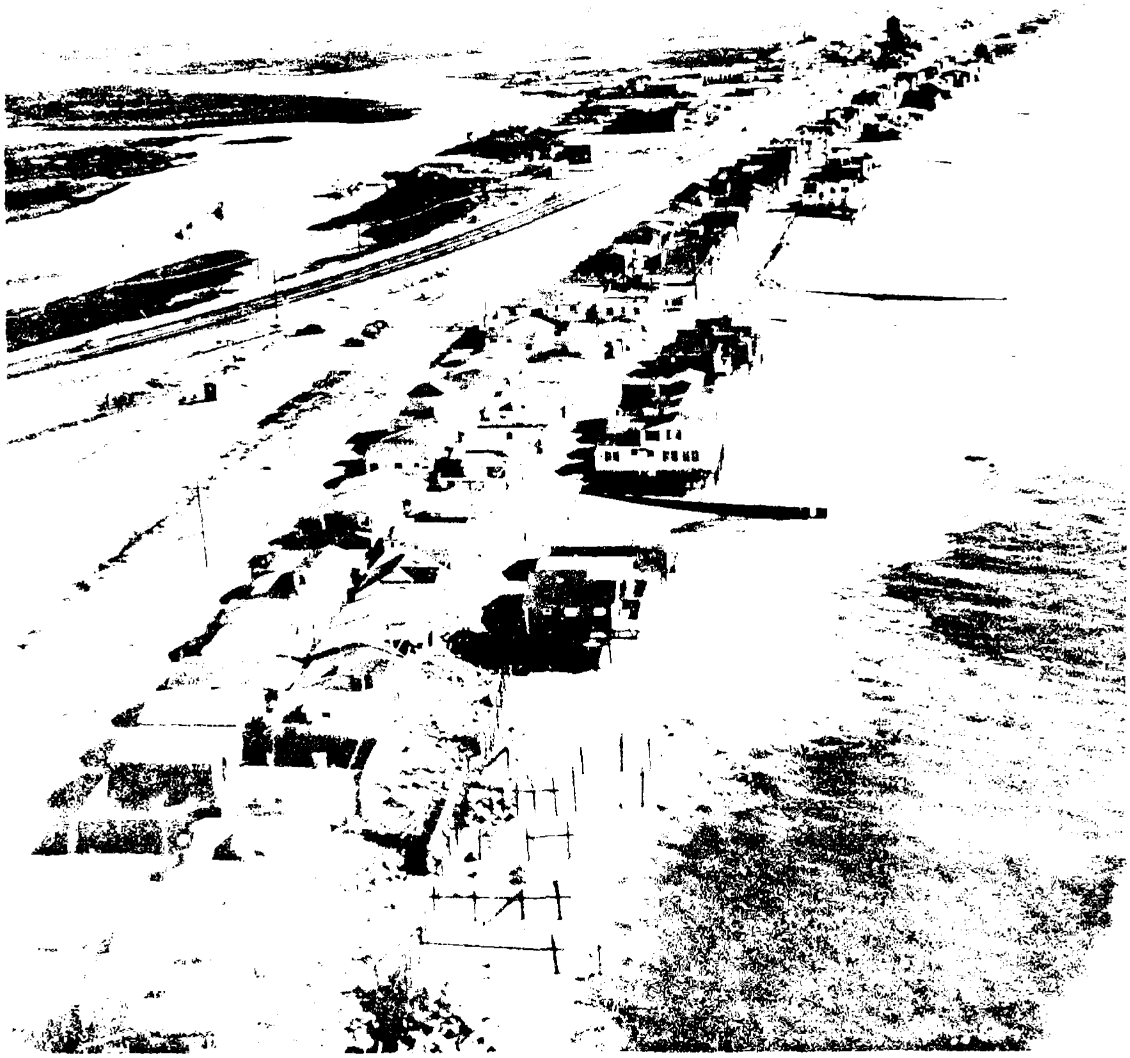
ANAHEIM BAY AND SURFSIDE

As remembered by OMAR LILLEVANG

The next problem in erosion was at Surfside and Anaheim Bay. They had a very severe erosion problem. I think it was probably the result, partially at least, of the 1940-49 extension of the offshore breakwater. That caused the point of the erosion to shift to the south. The breakwater protected the eroding beaches in front of Belmont Shore and Long Beach and it stabilized those pretty well. There was a little wave action inside--I guess it moved the sand some, but not much--and so that shifted the erosion focal point farther east until it was hitting in at Surfside very severely. When they dredged out Anaheim Bay Harbor and installed the jetties, they pumped a lot of the sand along the beach. I imagine the erosion has continued, but I haven't seen that beach for, I think, 20 years.

Next down the coast is Anaheim Bay. I remember it when there were no improvements at all when I was a boy. In fact, we stopped there once so I could take a swim, I think I was about 9 years old. At that time it was a plain meandering entrance and eventually the Navy, during World War II, went in and acquired it as one of their Pacific coast ammunition depots.

Colonel Leeds designed the Arrowhead-type breakwaters that are used to regulate the Navy entrance and prepared the plans and specs for the first dredging and for wharf construction in that harbor, while I was in the Navy



Surfside/Sunset. Post World War II

during World War II, so I didn't participate in that. However, about 1963, for the second time, the Navy decided once more to deepen the basin so as to bring larger vessels alongside. The original concept, for which Colonel Leeds designed it, had tow barges brought alongside the wharf, loaded with ammunition and then. taken out alongside ships of the fleet that were at anchor in the Los Angeles-Long Beach Harbor protected area. The ammunition was then loaded aboard ship. Subsequently, they had deepened it once so that small Navy vessels could come in and replenish ammunition supplies directly across the wharf and now they wanted to bring in ships as large as destroyer escorts, and perhaps destroyers, to do that. And it was an interesting thing because we could look at how the Arrowhead jetties had behaved in terms of quieting water inside.

Some structural concepts that had been prevalent when they were originally designed, we knew with later discoveries and dissemination of discoveries on diffraction and other phenomena of wave movement, probably were not at all needed and we removed them as part of the widening and didn't restore them. Particularly some little spike jetties that jetted outer right at the portals of the inner harbor were removed, and subsequently, it has been shown that they were not needed.

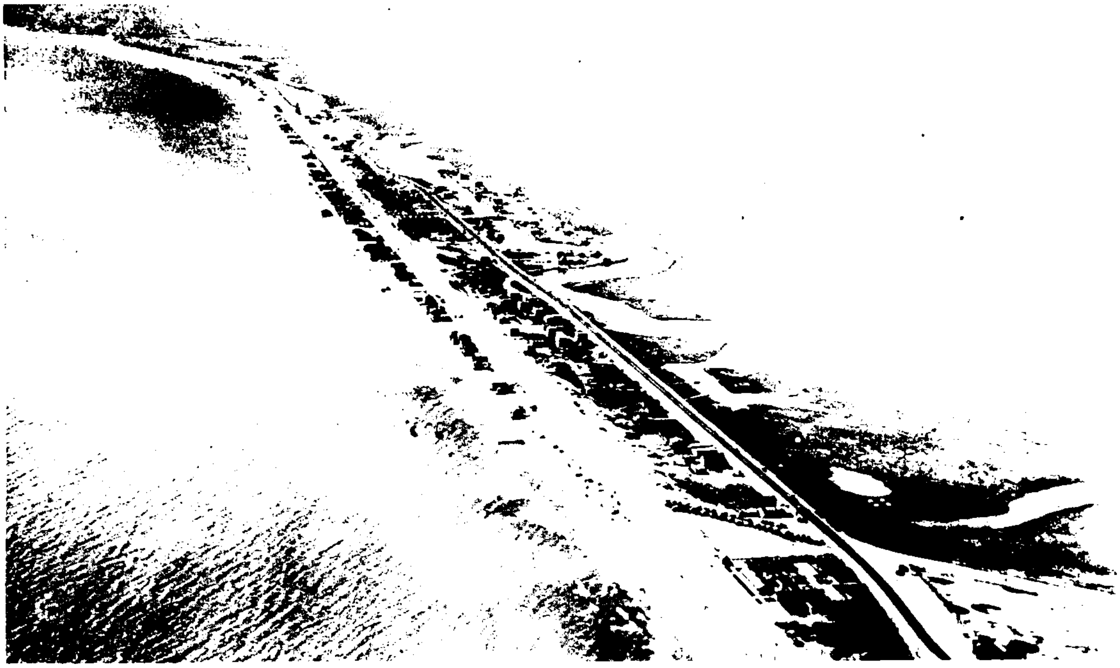
The deepening was accomplished while the facility continued to serve ships. The result was that the divers could not use gasoline engines to run their compressors, they had to be spark suppressed electric motors. They had to be down the wharf and the traffic problems just doing the survey investigation, not to mention those of construction work, while that harbor continued to load hot ammunition was something else.

About the time that I left Leeds, Hill & Jewett to open my own offices, we began work on a special wharf to accommodate the Navy's one and only tail-gated ship, the Landing Ship Dock, so that it could come in, drop its tail-gate on this special wharf and load onto it the Saturn second stage element which had been assembled by, I guess, North American, only 4 miles north of here.

An interesting commentary on theory versus practice is appropriate on this one I guess. The work was being funded by NASA and somebody back in, I don't remember where NASA's headquarters for these purposes were but it seems to me it was North Carolina. Somebody there got worried about the stability of the fill approaching this wharf for fear that there would be a slide, an unstable fill, that could cause their special multi-wheeled, multi-driven carrier, and its load of the second stage of the Saturn missile to go sideways into the harbor. They didn't look on that with much enthusiasm. So they insisted on some very, very sophisticated analytical procedures. The project engineer that we had assigned to the thing said, "That's really not very definitive because it always works in two dimensions--what are you going to do about the third?" So he advocated that instead they take another carrier that was there, with essentially the same kind of wheel configuration as the one that would carry the Saturn's second stage, and put one horrendous big tank on it and fill it with water to simulate the load and drive it out on the fill and let be expendable if there was a problem, but to take subsidence measurements all the way through with it. It took something like 6 months to get them to agree to a practical test of that kind rather than going through a sophisticated numerical solution.

Another thing that has nothing to do with coastal engineering but is related to this general area. My wife's parents bought a lot there and built a little beach cottage on it for recreation use about 1919, in what is now Sunset Beach. They used to go down there frequently, particularly during the depression years and after, and at that time the Anaheim Bay sloughs were very primitive and, I don't know if her father was that concerned, but her mother was definitely of the blue-nosed Methodist type concerning liquor and such things. The family insisted that the children, when they went out rowing their boat through those sloughs, stay away from Hog Island.

Hog Island can be found on the old C&GS topography sheets of that area and I think there is an antenna based on it right now. There was fresh water from an artesian well there and it was only after she grew up that her father told her the reason that they were not allowed to go near it. The family knew that was a place rum runners were using. Anaheim Bay was apparently very remote, inaccessible and, therefore, to the rum runners an attractive place to bring small boats in through the tidal slough mouth from larger vessels off the coast, deliver their contraband prohibition liquor to Hog Island, and then when the heat was off, to find ways to get it to trucks and other vehicles and deliver it to bootleggers.



Sunset Beach (1930)

Upcoast from Sunset Beach (1935)

ANAHEIM BAY JETTIES

As remembered by WILLIAM J. HERRON

The Navy arrowhead jetties at Anaheim Bay created two situations that had not really been anticipated. First, because of the relationship between the west jetty and the end of the outer harbor breakwater, the waves impinging on the west jetty hit at such an angle as to be cleanly reflected, and this accelerated the upcoast movement of sand along the Seal Beach City Beach. I have seen reflected the waves as high as 4 feet bounce off this west jetty.

The situation on the east jetty was quite different. Because of the angle of the Arrowhead jetties, this area was able to completely and freely receive the normal offshore wave action and full rates of littoral drift was resumed. But the angle with which these waves approached the jetty was so slight that there was not a clean reflection; rather there was a pile up of water along the jetty as the wave travelled its length and developed what some engineers have identified as a "mach stem" effect. Instead of reflected wave energies, the energies accumulated in the first 100 to 150 feet of the wave against the jetty.

This does have a very pronounced effect as this reinforced wave reaches the beach. Erosion is accelerated and it tended to cut out a pocket right at the base of the jetty. The Navy built a short step groin to try to break up this effect but, if it succeeded at all, it has been a very minor success.

SURFSIDE BEACH EROSION CONTROL

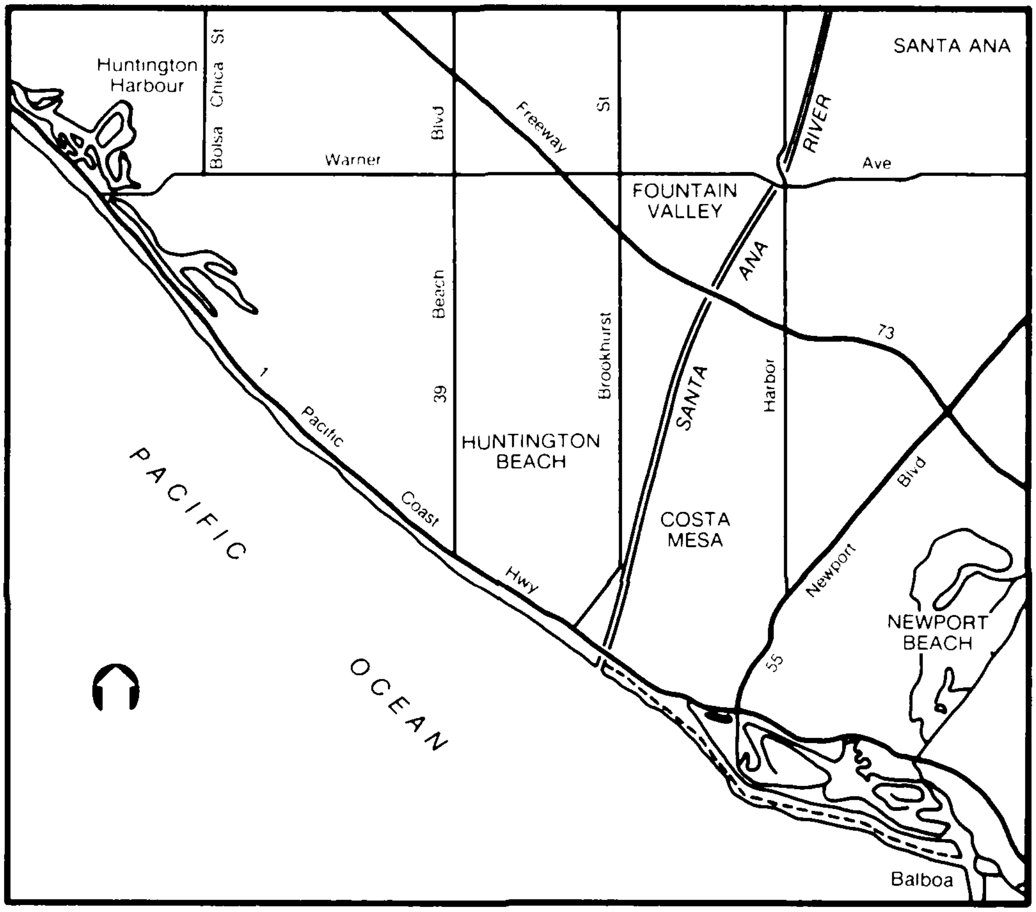
As remembered by JAMES DUNHAM

When I first went down there, getting my indoctrination in beach erosion about 1938-39, there was a series of old timber groins that had been built all along the Surfside beach to halt this erosion process. Of course the trouble was there was no sand feeding the beach, so the groins didn't do much good. It just continued to erode in that area. The Navy jetties at the Weapons Station, which were built during the war years and completed in 1945, accelerated the erosion at Surfside to the point that very severe damage was occurring in 1946.

Because there is no natural source of sand supply, that area would have to be nourished in perpetuity in order to maintain the rest of the beaches downcoast. We recommended that any material that was excavated in that area be placed on the Surfside beach, which would act as a feeder beach for the remainder of the beach area to the south.

Surfside Area (1954)

HUNTINGTON HARBOUR TO NEWPORT BAY ENTRANCE



In addition to lack of sand supply, waves impinging on the south jetty developed what was later called the "mach stem effect." I observed it, but I didn't know what caused it. Somebody else reviewed it and pinned the mach stem name on it. But what was observed was that a wave approaching at a fairly acute angle to the south Navy jetty would race along the side of the structure increasing in height, and by the time it reached shore, the wave was about twice its incident height. Also, waves being reflected off the jetty combined with incident waves at Surfside, adding to the severity of the erosion. I was told that Colonel Leeds (the Navy's consultant) had recommended shore-perpendicular jetties with shore-parallel doglegs at their ends in order to prevent such reflection, but the Navy changed his plans to show converging (Arrowhead) jetties.

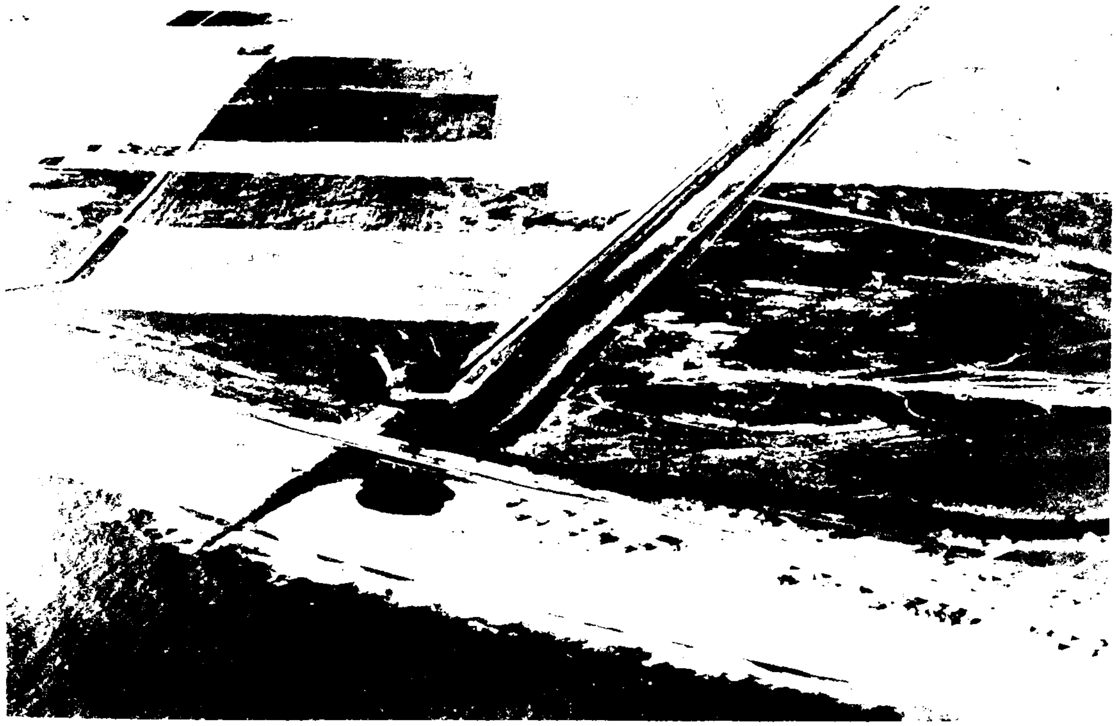
The first corrective action was to build the little stub groin that extends out about 50 feet near the base of the jetty. That helped some, but quite a bit of the mach stem effect apparently was still getting past the groin and severely eroding the beach. As a result, the Navy, in order to protect its own property, had to revet the little piece of beach extending from the root of the jetty down to the beginning of Surfside. Then, there was no sand in that area, and Surfside lost all of its sand. From then on the problem was very severe, and the Surfside beach has survived only as a result of periodic artificial nourishment.

Prior to this time, no Federal aid was authorized for privately owned beaches, and only cost sharing for public beaches that were damaged as a result of Federal structures. Local interests became aware of this inequity and appealed to Congress. As a result, Congress enacted a special law directing the Corps to review not only the Surfside case but also the Port Hueneme and Oceanside cases on the basis of equity. We did this about 1950-53, and in each case recommended Federal mitigation of damage regardless of beach ownership status. Congress approved these recommendations.

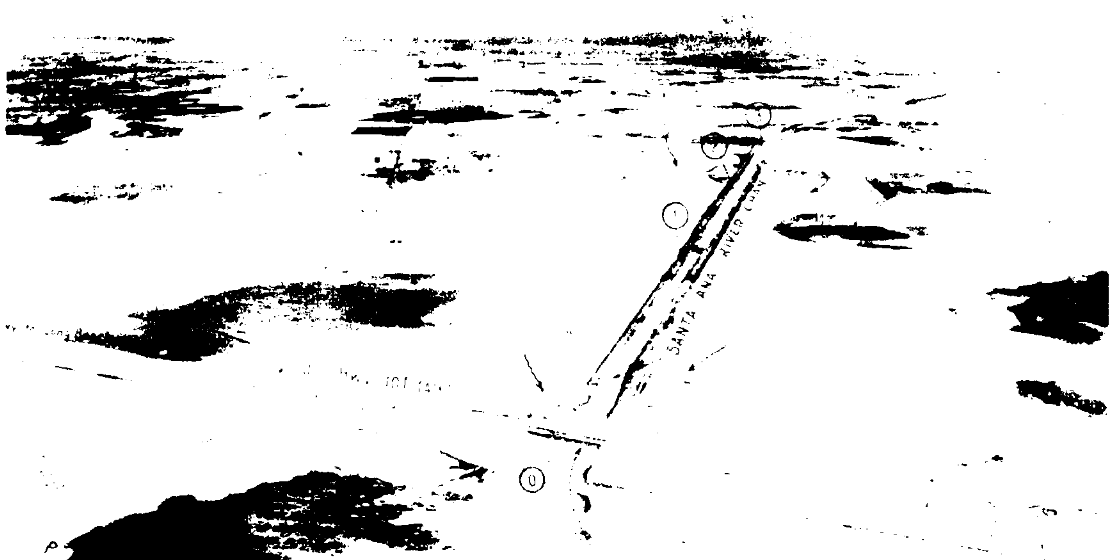
NORTH ORANGE COUNTY BEACH

As remembered by WILLIAM J. HERRON

There is about 14 miles of beach from the Anaheim jetties to the jetties defining the entrance of Newport Harbor, and with the loss of sand supply from the San Gabriel and Los Angeles Rivers, this entire littoral compartment has had a series of erosion problems that had to be corrected



Santa Ana River (October 1938)



Santa Ana River Flood (March 1938)

by separate solutions. The first generalized problem from the Navy jetties southward through Huntington Beach was a rather straightforward littoral current problem with lack of littoral supply, and it was determined through studies that this beach was eroding progressively from the north end towards the south losing probably around 200,000 cubic yards of sand a year. So, for this area, a sand replenishment program was established in which it was decided to place about a million yards of sand on this beach every 10 years to maintain it between erosion cycles. The initial dredge source was from between the Navy jetties. Advantage was taken of the Navy's need for a deeper channel into their ammunition docks and some double benefits were to derive from this dredging. In the most recent dredging episode the sand was taken from offshore, and this is a much finer sand than that between the jetties. There seems to be some problems with this sand leaving the upper end of the feeder beach more rapidly than had been anticipated. The beach downcoast for about a mile below the Navy jetties varies rapidly in width, but from there to the mouth of the Santa Ana River it has remained quite stable and in good condition since this program was established in 1963.

The next problem that was quite unique was the sudden and almost disastrous erosion of West Newport Beach; the upper end of the Newport City Beach. This beach is about a mile in length and extends from the mouth of the Santa Ana River south to the Newport jetty. Here, again, we have a similar problem--most of the sand supply from the Santa Ana River has now been interrupted by various upstream flood control structures. There is not a natural and continuous supply of sand.

At the Newport Pier, which I will discuss later, is the head of the Newport submarine canyon, which comes very close to the shore. This area was one of the early recreation beach developments in southern California, and along about 1936, there had been a fair number of beach homes built along this area and the beach had not given problems; but in the 1935-36 period, suddenly this beach began to erode very rapidly. Several houses were destroyed and others had to be moved back out of the reach of the sea. The odd part of this was that it was occurring in the August, September, October time period, which is usually a period of rather quiet wave action. Studies were made of this area by the Beach Erosion Board and a groin field was recommended to stabilize this section of beach. But, before the project was authorized and funded, the beach had stabilized again and rebuilt and there was no apparent need for these groins. The beach remained quite stable until about 1963, and then the same event occurred again. Very strong and violent wave action in September and, from observation, was coming from the south moving in an upcoast direction.

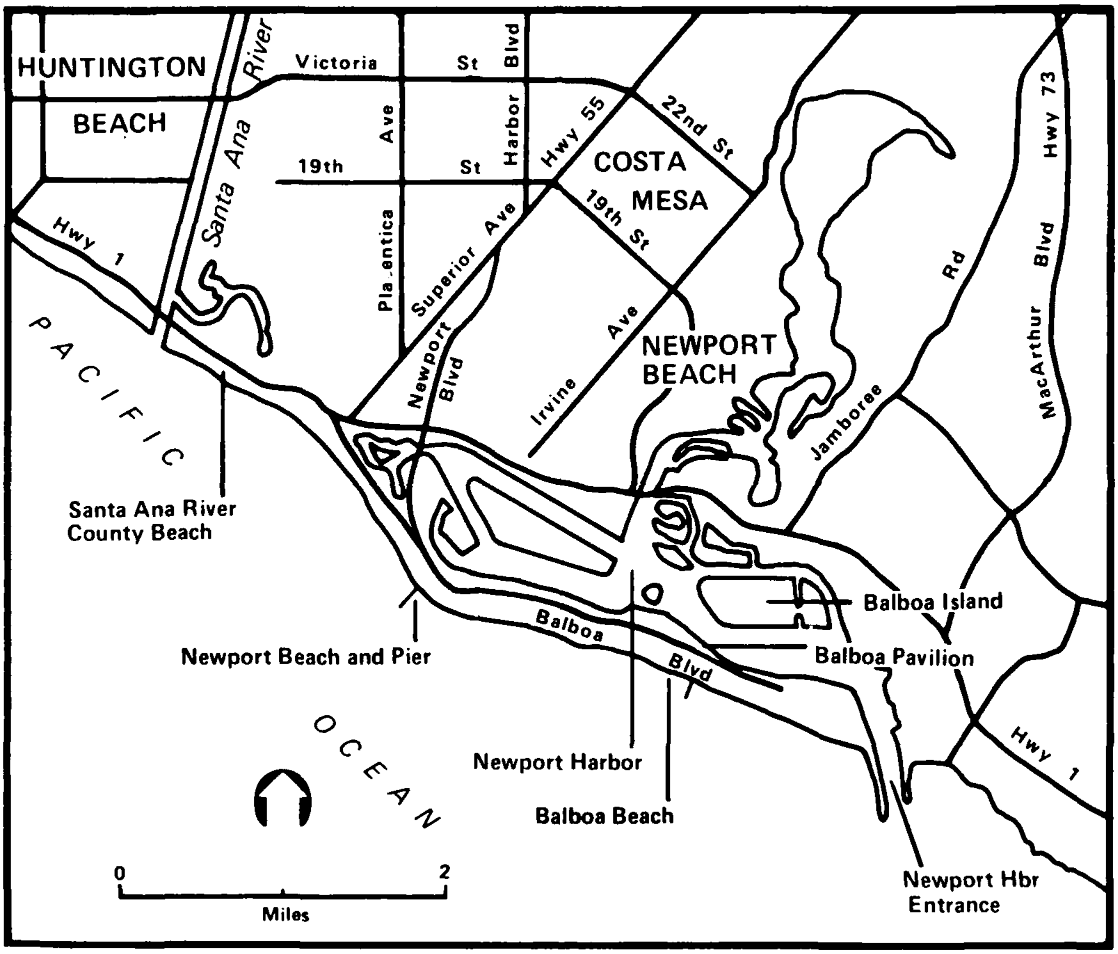
By this time, 1963, we realized that the submarine canyon was having a unique effect on this particular piece of shoreline and we also were more aware than we had been in the late 1930s of the problems occasionally created by southerly wave action, originating either from the small hurricanes off the coast of Mexico, known as Chubascos, or from very large storms in the South Pacific off the coast of Peru. We were able to determine that it was mostly the effect of the storms off Mexico that was causing this problem, and the condition lasted for 2 or 3 years.

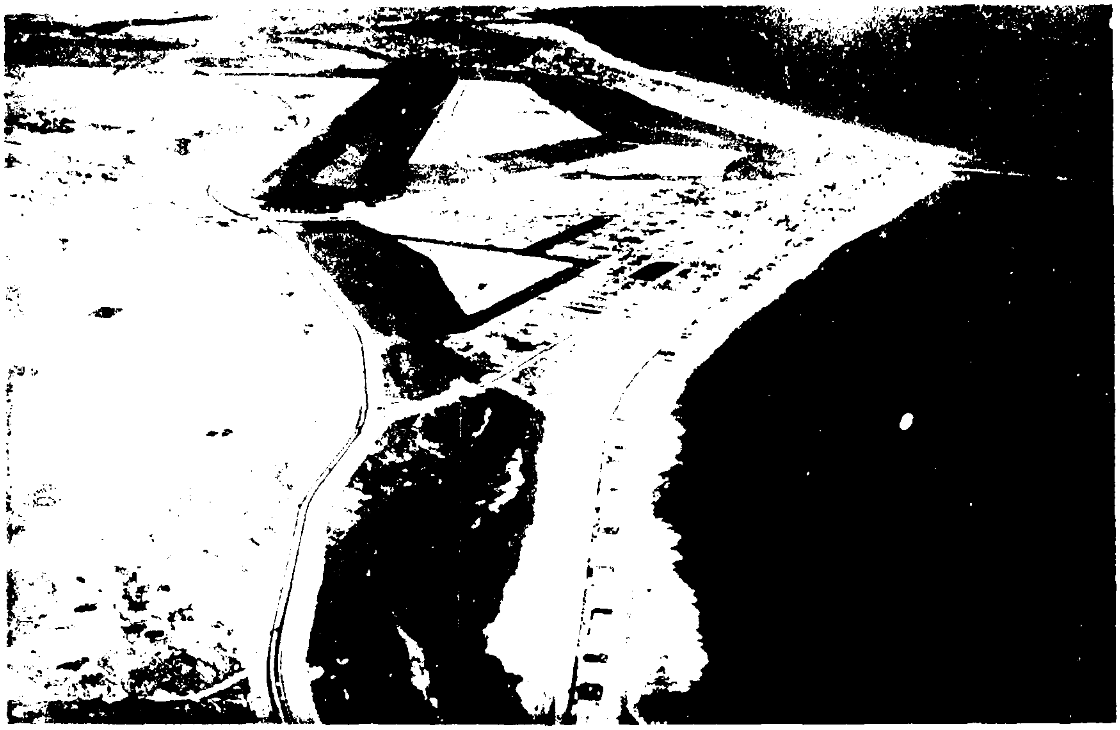
Twice emergency measures had to be taken to save the beach houses from destruction along this section of shoreline. The public beach was lost entirely. Fortunately there was also a flood control project going on in the Santa Ana River and they desired to have the bed of the river lowered for quite a ways upstream. So, this sand was used to replace sand lost along the beach plus surplus sand from the beach south of the Newport Pier was hauled up and, in conjunction with this, a design was developed and a series of seven groins was built along this area to stabilize the shore.

These groins are designed for littoral drift in either direction. They are far enough out from the structures to provide a minimal useable public beach at all times; and they have worked in just about this fashion. In the wintertime they will impound on the northerly side of the groins and in the summer and late fall the southerly Pacific storms will move the sand up the southside of the groins. This project, which is now about 15 years old, seems to have worked very well.

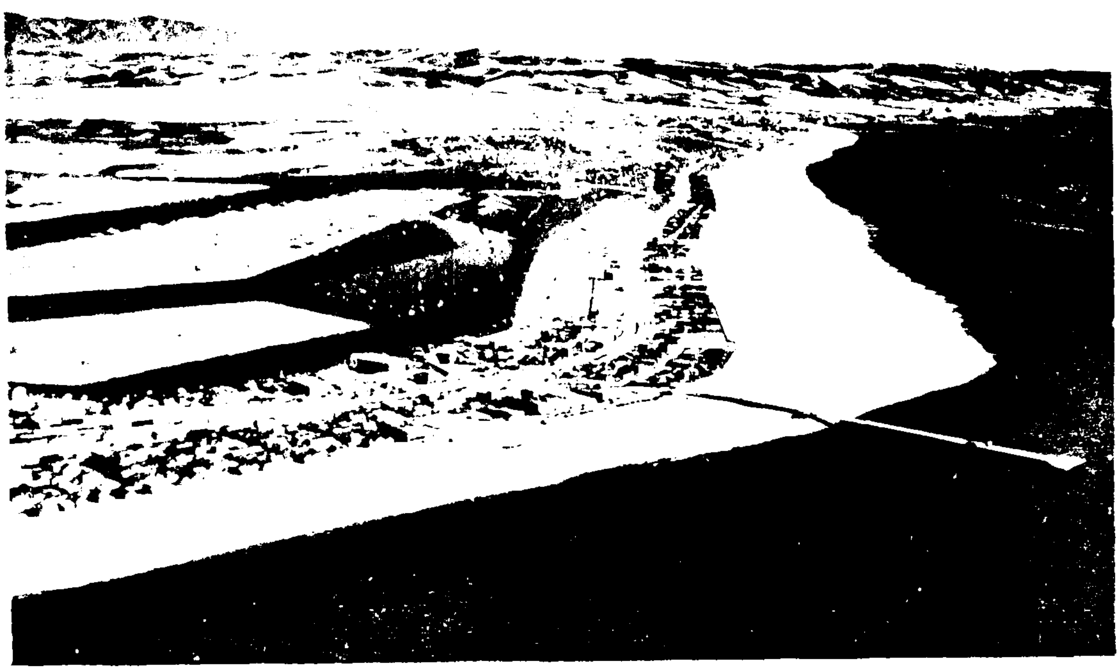
We had quite a time deciding whether this was an unusual number of Mexican storms or whether we were just becoming aware of more of them because of the additional weather information we now get from the weather satellites. Finally, a young oceanographer working on the Corps of Engineers' staff, was able to pretty conclusively develop that this was a similar occurrence as to that of about 1936 in which, for a period of 1 or 2 or 3 years, there was an unusually large number of these Mexican storms with a strong upcoast littoral effect.

NEWPORT BEACH/NEWPORT HARBOR





Looking Downcoast From 54th Street, Newport Beach (July 1933)



Looking Downcoast From Newport Pier (December 1936)

NEWPORT BEACH
As remembered by KENNETH A. PEEL

Going on south from Surfside, the next harbor would be Newport Harbor. They had a little erosion problem upcoast from Newport Harbor before we put the entrance channels in. The improvement of the harbor was started around 1933-34. A part of the material was pumped out on the beach north of the jetties from the dredging of the harbor, which curtailed the erosion problem for a long time, and I don't think since then that erosion has been so heavy there. I don't know of any real severe erosion problems now around Newport, but we did have them. One was in 1936, when the Corps did some studies along with Pat Patterson.

The design of the Newport Jetties was patterned somewhat after the detached breakwater. They were designed by the Corps of Engineers and they were just a random stone core with an armor stone surface. They haven't suffered too much damage. You don't get near the damage to a jetty perpendicular to shore that you do around those offshore breakwaters. Only the head of the jetty is taking the full force of the wave action and its shore arm receives just a small percentage of that on the head.

NEWPORT HARBOR
As remembered by OMAR LILLEVANG

My comments now are about Newport Harbor and they are not really related to my own experience, but rather to things that were talked about by Colonel Leeds when he was recollecting some of his experience in the area. I think he had just left the Corps of Engineers and entered into private practice when he was retained by interests in the Newport area that were directed toward developing Newport Harbor.

In order to have what is there today, the first thing that needed to be done after it had been isolated from the Santa Ana River was to regulate the entrance so that it could be kept in one location because, as with most of these sandspit isolated bays, the mouth had meandered quite a bit, never farther south that where it is now near the Corona del Mar headlands, but it had gone farther up toward the Balboa Pier from time to time.

He proceeded with limited funds and first contemplated just an upcoast jetty and now that I think about it, this must have been while he was still on duty with the Corps, and now I am getting fuzzy. I would have to look at dates on development down there to recall whether it was in this time as a regular officer before he was retired medically, or whether it was during the World War I era when he went back there as a Lieutenant Colonel and became District Engineer again. I think it was the earlier. He said that the man who became General Fries chided him for proposing an entrance with only a single jetty. This, perhaps, was without understanding of the financial constraints, and Colonel Leeds definitely wanted a second jetty but felt that the project could be put into business, even if a bit awkwardly at times, with a single jetty. That was the basis of the original design or concern to build that regulated entrance location with a single jetty; and the second jetty, which is on the Corona del Mar side, was put in later.

R.L. Patterson was there in the first dredging after Colonel Leeds was in private practice as resident inspector for Leeds & Bernard, the firm that did the work for the local interests. He spent quite some time, I imagine it was a couple of years there, with breakwater construction and dredging, and when the earliest phases of the work were finished, and there would be a hiatus of sometime before there would be any more, he was offered a job by the City of Newport Beach to become a full-time engineering employee. He talked to Colonel Leeds about whether or not he should leave Leeds & Bernard and go to work for the city on this and Colonel Leeds told him that, as it happened, there was nothing they could assign him to immediately, they would have to make work for him for awhile and, therefore, it seemed an ideal opportunity for him to try it out. If it didn't work, when Leeds & Bernard had anything for him again, he could come back.

Well, he never had to come back. He liked it. He made a career with the city and then as a Consulting Engineer. And the fact that he died, I believe a very wealthy man, was not because he had a successful career in engineering but because he had bought some tule sloughs in what became Balboa Island. He paid a tule slough price for them and sold them for housing sites for the wealthy.

As remembered by WILLIAM J. HERRON

Construction of Newport Harbor was actually started by the City of Newport in about 1915, and Lillevang discussed this somewhat in his comments, as his old mentor, Colonel Leeds, was in charge of the initial studies for the city. At that time the city did not have the capability of adequately building jetties and making the major judgments that were needed to make this a complete harbor.

In 1934, through a PWA act, the Corps of Engineers was brought into the picture, and this was one of the first purely recreational harbors the Corps of Engineers worked on because their normal authority was based on the value to the United States of Commerce. Orange County and the City of Newport brought them in through the back door by way of the PWA projects. But, nevertheless, again without any true wave analysis, working on experience and based on events that happened since the city had started the jetties in 1915, a complete jetty entrance was designed and the jetties were extended outward to about the 24- to 26-depth contour with a channel width of about 750 feet. The plan has worked very well. It has been an excellent harbor; there are very seldom any serious wave conditions, and maintenance has been very low.

We learned as time passed, that one of the reasons that this was such a successful harbor was that, under the original design, the entire interior parameter was sloped, sandy beaches, and these were ideal in absorbing wave energy. In recent years, more and more shoreside property owners have been going to vertical bulkheading to maximize the land use aspects of these extremely valuable properties. In the vicinity of the entrance, some problems of wave reflection and adverse wave energy have begun to crop up, and if they continue to change these wave absorbing beaches with one-on-six slopes to vertical bulkheading, it is possible that there will be more adverse wave action within Newport Harbor.

DANA HARBOR

As remembered by KENNETH A. PEEL

The next harbor downcoast would be Dana Harbor, which I had little to do with. We had just started the first preliminary examination when I left.

As remembered by WILLIAM J. HERRON

The next point of interest in Orange County is Dana Point and this is one of the most modern harbors in concept and execution in the United States. It was first conceived in about 1948, and Pat Paterson, a long-term Orange County engineer, was hired by Orange County to do a conceptional design. He laid out three alternative plans for different capacity harbors. The final design, as now laid out, follows remarkably close to one of his initial concepts.

Dana Point Harbor Area to San Juan Creek (1960)

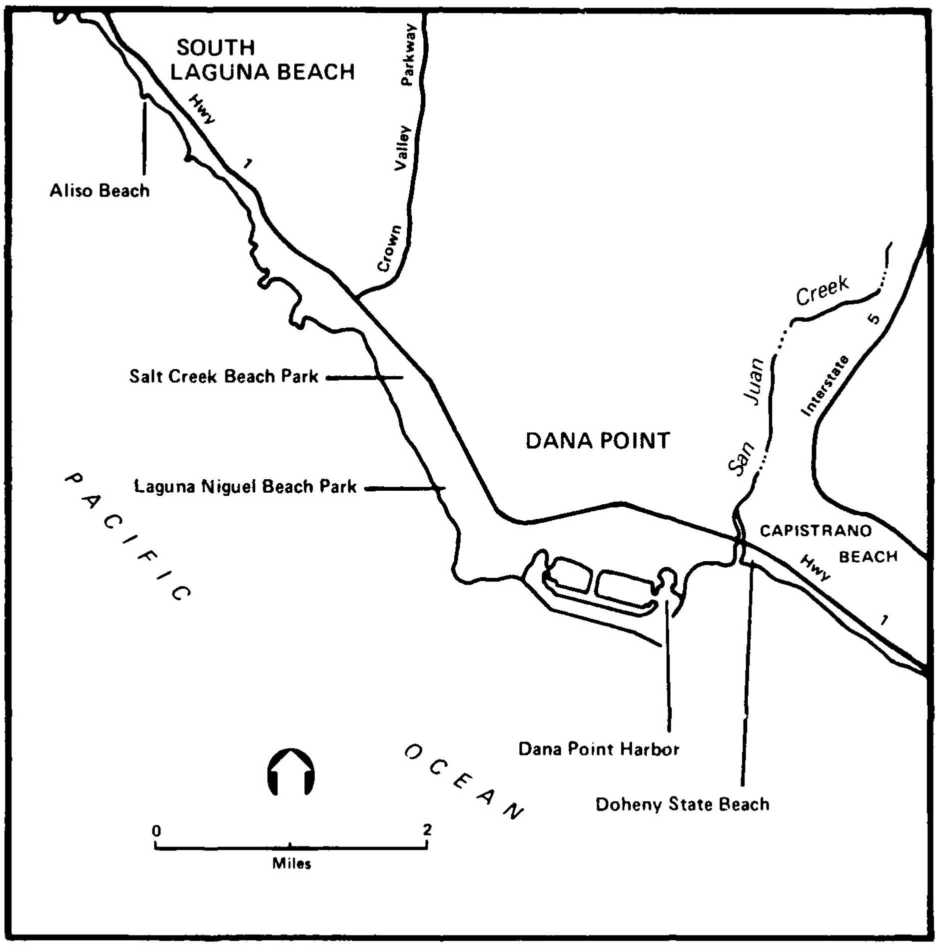
The harbor is located at Dana Point, which, of course, is one of the areas supposedly described in Richard Harding Dana's book, Two Years Before the Mast. There is some doubt that this is actually the point where the ship laid in the lee of the point and the hides were slid down from the top of the bluff to the shore where they were taken out to the boat in rowboats. But this is the legend and we can let it lie there.

This marina project, with a capacity for about 2000 small craft, took its normal course through Congress for study authorization and then later for project authorization, and construction was finally started in about 1963. It was a cooperative effort between the Corps of Engineers and the Orange County Harbor District. The harbor was completed in about 1970, and the slips were filled just as rapidly as they were made available due to the intense demand by boaters for slips in southern California during this period of time.

It is of interest to note that, even though we are now talking mid-1960, this was the first Corps of Engineers harbor to be completely modeled before construction was started. The other systems they had modeled were partially completed harbors or harbors completed that had problems and then the problems were analyzed. But, on this project, we started from scratch and completely modeled the harbor. As far as we can tell, with 12 years of experience, this harbor has acted almost exactly as indicated in the hydraulic model study.

Another interesting feature of this harbor was the fact that this entire bight had a hard bottom of similar material as the bluffs. While it would have been difficult to excavate in the wet, it was determined that in the dry it could been taken out by a ripper and would not require heavy equipment nor explosives. Koebig & Koebig Engineers were doing the interior design for the county and they developed a system where they completely enclosed the boat basins with a dike, which later would be incorporated into their land features. They dewatered the interior area in order to excavate it to the -10-foot elevation that was needed. Then they opened the dikes and permitted the water to return to the area, opened up the boating entrances and proceeded with normal construction. We were surprised when we dewatered this area and were able to examine a great deal of the bottom in this semi-sheltered bight that not a single artifact was found; nothing from the original days of the sailing ships or of the Indians who rather heavily inhabited this area.

DANA HARBOR/CAPISTRANO BEACH



This marina has a pretty good balance between usage strictly for recreational boating plus driveways, walkways, parkways, etc., for the general public. Also, uniquely, the area immediately to the south is a State Beach Park in which there are full facilities for daytime use of the beach and it makes a very good complimentary setup between the two types of recreation.

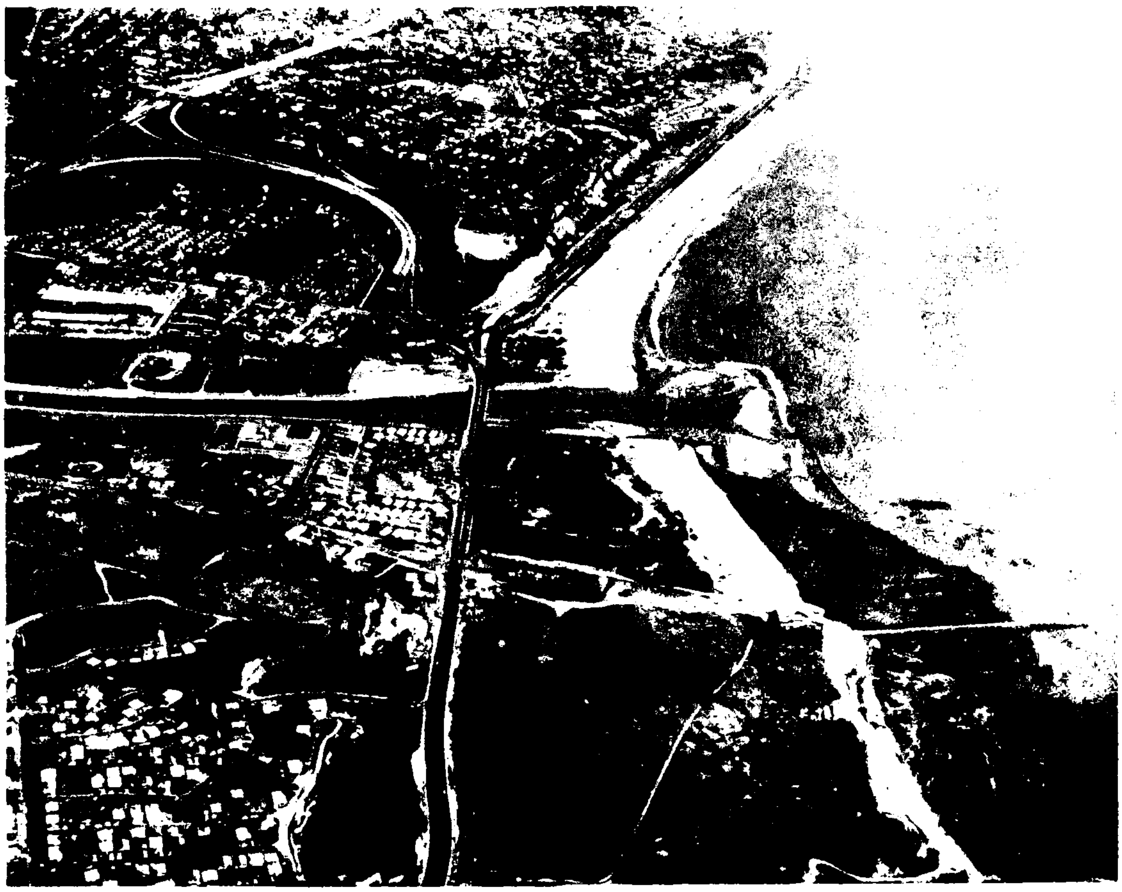
CAPISTRANO BEACH

As remembered by ***WILLIAM J. HERRON***

The beach park is split by Capistrano Creek and here we start our next beach erosion problem because this is the start of the next littoral cell. The area downcoast from Dana Point is essentially supplied with littoral beach sand from Capistrano Creek.

Again, in the 1960s, this area was eroding quite seriously because of lack of natural sand supply from Capistrano Creek, and there was serious erosion of the State Park Beach to the point where it was almost unusable as a beach. A number of homes were endangered farther south in what is known as Capistrano Colony. A beach replenishment plan was established in which it was decided, through the normal study efforts, that on a long-term projection, the Capistrano Creek only supplied about half of the sand necessary to maintain this beach and, of course, like all southern California streams, it did this at very irregular intervals. So a plan was set up in order to bring the beach back to usable and safe dimensions. It was determined that a supply of about 800,000 cubic yards of beach sand was needed.

There was no nearby sand available and we gave the prospective bidders several sources for sand, but after the contractor was awarded the bid, he came up with a new proposal that, to me, was quite unique. Their geologist had located a layer of ancient beach sand at an elevation of about a +100 to 150 feet in a ridge on the Marine Corps' Camp Pendleton Base. The contractor proposed to dry haul this sand to the beach, spread it out, and place it as a form of replenishment. This proposal was accepted and his final bid on the thing was 89¢ a yard to dry haul this ancient beach sand about 9 miles along the freeway and into the project and spread it out along the beach. It worked exceedingly well--we got the sand for low cost and while there was some mud and clay in it, the winds and rains worked this out in a matter of less than 2 years and it made a very fine beach.



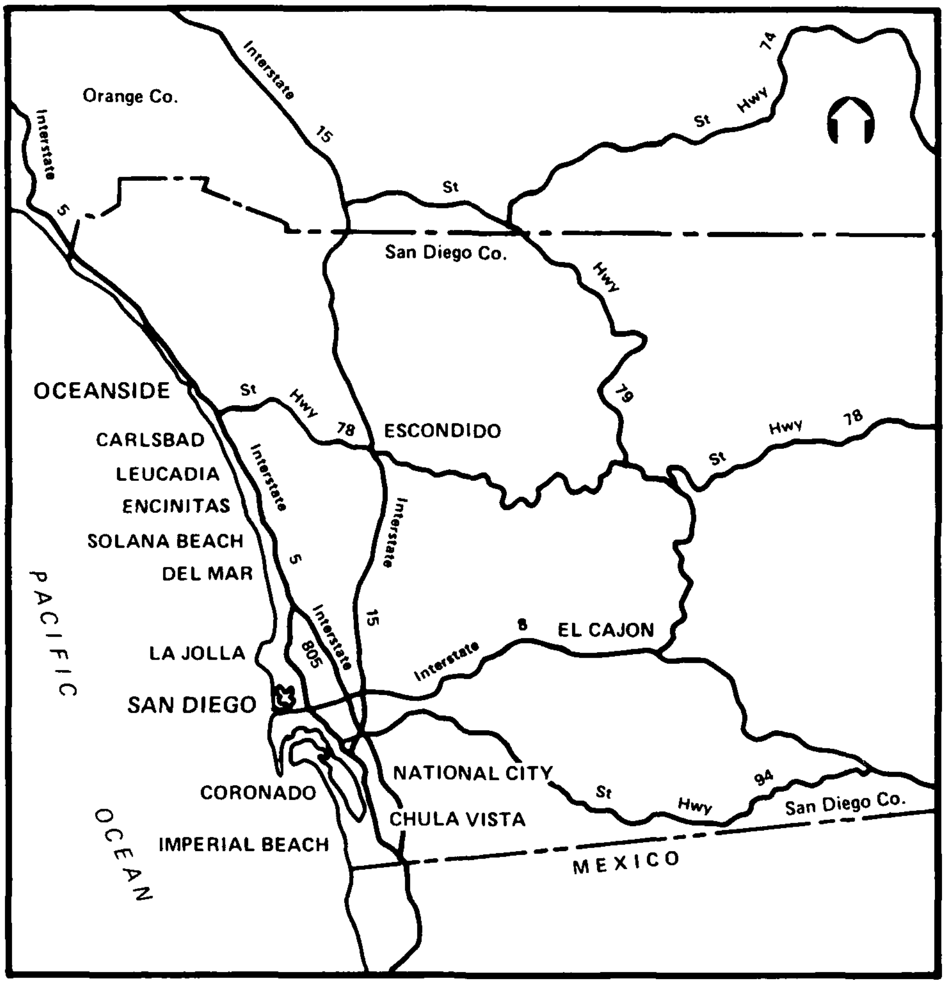
San Juan Creek and Capistrano Beach (1966)

In order to maximize the use of this sand, we did build a groin along the extension of the north bank of San Juan Creek and attempted to compartmentalize the beach between the San Juan Creek and Dana Point. This worked very well and this beach has been quite stable. On the southside it was determined that there would have to be periodic replenishment at such times as the river did not bring enough sand down to continue maintaining this beach.

The project did what it was needed to do for about 5 years. Since then we have had two or three major runoffs down Capistrano Creek and this entire beach is now in excellent condition. In fact, the groin is almost buried in sand and it appears it will be quite a few years before another replenishment program will be needed. I do note one attempt recently by the county to sell some of this sand, which was successfully resisted by those concerned about beaches, and this should not be permitted. On a long haul, there is no question in my mind but that there will be a deficiency of sand supply from its natural source--Capistrano Creek.

The 23 miles of Marine Corps property, known as Camp Pendleton, extending on downcoast from San Clemente, has remained pretty much in its natural state. While it is a very narrow beach, there have been no apparent problems in this area.

San Diego County



8 San Diego County

OCEANSIDE HARBOR

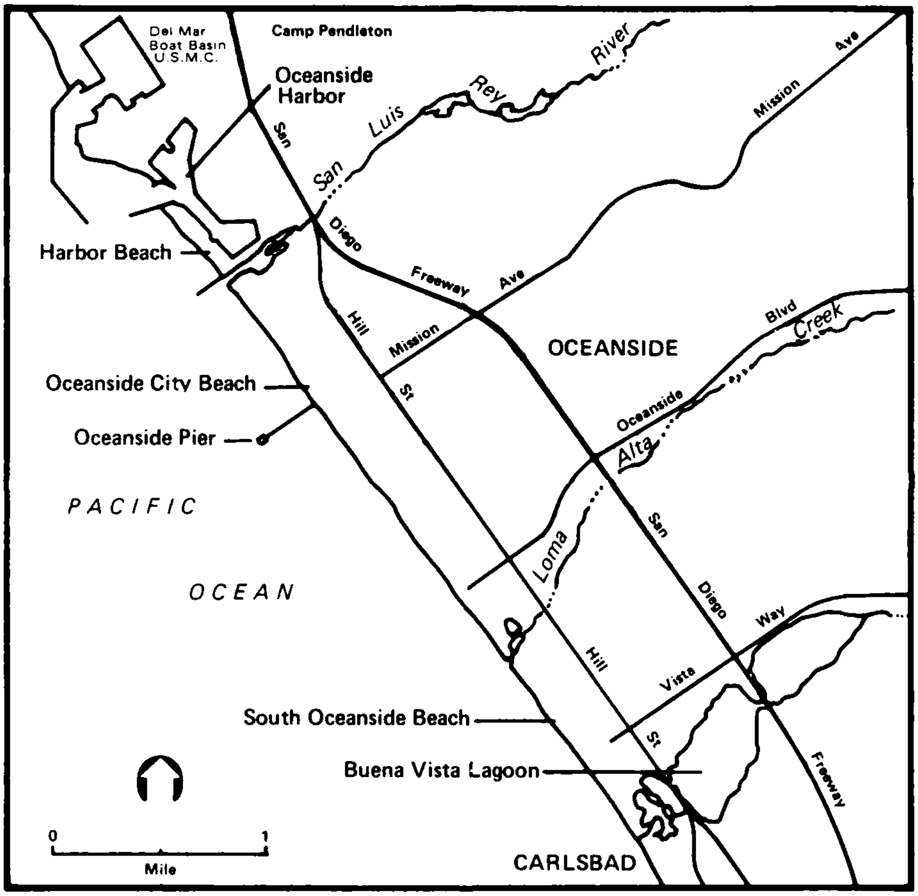
As remembered by KENNETH A. PEEL

Oceanside Harbor had a design problem and they also had a Marine Corps problem. The Marine Corps built the first harbor there at the start of World War II. Without much reference to anybody else, they just up and built it, and it promptly filled in. In fact, I don't know if they even got it built before it filled in. We finally worked out a deal with the Marine Corps and the City of Oceanside to go in south of the Marine Corps boat basin (Del Mar Basin) with a civilian small craft basin using the Marine Corps entrance from the sea as a common entrance channel.

They did one thing that we recommended they do—but they didn't do it as much as we recommended they do, as I recall—and that was to put in those jetties starting out wide and coming together at the entrance so as to let the waves expand as they came past the entrance. In this manner, when waves came through the entrance, they would diverge and the wave energy would be reduced and dispell more of the wave action. But as to the erosion, we pointed out to them that there could be erosion downcoast; but even then we were more concerned with the harbor than with the erosion. We asked that they put a great deal of the dredged material downcoast to prevent very short time erosion effects, so that by the time they had to do maintenance dredging then they could catch up on erosion.

We did review the harbor, the original Marine Corps plan, and did recommend a change in the alignment of the jetties. They had just straight Arrowhead jetties coming out. We did recommend—but I don't know how much good it did.

OCEANSIDE



Del Mar
Boat Basin
U.S.M.C.
Camp Pendleton
Oceanside
Harbor
San Luis Rey River
Mission Ave
San Diego Freeway
Harbor Beach
Mission Ave
Hill St
OCEANSIDE
Oceanside Blvd
Creek
Alta
Loma
Oceanside City Beach
Oceanside Pier
PACIFIC
OCEAN
San Diego Freeway
Vista Way
South Oceanside Beach
Buena Vista Lagoon
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Mile
CARLSBAD

In the revised plan, the entrance was to be stabilized and a plan developed providing for bypassing the sand as it filled up. I left there before that was built and I have only been down by there about once since then. But they did have an erosion problem south of the Marine Corps almost as soon as they built it. It started eroding downcoast, because it is on an unprotected open coast. The Marine Corps about that time had its first maintenance dredging program, I believe, and they pumped that sand on the beach and that held them for a year or two. They may have had another dredging program after that, but that was getting pretty costly.

I don't know how much of a problem it is now. It probably is a severe bypassing problem all the time, but the cost of it can be divided up a little bit. This was one of the points we sold Geoffrey Morgan, President of the Shoreline Planning Association, that I started talking about. I was explaining to him how we were including the bypassing of sand as part of the port cost, and that in justification of the harbor, we were including the cost of maintaining the downcoast beaches along with it. And that it is our impression, or our thought, the beaches would all be better off and could be maintained and that they could have both the harbor and the beach easier than they could have the beach alone. But that you had to include the cost of it in with the overall project costs, because with the harbor you had a long groin that would maintain the upcoast beach, and with the bypassing program you maintained the downcoast beach. The net result would be better for everybody. He finally saw it and he became one of our best advocates after that. He was quite a guy.

OCEANSIDE — DEL MAR HARBOR
As remembered by JAMES DUNHAM

Oceanside Beach was another eroding area. I forget just when it was that I was first called down to investigate the problem after World War II, but the Camp Pendleton breakwaters had an interesting history. It was about the early part of 1942, when the Marine Corps was considering building the Del Mar Boat Basin at Camp Pendleton. They asked the Corps of Engineers to send someone down to investigate and report on where would be the best place to put a small craft harbor. Because of my experience at the time with preparing beach erosion studies, I was sent down there. I took a look at this proposed site between two major rivers that discharged within 2 miles of each other and, realizing the problem littoral drift would create at the harbor entrance, recommended that the harbor not be built. It was, nevertheless, built as a military necessity during the war years.

Del Mar Boat Basin at Camp Pendleton (1949)

OCEANSIDE

As remembered by WILLIAM J. HERRON

The first problem of note in San Diego County that took a good many years to resolve, and is still not completely resolved, is that involved with the City of Oceanside and the Marine Corps' harbor, known as the Del Mar Boat Basin.

The Marine Corps acquired the 143,000-acre ranchero, known as the Santa Marguarita Ranchero, at the start of World War II and established an amphibious training base. The Commandant decided that he had to have a small craft harbor to support his training exercises and to provide a load-out point for large landing craft. They selected a location, which in retrospect, was probably the worst they could have picked along the 23 miles of beach fronting the base. It is located between the Santa Marguarita River and the San Luis Rey River. These are two very large rivers which, when they flood, perhaps every 30 years, can bring down tremendous amounts of sand and debris. However, they selected this point and when they were advised of the potential for shoaling problems and interference with beach supply downcoast, the answer was that, "we have a war to fight, we need the harbor, and we'll worry about the consequences after the war."

In retrospect, the best thing we could have done after the war would have been to have removed the harbor and brought things back to its natural course. However, the Marine Corps and the Navy proceeded with the construction of the Del Mar Boat Basin and the initial plan was for a pair of very short Arrowhead jetties. I don't know who did the design work on this harbor--this seems to be lost. However, before these jetties were even completed, it was obvious that they were not long enough and that there was a problem with north/south moving sand. So the north jetty was extended and hooked downcoast to form a combination jetty/breakwater situation. For a very short period of time the harbor was usable, but then sand was apparently coming around this north breakwater, curling up into the harbor and shoaling it. Through the latter stages of the war and after the war, the Marine Corps got very little use out of this harbor, except at high tide.

It did not take long after the construction of the harbor before the City fathers of the City of Oceanside noted that they were rapidly losing their public beach, which was one of their main sources of revenue. It attracted a great number of tourists and recreational people to their little city. So they immediately, of course, associated this with the construction of the harbor, and requested Federal studies to determine how to alleviate this condition.

Congress authorized the Corps of Engineers to undertake a beach erosion control study. The study, as authorized by Congress, had a very unique directive. In the 1950s the Congressional authorization was that the Federal Government would participate in one-third of the cost of the construction of the shore protection features to protect public beaches. Congress instructed the Corps of Engineers in this project to determine the Federal share based upon "equity" and not upon existing laws. This became a problem to unravel and to determine just how the Marine Corps' harbor adversely affected the city beach. Because it was also realized that, by this time, the upcoast and downcoast littoral drift in this area was very nearly in balance. The sand is very fine, and, to all appearance, there was a great deal of littoral drift: north to south through half the year and south to north the remaining half, with a slight southward or downcoast component. This was indicated by the great amount of sand that came upcoast into the lee of the north jetty in the summer and fall and dropped out shoaling the entrance to the Del Mar Boat Basin.

In retrospect, I think at this time, not enough attention was paid to the manner in which the two adjacent rivers supplied sand to these beaches. Their history has been that they had two very large floods in recent times; one in 1916 and another in 1927, which brought a great amount of sand and beach building material to the beaches. But between 1927 and these studies, around 1956, there had been almost a zero supply of sand. There had been a long dry spell and there had not been large enough floods and high enough velocities to bring much sand supply to the shore. However, the Corps' study findings was that the erosion of the downcoast beach from the Del Mar Boat Basin was caused by the interference of littoral processes by the Marine Corps jetties. Therefore, it was recommended that the Federal Government would assume 100 percent of the cost of bypassing beach sand around this boat basin. In part, because of the Korean and the Cuban problem, at no time had the Marine Corps seemed to seriously consider giving up this boat basin. So, the plan was to assume the boat basin would be there and a biannual beach erosion control project was set up to dredge out the impounded sand behind the jetty every 2 years and place it downcoast. This has been done since 1961.

In conjunction with the solution of this beach erosion problem, the City of Oceanside started looking at the concept of combining a civilian boat harbor, or marina, within the shelter of the jetties already built by the Navy. These had been extended in about 1957 by the Navy in an attempt to further improve the navigation entrance but the benefits were rather short-lived. But, nevertheless, the city engaged Leeds, Hill and Jewett as consultants and Omar Lillevang

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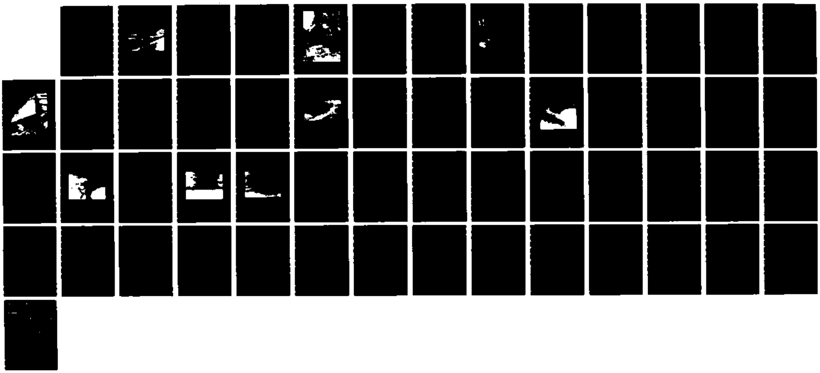
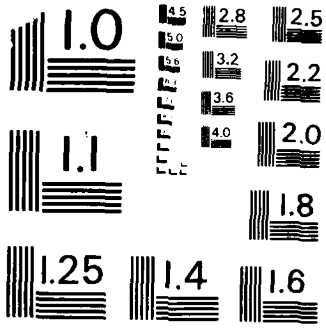




MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

Beach at Oceanside Prior to any Harbor Construction (1931) proceeded to develop a concept of a city recreational boat basin to the south of the Del Mar Basin; both to have a common entrance to the sea. The Corps of Engineers worked in conjunction with them in developing the sand bypass system. When the final plans were accomplished, and the city system financed, well over a million cubic yards of sand was dredged from the city boat basin and put on the beach plus the establishment of the sand bypassing program every 2 years. This still was not an adequate program to maintain the harbor and the downcoast beach remained wide for only a limited number of years even though the large deposition of sand did build a very wide beach just below the San Luis Rey River on downcoast for about 3 miles.

We had one backfire on building this beach--in the setting up of the dredging contract and the exploration of this "sand borrow area," which was to become the city's boat basin. It was found that there was a substantial amount of cobbles mixed in the sand. It was a rather curious combination--very fine grain sand and cobbles up to probably 2 to 3 inches in diameter. It was assumed that, as the sand was put on the beach and waves and littoral current actions took over, these cobbles would gradually sink down into the sand and we would maintain a sand beach. However, in the years following the project, this did not happen. Instead, littoral drift rather rapidly picked up the light sand, moved it on downcoast, but it did not move the cobbles, and in much of the city owned beach fronting the motels, the seaward face of the beach became a solid bed of cobbles sometimes as much as 6 feet thick. This had a rather adverse reaction on the tourists' season and the use of the beach.

However, in conjunction with this, every 2 years some several hundred thousand yards of almost entirely sand were dredged from the outer entrances of the harbor basins and placed on the beach and gradually over the years the cobbles situation has improved on the more northerly portions of the city beach. But they have not been able to maintain an adequate width of beach with simply the material being bypassed by the harbor. It does not appear, since about 1961 or 1963, that the harbor is the only cause of lack of supply of sand to the beach. Many of us have concluded that it is the lack of large floods on the two rivers, and their failure to supply sand to the littoral system, that is a major contributor to the Oceanside problem. This has been under study the last few years by the Corps of Engineers and they are just at present coming up with solutions.

In my opinion, this fine sand also contributes to the shoaling of the harbor in that, while the original line of the north jetty/breakwater extends seaward to about the 20-foot depth, this light sand seems to be in motion up to the 30- or 35-foot depths and is, perhaps, in part being deflected offshore where it is not stored in the harbor and does not appear to be part of the littoral stream, but nevertheless the sand is lost to the downcoast beaches. Jim Dunham in one study for the city, was able to get some quantity estimates. It appears there are well over a million cubic years of sand in this shoal area completely outside the breakwater system of the harbor. This should be taken into account in plans to revise the entrance in the harbor so that it does not shoal as rapidly as it does at present.

The project is a success, due to the fact that the marina is to full capacity of boats, and it is operational most of the time; but there is occasional shoaling that creates hazardous waves and it is not always a convenient harbor to enter, and, of course, we are still living with the beach erosion problem to the south. This beach erosion problem has actually been gradually extending downcoast until it now affects the entire shore front of Oceanside and Carlsbad, the adjacent city to the south, and it is beginning to extend on down below the Agua Hedionda Lagoon. In fact, there are also other areas further to the south where the beaches are narrower than they used to be and in some areas have retreated to where they are endangering the sandstone bluffs that make up this lower portion of San Diego County.

As remembered by OMAR LILLEVANG

For a number of years the Municipal Government at Oceanside had been looking for a way to create a small craft harbor for the enjoyment and benefit of their citizens and for others in contributing areas surrounding it and had been frustrated inasmuch as they recognized it as their best site. Maybe it would be better to call it their "least worst" site. It was at the north city limits, lying in part on what had been an overflow area at the mouth of the San Luis Rey River, and was, in part, low-lying ground of the Marine Corps Camp Pendleton facility.

They were always rebuffed in any attempt to discuss acquisiton of the Marine Corps property as a harbor site until another Commanding General came there, after a parade of many who had all turned down the city's request for consideration. A new General came along and became acquainted with the Mayor in a shooting blind; they were both avid bird shooters. In that blind one day, when there were no birds around to shoot, the Mayor asked the General, "General, why is it we can never get the time of day from you people when we want to talk about a harbor. You don't even know what we want to do and yet you say we can't do it?" The General, in a very receptive mood to this from his new friend said, "I don't know anything about it, why don't you come out and tell me." So we had a

Beach at Oceanside (1949)

Looking South From Wisconsin Avenue (1949) telephone call at the office and I went down to join the Mayor and a couple of others and we sat down with the General and explained the plan that we had devised and he said, "I have no way of knowing whether or not it will conflict with our operations; we use consultants for that, but there is no reason for me to spend Marine Corps money on consultants, so where do you go from there?"

The answer was, "Oceanside can provide services if you wish, but, of course, they can't be your consultants, can they?" And he said, "No, but who would your consultants be?" "Well, that would be the Corps of Engineers--principally the District Engineer at Los Angeles, but he has no money to do this either. How would it be if we do the work, satisfy him and his people, and they then, in turn, advise you as to whether or not what we are doing is harmonious or not harmonious with Marine Corps interests?" He said, "I don't care how the District Engineer reaches his conclusion if he reaches it. That's his affair."

The result then was that we went ahead, prepared studies and plans very closely informing and receiving critical comments from the District Engineer's staff, particularly Bill Herron in his Coastal Engineering Branch, and found that there was a basis on which a small craft harbor and the Marines could join, could be neighbors without inhibitions of either one's mission.

On that basis, negotiation for acquisition of Marine Corps property began. The upshot of it was that after about five trips to Washington, made by the Mayor, the City Attorney, and myself, the acquisition of Marine Corps property was completed. At the same time the city was negotiating with a private landowner of the river bottom area who had about 33 acres in addition to the Marine's 67 acres, and the 100 acres together then was used as a harbor site. But it wasn't really a harbor site. It was a "borrow" pit. It was a borrow pit to restore the beaches at Oceanside where it had been concluded in some earlier Corps of Engineers' studies that the United States facilities at the Marine Corps base were a proximate cause of the loss of the beach. The restoration of that beach then was authorized by Congress to be done at 100 percent Federal cost, provided that the local interests provided the borrow pit from which to remove the material for that restoration.

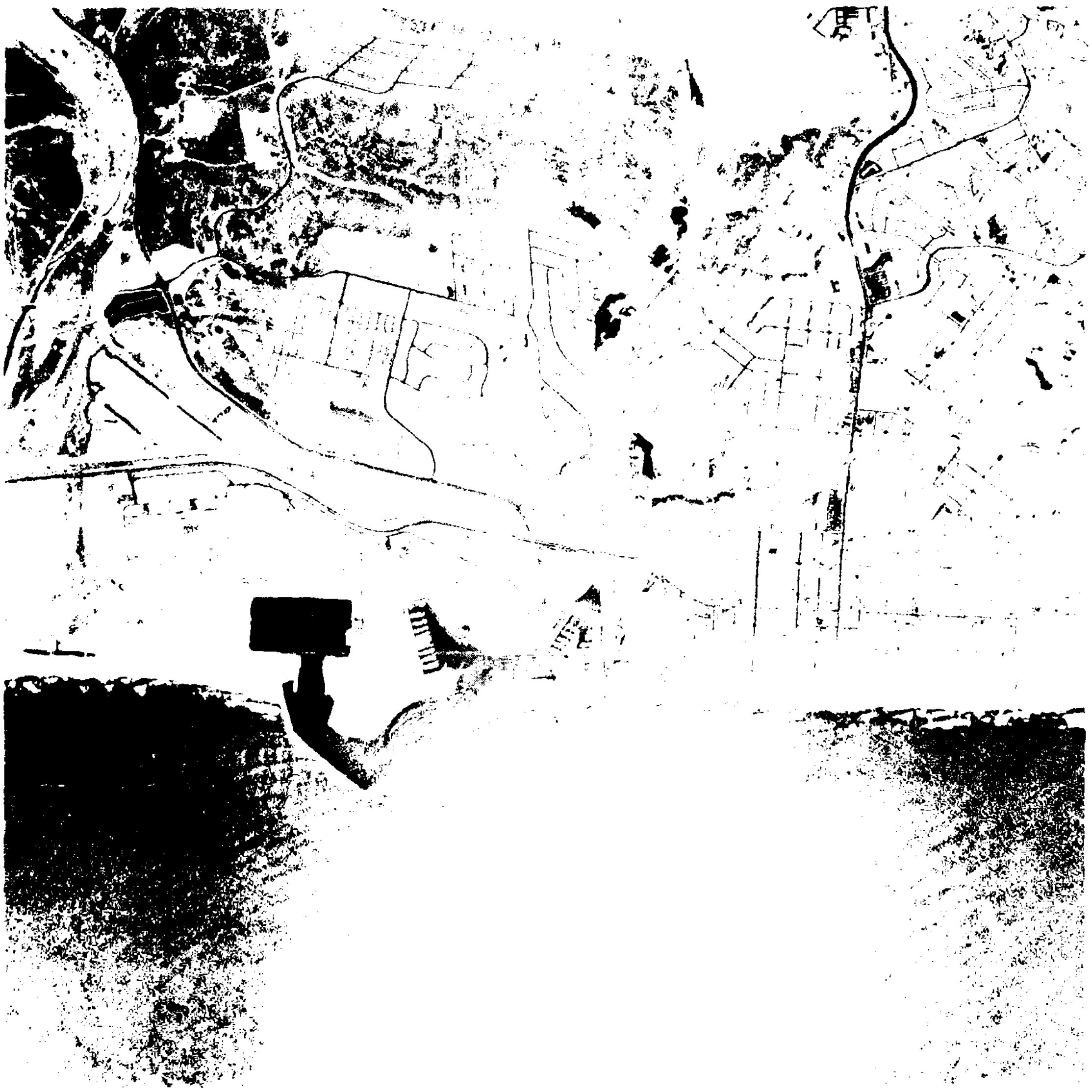
The 67 acres of Marine Corps and the 33 acres of private land together, then, constituted the "borrow pit" for the beach restoration. The dredging was done in accordance with geometric plans that were derived by the city's consulting engineer so that it, what do you know, turned out to be the outline of a harbor. So, there was a combination of solving the beach problem, of solving a harbor need, and of solving the problem of working with a military agency that needed to be persuaded that it could give up some of its reservation that resulted in the construction of Oceanside harbor.

It's an extremely difficult site. It lies close by one river and near another on the other side of it, both of which are big sediment producers when they are in flood. That doesn't happen often, but they do flood. It is also a jointly used entrance with military craft and civilian craft. The site was limited by bluffs that the Marine Corps would not sell so that the land area was small and the problems to achieve a usable, tranquil harbor that close to the ocean between two rivers were really very challenging ones. There are aspects of Oceanside Harbor that justify adverse comment, particularly by boaters. But boaters, of course get very emotional about a harbor that isn't perfect. I, nevertheless, take a lot of pride in Oceanside Harbor because I think what could be achieved with that site in that area has been achieved with a very satisfactory degree of suitability and they have a very useful facility where formerly there was nothing--and it's gratifying to be there.

I tied my own boat up there once on a long weekend and was rewarded to see it used really as a regional park. The water is clean, kids swim in it, barbecue braziers are out on the floats, there is a lot of camaraderie between boaters. There isn't this business that you see in larger, more impersonal harbors, where people go rushing to their boat, get aboard, stay out of sight, or go to sea and come back, hardly knowing who is in the neighboring facility. Oceanside is more like a community park; they thoroughly enjoy it. It has its problems with the entrance but I think, to me at least, there is great satisfaction in it.

The fact that the dredging was done to restore the beach, totally at Federal expense, represented a new philosophy in Federal coastal projects and Oceanside was a ground breaker on that and other projects fitted into the same philosophy; but it was at Oceanside that that new principle was derived that there was an appropriate basis for Federal contribution of the whole expense of restoring eroded beaches where the erosion responsibility was primarily Federal.

Another new precedent was established there in that previously natural harbors, or harbors with only minor improvements, got maintenance by the Federal Government as navigable facilities of the United States without cost to the harbor proprietors. But, where a harbor had been built entirely with non-Federal funds, even though entirely artificial, if it was a navigable feature of the United States, there was no policy based on which the Federal Government could do maintenance of the



Oceanside Harbor and Del Mar Boat Basin (1966) general navigation features. It was argued at Oceanside that this was illogical. That if somebody on the coast of Puget Sound or of Delaware Bay or Chesapeake or whatever, with modest additions or regulating works to natural assets, could have maintenance of those navigable channels, it was appropriate also that an existing facility, though entirely artificially created, merited as much consideration for maintenance as was merited by a natural facility.

This was a new concept. It was, however, submitted as being logical and equitable, and appropriate, and Congress eventually agreed; and that approach to maintenance of artificially created navigable facilities stems from presentations made of the Oceanside situation.

MISSION BAY

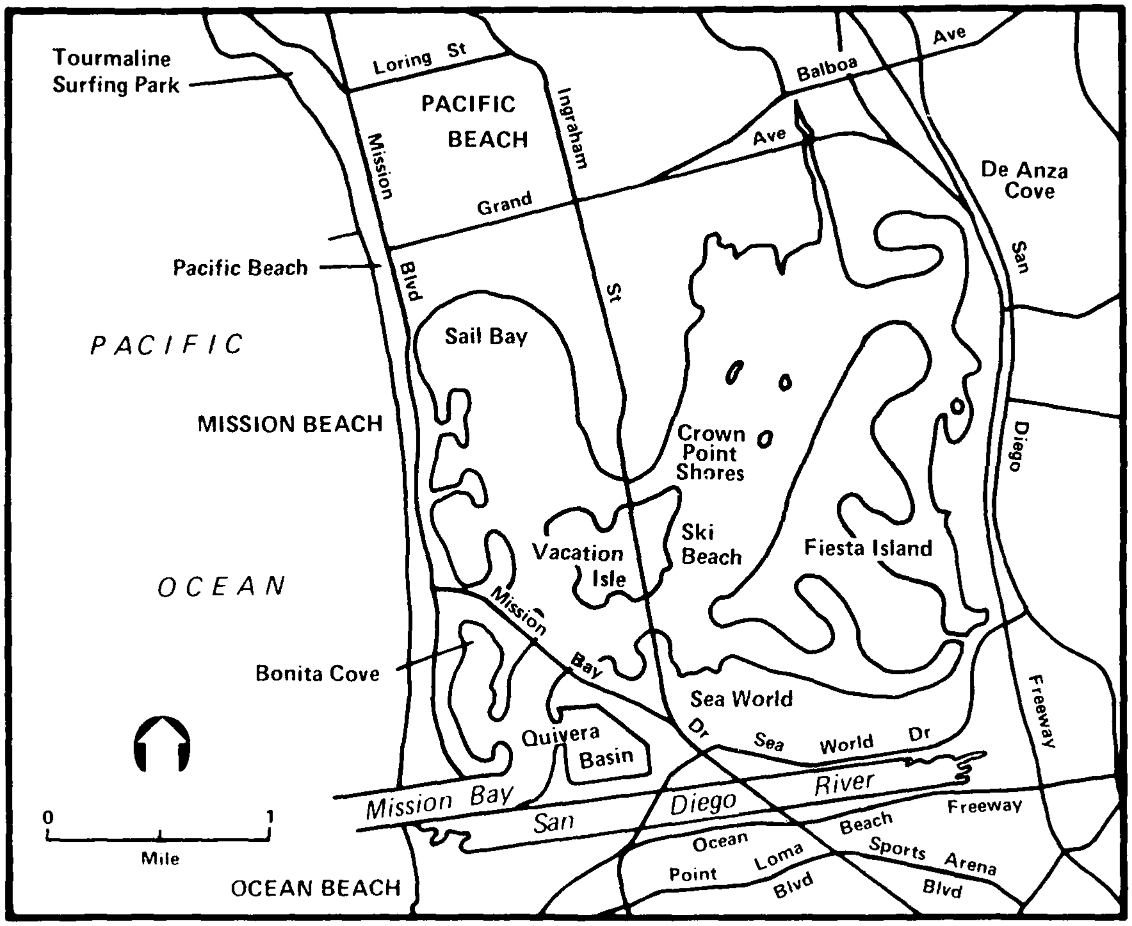
As remembered by KENNETH A. PEEL

So far as I know, Mission Bay has developed no particular problems. They may have had some problems downcoast along the bluffs, but I don't know. I think they have a little bit of maintenance dredging which went out on the beach and with that the problem couldn't extend too far because of the short distance to Point Loma and rocky headland there. It may even have helped to maintain the entrance to San Diego Harbor a little bit.

The first Corps of Engineers works was in 1855 when a levee was constructed to divert the river from San Diego Harbor. The river originally ran right into San Diego Bay, near where the Marine Corps Base is. They diked that off and diverted the whole river from San Diego Bay to flow out at the Ocean Beach area, or just north of the Ocean Beach area. There was a big superdooper flood that washed it out. A new dike was constructed in 1875, but that goes way back. I did read some of the ancient history and it has been stabilized for so long that people just quit worrying about it.

I wrote the Preliminary Examinations and the Survey Report just before I went to the Division Office, as a San Diego River Flood Control Project combined with Navigation at the mouth of the river. They originally had an unfavorable report--my first job was given to me by the Chief of the Engineering Division, Bebout. He handed me this report--he said, "It's unfavorable, make it favorable." So, we rewrote it, and made it unfavorable--and then the third time it stuck--as a good favorable report. It was built by the Corps of Engineers, the harbor dredging and entrance jetty construction with a separate initial entrance for the harbor.

MISSION BAY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Freeway
Pacific Beach
PACIFIC
Sail Bay
MISSION BEACH
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Fiesta Island
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OCEAN BEACH

One of the interesting things that came up on this project was we got a lot of flack and opposition from the State Fish and Game that we were going to destroy one of the prime breeding and feeding grounds for young fish. So, we left a part of the harbor as a wildlife area and unimproved as a fish breeding area; a small part of it, not too much, just enough to overcome what comment that they had ever had because of the added water area. As I recall, there were far more fish after the improvement than before.

The original plan for the joint river-harbor jetty called for a set of locks to interconnect the two bodies of water. I knocked this out in the final report and put in rock rubble. Tidal flow can get in and out through the voids in the rock but the flow, when the river is in flood, won't come through it.

MISSION BAY AQUATIC PARK

As remembered by JAMES DUNHAM

Mission Bay was a 4000 acre mud slough into which the San Diego river discharged and eventually found its way out somewhere near the present mouth of the bay. In my flood control work I had done the study on and helped write a report on flood control on the San Diego River. We recommended the best solution was to levee the banks and build jetties straight on out to sea, but we could find no way to justify it. Shortly after that, other personnel in the district office working from the harbor end at the request of the City of San Diego, saw the need for more small craft facilities in the area.

Glenn Rick, the City Planner, suggested that, "Isn't there something that we can do to improve Mission Bay? We would like to have it developed into a harbor." There were two or three Corps of Engineers' people that were involved in this: Charles Phillips, may have been; Kenny Peel was; and I think Lyman Markel also was involved. At any rate, they took over and combined our flood control report with a report on development of the bay, suggesting a project similar to Marina del Rey and the Ballona Creek improvement. When they combined the two, between flood control benefits and recreational benefits, land development and what not, they came up with justification for the combined project. So, the combined project involved leveeing the San Diego River from the hills to the ocean, separating the bay and river mouths, and putting three jetties in.

That was about the extent of my involvement with it except I did do the study on the effect of the entrance on the adjacent beaches, and designed the jetties leading into Mission Bay. This was the 1946-48 period, because I had done the flood

Original Jetty Construction of Mission Bay Entrances (1948)

Original Construction of Mission Bay Entrance (1948) control work just before the war and I did the design of the entrance jetties and the shore effect study after the war. There, again, I recommended the hooked north jetty, and for the same reason that my recommendation at Marina del Rey was turned down, the jetties were finally designed to extend straight into the ocean. Later, it turned out that there was considerable surge getting into Mission Bay through that entrance, especially to Quivera Basin, which was the nearest one, and by reflection into Glenn Rick Basin on the opposite side. It is interesting to note that when the entrance was first constructed, it was not dredged to its full depth, thinking that the tidal prism would perhaps widen and deepen it. The pilot channel was dredged to a depth, I think, of about 8 or 10 by 100 feet wide.

There were so many disasters, boats trying to come in that entrance, that they soon decided that it would have to be dredged out. So, it finally was dredged to its present full depth.

MISSION BAY — SAN DIEGO BAY
As remembered by WILLIAM J. HERRON

I can't think of any other major engineering problems along the shoreline of San Diego until we approach the Mission Bay area. Mission Bay and San Diego Bay are tied together by the history of the San Diego River and, I think I must start first with that and refer to some of the discussion by Kenny Peel. Actually, the San Diego River, historically, would sometimes discharge into San Diego Harbor, sometimes into Mission Bay.

In the 1850s and 1870s, some of the earliest Corps of Engineers' projects in California was a determination that it was not desirable for the San Diego River to discharge into San Diego Bay and continue to shoal and endanger shipping. This was probably, in part, brought about by the fact that there were a series of very severe floods between 1850 and 1890, and some of the resulting shoaling of the bay was obvious. Anyway, in 1875, a dike was finally constructed across the saddle between Old Town and Point Loma and the San Diego River was permanently diverted into Mission Bay, or as it was known in those days, False Bay.

After 1875, the floods on the San Diego River gradually built a delta, filling the inner end of Mission Bay. Mission Bay, itself, consisted of about 4000 acres of marshland at this time, and in the 1940s the city began to look at this as a potential recreation area. They had a city planning director by the name of Glenn Rick, who had a lot of vision and we have to give him credit with the conceptual development of the Mission Bay Aquatic Park plan.

San Diego River and Mission Bay Entrance (1950)

I think part of this concept was from looking at the success we had had up north in diverting Ballona Creek, the Los Angeles River and the San Gabriel River, out of harbor or marshland areas to the down drift side of the shoreline so that they did not have this continuing maintenance problem after every flood of dredging out these harbor or marshland areas. So, very early in the game, the concept was to treat Mission Bay as a combined flood control and a marina problem. This was one of the first civil work studies that the Corps got back into after the end of World War II.

In the 1946-48 period the Corps of Engineers, in conjunction with the City of San Diego, made extensive combined flood control navigation studies and evolved the concept we have now, where the San Diego River was confined by levees from the U.S. 101 Highway to the ocean and a pair of jetties was extended into the ocean to confine the river to this point. At the same time the area to the north was to be developed into Mission Bay as we know it today. It soon became realized that, as a practical engineering and cost factor, there had to be rough balance between dredging of channels and boating areas and filling of semi-submerged lands, to create land to support a recreational complex. The entrance was to be the same as had been considered in other areas—a third jetty was to be built—so we had a combined three-jetty entrance with the navigation channel to Mission Bay on the north and a river entrance on the south.

Construction started in about 1949 and the Corps of Engineers responsibility, which was a rather arbitrary division, was to do the normal flood control works in rebuilding railroad bridges and building the levees and excavating the channel for the river on down to where the jetties were to be built at the ocean.

On the navigation side, the Corps of Engineers assumed the responsibility of the navigation jetties and the navigation channel into what at that time was known as the Ventura Boulevard bridge. Seaward of the bridge they excavated a -20-foot channel which was considered to be the necessary depth in those days. This was one of the first projects, at least in the Los Angeles District, where the dynamics of wave action was considered in the jetty design. We had learned through World War II, and being exposed to Scripps University and the University of California, how to approach this wave energy problem. The Corps proceeded to do some wave refrection analysis and to give some consideration of wave heights and dynamic problems in designing of the jetties. However, not enough consideration was given to the entrance problems and these jetties were established at 960 feet apart extending directly west into the ocean. This allowed a very wide jettied entrance for wave action to come on inside.

An interesting problem developed about the time of the completion of the jetties and the major features of the flood control channel. The Korean war stopped many civil work efforts by the Corps of Engineers, including this one. It was decided to complete the flood control aspects, separate the river from Mission Bay, and then shut the project down until after the distractions of the Korean war.

In order to maintain clean water in Mission Bay, it was determined that they would dredge a channel 100 feet wide and 10 feet deep between the two navigation jetties so as to allow tidal waters to work back and forth in the Mission Bay. The results were quite drastic. The channel was dredged but, of course, immediately the sides collapsed and this channel spread out to form a bar across the 900-foot width of the entrance channel. At low tide, or with any kind of wave action, waves were breaking over this sandbar, and in spite of the efforts of the lifeguards to warn people and maintain some assemblance of control, 11 lives were lost over the next few years due to boats broaching, particularly during periods of high waves at low tide. Finally, the city council formally prohibited use of the navigation entrance by boats.

The entrance remained closed until 1959, when the Corps of Engineers resumed the project and proceeded to dredge the entire entrance to to a -20 feet and opened up access to the bay. The dredging projects continued (sometimes the Corps, sometimes the city) until the entire area was dredged and the land fills built much as the projects are seen today.

One thing I liked about this project is that while there is about 2000 acres of land within the Mission Bay complex, the City's philosophy is that only about 700 to 800 acres of this is to be put out for lease. These leases are anticipated to cover the operation and maintenance costs to the project, but no attempt is being made to recover the original investment in the project. This leaves over 1200 acres for free public use through the various facets of the Aquatic Park.

While Mission Bay has been a very successful project, there are two rather nagging problems that remain with it. First, the extremely wide entrance, 970 feet, does allow considerable wave energy into the entrance, and at times the waves in the outer portion of the jettied navigation channel can be quite unsafe to boats trying to get in or out. Also, as these waves travel down the length of the parallel jetties and reach the inshore end, the end is a curved section of rock revetment constructed at a low or flat angle in an attempt to absorb some wave energy. Actually a great deal of energy is reflected across into Basin B and even on up the channel, underneath the Ventura Boulevard bridge, and into the upper portions of the basin. This problem was studied once by hydraulic model at Vicksburg and a solution was developed at a rather low cost, which was to simply change this curve or revetment section to a series of echelon sections perpendicular to the entrance. The plan was to reflect a great deal of this energy back out through the entrance rather than absorbing it inside.

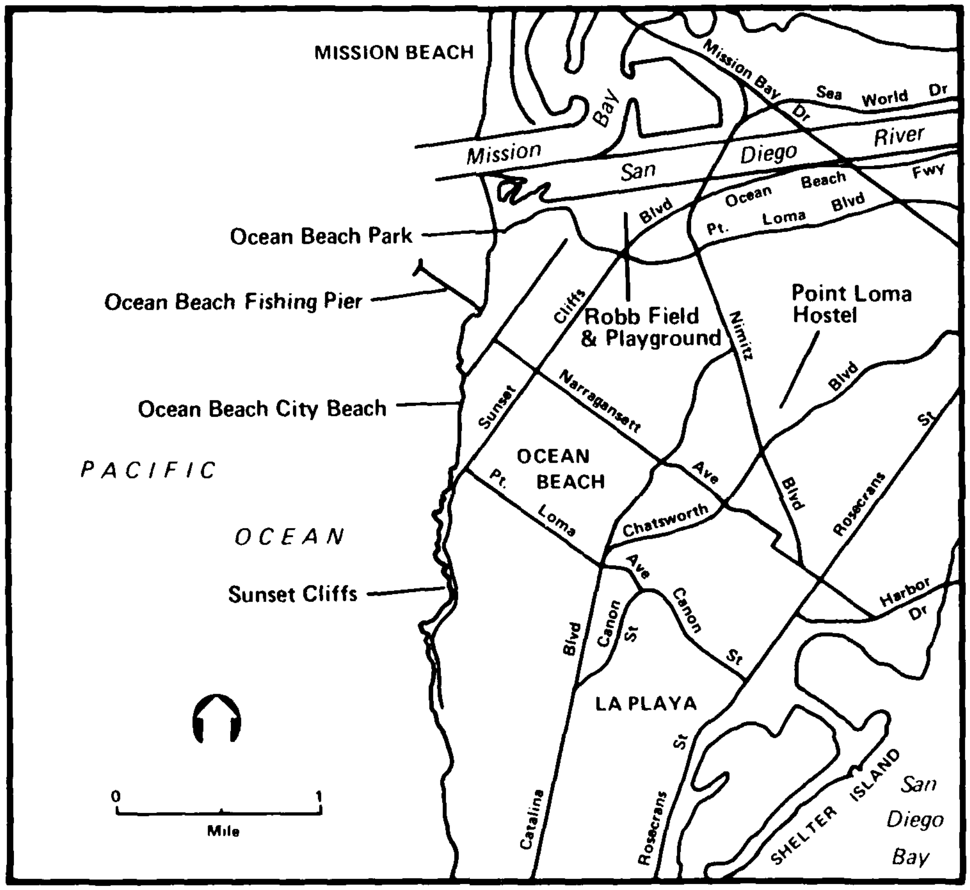
This did not really solve the outer entrance problem of occasional severe waves, so new measures are now being considered; that is to build an offshore breakwater to shelter the entrance in a similar manner to that at Marina del Rey. This is presently under Corps of Engineers study.

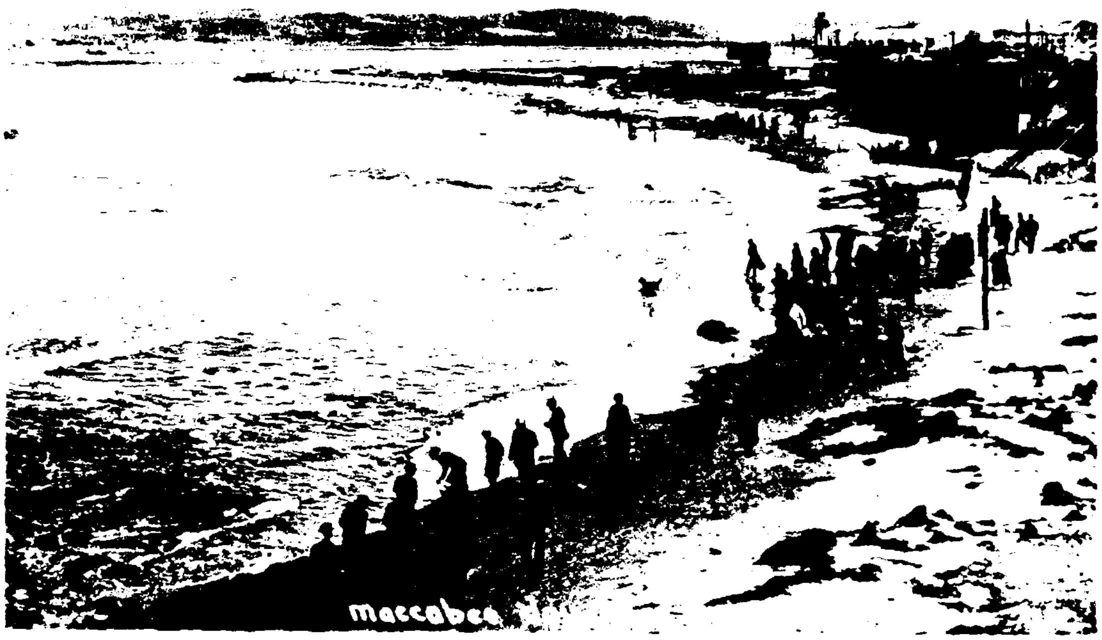
The other problem is a circulation problem within the inner part of the bay. It's a long distance from the entrance channel to the back portions of the bay, near 101 Highway, and in the back area is the very large island which we still call "Treasure Island." They are getting serious pollution back there and at times water contact sports are not permitted. However, there is a temporary solid fill causeway connecting this island to the shoreline that prevents full tidal circulation around the island. This is possibly part of the cause and the other part may be just inadequate tidal circulation, which needs to be restudied. This is under study by the City of San Diego and I understand they are having a tidal model study done by one of the consultants.

Again, there is a sand supply problem at Mission Beach and Ocean Beach, either side of the mouth of the San Diego River, which had apparently been adequately taken care of before water conservation dams were put across the San Diego River. There are about three dams across the San Diego River and very little floodflow and almost no sand supply reaches the shore any more. The construction of Mission Bay, particularly the entrance channel where there was a lot of good beach sand, has coped with this problem since 1950, because large quantities of sand from the harbor entrance were pumped, particularly on the Mission Beach side, to maintain that beach, and a lesser amount of sand was put on the Ocean Beach side to maintain that small beach between the jetties and the Point Loma cliffs—or Sunset Cliffs as they are called.

There will be future needs to supply sand, particularly to Mission Beach, and whether the maintenance dredging of the harbor will be enough, will have to be seen. They may be forced to look to other sources for sand to maintain that beach.

SUNSET CLIFFS





Ocean Beach and Entrance to Mission Bay (1916)

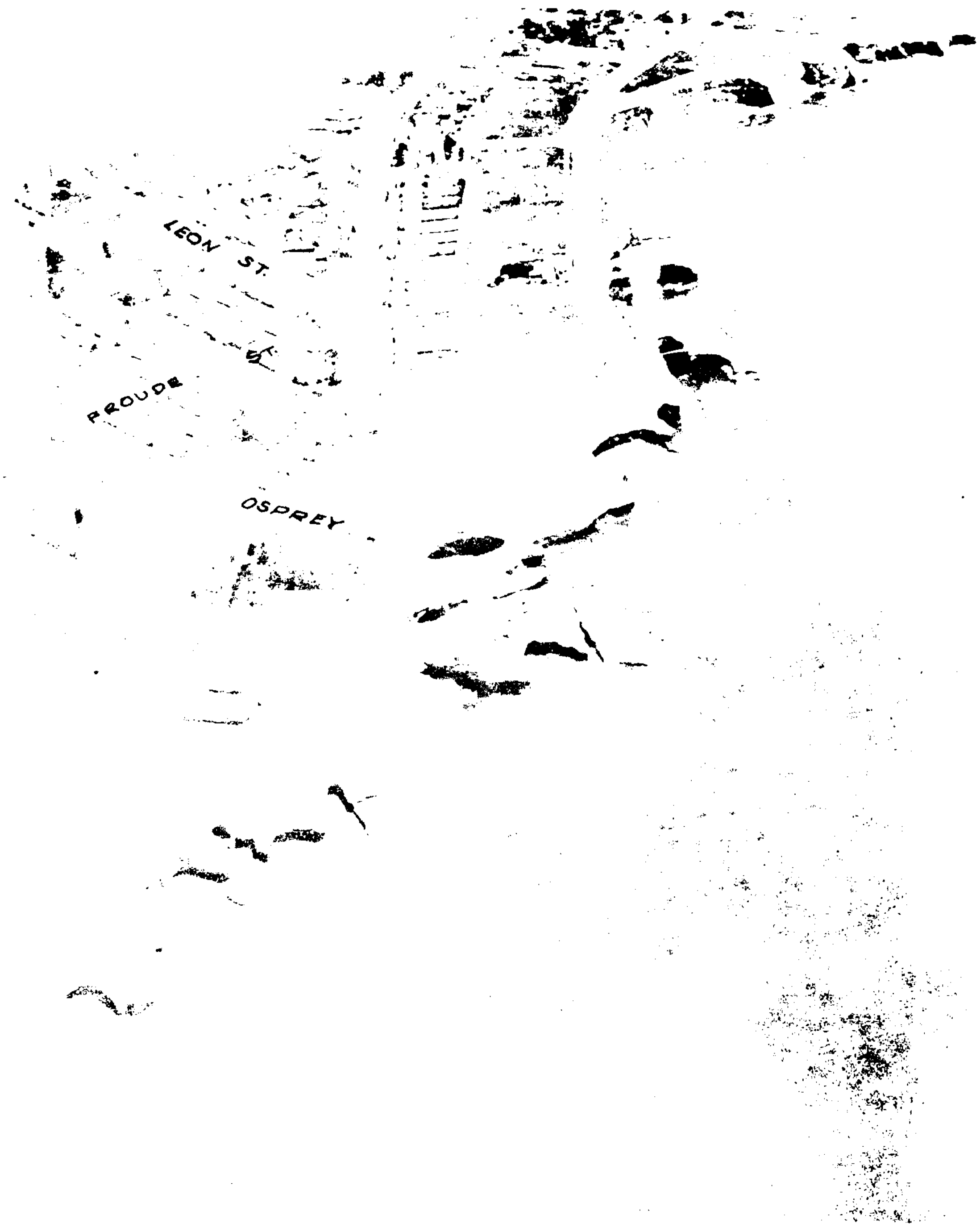
SUNSET CLIFFS

As remembered by WILLIAM J. HERRON

The next area of consideration, and which is a little unique for California, is what is known as the Sunset Cliffs area. These are the fairly soft cliffs extending from Mission Bay to the outer end of Point Loma. There has been considerable erosion of these cliffs, particularly if comparisons are made now against the photographs taken back around 1900. The access road, which serves a great many of the homes along Sunset Cliffs, has been endangered and portions of it have collapsed due to wave undercutting. The problem is that while the upper cliffs are fairly hard, there is a soft sedimentary formation at just about water level. Wave action continually eats into this soft layer and then as shear cracks form, the upper sections of the cliff collapse and tend to come down without warning. Uphill drainage has contributed to this problem also, as there has not been adequate control of the drainage that comes off the urbanization of Point Loma, and this has tended to cut gullies and even to collapse the roofs of some of the sea caves.

Some of these sea caves extend 50 to 200 feet inland underneath the streets and the homes in this area and it could be very disconcerting during a storm to hear or feel these waves working underneath your home. As evidence of past "commercialism," when our survey party was investigating these caves, they found one that was large enough to row a boat into. At the far end they found a concrete landing with a walled up entrance into the cliffs extending some place. They back tracked the cave on land overhead and found this point to be located in what is now a vacant lot. Upon questioning some of the old timers, they found out there used to be an old garage or shanty in that lot and this apparently, during bootlegging days, was a landing point for rowboats rendezvousing with the rumrunners offshore, bringing their loads into the cave and then up the passageway to the shed where they were slipped out to the market by car.

Portions of these cliffs and some of the caves are being protected by rock rubble revetment and we had one good project to protect one section with a sandy beach. But this was shot down by the property owners on top, who did not want to encourage large public use of this area because they feared the disturbance of beach users throwing beer cans and taking up parking on their streets, etc. This is frequently a public relations problem when you are trying to protect a public beach in a crowded urban area.



Sunset Cliffs (1951)

SAN DIEGO HARBOR

As remembered by KENNETH A. PEEL

In San Diego, they had some bad erosion problems after they built the jetty at the entrance to San Diego Harbor a long time ago. They started having trouble at Coronado. They had that big fancy hotel and the adjacent beaches began to erode and were threatening to cut the highway up to North Island. Just about that same time the Navy put in a base for hydroplanes, a seaplane base, at North Island. They dredged out a big area for a seaplane landing but I don't know if more than three seaplanes ever landed on it. But by dredging out the area for the seaplanes a good many millions--19 million cubic yards--of material were put out on that beach. I think most of it, at least some of it, is still there. That settled that erosion problem for a long while.

Then there were other improvements of the inside harbor, including several dredging projects. We didn't get too much beach material but we did pump some sand out in front of North Island and Coronado Island.

The Zuniga jetty was designed for a half tide jetty. It was not designed to break up high-tide waves but to serve as a training jetty only for tidal flow and as a half-tide jetty, it was built much lighter because it was not subject to the same wave action a full-height jetty would be.

As remembered by OMAR LILLEVANG

A final recollection of a story by Colonel Leeds. He told me that for a number of years it was a puzzle, but accepted as fact by the Coast and Geodetic Survey, that San Diego was the only place on the Pacific Coast that had uniform tides. And, the tide books, the predicted tides of those years, did so show tides that looked more like they had come from the Atlantic Coast; virtually equal high tides virtually equal low tides each day. Everywhere else was a mixed diurnal tide along the Pacific Coast but not San Diego. Something was unique there, and they didn't know what it was, but it was clear that they existed and the predicting machine had those parameters in it that produced those predictions.

Finally, somebody had enough time or enough curiosity or enough money to investigate this, because by that time there had been some further development in San Diego and to people who had been observing it, it was clear to them that there were mixed tides no matter what the predictions said. They found that the original tide characteristics had been developed in San Diego by observations of staff gauges as they had been elsewhere on the Pacific Coast; and in those days, the Coast and Geodetic Survey borrowed Navy parties to do this

San Diego Bay With Point Loma in Foreground (1963) kind of thing. Some Naval vessel was anchored in San Diego Bay and a tide board observing detail was established and these sailors were perched on a bank watching the tide staff for a "watch." Then they would be relieved by the next watch on a typical Navy rotation and hit the sack or go on shore leave or whatever. This went on over a period of some time of observing these tides so that those observations could be sent into Washington and incorporated in the descriptive parameters for tides at San Diego; the basis for programming their old tide predicting machine.

What they found out when they dug into it deep enough was that these tide parties, especially on the night watches, said, "Ah, let's sleep, we can figure out what they are, we are used to them on the east coast and at sea--the last one at about 5:00 this afternoon was so and so, or let's make it about 14 hours later--we'll be sleeping real good and we will make the same a tenth or two one way or another." So these were dishonest reports by people who had been sleeping and their transgressions of responsibility were not observed; they got into the whole system of tide predictions and existed for some period of time before the basis of the fallacy was discovered.

As remembered by JAMES DUNHAM

In regard to San Diego Harbor, most of this comes from stories via Harry McOuat and D. E. Hughes. The first harbor protection work that was done by the Corps of Engineers, originally the San Francisco District and now the Los Angeles District, was the dike in 1875 that extends from Old Town to the Point Loma Highland. It was put in because up to that time the San Diego River had alternately flowed into San Diego Bay and Mission Bay, which at that time was called False Bay. The dike was put in to forever keep the river flowing into False Bay rather than into the harbor. I recall that most of the trouble they had with that dike was caused by burrowing animals, mainly badgers that bored holes through the structure and could easily have caused it to "pipe" in case of a flood. They managed to maintain it and that never occurred.

When the San Diego Bay entrance channel was dredged to about 36 feet and about 400 feet wide in 1936, the material from the dredging was used to build the air base at North Island. It might be of interest to note that that was the cheapest dredging that was ever done on the Pacific Coast--some 14,000,000 cubic yards at a cost of 9¢ a cubic yard. I headed the cost section in my early days with the Los Angeles District and had to check all contractor's invoices.

Later, I was involved in the widening and deepening of the harbor entrance to 42 feet when I was on my first job with Moffatt & Nichol. The Navy retained us to determine the best place to dispose of the dredged material, and studies were made to determine whether it would be cheaper to pump it to the offshore beach, to build up other areas that needed enlargement bordering the bay, or to build a new island.

It turned out that the most economical means of disposal would be to use the material to create Harbor Island. It was built to specifications which I prepared. In the meantime, along the ocean frontage area of the City of Coronado, there had been a history of severe erosion north of the Coronado Hotel.

As remembered by WILLIAM J. HERRON

San Diego Harbor is unique because this is the first landing point of the Spaniards on the coast of California in around, I think, 1542. It is the only natural harbor in southern California that can take deep draft ships. The original Spanish ships logged 21 feet across the bar and this has slowly been deepened by man through the years until now there is an entrance channel 42 feet deep which will take the large aircraft carriers.

San Diego Harbor was primarily a military harbor until after World War II, and most of the development work was related to Navy activities. With the start of developing a strong Pacific Fleet in about 1921, a large Navy base was built near Chula Vista; their air arm developed on North Island; and the Point Loma Base developed. Then during World War II, in developing additional Navy facilities, some 25 to 29 million cubic yards were dredged from the bay to make various channels and seaplane landing areas. Part of this dredged material was used to fill in shoreline areas inside the bay and develop North Island and Coronado as we see it today. But the great bulk went on the beach.

Before this development, the Silver Strand was a very narrow sand spit separating the harbor from the ocean. During high tides it was frequently overtopped and impassable. The only access to Coronado and North Island was by boat.

With the widening of this beach between about 1942 and 1946, the Silver Strand has been very secure and there is now a full divided highway the length of the Silver Strand. But this material, and rather uniquely for southern California, moves in littoral drift from south to north instead of the normal north to south movement. It is slowly moving on upcoast.

To back up a little bit--before this fill was put in, around 1915--beach erosion was so severe as to endanger the Coronado Hotel and destroy about one-half of the street north of it. The local people, as an emergency measure, put in a massive seawall protecting this area and they have had no further problem. This erosion episode has not really been back tracked very good, but probably it was a period when the Tia River, which is the main supplier of beach sand in this area, had a long dry spell and there was not a supply of sand.

Then, in 1916 and again in 1927, there were major floods which brought a great amount of sand to the coastline of San Diego and these beaches were sustained until the big Navy fills of World War II.

The Silver Strand is again beginning to get rather narrow near the southern end and as part of the last commercial dredging of San Diego Harbor, additional yardage was put on this beach to sustain it. It has not been fully determined where this littoral sand goes. A lot of it moves northward up into the shelter at Point Loma and either is deposited on the Zuniga shoal or, because of the deteriorated condition of the Zuniga jetty, crosses the shoal and the jetty into the entrance channel to the bay were the ebbtides sweep it out to sea. Scripps Institute has determined that this does happen to at least some of the lighter materials, because they have found the deposit area in about the location where an eddy current off of Point Loma would probably drop it.

Whether tightening of the Zuniga jetty to prevent this sand flow would intercept the sand there and, perhaps, even improve the entrance channel, has not been really studied, it is more of a concept at this time.

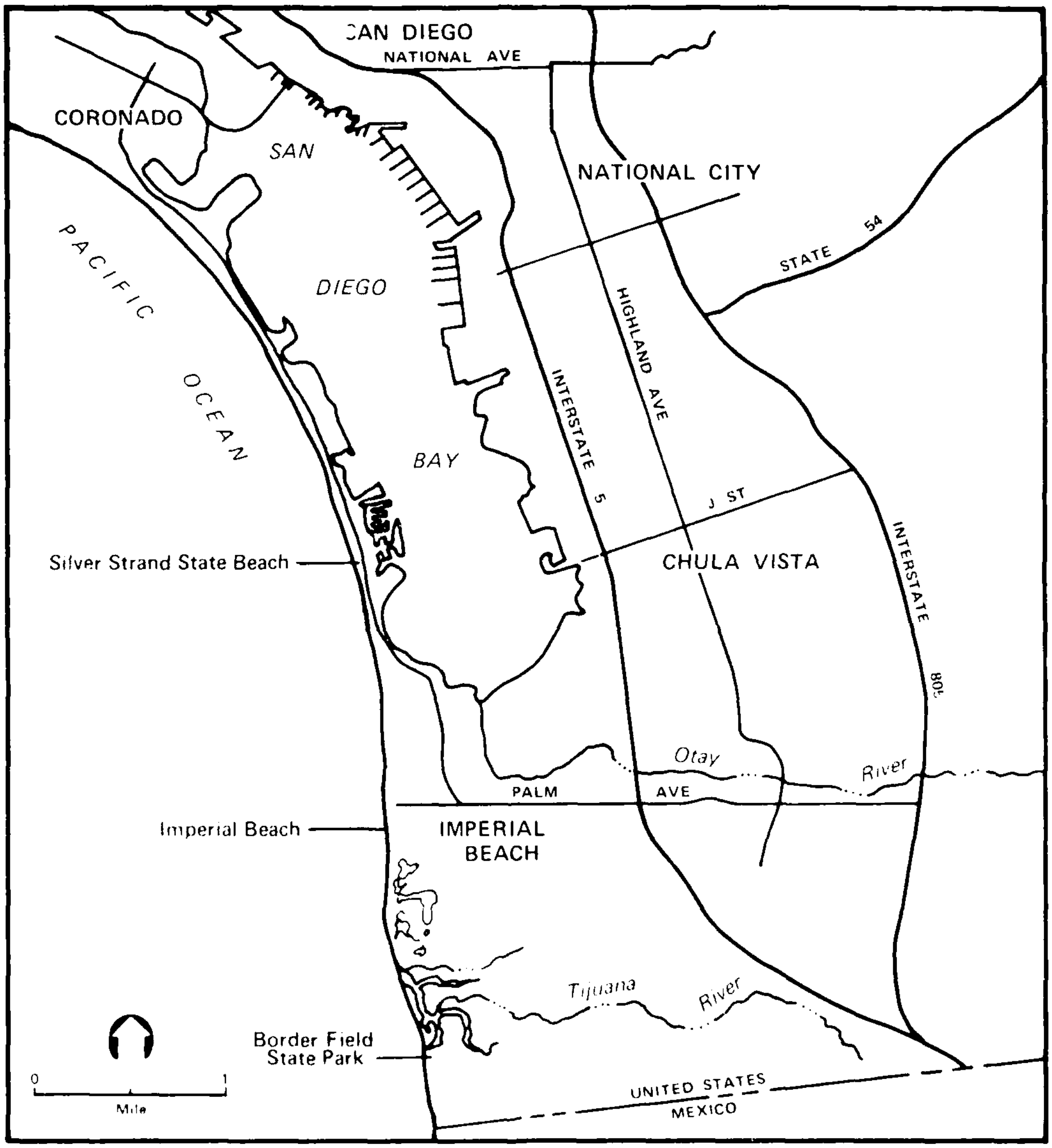
CORONADO BEACH

As remembered by JAMES DUNHAM

At the request of the City of Coronado, we included this in the third cooperative beach erosion control study. Again, this was one of these prewar cost sharing deals. They furnished all the old pictures and reports and what not. There was a big question as to whether that erosion had been caused by the little hotel jetty that had been built to enclose a small marina for the hotel guests or whether it had been caused by the Zuniga jetty that had been built by the Corps of Engineers.

The low height Zuniga jetty was built to protect the San Diego Harbor entrance, so the Corps was kind of put in the middle on this. I think we successfully showed that the erosion was caused by the hotel jetty. At this time the erosion had not been too severe to the south of that area—although it was beginning to show up—and the beach was quite narrow along Silver Strand. It was obvious to us that the hotel jetty had collected a considerable amount of sand, but still it was unknown whether it had come from the north, south, east, or west. The jetty had just acted as a trap.

CORONADO BEACH / IMPERIAL BEACH



The studies revealed that the first serious erosion had occurred back before the hotel jetty had an appreciable effect on the beach, about 1905, I believe. A big storm hit the area and washed out the road north of the hotel and caused considerable damage. This necessitated the seawall which was built by the city and has served as erosion protection ever since. However, the fill at North Island widened the beach from the Zuniga jetty to the hotel jetty and there has been no trouble in that area since that time.

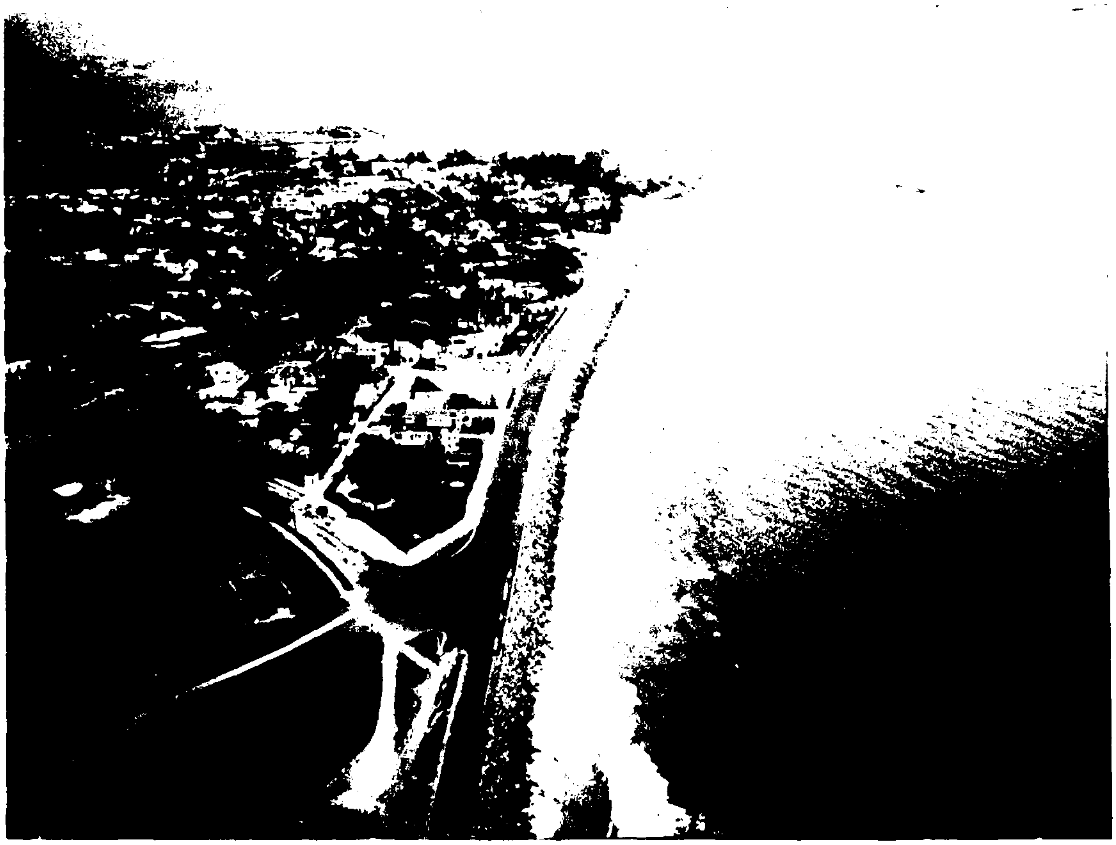
Then, during the war, the dredging of the Navy sea plane landing area in south San Diego Bay put about 27 million cubic yards of sand along the Silver Strand beach which widened it out considerably and prevented any further erosion problems in that particular area.

It is interesting to note that a court case came up in which I was employed as an expert witness, along with Omar Lillevang and Doug Inman. The owner of the beach (which I believe at the time was Spreckel's Company), south of the hotel, claimed that the beach widening was due to natural accretion rather than upcoast drift from the fill that had been built by the Navy as we contended. The Judge ruled against us so-called experts for the State, finding that it was indeed a natural accretion, and therefore, it belonged to the owners of the adjacent land. Since that time, the land has exchanged hands and is now the site of Coronado Shores and the condominium towers that have been built thereon.

IMPERIAL BEACH

As remembered by JAMES DUNHAM

Downcoast from that area, at Imperial Beach, erosion has been quite severe for a number of years. This is probably the result of three dams on the upper reaches of the river; two of them in California, on Cottonwood Creek (which is tributory to the Tijuana), and the Rodriguez Dam on the main stem in Mexico. The Tijuana River has not gone into full flood stage since those dams were built and very little sand has been brought down the river to the beach. Our studies with the Corps showed that the waves in that area generally come in almost normal to the shore. If there is any net littoral transport at all, it is probably to the north from the mouth of the Tijuana River. It is probable, historically, that material brought down by the Tijuana River, which has one of the largest drainage areas in southern California, drifted northward and built or at least maintained the Silver Strand and Coronado beaches. But, since that source has been cut off, there has been continuing erosion offset only by the artificial fills put in from the harbor dredgings.

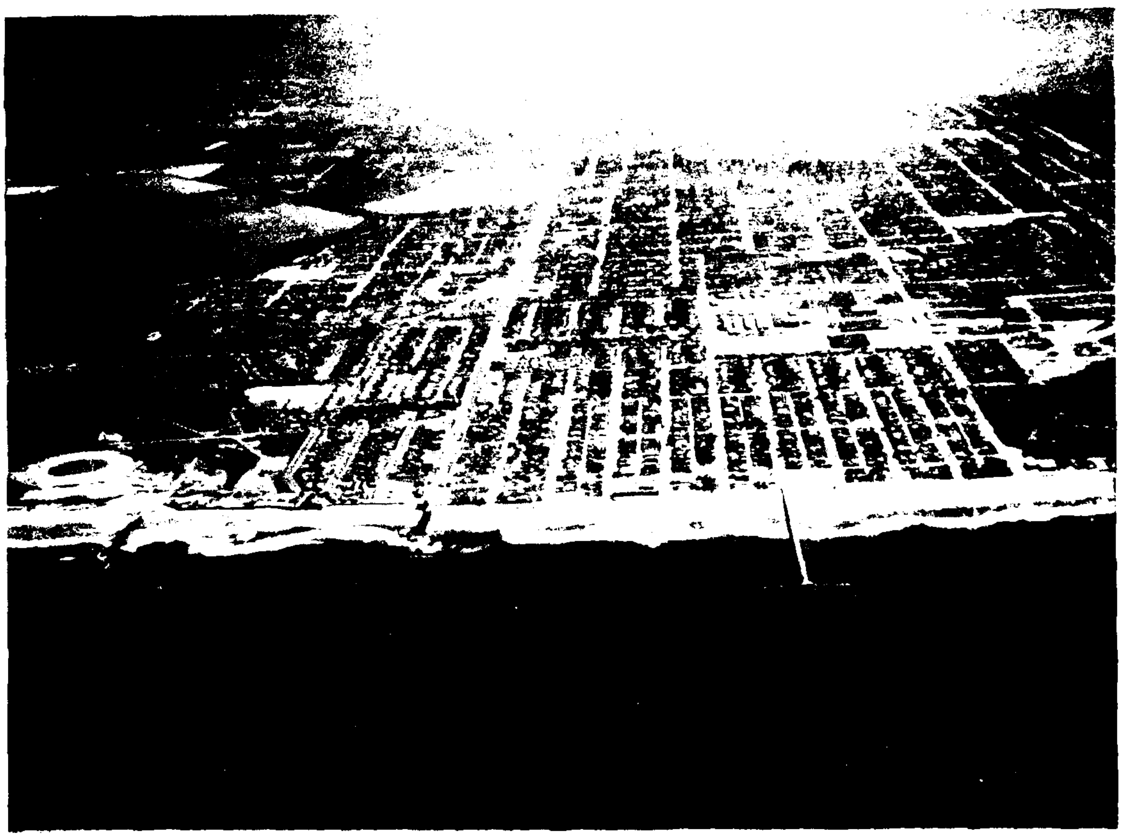


Coronado Hotel and Beach (about 1919)

As remembered by WILLIAM J. HERRON

The final beach erosion problem in San Diego County is at Imperial Beach, the southwest corner of the United States. This beach is supplied, or was supplied, by sand from the Tijuana River but, with the completion of Rodriguez Dam in 1928, and with the earlier construction of water resource or water conservation dams on the United States side of the border, all of the mountainous areas and the great majority (two-thirds) of the drainage area of the Tijuana River is now behind dams. So there has been no large river supply of beach sands to this coastline since 1928. It has been determined that this littoral movement from south to north probably starts a few miles below the Mexican border and carries an inadequate amount of littoral sand upcoast to sustain both Imperial Beach and the Silver Strand.

Attempts have been made to protect the Imperial Beach area by the constuction of two groins which, because of the very fine character of sand, has not worked well. An additional million cubic yards of sand were placed on this beach in about 1979, from the San Diego Harbor dredging, to improve its condition as a public beach. Imperial Beach is still a continuing problem that has not been resolved. Studies have been developed at Vicksburg, to help restrain this sand with possibly a series of offshore detached breakwaters. These are in the planning stage but have not been built yet.



Imperial Beach (1964)

Mouth of Tijuana River (1964)

9 Specific Coastal Studies

9 Specific Coastal Studies

HARBOR OF REFUGE STUDIES

As remembered by KENNETH A. PEEL

Harbor of Refuge Studies, made while I was in Los Angeles, extended on up to San Simeon but so far as I know, nothing has ever been built at San Simeon or on the Santa Barbara Channel Islands.

The San Francisco District picked up just north of San Simeon and the shoreline in the San Francisco District I wasn't intimately interested in. We did consider harbors out on the islands--Santa Barbara Channel Islands, one on Santa Cruz Island would have been especially nice. Both Dick Eaton and I advocated for a long time that the State buy Santa Cruz Island from Mr. Stanton for use as a State park. I believe he offered to sell to the State for a million dollars once and they sure should have bought it at that. I understand that the Federal Government bought it and I imagine he got a lot more for it. There were several nice harbor sites on that island and its a beautiful island.

COMPREHENSIVE HARBOR OF REFUGE STUDY

As remembered by OMAR LILLEVANG

Most studies are of a specific site but I did make an interesting comprehensive study of where harbors of refuge could be developed in the State of California. This was a statewide effort not limited to the waters of the Los Angeles District, but certainly did include a number of sites in the Los Angeles District. They were all conceptual; they were all sketches; they were not anything but intuitive design for our purposes of determining the best locations that would best fit a concept of spacing at 35 miles along the coast where small craft could take refuge, even during storms, from seas that were not hospitable or take refuge in order to rest and replenish, or to achieve repairs or medical assistance.

I won't enumerate those sites and what went into the thinking on them. There is a report—though I wrote 90 percent of it—my name is not on it. It was an interim report by Leeds, Hill and Jewett, Incorporated, to the State of California, Department of Small Craft Harbors, I believe that was the name at the time. That's somewhere around 1963. So skipping past that effort, which I might say parenthetically caused me to visit and fly over every foot of sea coast of the State of California, including the islands offshore. A very exciting, interesting, and growth producing kind of experience.

TSUNAMI WAVES

As remembered by WILLIAM J. HERRON

A coastal engineering program which is not exactly peculiar to southern California, but I think should be discussed, is the effect of tsunami waves on this coast. These come from the great earthquakes off Peru, Japan, and the Aleutian Islands, and occur generally about every 20 years. Their effects were not greatly noticed until the 1940s, but we now have documented several tsunami waves which have arrived as a result of quakes from these locations. The most destructive was probably in 1964 from the great earthquake off Peru; and while many areas were affected, the greatest property damage was inside Los Angeles—Long Beach Harbor. While this wave caused no great problem in the outer harbor, it did arrive in such a manner as to produce harmonic wave action in the channel behind Terminal Island that connects Wilmington and Long Beach, called Cerritos Channel. By observation, currents of up to 15 miles per hour were created in this channel and over a million dollars of damage was done to old and deteriorated marina facilities and other small dockside installation.

The effects of the Anchorage quake a few years later was not as pronounced, and because of all the new construction, damage was relatively minor. San Diego felt the effects of the Peruvian quake but oddly enough there was very little effect at Newport Harbor, and the damage at San Diego was not great but there was some impact inside Shelter Island.

Port San Luis had one of the largest rise and fall of water of anywhere along the southern California coast, and it has been reactive to almost all of these earthquakes. It's a little bit similar to Crescent City in this respect.

Another area of strong reaction which, to me, has not been fully explained, because usually the severe Tsunami waves show up in areas where the wave energies have been somewhat confined, is the Santa Monica area on Santa Monica Bay. They have experienced severe rise and fall of water due to the tsunami effect; as it is not confined, the horizontal currents have not been so strong as to do a great deal of damage. We have been fortunate in that with the two big quakes, the Anchorage quake and the Peruvian quake, the tsunami waves arrived in southern California during the low tide period so the worst effects were confined to low tide areas. There is no question, particularly in San Diego, if the tsunami wave had arrived at high tide stage, it would have caused a great deal more damage to docks and small boats.

COOPERATIVE BEACH EROSION CONTROL STUDIES

As remembered by JAMES DUNHAM

I had only been back on the job with the Corps about half a year after the war when Kenneth Peel, head of the Rivers and Harbors Section, came to me and said that the coastal districts had been assigned the job of writing a number of additional reports on beach erosion control. For this purpose, each district was directed to set up a beach erosion control unit. I was the one that had been selected to head up the unit for the Los Angeles District. We started out right away on this work. I think Santa Barbara was to be reviewed— I forget what all the other jobs were but the main impetus of the new work was to review the entire coast of California over a period of years, through a series of appendixes to a cooperative report in which the State and Corps would share the cost equally.

The first beach erosion study of this type was to extend along the entire Ventura coast, and it was aimed mainly at the erosion that had occurred along the area downcoast from Port Hueneme.

The second study was to extend from the Ventura County line to the San Pedro breakwater. These were then called Appendix 1 and Appendix 2 of the Corps of Engineers' Beach Erosion Control Study.

It was recognized that geology played a large part in what was going on along the coast, and that it was pretty important to determine the source of beach material. Where was it coming from? How far did it get? Where did it finally wind up?

While at that time Scripps Institution of Oceanography had been doing quite a bit of study on where it was going to, they did not know too much about where all the material was coming from. We decided it would be a good idea to get some geologic input on this, and for this purpose we brought in, on a part-time basis, a man who was working on his doctorate in geology, John Handin.

The work at Scripps was being done by Walter Munk, Francis Shepard, Doug Inman, and Robert Arthur, and later, by John Isaacs.

John Handin obtained geologic maps of the tributary areas along the coast and estimated rates of erosions by geologic evidence. Then, through a number of procedures best known to geologists, he came up with rates of surface erosion for these areas that could produce sand-size particles. Now these sources were mainly mountain areas where the basement rock was granite, which weathered to produce beach-type sand. As I recall, he estimated that the Santa Clara River alone should be contributing an average of 2 million cubic yards of sand a year to the coast. Then he did some petrographic analyses to determine the types of minerals that were in the sands that he collected from various places back in the headwaters of streams, near the mouth of streams and along the coast to trace routes of travel. He found that the key to this seemed to be the rare minerals—ones that did not occur too frequently—but it appeared that each stream had some type of rare mineral that could be traced. He would pick these up and find where they were going.

For the first time, these tracers showed that the sand grains were traveling long distances--not just short distances as had been thought before. This all was documented in the geology report on the two studies that we did—Appendix 1 and Appendix 2 of the Corps of Engineers' Beach Erosion Control Study. It was because of this study that we really appreciated the impact of the submarine canyon at Port Hueneme. Of course, Scripps had been talking about that for some time. What surprised all of us was that Scripps divers had been able to get into the canyon just as the time slides were occurring and they were able to document this pretty well. Large quantities of sand were going offshore through the canyon. My first introduction to this phenomenon was when I was called down to the Monstad Pier in Redondo.

The Corps was told that a part of the pier had washed out and that there was considerable damage going on underneath the pier. I went down there and talked to the man who owned the pier. He pointed out that he had been taking soundings with a lead line along the south side of the pier, which was the canyon side, and that morning the bottom was about 12 feet lower than the day before.

Monstad Pier was the little straight pier, and part of it was the anchor arm of the Horseshoe Pier. That is, it extended out a short distance, went out alongside the north side of the canyon. Apparently there had been one of these submarine slides, and several of the fender piles (which were not attached to the pier but just driven into the sand), had floated loose and were acting as battering rams, knocking out the main part of the pier close to the beach. So we knew quite well then that these canyons were areas of sand loss, but no one knew what to do about it. Apparently there was not much that could be done, but this alerted us later on when we were doing other studies of how to correct the situation; that is, steer clear of the heads of the canyons and try to prevent the sand from getting into them. This was, of course, the reason for placing the long groin on the south side of the canyon when the Redondo-Malaga Cove fill was placed.

10 Coastal Powerplant Projects

10 Coastal Powerplant Projects

DIABLO CANYON POWERPLANT PROJECT

As remembered by OMAR LILLEVANG

The Diablo Canyon Powerplant Project, on which I have been engaged and am still retained by the owner electric company in San Luis Obispo County, is situated on a piece of uninhabited and closed private property coastline between Morro Bay and Point San Luis. Breakwaters armored by 21- and 36-ton concrete Tribars were built to create shelter from waves during recurrent episodes of building pumping stations for condenser cooling water. The evolution of the concept, the design procedures, the construction problems that were met, and a repair episode that I was engaged in are all in an ASCE paper that I wrote and presented at the Specialty Conference on the Queen Mary called "Ports 77." It is in Volume 2 of the proceedings of that conference. Recently, subsequent to that 1977 paper, one of the breakwaters has been severely damaged and it is right now under intensive investigation. Any conclusions would be speculative at this time. There are not even any very strong hypotheses of the cause or mode of damage, but they will be known and when they are known, they will be disseminated, if nowhere else, publicly to the Nuclear Regulatory Commission.

It is some comfort to everybody that the breakwaters of the Diablo Canyon Power Station, which is a nuclear powerplant, have no relationship of any kind to the nuclear safety. Therefore, the repair procedures do not need to be a crisis type of effort. They can be more deliberate and thoughtful and that is of great comfort.

EDISON MANDALAY STEAM GENERATING STATION
As remembered by OMAR LILLEVANG

Southern California Edison Company's oil-fired and gas-fired power station, called Mandalay Steam Station, is located immediately west of Oxnard. I was pleased with what they had done at Redondo and at El Segundo to acquire a supply of cold "sea water" for condensing steam. They used two pipes going offshore to submerged tower risers, using one of them to take in cold water and the other one to return the warm water to the sea and occasionally reversing function in order to control the growth of marine organisms on them for a very low cost maintenance system. They had in mind doing the same thing at their Mandalay Steam Station site because, to the eye, it appeared to be very similar to El Segundo; it was backed by dunes with a relatively straight but slightly curving coast. They bought the site with the idea of using twin pipes.

I had some familiarity with the area having been at Port Hueneme for a year and a half or more during its early construction and was aware of major sand changes that were typical of the region, and very criticaly aware that this site was only a matter of a couple of miles from the mouth of Santa Clara River, which can be a prodigious producer of sediment. These intake systems, particularly the intake pipe, needed to be out at depths where one can be reasonably well assured that the ocean floor profile won't rise to some point that will cause ingestion of and with the flowing water into one of these conduits. The conduits varied from 10 feet in diameter on the earlier station that was built and in more recent years to the 15-foot-diameter line at San Onofre Nuclear Power Station in San Diego County. So, they are large pipes, and if you get them full of sand, you've got a major problem of clearing it out and that needs to be avoided if it possibly can be.

Colonel Leeds, my employer, mentor, professional "father" in a sense, had talked at times about observations that had been made by the late David Hughes about sand accretions at Ventura alongside the Ocean Pier, where in the days before the railroad came along the coast, small steamers came into an open roadstead pier, tied up, and took on agricultural products and delivered some commodities to the area.

In the freshets that came down in floods in 1916, shoal depths had occurred at the steamers mooring point on this pier so they could not occupy those moorings. In fact, as I remember Mr. Hughes' report, from going out and taking soundings personally off the end of that pier after that storm had brought sediment down, there was a 17-foot reduction in depth for one storm season and by the time he got people, or money for people, to go up and make a condition survey, it was a year later when they went there and found the bottom was back to what it had been before. So, I think there has never been a map to show that quick accumulation and dissipation of sediments from a major storm. It was probably largely from the Ventura River, but certainly it could have been a joint contribution of the Ventura River and the Santa Clara which bracket that site.

So, if nearby there could be a 17-foot change in depth in one season, one had to be very respectful of the distance out that one needed to go with a submerged tower intake in order to be reasonably confident that something as conservatively designed as a power station must be, would have a continuing supply of water without any maintenance problem to interfere with its continuing operation. At their lines at the stations that they were familiar with, and where their experience had already been good, one could go out something between 1500 and 2000 feet and get to depths where bottom changes could be accomodated with an intake system and be safe from sand coming in; here, it appeared that one had to go twice as far out.

Well, that represented virtually a doubling of the prudent cost estimate, and so I began looking for a reliable, less expensive way. Remembering my experience with the main discharger or collection and discharge ditch of the Oxnard Drainage District No. 1 (I am not sure about the number) which emptied into Hueneme Harbor, I took my son and we walked the bank of that drainage canal, which paralleled the coast about a half mile in and goes up to the neighborhood of the Mandalay plant from Hueneme Harbor. I wanted to determine whether or not there were any details of that alignment that I might have forgotten or had never observed that would preclude its feasibility as a modified ditch to take cooling water from the harbor to the station. Powerplants don't like to have their plans commented on before they have decided that they are plans. So in order to maintain a degree of quiet approach I told my son, who was about 9 years old at the time, that we were going to take a fishing pole along and if somebody questions us as to why we were walking along the celery fields alongside of this drainage ditch, "why we will let them assume that we are city people who think we can find fish in this ditch." He enjoyed that little subterfuge and it didn't seem to be grossly dishonest so I didn't mind him sharing in it. We walked the ditch to see if there was anything in the way and there seemed not to be.

Thus, the concept was born and presented to the Edison Company in the most "back of the envelope" style that the drainage district ditch could be converted to larger dimensions and deeper bottom elevation in order to take salt water from Hueneme Harbor and transport it to the station. It could still then accept the discharge of subdrainage systems for which it had been built. These had reclaimed the agricultural lands there from a gross alkaline condition to producing three crops a year. And, it could still dispose of those drainage waters, it could accept flood inflows when they took place, and it could serve the Edison Company as a maintainable facility for sea water taken from a harbor whose entrance was assured by the needs for navigation.

The Navy was approached very informally, because Edison Company didn't want to have a reaction on a formal request. It was done informally, by me without agency designation by my client, and the captain commanding the station who later became the director of the Navy's then Bureau of Yards and Docks and is now called the Facilities Engineering Command, was Eugene Peltier. Considering what we were looking at he agreed with me that there could be some benefit to the Navy by allowing sea water to be taken into this canal and transported through the Navy Base because it was taken from the end of the harbor where sometimes the water got a little bit debris laden. Inducing a flow there could help harbor conditions. I pointed out to him that it would be temporary until such time as Channel Island Harbor was built because the alignment of the drainage district went right through the basins that we were planning at the time for Channel Island's harbor. So with the discovery that the Navy wouldn't need to object and could cooperate, a formal request was then made and right-of-way agreements were concluded between the Edison Company and the Navy so the canal could be built.

Similarly, the county administration was easily shown that sea water taken out of their future harbor would create the same benefits as the Navy recognized for theirs and so they cooperated. The Mandalay Canal then was excavated and dredged along the alignment that fitted closely, precisely in fact, to the planned layout of the Channel Island Harbor's east basin and went along that line and, in fact, then created the first dredging elements of Channel Island Harbor without being a harbor. The canal then traversed through that and on up to the power station. Later when Channel Island Harbor was dredged, the Navy section of the canal was filled in, and the land reclaimed for the Navy to use once more as dry property, and the sea water service to Mandalay Steam Station has been by the Channel Island Harbor route ever since.

Warmed water from the condensers served by this supply of cold water is returned through a revetted open channel across the beach in front of the station. The return flow channel was a different kind of a problem, but an interesting one even though on a dimensional scale which is not very great. The concern had to be felt that the return flow channel be a free-flowing one, but that the means of keeping it reliable, free-flowing, and fixed-in-position would not cause any accretions on one side of the shoreline nor erosion on the other as one looked at it from the west towards the east.

The coast here, of course, trends more east and west than north and south. So quarry stone jetties, looking very much like groin built of quarry stone, were built to limit the hydraulic geometry of the return flow channel. But they were extended only far enough to be constructed entirely landward of the surveyed line of mean high tide--that way they did not encroach upon public land. They merely delivered water at the edge of public land to flow on into the sea. The flowing water would erode and make its own channel and, therefore, no dredging was necessary. It has been eminently successful in that I have never observed nor has there ever been any report of there being any accretion or erosion either upcoast or downcoast to these jetties. They seem to have absolutely no effect on the alignment of the mean high tide line in that area and that was an objective, which was important.

There was another thing about it which is certainly worthy of note, and it's tragic that things like this can be an attractive nuisance. Though posted and fenced out to the mean high tide line, this tumbling water coming out of the power station attracted people who wanted to get in it. A responsible family man, who is a professional, with two boys picnicked alongside. The boys, who were playing in the water, got caught in the turbulence of the release where it left the concrete structures to go into the sand bottomed return flow channel and they were both drowned in that turbulent water. I am told that the family acknowledged their carelessness and the fault was theirs and they took no legal action against the proprietor. That, of course, in present day liability climates is an unprecedented attitude of an aggrieved person. They were there, they saw the posted signs, they were advised of the danger, they minimized it, and as a tragic outcome, two young boys, teenagers, were lost. So nothing is for nothing and that was a very high price for that family.

In regard to possible tsunami effects, I forgot to mention that I was concerned that we be able to assure the farmer landowners through which this canal would go, that there would be no hazard to the root zone of their cropped land from introducing sea water to the area. Because we found that a perched groundwater plane, one that they did not exploit for irrigation from wells because it was such poor water, had a level about 8 feet below surface and that 8 feet down really was established by the effectiveness of the sub-drain system. That put the general level of their groundwater body at somewhere around elevation plus five to plus eight on sea level data and so there would always be groundwater profile toward a ditch which would come down to whatever level was in the ditch. In the sea water canal one could reason philosophically that it approximated mean sea level because the responsive flow through the salt particles would be as rapid as the drop or the rise at tide above and below mean sea level, and that, therefore, there would always be a positive flow from groundwater toward the canal, and there should be no salt water intrusion hazard.

It took a lot of talk, and acceptance by an independent engineering agency that the landowners turned to, to get them to feel comfortable about the idea that from a physical science standpoint there could be no jeopardy to their crops even if there had been good water in the ground. But, then, the concern existed as to whether or not there might be any resonant response to quick changes such as tides or other things that could cause this long canal, like an organ pipe, to begin seich or slosh.

Feeling that computations would need to be justified and, perhaps, in something less than a rational basis because there were bends and turns in the canal we elected, I recommended, and it was adopted, that we would build a scale model of the canal with flowing water and with tides. We built that model in an unused and vacated power station right near the brewery near the Los Angeles River along north Broadway. Edison Company owned the building and we built the model there and it was operated by two profesors from USC, Kent Springer and the senior man whose name I can't remember. He had done the Cape Cod canal job while he was at MIT and so he was the principal investigator.

The hydraulic model was built there and tides were introduced to it from actual maragrams that had been recorded at the Coast Geodetic Survey primary type station at Hueneme. We observed the canal behavior and tracked the profiles on it and were able to demonstrate more convincingly and probably more rationally with this model than by computations. The model was something like 200 feet long to represent about 4 miles of canal. We modeled it with Port Hueneme as the tide source and we modeled it with Channel Island Harbor as the tide source and it indicated that there was no adverse nor beneficial change. Nothing in behavior in nature since that time has indicated otherwise.

SAN ONOFRE NUCLEAR POWERPLANT

As remembered by OMAR LILLEVANG

Going downcoast farther, I guess my own involvement picks up at San Onofre where the first commercial sized nuclear powerplant in California was established about 12 years ago. Longer than that I guess, construction started about 17, 18 years ago. There, from studies of littoral regime and of wave motion that could be expected, I advised the utility on where to locate and on what profiles to place their offshore cooling water intake discharge facilities for the first reactor unit that was built and which has been operating for a good many years. That was a single point discharge, whereas all of the other Edison Company thermal shock systems were built with twin pipes.

The well water coming back was discharged at a single point into the ocean at the temperature it had been elevated to in the powerplant process through the condensors. It has always proved to be a good device, locally the warm water is certainly there and in evidence, but it is mixing and, therefore, by mixing the reduction of temperature is very, very rapid and not detectable at any great distance away from this point of discharge.

It can be argued whether or not warm water in the sea has any real detrimental effect. It has been referred to as thermal pollution--it is not so clear that it is a pollution. But the point discharge system was frowned upon by those who considered it a pollutant and in the units at San Onofre Number 2 and 3, which are now in the later licensing for operations stage, construction is nearly finished. A totally different system was devised, I was not involved in it, where the warm water return has to be defused into a field of acres and acres and acres, in multi-small diameter outlets. It involves a horrendous increase in capital cost, and with some grave uncertainty as to whether or not it really accomplishes anything that wasn't done as well or better with a single point discharge.

AGUA HEDIONDA POWERPLANT

As remembered by OMAR LILLEVANG

Alongside Oceanside, immediately south at the south limits of the town of Carlsbad, is the entrance to Agua Hedionda Lagoon. This sounds like a musical, poetic name that must have been dreamed up by a real estate developer looking into a Spanish dictionary to find things that were euphonious, harmonious, and good for a real estate brochure. As a matter of fact, Agua Hedionda means "stinking water." It is the old place name for that lagoon that got it because there are some sulfur springs that feed the creeks that flow into it. It has been a rather extensive lagoon that is crossed by rather small bridges of the old State highway system right near the beach and by a trestle of the Santa Fe Railroad, a wood trestle, about one third of the way inland from the sea.

San Diego Gas and Electric elected to build an oil-fired power generating station on the banks of that lagoon and bought most of it. They concluded that they would take the cooling water cooling water from the lagoon if the lagoon mouth could be disciplined to be reliably open at all times. This was studied, really with guidance from the principle that General Robins had published from work done by one of the people in the San Francisco District, Corps of Engineers, but more extensively reported upon and maybe originated by Dean Morrough P. O'Brien when he was the young instructor at Berkeley, where tidal prism related to cross-sectional area maintainable by that prism at the mouth of the bay or lagoon was a guide. On the basis of that guide, but with considerable other judgment and some field observations of behavior of the lagoon during tide changes, a mouth that frequently was plugged for months at a time was fitted with a pair of parallel quarry stone jetties, spaced at a distance to establish a tidal entrance whose area fitted the O'Brien-Robins criteria, but expanded beyond it really, and created a basis on which there would be strong flow--high velocity flow unsafe from a boating or swimming standpoint really--into and out of that lagoon during tide changes. It was recognized that sand would be carried into the lagoon during flood tides, but they provided a side area where it could deposit in shoals for systematic removal at intervals and pumped back to the beaches. It was built, and from the standpoint of the power station, has worked very satisfactorily ever since. They own a dredge which is kept in the lagoon permanently and every couple of years or so it goes to work on the accretion and puts it out on the beach to continue in the littoral budget toward San Diego.

The power company set aside areas for recreational fishing in their park lagoon and also contributed the use of the beach seaward for public use; and it is a very attractive recreational facility, remains so, and the sand bypassing system, if you will, works.

This brings up a point. A lot of times we have gone, in the past, to a historically surveyed history of accumulations behind or above an intercepting structure, calculated the volume accreted, and divided that by the number of years it took to do it, and published that as the rate of littoral transport at that location on the coast. Sometimes some rather erratic scatter of data points results when you try to compare one with another to see if there is any progression either of gain or loss from place to place along the coast, or in relation to the energy budget from waves coming onto that coast as opposed to others where you have a different figure. I believe what we overlooked was that the influence to trap or accrete has to relate to the width of littoral zone that is affected by the structure or device that traps or shelters or otherwise causes accretions. If you have something that is effective out to the minus-30 contour, that should accrete a certain number of cubic yards of material in will, or even close by, if you compare something reaching out to the minus-10 contour, I think it would have a different rate of accretion and there would be a lot of stuff going by that the minus-30 structure would catch and reflect in the analysis that the other one wouldn't. That may be part of the scatter and I don't know what value that comment is in the history, but I think it has something to do with history where we have tried to say that historically at one place there is one rate of accretion and at another is another. I don't believe we've got a common denominator for comparison which would be the effective width of the littoral zone in which the accretion was effective.

OTHER COASTAL PLANS

As *remembered by* OMAR LILLEVANG

Beginning at Redondo in 1947, Southern California Edison Company developed its twin pipe cooling water supply concept, in which heated water is delivered to the sea through the twin that normally brings cold water from offshore to the plant's condensers. The infant marine organisms that attached to the cold water supply pipe walls thus were killed and flushed out to sea. Colonel Leeds was the company's consulting engineer for placing, design, construction techniques and for ongoing monitoring of subsequent performance. His services, with my staff support in office and field, encompassed the seven generating units at Redondo (where very comprehensive and interesting sand-accretion studies were carried on for several years), at El Segundo (two units) and at Los Angeles Department of Water and Power's Scattergood Station at Hyperion.

11 Coastal Research Projects

11 Coastal Research Projects

FIELD RESEARCH

As remembered by JAMES DUNHAM

In 1947, we wanted to get a record of the height of waves that were coming into the Surfside-Newport Beach area. We had the idea that we could put a float gauge at the seaward end of the Huntington Beach Pier, and we worked on this in conjunction with some people in the District's flood control section on hydrology who had been putting in rain gauges. So I figured that we could put a tube at the seaward end of the pier, leave it open at the bottom and put a follower float in it attached to a counter weight so it would go up and down with the waves. This could be recorded on an ordinary tide gauge recorder. Of course, at this time, we were having discussions on the beach erosion problems with Joe Johnson and other people up at Berkeley. They flagged us on this; they said, "Before you do anything let us do some model studies on this, because we think you may have some resonance problems with that tube." So they did, and the model study showed that they could get a resonance factor of 5 out of it and that it absolutely wouldn't work unless you had an almost open cage. Therefore, we designed a cage built of rebars with rings and let the float work up and down inside that. It actually did work, except it soon wore the float out. Also, there were a number of mechanical problems with it as well.

The step resistance gauge was being developed by the Beach Erosion Board at that time, and they recommended that we substitute that for this gauge we had been experimenting with. It had no mechanical problems and worked quite well.

In the meantime, we wanted to get a handle on wave direction, and came up with the idea of a fin swivelling from one end, which would work on the principle of the vane on a wind gauge. Knowing the principles of orbital motion, we figured that as a wave came in, we would have to hold this vane in the upper half of the wave, and then as the wave trough passed, it would be out of the water. This posed a problem, because with the tides going up and down we had to keep running the gauge up and down as we did this. It didn't take very many experiments to show that the vane was not behaving at all like we had hoped it would. The last flick of the wave as it passed would kick the vane in either direction, sometimes spin it around, and even by experimenting with moving it up and down in the wave column, at no place could we get it to give a true indication of wave direction. We could see the waves coming, and we knew which way they were traveling, but the gauge was not responding. We eventually had to give up entirely on that type of gauge. Then we tried a Rayleigh disk in place of the fin, but that didn't work either.

RESEARCH AND DEVELOPMENT

As remembered by KENNETH A. PEEL

Mr. D. E. Hughes was involved in research and development even back in the 1890s. I spoke of the concrete test blocks he placed on the San Pedro breakwater prior to 1912. He also was noted for his use of oranges as floats to study tidal currents in and out of San Diego Bay. They barely floated but were quite visible and made good tracers.

At another time, the Chief's office wrote out and asked for an article to be written on seich and surge. Hughes sent it back and said that, "Seich and surge has been studied by the Coast Guard quite extensively and I suggest that it be sent to - (he named a certain officer in the Coast Guard)." Now that was the second endorsement; 19 endorsements later it came back to us with the statement, "If any man in the United States can write this, it is D. E. Hughes." And he said, "well, I guess I've gotta do it."

The Los Angeles District started using the DUKWs, or amphibian trucks, in conjunction with the Beach Erosion Board in 1948, for beach studies and studies of sand movement. I think another one of the main research projects, which I know Dunham worked on somewhat, was working with wave heights and wave directions gauges in about 1947-48. We got two more DUKWs from the military as replacements for them when they wore out. I went out on one of those things with Bill Bascom of the University of California, up around Eureka. That was a hair raising experience....

They told me that they had one DUKW operator who got it up to his neck and got so scared of it one day, when they were starting out through the surf up there, that he just left the wheel and started to jump overboard. They said they had to forcibly restrain him, get him back in there to keep the DUKW from turning turtle. One of them did turn over in the surf down at San Diego.

With regard to participation in coastal engineering projects, these were mostly done by the civilian staff with one exception; Colonel Putnam made the report for the Port of Chicago and he was interested in navigation and had not so much interest in flood control. All the reports that I prepared while he was our District Engineer, regardless of whether they were beach erosion or navigation, were gone through by him with a fine tooth comb. He read every word in them.

SOUTHERN CALIFORNIA COASTAL RESEARCH

As remembered by WILLIAM J. HERRON

I will now turn to research in southern California. I think probably because of our nearby exposure to Scripps Institution of Oceanography, California Institute of Technology and the University of California at Berkeley, we in southern California have been more receptive to research and original thinking in coastal engineering than many parts of the United States.

The Corps of Engineers really first started getting involved in shore protection measures in about 1932, with the formation of the Beach Erosion Board in Washington, D. C. In the operating districts there was so little known about these processes that actually, until about 1948, the Los Angeles District was the only district writing its own reports. The general procedure was to use the districts and the local people to acquire data under the direction of the Beach Erosion Board and then the Beach Erosion Board itself would write these reports. They were peculiarly well suited for it because they had a few specialists on the staff who were able to keep up with the latest knowledge of shore processes and then the Board itself was unique in that it had three civilians on it, all outstanding men in the field of shore protection. They were able to generally do a good job in coming up with solutions and writing up the final recommendations.

The southern California area started in about 1938, cooperating with the Beach Erosion Board and they were able to develop men knowledgeable enough that they could write these reports essentially in the style the Beach Erosion Board wanted and then they were published under the Beach Erosion

Board's name. With the increased knowledge and trained people gained by World War II experience, the districts began writing their own reports in most cases, and the Beach Erosion Board then became more of a critique and review agency and did provide correct help when so requested.

Our people in the Los Angeles District, starting with Mr. D. E. Hughes in about 1890, seemed to always have somebody with an inquiring mind who was wondering about these shoreline processes, kept in touch and discussed these things. It is interesting to note that Mr. Hughes was the outstanding authority in the United States on seiching action back through the 1910-20 and even up to the 1930 times, even though his degree was not in engineering, but in mathematics. He was also the guiding light behind the layout of the Los Angeles-Long Beach Harbor and its breakwaters as we know them today, and he pioneered the effort to reduce cost and achieve a double benefit by using the sands and clays of the dredging of the anchorage areas to build up the base of the Los Angeles and Long Beach outer breakwater. He realized that the more severe wave action was in the upper areas and not in these 30- and 40-foot-depths the breakwater was based on. He achieved these concepts and got them approved without the real use of the dynamics of wave actions such as we do today. It was through trial and error and good reasoning that he was able to arrive at his conclusions.

After World War II, I joined the Beach Erosion Board for about 7 years and spent a couple of years in southern California with a Beach Erosion Board field party based in the Los Angeles District. We used their personnel and through discussions were able to maintain a high interest in the research aspect. A problem with most Corps of Engineers districts is that they are project oriented. While frequently the Beach Erosion Board and the Chief of Engineers have tried to delegate research activities to the districts, in many cases, this effort played second fiddle to projects and was not carried out in a really satisfactory manner.

Two of the interesting field research tests that we did in southern California were the attempts to acquire knowledge of wave direction in which several direction devices, including the Raleigh disk and the wave rudder were field tested and found not feasible and dropped. We also worked with the Beach Erosion Board, installed recording wave gauges which we were able to keep in reasonably good operational condition, when these did not previously exist. The staff gauge on the Huntington Beach Pier was maintained at almost continuous operation from 1948 to 1965, and, perhaps, still holds the record for the longest operating wave recording gauge in the world. This step resistance gauge started out with about a 27-foot steel pipe loaded with modified spark plugs and melted paraffin and ended up in 5-foot lightweight aluminum sections that could be assembled to cover any tidal range or wave range that was needed, and the recording equipment, of course, also went through some of this same maturing and is now the basis for the surface staff gauges used by the Beach Erosion Board now known as the Coastal Engineering Research Center.

When Jim Dunham had the Los Angeles District, Beach Erosion Control section, from 1946 to 1953, he did a great deal of work in the use of wave refraction diagrams and helped pioneer the understanding of how wave refraction works over offshore contouring and also how wave diffraction works around structures such as the offshore breakwater at Santa Monica.

In another effort, the Los Angeles District provided logistical support for an experimental groin station at the Point Mugu Naval Base which operated for several years and was used in the study of wave instrumentation and shoreline processes.

Another research area in which the Los Angeles District participated was the Coastal Engineering Research Center's experimentation with nuclear sand tracers. We provided much of the manpower and floating plant for that effort, which evolved from restricted tests at Vandenberg, working off the Military Base, to some final testing at Oceanside on the civilian harbor, which was accomplished with full publicity and by openly acknowledging the type of radioactive sand we were using and the safeguards entailed to make it harmless, not only to people, but to sea life also. It was unfortunate that this program was not continued as they were bringing the cost down to where it was approaching a feasible field operational activity.

The newest entry in this field or research is being conducted jointly by the Corps of Engineers and the State of California Boating and Water Waves Division, in which with the cooperation of the Scripps Institution of Oceanography, they have established for the first time a chain of wave recording gauges along the coast of California. They have approximately 12 of these in place now, some of which record wave direction as well as wave heights, periods, and energy. The intriguing part of this program is that within 30 days after the end of a reporting month, through the use of computers, they are able to publish all of this data in a usable form. Our problem before, with the paper tapes that had to be hand analyzed, was than it was far easier to collect the mass of field data than it was to get it tabulated, analyzed, and published for use by the practicing engineer.

These gauges still have the weaknesses of being directly usable only in their immediate vicinity, but they are establishing some offshore wave buoys, and as this program continues to expand, for the first time, we may have hopes of having something better to analyze wave action than the statistical wave study that Dr. Kent, Paul Horrer, and I developed in 1960. We were only able to fund a 3-year statistical base, but that is still the most reliable basis of wave analysis for design problems.

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