NAVAL AMPHIBIOUS SURF MANUAL

APRIL 2024

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DEPARTMENT OF THE NAVY
COMMANDER, NAVAL BEACH GROUP TWO
1430 HELICOPTER ROAD, SUITE 100
VIRGINIA BEACH, VA 23459-8946

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Ser N00/067
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From: Commander, Naval Beach Group TWO
To: Director, Navy Warfare Development Center

Subj: LETTER OF APPROVAL

1. Navy Tactics, Techniques and Procedures 3-59.3 Manual (NTTP)/Marine Corps Reference Publication 2-10.3 (MCRP) April 2024 Naval Amphibious Surf Manual, is hereby approved.

2. NTTP 3-59.3/MCRP 2-10.3 provides surf forecasting guidance to Naval personnel assigned to support amphibious operations to include those collecting surf-zone data, those determining where and when a landing is suitable and those requesting support during the planning and execution phases of an amphibious operation.

3. NTTP 3-59.3/MCRP 2-10.3 was developed in accordance with Navy Tactical Reference Publication 1-01 March 2024, The Navy Warfare Library User Manual. This publication replaces the Joint COMNAVSURFPAC/COMNAVSURFLANT Surf Manual that was provided by COMNAVSURFPAC/COMNAVSURFLANT Instruction 3840.1B in January 1987 and cancelled August 2005.

4. NTTP 3-59.3/MCRP 2-10.3 is UNCLASSIFIED and approved for public release. Distribution is unlimited.

D. M. ROWLAND
Captain, United States Navy

NTTP 3-59.3/MCRP 2-10.3 April 2024 Naval Amphibious Surf Manual, is hereby provided as a doctrinal publication in the Navy Warfare Library.

B. M. VENNING
Colonel, United States Marine Corps
Commanding Officer / Assault Amphibian School

M. R. DURKIN, SES
Director
Navy Warfare Development Center

CONTENTS

Page No.

Page
No.

APPENDIX B—METEOROLOGICAL AND OCEANOGRAPHIC SUPPORT PRODUCTS AND PROCEDURES

APPENDIX C—REVIEW OF BEACH CHARACTERISTICS

APPENDIX D—SURF ZONE FEATURES AND THE FORMATION OF BREAKERS

LIST OF ILLUSTRATIONS

Page No.

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PREFACE

NTTP 3-59.3M/MCRP 2-10.3 (APR 2024), NAVAL AMPHIBIOUS SURF MANUAL, is available in the Navy Warfare Library (NWL).

This new publication provides surf forecasting guidance to naval personnel assigned to support amphibious operations to include those collecting surf-zone data, those determining where and when a landing is suitable, and those requesting support during the planning and execution phases of an amphibious operation. It was developed as a replacement for the Joint COMNAVSURFPAC/COMNAVSURFLANT Surf Manual that was cancelled in 2005.

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CHANGE BARS

Revised text is indicated by a black vertical line in the outside margin of the page, like the one printed next to this paragraph. The change bar indicates added or restated information. A change bar in the margin adjacent to the chapter number and title indicates a new or completely revised chapter.

WARNINGS, CAUTIONS, AND NOTES

The following definitions apply to warnings, cautions, and notes used in this manual:

WARNING
An operating procedure, practice, or condition that may result in injury or death if not carefully observed or followed.

CAUTION
An operating procedure, practice, or condition that may result in damage to equipment if not carefully observed or followed.

Note
An operating procedure, practice, or condition that requires emphasis.

WORDING

Word usage and intended meaning throughout this publication are as follows:

“Shall” and “must” indicate the application of a procedure is mandatory.

“Should” indicates the application of a procedure is recommended.

“May” and “need not” indicate the application of a procedure is optional.

“Will” indicates future time. It never indicates any degree of requirement for application of a procedure.

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CHAPTER 1
Introduction

1.1 PURPOSE

This publication provides surf forecasting guidance to naval personnel assigned to support amphibious operations, to include those collecting surf-zone data, those determining where and when a landing is suitable, and those requesting support during the planning and execution phases of an amphibious operation. The surf zone extends between the outermost breakers and the highest point on shore reached by the breaking waves. This chapter provides a review of many of the basic terms used to characterize the topography of the surf zone and a quick summary of some general effects that weather can have on amphibious operations. It concludes with a brief refresher on the various phases of an amphibious operation.

Subsequent chapters focus on specific issues and activities associated with surf forecasting. Chapter 2 provides a summary of the environmental data required to support an amphibious landing, to include preliminary data required during the planning process and more detailed data necessary when the operation begins. It provides a recommended schedule for requesting data and forecasts to support a landing. For descriptions of oceanographic factors that influence the performance of specific landing craft, see Chapter 3. Beach surveys and associated reports, surf observations, and surf forecasts are described in Chapters 4–6. Chapter 7 focuses on modified surf indexes.

Blank copies of worksheets commonly used during surf operations are provided in Appendix A. Meteorological and oceanographic (METOC) support products and procedures are explained in Appendix B. For a more detailed discussion of individual surf zone and beach characteristics, the formation of breakers, and the influence of tides and near-shore currents on overall surf conditions, see Appendixes C–E. For more detailed descriptions of the processes involved in the generation of the ocean waves that eventually impact amphibious landing, see Appendix F.

1.2 REVIEW OF SOME BASIC TOPOGRAPHIC AND OCEANOGRAPHIC TERMINOLOGY RELEVANT TO SURF FORECASTING AND AMPHIBIOUS LANDINGS

The terms defined in the following are used to describe the topographic components of the nearshore and surf environment. Figure 1-1 is provided to help visualize some of these features. Definitions taken from a specific dictionary, allied, joint, United States Navy, or United States Marine Corps publication are annotated. Additional terms associated with specific oceanographic features are reviewed in Appendixes C–F.

Note

> Some definitions stated in this publication may not match those used in some other warfare-specific Navy tactics, techniques, and procedures to describe tactically significant environmental features. In mine countermeasure operations, for example, the segments of the water column in which mines are hunted, neutralized, and/or swept are defined in terms of water depth rather than by the environmental factors presented in this publication. When conducting mission planning for amphibious operations, staffs need to be careful to ensure that descriptions of the physical environment are well understood and contextually appropriate for the particular aspect of the operation (mine countermeasures, ship-to-shore movement, etc.) being discussed.

Backshore. The area of a beach extending from the limit of high-water foam lines to dunes or the extreme inland limit of the beach. This area comprises of both ordinary (summer) and storm (winter) berms and is usually dry since it is only reached by the highest tides.

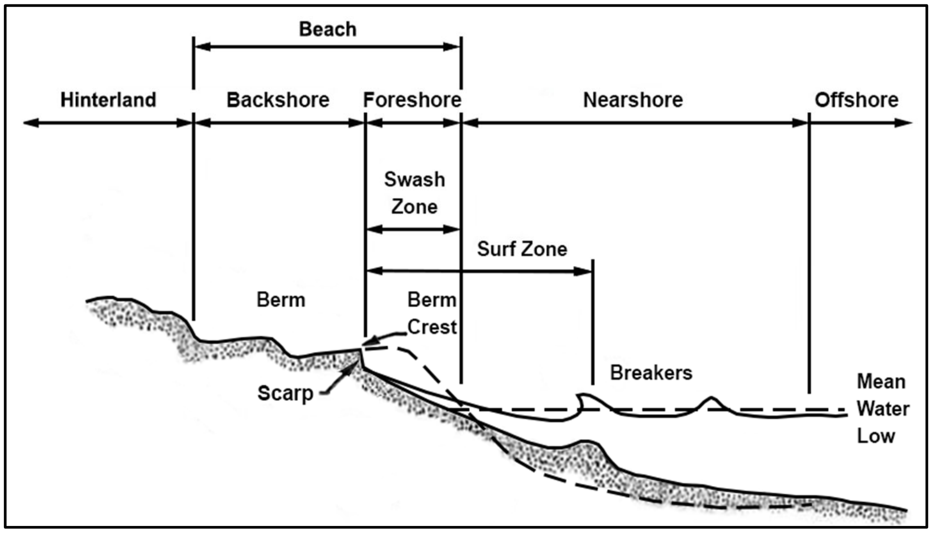

Figure 1-1. Beach Features

Beach. 1. The area extending from the shoreline inland to a marked change in physiographic form or material or to the line of permanent vegetation (coastline). 2. In amphibious operations, that portion of the shoreline designated for the landing of a tactical organization. (JP 3-02) A beach includes foreshore and backshore.

Beach gradient or slope. The rate of inclination to horizontal expressed as a ratio, such as 1:25, indicating a one unit rise to 25 units of horizontal distance.

Berm. The nearly horizontal portion of a beach or backshore having an abrupt fall and either formed by deposition of material by wave action at the limit of ordinary high tide or constructed to protect materials handling equipment during air-cushion vehicle operations.

Berm crest. The seaward limit up the shore; the highest point of a berm.

Deep water. In amphibious operations, water depth greater than one-half the wavelength. Deep-water conditions are said to exist when surface waves are not being affected by bottom topography.

Fetch. An area of the sea surface over which seas are generated by wind having a nearly constant direction and speed.

Foreshore. That portion of a beach extending from the low water (datum) shoreline to the limit of the normal high water wave wash. It stretches from the mean low water mark up to the beginning of the ordinary, or summer berm.

Inshore. The area from the line of departure (LOD) (amphibious operation) to the mean low-water mark. See the Glossary in this publication for a definition of LOD.

Nearshore. The zone bounded seaward by the 10-meter (approximately 33-foot) charted depth and shoreward by the mean low-water mark. (ATP-08(D)(1), Volume II)

Nearshore approach. That portion of the sea approach from the 5-fathom (approximately 9-meter) line landward to the mean low-water mark.

Offshore. Seaward of 10-meter charted depth. (ATP-08(D)(1), Volume II)

Scarp. A low, steep slope along a beach caused by wave erosion; an almost perpendicular, seaward-facing slope caused by wave action and erosion along the shoreline.

Sea. Waves generated or sustained by winds within their fetch.

Surf zone. The area between the outermost breakers defining the surf line and the limit of wave uprush on the beach.

Swash. The rush of water up onto the beach following the breaking of a wave. Also known as uprush.

Swash zone. The area of wave action on the beach, which moves as water levels vary, that extends from the limit of run-down to the limit of run-up.

Swell. Ocean waves that have traveled out of their generation area.

Tidelands. The zone between the mean high-water and mean low-water lines. It is identical with intertidal zone when the type of tide is semidiurnal or diurnal.

Tidal range. The difference in height of the water level between successive high and low tides. Tidal ranges are especially important near the shoreline where the rise and fall can exceed 50 feet, such as in the Bay of Fundy.

1.3 GENERAL EFFECTS OF WEATHER ON AMPHIBIOUS OPERATIONS

Weather can be either beneficial or detrimental to amphibious operations. Certain weather conditions can help to conceal landing operations while others can hinder landings and unloading, task force movement, and essential air-support operations. Figure 1-2 provides a general summary of weather effects on amphibious operations. To gain a full appreciation of the potential impacts oceanography, hydrography, and environmental conditions can have across the continuum of amphibious operations planning and execution, see JP 3-02, Amphibious Operations, and NTTP 3-02.1M/MCTP 13-10E, Ship-to-Shore Movement.

Category	General Weather Effects
Severe Weather	Hampers debarkation and landing craft operations, creates unacceptable surf conditions, can preclude landing, and interferes with construction support.
Winds (Surface)	Can cause postponement of landings. It affects the state of the sea and handling of landing craft.
Windchill	Can cause a requirement for special equipment and rigging for landing and for special supplies and equipment to support operations afloat and ashore.
Temperature (Surface)	Extreme surface temperatures can cause a requirement for special equipment and rigging for landing and for special supplies and equipment to support operations afloat and ashore.
Ceiling (Cloud and Sky Cover)	Can hamper air support operations and landing craft navigation. It can offer concealment from air reconnaissance.
Fog	Reduces visibility and increases landing craft navigation problems and water and terrain hazards. It can provide concealment.
Illumination	Can dictate the time of landing and support operations.
Freeze or Thaw Depth	Can hamper movement over the beach and construction support.

Figure 1-2. Overview of the Effects of Specific Weather Factors on Amphibious Operations

1.4 REVIEW OF THE PHASES OF AN AMPHIBIOUS OPERATION

An amphibious operation is a military operation launched from the sea by an amphibious force to conduct landing-force operations within the littorals. Amphibious operations generally follow distinct phases, though the sequence can vary. The phases are planning, embarkation, rehearsal, movement, and action. While planning occurs throughout the entire operation, it normally dominates staff actions prior to embarkation. Successive phases bear the title of the dominant activity taking place within the phase. When amphibious forces are forward deployed, or when subsequent tasks are assigned upon completion of the original mission, the sequence of phases can differ. This modified sequence accounts for the new mission, reconstitution of forces, and initial cross-decking of staff components or forces to support planning, preparation, and future actions. This sequence flows from planning through embarkation, rehearsal, and movement to the operational area and ends with action. An amphibious operation can be planned or executed within any of the phases of a major operation or campaign. The following provides a quick refresher of the phases of amphibious operations that surf forecasts support. For additional general information about amphibious operations, see JP 3-02 and the Navy 3-02, Amphibious Operations, series of publications.

1.4.1 Planning Phase

The planning phase normally denotes the period extending from the issuance of an initiating directive that triggers planning for a specific operation and ends with the embarkation of landing forces. Planning is continuous throughout the operation. Although planning never ends, it is useful to distinguish between the planning phase and subsequent phases because of the change that can occur in the relationship between amphibious force commanders at the time the planning phase terminates and the next phase begins.

1.4.2 Embarkation Phase

The embarkation phase is the period during which the landing force, with its equipment and supplies, embarks in assigned shipping. The landing plan and the scheme of maneuver ashore influence which staffs and units are embarked on which ships, the number and type of landing craft that will be embarked, and how the units will be phased ashore. The organization for embarkation needs to provide for flexibility to support changes to the original plan. The extent to which changes in the landing plan can be accomplished can depend on the ability to reconfigure embarked forces.

1.4.3 Rehearsal Phase

The rehearsal phase is the period during which the prospective operation is practiced to:

1. Test the adequacy of plans, timing of detailed operations, and combat readiness of participating forces.

2. Provide time for all echelons to become familiar with plans.

3. Test communications and information systems.

Rehearsal can consist of an actual landing or can be conducted as a command post exercise.

1.4.4 Movement Phase

The movement phase is the period during which various elements of the amphibious force move from points of embarkation, or a forward-deployed position, to the operational area. This move can be via rehearsal, staging, or rendezvous areas. The movement phase concludes when the various elements of the amphibious force have arrived at their assigned positions in the operational area.

1.4.5 Action Phase

The action phase is the period from the arrival of the amphibious force in the operational area through the accomplishment of the mission and the termination of the amphibious operation.

CHAPTER 2

Amphibious Landing Environmental Planning Factors

2.1 INTRODUCTION

To properly plan for and execute an amphibious assault or raid, it is necessary to acquire adequate environmental intelligence about the proposed landing site(s). One key step is the determination of surf conditions at the primary and any alternate landing sites. Although during the planning stage it may only be possible to evaluate surf conditions on a statistical basis at alternative sites, the probability of light or heavy surf action at the primary and alternate sites at the time of the landing is important. Alternate landing plans are desirable if early analyses indicate that markedly different surf conditions will exist if the proposed site(s) is exposed to waves of different directions and periods. Both the Marine Corps Intelligence Activity and the Naval Oceanographic Office (NAVOCEANO) have the capability to produce statistical studies of surf conditions. Annotated imagery of potential landing zones and alternate sites can be requested in advance. Well in advance to the initiation of a landing, surf photographs taken from the shore, sea, and air at a similar beach under a variety of surf conditions should be acquired so that when the final site selection is made, that imagery can be displayed in the briefing to simulate expected conditions.

Surface-borne ship-to-shore movement is influenced by multiple oceanographic conditions. Principal oceanographic considerations include:

1. Hydrographic features of nearshore and offshore areas

2. Extent and feasibility of transiting through mineable waters

3. Capacity of beaches for landing troops, equipment, and supplies

4. Suitability of beaches for landing craft and for employing causeways (maritime prepositioning force (MPF) operations) under expected weather, tidal, and wave conditions.

During the planning process, several additional terms may become important. The following is a list of these terms with definitions to help standardize their meanings.

1. **Exposed waters.** Waters more than 20 nautical miles from the mouth of a harbor of safe refuge. (Code of Federal Regulations (CFR) Title 46, § 175.400, Definitions of terms used in this subchapter)

2. **Partially protected waters.** Operation in waters not more than 20 miles from the harbor of safe refuge, unless determined to be exposed waters. (CFR, Title 46, § 175.400)

3. **Protected waters.** Sheltered waters presenting no special hazards (e.g., most rivers, harbors, and lakes) and is not determined to be exposed waters or partially protected waters. (CFR, Title 46, § 175.400)

4. **Safe haven.** A protected body of water or the well deck of an amphibious warfare ship. (DoD Dictionary)

2.2 CONSIDERATIONS FOR WAVE, BEACH, AND SURF CONDITIONS WHILE PLANNING

During the planning of an operation, the seasonal characteristics of the surf in the area should be examined. Seasonal changes in surf conditions are important considerations when selecting beaches for amphibious landings and when selecting which systems and landing craft should be involved in the landing.

2.2.1 Selection of Beaches

Within the limits set by operational and tactical considerations, the selection of landing areas should be informed by the possible surf and beach conditions due to different wave conditions at various tide levels. After evaluating available hydrographic information at the potential landing sites, wave refraction diagrams should be developed to show variations in surf conditions along the beach for the possible range of wave periods and deep-water directions. Alternative landing plans for each landing area are desirable if the analysis shows markedly different surf conditions under exposure to waves from different directions.

2.2.2 Selection of Landing Craft and Vehicles

The selection of appropriate landing craft and amphibious vehicles to use for an amphibious operation in relation to anticipated surf conditions should be initiated early in the planning stages of that operation. Although it is only possible to plan for surf on a statistical basis at this stage, the probability of light or heavy surf at the time and place of the landing should not be ignored.

2.3 OVERVIEW OF ENVIRONMENTAL DATA REQUIRED TO SUPPORT THE AMPHIBIOUS PLANNING PROCESS

2.3.1 Overview

Figure 2-1 provides a consolidated listing of recommended environmental data to consider while planning an amphibious operation, both during preliminary planning and during final preparations.

Preliminary Data Required During the Planning Stage	Data collected?	Data considered?
Prevailing winds (speed and direction (from)).		
Refraction diagram.		
Currents, littoral drift (speed and direction (to)).		
Prevailing sea and swell.		
Prevailing surf.		
Tides.		
Beach slope.		
Beach composition (materials and debris) and irregularities.		
Trafficability of beach.		
Water temperature.		
Bioluminescence potential.		
Kelp potential (or other fouling material).		
Percentage of time with cloud ceilings less than 1,000 feet.		
Percentage of time with visibility less than 3 miles.		
Solar/lunar data.		
Dangerous marine life.		
Endangered species.		

Figure 2-1. Amphibious Landing Environmental Planning Considerations (Sheet 1 of 3)

Data Required for D-day	Data collected?	Data considered?
Offshore Conditions		
Offshore current direction (to) and speed.		
Prevailing wind (speed and direction (from)).		
Sea heights (wind wave).		
Prevailing seas direction.		
Sea state (categorizes the force of progressively higher seas by wave height).		
Water temperature.		
Predominant swell height.		
Predominant swell period.		
Wavelength directly outside breaker line.		
Cloud cover and amounts.		
Visibility.		
Solar/lunar data.		
Breakers.		
Types of breakers present (spilling, plunging, surging) **(DELTA)**.		
Significant breaker height **(ALPHA)**.		
Maximum breaker height **(BRAVO)**.		
Period of breakers **(CHARLIE)**.		
Breaker angle to the beach **(ECHO)**.		
Number of lines of breakers **(GOLF)**.		
Depth of breaking.		
Surf beat detectable. Range (typically 10 percent of ALPHA).		
Secondary wave system present.		
Nearshore currents.		
Longshore/littoral current direction (to) and speed **(FOXTROT)**.		
Rip currents present.		
Rip current approximate width and speed.		
Rip current spacing along beach.		
Tides		
Type (diurnal, semidiurnal, mixed).		
Tidal range.		

Figure 2-1. Amphibious Landing Environmental Planning Considerations (Sheet 2 of 3)

Data Required for D-day	Data collected?	Data considered?
Surf Zone and Beach Characteristics		
Grid coordinates of left and right limits of the beach.		
Sand bars present. Average depth. Plotted.		
Reefs present. Average depth. Plotted.		
Rip currents (see nearshore currents).	----	----
Bioluminescence potential.		
Kelp potential (or other fouling material).		
Dangerous marine life (jelly fish, stingrays, sharks, etc.).		
Beach gradient/slope.		
Piers, jetties, or groins present. Plotted.		
Beach irregularities, submarine canyons/ridges.		
Beach composition.		
Beach trafficability.		
Legend: D-day unnamed day on which operations commence or are scheduled to commence		

Figure 2-1. Amphibious Landing Environmental Planning Considerations (Sheet 3 of 3)

2.3.2 Format of Location/Position Data

Degrees/minutes/decimal minutes is the standard for all position reporting, and World Geodetic System-1984 (WGS-84) datum is the standard for Global Positioning System (GPS) datum. WGS-84 is an Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. WGS-84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, and gravity and geomagnetic fields. The datum is defined and maintained by the United States National Geospatial-Intelligence Agency. Coordinates computed from GPS receivers are provided in terms of the WGS-84 datum. WGS-84 is also the geodetic reference datum standard for air navigation latitude/longitude coordinates.

2.4 RECOMMENDED SCHEDULE FOR REQUESTING DATA AND FORECASTS

METOC personnel assigned to an amphibious operation begin planning by acquiring data and products needed for the operation with the support from reachback operations at fleet weather centers (FWCs), the Fleet Numerical Meteorology and Oceanography Center (FNMOC), and NAVOCEANO. A list of products provided by the centers is available on the Commander, Task Group (CTG) 80.7 Command Center Portal and Catalog Service website under product catalog. That website is located at https://naval.oceanography.navy.(smil).mil/portal/home/. A common access card is required for access. All requests for FNMOC and NAVOCEANO products should be submitted to the Commander, Naval Meteorology and Oceanography Command (CNMOC) battle watch captain at cnmoc-bwc@us.navy.mil or cnmoc_bwc.fct@navy.smil.mil. CNMOC BWC will contact FNMOC and NAVOCEANO to initiate production. Limited information on relevant METOC products is provided in Appendix E. METOC personnel should begin planning by acquiring data on all known environmental parameters from the FWCs, FNMOC, and NAVOCEANO as soon as the operation objectives are known. Various METOC products and request timelines are listed in Figure 2-2.

Upon briefing of objectives for the operation,[1] submit a request to CNMOC battle watch captain for:	• Climatological data • Derived bathymetry • Nearshore model • Hydrography[2]
At least 60 days prior to D-day, submit a request to CNMOC battle watch captain for:	• Ocean currents model forecasts • Environmental support package • Analyzed littoral imagery
At least 60 days prior to D-day, submit a request to CNMOC battle watch captain for:	• All meteorology products
At least 30 days prior to D-day, submit a request to CNMOC battle watch captain for:	• Ocean wave and surf model forecasts • Annotated dynamic imagery • Two-color multiview
At least 30 days prior to D-day, submit a request to the FWC for:	• To initiate a 10-day subarea forecast starting 10 days prior to D-day with updates then provided every 24 hours through D-day • High-wind and sea warnings • Tropical cyclone and hurricane warnings • Sea height analysis from 72 hours prior to D-day to H-hour
Notes: 1. Information not contained in a standard NAVOCEANO product can be requested via a special request for essential elements of information tailored to the needs of the mission. 2. If hydrographic data is outdated or not available, submit a request for Naval Oceanographic Mine Warfare Center (NOMWC) support. See Appendix B for a discussion on NOMWC support. **Legend:** H-hour specific time an operation or exercise begins	

Figure 2-2. Timing of Advanced Requests for Environmental Data for an Amphibious Landing

The surf conditions (from swell) on a beach of known exposure and profile can be forecast fairly accurately up to a week in advance, depending upon the geography of the ocean basin offshore of the target site. In some cases (e.g., for the Pacific coast of Central America), accurate swell forecasts are achievable up to 2 weeks in advance of the landing. In contrast, nearshore wave models are typically accurate only 48 hours in advance of operations. To accurately forecast surf conditions, the characteristics of deep-water waves (sea or swell) that will approach and break on the beach during the forecast period must be identified. These characteristics are determined by combining spectral wave model output with numerical weather models. They are informed by remote sensing of winds and seas, wave-buoy measurements, and nearshore modeling. The direct measurement of waves via man-portable buoys is highly desirable. Buoys are principally used to verify or correct wave-energy models. Because a wave buoy only displays current wave conditions, buoys deployed near the landing area are not directly useful for forecasting future wave conditions. To be useful for nearshore wave predictions, wave buoys need to be deployed hundreds of miles offshore.

2.5 INTERPRETING AND ACCURACY OF FORECASTS

The trustworthiness of a surf forecast hinges on the accuracy of the modeled deep-water wave forecast and the precision of the bathymetry used by the nearshore model. The forecaster's skill at interpreting and communicating this information cannot be understated. Sparse observations, imperfect communications, erroneous hydrographic data, and poor wave model physics all affect the quality of surf forecasts. A surf forecast is considered accurate if the observed breakers are within the forecast limits found in Figure 2-3.

Height Range of Observed Breakers (feet)	Acceptable Error Range for Forecast Breaker Heights (feet)
0–5	±1
5–10	±2

Figure 2-3. Forecast Height Tolerance Allowed for Verification

Surf intelligence does not end with D-day. In planning follow-on landings of supplies and replacements, up-to-date knowledge of surf conditions is necessary. During the supply phase at Omaha Beach, Normandy, during World War II, forecasts of when heavy surf conditions would end were particularly useful for scheduling the resumption of unloading operations. After the objective is secured, knowledge of beach and surf conditions is valuable for choosing and developing harbors and anchorages.

2.6 ASSISTING PLANNERS IN REVIEWING RECEIVED INFORMATION

Planning support and information come from a variety of sources. Effective planning is characterized by good teamwork between the supported and supporting elements. As the plan develops and is completed, all aspects should be briefed, reviewed, and understood by planners and decision-makers. The following combat rubber raiding craft (Navy)/combat rubber reconnaissance craft (Marine Corps) (CRRC) mission planning checklist provides an example planning sequence guide that can be modified as required (Figure 2-4).

1. Analyze maps and charts for the objective area.
2. Request reconnaissance of the beach landing site.
3. Prepare weapons, boats, and equipment.
4. Review training area regulations/manuals dealing with navigation.
5. Review after-action reports from liaison visits to the local area.
6. Request advice of allied and coalition naval liaison officers that are familiar with the local area.
7. Request a local and experienced guide for transit.
8. Request air support for possible alternate means of withdrawal and medical evacuation operations.
9. Review meteorological, oceanographic, and tidal data.
10. Review potential navigation warfare tactics, techniques, and procedures; way points; and local navigation charts.
11. Request any other manuals helpful to navigation in the local area in addition to sailing directions and summary of corrections.
12. Review reconnaissance reports on file of the beach landing site to be transited.
13. Study photographs and satellite imagery of the beach landing site to be transited.
14. Request remote-piloted vehicle support or fixed- and rotary-wing visual reconnaissance, if available.
15. Obtain navigation advice and develop a plan (navigation track) with ship's navigator.
16. Have METOC personnel provide detailed environmental data for the intended navigation track to the beach landing site and return and determine potential hazards and obstacles along route.
17. Select primary, alternate, and contingency beach landing sites and consider emergency plans (abort criteria).

Figure 2-4. Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft Mission Planning Checklist

CHAPTER 3

Oceanographic Factors Impacting Amphibious Landings and Specific Landing Craft

3.1 INTRODUCTION

This chapter focuses on oceanographic factors that have an impact on amphibious landings and specific types of landing craft. These factors include the profile of the beach; the presence of reefs, sandbars, or other obstructions; the type, height, angle, and period of the breakers arriving at the beach; and tidal changes that occur during the landing. Some factors influence the behavior of all landing craft, whereas some hydrographic features influence displacement hulls much more than nondisplacement landing craft. See Appendix G for additional information about the characteristics of specific watercraft.

3.2 IMPACT OF BREAKERS ON AMPHIBIOUS OPERATIONS

This following focuses on the impact of breakers on landings. With spilling breakers, the wave crest slides down the face of the wave and gradually releases its energy over a wide area. With plunging breakers, the wave crest plunges over into the preceding trough while still offshore, causing a sudden release of energy over a narrow area. With surging breakers, the least common breaker type, waves build up like plunging breakers, but the very steep bathymetric slope prevents them from breaking offshore, and they explode onto the beach. A more in-depth discussion on breakers is provided in Appendix D.

3.2.1 Swell Impacts

Waves generated several thousand miles away from the intended landing zone can create hazardous nearshore conditions if storm intensity and motion work together to effectively point the wave energy towards the coast. These mid- to long-period (15–20 seconds) swells are capable of producing exceptionally large breakers, particularly at well-exposed locations (e.g., reefs, headlands, or developed sand bars where the waves meet a sudden decrease in depth). See F.4 for swell impacts.

3.2.2 Effects of Breaker Height on Landing Craft

Breakers of excessive height can swamp landing craft if the wave breaks over the craft as it is landing on or retracting from the beach. In the case of landing crafts, air cushion (LCACs), increasing breaker heights increase the danger of plow-in. High breakers can lead to the loss of control of all watercraft or injury to combat swimmer personnel.

3.2.3 Effects of Breaker Angle on Landing Craft

If waves strike a beach at an angle and continue to break down the beach in the direction they are traveling, a littoral current moving parallel to the shore develops in the surf zone. High waves breaking at a large angle to the beach can produce currents as great as 3–4 knots. A sharp, angular (rather than perpendicular) breaker angle on the beach makes it difficult for landing craft to remain in the boat lane during their approach. It may prevent the craft from landing on the correct beach. An amphibious craft traversing the surf zone under such conditions experiences wave impacts at an angle to their line of travel that can lead to broaching. Broaching occurs when landing craft are forced parallel to the beach (and are further grounded or swamped) by surf action. Broaching is further discussed in 3.6.1.3.

3.2.4 Effects of Breaker Period on Landing Craft

The breaker period determines the rapidity at which the craft encounters breaking waves. Breaking waves can hammer the craft with little respite, causing the craft to lose control, drift from the boat lane or the correct beach, and/or broach. The frequency of locally formed, short-period (6–12 seconds) wind waves may not allow the landing craft to pass the breaking point of a wave before meeting another breaking wave. In contrast, longer period waves (10–20 seconds) on steeper beaches permit landing craft to pass through the breaker zone between waves.

3.3 EFFECTS OF OSCILLATING SURF CONDITIONS ON AMPHIBIOUS OPERATIONS

There are two ways water moves in the surf zone—oscillatory (surf) and displacement (currents).

3.3.1 Effects of Surf Beat

Surf beat is the oscillation of the mean water level within the surf zone caused by groups of breakers of alternating height. As observed from the beach, it can be seen as a distinct rise and fall of the water level near shore following a series of larger breakers. A pattern often emerges as wave groups overlap. As a general rule, the surf beat is equal to about 10 percent of the breaker height. Surf beat can be significant for landing craft approaching submerged obstacles (e.g., reefs and bars). A rapid vertical oscillation can throw an amphibious assault vehicle (AAV)/amphibious combat vehicle (ACV) against a coral or rock reef hard enough to severely damage the suspension. The damaging effects of surf beat is mitigated if the tide provides sufficient clearance over obstacles or if the sandbar or reef is composed of soft material.

3.3.2 Impact of Tidal Ranges

Tides affect the type of surf, depth of water over sandbars and reefs, and the effectiveness of antilanding defenses (e.g., obstacles and mines). The rise and fall of water level due to changing tides can significantly change the bathymetric profile of the surf zone. At high tide, the surf zone may have a steep profile resulting in plunging breakers, whereas that same surf zone at low tide may have a mild profile with smaller, spilling breakers. The stage of tide also affects the width of the beach and surf zone. One good example of the impact of tidal ranges on amphibious operations is shown by their impact on AAV/ACV operations. High tides enable AAVs/ACVs to overcome sandbars, reefs, and obstacles more easily, but they tend to increase the percentage of plunging breakers by shortening the surf zone. Low tides can have the opposite effect by increasing spilling breakers. Extreme high and low tides, which may remain unchanged over the course of several days, can severely affect operations.

Planning around tides and tidal currents was a key factor in the successful invasion of Inchon, South Korea, during the Korean War. Intelligence reports indicated that high tides and mud flats presented major problems at potential landing sites along the entire west coast. Despite strong tidal currents induced by a narrow channel and one of the greatest tidal ranges in the world of up to 33 feet, Inchon was chosen as the landing site. To mitigate the challenges of extensive mud flats in the harbor and a seawall which averaged 16 feet above low water, a tidal height of 23 feet was needed for landing craft and 29 feet for tank landing ships. These conditions were forecast as achievable in 2-hour windows during spring tides between 15–18 September 1950, with the next opportunity coming a month later. The massive movement of water during the changing tides generated 6-knot currents which, compounded by low visibility and unwieldy craft, caused the coxswains to land outside of their assigned areas. The daring plan paid off, aided by the beaching at high tide of eight tank landing ships, which delivered crucial supplies to the fighting forces ashore that would otherwise have been delayed until the next spring tide, 12 hours later.

3.4 IMPACT OF THE BEACH PROFILE ON AMPHIBIOUS LANDINGS

Knowing the bathymetric profile (or gradient) of the littoral environment is critical to accurate surf forecasting. Steep to moderate (1:15 to 1:30) beach profiles normally lead to more plunging breakers, narrower surf zones, and less lines of surf. Gentle to mild (1:40 to 1:120) profiles tend to produce spilling breakers, wider surf zones, and more lines of surf. Knowing where channels, reefs, and sandbars are located is crucial for accurate wave and littoral current forecasts and safe boat operations.

3.4.1 General Beach Characteristics

The following characteristics of the beach are important considerations when planning and conducting amphibious operations:

1. **Reefs, sandbars, and other natural obstructions.** A distinct advantage that AAVs and ACVs have over conventional landing craft is their suspension, which enables rapid transition from water to land operations. Water obstacles (e.g., reefs, sandbars, and other natural barriers) should be identified and avoided if possible. Special consideration must be given when encountering obstacles (e.g., accounting for a tidal range that would allow for the safe maneuver over these impediments without grounding or jeopardizing the seaworthiness of the vehicle). The surf beat, vertical climb (maximum vertical obstruction height that an AAV can traverse), and the characteristics of the breakers must all be considered before AAVs and ACVs are navigated through those obstructions. Information needed for AAV/ACV operations over reefs or bars should include:

    a. Type and composition of the obstruction

    b. Location of the obstruction

    c. Slope (seaward)

    d. Depth of water at various tidal stages or height of obstruction above water

    e. Gaps or passages in the sandbar, reef, or other obstructions

    f. Breaker height.

2. **Beach composition.** The beach may be composed of silt, mud, sand, gravel, boulders, rock, coral, or any combination of these. The nature and composition of the foreshore, backshore, and hinterland can affect trafficability of vehicles that must negotiate this terrain.

    a. **Foreshore.** The most critical area of trafficability on the beach is the foreshore due to the relatively steep gradient and looseness of the beach material. Coarser materials (e.g., gravel, rocks, or cobblestones) provide poor traction. For example, since AAVs/ACVs are not fully grounded at the foreshore, they tend to slip on these coarse sediments. The heavier the AAV/ACV and the steeper the gradient, the less traction an AAV/ACV has.

    b. **Backshore.** Backshore sediments, especially sand, are usually soft, loose, and dry. Normally, the backshore does not present a problem to trafficability since the gradient is mild, but landing-force equipment (e.g., AAVs/ACVs, tanks, and wheeled vehicles) can lose traction in steeper gradients. Per equipment technical manuals, AAVs, ACVs, tanks, light armored vehicles, and trucks cannot negotiate terrain containing a gradient greater than 60 percent or slope greater than 0.6.

    c. **Hinterland.** The hinterland, the area just past the backshore behind the first line of permanent vegetation, may cause trafficability problems for landing-force equipment when dunes or cliffs are present. Depending on the size of the dunes or cliffs and the severity of the gradient of the terrain, landing-force assets (e.g., AAVs, ACVs, tanks, and wheeled vehicles) may need to employ armored combat earthmovers to shape the terrain to support vehicle traffic.

3.4.2 Specific Effects of Beach Gradient on Amphibious Operations

Beach gradients. The gradient is a unitless measure of the vertical rise to the horizontal run of the bottom (also known as rise-to-run ratio). Beach gradient refers to the average slope of the ocean bottom from the offshore area to the inshore area.

Gradient types. The five classifications of underwater gradients are:

1. Steep. More than 1:15 (more than 7 percent)

2. Moderate. 1:15 to 1:30 (7–3 percent)

3. Gentle. 1:30 to 1:60 (3–1.7 percent)

4. Mild. 1:60 to 1:120 (1.7–0.8 percent)

5. Flat. Less than 1:120 (less than 0.8 percent).

Gradient effects. A gentle gradient is preferred for amphibious operations. When attempting an amphibious assault over either mild or steep gradients, serious problems can occur:

1. On flat or mild gradients, landing craft run the risk of clogged sea-strainers that can lead to overheated engines and engine failures, which can possibly prevent landing craft retraction from the beach once the cargo is offloaded.

2. On moderate to steep gradients, wave action can cause landing craft to broach before the discharge of troops and equipment has been completed.

3. The beach gradient has little effect upon AAV and ACV operations unless it is a very steep to nearly vertical. The beach gradient often determines the width of the surf zone, the number of breaker lines, and the types of breaking waves. Steep gradients tend to produce a very high percentage of plunging breakers, narrow surf zones, and only one line of breakers. Moderate gradients tend to produce spilling breakers or a mixture of plunging and spilling breakers, sandbars, and extended surf zones with two to four lines of breakers. Mild gradients have a very high percentage of spilling breakers and tend to produce a series of bars that greatly extends the surf zone with multiple lines of breakers.

3.4.3 Land-fast Ice

Land-fast ice (also known as fast ice) is sea ice that has fastened to the coastline, to shoals along the shore, or to grounded icebergs. It can create several problems for amphibious landings:

1. Limits the ability of landing craft to properly beach, lower their ramps, or discharge their cargo while holding their position

2. Prevents landing force troops from crossing to the beach quickly and safely

3. Is likely to collapse under the weight of vehicles and support equipment.

3.5 OTHER ENVIRONMENTAL FACTORS IMPACTING AMPHIBIOUS LANDINGS

Other METOC conditions occurring between the debarkation ships and the start of the surf zone can significantly affect the execution of an amphibious landing. Winds, waves, currents, and reduced visibility can all disrupt disembarking, marshalling, and transiting operations, especially during ship-to-shore movement. Sea state can preclude landing or resupply of landing forces and can cause debarkation to be cancelled. It can endanger the use of landing craft, and severe conditions can degrade naval gunfire support. See MCRP 2-10B.6, MAGTF Meteorological and Oceanographic Operations, for additional information.

3.5.1 Impact of Currents

Those involved in planning amphibious operations often tend to focus on the effects of littoral (also known as longshore) currents; however, offshore currents, both tidal and nontidal, can have a greater effect on AAVs/ACVs. These currents can be cyclical (tidal), seasonal, or permanent. Offshore currents in excess of 3 knots adversely affect an AAV's and ACV's navigation and speed. Such currents can negatively impact the use of some mine-countermeasure neutralization systems, increasing risk for the ship-to-shore movement. For AAV and ACV operations, the speeds of both offshore and littoral currents should be determined and factored into plans.

Tidal currents. The strongest tidal currents occur around the entrances to bays and sounds, in channels between islands, between an island and the mainland, and in gaps between reefs. Generally, the smaller the gap, the higher are the tidal currents. Another general rule is the greater the tidal range, the stronger the tidal current. Tidal currents oscillate, which means they change direction every 6 or 12 hours depending upon whether the tide is semidiurnal or diurnal, respectively. At the surface, tidal currents may be visible as tide rips, which are areas of disturbed water and white caps. Strong tidal currents opposing wind waves will cause the wind waves to be higher than forecasted, if based on only wind speed. An example is that a 15-knot wind blowing for 6 hours would produce 2–3 feet sea (wind waves). If the sea direction is moving against a 2–3 knot-tidal current, the wave height would increase to 4–5 feet. Most global wave models do not account for tidal currents, but regional high-resolution wave models do take into account tidal current impacts for wind-wave development.

Tidal currents are predictable if sufficient observations have been made. Tidal current predictions for the continental United States are available from the National Oceanic and Atmospheric Administration (NOAA) at http://tidesandcurrents.noaa.gov/tide_predictions.html. Tidal current predictions for outside the continental United States operations and exercises can be obtained with advanced notice through requests for support (RFSs) to NAVOCEANO via the CNMOC battle watch captain (see B.5).

Nontidal currents. The flow of nontidal currents is related to global variations in the density of seawater and the effects of the wind. Examples of these types of currents are the Gulf Stream off the United States east coast and the Kuroshio flowing offshore of Japan.

Littoral (longshore) currents. Littoral currents are set up within the surf zone by breaking waves. They flow parallel to the shoreline inside the breaker line. The direction of flow is determined by the direction of the incoming wave angle and the nearshore bathymetry. Strong littoral currents can cause conventional landing craft to broach; however, once grounded and positive traction is achieved, they generally present less problems for AAVs and ACVs. Additional information about tides and currents is found within Appendix E.

3.5.2 Influence of Offshore Winds on Boat Operations

Onshore winds (blowing from sea to shore) are often advantageous by trending the breaker type to spilling. Landings have been made through the surf during 30-knot onshore winds without difficulty. In contrast, offshore winds (blowing from shore to sea) greater than 10 knots, when combined with sufficient surf, can cause increased surf zone width, increased wave steepness, and increased percentage of plunging breakers.

Any subsequent increases in wind speed produce further increases in the latter two parameters previously mentioned. Plunging breakers, combined with an offshore wind, can form dense streams of spray (spindrift), which can significantly reduce surface visibility.

3.5.3 Influence of Visibility on Boat Operations

Fog and rain have little influence on beach operations unless the surf zone is obscured. It is unwise to assume that the breaker conditions will remain constant for even a short period of time. The surf can increase or decrease in height, intensity, and character over short periods of time with the change in tide. New wave energy can arrive on a beach suddenly with wave heights increasing from very low to intense surf in less than an hour. A small wave buoy emplaced offshore of the landing site, combined with vigilant monitoring of surf conditions, will help ensure forecasts accurately reflect conditions in the surf zone.

3.5.4 Water Temperature

Another environmental factor to consider prior to any amphibious insertion or landing is water temperature. Although survival in seawater temperatures in excess of 70°F (21.1°C) depends more on fatigue factors than on hypothermia, colder temperatures decrease survivability of personnel in the water. Figure 3-1 shows 50 percent survival rate times for personnel in water of various temperatures.

	Seawater Temperature Versus 50-percent Survival Time (Hours)									
Seawater Temperature (°F)	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**
Seawater Temperature (°C)	**-1.11**	**-0.56**	**0.0**	**0.56**	**1.11**	**1.67**	**2.22**	**2.78**	**3.33**	**3.89**
-Without immersion suit	1.2	1.3	1.4	1.4	1.5	1.6	1.7	1.8	1.8	1.9
-With immersion suit	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3
Seawater Temperature (°F)	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**
Seawater Temperature (°C)	**4.44**	**5.0**	**5.56**	**6.11**	**6.67**	**7.22**	**7.78**	**8.33**	**8.89**	**9.44**
-Without immersion suit	2.0	2.2	2.3	2.5	2.6	2.8	2.9	3.0	3.2	3.3
-With immersion suit	3.5	4.0	4.4	4.8	5.3	5.8	6.2	6.7	7.1	7.6
Seawater Temperature (°F)	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**
Seawater Temperature (°C)	**10.0**	**10.56**	**11.11**	**11.67**	**12.22**	**12.78**	**12.78**	**13.89**	**14.44**	**15.0**
-Without immersion suit	3.5	4.3	5.2	6.1	6.9	7.8	8.6	9.4	10.3	11.1
-With immersion suit	8.0	9.2	10.4	11.6	12.8	14.0	15.2	16.4	17.6	18.8
Seawater Temperature (°F)	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**
Seawater Temperature (°C)	**15.55**	**16.11**	**16.67**	**17.22**	**17.78**	**18.33**	**18.89**	**19.44**	**20.0**	**20.56**
-Without immersion suit	12	12.9	13.7	14.6	15.4	16.3	17.1	18.0	18.8	19.6
-With immersion suit	20.0	21.2	22.4	23.6	24.8	26.0	27.2	28.4	29.6	30.8

Figure 3-1. Fifty-percent Survival Rate Times (Hours)

3.6 SPECIFIC TYPES AND CAUSES OF LANDING CRAFT CASUALTIES

The following focuses on casualties that can occur to landing craft as they approach or depart from a beach during an amphibious landing. A watercraft casualty is any mishap that puts a watercraft out of operation either temporarily or permanently. Casualties that can occur to both displacement hulls—hulls that displace or move an amount of water equal to the boat's weight out of the way so that the boat can move forward through the water—and nondisplacement hulls—designed to raise the boat to skim across the surface of the water rather then ploughing through it. Displacement hull watercraft casualties will be discussed first and then type of casualties that can occur to nondisplacement watercraft will be presented.

3.6.1 Displacement Watercraft Casualties

Various surf and beach conditions can contribute to casualties during amphibious landings despite there being expert craft-handling coxswain at the helm. These factors include the character of breakers (height, type, and period), littoral currents, the presence of sandbars and other obstructions, and the gradient of the beach, which, along with breaker height, determines the width of the surf zone. The following are three types of casualties that can occur to any displacement hull landing craft.

3.6.1.1 Swamping

Swamping is caused by breakers spilling a large amount of water into a landing craft as it approaches or retracts from a beach. It is rarely caused by surf conditions alone. Even with 10–12 foot breakers, an experienced craftmaster or coxswain can bring the craft safely through the breaker line. If a plunging breaker overtakes a craft, the craft is in danger of swamping. If a spilling breaker overtakes it, the craft may surf into the beach, get out of control, and/or collide with another craft or beach obstacle. If the surf zone is narrow, the craftmaster may not regain control before the craft hits the beach and broaches. During the retraction, there is greater danger of the craft being swamped, particularly if it ships water from several successive breakers. Retraction through plunging breakers is more hazardous than through spilling breakers, but the danger is partially offset by the longer periods of plunging breakers.

3.6.1.2 Hanging

Hanging is when a landing craft is grounded on a beach, sandbar, reef, or shoal. Most landing craft casualties occur because of hanging on a bar or on a beach. With the same depth of water over a bar, the risk of getting hung is greater when the breakers are low, because higher surf can lift the craft over the shallow water.

3.6.1.3 Broaching

Littoral currents are a frequent cause of broaching. Broaching occurs when a watercraft is thrown broadside to the wind and waves, against a bar, or against the shoreline. A beached landing craft broaches when it is forced parallel to the beach or sandbar and then further grounded by surf action. It frequently occurs when a powerful wave crest hits a beached craft. The power of the breaking crest hitting the beach depends on the height and speed of the breakers and their distance from the waterline. The danger of broaching is great unless the craft can be held firmly against the beach with enough steerageway to control its stern. This is typically attained by maintaining a slight forward-engine thrust while grounded. In a wide surf zone, the breaking crests expend their energy as they advance through shallow water and the up rush on the beach is gentle, decreasing the risk of broaching.

3.6.2 Nondisplacement Watercraft Casualties

Operators of nondisplacement hull watercraft, specifically LCACs, have to watch out for specific surf conditions that can result in casualties specific to these watercrafts. Such casualties include plow-in casualties, casualties caused by ingestion of plunging surf/green water through the propellers, and damage that can occur when the distance between wave crests (wavelength) approximately matches the length of the LCAC. Each of these types of potential LCAC casualties are explained in more detail in the following. An in-depth summary of the physical characteristics of LCACs is provided in G.2.

3.6.2.1 Plow-in Casualties

Plow-in is a phenomenon associated with LCACs in which the forward skirt of the LCAC collapses inward, causing excessive yawing and sideslip as the stern breaks from the surface. Plow-ins generally result from excessive bow-down trim coupled with extremely high speeds at high propeller pitch angles. It is an overwater phenomenon characterized by rapid deceleration in craft speed combined with a bow-down pitching or rolling of the craft. The danger of plow-in increases as the surf height increases or the gradient of the beach steepens. The most dangerous condition is a high-speed plow-in. Although plow-ins do not normally occur at speeds below maximum LCAC design speed of 50 knots in low significant wave height (SWH) seas, they can occur at speeds as low as 30 knots in high SWH seas. Figure 3-2, reproduced from S9LCA-AA-SSM-100, Volume VII, NAVSEA SEAOPS Manual for Landing Craft, Air Cushion (LCAC) Mission Planning, provides recommended maximum speeds various significant wave heights to prevent plow-in.

Significant Wave Height (feet)	Maximum Speed to Avoid Plow-in (knots)
0	50
1	50
2	45
3	40
4	35
5	30

Figure 3-2. Recommended Maximum Speed to Avoid Plow-ins for Various Wave Heights

3.6.2.2 Green Water Ingestion

During LCAC beach approaches, there is the risk of taking plunging surf through the propellers, which results in possible damage to the propellers and subsequent damage to the lift fans (NWP 3-02.12/MCRP 3-31.1A, Employment of Landing Craft Air Cushion (LCAC)). Green water in the lift fans or propellers causes failure of rotating equipment and possible operational loss of the watercraft. This reference recommends that beach approaches should be timed by the craftmaster to ensure arrival just behind a wave crest. The craftmaster needs to maintain forward motion of the watercraft until safely beyond the high-water mark, never allowing a wave to overtake the craft and break over its stern.

3.6.2.3 Surface Wave Lengths Closely Matching Landing Craft, Air Cushion Length

Landing craft, air cushion damage can occur when the distance between the crests of surface waves is approximately the same as the LCAC length. If an LCAC is heading into such seas, extensive craft pounding occurs because waves are continually hitting the bow. This effect can be reduced somewhat if the coxswain avoids setting courses directly into or down the sea when such conditions exist (NWP 3-02.12/MCRP 3-31.1A).

3.7 LIMITATIONS AND PLANNING CONSIDERATIONS FOR VARIOUS LANDING CRAFT

The following focuses on specific limitations and planning considerations for specific landing craft. Each type of landing craft has its own unique operating characteristics and limitations that need to be factored in when planning amphibious landings involving that watercraft. Limitations and planning considerations of the various displacement hull watercrafts are presented first, followed by the limiting factors for using the nondisplacement LCACs.

3.7.1 Limitations and Planning Considerations for Specific Displacement Hull Landing Craft

Per NTTP 3-02.1M/MCTP 3-31.5, the principal considerations for employing displacement landing craft include the following nearshore and surf zone related considerations:

1. Beach location, size, hydrographic features, and trafficability
2. Availability of hydrographic surveys for beach approaches
3. Suitable sea state and surf conditions.

The following detail limitations and planning consideration of each type of watercraft. An in-depth summary of the physical characteristics of each of these watercrafts is presented in Appendix G.

3.7.1.1 Specific Limitations and Planning Considerations for Landing Craft, Utility and Landing Craft, Mechanized

The landing craft, utility (LCU) is a highly versatile craft that has been adapted for many uses, to include salvage operations and ferrying operations for vehicles and passengers during noncombatant evacuation operations (NEOs). It transports wheeled and tracked vehicles, general cargo, and personnel from ship to shore, shore to ship, shore to shore, and in resupply, backload, or recovery operations. It is a self-sustaining craft with the habitability features typically found aboard ships. Per NTTP 3-02.14, Naval Beach Group Operations, sea state strongly affects crew day length, as shown in Figure 3-3. The no-go criteria for alongside cargo handling evolutions for LCUs is seas of 3 feet or higher (actual or predicted) to decrease the risk of parting lines, damaging equipment, injuring personnel, or creating undue difficulties for the craftmaster in controlling the LCU. When these craft are included in assault plans, it is especially important to consider currents, tidal times, and tidal ranges. Landing craft, mechanized (LCM)-8 crews are affected by the same external factors as LCU crews. Crews of LCM-8 (commonly referred to as Mike-8 boats) are affected by the same external factors as LCU crews. Since there are no onboard provisions for meals or head facilities aboard LCM-8s, even under the best conditions, LCM-8 crews generally require relief after 12 hours of steady operations.

Sea State	Wave Height (Bowditch)	Day Limit (hours)
1	0–0.3 feet.	16
2–3	0.3–1 foot to 1–4 feet	14
4–5	4–8 feet to 8–13 feet	10
Further increased sea state, nighttime, and low-visibility operations combination.		8 or less

Figure 3-3. Impact of Sea State on Crew Day Length of Landing Crafts, Utility (modified from NTTP 3-02.14)

3.7.1.2 Specific Limitations and Planning Considerations for Lighter, Amphibious Resupply, Cargo

Lighter, amphibious resupply, cargo, 5-tons (LARC-Vs) have the ability to swim from a ship to the beach. With their welded aluminum hulls, they can enter the water from the shore at up to 8 knots and participate in surf zone salvage, recovery, command and control roles, and the transportation of personnel and equipment. The craft is capable of traversing sand and coral beaches, unimproved roads, and off-road terrain and maneuvering through surf with 10-foot breakers in temperate, tropic, and arctic climates. It has a maximum speed of 29 miles per hour on land and 7.5 knots at sea. With its dual onboard fuel tanks, it has an at-sea range of 40 nautical miles. Its no-go criteria include ship-to-shore movement distances of greater than 4 nautical miles, swell heights greater than 6 feet, chop height greater than 4 feet (regardless of swell height), combination of wind (chop) and swell-wave heights greater than 6 feet, and wind speeds greater than 25 knots (regardless of wave height).

3.7.1.2.1 Lighter, Amphibious Resupply, Cargo, 5-tons Wet Well Operations Including Embarkation

LARC-Vs can operate from a wet well, but extreme care must be taken to prevent bumping by other craft. LARC-Vs have no watertight integrity and are subject to severe hull damage and flooding if not properly controlled in a wet well. When operational commitments allow, LARC-Vs are the first craft brought into the well to reduce the chance of bumping with other craft. They are not operated within wet wells when there are other live craft in the well. Any other craft in the well must be fully grounded. Wave action and improper line handling while moving craft in the well can result in significant damage to LARC-Vs. Steadying lines are not used on the LARC-V, except in an extreme emergency. The LARC-V aluminum hull and fittings are not designed to withstand the magnitude of force that would be applied. The light weight of the LARC-V would create a severe counter action when jerked by a steadying line. Increased danger to embarked personnel would result.

3.7.1.2.2 Debarkation of Lighter, Amphibious Resupply, Cargo, 5-tons Including Underway Launch

Whenever possible, launch and recovery of LARC-Vs are accomplished while the ship is at anchor. If an underway launch is absolutely necessary, avoid ship speeds exceeding 4 knots. LARC-Vs need to be launched individually. During the launching of LARC-Vs from well deck ships, the stern gate is lowered to the stops, and the well should not have more than 4 feet of water at the sill. This allows the LARC-Vs to remain in land drive in the well deck and launch as they cross the sill. The underway launch of a LARC-V is extremely dangerous and not recommended. Although amphibious, the LARC-V was not designed to enter the water at ship speeds in excess of 5 knots. If an underway launch with weight on is absolutely necessary, ship speeds exceeding 4 knots must be avoided. The draft of the ship’s propeller wash at greater speeds will cause the LARC-V to submerge after clearing the sill and sink. LARC-Vs do not have watertight integrity and cannot be subjected to submersion as AAVs/ACVs can. These launch restrictions further exemplify the need for accurate wave direction and height forecasting during all operations involving LARC-Vs.

3.7.1.3 Specific Limitations and Planning Considerations for Amphibious Assault Vehicle and Amphibious Combat Vehicle

Assault amphibian platoons typically deploy and move ashore in a wedge, line abreast, or echelon formation to reduce their vulnerability to hostile fire from the shore. These tactical formations require more maneuvering room than a staggered-column formation. When operating in a mined environment, the staggered-column formation is used to maneuver AAVs/ACVs ashore in cleared boat lanes, although this formation puts the AAVs/ACVs at greater risk from the effects of enemy weapons positioned ashore. Once the mine threat is reduced, commanders of subsequent AAV/ACV waves then rely upon the Army/Navy portable satellite navigation (AN/PSN)-13, Defense Advanced Global Positioning System Receiver (DAGR), and the amphibious assault direction system (AADS) to navigate ashore within cleared boat lanes. Despite the use of DAGR and AADS control methods, AAV and ACV crews are challenged to maintain their position in boat lanes while also responding to existing environmental conditions (e.g., tide, wind, current, surf, natural obstacles, etc.). Specific environmental considerations when operating AAVs/ACVs as part of an amphibious landing are presented in the following. See MCTP 3-10C, Change 1, Employment of Amphibious Assault Vehicles, for additional information related to operational characteristics of AAVs and amphibious planning factors. See MCRP 3-10C.1, Amphibious Combat Vehicle Employment, for additional information related to operational characteristics of ACVs and amphibious planning factors.

3.7.1.3.1 Amphibious Assault Vehicle/Amphibious Combat Vehicle Speed Afloat

Amphibious assault vehicle and ACV operations in the water can be especially challenging when many vehicles are operating in close proximity, especially during periods of limited visibility. As displacement landing crafts, AAVs and ACVs are more susceptible to tides and currents; therefore, they require greater lane widths to allow for a larger maneuver area. To compound this problem, AAVs/ACVs suffer from a lack of maneuverability, especially at slower speeds. Safe distances and speeds between vehicles must be observed. The maximum AAV speed afloat is 7.2 knots at 2,800 revolutions per minute in calm conditions (see MCTP 3-10C, Change 1). The maximum ACV speed afloat is 6 knots in calm conditions (see MCRP 3-10C.1). Factors (e.g., sea state, wind, current, and vehicle load) all greatly affect water speed. MCTP 3-10C, Change 1, and MCRP 3-10C.1 further state that during daylight with unrestricted visibility, 50 meters (or five AAV lengths) are kept between vehicles. During restricted visibility and at night, 50 meters or less are kept between vehicles, depending on the limit of visibility.

3.7.1.3.2 Amphibious Assault Vehicle/Amphibious Combat Vehicle Critical Values Related to Loading Versus Breaker Height and Breaker Period

The most dangerous portion of an amphibious landing is negotiating the surf zone, where the energy of the wave is released. Most landing craft casualties occur in the surf zone. Conditions in the surf zone that affect AAV and ACV operations are the combined result of the following factors:

1. Breaker type (i.e., spilling, plunging, or surging)
2. Maximum breaker height
3. Breaker period or interval
4. Number of breaker lines
5. Breaker angle
6. Vehicle load
7. Surf zone bottom type and gradient
8. Surf beat
9. Width of the surf zone
10. Littoral or longshore current.

METOC critical values highlight conditions that significantly reduce the effectiveness of operations, equipment, and weapons systems. Commanders need to know the critical values, consider them in planning, and weigh them against the tactical situation and the mission. Figure 3-4 lists critical values of maximum safe breaker height and breaker period allowed for each type of AAV and ACV load. The vehicle can handle shorter intervals between breakers and right itself as the cargo or ballast increases. The listed breaker periods (wave interval) should be read as the minimum interval in seconds. Exceeding these conditions is unsafe for AAV/ACV operations. Narrow surf zones can hinder operations if the surf is high (4–6 feet) and the littoral current exceeds 3 knots for both AAV and ACV. See Figure 3-4 for additional details.

Types of Breakers/Load Type	Maximum Breaker Height (feet)	Breaker Period (seconds: not less than)
Amphibious Assault Vehicle		
100-percent Plunging Surf		
Combat loaded	6	9
Troop loaded	6	9
Combat equipped	6	13
50-percent Plunging Surf, 50-percent Spilling Surf		
Combat loaded	6	8
Troop loaded	6	8
Combat equipped	6	10
100-percent Spilling Surf		
Combat loaded	6	5
Troop loaded	6	5
Combat equipped	6	7
Amphibious Combat Vehicle		
100-percent Plunging Surf		
Troop loaded	4	9
Crew loaded	4	13
50-percent Plunging Surf, 50-percent Spilling Surf		
Troop loaded	4	8
Crew loaded	4	10
100-percent Spilling Surf		
Troop loaded	4	5
Crew loaded	4	7

Notes:

AAV

1. Criteria are applicable to the amphibious assault vehicle-personnel carrier (AAVP7A1 RAM/RS); amphibious assault vehicle-command (AAVC7A1 RAM/RS); and amphibious assault vehicle-recovery (AAVR7A1 RAM/RS). Criteria are based on the following three load conditions:
   a. Combat load (10,000 pounds)
   b. Troop load (5,600 pounds)
   c. Combat equipped (no load).
2. Planning for combat operations should be predicated on the AAVP7A1 RAM/RS' demonstrated capability of negotiating 10-foot plunging waves in combat-load and troop-load conditions and 8-foot plunging waves in combat-equipped conditions.

ACV

1. Criteria are applicable to the amphibious combat vehicle-personnel (ACV-P) and amphibious combat vehicle-command (ACV-C) variants. Criteria are based on the following load conditions:
   a. Crew loaded (crew only, individual combat loads, individual loads include 1 day of supply on person and one additional day of supply) (64,280 pounds).
   b. Troop loaded (13 embarked troops ACV-P, seven embarked staff/ACV-C, individual combat loads, one additional day of supply, combat essential equipment) (70,771 pounds)

Figure 3-4. Maximum Safe Breaker Height and Period versus Types of Amphibious Assault Vehicle/Amphibious Combat Vehicle Loads

3.7.1.3.3 Surf Beat and Vertical Climb

The AAV and ACV suspension enable the rapid transition from water-to-land operations. Reefs, sandbars, and other natural obstructions can impede maneuver. Special consideration must be exercised, and planners should engage subject matter experts at the Marine Corps Assault Amphibious School, Camp Pendelton, California, to determine safe operating parameters. Information needed for AAV and ACV operations over reefs or sandbars should include:

1. Nature or types of obstructions
2. Location of obstructions (e.g., sandbars and reefs)
3. Slope (seaward)
4. Depth of water at various tidal stages or height of obstructions above water
5. Gaps or passages in the sandbar, reef, or other obstruction
6. Breaker height.

Surf beat. Surf beat is the distinct rise and fall of the mean water level within the surf zone. Surf beat is normally 10 percent of the breaker height. Surf beat can be of significance to AAVs/ACVs approaching submerged obstacles (e.g., sandbars or reefs). This quick raising and dropping of almost 1 foot at times can throw an AAV/ACV against a reef hard enough to severely damage the suspension, because reefs can be composed of coral or rock. The damaging effects of surf beat on a vehicle can be overcome if the tide provides sufficient water depth over the obstacle or if the composition of the sandbar or reef is soft material.

Vertical climb. On land, AAVs can vertically climb a 3-foot wall, and the ACV can vertically climb a 2-foot wall. In water, these vertical climb distances are less. The depth of the water over a steep-gradient obstruction (e.g., reef, sea wall) should be at least 3 feet for the AAV to allow the tracks to engage and 5 feet for the ACV to allow tires to engage and climb. This is not a concern where the gradient is less steep (e.g., sandbars), since the tracks or tires will grip the bottom and gain traction to transverse the obstacle. Because reefs are irregular and often contain many pockets or holes, care should be taken to avoid getting an AAV/ACV stuck in one without sufficient water depth to climb out.

3.7.1.3.4 Beach Composition and Amphibious Assault Vehicle/Amphibious Combat Vehicle Grade Climbing Ability

The beach may be composed of silt, mud, sand, gravel, boulders, rock, coral, or any combination of these. The nature and composition of the beach foreshore, backshore, and hinterland all affect the trafficability for AAVs and ACVs. The most critical area of trafficability is the foreshore due to the increased gradient and looseness of the material. Coarser materials (e.g., gravel, rocks, or cobblestones) in the foreshore provide poor traction for AAVs/ACVs as they begin to ground when moving out of the water. Since they are not fully grounded at the foreshore, they tend to slip on the coarse materials. The heavier the AAV/ACV and the steeper the gradient, the less traction the vehicle has. As the gradient increases to its peak, armored vehicles tend to become stuck or mired in the loose bottom material. On land, AAVs, when combat loaded, can ascend grades of 60 percent and negotiate side-slope grades of 40 percent. For comparison, the ACVs, at gross vehicle weight, can ascend grades of 60 percent and negotiate side-slope grades of 30 percent.

3.7.1.4 Special Purpose Watercraft Specific Limitations and Planning Considerations

Optimally, raiding-craft operations are only conducted in benign surf conditions where the SWH is 1 foot or less. The decision to enter surf using small boats (e.g., naval special warfare (NSW) rigid inflatable boats (RIB), rafts, or other raiding craft) should be based on operator experience and mission requirements.

3.7.1.4.1 Specific Limitations and Planning Considerations for Combat Rubber Raiding/Reconnaissance Craft

Environmental considerations when operating CRRCs in nearshore and surf zones are presented in the following.

3.7.1.4.1.1 Impact of Winds and Seas on Combat Rubber Raiding Crat/Combat Rubber Reconnaissance Craft Launch and Recovery

The stability of the launch platform is of prime importance during the launch and recovery of CRRCs. Although during normal operations CRRCs can be operated safely in sea-state 2 (equivalent to 0.3–1-foot wave heights), handling, launching, and recovering these watercraft from any launch platform can become extremely hazardous in sea states greater than 1 (equivalent to 0–0.3-foot wave heights). Combat rubber raiding craft/combat rubber reconnaissance craft launch and recovery operations in higher sea states carry the risk of a bow-ramp casualty, loss of the CRRC, or personnel injury. An appropriate heading must be found that minimizes pitch and roll of the launch platform and achieves the best launch and recovery conditions for the CRRC. A launch/recovery platform underway heading into seas at speeds ranging from 3–5 knots normally affords the most stable launch or recovery of a CRRC. Course and speed changes should be avoided during launch and recovery operations to reduce the possibility of cross-wave action across the stern gate or sill. Minimizing roll is especially important. Wind is an important factor to consider. Wind conditions can cause a cross swell, which is any sea state with two wave systems traveling at oblique angles. For all these reasons, close coordination on the launch platform between the bridge and the launch and recovery control station is required.

3.7.1.4.1.2 Sea State Limitations on Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft Operation

Per COMNAVSURFPACINST/COMNAVSURFLANTINST 3340.3F, Wet Well Operations Manual, the maximum sea state for CRRC operations is sea-state 3 (equals Bowditch wave height 1–4 feet). If caught in a sea state greater than 2, the craft must operate at a slower speed that results in longer transit times and increased fuel consumption. High winds and associated higher sea states adversely affect the maneuverability of a CRRC; however, an advantage is reduced vulnerability to detection. High seas degrade the detection range and effectiveness of electronic sensors and contribute to tactical surprise. Sea conditions can fluctuate rapidly. During the planning phase for an over-the-horizon operation, the navigator must consider the forecasted meteorological factors that could adversely affect the sea state throughout the mission.

3.7.1.4.1.3 Distance Limitations and the Pounding Effects of Swell and Wave Activity

The insertion point at which the raiding craft are launched from amphibious shipping in over-the-horizon operations is generally considered to be approximately 20 nautical miles from shore. The optimal distance from shore to launch is determined based on multiple factors, to include sea state, weather, transit times, and enemy electromagnetic detection capabilities. The objective is to keep the host platform undetected while minimizing the CRRC transit distance, thereby reducing the physical demands caused by long, open-ocean transits. While the CRRC is capable of transporting up to 10 personnel, it is highly recommended that no more than six personnel be embarked. Experience has shown that six personnel with mission-essential equipment, on average, are closer to the CRRC's weight ceiling. For extended transits or marginal sea conditions, consider limiting the maximum load to four persons. In a crowded CRRC, personnel in the forward positions are subjected to a greater degree of exposure and pounding from the effect of swell and wave activity on the bow. This beating can be physically exhausting during long transit periods. The increased physical stress may diminish operator ability to perform after arrival at the objective.

3.7.1.4.1.4 Surf Limitations

Surf conditions are critically important in making the final determination to launch or not launch a CRRC surf zone operation. The most important characteristics of the surf zone near any beach landing site are the significant breaker height, breaker period, and breaker type. These factors must be prudently evaluated, especially in light of boat or engine maintenance conditions and coxswain or boat-crew experience level. Figure 3-5 depicts the recommended operating limits for CRRC surf zone operations. Figure 3-5 plots breaker height versus breaker period and is applicable to both spilling and plunging waves. Plunging breakers are more dangerous to CRRC operations than spilling breakers. Greater care and judgment must be exercised as the percentage of plunging breakers increases. As is shown in Figure 3-5, danger increases as wave height increases and the period between waves lessens. These recommended surf limits are provided as a guide. They are not intended to usurp the judgment of officers exercising command. Significant wave height is normally used for open ocean. Significant or maximum breaker height are used in the surf zone.

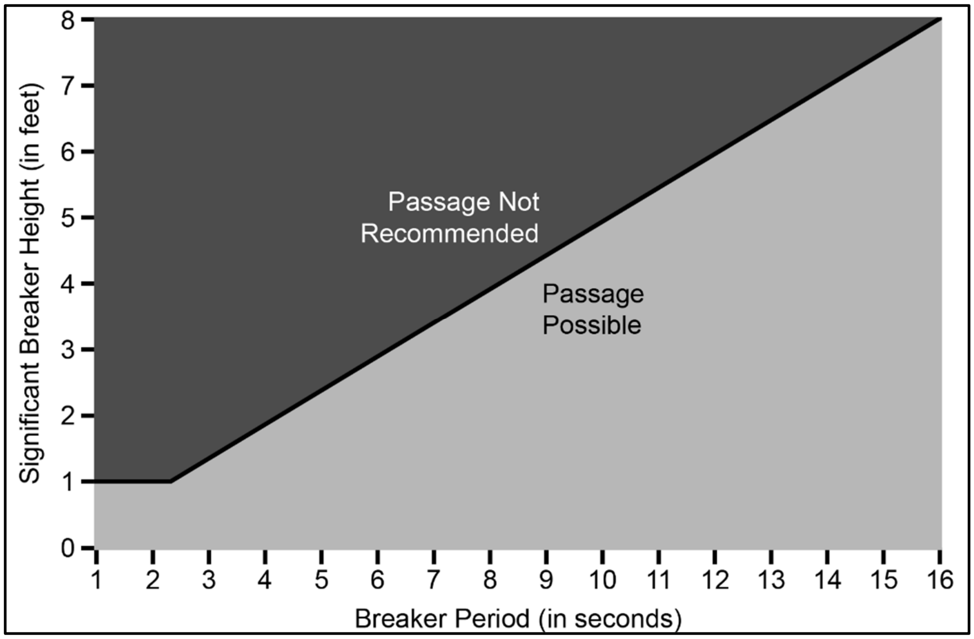

Figure 3-5. Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft Surf Safe Passage Limits

Once a CRRC is launched and arrives outside the surf zone at the beach landing site, the CRRC officer advises the officer in charge regarding the final beaching decision. If prelaunch surf observations, visual sighting, or mission necessity warrant further surf evaluation, the officer in charge can use scout swimmers for this purpose. The officer in charge must consider the surf conditions as they exist at the time, the mission and command guidance, boat or engine maintenance conditions, and coxswain or boat-crew safety.

3.7.1.4.2 Naval Special Warfare Combatant Craft Assault-specific Limitations and Planning Considerations

The missions of the combatant craft assault include short-range ship-to-shore insertion and extraction for special operations forces in low- to medium-threat environments, resupply of special operations forces along coastal littorals, and maritime surveillance. Naval special warfare combatant craft assaults can achieve speeds up to 50 knots with a 250 nautical mile range and are seaworthy up to sea-state 5.

3.7.2 Landing Craft, Air Cushion Specific Limitations and Planning Considerations

Environmental considerations related to the employment of the LCAC include:

1. LCACs are not constrained by tidal conditions and most hydrographic features.

2. Alternate beaches can be included to tactically employ the LCAC’s speed and mobility.

3. Prior to employment of LCACs, the anticipated significant wave heights (SWHs) and prevailing wind speed and direction in LCAC collections areas, LCAC launch areas, departure points, transit lanes, and LCAC holding areas should be evaluated.

4. A 500-yard separation is required between conventional displacement watercraft approach lanes and LCAC approach lanes. An exception is when conventional watercraft and LCAC approaches and landings can be separated by time at the same beach landing site.

5. LCACs require a minimum a 100-yard diameter area in the craft landing zone in which to discharge their load and return to the ship.

6. LCACs require a 50-yard radius separation between LCACs on a beach.

7. Twenty minutes are required between successive LCAC waves.

8. The significant wind and salt spray caused by LCAC operations can damage embarked equipment if left onboard the LCAC for long periods of operating time.

3.7.2.1 Impact of Seas on Landing Craft, Air Cushion Transit Times

Seas have a major impact on LCAC transit times and overall cycle times because of their effect on LCAC speed. While LCACs can travel faster than 40 knots in SWHs of 0–1 foot, higher seas, swells, and high-wind conditions can greatly reduce their maximum available speed depending on the heading and course of the craft relative to the winds and seas. Operating the craft above the craft-design weight or at speeds greater than appropriate for the given SWHs increases the likelihood of craft damage and mission failure. Wave period and shallow-water effect definitions follow.

Wave period. The time between successive wave peaks. The significant period is the average period of the highest one third of the waves. The significant period is approximately equal to the observed period (i.e., the period that is perceived by an individual).

Shallow-water effects. Effects experienced in water depths between 8 and 20 feet. As the water gets progressively shallower, the more the cushion wave is amplified by the bottom, with maximum drag occurring at the critical water depth of 10 feet. More power is required to accelerate over hump at these water depths.

The following environmental parameters should be documented for the operating area and used to plan any LCAC mission:

1. Seas:

    a. Significant wave height. The average wave height (vertical distance measured from trough to crest) of the highest third of the waves. Significant wave height typically matches the visually observed wave height if direct measurements are not available.

    b. Wave direction. The predicted prevailing direction from which waves will originate throughout the mission. In contrast, current direction describes the direction towards which a floating object is carried.

    c. Wave forecast. The predicted prevailing seas throughout the mission duration within the LCAC operating area.

    d. Tides. The times of the high tides (normally two per day).

    e. Tidal range. The difference in feet between the high tide and low tide.

    f. Surf height. Maximum surf height in feet for the vicinity of the LCAC beach.

    g. Surf condition. Description of breaker characteristics (e.g., spilling, plunging, or surging, in the surf zone) (see Figure G-1).

2. Ambient temperature. Surface air temperature in degrees Fahrenheit.

3. Winds:

   a. Wind speed. Predicted sustained wind speed in knots.

   b. Wind direction. The predicted direction from which prevailing winds will originate throughout the mission.

   c. Wind gusts. Predicted speed of sudden, brief, increases of wind (gusts) in knots.

   d. Wind forecast. Predicted wind conditions (speed, gust, and direction) during the mission.

4. Illumination and lighting:

   a. Visibility. Distance in nautical miles of the visible horizon.

   b. Visibility forecast. The predicted visibility.

   c. Sunrise. Time of local sunrise.

   d. Sunset. Time of local sunset.

   e. Moonrise. Time of local moonrise.

   f. Moonset. Time of local moonset.

   g. Moon illumination. Predicted percentage of light illumination by the moon.

   h. Background illumination. Anticipated ambient background illumination at the craft landing site.

   i. Lux. Predicted illumination for night-vision goggle use.

3.7.2.2 Over-hump Operations and Hump Speeds

When an LCAC is hovering over calm water at zero forward speed, the cushion pressure forms a depression in the water surface. As thrust is applied and forward speed increases, a series of waves are generated around the craft by the cushion. As craft speed increases, these waves change in both height and length. At certain speeds craft resistance becomes relatively high. These critical speeds are referred to as hump speeds, due to their hump-like appearance on a graph of speed versus resistance. Usually there are two significant hump speeds for the LCAC. The primary hump occurs at approximately 18–20 knots. A secondary hump occurs at approximately 11 knots. The relatively high resistance at these speeds is caused by the craft climbing a slope in the local water surface, which is caused by the cushion-generated waves. Operation at these speeds tends to result in high fuel usage. Operating above the primary hump speed leads to more efficient fuel usage and is referred to as an over-hump operation. LCAC speed capability is directly affected by the environment and craft status. As environmental conditions degrade, the maximum safe craft speed decreases. Degradations to the craft operating status reduce craft performance as well. Missions are typically planned for a craft speed of 35 knots.

3.7.2.3 Landing Craft, Air Cushion Maximum Breaker Height Calculation

The maximum breaker height is the height of the highest predicted breakers based on the beach gradient, anticipated SWHs (also known as open-water wave height), and wave periodicity. LCAC operators use maximum breaker-height predictions to determine if expected surf conditions will allow the safe operation of an LCAC within the surf zone. Figure 3-6 and the following variables are used to predict the maximum breaker height for the prevailing sea conditions:

1. Beach gradient, in degrees

Open-water Wave		Beach Slope (degrees)									
Height (feet)	**Period (seconds)**	**1 or less**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	2	0.90	1.00	1.05	1.10	1.15	1.17	1.20	1.20	1.20	1.20
	4	1.20	1.40	1.50	1.60	1.65	1.70	1.70	1.75	1.80	1.80
	6	1.55	1.75	1.90	2.00	2.05	2.10	2.15	2.20	2.20	2.30
	8	1.70	2.08	2.20	2.30	2.40	2.45	2.50	2.55	2.60	2.65
	10	2.00	2.25	2.40	2.50	2.60	2.65	2.70	2.75	2.80	2.85
2	2	1.80	1.85	1.90	1.95	2.00	2.00	2.00	2.05	2.05	2.05
	4	2.05	2.30	2.45	2.55	2.65	2.70	2.75	2.80	2.85	2.90
	6	2.55	2.90	3.10	3.30	3.40	3.50	3.60	3.65	3.70	3.75
	8	2.95	3.40	3.65	3.85	4.00	4.10	4.20	4.30	4.40	4.45
	10	3.35	3.80	4.10	4.30	4.40	4.55	4.65	4.75	4.80	4.90
3	2	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	4	2.80	3.20	3.40	3.55	3.70	3.80	3.85	3.90	4.00	4.05
	6	3.40	3.90	4.10	4.30	4.50	4.60	4.70	4.80	4.85	4.90
	8	4.05	4.60	4.95	5.20	5.40	5.50	5.65	5.75	5.85	5.95
	10	4.60	5.20	5.55	5.80	6.00	6.20	6.30	6.45	6.55	6.65
4	2	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	4	3.55	4.0	4.20	4.40	4.55	4.65	4.75	4.80	4.90	4.95
	6	4.20	4.80	5.10	5.35	5.55	5.70	5.80	5.90	6.00	6.10
	8	4.95	5.60	6.05	6.30	6.55	6.75	6.90	7.00	7.15	7.25
	10	5.50	6.35	6.85	7.20	7.45	7.70	7.90	8.05	8.20	8.30
5	2	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	4	4.40	4.75	5.00	5.10	5.20	5.30	5.40	5.50	5.55	5.60
	6	4.90	5.55	5.95	6.20	6.45	6.60	6.80	6.90	7.00	7.10
	8	5.75	6.60	7.05	7.40	7.70	7.90	8.10	8.25	8.40	8.50
	10	6.50	7.45	8.00	8.40	8.70	8.90	9.15	9.30	9.50	9.60
6	2	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
	4	5.30	5.65	5.90	6.05	6.20	6.30	6.35	6.40	6.50	6.55
	6	5.70	6.50	7.00	7.30	7.60	7.80	7.95	8.10	8.25	8.40
	8	6.50	7.40	8.00	8.40	8.70	8.95	9.20	9.40	9.55	9.70
	10	7.45	8.50	9.20	9.60	10.0	10.3	10.5	10.7	10.9	11.0

Figure 3-6. Maximum Breaker Heights for Given Beach Slope and Open Water Wave Height (Sheet 1 of 2)

Open-water Wave		Beach Slope (degrees)									
Height (feet)	Period (seconds)	1 or less	2	3	4	5	6	7	8	9	10
7	2	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
	4	6.23	6.53	6.77	6.95	7.14	7.21	7.22	7.29	7.38	7.42
	6	6.50	7.43	7.86	8.21	8.56	8.79	8.90	8.99	9.24	9.34
	8	7.37	8.43	8.97	9.41	9.76	10.1	10.2	10.4	10.6	10.7
	10	8.29	9.51	10.3	10.8	11.2	11.5	11.8	12.0	12.1	12.5
8	2	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
	4	7.20	7.40	7.60	7.60	8.00	8.00	8.00	8.20	8.20	8.20
	6	7.28	8.30	8.67	9.05	9.43	9.68	9.74	9.79	10.1	10.2
	8	8.20	9.20	9.80	10.2	10.6	10.8	11.0	11.2	11.4	11.6
	10	9.16	10.5	11.1	11.7	12.2	12.5	12.8	13.0	13.2	13.4

Figure 3-6. Maximum Breaker Heights for Given Beach Slope and Open Water Wave Height (Sheet 2 of 2)

2. Open water wave height, in feet

3. Wave periodicity, in seconds.

Note

Estimates of maximum breaker height are used when actual surf observations (reports) (SUROB) by trained personnel are not available. When a SUROB is available and contains breaker-height information, this calculation is not required.

- Example 1. Determining that there is a 4-foot SWH with an 8-second wave period and the beach slope is 7 degrees, the maximum wave height (surf) will be 6.90 feet.

- Example 2. Determining that there is a 6-foot SWH with a 6-second wave period and the beach slope is 9 degrees, the maximum wave height (surf) will be 8.25 feet.

3.7.2.4 Maximum Landing Craft, Air Cushion Surf Capabilities

Limiting conditions for operating LCACs in the surf zone are based on the sizes of their loads and the significant breaker height, as shown in Figure 3-7. Modified surf index (MSI) calculations are not applicable to the LCAC, since it is a nondisplacement craft. See Chapter 7 for more information on MSIs.

3.7.2.5 Surf Zone Transitions for Landing Crafts, Air Cushion

The LCAC is designed to operate in waves up to 8 feet high; however, operations in surf up to 12 feet high are possible and depend on the capability of the operator to avoid structural damage to the craft. Figure 3-8 summarizes operational considerations affecting movement of the LCAC from water to land and back to water, to include surf penetrations in both directions.

Load	Significant Breaker Height Maximum (approximately—feet)	Maximum Speed (knots)	Departure Speed (knots)
75 tons (overload)	0–4	50	30
60 tons (normal load)	4–8	30	20
45 tons (reduced load)	8–12	20	10

Figure 3-7. Significant Breaker Heights Versus Landing Craft, Air Cushion Speed

<table>
<tr><th>Characteristic</th><th colspan="4">Low Surf</th><th colspan="4">Medium Surf</th><th colspan="5">High Surf</th></tr>
<tr><td>Height (feet)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>Heading to Surf Line (degrees)</td><td colspan="4">90 ±10</td><td colspan="4">90 ±10</td><td colspan="5">90 ±10</td></tr>
<tr><td>Maximum Speed During Beach Approach (knots)</td><td colspan="4">50</td><td>50</td><td colspan="3">30</td><td>30</td><td colspan="4">20</td></tr>
<tr><td>Maximum Speed During Beach Departure (knots)</td><td colspan="4">25</td><td>25</td><td colspan="3">20</td><td>20</td><td colspan="4">10</td></tr>
<tr><td colspan="14">Notes:
• Inside the surf zone, craft speed is adjusted, taking into account wave speed, surf condition, beach gradient, beach terrain, and cargo load.
• Speed should be reduced with a steep beach gradient to avoid plow-in and hard-structure damage.
• The maximum surf height for structural design considerations is 8 feet. Transitioning through surf higher than 8 feet can result in damage to the craft structure or skirt.
• To minimize bow-skirt damage in high surf, depart the beach at an angle. Do not exceed 10 degrees from perpendicular.</td></tr>
</table>

Figure 3-8. Landing Craft, Air Cushion On-cushion Operations in Surf

3.7.2.5.1 Landing Craft, Air Cushion Beach Approach

Due to the vulnerability of LCAC propellers, LCAC surf operations differ from conventional landing craft operations. There is a great risk of taking plunging surf through the propellers, causing the loss of the craft—particularly on the approach to the beach. Operators need to time their beach approaches such that the LCAC arrives at the beach just behind a breaking wave. Waves should never be allowed to overtake the craft and break over the stern. The major factors are surf speed and available landing area. Once clear of the water and on land, the craft will tend to accelerate rapidly, potentially causing a hazardous situation if not stopped in the available landing area. The surf-to-land transition is summarized in Figure 3-8.

3.7.2.5.2 Landing Craft, Air Cushion Beach Departure

Due to propeller vulnerability, LCACs always enter the surf bow-on. The major considerations on departure are the beach gradient and the breaker height. Plow-in within the surf zone with accompanying hard-structure impact and damage to the craft can result if the beach departure is not timed correctly. The danger of plow-in increases with increasing breaker height or beach gradient steepness. LCACs can be operated satisfactorily in plunging surf if the operators study the wave patterns and frequency and time their departures to arrive at the breaker line during a reduced wave period (between wave crests). An angle of approach to the breaker line of 10 degrees is also used when heavy surf exists to reduce the possibility of plow-in.

3.7.2.5.3 Landing Craft, Air Cushion Maximum Approachable Slope

The LCAC is designed to climb up to a 6-degree beach gradient from a standing start. Climbing a beach gradient greater than 6 degrees requires forward speed prior to approaching the slope. Factors that influence the amount of speed required to climb a slope include available craft thrust, total craft weight, winds, and the gradient of the slope. Inclines in which the LCAC cannot climb from a standing start but can traverse given an initial speed are termed approachable slopes. The maximum approachable slope equates to the maximum slope an LCAC can safely traverse two craft lengths (160 feet) past the surf zone at a known craft weight and craft speed. A distance of two craft lengths beyond the point where the stern crosses the water's edge is the standard of beach traverse. For the LCAC, the maximum slope for which this penetration can be achieved is a function of approach speed and total craft weight at maximum continuous power. It is assumed that the ground is packed and reasonably smooth. S9LCA-AA-SSM-100, Volume VII, provides further guidance on how to compute maximum approachable slope.

3.7.2.5.4 Landing Craft, Air Cushion Slope for Continuous Climbing

Slopes that are small enough for LCACs to climb indefinitely are referred to as continuously climbable. The craft's maximum slope for continuous climbing varies with craft weight and environmental conditions (e.g., soft sand, tall grass, etc.). The maximum slope for continuous climbing is considered a go/no-go criterion when the craft landing zone is located inland greater than 160 feet from craft's penetration point at water's edge. S9LCA-AA-SSM-100, Volume VII, provides further guidance.

CHAPTER 4

Beach Surveys and Associated Beach Survey Reports

4.1 PURPOSE

Beach surveys provide a comprehensive overview of the beach and surf zone using a variety of resources, sensors, and on-scene data. Beach surveys provide the commander a summary of the characteristics of the selected beach and its surf zone for enhanced mission planning. The resulting beach survey report is typically presented to the operational commander prior to the confirmation brief. Beach surveys should support both displacement-hull watercraft and nondisplacement LCAC operations. Any exceptions must be noted in the survey report. The beach remains unsuitable for the omitted craft until appropriately surveyed. This chapter reviews who is responsible for conducting beach surveys, lists the necessary equipment, provides step-by-step procedures for completing a beach survey, and describes the elements of the resulting beach survey report.

4.2 SUGGESTED SCHEDULE FOR REQUESTING BEACH SURVEYS, ASSOCIATED REPORTS

Landing site surveys are conducted during the amphibious operation planning phase. Due to the significant planning required, a beach survey for a peacetime training or exercise event should be requested greater than 4 months in advance to the respective BMU, who will coordinate with NOMWC's littoral hydrographic survey (LHS) resources, NSW, FORECON, and/or EODMU-1 to conduct a rapid littoral survey (hydrographic survey). When requesting beach surveys with less than a 4-month notice, the operational commander will request a beach survey from the respective BMU and a hydrographic survey from NOMWC's LHS resources, NSW, FORECON, or EODMU-1. All beach surveys shall be conducted in accordance with Figure 4-1 at a minimum of every 24 months. A site survey is required to be completed for surveys that are greater than 12 months old. Appendix B provides a summary of support products available to the amphibious community from the various METOC commands.

4.3 RESPONSIBILITY FOR COMPLETING BEACH SURVEYS

Beachmaster unit beach party teams (BPTs) are responsible for completing beach surveys under permissive conditions from the 2-meter curve up to the beginning of the hinterland. Beachmaster personnel are neither trained nor equipped to conduct hydrographic surveys from the 2-meter curve out to the beginning of the offshore (seaward of the 10-meter charted depth). Navy special warfare or Marine Corps FORECON teams are preferred for conducting hydrographic surveys at contested landing sites. When specialized forces are required to conduct a hydrographic survey (e.g. LHS, NSW, FORECON, EODMU-1, etc.), they are requested by the operational commander. When a BMU is tasked to conduct a beach survey, their policy is that the survey is conducted by a qualified beach survey team officer in charge/commander and, whenever possible, a qualified craftmaster for the type of craft to be used. An LCAC detachment craftmaster and beachmaster officer in charge or assistant officer in charge conducts all LCAC landing site surveys. It is BMU policy that if a BPT commander/officer in charge/assistance officer in charge is unavailable for an LCAC landing site survey, then a senior beachmaster representative conducts the survey.

Beach Survey Report—Overview and Summary	
Introduction	Date and time of survey (Z and local time):
Designation and Location	Beach name: Note: Additional beach information provided in the following.
	Country name:
Survey Team Overall Summary/Recommendations	MSI: Low: High:
	LCAC operations (acceptable/waiver required/unacceptable).
	-Remarks:
	Conventional operations (acceptable/waiver required/unacceptable).
	-Remarks:
	Specific hazards/considerations to operations.
	ORM recommendations to mitigate.
	Surveyors' names.
	Other remarks.
Diagrams, Charts, Maps, Photographs	Beach diagram (include position and direction of photos taken).
	Charts (including edition, scale, datum, depths (feet/meters)).
	Maps (including scale).
	Photographs:
	-Aerial photos available.
	-Ground photos taken (exits, trafficability, surface features).
	-Offshore photos taken (approach lanes, landmarks).
	Other publications used.
Location Climatology	Average high temperature (by month).
	Average low temperature (by month).
	Precipitation (inches/millimeters).
	Other available climatology (snow, thunderstorm occurrence, winds, visibility/fog, cloud cover, extreme temperatures, ice incidence, etc.).
Beach Dimensions	Total length (yards/meters).
	Survey length (yards/meters).
	Usable length (yards/meters).
	Depth (width) of beach: maximum and minimum (yards/meters).
	Shape of beach (straight, concave, convex, etc.).
	Normal axis of beach.
	True degrees (facing shoreward) perpendicular to baseline.
	Left beach flank coordinates (latitude/longitude, datum, GPS FOM, UTM).
	Beach center coordinates (latitude/longitude, datum, GPS FOM, UTM).
	Right beach flank coordinates (latitude/longitude, datum, GPS FOM, UTM).

Figure 4-1. Elements of a Beach Survey Report (Sheet 1 of 4)

Beach Survey Report—Details	
Characteristics of Sea Approaches	Offshore NAVAIDS.
	Onshore NAVAIDS.
	Other approach landmarks and markings. Descriptions, latitude/longitude, military grid reference (to aid to landing team in identifying beach visually).
	Background lighting present.
	Offshore currents (velocity, direction, reference to specific charts (if any)).
	Types of sediment/substrate found in offshore (anchor-holding qualities).
	Any offshore obstructions (2-meter curve to seaward) (e.g., wrecks, coral reefs, sandbars, other offshore impediments). Note: Beachmaster personnel are not trained or equipped to conduct hydrographic surveys. Navy special warfare or Marine Corps FORECON teams are preferred for conducting hydrographic surveys and will provide a hydrographic survey report to all concerned.
Tidal Information	Tide type.
	Tidal range (observed/predicted).
	Stage of tide during survey.
	High tide: Time: Low tide: Time:
	Location of reference tidal gauge/station.
	Tidal currents present.
Surf and Breakers	ALPHA—significant breaker average (nearest 1/2 foot).
	BRAVO—maximum breaker height (feet).
	CHARLIE—breaker period (nearest 1/2 second).
	DELTA—breaker types. Percent plunging, percent spilling, percent surging.
	ECHO—breaker angle.
	FOXTROT—littoral currents.
	GOLF—width of surf zone.
	HOTEL—relative wind direction and speed.
	HOTEL—visibility.
	HOTEL—weather during survey.
	HOTEL—secondary wave system (period, direction).

Figure 4-1. Elements of a Beach Survey Report (Sheet 2 of 4)

Beach Survey Report—Details	
Nearshore Characteristics (2-meter to LWM)	Nearshore hydrographic survey available.
	Nearshore gradient (include units).
	Composition of nearshore sediment.
	Sea walls, jetties, breakwaters, groins, or bulwarks present.
	Wrecks in nearshore.
	Coral reefs or rocky outcrops in nearshore.
	Sandbars in nearshore.
	Rooted vegetation (kelp, grasses, reeds, etc.).
	Water clarity.
	Bioluminescence present.
	Marine animals present.
Foreshore Characteristics (LWM to HWM)	Foreshore gradient (include units).
	Types of sediment/substrate found in foreshore (type of sand or other material).
	Berm present. Describe.
	Sea walls, jetties, breakwaters, groins, or bulwarks present.
	Other obstructions to LCACs (height greater than 4 feet, short gradients greater than 10 degrees).
	Wrecks or natural obstructions (dunes, swamps, hills, mangroves, rocks, etc.).
	Locations and depths of streams crossing foreshore (tidal) flats.
	Vegetation. Salt marshes.
Beach Trafficability	**Wheeled (good, fair, poor)—Wet**
	Wheeled (good, fair, poor)—dry.
	Tracked (good, fair, poor)—wet.
	Tracked (good, fair, poor)—dry.
	Personnel (good, fair, poor)—wet.
	Personnel (good, fair, poor)—dry.
	Matting required (yes/no).
	Type of beach pack (soft sand, mud, etc.).
	Noted hazard zones for vehicular mobility (include obstructions to LCACs—height greater than 4 feet).
	Required construction to make beach trafficable prior to or during operation.
Backshore Characteristics (HWM to hinterland) Note: Depth of hinterland is approximately 10 kilometers or to nearest good road if less than 10 kilometers (per ATP-08(D)(1), Volume II, Tactics. Techniques, and Procedures for Amphibious Operations).	Types of sediment/substrate found in backshore.
	Backshore gradient (include units).
	Natural obstructions (dunes, swamps, hills, mangroves, rocks, etc.).
	Man-made obstructions present (walls, fortifications, etc.).
	Noted drop zones.
	Indigenous wildlife observed.

Figure 4-1. Elements of a Beach Survey Report (Sheet 3 of 4)

Beach Survey Report—Details	
Exits	Optimal terrain exits from beach (include grid reference and width of exit).
	Exits usable by infantry only.
	Paved exits from beach to interior (include grid reference and width of exit).
Cover and Concealment	Vegetation/large stands of brush or trees.
	Other natural concealment opportunities.
Local Area Information/Resources	**Helicopter landing sites.** Descriptions of man-made or natural areas that can be used for landing rotary-wing aircraft.
	Aviation facilities. List airfields in the general area.
	Port facilities. List any port facilities in the general area.
	Availability of fresh water in beach area.
	Proximity of tactical targets (towns, airfields, refineries, railroads, roads, etc.).
	Town or village shops for acquiring resources.
	Natural resources that can be used for occupation and transition.
	Any local contacts made over course of survey (enemy observed or encountered, police, port authority, husbanding agents, etc.).
Legend:	
FOM	figure of merit
NAVAIDS	navigational aids
ORM	operational risk management
HWM	high-water mark
UTM	universal transverse Mercator
Z	time zone indicator for Coordinated Universal Time

Figure 4-1. Elements of a Beach Survey Report (Sheet 4 of 4)

4.4 BEACH SURVEY KITS

The BMUs provide each BPT with two complete beach survey kits, enabling them to conduct surveys during split-amphibious ready group operations. The officer in charge signs for these materials and is responsible for their maintenance. Each beach survey kit includes:

1. Range finder
2. Global Positioning System device
3. Binoculars
4. Compass
5. Night-vision goggles
6. Note pad, pencil/pen
7. One hundred-foot plumb line with level
8. One hundred-foot tape measure
9. Stopwatch
10. Blank SUROB forms

11. Calculator
12. Handheld anemometer (wind gauge)
13. Ball-throwing device
14. Tennis ball (day); red chemical light (night)
15. Digital camera
16. Chart and topographical maps of assigned operational areas (if available)
17. Tides and currents information (if available)
18. Hydrographic survey (if available).

4.5 PROCEDURES FOR CONDUCTING BEACH SURVEYS

Surveys are optimally conducted over a 24-hour period to collect data over the daily tidal cycle, to document shipping/pedestrian traffic patterns, and to observe lighting conditions. If a 24-hour survey is not feasible, the minimum survey period should cover one complete tidal cycle. Survey teams should observe the day-to-night transition to evaluate the impact of background lighting on night-vision goggle operations. Beach party team tasks include:

1. Inventory survey kit and ensure all equipment is functioning properly.
2. Identify survey team members and establish a chain of command.
3. Assist in preselection of beach landing areas:
    a. Beach selection depends on the surf and beach conditions under exposure to different wave conditions.
    b. Obtain and review hydrographic information for each area.
    c. Obtain, review, and compare any available previous beach surveys for the landing areas. Determine the datum used for those surveys (coordinate with commander, amphibious task force (CATF), the craftmaster, and landing-force personnel). Verify the beach survey datum against the available chart datum. Ensure GPS is set to the appropriate datum.
4. Use prior beach surveys and other pertinent documents (e.g., charts, port directives, sailing directions, fleet guides, etc.) and assistance from the ship's navigation department to identify:
    a. Prevailing surf, sea, and swell.
    b. Tides.
5. Survey the beach and record beach measurements/information for D-day planning as described in the following:
    a. Determine the length, depth (width), and general shape of the usable beach area.
    b. Use magnetic compass bearings to identify the beach axis and baseline for the optimal beach approach.
    c. Determine the left beach flank, right beach flank and center beach coordinates. The distance between each area should be 100 feet or greater.

d. Determine other characteristics of the beach, to include the composition and gradient of the nearshore, foreshore, and backshore. Hydrographic surveys are used to determine composition and gradient from the water line to the 3 fathom curve/surf zone. Identify and describe any berms and other obstructions.

e. Identify reference points, to include landmarks and navigational aids.

f. Identify background lighting for potential impacts on landing craft and night-vision goggle operations.

g. Identify suitable egress points.

6. Take surf observations at high and low tide.

7. Take digital photos of the beach from different angles.

a. Use people or vehicles as size/distance references, if possible.

b. At least one photo should be taken that covers the entire beach. Other photos should include beach center looking left and right, from the left flank, from the right flank, and from seaward (day and night).

c. Photos should include offshore and onshore navigational aids (NAVAIDS) and/or obstructions.

8. Draw a diagram of the beach and shoreline. Be very detailed and clearly identify obstructions, distances, and dimensions involved.

a. Document the extent of submerged beach sections, especially during low-tide conditions.

b. Document the extent of foreshore.

c. Document the location of dry sections, to include berm and backshore, soft or hard sand, depth of sand, obstructions, or ground clutter.

d. Document the location of back beach area—dunes, swamps, hills, mangroves, and rocks.

e. Mark routes for all proposed craft landing zones.

9. Observe beach traffic (people/vehicles) and beach conditions affecting trafficability. Record and report changes to trafficability throughout the observation period.

a. Determine if the beach is conducive for personnel and wheeled/tracked vehicles. Annotate if wet/dry conditions are good, fair, or poor.

b. Determine if matting is required for wheeled and/or tracked vehicles.

c. Identify suitable vehicle staging areas.

d. Identify egress routes.

e. Evaluate changes to patterns throughout the observation period.

10. Draw wave refraction diagrams to show variations in surf conditions for different deep-water wave periods and directions.

11. Mark egress routes for all proposed craft landing zones.

12. Determine beach suitability for LCAC operations—the tidal effect on how many craft can be safely landed at one time at a craft landing zone.

13. Determine beach suitability for conventional displacement landing craft operations.

14. Determine how many crafts can be safely landed at one time and whether tidal patterns affect this capability.

15. Identify any unique ORM concerns (e.g., proximity to obstacles, shipping density, underwater obstacles, and restricted egress routes).

16. Complete a beach survey report and prepare a brief with supporting digital photos for the operational commander.

17. Route copies of the beach surveys to all appropriate decision-makers in the amphibious task force.

18. Archive beach surveys on appropriate websites.

4.6 ELEMENTS OF A BEACH SURVEY REPORT

Figure 4-1 is a merged listing of recommended elements of a beach survey report as found in ATP-08(D)(1), Volume II and historic Navy beachmaster handbooks. Individual elements may not be applicable depending upon the location of the landing and the specifics of the mission. The Navy BMU beach survey report form is provided in A.6 as an example.

4.7 SUBMISSION OF BEACH SURVEY REPORTS

Beach surveys completed greater than 4 months in advance of the planned operation will be forwarded to the appropriate BMU for review and approval by the commanding officer. Beach surveys completed while deployed will be reviewed and approved by the operational commander, and electronic copies will be forwarded to both BMU-1, BMU-2, and BMU-7 for archive. If unable to conduct a beach survey due to lack of timing or beach survey team assets, operational commanders should use any and all beach survey products available to them, to include foreign, NSW, and Marine Corps FORECON beach survey products. Use of a BPT, LCU, and LCAC craftmasters attached to an amphibious ready group to review these products will help inform the operational commander's decision on if a beach landing site is feasible for landings. In preparation for a normal deployment, the beach survey report is typically presented to the operational commander prior to the confirmation brief for all beaches that are planned for use. Forward surveys conducted within the Commander, United States SEVENTH Fleet area of responsibility to Commander, Amphibious Squadron ELEVEN and BMU-7. Beach survey reports conducted by the Marine Corps, BMUs, Navy Expeditionary Combat Command, or other expeditionary unit should be submitted to the respective amphibious ready group/task force intelligence who will forward them to the NAVOCEANO tactical operations center at EXWData@ocean.navo.navy.mil and https://www.ecr.cas.navy.smil.mil/mc/20.site.nsf/main.html?openpage for archiving and use by data analysts. Even old beach survey reports can contain valuable information not otherwise available.

CHAPTER 5
Surf Observations

5.1 TAKING SURF OBSERVATIONS

Accurate and timely surf observations play a key role in any decision concerning the safe transit of forces through a surf zone. Qualified personnel from NSW elements, underwater construction teams, or FORECON (depending upon the specific operation) can be tactically inserted to collect and transmit observational data on surf conditions via SUROB until conditions permit beachmaster personnel to assume that responsibility. Once deployed, beachmaster representatives maintain direct communications with CATF and the primary control ship and provide surf observations at hourly or other intervals designated by CATF. Beachmasters must promptly notify CATF and the primary control ship of changing beach conditions and be prepared to use emergency visual signals to turn away forces, if necessary.

Nighttime surf observations are less reliable than daylight observations. Darkness impedes an observer's ability to determine critical parameters such as breaker type, height, and angle. Nighttime observations should be validated by reviewing the preceding day's MSI trends to determine if the MSI is increasing, decreasing, or constant. Planners should consider surf trends and observations, and current and forecast METOC conditions to assess subsequent nighttime surf conditions.

5.2 SCHEDULING SURF OBSERVATIONS

Surf observations support a beach landing. A SUROB is required before or upon the initial landing. Follow-on SUROBs are normally conducted every hour during operations unless weather and sea states change or when directed by higher authority. The periodicity of SUROBs vary with the scope of the exercise and is usually defined in the operation order for the amphibious landing.

5.3 METHOD OF OBSERVATION

The height of breakers should be directly observed rather than estimated based on incoming deep-water wave heights. As waves approach a beach, they begin to feel bottom, slow, and build in height (the increased height is results from conservation of energy as the wave slows) until they reach a critical point and collapse as a breaker. Accurately estimating breaker height is difficult for inexperienced personnel. Breakers are usually larger than they appear from the beach. One method of visually estimating a breaker's height without mechanical or optical aids is to adjust one's position vertically so that the line of sight corresponds with an imaginary line drawn from the top of the breaker to the horizon. The vertical distance from this line to the lower limit of the backwash is the approximate height of the breaker. The lower limit of the backwash approximates the lower limit of the breaker trough. This procedure becomes progressively less accurate as distance to the backwash increases. This procedure is illustrated in Figure 5-1.

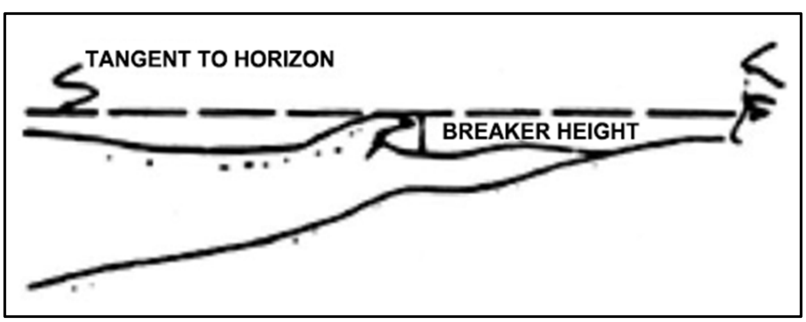

Figure 5-1. Method for Estimating Breaker Heights

5.4 ELEMENTS OF A SURF OBSERVATION

A SUROB requires observers to record wave heights and breaker types for 100 successive breakers (or 50 breakers in a combat or hostile environment) on a given date and time. These observations are used to determine SUROB values ALPHA through DELTA (discussed in more detail in the next subsection). Figure 5-2 displays an example report. Blank forms for logging data and calculating the individual elements of a surf observation are provided in Appendix A. The following describe the individual elements of a surf observation in more detail.

SUROB Number ___________ **for Beach** ___________________________________ **on Date-time (Z)** ___________________________ **Observer's Initials** ________	
ALPHA	____4.0____ **Significant Breaker Average** of highest 1/3 breakers (measured and reported to the nearest 1/2 foot)
BRAVO	____5.5____ **Maximum Breaker Height** (measured and reported to the nearest 1/2 foot)
CHARLIE	____7.5____ **Period** (reported to the nearest 1/2 second)
DELTA	_____5_____ **Percent Plunging;** _____95_____ **Percent Spilling;** _______ **Percent Surging**
ECHO	_____5_____ degrees towards (RIGHT/LEFT) Flank **(Breaker Angle)**
FOXTROT	____0.8_____ knots towards (RIGHT/LEFT) Flank **(Littoral)**
GOLF	___3___ to ___4___ lines in a ___300___ foot width **(Line of Breakers and Width of Surf Zone)**
HOTEL	____15____ knots at ___25___ degrees (ONSHORE/OFFSHORE); (RIGHT/LEFT) Flank **(Relative Wind Direction and Speed)**
	____10____ miles (visibility); unrestricted/overcast/foggy/hazy/clear **(Weather)**
	____N/A____ **Secondary Wave Height** (feet) _________ **Period** (seconds) _________ degrees towards (RIGHT/LEFT) Flank **(Secondary Wave System Angle)**, if applicable

Figure 5-2. Example Surf Observation Report

5.4.1 Significant Breaker Height (ALPHA)

The ALPHA entry is the significant breaker height—the average height of the one-third-highest breakers at a given location on a beach. To determine the average, go back to the observation form and count the number of times that the highest breaker occurred. Then count the number of times the next highest breaker height occurred. Continue the process until the occurrence column totals 33. Finally, the product column is added, and the total is divided by 33. Enter ALPHA to the nearest 1/2 foot. See Figure A-4 for an example table for computing significant breaker height.

5.4.2 Maximum Breaker Height (BRAVO)

The BRAVO entry documents the highest breaker observed on the beach. This observation is reported to the nearest 1/2 foot.

5.4.3 Breaker Period (CHARLIE)

The CHARLIE entry is the average breaker period—the computed average time interval between individual observed breakers. CHARLIE is determined by dividing the elapsed time span (in seconds) of a series of successive breakers by the number of breakers observed (typically 100). The resulting computed wave period is reported to the nearest 1/2 second. Figure A-3 provides an example computation worksheet.

Note

If more than one set of swells are forming breakers, count the breaking wave crests from the same set to determine each set's period. Do this for each set of swells to produce a more accurate MSI with respect to wave period.

5.4.4 Breaker Types (DELTA)

The DELTA entries document the types and percentage of observed breakers. Surging breakers mainly occur on beaches with steep gradients relative to the breaker height. They typically do not occur in conjunction with spilling breakers. See Figure A-2 for an example worksheet for documenting breaker type observations.

5.4.5 Breaker Angle (ECHO)

The ECHO entry is the angle at which the breakers are striking the beach—expressed as an acute (less than 90 degree) angle relative to either the right or left flank of the beach. Left flank and right flank refer to direction left or right as seen from boats and landing craft approaching the beach. This can be confusing. Observers must ensure that the direction toward which breakers are moving is reported is relative to being viewed from seaward. See Figure 5-2 for beach flank directions. If several breaker angles exist and breaker lines are moving toward both flanks, the appropriate ECHO entry would be, for example, 10–20 toward right/left flank. If the breakers are parallel to the beach, the entry would be zero toward right/left flank.

5.4.6 Littoral Current (FOXTROT)

The FOXTROT entry documents the direction and velocity (in knots) of the littoral current (also known as the longshore current) flowing adjacent to the shore. Such currents are caused by waves breaking against the beach at an angle and by nearshore bathymetric features. Littoral currents move parallel to and adjacent to the shoreline with maximum velocity occurring roughly two thirds the distance to the outermost breaker line from shore. Velocity is estimated by throwing a floating object into the fastest-moving part of the current, then pacing off the distance in feet the object moves in 1 minute. Each 10 feet of movement is approximately equal to a velocity of 1/10 knot. For example, an object that moves 80 feet toward the right flank in 1 minute would indicate a littoral current of about 0.8 knots. This method may underestimate the current by a small margin, unless the beach gradient is steep, and the surf zone width is small. Several measurements should be made, and the results averaged to ensure that the most representative current is reported. Currents are strongest following a set of waves. As with the ECHO entry, the reported direction of littoral current flow is left or right (left flank and right flank) as seen from boats and landing craft approaching the beach. This is the direction toward which the current would push a boat traveling toward the beach.

5.4.7 Width of Surf Zone and Number of Lines of Breakers (GOLF)

The surf zone extends from the outermost breaker line to the upper limit of the swash zone on the beach. The GOLF entry is determined by counting the number of lines of breakers within the surf zone and measuring the width of the surf zone in feet. The GOLF entry consists of the number of lines of breakers within the surf zone followed by the measured width of the surf zone.

5.4.8 Remarks (HOTEL)

The HOTEL entry is used to report any other significant factor that might affect boat operations such as wind direction and velocity, visibility, debris in the surf zone, secondary wave system, dangerous conditions, etc. Some mandatory remarks are:

1. **Relative wind direction and speed.** Estimate wind speed and determine relative wind direction, as indicated in Figure 5-3. Wind direction is always reported as the angle between the point from which the wind is blowing and a line normal (perpendicular) to the beach, the flank toward which it is blowing, and whether it is blowing onshore or offshore. Example entry using the Figure 5-2 diagram—REL WIND 025° 15 KTS R FLANK ONSHORE.

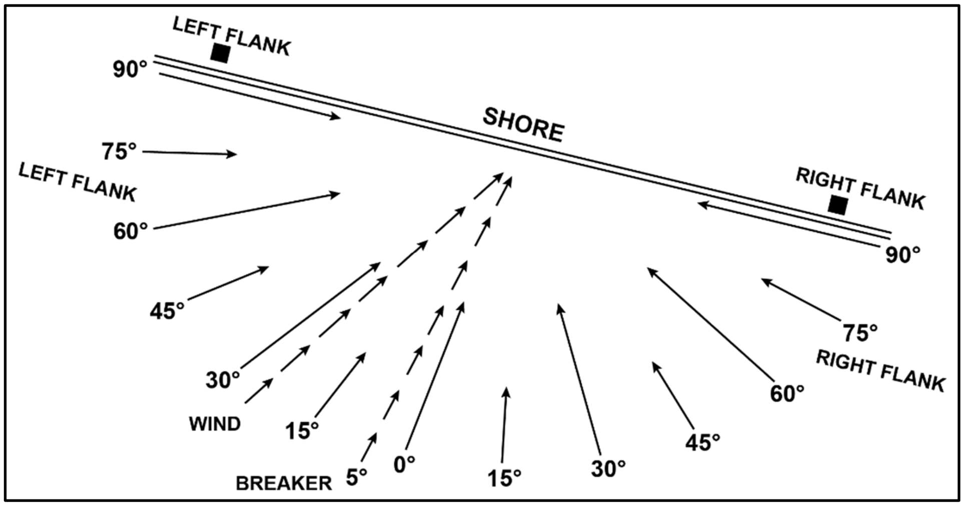

Figure 5-3. Relative Wind Direction to a Beach

2. **Weather.** Report presence of rain, thunderstorms, lightning, etc. Example: HEAVY RAIN/THUNDERSTORM 10 MILES SE.

3. **Visibility.** Estimate visibility in miles and report obstructions to vision. For example, VSBY SEAWARD UNRESTRICTED, VSBY INLAND 2 MILES FOG. (Note: VSBY is a weather community abbreviation for visibility.)

4. **Presence of a secondary wave system**. Report height, period, and angle.

5.5 SURF OBSERVATION REPORTS

Surf observation reports are passed to the CATF; the commander, MPF; the commander, landing force (CLF); the primary control officer; and the offload control officer. The SUROB format is the same format as the surf forecast (SURFCST) described in Chapter 6. The SUROB number, beach designation, and time of observation appear at the top of the message. The primary control officer uses the SUROB to calculate the MSI. The CATF uses the MSI to judge the feasibility of landing each type of lighterage and amphibious vehicle. Modified surf indexes are discussed in more detail in Chapter 7.

5.6 EXCHANGE OF SURF INFORMATION

Routine surf observations should be forwarded to the embarked strike group oceanography team, ship's company METOC personnel, or embarked mobile environmental team as directed at least every 12 hours for use in preparing surf forecasts. Surf observation reports that reflect unexpected changes in conditions should be forwarded at any time. At the conclusion of an operation, copies of all surf observations are provided to the NAVOCEANO TOC at EXWData@ocean.navo.navy.mil and the appropriate FWC for archiving.

CHAPTER 6
Surf Forecasts

6.1 SURF FORECASTS

Surf forecasts, whether prepared by METOC personnel directly supporting the operation, the Naval Oceanography Special Warfare Center (NOSWC), or the regional FWC, are created based on surf observations collected during the operation and on forecasted sea and weather conditions. Upon request, NAVOCEANO can prepare a numerical model to forecast surf conditions.

6.1.1 Suggested Schedule and Ordering

Surf forecasts are normally issued every 12 hours and are valid for 24 hours. These products can be requested from the NOSWC via the Navy Special Warfare Mission Support Portal at https://www.seal.navy.smil.mil/splash.asp or via email at mscmetocsupport@socom.smil.mil. Surf forecasts can be requested from the regional FWC or NAVOCEANO. Appendix B provides more information on related METOC support products and their ordering procedures.

6.1.2 Elements of Surf Forecast

Surf forecasts and surf observations use the same format. The beach designation and time of observation appear at the top of the message. The following are brief descriptions of each of the elements of a SURFCST.

ALPHA. Significant breaker height is the forecast average height of the expected one-third highest breakers on the specified beach. The unit of measure is feet.

BRAVO. Maximum breaker height is the forecast highest breakers that will occur during the period of the forecast. The unit of measure is feet.

CHARLIE. Breaker period is the forecast average time interval between breakers during the specified time frame of the forecast. The unit of measure is seconds.

DELTA. Breaker type is the forecast types of breakers and percentage of each that will occur during the period of the forecast.

ECHO. Breaker angle is the forecast acute angle (degrees) and direction relative to the beach (towards right or left flank) that breakers will make with the beach during the period of the forecast. Left flank and right flank refer to direction left or right as seen from boats and landing craft approaching the beach.

FOXTROT. Littoral current is the direction and speed (knots) of the littoral current during the period of the forecast. Littoral currents move parallel to and adjacent to the shoreline with maximum velocity at roughly two thirds of the distance to the outermost breaker line from shore. Currents are strongest following a set of waves. The forecast direction, specified as either left flank and right flank, refers to the relative direction (to the left or to the right) the current is moving towards as seen from boats and landing craft approaching the beach. The unit of measure is knots.

GOLF. Surf zone is the forecast of the number of lines of breakers and the width of the surf zone in feet during the period of the forecast. The surf zone extends from the outermost breaker line to the limit of the uprush on the beach. The unit of measure is feet.

HOTEL. Remarks is used to forecast any additional elements that could influence successful boat operations (e.g., wind direction and velocity, visibility, a secondary wave system, etc.).

6.1.3 Sample Transmitted Surf Forecast

In an onsite forecaster is unavailable, forecast elements can be acquired from the regional FWC, the NOSWC, or NAVOCEANO. The following is an example SURFCST:

```
SURFCST WILSON COVE VALID 180600U TO 190600U

ALPHA 3 PT 5

BRAVO 4 PT 5

CHARLIE 8 TO 10

DELTA 100 SPILLING

ECHO 5 DEG RIGHT FLANK

FOXTROT 0 PT 5 RIGHT FLANK

GOLF 3 TO 4 LINES 150 FT

HOTEL DELTA BECOMING 50 PLUNGING 50 SPILLING BY 181200U
```

6.2 AMPHIBIOUS BATTLESPACE FORECASTS

Amphibious objective area forecasts (AOAFCSTs) are one of the three types of special Marine Corps METOC summaries that provide METOC information and support for specific Marine air-ground task force (MAGTF) operations and/or functions. The other two categories of special METOC summaries are strike forecasts and assault forecasts.

6.2.1 Amphibious Objective Area Forecast

The AOAFCST supports amphibious rehearsals and landings. It includes a plain-language meteorological situation, a 24-hour forecast for the amphibious objective/landing area, SURFCSTs for target beaches, a tactical assessment, an abbreviated atmospheric summary, and astronomical data. A radiological and chemical fallout forecast is appended as the tactical situation dictates.

6.2.2 Elements of Amphibious Objective Area Forecasts

Figure 6-1 provides an example AOAFCST. The AOAFCST is inserted into the MAGTF Standard Tactical METOC Support Plan of a Marine Expeditionary Force (MEF) Operation Order. A SURFCST is typically embedded as section 3 of these forecasts.

```
                                   I MARINE EXPEDITIONARY FORCE
                                         CAMP PENDLETON BLUELAND
                                                 012200T MAR 16
(PASS TO (CATF/CLF/MEF WEATHER SUPPORT TEAM/ACE))
MSGID/GENADMIN/UNIT/SERIAL/MON/YR//
SUBJ/AMPHIBIOUS OBJECTIVE AREA FORECAST (AOAFCST)//
RMKS/

1. METEOROLOGICAL SITUATION AT Z

2. 24-HOUR FORECAST COMMENCING Z FOR AMPHIBIOUS OBJECTIVE AREA
(Note: Include separate forecast for landing area if significantly
different from amphibious objective area weather.)
  a. Sky/Weather
  b. Visibility (nautical miles)
  c. Surface Winds (knots)
  d. Maximum/Minimum Temperatures (°F) (Note: include wind-chill
  factor/heat index, if applicable.)
  e. Sea Surface Temperature (°F)
  f. Combined Seas (feet)
  g. In-water Survival Time (hours)
  h. Aviation Parameters
    (1) Clouds/Ceilings (feet)
    (2) Winds/Temperatures Aloft (flight level/direction/speed
    (knots)/temperatures (°C))
    (3) Turbulence
    (4) Freezing Level (feet)
    (5) Icing
    (6) Minimum Altimeter Setting (inches of mercury)
    (7) Maximum Pressure Altitude (PA)/Density Altitude (DA)
    (8) Contrail Formation
    (9) Slant-range Visibility (nautical miles).

3. SURF FORECAST FOR (RED)/(BLUE) BEACH
  a. ALPHA. Significant Breaker Height (nearest 1/2 foot)
  b. BRAVO. Maximum Breaker Height (nearest 1/2 foot)
  c. CHARLIE. Dominant Breaker Period (nearest 1/2 second)
  d. DELTA. Dominant Breaker Type (percent spilling, plunging,
  surging)
  e. ECHO. Breaker Angle (degrees)
  f. FOXTROT. Littoral Current (knots)
  g. GOLF1. Number of Lines of Breakers.
     GOLF2. Surf Zone Width (feet)
  h. MSI
  i. High/Low Tides (Coordinated Universal Time (UTC) or Local)
  j. Beach Conditions (summary of hydrographic reconnaissance data,
  including bottom type, beach slope/type/trafficability, and
  significant obstacles (locations) ashore and in shallows).
```

Figure 6-1. Example Amphibious Objective Area Forecast (Sheet 1 of 2)

```
4. TACTICAL ASSESSMENT (discussion of modified surf limits for
various landing craft types, discussion of no-go criteria, LCAC
limitations, etc.)

5. ATMOSPHERIC REFRACTIVE SUMMARY
  a. Evaporative Duct Height (feet)
  b. Surface-based Duct Height (feet)
  c. Elevated Duct Heights (Bottom top) (feet)
  d. Radar Propagation Conditions Summary
    (1) Surface-to-surface Radar Ranges (Note: Expand on the
    guidance contained in electromagnetic (EM) propagation
    conditions summary module.)
    (2) Surface-to-air Radar Ranges
    (3) Air-to-air Radar Ranges
    (4) Air-to-surface Radar Ranges
  e. Communication Range Predictions
    (1) Ultrahigh Frequency Communication Range
    (Normal/Extended/Greatly Extended)
    (2) High-frequency Radio Propagation Summary

6. ASTRONOMICAL DATA (UTC OR LOCAL)
  a. Sunrise/Sunset
  b. Beginning Morning Nautical Twilight/Begin Morning Civil
  Twilight/End Evening Civil Twilight/End of Evening Nautical
  Twilight
  c. Moonrise/Moonset/Percent Illumination
  d. Night-vision Effectiveness (Lumens)

7. 24-HOUR RADIOLOGICAL FALLOUT/CHEMICAL FALLOUT FORECAST
(Note: Include as tactical situation dictates.)
  a. Effective Downwind Direction (true)/Speed (knots)
  b. Distance (nautical miles)

8. RELEASED BY (Note: Include when minimize imposed.)//
DECL///
```

Figure 6-1. Example Amphibious Objective Area Forecast (Sheet 2 of 2)

CHAPTER 7

Modified Surf Index

7.1 DESCRIPTION AND USE OF THE MODIFIED SURF INDEX

The MSI is a dimensionless number, derived from data supplied within SUROBs and SURFCSTs that gives the commander an objective metric for evaluating the feasibility of landing operations using different types of amphibious vehicles and landing craft with the exception of LCACs, rigid raiding crafts, and CRRCs. LCACs, being nondisplacement watercraft, are not affected in the same way displacement-hull watercraft are by the elements that factor into the MSI value. Raiding craft (CRRC, rigid raiding craft) operations are generally only conducted in benign surf conditions where the SWH is 1 foot or less.

7.2 MODIFIED SURF LIMITS FOR WATERCRAFT

Both training/operations and wartime MSI limits are assigned to individual types of displacement amphibious vehicles and landing craft. They represent the maximum surf conditions that should be attempted for routine operations.

WARNING

Conducting displacement craft operations in conditions exceeding the crafts' MSI limits risks capsizing, broaching, or sinking; loss of equipment; and possible injury or death.

If the MSI is less than the MSI limit of the craft, the landing is feasible. Figure 7-1 provides current MSI limits for various types of displacement watercraft.

Watercraft	Training/Operations MSIs	Wartime MSIs
LARC-V/LCM-8	6*	9
LCU	6*	12
INLS CF, WT	6	9
MPFUB	3	3
AAV	6	6
ACV	4**	4**

* The standard maximum MSI for LCU and LCM-8 operations is four during normal peacetime operations when seaward salvage is not available. The LCU and LCM MSIs listed previously are for normal peacetime operations when seaward salvage is available.

** Modified surf index littoral current value is not to exceed 1 knot.

Legend:

CF	causeway ferry
INLS	improved Navy lighterage system
MPFUB	maritime prepositioning force utility boat
WT	warping tug

Figure 7-1. Watercraft Modified Surf Index Limits

7.3 MODIFIED SURF INDEX CALCULATIONS AND TABLES

Modified surf indexes can be calculated from data contained in a SUROB or a SURFCST. The beachmaster community has developed a combination SUROB/MSI Calculation Worksheet for recording observations of the individual elements of a surf observation and for computing an MSI from the resulting surf observation values (Figure 7-2). The six modification tables required to calculate an MSI value are shown in Figures 7-3 thru 7-8. A blank copy of the MSI calculation worksheet is also provided in A.5.

Modified Surf Index Calculation Sheet		
Date/Time of SUROB Report/SURFCST: ______ **Beach Designation:** ______ ______ **Required SUROB Report/SURFCST Elements:**	**A:** ______ (significant breaker height—feet) **C:** ______ (average breaker period–seconds) **D:** ______ (% spilling ______ % surging) **E:** ______ (breaker angle—degrees) **F:** ______ (wind speed–knots) **H:** ______ (wind speed–knots; onshore/offshore) **H:** ______ (secondary wave height—feet (if applicable))	
1. **Significant Breaker Height.** Enter reported/forecast **ALPHA** value (i.e., average significant breaker height to nearest 1/2 foot) for specified beach.		______
2. **Breaker Period Modification Value.** Using reported/forecast **CHARLIE** value (i.e., average breaker period to nearest 1/2 second) and the reported/forecast **ALPHA** (step 1), obtain a breaker period modification value from the Breaker Period Modification Table (Figure 7-3).		______
3. **Breaker Type Modification Value.** Use the reported/forecast **ALPHA** (step 1) and the reported/forecast **DELTA** percent value for the breaker type (spilling or surging) that occurred more often to obtain an MSI breaker type modification from either Figures 7-4 or 7-5, as appropriate. Notes: • No modification for plunging breakers. • Round up to the reported **DELTA** value to the next higher percent value listed on the vertical axis of the selected figure before applying it to the table.		______
4. **Breaker Angle Modification Value.** Use the reported/forecast **ALPHA** (step 1) and the reported/forecast **ECHO** value (i.e., breaker angle) within the Wave Angle Modification Table (Figure 7-6) to obtain an MSI wave angle modification value.	______	
5. **Littoral Current Modification Value.** Apply the reported/forecast **FOXTROT** value (i.e., littoral current speed in knots) to the Littoral Current Modification Table (Figure 7-7) to obtain an MSI littoral current modification value.	______	
6. Enter the larger of the two values determined in previous steps 4 and 5.		______
7. **Wind Modification Value.** Apply the reported/forecast wind direction (onshore/offshore) and velocity (knots) values (i.e., **HOTEL**) to the Wind Modification Table (Figure 7-8) to obtain a wind modification value.		______
8. **Secondary Wave Height.** Enter reported/forecast secondary wave height (to the nearest 1/2 foot) for specified beach (if applicable).		______
9. **Modified Surf Index.** Sum all entries in the right-hand column to obtain the MSI.		______

Figure 7-2. Modified Surf Index Calculation Sheet

Breaker Period (seconds)												
	17	0	0	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.0
	16	0	0	0	-0.1	-0.1	-0.2	-0.3	-0.3	-0.4	-0.5	-0.7
	15	0	0	0	0	-0.1	-0.1	-0.2	-0.2	-0.2	-0.3	-0.3
	14	0	0	0	0	0	0	0	0	0	0	0
	13	0	0	0	0	0.1	0.1	0.1	0.2	0.2	0.3	0.3
	12	0	0	0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7
	11	0	0	0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0
	10	0	0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3
	9	0	0	0.1	0.1	0.3	0.3	0.6	0.8	1.1	1.3	1.7
	8	0	0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0
		0	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
		Significant Breaker Height (feet)										

Figure 7-3. Modified Surf Index Breaker Period Modification Table

Percent Spilling Breakers												
	100	0	-0.1	-0.2	-0.5	-0.8	-1.3	-1.8	-2.5	-3.2	-4.1	-5.0
	90	0	0	-0.2	-0.4	-0.7	-1.1	-1.6	-2.2	-2.9	-3.6	-4.5
	80	0	0	-0.2	-0.4	-0.6	-1.0	-1.4	-2.0	-2.6	-3.2	-4.0
	70	0	0	-0.1	-0.3	-0.6	-0.9	-1.3	-1.7	-2.2	-2.8	-3.5
	60	0	0	-0.1	-0.3	-0.5	-0.8	-1.1	-1.5	-1.9	-2.4	-3.0
	50	0	0	-0.1	-0.2	-0.4	-0.6	-0.9	-1.2	-1.6	-2.0	-2.5
	40	0	0	-0.1	-0.2	-0.3	-0.5	-0.7	-1.0	-1.3	-1.6	-2.0
	30	0	0	-0.1	-0.1	-0.2	-0.4	-0.5	-0.7	-1.0	-1.2	-1.5
	20	0	0	0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.0
	10	0	0	0	0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5
	0	0	0	0	0	0	0	0	0	0	0	0
		0	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
		Significant Breaker Height (feet)										

Figure 7-4. Modified Surf Index Spilling Breaker Modification Table

Percent Surging Breakers												
	100	0	0.1	0.2	0.5	0.8	1.3	1.8	2.5	3.2	4.1	5.0
	90	0	0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.8	4.7
	80	0	0	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.6	4.5
	70	0	0	0.2	0.4	0.6	1.0	1.5	2.0	2.7	3.4	4.2
	60	0	0	0.2	0.3	0.6	1.0	1.4	1.9	2.5	3.1	3.9
	50	0	0	0.1	0.3	0.6	0.9	1.3	1.7	2.3	2.9	3.5
	40	0	0	0.1	0.3	0.5	0.8	1.1	1.5	2.0	2.6	3.2
	30	0	0	0.1	0.2	0.4	0.7	1.0	1.3	1.8	2.2	2.7
	20	0	0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.2
	10	0	0	0.1	0.1	0.3	0.4	0.6	0.7	1.0	1.3	1.6
	0	0	0	0	0	0	0	0	0	0	0	0
		0	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
		Significant Breaker Height (feet)										

Figure 7-5. Modified Surf Index Surging Breaker Modification Table

Wave Angle (degrees)												
	40	0	0.1	0.3	0.7	1.3	2.0	2.9	3.9	5.1	6.5	8.0
	35	0	0.1	0.3	0.6	1.1	1.8	2.5	3.4	4.5	5.7	7.0
	30	0	0.1	0.2	0.5	1.0	1.5	2.2	2.9	3.8	4.9	6.0
	25	0	0.1	0.2	0.5	0.8	1.3	1.8	2.5	3.2	4.1	5.0
	20	0	0	0.2	0.4	0.6	1.0	1.4	2.0	2.6	3.2	4.0
	15	0	0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	3.0
	10	0	0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0
	5	0	0	0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0
	0	0	0	0	0	0	0	0	0	0	0	0
		0	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
		Significant Breaker Height (feet)										

Figure 7-6. Modified Surf Index Wave Angle Modification Table

Current (knots)	Modification Value
0.0	0.0
0.1	0.3
0.2	0.6
0.3	0.9
0.4	1.2
0.5	1.5
0.6	1.8
0.7	2.1
0.8	2.4
0.9	2.7
1.0	3.0
1.1	3.3
1.2	3.6
1.3	3.9
1.4	4.2
1.5	4.5
1.6	4.8
1.7	5.1
1.8	5.4
1.9	5.7
2.0	6.0
2.1	6.3
2.2	6.6
2.3	6.9
2.4	7.2
2.5	7.5
2.6	7.8
2.7	8.1
2.8	8.4
2.9	8.7
3.0	9.0

Figure 7-7. Modified Surf Index Littoral Current Modification Table

Wind Speed (knots)		Onshore			Offshore		
	36–40	2.0	3.0	4.0	1.5	2.0	4.0
	31–35	1.5	2.0	3.0	1.0	1.5	3.0
	26–30	1.0	1.5	2.0	0.5	1.0	2.0
	21–25	0.5	1.0	1.5	0	0.5	1.5
	16–20	0	0.5	1.0	0	0	1.0
	11–15	0	0.5	1.0	0	0	1.0
	6–10	0	0	0.5	0	0	0.5
	0–5	0	0	0	0	0	0
		0–30	**30–60**	**60–90**	**0–30**	**30–60**	**60–90**
		Wind Angle Relative to the Beach (degrees)					

Figure 7-8. Modified Surf Index Wind Modification Table

APPENDIX A

Worksheets Commonly Used During Surf Operations

A.1 INTRODUCTION

For ease of copying and use independent of this publication, this appendix contains the following worksheets commonly used during surf operations.

Figure A-1. Index of Appendix A

A.2 ONE HUNDRED WAVE COUNT TABLE

Surf Observation Wave Data for Beach ________________________________ on Date-time (Z) _________________________ Observer's Initials ________											
Wave Number	**Wave Height (feet)**	**Wave Type**	**Wave Number**	**Wave Height (feet)**	**Wave Type**	**Wave Number**	**Wave Height (feet)**	**Wave Type**	**Wave Number**	**Wave Height (feet)**	**Wave Type**
1			26			51			76		
2			27			52			77		
3			28			53			78		
4			29			54			79		
5			30			55			80		
6			31			56			81		
7			32			57			82		
8			33			58			83		
9			34			59			84		
10			35			60			85		
11			36			61			86		
12			37			62			87		
13			38			63			88		
14			39			64			89		
15			40			65			90		
16			41			66			91		
17			42			67			92		
18			43			68			93		
19			44			69			94		
20			45			70			95		
21			46			71			96		
22			47			72			97		
23			48			73			98		
24			49			74			99		
25			50			75			100		
Legend: S spilling wave P plunging wave X surging wave											

Figure A-2. One Hundred Wave Count Table

A.3 SIGNIFICANT BREAKER HEIGHT AND AVERAGE BREAKER PERIOD COMPUTATION TABLES

The following tables are provided as templates for quickly computing significant breaker height (ALPHA) and average breaker period (CHARLIE).

A.3.1 Significant Breaker Height (ALPHA) Computation

The following instructions are provided for quickly computing significant breaker height (ALPHA):

1. From the 100 wave count table (Figure A-2) of breaker observations, count the number of times that the highest breaker height occurred. Enter that breaker height and number of observations in the following table.

Next count the number of times the next highest breaker height occurred. Add this data to the following table. Continue the process until the occurrence column totals to 33.

Wave Height (feet)	(times)	Number of Occurrences	(equals)	Product
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
	×		=	
			Total	
			Divide by	**33**
			Result (ALPHA)	
Notes: Report ALPHA (significant breaker height) to nearest 1/2 foot.				

Figure A-3. Significant Breaker Height Computation Table

2. Multiply each wave height value (left column) by its corresponding number of occurrences (center column). Enter the totals in the right-hand product column.

3. Sum the values in the product column.

4. Divide the total by 33. The resulting ALPHA value should be reported to the nearest 1/2 foot.

A.3.2 Breaker Period (CHARLIE) Computation

Average Breaker Period Calculation	Time (hour-minutes-seconds)
Start Time of 100-wave Observation Period	
Stop Time of Observation Period	
Time Difference	
Time Difference (converted to seconds)	
Average Breaker Period (CHARLIE) (divide time difference by 100)	
Notes: Report CHARLIE (average breaker period) to nearest 1/2 second.	

Figure A-4. Breaker Period Computation Table

A.4 SURF OBSERVATION REPORT FORM

SUROB Number ___________ for Beach ___________________________________ **on Date-time (Z) ___________________________ Observer's Initials ________**	
ALPHA	________ **Significant Breaker Average** of highest 1/3 breakers (measured and reported to the nearest 1/2 foot)
BRAVO	_________ **Maximum Breaker Height** (measured and reported to the nearest 1/2 foot)
CHARLIE	_________ **Breaker Period** (reported to the nearest 1/2 second)
DELTA	_________ **Percent Plunging;** _______ **Percent Spilling;** _______ **Percent Surging**
ECHO	_________ degrees towards (RIGHT/LEFT) Flank **(Breaker Angle)**
FOXTROT	_________ knots towards (RIGHT/LEFT) Flank **(Littoral Current)**
GOLF	______ to ______ lines in a ______ foot width **(Line of Breakers and Width of Surf Zone)**
HOTEL	_________ knots at ________ degrees (ONSHORE/OFFSHORE); (RIGHT/LEFT) Flank **(Relative Wind Direction and Speed)**
	_________ miles (VISIBILITY); unrestricted/overcast/foggy/hazy/clear (Weather)
	_________ **Secondary Wave Height** (feet) _______ **Period** (seconds) _______ degrees towards (RIGHT/LEFT) Flank **(Secondary Wave System Angle)**, if applicable

- - - - - - - - - - - - - - - - (cut here to create two individual SUROB forms for field use) - - - - - - - - - - - - -

SUROB Number ___________ for Beach ___________________________________ **on Date-time (Z) ___________________________ Observer's Initials ________**	
ALPHA	_________ **Significant Breaker Average** of highest 1/3 breakers (measured and reported to the nearest 1/2 foot)
BRAVO	_________ **Maximum Breaker Height** (measured and reported to the nearest 1/2 foot)
CHARLIE	_________ **Period** (reported to the nearest 1/2 second)
DELTA	_________ **Percent Plunging;** _______ **Percent Spilling;** _______ **Percent Surging**
ECHO	_________ degrees towards (RIGHT/LEFT) Flank **(Breaker Angle)**
FOXTROT	_________ knots towards (RIGHT/LEFT) Flank **(Littoral)**
GOLF	______ to ______ lines in a _______ foot width **(Line of Breakers and Width of Surf Zone)**
HOTEL	_________ knots at ________ degrees (ONSHORE/OFFSHORE); (RIGHT/LEFT) Flank **(Relative Wind Direction and Speed)**
	_________ miles (VISIBILITY); unrestricted/overcast/foggy/hazy/clear **(Weather)**
	_________ **Secondary Wave Height** (feet) _________ **Period** (seconds) _________ degrees towards (RIGHT/LEFT) Flank **(Secondary Wave System Angle)**, if applicable

Figure A-5. Example Surf Observation Report Forms

A.5 MODIFIED SURF INDEX CALCULATION SHEET

<table>
<tr><th colspan="3">Modified Surf Index Calculation Sheet</th></tr>
<tr><td colspan="2">Date/Time of SUROB Report/SURFCST: ______________
Beach Designation: ________________________________
____
Required SUROB Report/SURFCST Elements:</td><td>A: ________ (significant breaker height—feet)
C: ________ (average breaker period–seconds)
D: ________ (% spilling ________ % surging)
E: ________ (breaker angle—degrees)
F: ________ (wind speed–knots)
H: ________ (wind speed–knots; onshore/offshore)
H: ________ (secondary wave height—feet (if applicable))</td></tr>
<tr><td colspan="2">1. Significant Breaker Height. Enter reported/forecast ALPHA value (i.e., average significant breaker height to nearest 1/2 foot) for specified beach.</td><td>____________</td></tr>
<tr><td colspan="2">2. Breaker Period Modification Value. Using reported/forecast CHARLIE value (i.e., average breaker period to nearest 1/2 second) and the reported/forecast ALPHA (step 1), obtain a breaker period modification value from the Breaker Period Modification Table (Figure 7-3).</td><td>____________</td></tr>
<tr><td colspan="2">3. Breaker Type Modification Value. Use the reported/forecast ALPHA (step 1) and the reported/forecast DELTA percent value for the breaker type (spilling or surging) that occurred more often to obtain an MSI breaker type modification from either Figures 7-4 or 7-5, as appropriate.
Notes:
• No modification for plunging breakers.
• Round up to the reported DELTA value to the next higher percent value listed on the vertical axis of the selected figure before applying it to the table.</td><td>____________</td></tr>
<tr><td>4. Breaker Angle Modification Value. Use the reported/forecast ALPHA (step 1) and the reported/forecast ECHO value (i.e., breaker angle) within the Wave Angle Modification Table (Figure 7-6) to obtain an MSI wave angle modification value.</td><td>____________</td><td rowspan="2"></td></tr>
<tr><td>5. Littoral Current Modification Value. Apply the reported/forecast FOXTROT value (i.e., littoral current speed in knots) to the Littoral Current Modification Table (Figure 7-7) to obtain an MSI littoral current modification value.</td><td>____________</td></tr>
<tr><td colspan="2">6. Enter the <u>larger</u> of the two values determined in previous steps 4 and 5.</td><td>____________</td></tr>
<tr><td colspan="2">7. Wind Modification Value. Apply the reported/forecast wind direction (onshore/offshore) and velocity (knots) values (i.e., HOTEL) to the Wind Modification Table (Figure 7-8) to obtain a wind modification value.</td><td>____________</td></tr>
<tr><td colspan="2">8. Secondary Wave Height. Enter reported/forecast secondary wave height (to the nearest 1/2 foot) for specified beach (if applicable).</td><td>____________</td></tr>
<tr><td colspan="2">9. Modified Surf Index. Sum all entries in the right-hand column to obtain the MSI.</td><td>____________</td></tr>
</table>

Figure A-6. Modified Surf Index Calculation Sheet

(CLASSIFICATION)
(When filled in, properly classify as UNCLASSIFIED, CUI, CONFIDENTIAL, SECRET, etc.)

A.6 BEACH NAME BEACH SURVEY REPORT

A.6.1 Date/Time (DDMMMYY/HHMM) of Survey (Commencement/Completion)

(Zulu): __________/___________

(Local): __________/___________

A.6.2 Date of Previous Survey: ______________

A.6.3 Designation and Location

A.6.3.1 Designation:

1. Beach location/name: ____________________
2. Beach left flank: DD MM SS.S N/S/DDD MM SS.S E/W GPS FOM: X
3. Beach center: DD MM SS.S N/S/DDD MM SS.S E/W
4. Beach right flank: DD MM SS.S N/S/DDD MM SS.S E/W
5. Beach center UTM coordinate: ______________

Note

DDD (or DD) MM SS.S N/S/E/W means degrees, minutes, seconds north/south/east/west.

A.6.3.2 Country: ____________________

A.6.4 Charts, Maps, Publications, and Photographs

A.6.4.1 Charts

1. Publisher (NGA, British Admiralty, etc.): ______________
2. Edition: ______________
3. Datum: ______________
4. Scale: ______________
5. Depth (fathoms, meters, or feet): ______________

A.6.4.2 Maps

1. United States Marine Corps/United States Army map associated with the area: ______________
2. Scale: ______________
3. Grid Reference: ______________

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A.6.4.3 Publications

Reference to relevant publications (e.g., sailing directions, coastal pilots, local publications, etc.).

A.6.5 Meteorology

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average High Temperature													
Average Low Temperature													
Precipitation (R or S in inches)													

Climatology remarks. Unique regional climatology that may affect operations (e.g., winds, sandstorms, ice floes, fog, etc.).

A.6.6 General Remarks

A brief paragraph is required to set the scene (location, size, nature of the beach, and exit possibilities). It should include notes on the proximity of tactical targets (e.g., towns, airfields, refineries, etc.) and any overriding virtue or limitation. A drawing is requested to facilitate understanding of the beach layout (see Figure A-7).

A.6.7 Sea Approaches

A.6.7.1 Landmarks

Description and reference points in latitude and longitude, and military grid reference.

A.6.7.2 Approaches

1. General information on the approach from nearest navigable waters to the beach.

Note

During amphibious landings, naval beach groups divide the coastal zone into three segments for survey purposes:

a. **Offshore segment.** Seaward of 10-meter charted depth and annotated on charts.

b. **Nearshore segment.** Between 10-meter curve and the low-water mark.

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Note

Under benign conditions, a beach survey team member will walk out into the water to approximately the 2-meter curve and identify the locations of hazards and obstructions between the 2-meter depth and the low water mark. Supplementary littoral hydrographic survey resources are required to survey from the 2-meter curve out to the 10-meter depth.

c. **Foreshore/backshore segment.** Between low-water mark and beginning of the hinterland.

2. Locations and depths of hazards (e.g., reefs, bars, rocks, grass, reeds, undergrowth, shoals, and wrecks).

3. Location of hazards to LCAC movements.

A.6.7.3 Possible Craft and Ship Anchorages

To include location (range and bearing from beach center), depths, bottom materials, holding qualities and exposure.

A.6.7.4 Sea, Surf, and Swell

1. Low-tide time: HHMMZ/HHMM (local time zone)

2. Low-tide height (feet): ______________

3. High-tide time: HHMMZ/HHMM (local time zone)

4. High-tide height (feet): ______________

5. Location of reference station: ______________

6. SUROB (measured at highest tide):

ALFA	feet: ____________________
BRAVO	feet: ____________________
CHARLIE	seconds or minutes: ____________________
DELTA	percent plunging: ____________________
	percent spilling: ____________________
FOXTROT	knots: ____________________
GOLF	feet: ____________________
HOTEL	knots: ____________________

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(When filled in, properly classify as UNCLASSIFIED, CUI, CONFIDENTIAL, SECRET, etc.)

VISIBILITY miles: ____________________

MSI: ____________________

7. SUROB (measured at lowest tide):

ALFA feet: ____________________

BRAVO feet: ____________________

CHARLIE seconds or minutes: ____________________

DELTA percent plunging: ____________________

percent spilling: ____________________

FOXTROT knots: ____________________

GOLF feet: ____________________

HOTEL knots: ____________________

VISIBILITY miles: ____________________

MSI: ____________________

A.6.7.5 Offshore Current (If Not Included in Area or Sector Description)

Velocity and direction, to include seasonal characteristics. Reference to current tables and charts (if any).

A.6.7.6 Sea Ice Conditions (if any): ____

A.6.7.7 Hydrographic Survey Conducted By: ____________________ Date: ______________

A.6.8 Beaches

A.6.8.1 Diagram of Beach using PowerPoint or Paint (Separate Sheet)

A.6.8.2 Dimensions of the Beach

1. Total length: ____________ Yards: ____________ Meters: ____________
2. Survey length: ____________ Yards: ____________ Meters: ____________
3. Usable length: ____________ Yards: ____________ Meters: ____________
4. Depth of beach: __________ Yards: ____________ Meters: ____________
5. Center of beach depth: ____________ Yards: ____________ Meters: ____________
6. Maximum width: ____________ Yards: ____________ Meters: ____________

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7. Minimum width: ____________ Yards: ____________ Meters: ____________

8. Shape of the beach: Convex/Concave/Straight

9. Normal axis of the beach: ____________ degrees

10. Approach axis of the beach from center of beach ____________ degrees

A.6.8.3 Nature

1. Nature of the beach. The type of sand and/or other material.

2. Trafficability. GOOD or BAD.

   a. Two-wheeled: Wet: ____________ Dry: ____________

   b. Four-wheeled: Wet: ____________ Dry: ____________

   c. Tracked: Wet: ____________ Dry: ____________

   d. Personnel: Wet: ____________ Dry: ____________

   e. Matting required: Yes/No

   f. Type of pack: Hard/Soft

3. Sea walls, jetties (refer to separate report if described as a landing place), breakwaters, bulwarks, and obstructions.

4. Obstructions to LCAC movement.

5. Tidal ridges, foreshore (tidal) flats, and salt marshes.

6. Location and depths of streams and runnels within the foreshore (tidal) flats.

7. Liability of changes due to natural conditions.

8. Location of long beach gradient in excess of 5 degrees and short gradients in excess of 10 degrees for ACV use.

A.6.8.4 Backslope Composition

1. Slope: ________________________

2. Obstructions. Description of any obstacle to movement (e.g., a wall, fortifications, steep bank, etc., to include details of height, gradient, and composition).

A.6.8.5 Exits

Parts where wheeled/tracked vehicles and LCACs can leave, with details of surface, width, length, and gradient and whether preparation is required.

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A.6.8.6 Foreshore Composition (Low-water Mark to High-water Mark)

1. Slope: ______________________________
2. Obstructions: ____
____
____

A.6.9 Man-made Ramps

If surveying a man-made ramp, use the following in lieu of A.6.8.

A.6.9.1 Jetties

Depths alongside, referred to chart datum. Height of deck above mean high water springs. Dimensions, type of construction, and bearing capacity. Capabilities of cranes. Exits.

A.6.9.2 Man-made Ramp

1. Slope: ____
2. Width: ____
3. Length: ____
4. Depth at seaward end (relative to chart datum): ______________________________________
5. Construction (concrete, reinforced concrete, macadam): ______________________________
6. Bearing capacity: ______________________________________
7. Exits: ____
8. Suitability for LCAC: ____

A.6.10 Hinterland

Depth of hinterland to approximately 6 miles inland, or to the nearest good road, if less than 6 miles.

A.6.10.1 Terrain

Description of are (e.g., landforms, surface, vegetation characteristics, populated areas, and features of tactical importance (e.g., natural corridors and passes, natural obstacles, man-made features forming artificial obstacles, cover and concealment, suitability for transit, transshipment and maintenance areas, and prospect of cross-country movement)).

A.6.10.2 Transport Network

Roads, tracks, railways, inland waterways, etc., leading inland.

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A.6.11 Ports

A.6.11.1 Nearest Port for Common Commercial Unloading: ________________________________

____

A.6.11.2 Nearest Port for Amphibious and/or Maritime Prepositioning Force Unloading: ______

____

A.6.12 Airfields

General description, to include grid reference and/or latitude/longitude, dimensions, orientation, capability, facilities, state of repair, nature of ground, air hazards (e.g., pylons, high-tension cables, etc.), exits, and ground transportation possibilities as appropriate to both man-made areas and natural sites which can be used with a minimum of effort.

A.6.12.1 Nearest Airfields and Aircraft Landing Strips Suitable for Jets/Other Aircraft: ________

____

A.6.12.2 Helicopter Landing Zone: ____

____

A.6.13 Resources

A.6.13.1 Water

Availability of fresh water, including drinking supplies, in the beach area.

A.6.13.2 Engineer Resources

These should include information on dumps of construction materials (stone, cement, aggregate, timber, etc.) in the beach area and details of nearby quarries, natural timber, etc., in the event organic beach improvements are required.

A.6.13.3 Local Contacts and Contact Information

Any local contacts made over the course of the survey (e.g., port captains, husbanding agents, local law enforcement, etc.).

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A.6.14 Survey Team Composition and General Remarks

A.6.14.1 BPTC: ____

A.6.14.2 SRM: ____

A.6.14.3 LCAC CM: ____

A.6.14.4 LCU CM: ____

A.6.14.5 INLS CM: ____

A.6.14.6 Any Other BST Participants and Name of Parent Organization: ____________________
____

FIRST INITIAL. MIDDLE INITIAL. LAST NAME, RANK, USN
Beachmaster Unit ONE/TWO Date: DDMMMYYYY

(CLASSIFICATION)
(When filled in, properly classify as UNCLASSIFIED, CUI, CONFIDENTIAL, SECRET, etc.)

Guidance Concerning Photographic Enclosures

1. Photographs should be labeled and include personnel for scale.

2. Photographs, at a minimum, should be taken at day and night and at high and low tides from:

   a. Left flank looking towards center beach

   b. Right flank looking towards center beach

   c. Center beach looking seaward

   d. Center beach looking towards the hinterland

   e. At each beach access point looking seaward and towards the hinterland

   f. Beach overview

   g. Labeled beach overhead view with LF, CB, RF, exits, and obstructions (e.g., Google Earth, NGA imagery, mensurated photographic intelligence (if unclassified)).

3. Ensure obstacles are labeled and annotated with approximate positions (example: large rocks approximately 200 yards from beach center bearing 045—covered at low tide).

4. Ensure any objects of interest are labeled and annotated with positions (e.g., any object not on a chart that could be used as a visual aid).

Beach Survey Form Legend

BPTC	beach party team commander
BST	beach survey team
CB	center beach
DD	A standard format for a numbered day (e.g., 01 or 31 identifies the 1st or 31st day of the month).

DDD or DD	degrees
E/W	east/west
HH	A standard for a particular hour (e.g., 1300 or 1 PM would be 13).
HHMM	time of hour and minute in Zulu time zone
HHMMZ	same as HHMM
INLS CM	craftmaster of improved Navy lighterage system
LCAC CM	craftmaster of landing craft, air cushion
LCU CM	craftmaster of landing craft, utility
LF	left flank
MM	The same as MMM but refers to minute within the hour (e.g., in 1315 the 15 would identify the minute in the time described).
MMM	One standard format for month in the year (e.g., JAN, DEC, etc.).
N/S	north/south
NGA	National Geospatial Intelligence Agency
R	rain
RF	right flank
S	snow
SRM	senior ramp marshal
SS or SS.S	seconds (time or geographic position, depending upon application)
YY	A standard format for the last two digits of the year (e.g., 23 for 2023).

BEACH NAME

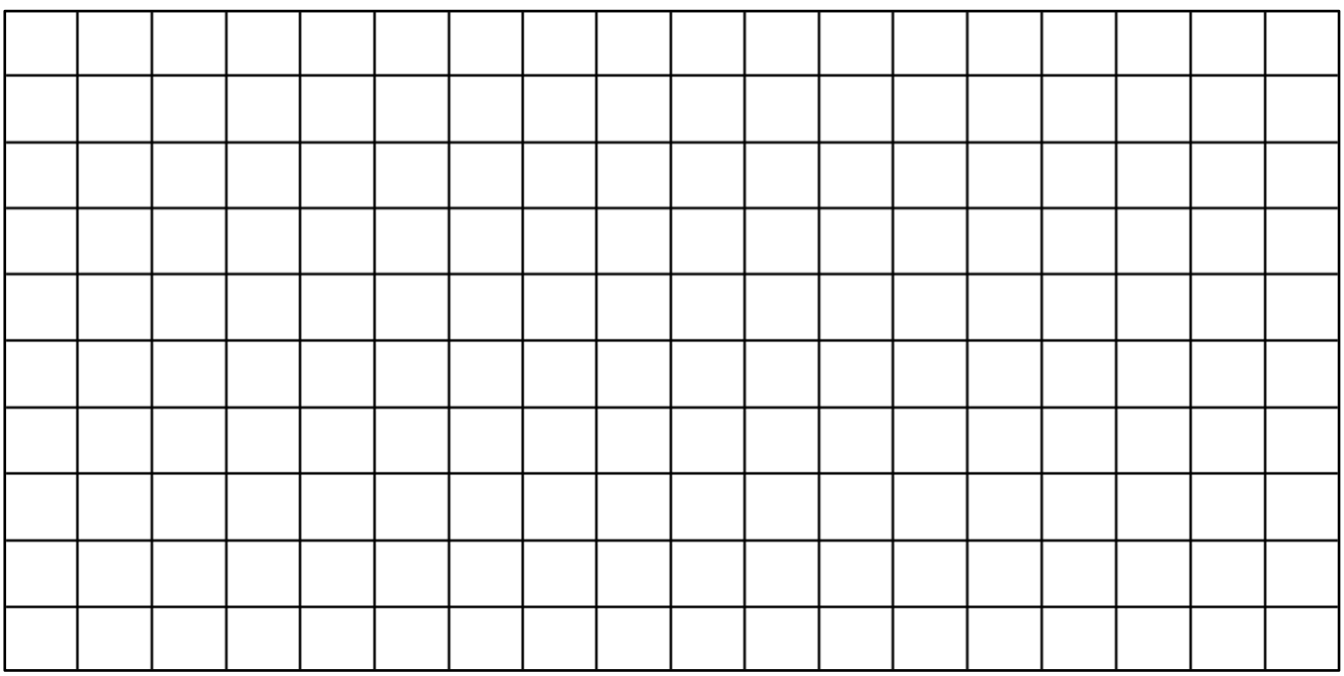

Figure A-7. Diagram of Beach

APPENDIX B

Meteorological and Oceanographic Support Products and Procedures

B.1 PURPOSE

This appendix summarizes the METOC support products and procedures available to the amphibious force. It includes the tools and models for generating surf zone forecasts during planning through execution.

B.2 THE NEARSHORE FORECAST PROCESS OVERVIEW

Figure B-1 summarizes the process used to produce a surf zone forecast.

Steps	Elements
1. Research	**Wave Climatology.** Seasonal patterns, wave windows, locations of coastal/littoral features (rivers, headlands, reefs, beach compositions, changes over time in imagery). **Beach Profile.** Slope; areas of positive/negative wave energy discernable from imagery and nautical charts. Include any confirmation available. **Tides.** Request and evaluate the impacts of tides to the beach profile throughout the daily tidal cycle.
2. Request parameterized nearshore modeling (request dynamic nearshore modeling in addition if bandwidth permits)	**Assemble range of location's typical wave parameters.** Height, period, direction: • Model domain depends upon offshore features/influences. (Dynamic domain is confined to the shoreline of interest.) • Assess communication/bandwidth needs. • Bandwidth determines product availability. This is a critical factor in the planning.
3. Request spectral wave bulletins (SWBs)	Choose deep-water locations away from wave disrupting features—islands, land blocks, etc.
4. Generate breaker forecast using calculator/nomograms	Enter calculator(s)/Geophysics Fleet Mission Program Library (GFMPL)/nomograms with best deep-water forcing parameters and beach profile information. Deep-water wave input is a forecaster assessment of SWBs in conjunction with any additional remote sensing or buoy data. Compare to other available dynamic models/observations/remote sensing to refine the best forecast.
5. Communicate forecast	Include all necessary elements of the surf forecast (A–H) (see 6.1.2). Include impacts and describe in non-METOC terminology what conditions really mean to the mission. Make recommendations based on findings and mission set.

Figure B-1. Nearshore Forecast Process

B.3 BATHYMETRIC SURVEYS

Accurate nearshore models require accurate coastal bathymetry. The accuracy of a nearshore model's output directly reflects the quality of the bathymetry. Nearshore models derived from coarse bathymetry can be useful for identifying wave patterns; however, the forecaster should use other means (e.g., wave observations from aerial imagery) to improve the forecast.

B.3.1 Introduction

If lead time and permissibility/operational security allow, a bathymetric survey should be requested for integration into the nearshore oceanographic model. CNMOC executes the Navy's operational oceanography program within its designation as CTG 80.7, the operational commander of all naval oceanography commands. CTG 80.7 executes the Navy's oceanographic, hydrographic, and bathymetric survey program using six multipurpose oceanographic survey ships, the airborne coastal survey, and littoral hydrographic survey assets provided by the NOMWC.

B.3.2 Airborne Coastal Survey

The airborne coastal survey uses an integrated laser light detection and ranging/imaging system. The system, installed in a King Air 200 (equivalent to a C–12) aircraft, collects hydrographic information in relatively clear, shallow waters and topographic data over land to produce seamless coastal charts and maps. High-resolution imagery collected by airborne coastal survey are stitched together to form mosaics of the survey areas onto which hydrographic and topographic data can be overlaid.

B.3.3 Naval Oceanographic Mine Warfare Center Hydrographic Surveys

NOMWC, a subordinate activity of the Naval Oceanographic Operations Command, provides rapidly deployable units to conduct littoral river, beach, and harbor surveys in support of military operations, international cooperative surveys, theater security cooperation, and humanitarian assistance/disaster relief operations. The NOMWC has a rapid LHS capability that uses hand-carried hydrographic sensor suites to produce graphical depictions of submerged hazards to navigation, beach gradients, and beach profiles in support of ship-to-shore movements. NOMWC LHS units can work with naval expeditionary force underwater construction teams for port assessment surveys and Marine Corps FORECON platoons for littoral surveys. The primary deployable collection platforms used by LHS units include CRRC and unmanned surface and underwater vehicles equipped with multibeam echosounders and autonomous underwater vehicles (AUVs) equipped with interferometric side-scan sonars. Individual units can operate from boats of opportunity, to include various locally available watercraft. Littoral hydrographic survey units typically operate from shore but can stage operations from amphibious assault ships (multipurpose) (LHDs) and amphibious assault ships (general purpose) (LHAs). The following are examples of the types of mission support:

1 Tactical access. Expeditionary assessments of beaches and rivers for amphibious/riverine forces. These are accomplished using AUVs with side-scan sonars capable of determining depth in addition to side-scan imagery. Autonomous underwater vehicles are capable of collecting data between the surf zone and 100 meters of water depth. The data is used to produce layered tactical decision aids in GeoPDF format.

2. Operational safety:

   a. International Hydrographic Office (IHO)-Navigation Standard surveys of ports and harbors. Perform near-shore surveys to aid in the safe navigation of U.S. forces and delivery of supplies to provide hydrographic data to the National Geospatial Intelligence Agency (NGA) to update digital nautical charts (DNCs). These surveys employ multibeam echosounders, tide gauges, and GPS sensors. They require extensive development time (greater than 1 year) to publish an updated DNC. Layered tactical decision aids in GeoPDF format are provided upon request for more timely updates, but all are labeled NOT FOR NAVIGATION, as they have not undergone the quality assurance process required by the IHO. IHO-standard surveys are led by certified Category A and Category B hydrographic surveyors in order for data to be accepted for DNC updates.

   b. Humanitarian assistance/disaster relief clearance surveys. Rapid searches to clear approach lanes of hazardous obstructions. This type of LHS employs either AUVs or multibeam echosounders to produce layered tactical decision aids in GeoPDF format.

3. Strategic shaping:

   a. Theater security cooperation. Global partnership building through maritime safety, security, and training. Typically done with international partners' hydrographic offices, charting authorities, or hydrographic-capable Navy and Marine Corps units.

   b. International cooperative surveys. Host-nation participation in IHO-standard surveys or combined military exercises.

Activities can request NOMWC support using a request for forces for joint force requirements, an RFS for Navy augmentation requirements, and the Joint Training Information Management System for joint exercises. Refer to NWP 3-59M/MCRP 2-10.2, Operational Meteorology and Oceanography, for additional information on such requests.

B.4 SENSORS

Sensors play an important role in predicting and monitoring nearshore conditions. The GPS provides the positioning, navigation, and timing services to ensure all datasets are precisely documented in terms of three-dimensional position, velocity, and time.

B.4.1 Man-portable Spectral Wave Buoy

Sensors play an important role in predicting and monitoring nearshore conditions. Man-portable spectral wave buoys, originally developed as drifting buoys by the Scripps Institution of Oceanography, are positioned and used to report spectral wave energy and direction data to compare with and validate wave model spectral outputs. The GPS provides the positioning, navigation, and timing services to ensure all data sets are precisely documented in terms of three-dimensional position, velocity, and time.

B.4.2 Global Positioning System

The GPS is a global navigation satellite system designed by the DoD to satisfy the need for a global, highly accurate, and survivable source of positioning and timing services. A constellation of satellites broadcasts precise signals used by civilian and military receivers to compute the three-dimensional position, velocity, and time.

B.4.2.1 Satellites

At least 24 (typically more than 30) GPS satellites are arranged in six orbital planes in medium-Earth orbit to ensure at least four spacecraft are visible to receivers to provide worldwide, continuous coverage. The satellites broadcast relatively low-powered encrypted and unencrypted coded signals across two frequencies. Receivers compare the broadcast times coming from each satellite to calculate a three-dimensional position.

B.4.2.2 Datum

The Earth is a somewhat pear-shaped ellipsoid with a slightly larger southern hemisphere than northern hemisphere. No single mathematical formula works for all the Earth's surface, so different regions are represented by different formulas. Position coordinates determined for one formula (datum) do not usually match the position values determined by another datum. United States Geological Survey topographic maps specify the reference datum in the information at the bottom of the map. Most GPS receivers allow the user to select the desired datum from a list of common datum. North American Datum (NAD) 1927 and DoD WGS-84 are commonly used in North America. Most United States Geological Survey 7.5-minute series maps for regions in the United States use NAD 27. When providing your position coordinates to someone from another agency (e.g., a helicopter pilot), be sure to include the datum as part of the information.

B.4.2.3 Accuracy Levels

The GPS provides two levels of service—precise positioning service and standard positioning service. Precise positioning service is the more accurate and resilient service. It is used by the U.S. military, government agencies, and other authorized users. Use of the precise positioning service requires the cryptographic keying material.

B.5 MODEL PRODUCTS

NAVOCEANO and FNMOC production centers, described in more detail in the following, provide modeling support for expeditionary forecasters. Requests for information are submitted via email, phone or online on the CTG 80.7 Command Center Portal and Catalog Service website located at https://naval.oceanography.navy.(smil).mil. The models and tools referenced in the following are not exhaustive; rather, they are those most relevant to surf zone forecasting.

B.5.1 Preforced Parameterized Nearshore Waves

Preforced parameterized nearshore model runs are simulations of how a coastal region reacts to differing incoming wave parameters. These model runs are very useful during the planning phase and serve as an excellent forecast aid during operations, particularly when bandwidth is low, and when forecasts are required outside of the high-resolution 48-hour model forecast. In the past, the laborious, time-consuming task of creating refraction diagrams was generated by hand. Refraction diagrams depicted how swells from different periods and directions impact a shoreline by noting where streamlines converge/diverge. Preforced nearshore modeling has replaced the need for hand-drawn refraction diagrams. Preforced parameterized nearshore modeling helps forecasters visualize how different swell parameters can affect a coastline. Then more specific locations of shadowing and refractive/diffractive enhancements/dampening can be identified. Since nearshore bathymetry changes seasonally along sandy shores and between storms, this methodology supports wave height forecasts outside of the surf zone where the bathymetry changes minimally.

B.5.2 Dynamic Nearshore Waves, Currents, Orbital Velocity

Global or regional scale numerical wave models are used to dynamically force nested nearshore models. If bandwidth is sufficient, this option is highly recommended during an exercise. These nearshore models do not replace preforced runs, SWBs, or nearshore calculations. They are employed in conjunction with all available tools as a general first look at the wave environment. This is especially important if more than one swell is present. The two-dimensional model view often smooths and averages wave speeds, directions, and heights of the swells and wind wave, which could possibly obscure significant wave events. This is common along west coasts, since many swell events overlap due to the large expanse of open ocean to the west of these locations. In addition to forecasting waves, nearshore models can predict currents, orbital velocities, and a myriad of other parameters.

B.5.3 Spectral Wave Bulletin

The SWB is used by forecasters to determine a model-based wave spectrum at any point on any ocean in an easy to decipher format. When a particular deep-water point is chosen, the wave model output is partitioned, showing the wind and swell events present over that location through time (global forecast goes out to 144 hours). This capability enables precise dissection of the modeled sea state at that point in the ocean. The SWB is used in conjunction with the preforced nearshore modeling. Spectral wave bulletins can be requested on the CTG 80.7 Command Center Portal and Catalog Service website located at https://naval.oceanography.navy.(smil).mil. The product can be received up to twice a day via email, web, or message traffic. Note that once a subscription is set up, reception of the product is delayed until the processing of the next model run, either 00Z or 12Z. The viewing and reception of the bulletin is not instantaneous.

B.5.4 Wave Visualization

Wave visualization (WaveViz) is a map-based interface allowing near instantaneous retrieval of spectral wave information in a color-plotted format. A text view of the spectral wave information is accessible by clicking on a link below the plot. The primary difference between WaveViz and the SWB is the means by which the product is accessed and viewed. Unlike the SWB, WaveViz requires high bandwidth. Thus, WaveViz is ideal for reachback center forecasters who require immediate spectral wave information.

B.5.5 Relocatable High-resolution Atmospheric Forecasts

The FNMOC produces high-resolution atmospheric graphics for any location in the world. Requests can be made for resolutions as small as 1–2 kilometers. The current FNMOC portal sites are FNMOC Non-classified Internet Protocol: https://portal.fnmoc.navy.mil/ and FNMOC SECRET Internet Protocol Router: https://portal.fnmoc.navy.smil.mil/.

B.6 SUPPORT FACILITIES

The following briefly summarizes the missions of the Navy's two FWCs, the FNMOC, NAVOCEANO, and the roles that they play in supporting surf forecasting.

B.6.1 Fleet Weather Centers

The mission of the Navy's two FWCs, FWC Norfolk, Virginia, and FWC San Diego, California, is to keep the fleet safe from hazardous weather and to enable effective operations and planning decisions. The FWCs provide METOC support ashore and afloat for aviation and maritime safety, optimum track ship routing, and resource protection. Embarked METOC support is provided through the strike group oceanography team hosted at each FWC. The two FWCs provide weather conditions and current sea heights for amphibious and expeditionary operations and subarea forecasting. If there is no organic or embarked METOC support available to the amphibious force, planners should contact CTG 80.7 or the responsible FWC to coordinate operational forecasts. Naval special warfare operations support requests should be directed to the Naval Special Warfare Mission Support Center.

B.6.2 The Naval Oceanographic Office

NAVOCEANO, located at the Stennis Space Center, Mississippi, is the Navy's oceanographic production center. Core functions include hydrography, bathymetry, geophysics, acoustics, physical oceanography, and geospatial intelligence. NAVOCEANO acquires and analyzes global ocean and littoral data to provide timely and operationally relevant products and services for the DoD and other civilian, national, and international customers. Using space-based, airborne, surface, and subsurface platforms, and state-of-the-art, high-performance computing and modeling techniques, NAVOCEANO fuses data from multiple sources to create products and services tailored to the operation.

B.6.3 Fleet Numerical Meteorology and Oceanography Center

The Fleet Numerical Meteorology and Oceanography Center, located in Monterey, California, is the Navy's meteorological production center. It maintains core expertise in meteorology, oceanography, numerical modeling, and information technology to provide the necessary foundation for on-demand support to naval, joint, coalition, multinational, and other national missions. The Fleet Numerical Meteorology and Oceanography Center leverages its expertise in numerical modeling to host a suite of state-of-the-art METOC models on high-performance computers to provide scheduled and on-demand products.

B.7 FORECASTER SOFTWARE TOOLS

The following provide brief overviews of some of the software tools available to METOC forecasters in their support of amphibious landings.

B.7.1 Joint Meteorological and Oceanographic Viewer

The Joint Meteorological and Oceanographic Viewer (JMV) is a thick-client environmental products software viewer that enables a forecaster to view synoptic atmospheric/oceanographic product layers. Unlike thin client setups that rely on a network connection for computing, thick clients do not require a constant network connection to process client/server applications. The model files are delivered via email, web, or message traffic within the Mobile Meteorology and Oceanography Support capability. The Mobile Meteorology and Oceanography Support provides environmental products to DoD units via standard telecommunication and circuits. The files are delivered in a coded text format, then imported into the JMV and viewed as standard two-dimensional plots. For high-bandwidth situations, model files are ingested via FNMOC's METOC Broadcast (also known as METCAST) System. Data for the JMV can be provided via the Global Broadcast System.

B.7.2 Sea Swell Surf Calculator

Nomograms and other manual tactical decision aids have been historically used to produce beach forecasts. The Sea Swell Surf Calculator simplifies beach forecasting by eliminating the requirement of using nomograms to produce a forecast. The calculator computes conditions based on a forecaster's inputs of basic parameters. Within the SURF portion of the calculator, the operator enters six basic required fields. The resulting prediction is a one-dimensional transect; therefore, unless the beach is completely uniform, users need to compute breaker characteristics at multiple points along the beach. With an irregular shoreline, this could be on the order of 100 yards or less per forecast. Familiarity with the calculator is important because an inaccurate output may result if initial parameters are erroneous, particularly if the refraction coefficient is incorrect. Refer to the Navy's Littoral Oceanography Course (also known as LOC) and the Cooperative Program for Operational Meteorology, Education and Training (COMET) training courses for details on how to estimate refraction coefficients. The calculator can be found on the FNMOC websites at https://portal.fnmoc.navy.mil/waveviz/swellcalc.html or https://portal.fnmoc.navy.smil.mil/waveviz/swellcalc.html.

B.7.3 Geophysics Fleet Mission Program Library

GFMPL is a software library available on compact disc by request from NAVOCEANO. GFMPL includes software for tides, solar and lunar conditions, surf predictions, and much more. The modules of GFMPL use in situ and historical environmental data run through module-specific algorithms. The surf forecasting section allows a user to import or create a beach profile and enter deep water forcing wave parameters and tide height to calculate the ALPHA through HOTEL elements and the MSI. Another application allows the user to input a SUROB to calculate the MSI. The output is textual and graphical.

B.8 TRAINING RECOMMENDATIONS

B.8.1 Marine Meteorology and Nearshore Forecasting

The following supplementary courses are available at the COMET website (https://www.meted.ucar.edu):

1. Analyzing Ocean Swell
2. North Wall Effects on Winds and Waves
3. Introduction to Ocean Models
4. Nearshore Wave Modeling
5. Introduction to Ocean Tides
6. Introduction to Ocean Currents
7. Introduction to Hydrography
8. Operational Use of Wave Watch III
9. Rip Currents: Nearshore Fundamentals
10. Rip Currents: Forecasting

11. Wave Types and Characteristics

12. Wave Life Cycle I: Generation

13. Wave Life Cycle II: Propagation and Dispersion

14. Shallow Water Waves

15. Tsunami Strike.

B.8.2 Naval Information Warfare Training Group Gulfport

The following supplementary courses are offered by the Naval Information Warfare Training Group (IWTG) Gulfport located at Naval Construction Battalion Center, Gulfport, Mississippi. The IWTG Gulfport detachments at Norfolk, Virginia; San Diego, California; and Yokosuka, Japan, can provide these courses. Contact IWTG Gulfport for class availability, enrollment, and more details at commercial: (228) 871-2916:

1. METOC Support for Amphibious Warfare (course number C-5B-0017)

2. Littoral Oceanography Course (course number S-420-0614).

B.8.3 Expeditionary Warfare Training Group Atlantic/Pacific

The following supplementary courses are offered by Expeditionary Warfare Training Group Atlantic and Pacific:

1. Amphibious Warfare Indoctrination (course number K-26-0037)

2. Expeditionary Staff Planning (course number J-2G-0048).

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APPENDIX C
Review of Beach Characteristics

C.1 INTRODUCTION

The characteristics of a beach are the result of both the supply and type of sediment available and the intensity and types of waves to which it is subjected both seasonally and over decadal and longer time frames. The relationship between beach composition and beach gradient is well correlated. Beaches predominantly made up of larger grain size sediments typically yield steeper gradients, while those consisting primarily of finer particle-size sediments lend towards more gradual gradients. Since the gradient is the overall slope of the bottom from the high-water mark to the seaward limit upon which the maximum breakers occur, beaches in certain areas may be measured only to 10–12 feet of water and for others to 50–60 feet.

C.2 CHARACTERISTICS OF STEEP GRADIENT BEACHES

Steep beaches have gradients of more than 7 percent (1:15), normally have plunging breakers, and typically only have one incoming line of waves in the surf zone at any one time. Generally, these beaches are composed of course sand particles, pea gravel, or gravel. During periods of low-wave energy, steep beaches tend to become steeper, the summer berm advances outward, and underwater berms and bars tend to disappear. During high-energy periods, very steep beaches form bars and moderately steep beaches form berms offshore at the breaking point. See D.4 for more information on how beach profiles affect breaker types.

C.3 CHARACTERISTICS OF MODERATE GRADIENT BEACHES

Beaches with gradients of 3–7 percent (1:30–1:15) are classified as moderate gradient beaches. These beaches are mostly composed of moderately fine sand, although a gravel berm can exist at extreme high water. Plunging and spilling breakers are equally common on these beaches. Moderate gradient beaches generally have an offshore bar during all seasons of the year unless they are within partly protected bights or bays. The bar becomes more pronounced and the beach face flattens when high waves exist. During periods of low waves, the beach face tends to steepen, and the bar disappears or becomes discontinuous. Moderate gradient beaches rarely have more than one bar.

C.4 CHARACTERISTICS OF GENTLE-, MILD-, AND FLAT-GRADIENT BEACHES

Beaches with gradients 2–3 percent (1:60–1:30) are classified as gentle-gradient beaches. Beaches with gradients 1–2 percent (1:100–1:60) are categorized as mild-gradient beaches. Beaches that slope less than 1 percent (1:100) are classified as flat-gradient beaches. These beaches are typically composed of fine sand, although a pea gravel or gravel beach face can be occasionally encountered if the mouth of a small creek extends across one of these beaches. Spilling breakers predominate. Plunging breakers are less common and usually result from a temporary steep section of the beach profile.

Flat-gradient beaches typically have several offshore bars at all seasons of the year unless they are partly protected. Although these beaches are generally suitable for amphibious operations, there are exceptions (e.g., during extreme high tides when the surf zone ends at backshore obstructions or during heavy weather when segments of the beach can erode rapidly making the beach potentially impassable along the beach face for tracked vehicles). Because of the extremely small beach particle size, mud beaches tend to be very flat and can have severe trafficability issues for both vehicles and personnel at low tide. Flat gradient beaches can be extremely dangerous if an opposed landing occurs during low tide because of the increased duration of exposure of the landing force to enemy fire.

C.5 EFFECTS OF EXPOSURE ON BEACH TYPE

In general, beaches which are subjected to waves from a variety of directions, periods, and heights are more complex than beaches affected by simpler wave patterns. The simplest case is a beach at the head of a bay where the only waves reaching the shore are refracted and diffracted remnants of ocean swell that enter the bay together with local wind waves. Beaches in large, open bays or extremely long beaches subjected to waves from a constant angle generally have relatively simple profiles, since the forces acting come from a nearly constant direction. In contrast, beaches that are affected by waves of varying types coming from many directions usually have a complex profile. For example, on high-energy beaches, cusps and undulations form along the shore. These features can vary in length from 20–500 feet or more. Littoral currents, which can change in direction from day to day, affect beaches as well. The currents can form irregular, discontinuous bars of varying number, flat, and steep sections. Such sandbars can create channels or rips at irregular intervals.

C.6 THE SEASONAL CHANGE OF BEACH TYPE

During extended periods of low waves, beaches can build high berms on the foreshore and very steep profiles on the beach face. Bars may disappear or become discontinuous. During periods of high waves, bars become more pronounced, the beach face becomes less steep, the berm is eroded back, and the resulting steeper berm face may impede the operation of amphibious vehicles. Cusps on beaches can be truncated, moved, and reformed when wave conditions change. This can result in beaches with a series of steep escarpments where the crest of each cusp has been cut away and soft sand deposited in the troughs of the old cusps. If the cusps were originally large, this can result in very difficult operational conditions.

APPENDIX D

Surf Zone Features and the Formation of Breakers

D.1 INTRODUCTION

The surf zone is the area between the outermost breakers and the shoreward limit of wave uprush. The characteristics of this zone determine how far offshore waves begin to break and what kind of breakers develop. Although the character of the surf zone is primarily dependent on the height, type, angle, and period of the breakers entering the surf zone, several other characteristics of this zone impact amphibious operations. These include multiple wave fields, surf beat, sandbars, beach gradient, tidal flux, refraction, and littoral currents. For example, tides influence the location of wave breaking, because the overall water level throughout the surf zone changes as the tide changes through the tidal cycle.

Local surf conditions are caused by of a combination of factors, to include local topography, the swell conditions, and interactions between the swell and locally generated wind waves. The interaction of a swell with local wind waves can cause the surf zone to assume a mixed and irregular character. Other factors contributing to confused and potentially dangerous surf conditions include multiple swells arriving simultaneously from different directions and superimposed wave trains.

A surf zone predominantly affected by a swell is characterized by regular crests, plunging breakers, and long lines of foam. The period of the breakers ranges from 10–20 seconds, and the crest length at breaking is usually greater than 150 feet. Offshore, these waves appear low and rounded. They peak sharply before they break and, in some cases, can double their deep-water height. Western continental coasts have a high percentage of swell waves, since they are open to large expanses of ocean over which storms can develop and propagate. In contrast, surf caused by local wind waves is characterized by short irregular crests and spilling breakers. Wave periods are short, usually about 5–6 seconds. Protected coastlines, typically in bays or harbors, may only be affected by wind waves.

D.2 SURF ZONE TOPOGRAPHY AND FORMATION OF BREAKERS

As the bottom of the wave begins to interact with the sea floor, the wave slows down, yet its period remains constant (Figure D-1). As the wave slows, energy is conserved—the wave's kinetic energy is converted into potential energy as the wave's height builds. The wave's height increases as it moves into progressively shallower water. This process continues until the wave becomes unstable and collapses or breaks.

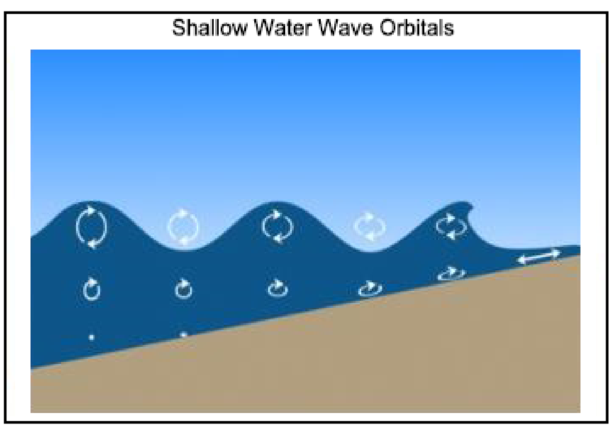

Figure D-1. Orbital Motion of Energy and Its Compression as a Wave Moves into Shallow Water

D.2.1 Submarine Ridges and Bars

Beaches are in a constant state of flux. Beach sediment grain size and wave energy are the primary determinants of beach topography. Beaches composed of sand or other small particles frequently change morphology with each season, whereas changes to cobble or boulder beaches tend to occur over longer time scales. Bars, the associated embankments of sand, gravel, or mud that get built up by waves and currents in nearby offshore areas, can change over a time scale of days. Because bars are continuously battered by the surf, their shape can change, and their location can move, especially after a large storm. Seasonal changes are generally associated with high- and low-energy wave periods. Considerable differences can exist in beach width and the distribution of sandbars between these high- and low-energy wave periods. The following simple relationship is generally valid for most beaches—during seasons with high wave activity, beaches are narrower with developed bars extending offshore, and during seasons of less wave activity, those same beaches are wider, and the bars may disappear entirely. Figure D-2 depicts the typical seasonal changes in the cross section of a beach and its associated sandbar. Due to seasonal changes in the bottom topography of beaches, beach surveys should be conducted as close to the exercise/mission timeframe as possible. The age of a beach survey report should be considered when evaluating its accuracy.

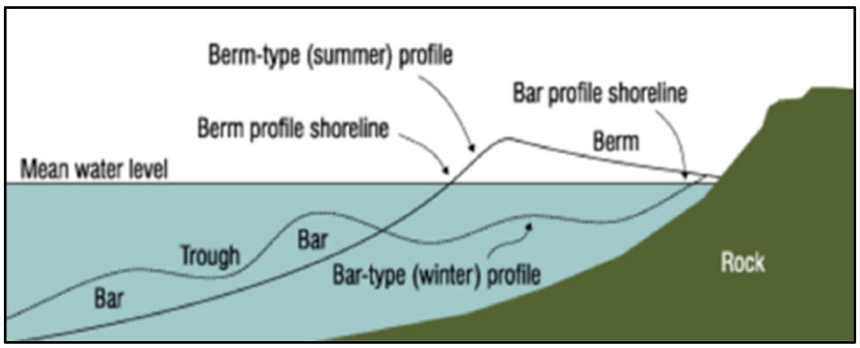

Figure D-2. Expected Bar and Berm Profile of a Typical Beach

D.2.1.1 Configuration of Sandbars and Impact of Offshore Bars on Landings

Sandbars parallel most of sand beaches. In some places, they only occur during the winter storm season, whereas elsewhere they persist throughout the year. In some very sandy areas, a series of these bars can extend for miles out to sea with the outer sandbars typically having depths too great to interfere with amphibious operations. Bars can be located by hydrographic surveys, observations of wave action, analysis of satellite imagery, and photo reconnaissance. Offshore bars, particularly shallow and exposed bars, can seriously impede landing craft. If a landing craft gets hung on the crest of a bar, considerable time may elapse before it can be freed, thus making it an easy stationary target for enemy gunners. If troops debark while a craft is hung on a bar, they then have to cross a channel between the bar and the beach. The channel may be too deep to cross by wading, and a strong current may be present. Strong currents and waves breaking over the bar can broach a hung landing craft.

D.2.1.2 Impact of Sandbar Depth on Wave Breaking

The typical depths of longshore sandbars range from 3–15 feet below mean low water. The water depth over the bar and the wave height determine whether breaking takes place on or near the bar. If the water depth over the bar is more than twice the significant breaker height, nearly all waves pass over the bar without breaking, but the crests peak up distinctly. If the water depth over the bar is between one and two times the breaker height, waves break near or over the bar with some breaking on the shoreward side. When the water depth over a bar is less than the breaker height, waves typically break on the seaward side. A series of parallel bars may exist, causing waves to break and reform until they reach the beach. Bars can extend continuously, longitudinally along a beach for miles, but they are more likely to be discontinuous. Bar locations and breaks in the bars can be detected from the air and in aerial photography by analyzing the breaker pattern. They can be located by hydrographic surveys.

D.2.2 Reefs

Reefs and rocks can be even more hazardous than sandbars because of the potential for structural damage to displacement landing craft. Reefs are divided into three general types:

1. **Fringing reefs.** Fringing reefs are coral reefs attached to the land. The width can vary from a few feet to more than a mile. The highest point of a fringing reef is just below the level of the water. An inshore channel is often present on fringing reefs but may not be present when the reef is narrow and exposed to heavy surf. These channels are about 1–5 feet deeper than the coral flat, 10–50 yards wide, and can be a mile or more in length.

2. **Barrier reefs.** Barrier reefs lie offshore and differ from fringing reefs by being separated from the land by a body of water called a lagoon. Barrier reefs can vary in width from a few feet to more than a mile and may include reef islands. The difficulty in crossing this type of reef is similar to that of the fringing reef. If the barrier reef is wide, it will contain irregularly shaped deep holes that are lined with jagged coral. If the ship or landing craft operating areas can be established inside the reef, more stable sea conditions and anchorages are likely.

3. **Rock reefs.** Rock reefs are a rocky ledge or ridge offshore where waves often concentrate and plunge with great force. If the waves do not break over it in heavy seas, it can be assumed that all but the largest type of craft will be able to cross at high tide. Rock reefs are likely to have a very rough surface and impede the movement of LARC-Vs, AAVs, and ACVs. Planners should exercise caution to prevent grounding or damaging craft that would hinder maneuver or affect seaworthiness by crossing when the water is sufficiently deep.

D.2.3 Bottom Configuration Versus Location of Breakers

In general, the largest waves occur where there is an offshore obstruction forcing waves to break far from shore. The forcing mechanism is likely a submarine ridge, rock reef, or sandbar. Such configurations lead to a convergence of waves on the beach immediately shoreward of the feature. Conversely, in conditions where the outer breakers break closer to shore, there is often wave divergence over a small channel. The presence of rip currents in such channels complicates the refraction pattern. There are normally two opposing situations in this instance—first, the currents which tend to make the waves converge, and second, the partial channel which tends to make the waves diverge.

D.2.4 Depth of Breaking Versus Speed of Breakers

The speed of a breaker depends upon the depth of breaking. For a 6-foot breaker, the depth of breaking is 10 feet, and it follows that this breaker advances with a speed of about 10 knots. The relationship of breaker height to breaker speed of advance for a water depth of 10 feet is shown in Figure D-3. Waves in different depths can behave dissimilarly.

Breaker Height (feet)	Breaker Speed of Advance (knots)
4	8.1
6	9.9
8	11.4
10	12.8
12	14.0

Figure D-3. Breaker Height Versus Expected Speed of Advance—10-foot Water Depth

D.3 TYPES OF BREAKERS

Breaker height and breaker type are the most important surf factors for determining the feasibility of an amphibious beach operations. When a wave moves into water shallower than one-twentieth the wavelength (L), the wave height increases and the wavelength decreases (see Figure D-4). At a water depth of roughly one and sixty-seven hundredths' times the wave height, the water supply is sufficiently reduced, and the wave becomes unstable and breaks. The three types of breakers are described in the following.

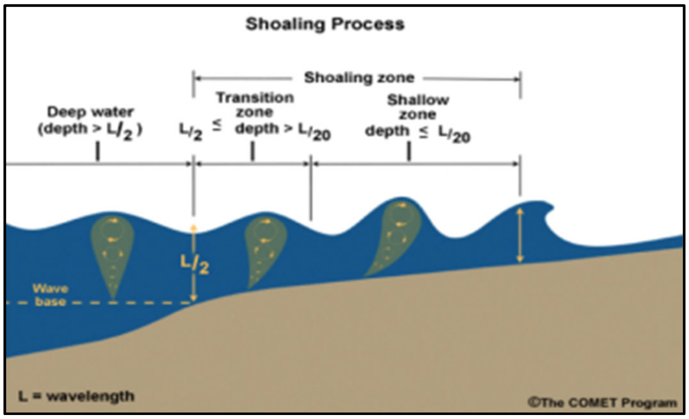

Figure D-4. Shoaling Process of Deep-water Waves

D.3.1 Spilling Breakers

1. **Description.** Spilling breakers normally occur on flat, mild, and gentle beach gradients and, to a lesser extent, on moderate gradients. The crest slides down the face of the wave forming foam and gradually releasing energy over a wide area (see Figure D-5).

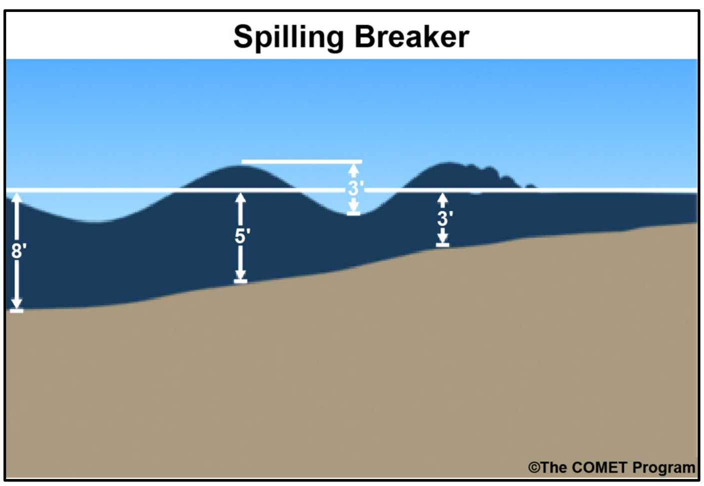

Figure D-5. Shoreward Transition of Spilling Breakers

2. **Cause.** Nearby storm waves are not only more likely to spill when they reach shore but are also more likely to be disturbed because of the presence of short choppy waves.

3. **Impact.** Spilling wave action is generally considered the least dangerous to small boats and landing craft. These types of breakers are preferred for conducting amphibious operations.

D.3.2 Plunging Breakers

1. **Description.** Plunging breakers occur on moderate to steep gradients. The crest plunges over into the preceding trough with a sudden release of energy over a narrow area (see Figure D-6).

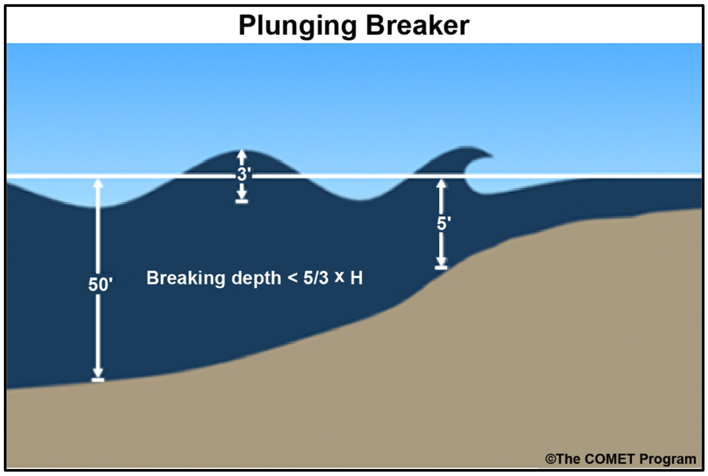

Figure D-6. Shoreward Transition of Plunging Breakers

2. **Cause.** Long-period swell waves typically produce plunging breakers. They are more likely to do so if disturbing wind waves are absent at the time of their arrival. Long-period swell is unaffected by offshore wind. When the wind is offshore, ideal conditions exist for the production of plunging breakers. There seems to be an aerodynamic condition causing the waves to plunge more violently under this situation than they would if no offshore wind were present. The waves seem to pass the normal breaking point and peak up to a greater height before breaking when the wind is opposing. Beaches in partly protected bays and estuaries almost always produce plunging breakers due to wave refraction.

3. **Impact.** This condition is less preferred for amphibious operations and can be dangerous for diving operations because the breaking action is sudden and concentrated.

D.3.3 Surging Breakers

1. **Description.** Surging breakers are the least common breaker type. The wave builds like a plunging breaker, but the very steep-beach gradient prevents breaking offshore, and the breaker explodes onto the beach (see Figure D-7).

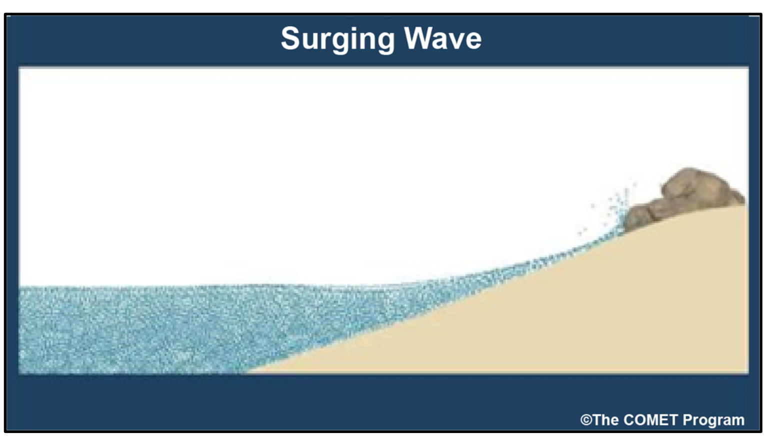

Figure D-7. Shoreward Transition of Surging Breakers

2. **Cause.** These breakers occur on steep gradients.

3. **Impact.** Surging wave action is generally the most violent and dangerous to small boats and landing craft, because the breaking action occurs directly on the beach. Operators of landing craft must be aware of the potential extent of wave run up. Since they do not break offshore, they do not lose energy and may run relatively far up the beach with significant force.

D.4 BEACH PROFILE VERSUS TYPE OF BREAKERS FORMED

The magnitude of the beach gradient affects the width of the surf zone. Generally, the steeper the gradient, the closer the breaker line is to the beach and the smaller the surf zone width. The more gradual a beach gradient, the farther offshore waves may break and the wider the surf zone becomes. A crude approximation for the width of the surf zone can be found by dividing the breaker height by the beach gradient (decimal percentage), then multiplying that value by 1.67. The results of such calculations for 6-foot breakers are shown in the right-hand column of Figure D-8.

Beach Gradient			Surf Zone Width (feet)
Steep	greater than 1:15	greater than 7 percent	less than 150
Moderate	1:15–1:30	3–7 percent	150–300
Gentle	1:30–1:60	2–3 percent	300–600
Mild	1:60–1:120	1–2 percent	600–1,200
Flat	less than 1:120	less than 1 percent	greater than 1,200

Figure D-8. Approximate Surf Zone Width Based on Beach Gradient and 6-foot Breakers

The magnitude of the beach gradient generally dictates breaker type. Flat beaches frequently have an irregular profile and bottom irregularities produce spilling breakers. There is a greater tendency for plunging breakers to occur on steeper beaches than on beaches with flatter gradients. When plunging breakers do occur on generally flat beaches, they are typically caused by steep sections of the beach or (most likely) a sandbar in the breaker zone.

Steep beaches have gradients of more than 1:15 (7 percent). During normal conditions, only one wave exists in the surf zone of a steep beach at any one time. In this condition, a wave breaks and the swash runs up the beach face then retreats with the backrush reaching its lower limit before another wave breaks. Although steep beaches normally have plunging breakers, if they are very steep (1:7 to 1:4, 14 percent to 25 percent), they are sometimes so balanced that the breakers are of an unusual type. In this situation, water flowing down the beach fills the curling wave form with water and the breaker, instead of plunging, rolls over without impact. This type of breaking leads to the swash flowing up the beach with unusual velocity, reaching a height on the beach face much greater than the height of the waves. Spilling breakers are rare on a steep beach, unless onshore winds cause waves to break prematurely as white caps run down the face of the wave. Figure D-8 provides comparative estimates of the surf zone widths that result when 6-foot breakers strike beaches of various gradients.

D.5 REFRACTED AND REFLECTED WAVES

The surf is not only dependent upon the beach gradient. It is also affected by the bottom contours at great distances from the coast. The generation of refracted and reflected waves and their impact on surf conditions are explained in the following.

D.5.1 Refracted Waves

When a wave approaches a straight section of coast line at an angle, the part of the wave that reaches shallow water first slows down as it feels bottom, whereas the part of the wave still in deep water maintains velocity, with the result that the slowing wave crest swings around and tends to become parallel to the coastline. This bending of the crest is called refraction. Refraction accounts for the fact that breakers tend to be nearly parallel to the beach, even when the incoming offshore waves arrive at a considerable angle with the coastline. Figure D-9 illustrates a swell approaching an open, straight coastline at an angle. Note the waves bending to near parallel upon breaking.

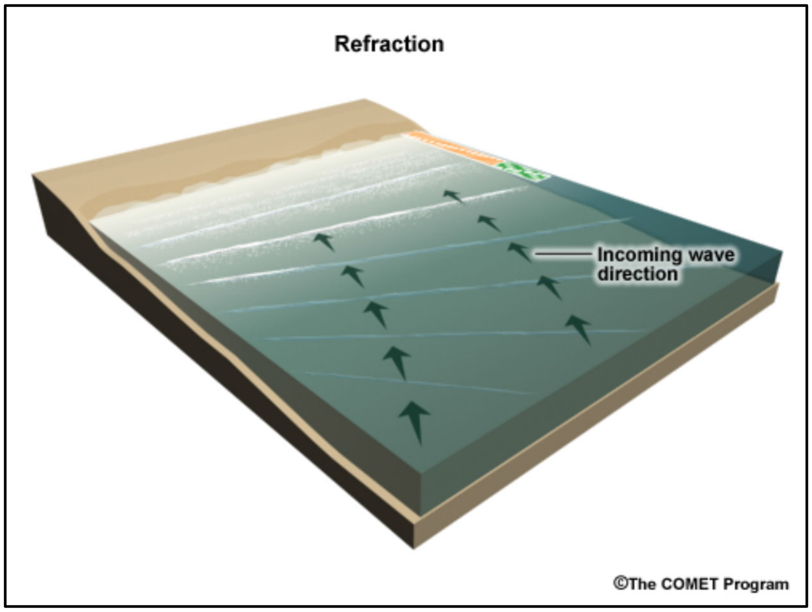

Figure D-9. Waves Refraction Along a Coastline

Refraction also occurs when waves travel over an irregular bottom. The portion of a wave passing over shoal water slows down, and the portions on either side tend to swing in toward the shoal. Where the waves swing together, each crest is squeezed, and the wave heights increase. Heavy surf is found wherever a submarine ridge extends out from a coast. A submarine canyon has the opposite effect. The portion of the wave passing over the canyon travels faster than that on either side and tends to fan out. Where the wave fans out, the crest is stretched, and the wave height is decreased. As a result, the surf is lighter wherever a submarine canyon extends out from the coast.

Refraction also causes waves to swing in behind islands and peninsulas where they would otherwise be blocked by the land (see Figure D-10). There exists a small shadow on the leeward side, but further offshore the pattern of convergence becomes complex and potentially hazardous if shallow banks are present. The amount of protection afforded by headlands, peninsulas, islands, and other obstructions depends as much upon the underwater topography as upon the shape of the coastline. To predict the variation in surf along a coastline, high-resolution nearshore modeling must be employed. Such models can reveal locations of intense focusing and dampening of waves as they interact with the nearshore bathymetry. These models take the place of hand-produced refraction diagrams, which are no longer generated.

D.5.2 Reflected Waves

Breakers are more likely to plunge or surge along steeper beaches, leading to strong reflection of wave energy back towards the incoming waves (Figure D-11). Backwash is more common along steeper beaches. The collision between reflected waves, backwash, and incoming waves can produce explosive results. Reflected waves from nearby structures or topography meeting incoming waves can double breaker heights over a short, concentrated distance.

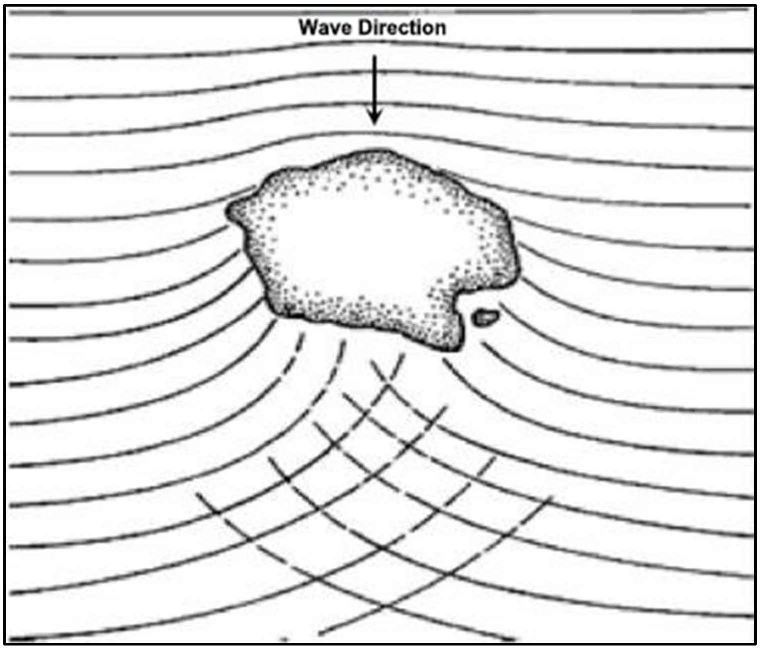

Figure D-10. Swells Can Wrap Completely Around an Island

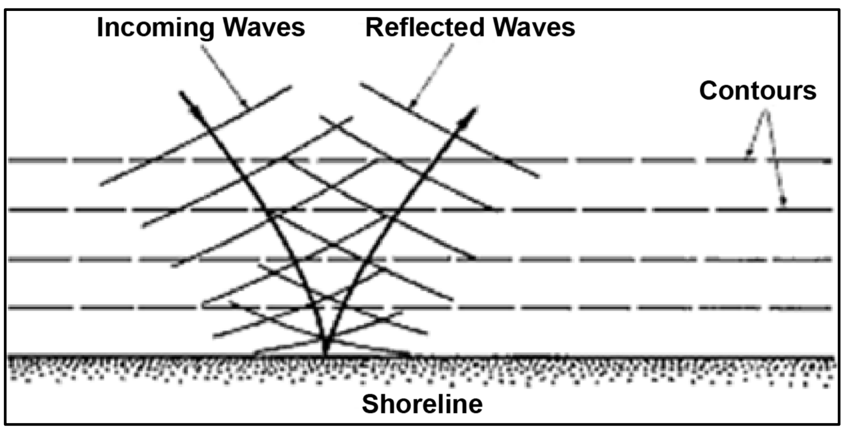

Figure D-11. Waves Reflecting Off a Shoreline

APPENDIX E

Tides and Nearshore Currents

E.1 INTRODUCTION

Tides are the periodic variation in the surface level of oceans, bays, gulfs, and inlets caused by gravitational effects of the sun and moon. Ocean tidal currents and nearshore wave-induced currents can significantly affect amphibious operations. The stage of the tide can have a profound effect on the width and character of the surf zone, to include the height of the breakers. Tidal fluctuations along a coastline characterized by shallow, flat, bathymetry can dramatically alter the distance to shore. On a shallow beach with a high tidal range, the waterline at low tide can occur hundreds of yards away from where it occurs at high tide. Low tide can expose rocks or coral that would otherwise be below the draft of the landing craft.

The breaker line, relative to the shoreline, varies depending on the tidal stage. A beach at high tide can have the characteristics of a steep beach as the surf zone moves higher up the beach and waves pass over outer bars and break on the inner bars. At low tide, the same beach may be more characteristic of a gradually sloped beach with waves breaking further offshore on the outer bar and only lines of foam present in a relatively calm surf zone.

E.2 TIDAL TERMINOLOGY

Several important tidal features and levels (also known as tidal datums) are reviewed in Figure E-1. Most of the depths on the Navy's charts are based on tide at mean lower-low water tide levels.

Tidal Feature	Description
high water	The highest level of a single tide.
low water	The lowest level of a single tide.
mean high water	The arithmetic 19-year mean of the high-water heights observed.
mean low water	The arithmetic 19-year mean of the low-water heights observed.
mean lower-low water	The arithmetic 19-year mean of the lower-low water heights observed. Only the lower of each pair of low waters of a tidal day is included in this mean.
lower-low water	The lower of the two low-water tides of each tidal day.
tidal range	The vertical distance between high- and low-tide levels.
tidal period	The time required to complete one full tidal cycle.

Figure E-1. Important Tidal Features and Levels

The three commonly observed tidal patterns are:

1. **Semidiurnal (twice daily)**. Consists of two high tides and two low tides of nearly equal size every lunar day (24-hour and 50-minute period (see Figure E-2).

2. **Diurnal (daily).** Consists of one low tide and one high tide every lunar day (see Figure E-3).

3. **Mixed tides.** Two high tides and two low tides of conspicuously unequal size every lunar day or have a high-tide inequality but consistent low-tide levels (see Figure E-4).

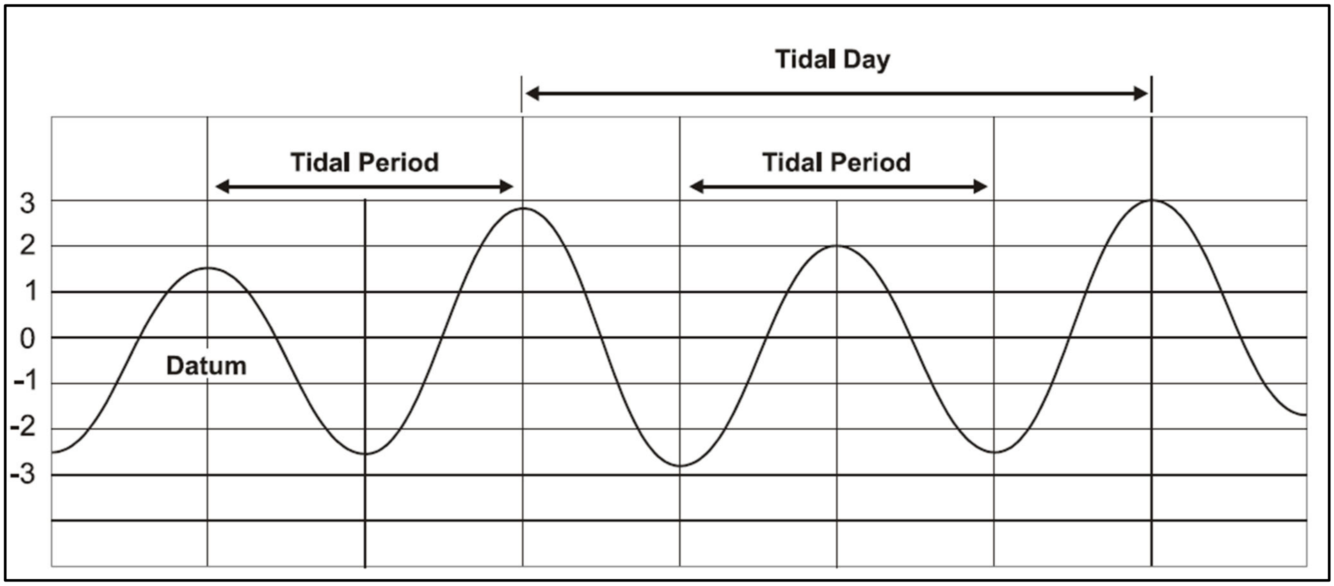

Figure E-2. Graph Showing a Semidiurnal Tidal Pattern

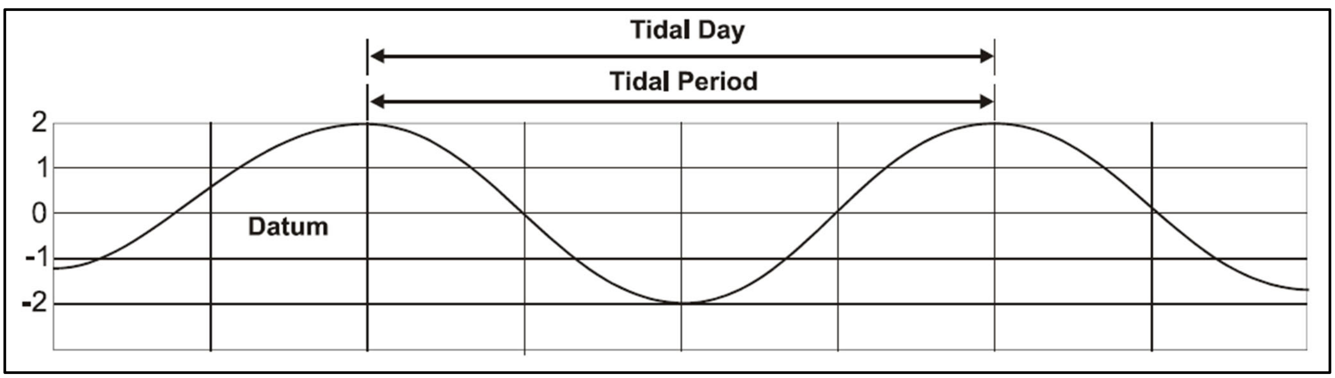

Figure E-3. Graph Showing a Diurnal Tidal Pattern

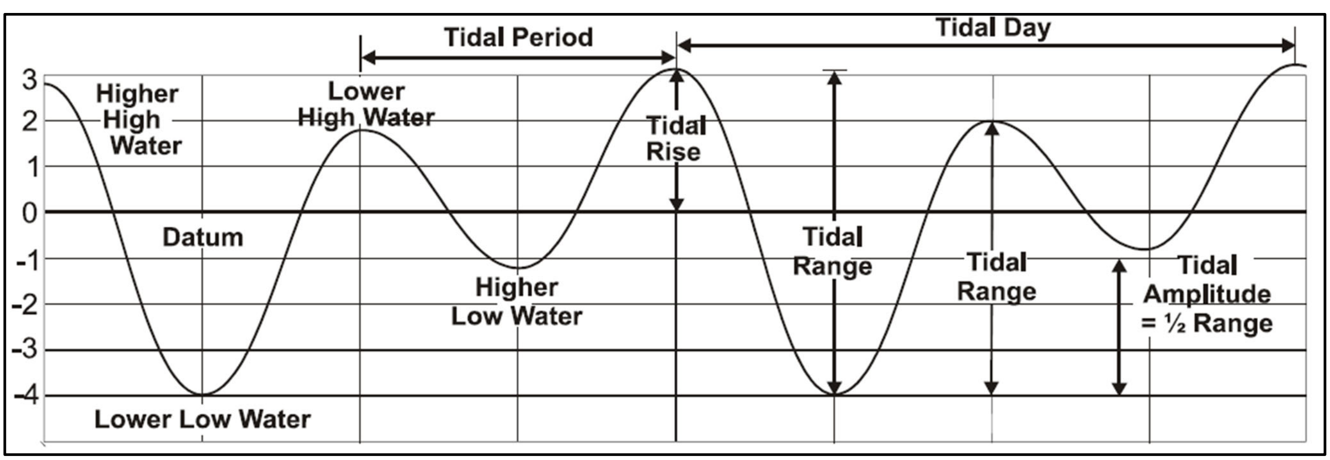

Figure E-4. Graph Showing a Mixed Tidal Pattern

Two other, less commonly observed, tidal patterns are:

1. **Neap tide.** A small tide range, occurring at the first and third quarters of the moon, when the gravitational pull of the sun opposes that of the moon.

2. **Spring tide.** Either of the two tides that occur at, or just after, new moon and full moon when the tide-generating force of the sun acts in the same direction as that of the moon, reinforcing it and causing the greatest rise and fall in tidal level.

E.3 OSCILLATORY TIDAL CURRENTS AND THEIR RANGES

Tidal currents are oscillatory because they change direction every 6 or 12 hours, depending upon whether there is a semidiurnal or a diurnal tide. On the surface, these currents can be visible as tide rips or areas of breaking water and white caps. Tidal currents predominate around the entrances to bays and sounds, in channels between islands, between islands and the mainland, and between gaps in reef channels. Generally, the tighter the gap, the higher these currents are. They may reach velocities of several knots in narrow sounds. As a general rule, the greater the change in tide height over a smaller period of time, the stronger these oscillatory currents are. Tidal currents are predictable if sufficient observations have been made because they repeat themselves as regularly as the tides to which they are related. As mentioned in 3.5.1, continental United States tidal current predictions can be obtained from NOAA at http://tidesandcurrents.noaa.gov/curr_pred.html. Tidal current predictions operations and exercises outside the continental United States can be obtained with advanced notice through RFS support to NAVOCEANO (see B.5).

E.4 NEARSHORE WAVE-INDUCED CURRENTS

Three important interacting factors have a significant role when determining surf zone circulation—breaking wave angle, wave height, and surf zone bathymetry. As waves break in the surf zone, some of their energy and momentum supports the development and sustainment of nearshore currents. The nearshore current magnitude is a function of breaking wave angle and wave height. The periodicity of the breaking waves, combined with the range of the daily tides, can lead to considerable modulations of the resulting nearshore currents in terms of strength, time, and location.

E.4.1 Shore Currents

When incoming waves break at an angle to the beach, a current develops and flows roughly parallel to the shoreline. This type of nearshore current is called a longshore current or littoral drift. These currents typically occur along straight beaches. In areas where littoral currents are common, sandbars are usually present. The direction of the flow is determined by the direction of the incoming wave angle and nearshore bathymetric features. The magnitude of the flow increases with increasing wave height, angle of approach to the beach, and steeper beach gradients and decreases with increasing wave period. Peak current velocities occur when breaking waves approach from 45 degrees. The magnitude of the current varies across the surf zone. On a planar (relatively flat) beach, the maximum velocity occurs roughly two thirds the distance to the outermost breaker line from shore, as shown in Figure E-5. Winds blowing alongshore can cause or augment existing longshore currents. Longshore currents are predictable, but the forecast accuracy depends upon the accuracy of the wave forecast on which it is based. When longshore currents encounter significant bottom irregularities (e.g., breaks in bars, relatively deeper channels running perpendicular to the beach, or even shoreline structures (e.g., piers or jetties or groins)), they are deflected offshore as rip currents.

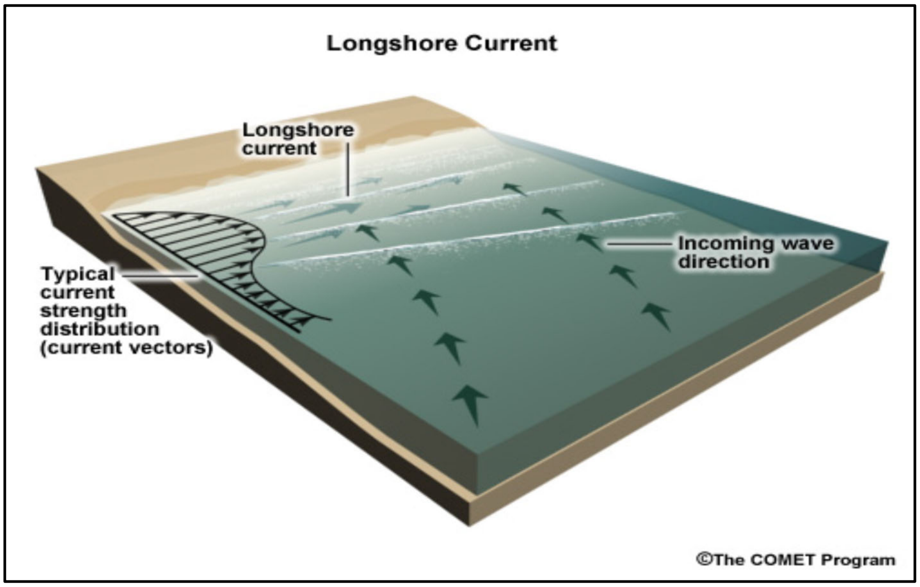

Figure E-5. Relative Strength of a Longshore Current versus Distance from Shore

E.4.2 Rip Currents, Their Parts, and Their Formation

Rip currents are localized currents of rapidly moving water running generally perpendicular to the beach and extending from near the shoreline out through, and past, the line of breakers. They form due to water being piled or mounded up against the shore in the surf zone by wave action. Rip currents serve as a release to the built-up water level against the shore. They can occur in areas with either rocky or soft-bottom (sand or silt) sea floors. Rip current indications include:

1. A channel of churning, choppy water extending seaward with a mushroom-shaped appearance at the seaward end

2. A difference in water color due to suspended sediments being transported back to sea in the rip current

3. A line of foam extending seaweed, or debris moving out to sea

4. Breaks in the incoming wave pattern. Locations with relatively smooth water in the breaker zone may indicate rip currents. Rip currents above deep sandbar channels look like calm patches of water.

E.4.2.1 Parts of a Rip Current

As shown in Figure E-6, rip currents consist of three parts—feeder currents, a neck, and a head.

1. **Feeder currents.** Longshore currents that flow parallel to shore inside the breakers.

2. **Neck.** Where the feeder currents converge and flow through the breakers in a narrow band, or rip. A rip current's neck can be very narrow or more than 150 feet wide, though it is typically not more than 80 feet wide. Because rip currents often form over relatively deep channels, the neck often appears as a stretch of unbroken water in the breaker line. While rip current velocities average between 0.5–1 knot, moderate to strong rip currents can have speeds at or over 4 knots. Changes in rip current velocities occur in response to changes in incoming wave height and period and with changes in water level. Velocities can increase within minutes due to the arrival of larger wave groups or nearshore circulation instabilities.

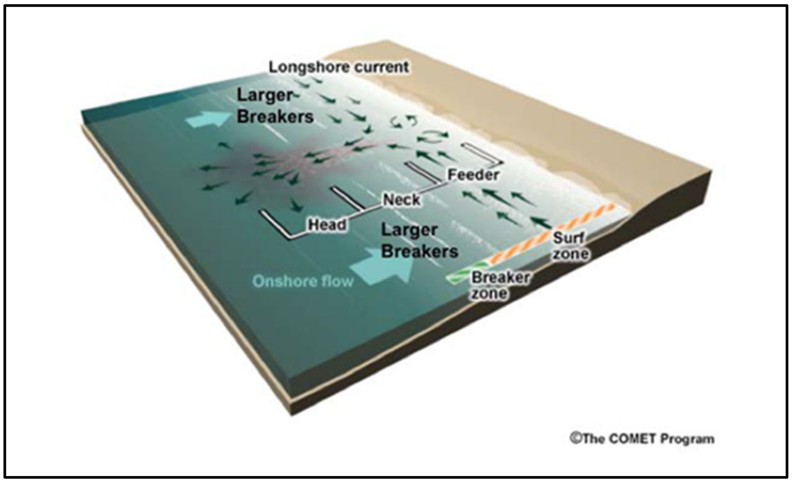

Figure E-6. Basic Rip Current Cellular Circulation Along a Beach

3. **Head.** Where the current widens and slackens outside the breaker line. A rip current head is typically seen just beyond the breaker zone. Patches of foam and broken water usually mark the outer line of the current in the head. The head itself is usually discolored by suspended sediment transported seaward from the surf zone. When viewed from above, the head provides a clear indication that a rip current is present (see Figure E-7). The seaward extent of rip currents can vary from just beyond the line of breaking waves to hundreds of yards offshore, extending up to a maximum of two and a half times the surf zone width.

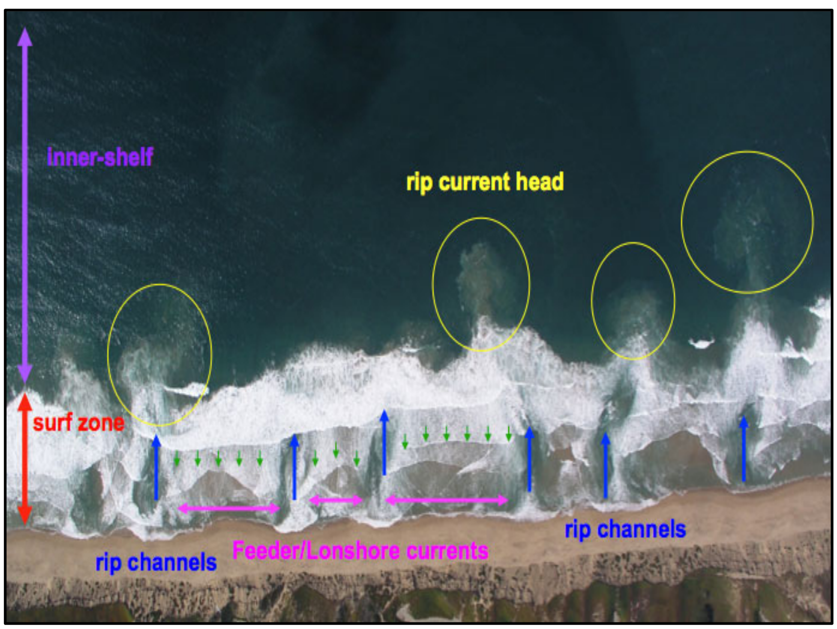

Figure E-7. Wave Patterns and Resulting Nearshore Currents

E.4.2.2 Influence of Wind and Wave Direction on Rip Current Formation

Rip currents form when waves arriving at the coastline pile up water against the shoreline and produce a setup or rise in the mean water level above the still water level. Rip current formation is more likely as the breaking wave angle approaches zero. A wind blowing onshore directly perpendicular to shore has a much higher probability of producing a dangerous rip current than wind from other directions.

E.4.2.3 Influence of Bottom Topography on Rip Current Formation and Flow Patterns

Rip currents are more commonly associated with beaches with relatively gentle gradients. Wider surf zones on gently sloping beaches result in relatively more waves breaking shoreward of existing sandbars. More waves breaking in this nearshore zone result in more water accumulating or becoming trapped between sandbars extending parallel along the coast and the shoreline. In areas with steeper slopes, less water accumulates in this immediate nearshore zone. This is because of the greater depth between the water surface and the top of the sandbar, thereby allowing easier transport of the water back away from the beach. The result is a weaker rip current.

The longshore flow develops as the water piled up near the shore flows from high to low setup areas. This flow converges and is deflected back offshore in narrow rips upon encountering significant bottom irregularities (e.g., lower spots or breaks in offshore bars, other areas of relatively deeper channels running perpendicular to the beach, or permanent shoreline structures (e.g., piers, jetties, or groins)). Low spots in the bars become the path of least resistance for the return flow of water. Developing rip currents are sufficiently strong to move bottom sand and carve out rip channels across low points in the sandbar. For these reasons, natural changes (e.g., sediment transport and major storms) and human changes (e.g., major sand replenishment projects) can significantly impact the surf zone environment, leading to changes in rip current frequency and intensity.

E.4.2.4 Transitory Nature of Rip Currents

Quickly changing wave heights (e.g., a set of heavy breaking waves) can trigger the sudden formation of a rip current. Individual rip currents tend to be short-lived, generally lasting only 10–20 minutes, yet a stretch of beach can be affected by a sequential series of cells forming over a short period. Conditions conducive to the formation of multicell rip currents include when multiple gaps exist in a sandbar, when the breaking wave angle is close to zero and the beach has multiple small headlands or cusps, and when one current is created as another dissipates near the same location. The spacing between multicell rip currents is generally less than 500 meters. If wave activity approaching a beach is slight, several rip currents of various sizes and velocities can form. In heavier wave action, fewer, more concentrated rip currents tend to form. Generally, on a given beach, the potential for rip currents formation is directly proportional to wave strength. Rip currents are more likely when waves are larger. An isolated rip current generally indicates a higher velocity current, whereas multiple rip currents in the same area tend to indicate lower rip-current velocities. Although individual rip currents are rarely sustained for an hour or more, rip currents caused by human structures are the exception. Artificial boundaries, like jetties and groins, can result in semipermanent rip currents. Likewise, on rocky or coral beaches, outcroppings and natural channels tend to have semipermanent rip currents.

Tides have an impact on the character of rip currents through their effects on the size of the surf zone and the position of the breaker zone. Higher water levels during high tide cause the breaker zone to move closer to shore. In contrast, low-tide conditions result in the breaker zone shifting away from the beach, typically producing wider surf zones that transport more water mass. If a sandbar is present in the surf zone, high tide allows easier transport of water away from the beach than at low tide. This is due to a greater depth between the water surface and the top of the sandbar. Rip currents are more often observed in the hours immediately before and after low tide; however, these currents can occur at any time. Rip currents are most hazardous around low tide when water is already pulling away from the beach.

APPENDIX F

Review of Open-ocean Wave Generation

F.1 INTRODUCTION TO WAVES

As a quick review, in physics, a wave is described as a periodic disturbance of the particles of a substance which may be propagated without net movement of the particles, such as in the passage of undulating motion (Concise Oxford English Dictionary, 2019). The following terms describe various features of a wave on the ocean surface. Several of these terms are illustrated by Figure F-1.

1. **Wave crest.** The highest part of a wave; the peak, or upper limit, of an individual wave.

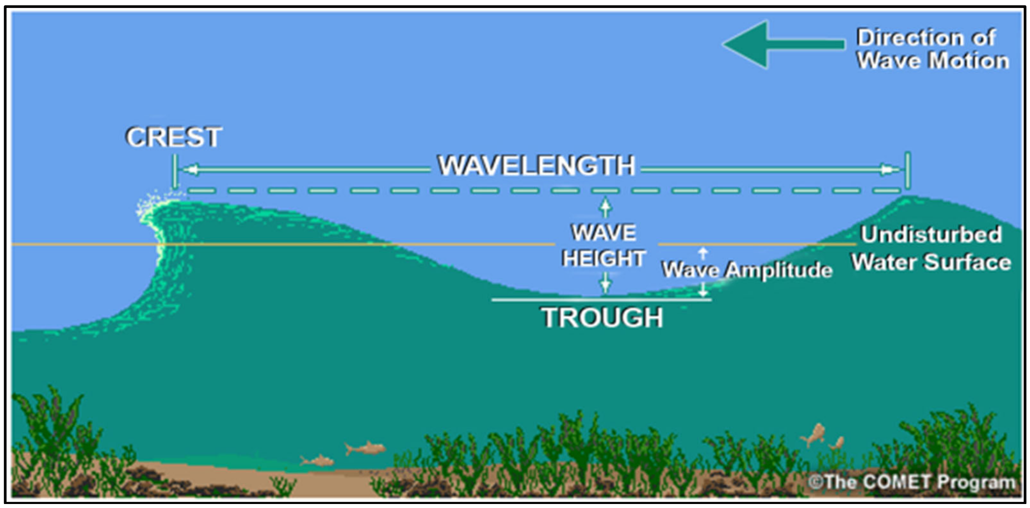

Figure F-1. Wave Characteristics

2. **Wave trough.** The lowest point of an individual wave; the horizontal, almost flat area, between crests.

3. **Wave height.** The vertical distance between trough and crest.

4. **Wavelength.** The horizontal, perpendicular distance from one crest to the next crest or from one trough to the next trough.

5. **Wave period.** The time period it takes for two successive wave crests to pass a given point.

6. **Wave amplitude.** The water displacement from its undisturbed state. Wave amplitude is always one-half the wave height (at least for a symmetric wave).

7. **Wave steepness.** The slope of a line from crest to succeeding trough; wave height divided by wavelength.

Almost every wave that occurs on the surface of the world's oceans can be classified into one of four basic types—wind-generated waves, tides, seiches, and tsunamis. This appendix focuses on how wind-generated waves develop in the open ocean.

F.2 GENERATION OF OPEN-OCEAN SEAS

Waves created by wind blowing over, and interacting with, the water surface are known as wind-generated waves. There are two types of wind-generated waves that are important for amphibious operations—wind waves and swell. Wind waves is the term given to waves while they remain within the region where they were initially generated. Wind waves are typically somewhat confused, have short wave periods, and are steep and choppy. The crests often break in deep water due to their steepness. When small, these breaking waves are called white caps. When large, they are often referred to as combers or breaking seas. Once a wave travels out of its source region, it is referred to as a swell. Waves created by wind blowing over and interacting with the water surface are known as wind-generated waves. There are two types of wind-generated waves that are important for amphibious operations—wind waves and swell. Wind waves is the term given to waves while they remain within the region where they were initially generated. Wind waves are typically somewhat confused, have short wave periods, and are steep and choppy. The crests often break in deep water due to their steepness. When small, these breaking waves are called whitecaps. When large, they are often referred to as combers or breaking seas. Once a wave travels out of its source region, it is referred to as swell. Swell is discussed further in F.3. The source region for a wave is typically defined by fetch. Fetch is the uninterrupted distance or area over which wind blows from a nearly constant direction and at a nearly constant speed. If the wind abruptly speeds up, slows down, or changes direction significantly, a new fetch distance or area begins.

F.2.1 Wave Formation

As wind blows over water, friction causes a wave to form. The initial wind stress on the water surface causes small capillary waves to form. These waves are commonly called ripples or cat's paw waves. Once capillary waves form, wind pushes against their windward surfaces, and they begin to grow. Wind waves any longer than the maximum wavelength of a capillary wave (0.68 inches) are termed gravity waves, since it is gravity that acts to restore these longer wavelength waves to equilibrium.

F.2.2 Wave Growth

The three primary factors affecting gravity wave growth in a source region are wind speed, fetch or fetch length, and duration. Duration is the length of time a wind in a given fetch affects wave growth. A fourth factor, fetch width, affects wave height, but it is not nearly as important as the other three factors. Wave height is most sensitive to wind speed, even for fetch-limited or duration-limited cases. The greater the area of water over which a constant wind blows (i.e., fetch), the duration of that constant wind, and the higher the wind's speed, the larger these gravity waves become. For a particular fetch and wind speed, there is a maximum wave height and period that can develop, regardless of the duration of the wind. Wave growth eventually reaches an equilibrium where the energy supplied to the waves by the wind equals the energy dissipated through wave dispersion and breaking. A fully developed or fully arisen sea describes a sea state in which the wave characteristics are not changing.

F.2.3 Estimating Wave Heights Using Wind Conditions

Figure F-2, the Bretschneider wave analysis and forecasting nomogram, graphically depicts the relationship between wind speed, fetch length, wind duration, wave height, and wave period. This nomogram provides a quick, manual method of estimating wave heights based on specific wind conditions. In Figure F-2, the horizontal (x) axis indicates fetch length in nautical miles, the vertical (y) axis indicates wind speed, the curved solid blue lines indicate resulting SWH in feet, the solid white curved lines indicate significant wave period (T_s) in seconds, and the forward-slanted dashed blue lines indicate wind duration. As an example, the nomogram predicts that a 30-knot wind blowing along an 80-nautical mile fetch can produce 10-foot waves with a period of 7 seconds. It also predicts that a 30-knot wind blowing for 6 hours is capable of creating 8-foot waves with periods of just over 6 seconds.

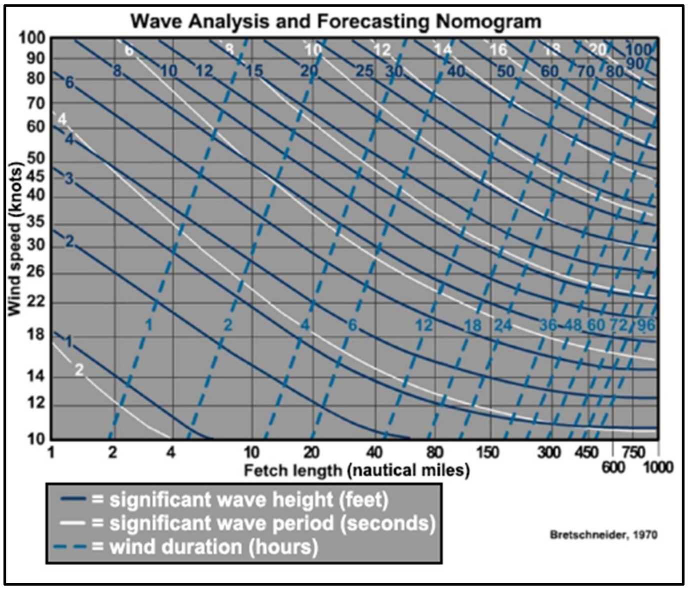

Figure F-2. Bretschneider Wave Analysis and Forecasting Nomogram

F.3 DEVELOPMENT OF SWELL

Wind waves in their generation region have a wide range of heights and periods. They are somewhat chaotic, steep, and short crested with many breaking as white caps. As waves move out of the area where they were generated and become swell, a phenomenon called dispersion (or wave spreading) gradually provides a sense of order, sorting the waves into groups based on their speed. The longer its period (and its wavelength), the faster a deep-water wave moves. As waves propagate further away from their source region, their choppiness gradually decreases, and they form the relatively smooth undulations of the sea surface called swell. The resulting swell waves may be completely obscured by other locally generated wind waves, and the masked swell may only become recognizable nearshore as it builds in height in the surf zone.

Once a wave is generated, it maintains energy and momentum, even without the influence of wind. If the wave moves from its source region into an area where the wind speed is slower than the wave speed, the wind has no effect on the wave; however, if the wave moves into an area where the wind speed is greater than the wave speed, the wave will grow. In contrast, the effect of opposing winds or wave energy on propagating swell is surprisingly small, especially if the swell's steepness is small. If a swell moving south encounters a south wind and waves moving north, only negligible changes in swell height and period occur. Another interesting wave characteristic to follow as a wave moves further out from its source region is wave steepness. As a review, wave steepness is determined by dividing a wave's height by its wavelength. Wind waves in their source region are typically steep. As the swell propagates away from its source region and experiences dispersion and angular spreading, swell height decreases while wave period (and hence wavelength) for an individual swell increases. Relatively low wave steepness indicates a swell group that has traveled far from its origin.

F.4 SWELL IMPACTS ON AMPHIBIOUS OPERATIONS

Knowledge of beach exposure and orientation to open-ocean storms is critical to determining the operational impact of ocean swell on specific sections of coastline. Waves generated several thousand miles away can create hazardous nearshore conditions, depending on storm intensity, geography, and nearshore morphology. Mid- to long-period swells (15–20 seconds) can produce exceptionally large breakers, particularly at exposed locations (e.g., reefs, headlands, or developed sandbars) where the incoming swell wave meets a sudden decrease in depth. It is important to monitor significant distant and local storm activity prior to, and during, an amphibious operation to ensure proper situational awareness of possible changing beach conditions.

Ocean swell moves in straight lines along great circle tracks—the shortest distance between two points on a sphere. This is important to keep in mind when evaluating the swell windows for a location. The swell windows for a beach are those quadrants or corridors radiating out seaward in great circle tracks from that location that is unobstructed by physical objects (e.g., continents, islands, shoals, and other shallow water features). With the exception of continental barriers, swell energy either refracts around barriers or dissipates significantly as the swell encounters shallow waters. Combining a map of the swell windows for a landing site with hemispheric weather maps helps forecasters recognize which distant storms may affect local operations. METOC forecasters with access to ocean buoy and satellite wave measurements may be able to confirm the presence of significant ocean swells heading towards a landing area. They will have oceanographic models available to forecast wave conditions.

Swell has little effect on small craft operating in deep water; however, it can be very dangerous during alongside operations due to the rolling and pitching of large vessels, the heavy stress imposed on gear being operated over the side, and the increased crew fatigue. The effect of swell on small craft is especially critical as these watercraft approach shallow water. Under the right conditions, swell-induced shallow water wave heights can double from their observed deep-water heights, creating dangerous surf conditions that can damage or destroy beach equipment and make harbor entrances impassible. Swell arising from distant storms can approach the coast at high speeds and energy. Swell waves ordinarily arrive prior to the storm system. Ships attempting to reach the protection of a harbor ahead of a storm may find that the entrance is already impassable due to breaking waves.

Locations across the North Pacific orientated to the south and southwest, are particularly vulnerable to large swells from powerful southern-hemisphere storms whose decay distances often exceed 5,000 nautical miles. Swells from this distance can take a week or more to arrive at a location, long after the storm has dissipated.

F.5 SIGNIFICANT WAVE HEIGHT

There is considerable variation between individual wave heights and periods in a group of waves traveling through the water. This makes it difficult to determine a representative wave height and period by looking at just a few waves. Heights and periods are determined statistically by averaging a large sampling of waves. From an operations standpoint, the higher waves have the most impact on landing craft. For this reason, only the highest third of the waves observed during a sampling period are used to calculate SWH values. Ideally, the sample size should be at least 100 successive waves, thus an average of the highest 33 waves would be used to find the significant wave height. Figure F-3 shows the distribution of wave heights statistically over a sample period. Per the NOAA glossary, combined seas (also known as seas) is used to describe the combination or interaction of wind waves and swell in which the separate components are not distinguished. This includes the case when swell is negligible or is not considered in describing sea state.

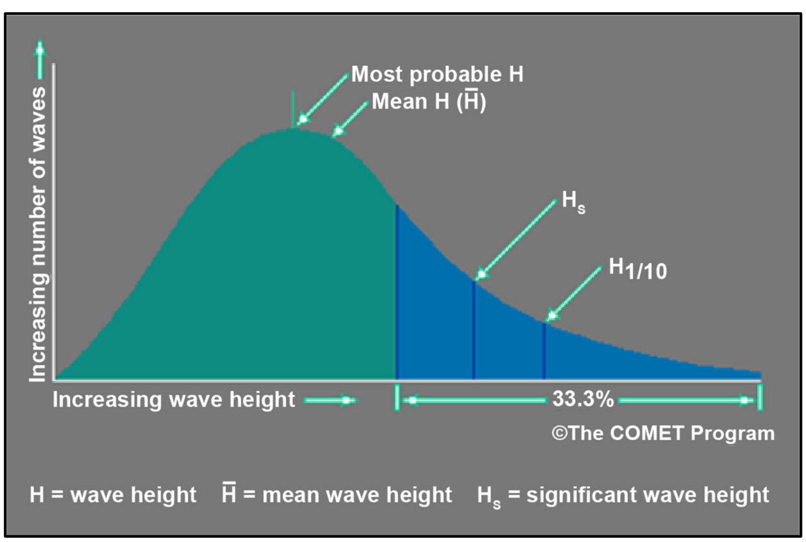

Figure F-3. Graphic Depiction of Significant Wave Height

F.6 SEICHES

A seiche is a shallow-water standing wave that oscillates back and forth within a bay or basin. Seiches can be generated by an impulse disturbance (e.g., an earthquake or avalanche) or by short duration winds in a squall line. Seiches are usually created by persistent strong winds blowing down the long axis of a large water body. The winds create a surface current that pushes the water level higher in the downwind direction, relative to the water level in the upwind direction. When the wind relaxes, the water seeks a return to a horizontal equilibrium as a seiche wave. Like water sloshing in a tub, the water in the bay or basin oscillates back and forth with the amplitude of the oscillation gradually decreasing due to frictional effects. The rise and fall can be from a few inches to over 10 feet and can cause flooding and erosion at one end of a bay and shallow-water hazards to navigation at the other end. Although seiche waves are uncommon, knowing whether an area is subject to seiches is an important consideration during the planning phase of an operation. In such cases, planners should request specific seiche forecasts from METOC forecasters.

F.7 TSUNAMIS

Tsunamis are long-period impulse waves caused by high-magnitude seismic events (e.g., earthquakes, underwater volcanic eruptions, or landslides on the seafloor) that rapidly displace large quantities of ocean water. The resultant waves, commonly, but incorrectly, referred to as tidal waves, radiate in all directions from the area of the disturbance and can damage shorelines and low-lying regions thousands of miles from their generation area. Tsunamis have a wavelength 1,000–2,000 times longer than wind-generated waves, wave periods of greater than 15 minutes, and deep-water speeds of nearly 500 miles per hour. These long wavelength, high-speed waves lose very little energy as they travel long distances across open oceans.

Because of their low wave height and gentle slope while in deep water, tsunamis are barely felt by ships at sea; however, they contain an enormous amount of energy and can become deadly as they approach the shore. They frequently manifest at the beach as a quickly rising tide rather than a giant wave. Although it slows down considerably upon reaching shallow water, a tsunami still travels at speeds greater than 30 knots and is strong enough to move boats, vehicles, and buildings inland or out to sea and force rivers to flow upstream over considerable distances. Damaging effects are amplified in harbors and bays where the tsunami is funneled by geography. Wave heights over 100 feet have been recorded. It is important to monitor seismic events during littoral operations and to be able to assess, without hesitation, the need to move forces away from the beach.

The Joint Typhoon Warning Center, located at Pearl Harbor, Hawaii, and NOAA's tsunami warning centers monitor seismic activity and will send out warnings and advisories as needed. Locations close to the epicenter of seismic activity may only have minutes before the tsunami strikes and may not receive a warning. There are visual cues that can identify impending danger. One of those signs is an unusual sudden retreat of water from shore. Other signs of an impending tsunami are:

1. Feeling a strong earthquake near the coastline
2. An unusually low tide
3. Fast, frothy currents
4. Unusual water movement.

These conditions can foreshadow an imminent tsunami and the need to take immediate action. Planners should prepare an action plan that includes an evacuation route to high ground and a sortie plan for landing craft.

F.8 SEA-STATE CODES

Sea state is one of many factors used to determine the feasibility of naval operations and the functionality of maritime platforms. Higher sea states can impede shipboard debarkation operations, landings, the resupply of landing forces, and the use of specific landing craft during amphibious operations. Severe conditions can degrade naval gunfire support.

Sea-state scales and the Beaufort wind-force scale. Numerous sea-state scales have been developed over the years to categorize the force of progressively higher seas by wave height. The Beaufort wind-force scale, ranging from force 0–force 12, is typically used as a standardized method of bracketing the force of wind necessary to achieve specific levels of sea-surface disturbance and waves of a specific height range in the open ocean. Increased wave heights are represented by increased sea-state scale values. These values range from zero to 10. The different sea-state scales currently cited within various current Navy and Marine Corps doctrine and operators manuals include the Bowditch sea-state code taken from Nathaniel Bowditch's Pub. No. 9, Volume I, American Practical Navigator: An Epitome of Navigation, the Douglas sea and swell scales, the Wilbur Marks scale, the Pierson-Moskowitz scale, and the matching World Meteorological Organization Code Table 3700 and North Atlantic Treaty Organization (NATO) sea-state code. Unfortunately, in many of these doctrinal publications, specific sea-state limitations are stated for specific activities or the operation of specific watercraft, but the guidance does not explicitly state which of these various sea-state scales was applied when operational limitations or restrictions were established. As Figure F-4 shows, the wave height ranges given by the various scales for individual sea-state code values are relatively close in most cases.

Sea-state scale tables. In almost all cases, the tables used to present sea-state scales display the 0–12 Beaufort wind-force scale on the left-hand side of the table, and the bracketed resulting wave height ranges and corresponding sea-state scale values ranging from 0–10 on the right-hand side of the table. Figure F-4 is provided to compare the various sea-state scales against one another. The Bowditch sea-state scale is probably the most commonly used scale. It is the one used by the Navy's METOC community. When using any of these scales, one should remember what is stated within Bowditch: "The sea conditions described for each Beaufort (wind) force are steady-state conditions; i.e., the conditions which result when the wind has been blowing for a relatively long time, and over a great stretch of water." The greater the area of water over which a wind blows (i.e., fetch), the duration of that wind, and the higher the wind's speed, the larger the wind waves become. At any particular time at sea, the duration of the wind, the fetch, or both may not have been great enough to produce these steady-state conditions. When operating in restricted waters and/or close to a coast with the wind blowing offshore, it may be necessary to make allowances for the shorter stretches of water over which the wind is blowing. Accordingly, observations of wind and seas conditions taken from the shoreline may not accurately reflect wind, and, more importantly, wave conditions occurring just offshore, especially if the elevation of the coastal terrain increases rapidly away from the shoreline. Moreover, in relation to operations that encompass the surf zone, it is imperative to keep in mind that the SUROB and MSI only consider the conditions in the surf zone and may greatly differ from what is encountered in the open ocean.

Beaufort Wind-force Scale/Number	Wind Velocity		Wind Description	Descriptions of Beaufort Wind-force-generated Waves	Sea-state Code	Sea-state Scales Comparison					
	Knots	Miles per Hour				Bowditch Wave Height (feet)	NATO Significant Wave Height (feet) (North Atlantic)	WMO Sea-state Code Table 3700: Wave Height (feet)	Douglas Sea Scale Wave Height (feet) (not swell)	Pierson-Moskowitz Wave Height (feet) (North Atlantic)	Wilbur Marks Significant Wave Height (feet)
0	**<1**	**<1**	Calm	Sea surface smooth and mirror-like	**0**	**0**	0–0.33	0	no wave	0.1–0.16	
1	**1–3**	**1–3**	Light Air	Scaly ripples, no foam crests	**1**	**0–0.3**		0–0.33	0–0.33	0.5–1.2	0.29–1
2	**4–6**	**4–7**	Light Breeze	Small wavelets, crests glassy, no breaking	**2**	**.03–1**	0.33–1.64			1.5–3	1–2.9
3	**7–10**	**8–12**	Gentle Breeze	Large wavelets, crests begin to break, scattered white caps	**3**	**1–4**	1.64–4.1	0.33–1.64	0.33–1.64	3.5–5	2.9–4.6
4	**11–16**	**13–18**	Moderate Breeze	Small waves, becoming longer, numerous white caps	**4**	**4–8**	4.1–8.2	1.64–4.1	1.64–4.1	6–7.5	4.6–6.9
5	**17–21**	**19–24**	Fresh Breeze	Moderate waves, take longer to form, many white caps, some spray	**5**	**8–13**	8.2–13.1	4.1–8.2	4.1–8.2	8–12	6.9–12
6	**22–27**	**25–31**	Strong Breeze	Larger waves, white foam steaks off breakers	**6**	**12–20**	13.1–19.7	8.2–13.1	8.2–13.1	14–20	12–18
7	**28–33**	**32–38**	Near Gale	Sea heaps up, white foam steaks of breakers	**7**	**20–30**	19.7–29.5	13.1–19.7	13.1–19.7	25–40	18–40
8	**34–40**	**39–46**	Gale	Moderately high, waves of greater length, edges of crests begin to break into spindrift, foam blown streaks	**8**	**30–45**	29.5–45.9	19.7–29.5	19.7–29.5	45–60	40–64
9	**41–47**	**47–54**	Strong Gale	High waves, sea begins to roll, dense streaks of foam, spray may reduce visibility	**9**	**45 and over**	45.9 and over	29.5–45.9	29.5–45.9	70–100	
10	**48–55**	**55–63**	Storm	Very high waves, with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility							
11	**59–63**	**64–72**	Violent Storm	Exceptionally high waves. foam patches cover sea, visibility more reduced							
12	**64 and over**	**73 and over**	Hurricane	Air filled with foam, sea completely white with driving spray, visibility greatly reduced							

Figure F-4. Beaufort Wind-force Scale and Various Sea-state Scales

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APPENDIX G

Summary of Characteristics of Amphibious Landing Craft and Assault Vehicles

G.1 INTRODUCTION

The following provide brief descriptions of the various amphibious landing craft, AAVs, and small boats currently used in amphibious and expeditionary operations. These descriptions provide the surf forecaster with quick access to basic characteristics of watercraft and amphibious vehicles involved in an amphibious landing. Specific oceanographic factors that affect these crafts and boats are presented in Chapter 3. Figure F-4 provides corresponding sea-state tables for use when considering the operational limitations and impacts of sea-state conditions on the platforms provided within.

G.2 NONDISPLACEMENT LANDING CRAFT

The LCAC (see Figure G-1) is a nondisplacement, ship-to-shore, and over-the-beach amphibious landing craft used to conduct high-speed, ship-to-shore, and over-the-beach maneuvers in conjunction with the vertical maneuver capabilities of the Marine Corps' rotary-wing and MV–22 tiltrotor aircraft. LCACs are highly maneuverable and have an excellent navigation system. The LCAC derives its amphibious capability by supporting itself on a cushion of air.

Figure G-1. Landing Craft, Air Cushion
(U.S. Navy photo by Mass Communications Specialist 2nd Class Jose Jaen (RELEASED))

The ship-to-shore connector (also known as the LCAC 100-class) is a system being developed by the Navy as a replacement for the legacy LCACs. It offers an increased capacity to cope with the growing weight of equipment used by the Army and Marine Corps. Although the design of the LCAC 100 is broadly similar to the LCAC, there are several significant differences, to include more powerful engines, extensive use of composites and aluminum alloys for corrosion resistance, and an advanced skirt design instead of a deep skirt for less drag and reduced craft weight. Figures G-2 and G-3 present the operational characteristics of the LCAC and LCAC 100.

<table>
<tr><th colspan="2">Landing Craft, Air Cushion</th></tr>
<tr><td colspan="2">Description. The LCAC combines the heavy-lift capability of a displacement landing craft with the high speeds of helicopter-borne assaults. It can transport equipment, cargo, and weapons systems from ships through the surf zone, across the beach, to landing points beyond the HWM in a variety of environmental conditions.</td></tr>
<tr><th>Characteristic</th><th>Specifications</th></tr>
<tr><td>Dimensions</td><td>Length: 91.79 feet with deep skirt (on cushion)
Beam: 48.3 feet at design N2 (on cushion); Beam: 49.17 feet at reduced N2 (on cushion)
Ramp width: 28 feet forward, 14 feet aft</td></tr>
<tr><td>Displacement</td><td>168 tons (design load)</td></tr>
<tr><td>Crew</td><td>Five crew and 23 troops (or 15 combat loaded): craftmaster, engineer, navigator, wave and troop commander (when embarked)
Seven troops, loadmaster, deck engineer and 16 troops</td></tr>
<tr><td>Range[1]</td><td>200 nautical miles; range of 300 nautical miles at 35 knots</td></tr>
<tr><td>Maximum Speed</td><td>40+ knots;[2] overland maximum speed (terrain dependent): 25 knots</td></tr>
<tr><td>Limitations</td><td>Maximum surf:[3] 8 feet; sea state:[4] 3</td></tr>
<tr><td>Draft, Off Cushion</td><td>Empty: 2 feet, 2 inches
Full: 2 feet, 7 inches</td></tr>
<tr><td>Slope Standing Start</td><td>6 degrees</td></tr>
<tr><td colspan="2">Notes:
1. Range. Craft range is determined by fuel load, fuel consumption rate, and the maximum safe speed (in knots) that is attainable for a given mission. Whenever possible, craft range should be planned based on a craft speed of 35 knots. Craft range is severely restricted during subhump operations because fuel burn rates are nearly the same as posthump operations, but craft speed is nominally less than 15 knots. For additional information on over-hump operations and hump speeds, see 3.6.3.2.
2. Speed. Payload, relevant sea and weather conditions, and craft-degrading casualties determine safe speed. LCAC cushion operations require maintaining speeds above 18–20 knots (hump speed).
3. Maximum surf: favorable: Less than 7 feet
marginal: 7–8 feet
unfavorable: less than 8 feet
4. Sea state limitations: favorable: 3 (equals Bowditch wave height 1–4 feet)
marginal: 4 (equals Bowditch wave height 4–8 feet)
unfavorable: greater than 4 (equals Bowditch wave height 8 feet and greater)
<u>Legend:</u>
N2 power turbine revolution per minute (in percent)</td></tr>
</table>

Figure G-2. Mission and Characteristics of Landing Craft, Air Cushion

Mission	
The LCAC 100 combines the heavy-lift capability of a displacement landing craft with the high speeds of the helicopter-borne assault. It can transport equipment, cargo, and weapons systems from ships through the surf zone, across the beach, to landing points beyond the HWM in a variety of environmental conditions.	
Cargo/Personnel Capacity, Design	67.13 metric tons (74 short tons), 148,000 pounds, 26 combat-equipped troops
Crew	Five enlisted
Range	86 nautical miles at 35 knots with payload
Maximum Speed	50 knots (see note)
Draft, Off Cushion	Minimum (empty craft) 0.75 meters (2.46 feet) Maximum (maximum allowable craft weight) 1.0 meters (3.28 feet) Skirt (craft dead in water) 1.78 meters (5.83 feet)
Notes: 1. Fifty knots may be exceeded only when authorized by a safe engineering and operations (SEAOPS) waiver. 2. U.S. Navy photo by Ronald Newsome.	

Figure G-3. Mission and Characteristics of the Landing Craft, Air Cushion 100

Key oceanographic and environmental factors, to include SWH, water depth, and ambient temperature at the main engine air inlets, must be considered when planning LCAC operations. Weather can affect LCAC operations but is of lesser concern than other ship-to-shore delivery options. At over-the-horizon ranges of 12–100 nautical miles, load and SWH permitting, LCACs can not only support ship-to-shore movement during amphibious operations, but also personnel transfers, NEO, foreign humanitarian assistance, civil support, military assistance for civil disturbances, and support of military deception operations. For additional specific information on employment of LCACs, see NWP 3-02.12/MCRP 3-31.1A.

Once the total allowable craft weight has been determined, it is necessary to determine the maximum speed at which an LCAC can be operated without causing structural damage. The stress on the structure of an LCAC becomes larger with an increase in gross weight and with an increase in the combination of significant wave height and forward speed. Since the hull of an LCAC is a relatively light structure, as compared to the hull of a conventional landing craft, there are strict limits on how fast the craft should be operated. These limits are graphed out in S9LCA-AA-SSM-100, Volume VII. The S9LCA-AA-SSM-100, Volume VII, graph shows the allowable speed in knots for various wave heights plotted against craft gross weight. All LCAC craftmasters will have this document.

G.3 DISPLACEMENT LANDING CRAFT

The LCAC is designed to operate in a nondisplacement mode in which it rides on the surface of the water supporting itself on a cushion of air. In contrast, vessels with displacement hulls cut through the water and use less propulsion by pushing the water aside. Boats with planning hulls are designed to rise up and glide nearer to the surface of the water when enough power is supplied. These boats operate as displacement hulls when at rest or at slow speeds but climb towards the surface of the water as they move faster. The various watercraft described in the following all have some form of displacement hulls and are more susceptible to wave action than LCACs are. They are impacted by currents. They are subject to damage from contact with submerged obstacles (e.g., reefs and bars).

G.3.1 Landing Craft, Utility

The LCU (see Figure G-4) is a highly versatile displacement craft designed to beach where hydrographic and weather conditions permit, unload/load, and retract while performing its mission to land heavy vehicles, equipment, personnel, and cargo in an amphibious operation. Landing crafts, utility transport wheeled and tracked vehicles, general cargo, and personnel from ship-to-shore, shore-to-ship, shore-to-shore, and in resupply, backload, or recovery operations (see Figure G-5). Roll-on/roll-off-type missions are accomplished using the vessel's bow and stern ramps. Landing crafts, utility have been adapted for other uses (e.g., conducting salvage operations and serving as ferries for vehicles and passengers (including NEO)). They are valuable in logistics over-the-shore operations and intratheater transport using harbor and inland waterway routes. They are self-sustaining crafts with the habitability features typically found aboard ships. These craft are usually preloaded in and employed from LHDs or amphibious transport dock (LPD) well decks. Additional information on LCUs can be found in NTTP 3-02.14.

Landing Craft, Utility	
Description. The LCU is designed to beach, unload/load, and retract, while landing heavy vehicles, equipment, personnel, and cargo. LCUs transport wheeled and tracked vehicles, general cargo, and personnel from ship-to-shore, shore-to-ship, and in resupply, backload, or recovery operations. It is valuable in logistics over-the-shore operations and intratheater transport. For additional information, see G.3.1 and NTTP 3-02.14, Naval Beach Group Operations.	
Characteristic	**Specifications**
Dimensions	**Length:** 134.75 feet **Beam:** 29.75 feet **Bow ramp minimum width:** 14.25 feet **Stern gate:** 18 feet width **Length of well:** 100 feet
Displacement	198 tons (light load) 368 tons (full load)
Crew	Craftmaster (chief petty officer or equivalent) plus 10 other enlisted (14 in wartime with the addition of gunner's mate/information technology personnel). Ratings represented on the craft are boatswain's mate, engineman, quartermaster, information systems technician, culinary specialist, and nonrated seamen and firemen.
Range	1,200 nautical miles or 10 days (has the capability of sustained independent at-sea operations for approximately 10 days)
Maximum Speed	11 knots
Limitations	Winds greater than 35 knots, seas greater than 8 feet, MSI greater than 6 (training, operations), MSI greater than 12 (wartime)
Draft, Light Load	Forward: 2 feet, 6 inches Aft: 4 feet, 8 inches
Draft, Full Load	Forward: 4 feet, 4 inches Aft: 6 feet, 10 inches
General Information	-It is home for its crew and can operate independently of the amphibious ships in which embarked. Sleeping quarters, a washroom and shower, clothes washer and dryer, a lounge with a television, and a complete galley are built into the craft. -Can be used in conjunction with other LCUs as a causeway section under ideal sea conditions. -At distances of 10 nautical miles or less, it can deliver light-armored vehicles and tanks more efficiently than an LCAC.

Figure G-4. Mission and Characteristics of Landing Crafts, Utility

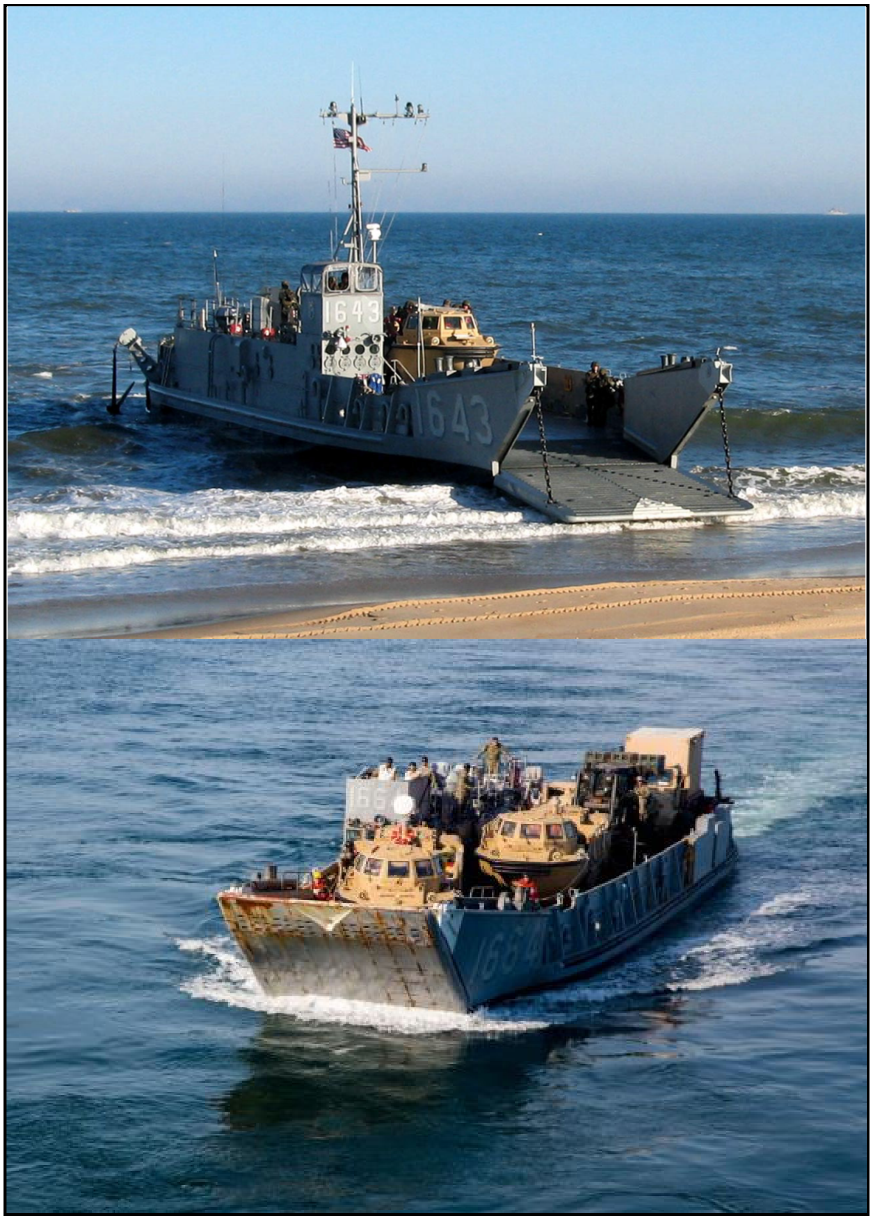

Figure G-5. Landing Craft, Utility (Lower photo: U.S. Navy photo by Mass Communications Specialist Seaman Apprentice Ryre Arciaga (RELEASED))

G.3.2 Landing Craft, Mechanized

The LCM (Figure G-6) (commonly called a Mike-8 boat) is another displacement craft with the primary mission of supporting MPF operations, conducting ammunition transfers, harbor tours, and serving as a search and rescue platform. Designed to transport cargo, troops, and vehicles from ship-to-shore or in retrograde movements, it can be operated through breakers and be grounded on the beach (Figure G-7). The large bow ramp allows operations with wheeled and certain tracked vehicles, and its relatively small size allows for use in confined areas. Additional information on LCMs can be found in NTTP 3-02.14.

Landing Craft, Mechanized, Mark 8		
Description. The LCM-8 can transport cargo, troops, and vehicles from ship-to-shore or shore-to-ship. It is no longer routinely deployed aboard amphibious ships and is now more often used for utility work in harbors and lighter work during MPF operations.		
Characteristic	**Specifications**	
	Steel	**Aluminum**
Dimensions	**Length:** 73.6 feet **Beam:** 21.0 feet	**Length:** 73.25 feet **Beam:** 21.04 feet
Displacement	134,000 pounds (light; hoisting weight) 254,000 pounds (full load)	75,500 pounds (light) 215,000 pounds (full load)
Crew	5 enlisted	5 enlisted
Range	190 nautical miles	150 nautical miles
Maximum Speed	12 knots (light) 9 knots (full load)	12 knots (full load)
Limitations	Maximum Surf: 8 feet	Maximum Surf: 8 feet
Draft, Loaded	Forward: 3.8 feet Aft: 5.2 feet	Forward: 3.8 feet Aft: 5.2 feet

Figure G-6. Mission and Characteristics of Landing Crafts, Mechanized

Figure G-7. Landing Craft, Mechanized (Upper photo: U.S. Navy photo by Scott A. Thornbloom (RELEASED))

G.3.3 Amphibious Assault Vehicles

Amphibious assault vehicles (Figure G-8), armored assault full-tracked landing vehicles, provide a forcible entry amphibious capability that is unique to the Marine Corps. Amphibious assault vehicles are organic to the landing force. Employed from well deck ships, AAVs come in multiple variants, to include the personnel carrier version, the command version, and the recovery version. The AAVP7A1 RAM/RS, the personnel carrier version of the AAV, provides protected transport through rough water and the surf zone to the beach for a crew of three and up to 21 combat-loaded Marines during ship-to-shore movements. The vehicle can move at speeds of up to 8 knots at sea (Figure G-9) and can also carry troops to inland objectives at speeds of up to 45 miles per hour.

Amphibious Assault Vehicle	
Descriptions. The unique combination of armor and amphibious capabilities of the AAV make it the mainstay of surface assault forces conducting amphibious assaults. **Mission of AAVP7A1 RAM/RS.** Provide armor protected transportation for landing forces, and their supporting equipment and supplies. **Mission of AAVP7A1 RAM/RS Personnel AAV, Mine Countermeasures-equipped.** Conduct minefield and obstacle breaching during amphibious and sustained operations ashore. **Mission of AAVC7A1 RAM/RS.** Mobile command post designed to give the commander the basic communication capability of a static combat operations center. **Mission of AAVR7A1 RAM/RS.** Recovery of AAV or similar size craft and vehicles from open ocean, surf, swamps, etc. Provides the basic maintenance equipment necessary for first- through third-echelon maintenance and repair of the AAV family of vehicles in the field.	
Characteristic	**Specifications**
Dimensions	**Length:** approximately 27 feet **Beam (width):** approximately 11 feet
Crew	3 (AAVP7A1 RAM/RS, AAVC7A1 RAM/RS) 5 (AAVR7A1 RAM/RS)
Range	Approximately 56 nautical miles in water: (6–8 miles per hour, 7 hours) 200+ miles on land (45 miles per hour)
Maximum Speed	7.2 knots (8.3 miles per hour) afloat at 2,800 revolutions per minute in calm conditions
Limitations	-Factors (e.g., sea state, wind, current, and vehicle load) greatly affect water speed. -Susceptible to multiple types of casualties[1] -Able to negotiate sea-states 1–3 (equals Bowditch wave height up to 4 feet), but experiences difficulty maintaining speed and maneuverability in sea-state 4 (equals Bowditch wave height 4–8 feet). Amphibious assault vehicles can survive operations in sea-state 5 (equals Bowditch wave height 8–13 feet) but at reduced effectiveness. Troops should not be embarked aboard AAVs in sea-state 5 conditions. Amphibious assault vehicle operations in sea-state 5 or greater not advised. (MCTP 3-10C, Change 1)
Mean Seawater Draft	81.8 inches (cargo loaded) Freeboard at bow: 25.5 inches Freeboard at stern: 11.5 inches
Notes: **1. Types of AAV casualties:** a. Swamping, flipping, or capsizing by breakers. Vehicle is self-righting and can be flipped back over unless beached/grounded. b. Sinking due to structural damage sustained from impacting reefs or other natural obstructions. c. Broaching on a sandbar, obstacle, or the beach. **2. Visibility.** During daylight with unrestricted visibility, 50 meters or five AAV lengths should be kept between vehicles. During restricted visibility and at night, 50 meters or less should be kept between vehicles, depending on the limit of visibility. **3. Water propulsion.** Two aft-mounted water-jet pumps located port and starboard. Vehicle can propel itself with tracks in the water, albeit slower. 4. Able to negotiate 6-foot plunging surf, cargo loaded, and survive 10-foot plunging surf without sustaining mission failure.	

Figure G-8. Mission and Characteristics of Amphibious Assault Vehicles

Figure G-9. Amphibious Assault Vehicle

The AAVC7A1 RAM/RS variant has the same basic characteristics as the personnel carrier version but is designed to provide a mobile regimental or battalion tactical command-post platform. The system consists of six functionally interchangeable staff workstations capable of hosting current MAGTF command and control applications. In addition to its crew of three, it can carry a commander and staff of up to 10 personnel.

The AAVR7A1 RAM/RS has the same basic characteristics as the personnel carrier version, but this variant is designed to recover similar or smaller-sized vehicles on land and carries basic maintenance equipment, to include a generator, air compressor, welder, hydraulic crane, and a winch to provide field-support maintenance to vehicles in the field. For more information on AAVs, see MCTP 3-10C, Change 1.

G.3.4 Amphibious Combat Vehicles

Amphibious combat vehicles (Figure G-10), armored-assault, 8×8, all-wheel-drive landing vehicles, provide a forcible entry amphibious capability that is unique to the Marine Corps. Amphibious combat vehicles are organic to the landing force. Employed from well deck ships, ACVs come in multiple variants, to include the personnel carrier variant, the command variant, the 30-millimeter gun variant, and the recovery variant. The ACV-P provides protected transport through rough water and the surf zone to the beach for a crew of three and up to 13 combat-loaded Marines during ship-to-shore movements. The vehicle can move at speeds of up to 6 knots at sea (see Figure G-11) and can carry troops to inland objectives at speeds of up to 65 miles per hour on primary roads.

The ACV-C variant has the same basic characteristics as the personnel carrier version but is designed to provide a mobile regimental or battalion tactical command-post platform. The system consists of functionally interchangeable staff workstations capable of hosting MAGTF command and control applications. In addition to its crew of three, it can carry a supported unit commander and six embarked staff members.

<table>
<tr><th colspan="2">Amphibious Combat Vehicle</th></tr>
<tr><td colspan="2">Descriptions. The unique combination of armor and amphibious capabilities of the ACV make it the mainstay of surface assault forces conducting amphibious operations.
Mission of ACV-P. Provide armor-protected transportation for landing forces and their supporting equipment and supplies.
Mission of ACV-C. Mobile command post designed to give the commander the basic communication capability of a static combat operations center.
Mission of Amphibious Combat Vehicle-30-Millimeter Gun (ACV-30). Provide on-the-move medium-caliber lethality to support infantry operations ashore and destroy the threat from lightly armored vehicles.
Mission of Amphibious Combat Vehicle-Recovery (ACV-R). Recovery of ACV or similar size craft and vehicles from surf, swamps, etc. Provides the basic maintenance equipment necessary for field-level maintenance and repair of the ACV family of vehicles.</td></tr>
<tr><th>Characteristic</th><th>Specifications</th></tr>
<tr><td>Dimensions</td><td>Length: approximately 30 feet
Beam (width): approximately 11.5 feet</td></tr>
<tr><td>Crew</td><td>3 (ACV-P, ACV-C, ACV-30)
4 (ACV-R)</td></tr>
<tr><td>Range</td><td>Approximately 33 nautical miles (sea only)
200+ miles on varied terrain (land only)</td></tr>
<tr><td>Maximum Speed</td><td>Approximately 6 knots (6.9 miles per hour) afloat at 2,180 revolutions per minute in calm conditions
65 miles per hour on primary roads</td></tr>
<tr><td>Limitations</td><td>-Factors, such as sea state, wind, current, and vehicle load, greatly affect water speed.
-Susceptible to multiple types of casualties[1]
-Able to negotiate sea-states 1–3 (equals Bowditch wave height up to 4 feet) but experiences difficulty maintaining speed and maneuverability in sea-state 3 (equals Bowditch wave height 1–4 feet). Amphibious combat vehicle operations in sea-state 4 or greater (equals Bowditch wave height greater than 4 feet) is not advised.</td></tr>
<tr><td>Mean Seawater Draft</td><td>98.7 inches (troop loaded)
Freeboard at Bow: 16.7 inches
Freeboard at Stern: 12 inches</td></tr>
<tr><td colspan="2">Notes:
1. Types of ACV casualties:
a. Swamping, flipping, or capsizing by breakers. Vehicle is self-righting and can be flipped back over unless beached/grounded.
b. Sinking due to structural damage sustained from impacting reefs or other natural obstructions.
c. Broaching on a sandbar, obstacle, or the beach.
2. Visibility. During daylight with unrestricted visibility, 50 meters or five ACV lengths should be kept between vehicles. During restricted visibility and at night, 50 meters or less should be kept between vehicles, depending on the limit of visibility.
3. Water propulsion. Two aft-mounted water propeller units located port and starboard.</td></tr>
</table>

Figure G-10. Mission and Characteristics of Amphibious Combat Vehicles

Figure G-11. Amphibious Combat Vehicle

The ACV-30 variant currently under development will provide a stabilized, medium-caliber weapon system that is optimized towards infantry support but includes lethality up to the ability to destroy armored vehicles. The ACV-30 will have a crew of three and embark up to eight combat-loaded Marines during ship-to-shore movements. The initial operational capability of the ACV-30 is Fiscal Year 2026.

The ACV-R variant currently under development will have the same basic characteristics as the personnel carrier version, but this variant will be designed to recover similar or smaller-sized vehicles on land and carries basic maintenance equipment, to include a generator, air compressor, welder, hydraulic crane, and a winch, to provide field-support maintenance to vehicles in the field. The initial operational capability of the ACV-R is Fiscal Year 2028. For more information on ACVs, see MCRP 3-10C.1.

G.3.5 Lighter, Amphibious Resupply, Cargo, 5-ton

LARC-Vs (Figure G-12) are used by naval beach groups for surf zone salvage, recovery, dewatering, ship-to-shore movement, medical or casualty evacuation, command and control roles, ramp checks, detection and marking of obstructions in the surf zone after the landing site is determined to be feasible, and occasionally for the transportation of personnel and equipment (Figure G-13). The LARC-V is a single-propeller, four-wheeled, self-propelled amphibious vehicle powered by a diesel engine. Each BPT is equipped with two vehicles. Additional information on LARC-V can be found in NTTP 3-02.14.

Lighter, Amphibious Resupply, Cargo, 5-ton	
Description. The general mission is to provide the BPT with surf zone salvage capabilities (e.g., towing disabled rolling stock, dewatering, passing tow line messengers to seaward salvage assets, and transporting personnel/cargo from ship-to-shore).	
Characteristics	**Specifications**
Dimensions	**Length:** 35 feet **Beam:** 10 feet
Displacement	26,000 pounds dry weight
Crew	3 enlisted
Range	40 nautical miles (sea) 285–335 miles (land)
Maximum Speed	7.5 knots (sea) 29 miles per hour (land)
Limitations	-**Ocean Current.** No-go if ship-to-shore movement is greater than 4 miles; should not be attempted at night or in conditions of low visibility or when current is greater than 4 knots. -**Swell Height.** No-go if swell heights greater than 6 feet or any combination of sea and swell heights greater than 6 feet. -**Chop Height.** No-go if chop height greater than 4 feet, regardless of swell height. -**Wind Speed.** No-go if wind speed greater than 25 knots, regardless of wave height. -**Beach Gradient.** 60 percent (31 degrees). -**Modified Surf Index.** Wartime—no-go if MSI exceeds 9 Training—no-go if MSI exceeds 6.
Draft, Fully Loaded	Forward: 4.1 feet Aft: 4.3 feet
Draft, Light	Forward: 3.3 feet Aft: 3.8 feet

Figure G-12. Mission and Characteristics of Lighter, Amphibious Resupply, Cargo, 5-ton

Figure G-13. Lighter, Amphibious Resupply, Cargo, 5-ton

G.3.6 Improved Navy Lighterage System Causeway Ferry

The INLS is the name given to the system of specialized platforms, vessels, and related equipment in use by the Navy to transport heavy equipment (tanks, trucks, etc.) and other containerized cargo between ships and shore areas when conventional port facilities are unavailable or inadequate and sea conditions permit. The major components of the INLS can be assembled into both a temporary at-sea staging area and ship-to-shore delivery system that is capable of being used in sea-state 3 conditions.

Once assembled in the CF configuration, the assemblage becomes a powered, cargo-transfer, lighterage platform capable of loading, transferring, and discharging equipment and cargo from ships anchored offshore to the shore during maritime pre-positioning, logistics over-the-shore, and assault follow-on operations. The CF is created by rigidly connecting its three functional components—a WT, which serves as the PM; one or more IMs; and a beach module (BM). Although the WT is not designed or equipped to carry cargo itself, it serves as both a module of the

CF and a platform in itself that operates independently of all other modules. It assists in platform assembly, disassembly, installation, anchor deployment, anchor retrieval, salvage, relocation, station keeping, and other logistics over-the-shore support tasks for a full range of operations. Its primary function is to support the cargo-carrying lighterage and lighterage platforms by assisting in the flexible positioning and maneuvering of nonpowered CF modules during assembly and disassembly. In addition to serving as PM of the CF, the WT is used to assist and support other INLS platforms and operations. It is the primary vessel for seaward salvage operations during ship to shore movement. The basic characteristics including METOC limitations of the CF and its WT are provided in Figure G-14. An example causeway ferry configuration is shown in Figure G-15.

Improved Navy Lighterage System				
Description: The WT is the powered module (PM) used to assist and support other INLS platforms and operations. The WT is both a module and platform by itself. The INLS CF is capable of loading, transferring, and discharging cargo from ships anchored in-stream to the shore during maritime pre-positioning, logistics over-the-shore, and assault follow-on operations. The CF is configured using some combination of its three modules (PM, intermediate module (IM), and BM), as shown in the following.				
	Specifications			
Characteristic	**WT PM**	**PM+BM**	**PM+IM+BM (standard configuration)**	**PM+IM+IM+BM**
Dimensions	**Length:** 88 feet **Beam:** 26 feet	**Length:** 168 feet **Beam:** 26 feet	**Length:** 256 feet **Beam:** 26 feet	**Length:** 336 feet **Beam:** 26 feet
Displacement	115 long tons	353 long tons	562 long tons	770 long tons
Crew	7	8	8	8
Maximum Speed	10 knots maximum	10 knots maximum	10 knots maximum	10 knots maximum
Limitations (Sea states listed are based on Pierson-Moskowitz)	Sea-state 4 Maximum MSI 9	Sea-state 3 Maximum MSI 9	Sea-state 3 Maximum MSI 9	Sea-state 1 or harbor-like conditions. Beaching not recommended in this configuration.
Draft, Loaded	4 feet	4 feet	4 feet	4 feet

Figure G-14. Mission and Characteristics of Improved Navy Lighterage System

Figure G-15. Improved Navy Lighterage System Causeway Ferry

G.4 SPECIAL PURPOSE WATERCRAFT

Special purpose craft are employed by landing FORECON teams, SEAL teams, and troop units to conduct advance-force operations, clandestine assault support, and raids. They are used to carry boarding and inspection teams during maritime interception and visit, board, search, and seizure operations. These relatively smaller rubber or fiberglass watercrafts are significantly affected by surf conditions. When planning for using these watercraft, operating areas are more carefully selected, and environmental conditions are continuously monitored. Any of these smaller watercraft can be operated by a single operator and carry two to four passengers are categorized as a combatant craft-light. The CRRC (average 15 feet in length) is an inflatable combatant craft-light capable of carrying four or five SEALs or other personnel for landing and recovery on a beach/shore over short distances. In contrast, the 11-meter NSW RIB and NSW's special operations craft-riverine are categorized as a combatant craft-medium.

G.4.1 Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft

Combat rubber raiding crafts/combat rubber reconnaissance crafts (see Figures G-16 and G-17) are used by the Navy for clandestine surface insertion and extraction of lightly armed special operations forces and for over-the-horizon operations. Limited to operating in 8-foot combined seas, their nominal range is 36 nautical miles though their endurance is dependent on the size of the motor and amount of fuel carried. The Marine Corps use this watercraft in much the same manner as the Navy although not for over-the-horizon operations. Smaller CRRCs are sometimes employed. The smaller CRRC is a 130-pound, motor-driven raft that can carry a maximum payload of 2,000 pounds and operate at 15 knots with four combat swimmers and equipment weighing up to 1,000 pounds. Combat rubber raiding crafts/combat rubber reconnaissance crafts can be launched by various aircraft (airdrop (C–130, C–17, and larger)/helo-cast (H–53, H–47, and H–60 helicopters)), NSW RIBs, amphibious ship well decks, and from surface vessels with appropriate low davits. When a CRRC is parachuted from an aircraft, it is referred to as a rubber-duck drop. Combat rubber raiding crafts/combat rubber reconnaissance crafts can be deck-launched or recovered from surfaced attack submarines or locked in and out from submerged, dry deck, shelter-equipped submarines. Additional information on CRRCs can be found in NTTP 3-05.44.

Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft	
Description. Capable of over-the-horizon operations; used for clandestine surface insertion and extraction of lightly armed special operations forces.	
Characteristics	**Specifications**
	Large[1 2]
Dimensions	**Length:** 15 feet 5 inches **Beam:** 6.25 feet
Weight	265 pounds (light, without motor or fuel)
Crew	One coxswain
Range[3 4]	36 nautical miles (nominal)
Maximum Speed	18+ knots, no load Economical speed: 15 knots (sea-state 0)
Limitations	Limited to operating in 8-foot combined seas
Draft	1 foot
Notes: 1. Classified as a combatant craft-medium. 2. Also referred to as the Zodiac F470. 3. Range varies with the number of fuel bladders carried. 4. Endurance dependent on the size of the motor and the amount of fuel carried.	

Figure G-16. Mission and Characteristics of Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft

Figure G-17. Combat Rubber Raiding Craft/Combat Rubber Reconnaissance Craft
(U.S. Navy photo by Ensign Sarah Thomas (RELEASED)

G.4.2 Naval Special Warfare Combatant Craft Assault

The primary mission of the NSW combatant craft assault (CCA) is to provide medium-range insertion and extraction of special operations forces into hostile/denied littoral coastal areas and to provide tactical surface mobility for visit, board, search, and seizure operations and coastal patrol operations. One of the CCA's benefits is that it is light enough to be loaded into MC–130 and C–17 type aircraft and then low-velocity airdropped into the sea under parachute, thereby allowing naval special operations forces rapid insertion from anywhere into the world's oceans. It can be hoisted on and off naval vessels via a crane. It is 41 feet long, has a deep-V monohull, is powered by high-performance diesel engines, and has an open design with a windshield/shroud around the crew compartment. Other specifications are provided in Figure G-18. Figure G-19 provides an overhead image of a CCA.

Naval Special Warfare Combatant Craft Assault	
Description. The NSW CCA's high-speed and shallow draft make it an ideal platform for conducting special operation missions of short-range, ship to shore insertions and extractions of special operations forces in various threat environments.	
Characteristics	**Specifications**
Dimensions	**Length:** 41 feet (approximately 12.5 meters) **Beam:** 8 feet, 11 inches
Weight	26,661 pounds
Crew	3
Range	**Maximum range:** 3,000 nautical miles **Planning range:** 250 nautical miles
Maximum Speed	**Maximum speed:** 50 knots **Cruise speed:** 40 knots
Limitations	Sea state: 5 (Bowditch), 10-foot combined seas, 35-knot sustained winds
Draft	3 feet, 8 inches

Figure G-18. Mission and Characteristics of Naval Special Warfare Combatant Craft, Assault

Figure G-19. Naval Special Warfare Combatant Craft Assault (Photo credit: MC1 Fred Gray IV)

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MCRP 2-10A.7, Reconnaissance Reports Guide

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GLOSSARY

breaker line. The approximate seaward border of the surf zone found where the depth to the bottom equals roughly 1.3 times the significant breaker height. (NTTP 3-59.3M/MCRP 2-10.3)

coastal terrain. The area from the storm berm, inland. (NTTP 3-59.3M/MCRP 2-10.3)

foreshore. In amphibious operations, the time at which the first waterborne wave of an amphibious assault lands or is due to land on a beach. (NATOTerm)

H-hour. In amphibious operations, the time at which the first waterborne wave of an amphibious assault lands or is due to land on a beach. (NATOTerm)

high water. The highest level of a single tide. (NTTP 3-59.3M/MCRP 2-10.3)

line of departure. In amphibious operations, a suitably marked offshore coordinating line, which is located at the seaward end of a boat lane, to assist in the landing of landing craft and amphibious vehicles on designated beaches at the scheduled times. Also called **LOD**. (DoD Dictionary)

littoral. A subset of the maritime domain comprised of two segments: the area from the open water to the shore which must be controlled to support operations ashore, and the area inland from the shore where operations can be supported and defended from the sea. (NTTP 3-59.3M/MCRP 2-10.3)

low water. The lowest level of a single tide. (NTTP 3-59.3M/MCRP 2-10.3)

mean high water. The average of high tides. (NTTP 3-59.3M/MCRP 2-10.3)

mean low water. The average of low tides. (NTTP 3-59.3M/MCRP 2-10.3)

sea state. A scale that categorizes the force of progressively higher seas by wave height. (DoD Dictionary)

surf line. The point offshore where waves and swells are affected by the underwater surface and become breakers. (NTTP 3-59.3M/MCRP 2-10.3)

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LIST OF ACRONYMS AND ABBREVIATIONS

AAV	amphibious assault vehicle
AADS	amphibious assault direction system
AAVC7A1 RAM/RS	amphibious assault vehicle-command
AAVP7A1 RAM/RS	amphibious assault vehicle-personnel carrier
AAVR7A1 RAM/RS	amphibious assault vehicle-recovery
ACV	amphibious combat vehicle
ACV-30	amphibious combat vehicle-30-millimeter gun
ACV-C	amphibious combat vehicle-command
ACV-P	amphibious combat vehicle-personnel
ACV-R	amphibious combat vehicle-recovery
AN/PSN	Army/Navy portable satellite navigation
AOAFCST	amphibious objective area forecast
AUV	autonomous underwater vehicle
ATP	Allied tactical publication
BM	beach module
BMU	beachmaster unit
BPT	beach party team
BPTC	beach party team commander
BST	beach survey team
C	center
CATF	commander, amphibious task force
CB	center beach
CCA	combatant craft assault
CF	causeway ferry
CFR	Code of Federal Regulations
CLF	commander, landing force
CM	craftmaster
CNMOC	Commander, Naval Meteorology and Oceanography Command
COMET	Cooperative Program for Operational Meteorology, Education and Training
COMNAVSURFLANTINST	Commander, Naval Surface Forces, Atlantic instruction
COMANVSURFPACINST	Commander, Naval Surface Forces, Pacific instruction
CRRC	combat rubber raiding craft (USN)/combat rubber reconnaissance craft (USMC)
CTG	commander, task group
D-day	unnamed day on which operations commence or are scheduled to commence
DAGR	Defense Advanced Global Positioning System Receiver
DD	standard format for a numbered day
DDD	degree
deg	degree
DNC	digital nautical chart

DoD	Department of Defense
E/W	east/west
EM	electromagnetic
EODMU	explosive ordinance disposal mobile unit
FNMOC	Fleet Numerical Meteorology and Oceanography Center
FOM	figure of merit
FORECON	force reconnaissance
FS	foreshore
ft	foot
FWC	fleet weather center
GFMPL	Geophysics Fleet Mission Program Library
GPS	Global Positioning System
H	wave height
$\bar{H}$	mean wave height
H-hour	undesignated time upon which operations commence or are scheduled to commence
HH	standard for a particular hour
HHMM	time of hour and minute in Zulu time zone
HHMMZ	time of hour and minute in Zulu time zone
H_s	significant wave height
HWM	high-water mark
IHO	International Hydrographic Officer
IM	intermediate module
INLS	improved Navy lighterage system
JMV	joint meteorological and oceanographic viewer
JP	joint publication
km	kilometer
kt	knot
L	wavelength
LARC-V	lighter, amphibious resupply, cargo, 5-ton
LCAC	landing craft, air cushion
LCM	landing craft, mechanized
LCU	landing craft, utility
LCVP	landing craft, vehicle, personnel
LF	left flank
LHA	amphibious assault ship (general purpose)
LHD	amphibious assault ship (multipurpose)
LHS	littoral hydrographic survey
LOC	Littoral Oceanography Course
LOD	line of departure (amphibious operations)
LPD	amphibious transport dock
LWM	low-water mark

MAGTF	Marine air-ground task force
m	meter
MCRP	Marine Corps reference publication
MCTP	Marine Corps tactical publication
METCAST	meteorological and oceanographic broadcast
METOC	meteorological and oceanographic
MM	minute within the hour
MMM	one standard format for month in the year
MOD	moderate
MPF	maritime prepositioning force
MPFUB	maritime prepositioning force utility boat
MSGID	message identifier
MSI	modified surf index
MTF	message text format
N/S	north/south
N2	power turbine revolution per minute (in percent)
NAD	North American datum
NATO	North Atlantic Treaty Organization
NAVAIDS	navigational aids
NAVOCEANO	Naval Oceanographic Office
NAVSEA	Naval Sea System's Command
NEO	noncombatant evacuation operation
NEP-Oc	Navy Enterprise Portal-Oceanography
NGA	National Geospatial Intelligence Agency
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NOMWC	Naval Oceanographic Mine Warfare Center
NOSWC	Naval Oceanography Special Warfare Center
NSW	naval special warfare
NTRP	Navy technical reference publication
NTTP	Navy tactics, techniques, and procedures
NWP	Navy warfare publication
ORM	operational risk management
PA	pressure altitude
PM	powered module
PT	point
R	rain
RF	right flank
RFS	request for support
RIB	rigid inflatable boat
S	snow
SS	seconds

SS.S	seconds
SEAOPS	safe engineering and operations
SRM	senior ramp marshal
SURFCST	surf forecast
SUROB	surf observation (report)
SWB	spectral wave bulletin
SWH	significant wave height
TM	tactical memorandum
T_s	significant wave period
UTC	coordinated Universal Time
UTM	universal transverse Mercator
VSBY	visibility
WaveViz	wave visualization
WGS-84	World Geodetic System 1984
WT	warping tug
yd	yards
YY	last two digits of the year
Z	time zone indicator for Universal Time

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NTTP 3-59.3M/MCRP 2-10.3
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