UNIVERSITY OF CALIFORNIA

INSTITUTE OF ENGINEERING RESEARCH

BERKELEY, CALIFORNIA

~~RESTRICTED~~

FINAL REPORT ON CONTRACT N7-onr-29519

AMPHIBIOUS OCEANOGRAPHY

by

R. L. Wiegel

and

Lt. D. A. Patrick, CEC, USN

SERIES NO. 29

ISSUE NO. 52

DATE September, 1951

[redacted]

University of California
Department of Engineering

Navy Department - Office of Naval Research Contract N7onr-29519
Naval Research Project 256-001

Institute of Engineering Research
Waves Investigation Laboratory
Technical Report
Series 29, Issue 52

Final Report On Contract N7onr-29519
Amphibious Oceanography

by

R. L. Wiegel [redacted] D. A. Patrick, CEC, USN

Berkeley, California
30 September 1951

[redacted]

[redacted]

UNCLASSIFIED

Amphibious Oceanography, NR 256-001
Technical Report No. 155-52
Final Report on Contract N7onr - 29519

Amphibious Oceanography
by
R. L. Wiegel and Lt. D. A. Patrick, CEC, USN.

INTRODUCTION

The objective of the Amphibious Oceanography Project (NR 256-001, Contract N7onr-29519) investigations was to evaluate the various immediate factors of beach and surf conditions as limiting the operation of amphibian vehicles and amphibious craft and extending the evaluation of these factors to ascertain the important oceanographic, geomorphic and meteorological features which give rise to beach forms and surf conditions of concern to amphibious operations.

Specifically, the principle missions of the project were:

(i) Produce information that would be of value during the movement to the objective area and the landing and assault phases of an amphibious operation.

(ii) Develop techniques for forecasting waves and surf of concern to landing operations.

(iii) Produce information which would aid in the training of operating personnel of amphibian vehicles and amphibious craft.

(iv) Produce information that would advance the safety of personnel engaged in amphibious training exercises by establishing conditional limitations within which amphibious landing craft and amphibian vehicles may safely operate.

The technical reports in which the information obtained in fulfillment of these missions are listed in this report together with an abstract of each report.

RECOMMENDATIONS

Training

1. It is felt that all surf casualties during training and combat operations should be examined so that a file may be assembled listing all the accidents together with the causes of such accidents.

2. All future training (and combat operations, if feasible), should be covered to obtain the statistical data necessary for a thorough understanding of the problem.

3. Permanent forecasting and wave recording sections should be made an integral part of any amphibious training command.

UNCLASSIFIED [redacted]

4. A practical means should be developed for using wave recorders by Boat Control Officers or Beachmasters to send craft through the surf while low breakers are present.

5. Training of crews should be performed on a wide variety of beaches under a variety of surf conditions.

Wave Climate

1. Data necessary for the development of a "wave climate" for all training areas should be accumulated.

2. These same data should be accumulated over a period of years by Intelligence for any area where there is a possibility of the need for combat amphibious landings.

Craft Characteristics

1. Use should be made of model studies for the prediction of surf characteristics of any proposed amphibious craft for amphibian vehicle. It is possible with the existing wave channels to perform many tests of this nature as well as to test modifications of either existing or proposed craft.

2. It would be extremely desirable to build a larger wave channel so that tests of craft motion in three dimensions could be made. This same channel could also be used to extend the range of breaker studies.

3. Tests should be made of craft motion in non-uniform wave trains.

4. Extensive tests, similar to those for the LVTs, should be made on LCMs, LCVPs, etc.

5. The most serious flaw in the present type of craft motion theory appears to be the assumption that the craft does not perturb the water motion. Certain quantities called the virtual mass and moment of inertia are grafted onto the simplest theory from values determined experimentally in "still water". It is scarcely necessary to point out that there is only one boundary value problem here, namely that of a rigid body floating on a free water surface. An adequate theory should be able to predict the complete oscillations of the body with no undetermined parameters. The values of virtual mass, damping coefficient, position of the roll axis, character of the waves generated by the body, etc. should be important by-products of this calculation.

Perhaps the greatest uncertainties in the present theory are the values of virtual mass and damping coefficients in waves, particularly for second harmonic terms.

Pioneering attempts to treat the motion of a floating body have been made by two mathematicians, John(1) and Ursell(2). A general analysis is made by John but because of the difficulty of solution of the general problem explicit calculations are carried out only for long flat bodies in shallow water. Ursell(2) has treated the rolling motion of a cylinder

(1) John, Frits - " On the Motion of Floating Bodies, I, II. - communications on Pure and Applied Mathematics, II (1), 13-58; 1949, III (1), 45; 1950.
(2) Ursell, F. - "On the Rolling Motion of Cylinders in the Surface of Fluid"- Quarterly Journal of Mechanics and Applied Mathematics, Vol. II, p.335, 1949.

with a horizontal axis in deep water. The continuation and extension of these theories is the direction further theoretical research should take. Extensions of the theories to include the effect of viscous and eddy resistance, cylinder length, arbitrary finite depth are certainly desirable.

The classical theory may be followed in determining the motion of a craft moving past a solitary wave and a wave of translation. The results would presumably be of value in evaluating the performance of craft up to and through the surf zone. A further extension of the classical theory should be undertaken for the motion of a craft on short-crested waves, particularly in deep water. The properties of such waves have recently been investigated(3). It is well known that the wave situation most commonly encountered by deep-water ships is the wind-waves which are definitely short-crested. The presently available classical theory is only a rough approximation to actual ocean conditions.

John(1) has treated the reflection of shallow water waves by long flat bodies. For freely floating bodies he shows that the reflection coefficient is of the order of $(d/L)^5$ where D is the diameter of the body; for rigid obstacles at the surface the reflection coefficient is of the order of D/L. Thus, in our case of a freely floating body, the effect of the craft on the wave is negligible. When the craft is in motion, however, this interaction probably more nearly resembles that of a rigid obstacle and the effect cannot be overlooked. The exact motion should be investigated along the lines of John's theory for a craft in motion.

Trafficability

1. Extensive basic research should be undertaken on the physics of granular inorganic inter-tidal materials.

2. Development of equipment for use by Intelligence Sections for the purpose of evaluating natural beaches should be performed.

3. Studies of the stabilization of inter-tidal materials should be made.

4. Studies of the buoyancy of deep inter-tidal muds should be made.

5. Studies should be made on the determination of inter-tidal mud types from aerial photographs.

Surf Forecasting

1. The results of the present studies indicate that a new basic mathematical theory of the formation of waves by winds should be developed.

2. The mechanisms by which waves decrease in height after leaving the fetch area should be investigated. At the same time mathematical studies are needed on the increase of wave period in the decay area.

3. The mechanisms by which the short length crests become long should be studied.

(3) (University of California, Institute of Engineering Research, Technical Report, Series 3, Issue 326).

4. The effect of beach slope of breaker characteristics should be continued. Studies in long wave channels should be made. Especially the study of the wave transformation over shoaling beaches of varying slope should be made. Comprehensive field studies of this phenomena should be made.

5. Emphasis should be placed on the study of forecasting waves from tropical storms.

Intelligence

1. Telemetering wave recorders should be developed for use by Intelligence.

2. Equipment of surveying in the surf zone by Underwater Demolition Teams should be developed.

3. Model refraction studies should be made to determine the limits of the present methods and to develop new methods for special cases.

Landing Sites

1. Long range studies of the way that a beach profile changes should be made.

2. Complete intelligence data should be obtained and properly evaluated for any section of the world where future combat amphibious landings might be conducted.

3. More comprehensive studies of ground water in the beach head section are needed.

Statistical Studies

1. Statistical studies of actual breaker measurements are needed.

2. Detailed statistical studies of all types of amphibious craft shcuid be made.

3. Statistical studies of supply tonnage moved across a beach-head versus landing or ship type should be made.

Equipment

1. Development of a telemetering wave recorder.

2. Development of a wave direction recorder.

3. Development of a current recorder.

4. Development of an electronic instrument to automatically transform the bottom pressures recorded by the present wave recorders to the actual surface record. This would allow an observer to read the actual surface wave height directly on the recorder chart.

Miscellaneous

1. The most necessary piece of equipment needed in a long range program of wave and surf investigations is a relatively large wave channel.

2. The primary cause of LCM and LCVP surf casualities is broaching. Methods of making these craft to be semi-amphibian should be devised and tested. If some mechanism could be developed to permit these craft to always travel a few feet shoreward of the breaker uprush, casualties could be reduced to a minimum.

3. "Operational research" studies should be made to determine if the use of small landing craft is justifiable except in special circumstances. Landing ships can carry much more tonnage and are affected only by very large breakers while amphibian vehicles are more versatile for use over reefs, bars and steep beaches.

LIST OF TECHNICAL REPORTS ISSUED

The following reports were issued as Series 29 of the Institute of Engineering Research, University of California.

1. "Landing Craft Test Operations: Santa Margarita River Beach, Oceanside, California" - by R. L. Wiegel, 18 April 1949.

   The initial beach survey, sand analyses, camera tower locations and proposed camera coverage for the amphibian tractor surf tests are presented in this report.

2. "Installation of the Thermopile Wave Meter at Santa Margarita River Beach, Camp Del Mar, Oceanside, California" - by R. L. Wiegel, 18 April 1949.

   This report covers the temporary installation of the Thermopile Wave Meter (the "MarkV") on 7 March 1949 and its operation until 22 March 1949 when it became inoperable due to a cable break. It also covers the installation and operation of the Mark V which was permanently installed on 4 May 1949.

3. "Characteristics of Kalsin Bay Beach, Kodiak Island, Alaska on 12 February 1949" - by R. L. Wiegel, 24 May 1949.

   The beach profile, beach material analyses and vehicle bearing data are presented for this arctic beach. The data presented were obtained by the 105th Naval Construction Battalion during the maneuvers of January and February 1949.

4. "Wave Refraction at Santa Margarita River Beach, Camp Pendleton, Oceanside, California" - by LTJG D. A. Patrick, CEC, USN, 6 July 1949.

   The results of the refraction studies made for this area by Patrick are presented. Data for waves of 6, 9, 12, 15, 18 and 21 seconds are presented for waves arriving from the major compass points.

5. "Description of Beaches to be Used for Amphibian Vehicle Tests" - by W. N. Bascom, June 1949.

This report consists of sixty pages of aerial photographs, land photographs, beach profiles and descriptions of fifteen beaches between the Mexican Border and the Canadian Border which would fill the requirements for the field tests of the projects test amphibian vehicles. The photographs and profiles were obtained from the University of California Waves Investigation Laboratory files. The information includes harbor facilities for an LST, air base facilities, accessibility, land ownership, distances from repair facilities, etc.

6. "Specifications for the Oceanographic Coverage of an Amphibious Operation" - by R. L. Wiegel, 1 August 1949.

Types of oceanographic information to be obtained from an amphibious rehearsal are listed in this report together with the personnel and equipment necessary to obtain this information.

7. "Proposed Procedures and Results for the Surf Tests of Amphibious Craft" - by R. L. Wiegel, 1 August 1949.

This covers the procedures developed for testing craft at Camp Pendleton and in the field as well as discussing the type of results that are to be expected.

8. "Wave, Surf and Beach Intelligence for Amphibious Operations" - by M. P. O'Brien, W. N. Bascom and J. W. Johnson, 9 September 1949.

This report outlines the oceanographic intelligence information necessary for planning an amphibious operation, together with available methods of obtaining this information.

9. "Statistical Study of Operation MIKI and its Rehearsal at Aliso Canyon" - by R. L. Wiegel, 19 September 1949.

An outline of the information which was to be obtained from operation MIKI and its rehearsal is presented together with a list of the personnel and equipment necessary to carry out the assignment.

10. "Progress Report: The Wave Velocity Method of Depth Determination by Aerial Photographs" - by J. W. Johnson, 7 October 1949.

The report presents a procedure for analyzing aerial photographs for depth determination by the wave-velocity method. An attempt is made to determine the accuracy of this method by the statistical approach. This latter analysis, however, is not conclusive in view of the fact that profiles by soundings were not available for the same days on which the aerial photographs were obtained. Although the statistical analysis indicates that relatively large errors in depths at individual points are possible, the beach slopes as obtained from the aerial photos and by soundings appear to fall reasonably well within certain general classifications. The procedure for applying the wave-velocity method for depth determination and the statistical analysis for evaluating its accuracy are recommended as a working procedure in any investigation designed to test rigorously the reliability of this method of bottom surveying.

11. "Camp Pendleton Sea Sled" - by J. W. Johnson, 12 October 1949.

A sea sled is a device, propelled by wave action, for traversing a sandy - bottomed surf zone. This device is moved along the ocean bed through the surf zone by the oscillating motion of the water due to wave action. This report includes the manufacturing drawings of the sea sled, together with a summary and photographs of its operation.

12. "Proposed Wave Recorder at Guadalupe Island, Mexico" - by J. W. Johnson, 14 October 1949.

During the summer months, and possibly at times during the other seasons, the surf at Coronado and Oceanside, California, is dominated by swells originating in the southern hemisphere - in an area for which barometric pressures and winds are not reported. Consequently, the arrival time and characteristics of these swells cannot be forecast by the usual forecasting techniques. Warning of the arrival of an increase in swell intensity and an empirical forecast of their duration would be provided by placing a wave recorder at the weather station on Guadalupe Island, Mexico and by arranging for the interpretation of the record and the transmission of these data with the weather data reported at six hour intervals. The distance from Guadalupe Island to the San Diego area is such that approximately eight hours would be required for the waves to travel to this area from the recorder. This length of time should provide ample warning to permit a change in planning of amphibious training operations and other work that might be affected by high waves. This report discusses the type and location of the recorder, method of reporting, and the approximate cost to install and maintain the unit.

13. "Operation MIKI, Rehearsal at Oceanside (LEX-4), California on 9 October 1949; Ground Coverage" - by LTJG D. A. Patrick, CEC, USN, 15 February 1950.

This report covers the rehearsal landings of Operation MIKI (LEX-4) which took place on the Camp Pendleton beaches at Oceanside California on 9 October 1949, Emphasis is on the "industrial engineering" type of coverage. Special attention is given to the causes of the broaching of craft and the effect of type and intensity of surf on the efficiency of the landings.

14. "Operation MIKI, Hawaiian Amphibious Phase: Ground Coverage" - by R. L. Wiegel and Lt. H. L. Kimberley, USN, 25 October 1949.

In order to obtain statistical information on the effect of various beach and surf conditions on landing craft personnel from this Project (Office of Naval Research, NR 257-201) attended operation MIKI, an amphibious assault on the west coast of Oahu, T. H. The beaches upon which the landings took place were studied both before and after the operation. Meteorological and surf conditions also were studied. Emphasis in this report is given to the "industrial engineering" type of coverage. Special attention was given to the causes of the broaching of craft and the effect of the type and intensity of surf on the efficiency of the landings. The effect of the beaches on vehicle trafficability is also discussed.

15. "Operation MIKI, Hawaiian Amphibious Phase: Aerial Coverage" - by W. N. Bascom, 25 October 1949.

The evaluation of the success of a complicated and extensive amphibious operation is a difficult job. In operation MIKI, three beaches were involved at Oahu and a large scale practice maneuver of similar dimensions was conducted at Camp Pendleton, Oceanside, California. The problem of keeping track of exactly what happened at what time seems to have been partly solved by the method presented in this report. This report includes the following information:

(i) Method of making an aerial photo record.

(ii) Suggestions for evaluation - from the photos.

(iii) Conclusions and criticisms.

16. "Southern Swell Observed at Oceanside California from May through September, 1949" - by R. L. Wiegel and Lt. H. L. Kimberley, USN, 13 December 1949.

A wave recorder was in operation at Camp Pendleton Oceanside, California during the period from 4 May 1951 until 15 January 1950. Due to its fortunate location in relation to the Western Hemisphere's hydrography, it recorded southerly swell almost continuously throughout the summer of 1949. The origins of these swells appear to lie in the area between 40° and 65° south latitude and between 120° and 160° west longitude.

Swell from the south through south west was found to run almost continuously from May through September, and to dominate the surf zone for that period. Twenty to thirty minute averages (taken three times daily) of the "significant" breaker heights ranged from two to six feet with most breakers being between two and four feet. The highest breakers occurring during the measured intervals were usually between four and eight feet, with heights of ten to twelve feet observed on occasions. The average wave period of the southern swell ranged from twelve to eighteen seconds with short-time averages of predominant groups as great as twenty-two seconds.

This report includes the daily records of periods significant breaker heights, maximum breaker heights, direction from which the swell came and littoral current observations for the five summer months.

17. "Portable Mark V Wave Recorder" - by LTJG D. A. Patrick CEC, USN, and R. L. Wiegel, 10 January 1950.

This report presents the manufacturing drawings of the special equipment that was necessary, together with a brief summary of the experiments and a sample record.

18. "Breaker Height Measuring Devices" - by LTJG D. A. Patrick CEC, USN and R. L. Wiegel, 6 March 1950.

One of the most important factors that determine whether an amphibian vehicle or a landing craft can successfully traverse the surf zone is the height of individual breakers. Several methods of directly measuring breakers were attempted by this Project. One, the use of a Thermopile Wave Meter (the "Mark V") was covered in a previous report (Series 29, Issue 17). It was found to be inadequate for directly measuring breaker heights although very useful in measuring wave heights when installed in deeper water.

Three other methods, a large Breaker Height Pole, a series of pipes jetted into the sand at intervals through the surf zone, and a stadia pole mounted on a sea sled (surf stadia sled) are described and discussed in this report.

19. "The Thermopile Wave Recorder (Mark V), Its Calibration and Record Analysis" - by R. L. Wiegel, 7 March 1950.

A Thermopile Wave Meter (Mark V) consists of a synthetic rubber bellows mounted on a plastic base with an encased thermopile. The hot junctions of the thermopile are in contact with the air chamber in the bellows while the cold juntions are in thermal contact with the surrounding sea water. The plastic base, in turn, is attached to a brass cable connection. This entire unit (the "pressure head") is connected by a submarine cable to a commercial self-balancing potentiometer type recorder located on shore.

This report covers the calibration of the instrument and the method of analyzing the records.

20. "Tests of Landing Craft at Monterey Bay, California" - by W. N. Bascom, April 1950.

The results of field tests of LCMs, LCVPs and an LSU are covered in this report. Limiting breaker heights, for the plunging type on a steep beach, were found for the LCM and the LCVP. Effects of bars and surf rip currents are discussed in detail.

21. "Methods for Surveying and Plotting Beach Profiles" - by LTJG D. A. Patrick, CEC, USN and W. N. Bascom, 5 May 1950.

The quickest and most convenient method for getting information to plot beach profiles, consistent with necessary accuracy, is one of the requirements in amphibious oceanographic studies. This report presents the methods now used for these surveys. The information is discussed in two categories, field work and office work, inasmuch as certain conditions may vary the priority of these two factors.

22. "Field Studies in Amphibious Oceanography - I" - by R. L. Wiegel 16 May 1950.

The primary missions of this project were threefold. One was to study the operations of landing craft and amphibian vehicles in the surf and on the beaches, together with the factors that effect these operations. The second was to determine improved methods and suggest improved equipment for amphibious operations. The third was to develop means for determining in advance conditions to be expected on given enemy - held beaches and how to choose beaches and times for improved landings from an oceanographic standpoint within set tactical limits.

This report covers the procedures by which the staff of this Project attempted to fulfill its missions during the field tests. Illustrations of the data obtained together with the analyses which were made are presented.

23. "Operations at Monterey Bay, California" - by M. P. O'Brien and R. L. Wiegel, 1 June 1950.

The operations performed while at Monterey are covered in this report. Surf testing of the amphibian vehicles, tests of aerial photography in regard to the wave velocity method of depth determination, maintenance problems, wave forecasting results, and trafficability studies are discussed in detail.

24. "Underwater Demolition Team at Monterey" - by W. N. Bascom, 10 May 1950.

An outline of the information obtained by U.D.T. #1 at various beaches along Monterey Bay, California, area are compared with that obtained by members of this Project. A discussion of the methods, reliability and types of information needed is included. The main conclusions were:

(i) Underwater Demolition Teams need training under a great variety of surf conditions

(ii) The limit of wave backrush is a better datum for soundings than is the limit of uprush.

25. "Surf Conditions and Beach Profile Records for Santa Margarita River Beach, Oceanside, California for 1949" - by R. L. Wiegel, LTJG D. A. Patrick, CEC, USN, and Lt. H. L. Kimberley, USN, May 1950.

All the data on beach profiles, wave forecasts and actual wave records that were obtained by this Project during its stay at Camp Pendleton are presented. A discussion of the various beach changes is included.

26. "Pitch and Yaw Recorders for LVTs" - by F. E. Snodgrass, June 1951.

Equipment to record the pitch, yaw and roll of an LVT was designed to study the surf characteristics of this amphibian. The LVTs were tested at Oceanside, California, Monterey, California and Clatsop Spit, Oregon. Reasonable accuracy and satisfactory operation were obtained using this equipment in regard to design considerations test and calibration results, and the records obtained.

27. "Recording Waves in Shallow Water at Sea" - by W. N. Bascom, 17 May 1950.

The amphibious forces have long been in need of a wave recorder which can be rapidly installed under combat conditions and used to direct the movements of craft in the surf zone. Such a device operating on a control craft would greatly reduce surf casualties. This report discusses the installation and operation of such a portable wave recorder (the Mark V) by an Underwater Demolition Team (No. 1) under simulated combat conditions. A discussion of its possible future use is included.

28. "A Study of Two Local Storms and Their Effect on Wave and Beach Conditions at Camp Pendleton, Oceanside, California" - by R. L. Wiegel, D. K. Todd and Lt. H. L. Kimberley, USN, 9 August 1950.

Usually the large waves which break on the beaches of southern California come from storms hundreds or even thousands of miles away. However, on occasions local winds create waves of dimensions large enough to cause serious damage, both to beaches and to landing operations. These waves are of short period, often arriving at large angles to the beach with the result that they rapidly cut the beach back and form a scarp in the process. The breakers build up from a safe height to a dangerous height (from a landing standpoint) in a very short time. The causes and effect of two such storms are discussed in this report.

29. "Know Your Surf" - by J. W. Johnson and R. L. Wiegel, 1 September 1950.

This report is a simple pictorial presentation of information on the cause and effect of surf that should be understood by amphibious craft and amphibian vehicle operators. Methods of performing surf operations more safely are presented.

30. "Trafficability Studies of Selected Beaches On the Pacific Coast of the United States and Oahu, T. H." - by R. L. Wiegel, 15 September 1950.

One of the most important factors in an amphibious operation is that of getting vehicles from the landing ship or craft across the beach and onto hard terrain. As little work had been done on this problem of beach trafficability one of the primary objectives of this Project was to develop some means of correlating information that could be obtained by intelligence units with the trafficability of beaches. The findings presented in this report cover a representative selection of the beaches along the Pacific Coast of the United States, and Oahu, T. H. It was found that from an operational standpoint the trafficability of a beach is primarily related to the steepness of the beach face and to the moisture content of the sand. The flatter the beach face of sand beaches the better is the trafficability, and also the greater the moisture content the better is the trafficability.

Correlations between beach slope, moisture content and trafficability of representative beaches are presented in this report. A table has been included which shows the likelihood of being able to operate any or all of several types of military vehicles on beaches of various slopes. Photographs of vehicles operating on the beaches, photomicrographs and sieve analyses of beach sands, aerial photographs and surveyed profiles are also presented.

31. "Preliminary Report on Stabilization of Inter-tidal Materials" - by Milos Polivka and W. N. Bascom, 13 September 1950.

In amphibious warfare, a major problem is the movement of vehicles and equipment from the craft which bring them ashore to the local road system. Very few locations allow vehicles to traverse this critical area unassisted. The width of this zone depends upon the nature and grain size of the materials and the slope of the beach. Materials of the inter-tidal zone include mud, fine and coarse sand, pebbles and cobbles. Generally, the muds and coarse sands are the most difficult to traverse. The slope of the beach is related to the particle size in such a manner that fine grained muds have a very flat slope and the coarse sands a very steep slope. Moreover, the location of this troublesome area may change with the tide.

It is necessary to develop for use during the early phases of amphibious operations a cheap and easy to use means of stabilizing beaches. Results of a limited series of tests performed at the University of California on several mixtures are discussed in this report.

32. "Operations at Clatsop Spit, Oregon" - by R. L. Wiegel, 7 September 1950.

The primary mission of this Project while at Clatsop Spit Oregon was to discover the effect of a very flat beach on the surf and on the behavior of the amphibian vehicles. At the same time information was gained on (i) the trafficability of the beach, (ii) accuracy of surf and weather forecasts, (III) the efficiency and accuracy of aerial intelligence in regard to the oceanographic factors affecting amphibious landings, and (iv) fresh water table information for this type of beach.

This report presents and discusses all the information obtained on these subjects.

33. "Application of Breaker Height Distribution to Amphibian Tractor Landing Problems" - by R. R. Putz and R. L. Wiegel, September 1951.

Several related examples are supplied as possible concrete applications of the predicted breaker height distribution function. These examples provide an opportunity to evaluate the significance of an error of a given magnitude in the predicted distribution function.

With this purpose in view, hypothetical models for predicting variables associated with amphibian tractor (landing) operations are applied to simple problems. Two of these problems consider the determination of the random number of amphibian tractors involved in an operation in the cases where (i) each amphibian tractor encounters one breaker and where (ii) each tractor encounters more than one breaker. Numerical examples are considered for each situation, parameters of the theoretical distribution of the number of amphibian tractors being obtained from prepared curves. A method of obtaining approximate probability limits at various probability levels is illustrated. Examples are given of the magnitude of the errors in probability limit determination due to errors in the probability of a safe wave and due to errors in the mean wave height forecast. Tentative conclusions about the required accuracy in wave forecasting are considered. The landing craft operation models employed are discussed in regard to present adequacy as well as possible refinements and extensions.

34. "Remote Control Equipment for Amphibian Tractors" - by F. E. Snodgrass, September 1950.

This report covers the installation, testing and modification of remote control equipment to amphibian tractors as used by this Project during field tests.

35. "Ground Water Adjacent to Four Pacific Ocean Beaches" - by LTJG D. A. Patrick, CEC, USN, 21 September 1950.

Potable water is essential to all military operations. It is especially important to amphibious operations where logistical support phases are critical because materials must usually be handled several times, often manually or with primitive equipment, and often under adverse conditions of weather, sea and the enemy. Cooling water for machinery is an important secondary requirement for modern military forces and the upper allowable salinity limits are about the same as for potable water.

The data presented in this report are relatively meager and inconclusive in themselves and are presented primarily to emphasize the proximity of potable water to the beach as well as to corroborate and augment the data of other agencies.

36. "A Comparison of Beach Elevations at Limit of Backrush and Uprush with USC&GS Tide Prediction on Several Pacific Ocean Beaches" - by LTJG D. A. Patrick, CEC, USN, 5 October 1950.

The findings discussed in this report, which are based on some two hundred field readings of elevations of limits of backrush and uprush, show no crucial direct relationship between those readings and the USC&GS tide predictions. The beach slope between the uprush and backrush does not appear to be significant with respect to the above relationships. A limited statistical analysis indicates that the limit of backrush is a better index to predicted tide stage than limit of uprush, and is generally somewhat below predicted tide stage.

37. "Rubber Boat Surf Casualties" - by R. L. Wiegel, 18 October 1950.

This report discusses observations made during the rubber boat crew training period (1950) at Camp Pendleton, Oceanside, California.

The relative effect of approaches and retractions are discussed, as well as several possible means of decreasing the casualties.

38. "Beach Slope Effect on Breakers and Surf Forecasting" - by H. W. Iversen, R. C. Crooke, M. J. Larocco and R. L. Wiegel, 7 December 1950.

Determination of breaker heights and depths at breaking on a beach from known deep water waves which approach the beach are detailed in Hydrographic Office Publication No. 234, "Breakers and Surf, Principles in Forecasting". The numerical evaluation of breaker heights and depths are based upon observations which are reported in that publication.

Recent studies and observations in the laboratory and in the field indicate that the breaker heights and depths at breaking are a function of the beach slope as well as the initial wave steepness and refraction pattern.

This report presents a modification of H.O. No. 234 to include the effect of beach slope on the prediction of breaker heights and depths at breaking. These are based upon the results of a laboratory study at the University of California. Details of the program and the formulation of the results are contained in the Appendix.

39. "Comparisons of Wave Forecasts" - by C. L. Bretschneider, D. K. Todd and Lt. H. L. Kimberley, USN December 1950.

Three forecasters (the authors) made wave forecasts for the same period and from the same set of weather maps. Comparisons of wave heights and periods were made between forecasts of the different forecasters. It was found that one forecaster was considerably higher in his heights than either of the other two forecasters. In general, the disagreement between forecasters was relatively large for both the height and period comparisons. The discrepancies were due to each forecasters interpretation of the meteorological elements used in wave forecasting. A number of tables of errors that might be expected from the interpretation of the meteorological elements have been prepared. From these tables it is seen that unless the forecasters agree in the interpretation of the meteorological elements large errors in the wave forecasts can be expected.

From three different sets of weather maps for the same period one forecaster made separate forecasts. The comparisons of wave heights and periods here also were in large disagreement. The discrepancies were due to the analysis of the synoptic situation and the drawing of the isobaric pattern, and also to the method of application of the wave forecasting theory. The method of application of the principles in wave forecasting does not hold for all types of weather maps of different time intervals, and this introduces large discrepancies in the wave forecasts, even though the forecaster may be consistant in the interpretation of the meteorological elements.

40. "A Practical Manual for Wave Forecasting" - by Kenneth Kaplan, September 1951.

In recent years the need for making forecasts and hindcasts of waves generated by winds has become increasingly apparent. Accurate wave forecasting can determine beforehand the success or failure of many amphibious operations. Hindcasting will find ever widening use in releasing for statistical analysis the great wealth of wave data available on long compiled weather charts. Both the growth of the applicable theories of forecasting and the assimilation into these theories of recorded and empirical wave data has been most rapid. However, the development of the mechanical procedures of forecasting has been left behind. The simple wind wave developing weather situations were easily analyzed by the elementary procedures derived directly from the basic theories. The analysis of the more common, complex situations was difficult and laborious. For every different wind pattern particular practical applications of forecasting theory had to be developed.

On examination, it has been found that since these ever changing weather situations lend themselves to being categorized according to easily measured or calculated parameters; and that for each of these categories forecasts with elementary techniques are possible. Therefore in the interest of standardizing and simplifying wave forecasting procedures, and of making possible accurate wave forecasts by those with only a cursory knowledge of meteorological and wind wave theories, this manual for forecasting has been developed. The methods of making synoptic chart measurements are presented only as "rules of thumb".

This report is divided into four parts: the first is a short summary of the present knowledge of the growth and decay of wind waves, and is included primarily for its definitions of terms and symbols; the second is a presentation of the proposed means of almost mechanical forecasting; and the third is a section devoted to the justification of the procedures outlined in the second part. The last section is the complete analysis and forecast of a severe storm which occurred off the coast of northern California.

41. "Comparison Between Wave Forecasts and Observed Waves" - C. L. Bretschneider, February 1951.

Forecasted and observed waves for the same periods and places as discussed in a previous report (Series 29, Issue 39) were studied. Short period waves were forecast too low in period and too high in height. Long period waves were forecast too high in period and too low in height. A method is described in which the forecasts made using the data in H.O. 234 can be adjusted to allow for the above errors.

NOTE: If the forecasting curves presented in report 47, Series 29, are used these corrections are not needed.

42. "West Bay Beaches, Grand Cayman, BWI" - by E. B. Doran and R. L. Wiegel, January 1951.

This report presents information which became available on a typical island in the Caribbean.

43. "A Study of the Pitching Action of a Model LVT(3)(C)" - by H. W. Iversen, R. C. Crooke, and M. J. Larocco, 22 January 1951.

An initial investigation of a model study of the pitching of an LVT in the breaker zone was reported in Technical Report No. 4, Series 30, ONR contract N7onr-29517. For the limited range of investigated conditions the model pitch motion corresponded to prototype motion as obtained from field data. In order to substantiate this preliminary work and to extend the ranges of investigated variables farther work was performed on model LVT tests for pitching motion in the breaker zone. This report contains the results of these investigations together with comparisons with field data on prototype LVT performance.

A 1:22½ self-propelled model motion was studied in six different breakers on a beach slope of 1:15. The breakers corresponded to a range of prototype heights from 4 ½ to 8 ½ feet, and the periods ranging from 9 to 14½ seconds. In all cases the model and prototype maximum pitch angles corresponded within three degrees. Pitch-time histories showed, in general, higher pitch and recovery rates from the model results as compared to the prototype. The present results checked the initial investigation results (Report 4, Series 30) which were made on a 1:25 model.

For the craft in two of the breakers, 8½ feet and 14½ seconds and 7 feet and 9 seconds, the craft was operated over a prototype speed range of 3.1 to 4.75 miles per hour. Differences in maximum pitch angles in the higher wave amounted to approximately 20% with no consistent trend as a function of speed.

A modification of the model was made in an effort to decrease the pitching motion. A flat rigid plate extension was attached to the bottom of the model which extended horizontally 0.465 feet (10.5 feet on prototype) beyond the point of attachment. In the two waves, for which the variable speed data were obtained this flat plate extension resulted in maximum pitch angles of approximately one-half the magnitude of those of the original craft.

44. "Qualitative Report On Surf Operations of Landing Vehicles, Tracked" - by LTJG D. A. Patrick, CEC, USN and R. L. Wiegel, February 1951.

Several hundred trips through the surf were made in Landing Vehicles, Tracked (the "amtrack") on various beaches along the Pacific Coast of the United States by personnel of the U. S. Marine Corps who were assigned to this Project. As a result of these tests, as well as model studies simulating field conditions, certain relationships between the breaker dimensions, beach and bottom configurations, craft position and craft action have been discovered. This report presents discussions of these relationships and presents some operating instructions which, if used, should lessen the hazard of surf operations. A background discussion of oceanographic phenomena has been included to provide coherence and insure understanding.

45 "Summary Report of Amphibious Oceanographic Studies for the Period 1 January 1949 to 30 December 1950" - by, Staff of Naval Research Project 256-001.

The objective of the Amphibious Oceanography Project investigation was to evaluate the various immediate factors of beach and surf conditions as limiting the operation of amphibian vehicles and amphibious craft and extending the evaluation of these factors to ascertain the important oceanographic, geomorphic and meteorological features which give rise to beach forms and surf conditions of concern to amphibious operations.

Specifically, the principle missions of the project were:

(i) Produce information that would be of value during the movement to the objective area and the landing and assault phases of an amphibious operation.

(ii) Develop techniques for forecasting waves and surf of concern to landing operations.

(iii) Produce information which would aid in the training of operating personnel of landing craft and amphibian vehicles.

(iv) Produce information that would advance the safety of personnel engaged in amphibious training exercises by establishing conditional limitations within which amphibious landing craft and amphibian vehicles may operate safely.

It is the purpose of this summary report to discuss the findings in regard to the above mentioned objectives as well as other factors contributing to the oceanographic phases of such operations.

46. "The Generation and Decay of Wind Waves in Deep Water" - by C. L. Bretschneider, 27 August 1951.

Data on the generation and decay of wind generated waves gravity waves have been collected for several years by the University of California. This paper presents the analysis and incorporation of these data, and also the original data presented in Hydrographic Office (U. S. Navy) Publication No. 601. These data are analyzed and the results presented in dimensionless graphs suitable for use in wave forecasting.

The dimensionless parameters presented by Sverdrup and Munk in H.O. Publication No. 601 (C/U, tU/F, gH/U^2 and gF/U^2) are suitable for the generation of waves; however, new curves were constructed to include the new data.

In order that the data on the decay of waves could be presented in a logical manner a concept based upon the following observations, was introduced:

(i) Individual waves do not maintain their identity in deep water.

(ii) A spectrum of lengths and heights is present in both the fetch and decay areas.

(iii) At any particular decay distance the significant period decreases with time.

(iv) The significant period increases with decay distance in a manner different than that assumed by Sverdrup and Munk for their decay relationships.

(v) Travel time depends upon the group velocity associated with the period at the end of the decay distance.

It was found that the wave height and period at the end of the decay distance depend upon the length of the fetch and the height and period at the end of the fetch, as well as upon the decay distance.

47. "Revised Wave Forecasting Curves and Procedure" - by C. L. Bretschneider, September 1951.

Data on the generation and decay of wind generated water gravity waves have been collected for several years by the University of California. The presentation of these data, in dimensionless form were printed in Technical Report 46, Series 29. In order to present these data in a manner readibly usable by aerologists "forecasting graphs" were prepared for this report.

Section I deals with the growth and decay of wind waves in a qualitative manner (the theoretical aspects having been discussed Technical Report 46, Series 29. It is believed that the illustrations presented here in non-technical form, show clearly the physical reasoning involved in the growth and decay of wind waves.

Section II describes the practical applications of the theory for making reliable forecasts of wind waves and swell. Included are the theory and procedures used to determine from weather maps the forecasting variables, wind velocity, wind duration, fetch, decay distance, etc.

A step by step example of a wave forecast is presented in the appendix. The problems involved in this particular forecast underline the importance of judgment and experience in measuring the several variables required.

48. "Beach Profile Determination from Timed Vertical Aerial Photographs" - by R. C. Crooke, R. L. Wiegel, Captain O. J. Koestor, USMC, and 1/Sgt. G. E. Thomas, USMC., June 1951.

Many accurately timed vertical aerial photographs were analyzed for the purpose of determining profiles through the surf zone by the wave velocity method of depth determination. As a result of these studies and review of other reports on the subject it has been concluded that depths cannot be determined accurately by this method. The inadequacy of the simplified theory (based upon a train of regular waves) is probably more responsible for the inaccurate results rather than errors due to the mechanics of analysis. Depths determined seaward of the outermost breakers were in greatest error while depths in shallow water (determined from the foam lines) were in least error. The method does give offshore average gradients which are probably of acceptable accuracy.

In addition to the depth determination, limited studies were made to determine beach face slopes by the water line method. The slopes so determined were in good agreement with the survey data.

Aerial photographs, of the type taken for depth determination, are useful in obtaining valuable information such as the width of surf zone, location of bars and rip currents, approximate littoral currents, beach width, some underwater obstacles, etc. Because of this, much attention was given to the problem of "best photographic light". Concrete examples of what constitutes good photographic light are given in this report. It was found that the "texture" of the sea surface and the steepness of the profiles through the surf were at least as important as the "lighting".

The required combination of photographic weather, tide conditions, suitable waves, best time of day for wave photography, light surface winds, etc., does not occur frequently. Favorable conditions should not be missed, nor should reconnaissance flights be sent out when conditions are unfavorable. Tight coordination of aerologists, photographers, photo interpreters, and flight crews is essential, and all key personnel must understand the requirements to be met.

49. "Oscillations (in Waves) of a Floating Rectangular Block" - by R. A. Fuchs and J. Einarsson, February, 1951.

The buoyant force and moment are explicitly derived for a floating retangular block in waves of irrotational type and water of an arbitrary finite depth. Differential equations describing pitching, heaving and surging oscillations are solved explicitly for the case in which damping terms are proportional to the first powers of the velocities, mass and damping coefficients being assumed constants equal to their values determined from oscillations in still water. First and second order theories are presented for motion on sinusoidal waves and "high" waves respectively. The effect of the second order terms is to exhibit a coupling between the three oscillations, to modify slightly the phase and amplitude of pitching and heaving, and to introduce additonal small oscillations in the pitching and heaving curve in the vicinity of the trough of the wave.

Four runs were made (for different wave characteristics) in the laboratory wave channel and the motion, superimposed on a graduated scale, was recorded on 35 mm. film. This film was then analyzed by frames for a time history of the oscillations. The results are compared with the predictions of the first order theory mentioned above and with the results of a theory for motion on sinusoidal waves in which the forces are purely hydrostatic. One comparison is made with the complete second order theory.

In one case the theoretical damping coefficient is used to determine pitching to a second approximation. The experimentally determined damping coefficients are compared with the results of a theory due to Havelock.

For the four runs having water depths of 1.6 to 0.8 ft. and H/L ratios of 0.066 to 0.053 the average errors in amplitude of heaving were

13% (hydrostatic formula)

2% (first order theory without relative motion effects)

11% (first order theory with relative motion effects)

4% - Run No. 1 (second order theory with experimentally determined damping coefficient)

0% - Run No. 1 (second order theory with theoretically determined damping coefficient)

and the average errors in amplitude of pitching were

0.5% (hydrostatic formula for pitching)

- 5.8% (hydrostatic formula for rolling)

-12.2% (first order theory without relative motion effects)

- 2.3% (first order theory with relative effects)

-20.2% - Run No. 1 (second order theory with experimentally determined damping coefficients)

- 8.2% - Run No. 1 (second order theory with theoretically determined damping coefficients)

The classical theory as developed in this paper appears to describe the motion of a floating body quite accurately. Possible sources of error are the slight non-uniformity of the actual waves, standing waves set up in the channel when determining heaving in still water and uncertainty as to what values of the damping coefficients to use. Recommendations for further theoretical research are made.

50. "The Effect of Wave Geometry on the Pitching Action of a Model LVT(3)(C)" - by R. C. Crooke and L. M. Harlander, September 1951.

A model LVT(3)(C), (Scale 1:22½) was tested under controlled conditions in a 1' x 3' x 60' wave channel to determine the effect of the variables of wave steepness, breaker height, wave period, and beach slope. It was found that the breaker height was the primary factor affecting the pitching action, the wave period had a much smaller effect: for constant breaker height it was found that the shorter periods caused lower pitch angles; hence the craft could safely encounter a higher spilling than plunging wave. It was also found that the model pitched to a lesser degree on the flatter beaches, breaker height and periods being constant.

The experimental data from which these conclusions are drawn are presented in detail in this report.

51. "Design, Construction and Preliminary Testing of a 1:24 Scale Model LCM-6". - by R. C. Crooke and L. M. Harlander, September 1951.

A self-propelled 1:24 scale model LCM-6 which could be steered remotely was designed and built at the University of California. It was hoped that this model could be used in a 1 foot wide wave channel and

[redacted]

UNCLASSIFIED

"surf-tested" in the same manner as the LVT(3)(C) (See University of California, Institute of Engineering Research Technical Reports - Series 29, Issues 43 and 50 and Series 30, Issue 4). This was not realised because the LCM model scale could be no smaller than 1:24 and still keep the model displacement equal to the lightship displacement of the prototype while this was still too large for channel. When the LCM-6 model was run in the wave channel at scaled prototype still water speed the resistance was greater than when run in a towing tank. Because of this it is impossible to use the model for this type of test until a larger wave channel is available.

52. "Final Report On Contract N7onr-29519: Amphibious Oceanography" - by R. L. Wiegel and Lt. D. A. Patrick, CEC, USN., 30 September 1950.

This report lists and summarizes all the technical reports issued under contract N7onr-29519, between the Office of Naval Research and the University of California.

Recommendation of future research and military applications of past research are also made.

[redacted]

UNCLASSIFIED

DISTRIBUTION LIST

Project NR 256 001

Chief
Office of Naval Research
Washington 25, D. C.
Attn: Code 465 (Amphibious Branch)
(2 copies)

Commanding Officer
Office of Naval Research
Branch Office
1000 Geary Street
San Francisco 9, Calif. (2 copies)

Naval Research Project NR 256 001
Surf & Weather Station
Headquarters, Camp Coronado
Camp Del Mar
Oceanside, Calif. (2 copies)

Director
Naval Research Laboratory
Washington 25, D. C.
Attn: Technical Information Officer
(9 copies)

Waves Investigation Project
244 Hesse Hall
University of California
Berkeley 4, Calif. (2 copies)

H. A. Schade, Director
Institute of Engineering Research
Room 205, Building T-3
University of California
Berkeley 4, California

Chief of Naval Operations (Op 531E)
Room 5E609, Pentagon Building
Washington 25, D. C.

Bureau of Ships
Room 4415, Main Navy Building
18th and Constitution Ave. N.W.
Washington 25, D. C.
Attn: Code 519D4
Major R.D. Horner, USMC

Bureau of Yards and Docks
Yards and Docks Annex
Washington 25, D. C.
Attn: Code P-300

The Hydrographer
Hydrographic Office
Department of the Navy
Washington 25, D. C.

U. S. Naval Photographic Interpretation Center
U. S. Navy Receiving Station
Washington 25, D. C.
Attn: Mr. Page Truesdell

Commandant Marine Corps
Headqaurters Marine Corps
G-4, Room 2131
Arlington Annex
Washington 25, D. C.
Attn: Capt. E.A. Hedall, USMC

Professor D. J. Belcher
Airphoto Research
202 Lincoln Hall
Cornell University
Ithaca, New York

Commander, Amphibious Training Command
U. S. Naval Amphibious Base
Atlantic Fleet
Little Creek, Norfolk, Virginia

Chairman, Ship to Shore Continuing Board
U. S. Atlantic Fleet
Commander, Amphibious Training Command
U. S. Naval Amphibious Base
Little Creek, Norfolk, Virginia

Commander, Amphibious Forces
Atlantic Fleet
U. S. Naval Amphibious Base
Norfolk, Virginia

Commander, Amphibious Forces
Pacific Fleet
San Francisco, California

Commanding Officer
U. S. Naval Civil Engineering Research
Evaluation Laboratory
Port Hueneme, California

Commander, Amphibious Training Command
Coronado
San Diego, California

Department of the Army, Corps of Engineers
Beach Erosion Board
5201 Little Falls Road, N.W.
Washington 16, D. C.

Corps of Engineers, U. S. Army
Office of the District Engineer
San Francisco District
180 New Montgomery Street
San Francisco, California