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Naval Environmental Prediction Research Facility
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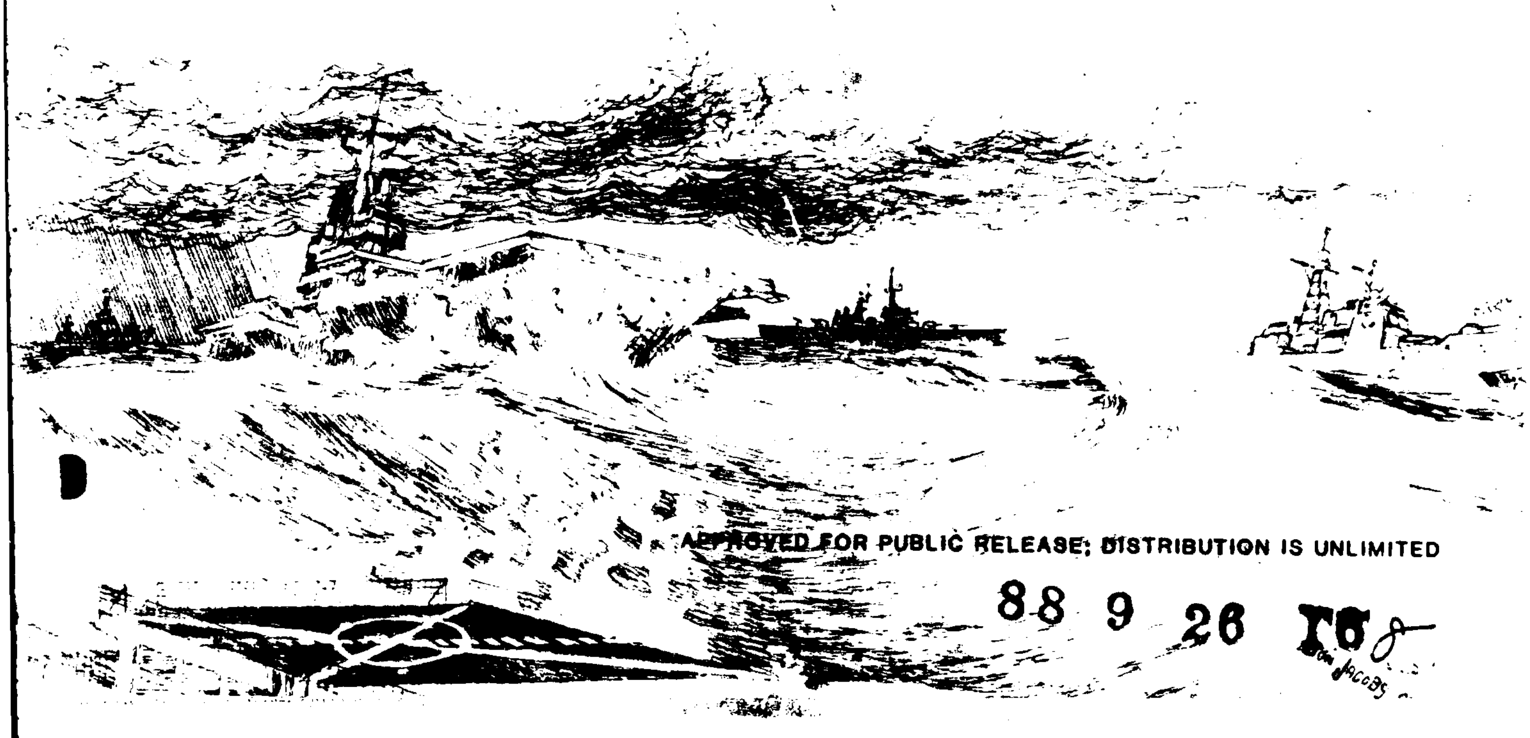
SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

3. CATANIA



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This handbook for the port of Catania, one in a series of severe weather guides for Mediterranean ports, provides decision-making guidance for ship captains whose vessels are threatened by actual or forecast strong winds, high seas, restricted visibility or thunderstorms in the port vicinity. Causes and effects of such hazardous conditions are discussed. Precautionary or evasive actions are suggested for various vessel situations. The handbook is organized in four sections for ready reference: general guidance on handbook content and use; a quick-look captain's summary; a more detailed review of general information on environmental conditions; and an appendix that provides oceanographic information.

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CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Naval Environmental Prediction Research Facility to create products for direct application to Fleet operations. The research was conducted in response to Commander Naval Oceanography Command (CNOC) requirements validated by the Chief of Naval Operations (CNO).

As mentioned in the preface, the Mediterranean region is unique in that several areas exist where local winds can cause dangerous operating conditions. This handbook will provide the ship's captain with assistance in making decisions regarding the disposition of his ship when heavy winds and seas are encountered or forecast at various port locations.

Readers are urged to submit comments, suggestions for changes, deletions and/or additions to NOCC, Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to the Naval Environmental Prediction Research Facility for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

M. G. SALINAS
Commander, U.S. Navy

PORT INDEX

The following is a tentative prioritized list of Mediterranean Ports to be evaluated during the five-year period 1988-92, with ports grouped by expected year of the port study's publication. This list is subject to change as dictated by circumstances and periodic review.

1988 NO.	PORT
1	GAETA, ITALY
2	NAPLES, ITALY
3	CATANIA, ITALY
4	AUGUSTA BAY, ITALY
5	CAGLIARI, ITALY
6	LA MADDALENA, ITALY
7	MARSEILLE, FRANCE
8	TOULON, FRANCE
9	VILLEFRANCHE, FRANCE
10	MALAGA, SPAIN
11	NICE, FRANCE
12	CANNES, FRANCE
13	MONACO
14	ASHDOD, ISRAEL
15	HAIFA, ISRAEL
	BARCELONA, SPAIN
	PALMA, SPAIN
	IBIZA, SPAIN
	POLLENSA BAY, SPAIN
	VALENCIA, SPAIN
	CARTAGENA, SPAIN
	GENOA, ITALY
	LIVORNO, ITALY
	SAN REMO, ITALY
	LA SPEZIA, ITALY
	VENICE, ITALY
	TRIESTE, ITALY

1989	PORT
	SPLIT, YUGOSLAVIA
	DUBROVNIK, YUGOSLAVIA
	TARANTO, ITALY
	PALERMO, ITALY
	MESSINA, ITALY
	TAORMINA, ITALY
	PORTO TORRES, ITALY

1990	PORT
	BENIDORM, SPAIN
	ROTA, SPAIN
	TANGIER, MOROCCO
	PORT SAID, EGYPT
	ALEXANDRIA, EGYPT
	ALGIERS, ALGERIA
	TUNIS, TUNISIA
	GULF HAMMAMET, TUNISIA
	GULF OF GABES, TUNISIA
	SOUDA BAY, CRETE

1991	PORT
	PIRAEUS, GREECE
	KALAMATA, GREECE
	THESSALONIKI, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	VALETTA, MALTA
	LARNACA, CYPRUS

1992	PORT
	ANTALYA, TURKEY
	ISKENDERUN, TURKEY
	IZMIR, TURKEY
	ISTANBUL, TURKEY
	GOLCUK, TURKEY
	GULF OF SOLLUM

PREFACE

Environmental phenomena such as strong winds, high waves, restrictions to visibility and thunderstorms can be hazardous to critical Fleet operations. The cause and effect of several of these phenomena are unique to the Mediterranean region and some prior knowledge of their characteristics would be helpful to ship's captains. The intent of this publication is to provide guidance to the captains for assistance in decision making.

The Mediterranean Sea region is an area where complicated topographical features influence weather patterns. Katabatic winds will flow through restricted mountain gaps or valleys and, as a result of the venturi effect, strengthen to storm intensity in a short period of time. As these winds exit and flow over port regions and coastal areas, anchored ships with large 'sail areas' may be blown aground. Also, hazardous sea state conditions are created, posing a danger for small boats ferrying personnel to and from port. At the same time, adjacent areas may be relatively calm. A glance at current weather charts may not always reveal the causes for these local effects which vary drastically from point to point.

Because of the irregular coast line and numerous islands in the Mediterranean, swell can be refracted around such barriers and come from directions which vary greatly with the wind. Anchored ships may experience winds and seas from one direction and swell from a different direction. These conditions can be extremely hazardous for tendered vessels. Moderate to heavy swell may also propagate outward in advance of a storm resulting in uncomfortable and sometimes dangerous conditions, especially during tending, refueling and boating operations.

This handbook addresses the various weather conditions, their local cause and effect and suggests some evasive action to be taken if necessary. Most of the major ports in the Mediterranean will be covered in the handbook. A priority list, established by the Sixth Fleet, exists for the port studies conducted and this list will be followed as closely as possible in terms of scheduling publications.

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

This handbook is designed to provide ship captains with a ready reference on hazardous weather and wave conditions in selected Mediterranean harbors. Section 2, the captain's summary, is an abbreviated version of section 3, the general information section intended for staff planners and meteorologists. Once section 3 has been read, it is not necessary to read section 2.

1.1.1 Objectives

The basic objective is to provide ship captains with a concise reference of hazards to ship activities that are caused by environmental conditions in various Mediterranean harbors, and to offer suggestions for precautionary and/or evasive actions. A secondary objective is to provide adequate background information on such hazards so that operational forecasters, or other interested parties, can quickly gain the local knowledge that is necessary to ensure high quality forecasts.

1.1.2 Approach

Information on harbor conditions and hazards was accumulated in the following manner:

A. A literature search for reference material was performed.

B. Cruise reports were reviewed.

C. Navy personnel with current or previous area experience were interviewed.

D. A preliminary report was developed which included questions on various local conditions in specific harbors.

E. Port/harbor visits were made by NEPRF personnel; considerable information was obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained (See section 3 references).

F. The cumulative information was reviewed, combined, and condensed for harbor studies.

1.1.3 Organization

The Handbook contains two sections for each harbor. The first section summarizes harbor conditions and is intended for use as a quick reference by ship captains, navigators, inport/at sea OOD's, and other interested personnel. This section contains:

A. a brief narrative summary of environmental hazards,

B. a table display of vessel location/situation, potential environmental hazard, effect-precautionary/evasion actions, and advance indicators of potential environmental hazards,

C. local wind wave conditions, and

D. tables depicting the wave conditions resulting from propagation of deep water swell into the harbor.

The swell propagation information includes percent occurrence, average duration, and the period of maximum wave energy within height ranges of greater than 3.3 feet and greater than 6.6 feet. The details on the generation of sea and swell information are provided in Appendix A.

The second section contains additional details and background information on seasonal hazardous conditions. This section is directed to personnel who have a need for additional insights on environmental hazards and related weather events.

1.2. CONTENTS OF SPECIFIC HARBOR STUDIES

This handbook specifically addresses potential wind and wave related hazards to ships operating in various Mediterranean ports utilized by the U.S. Navy. It does not contain general purpose climatology and/or comprehensive forecast rules for weather conditions of a more benign nature.

The contents are intended for use in both pre-visit planning and in situ problem solving by either mariners or environmentalists. Potential hazards related to both weather and waves are addressed. The oceanographic information includes some rather unique information relating to deep water swell propagating into harbor shallow water areas.

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested pre-cautionary/evasive actions for various combinations of environmental threats and vessel location/situation are provided. Local indicators of environmental hazards and possible evasion techniques are summarized for various scenarios.

CAUTIONARY NOTE: In September 1985 Hurricane Gloria raked the Norfolk, VA area while several US Navy ships were anchored on the muddy bottom of Chesapeake Bay. One important fact was revealed during this incident: Most all ships frigate size and larger dragged anchor, some more than others, in winds of over 50 knots. As winds and waves increased, ships 'fell into' the wave troughs, BROADSIDE TO THE WIND and become difficult or impossible to control.

This was a rare instance in which several ships of recent design were exposed to the same storm and much effort was put into the documentation of lessons learned. Chief among these was the suggestion to evade at sea rather than remain anchored at port whenever winds of such intensity were forecast.

2. CAPTAIN'S SUMMARY

The Port of Catania is located on the east coast of the Italian island of Sicily (Figure 2-1) about 225 n mi south-southeast of Naples.

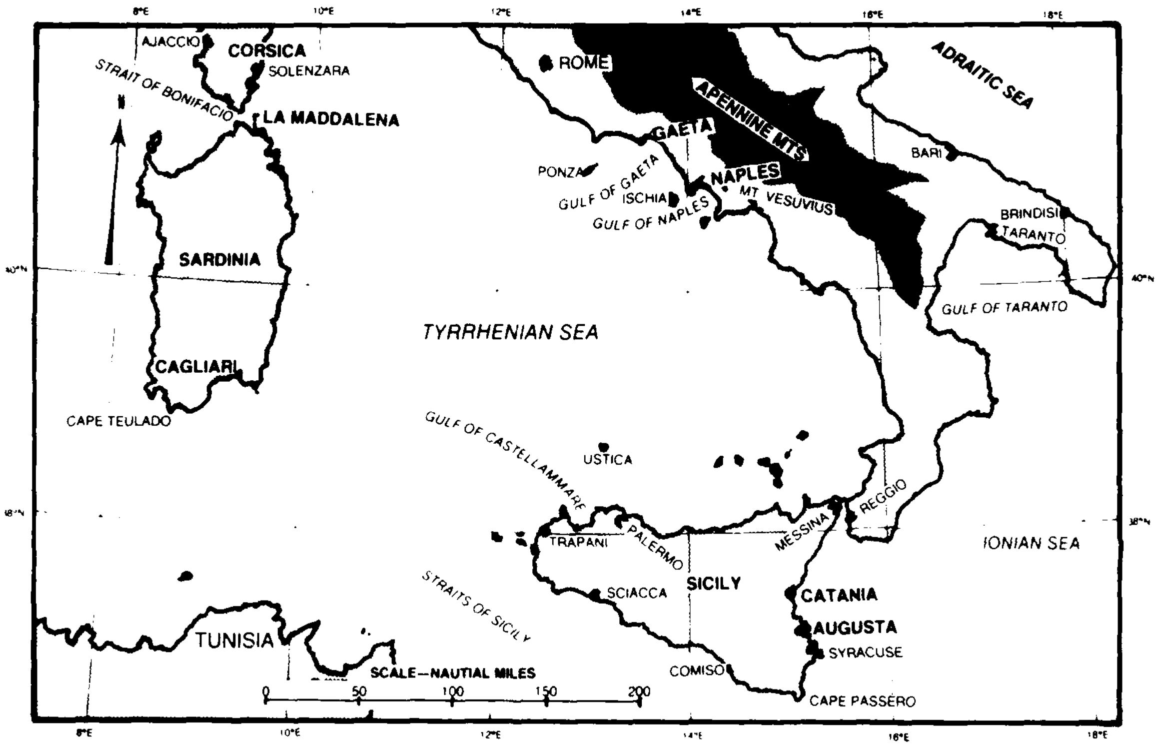

Figure 2-1. Ports of Italy, Sicily, and Sardinia.

The Port of Catania is positioned at the northwest corner of the Gulf of Catania, about 55 n mi south-southwest of the Strait of Messina. Mt. Etna, an active volcano, is about 16 n mi to the north-northwest of the port (Figure 2-2).

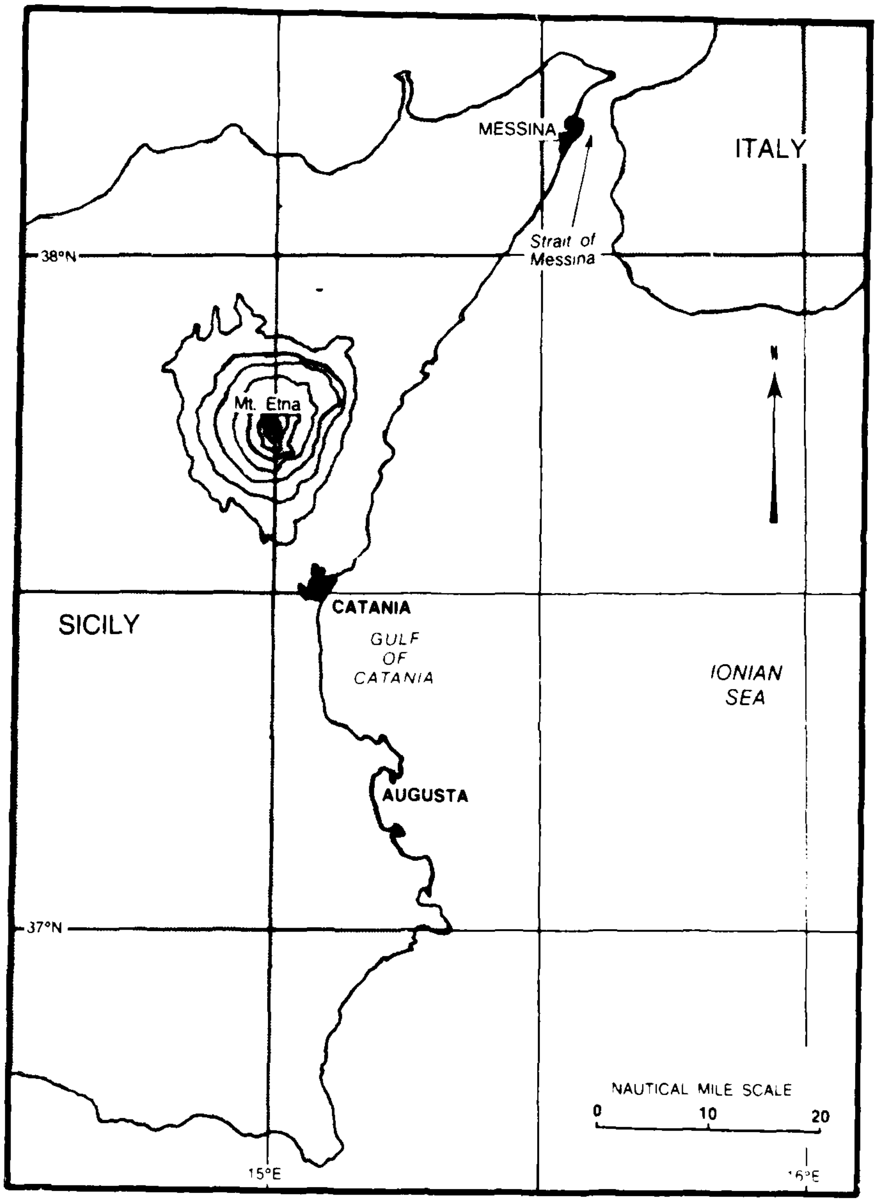

Figure 2-2. Gulf of Catania

The Port of Catania inner harbor, although protected from the direct force of open ocean waves by a long breakwater and a mole, experiences some wave motion from waves that refract through the entrance (Figure 2-3). The harbor is exposed and vulnerable to wind. The port area also experiences infrequent ash falls from Mt. Etna.

The inner harbor is bordered on the west and north by the city of Catania, the second largest city on the island. The eastern boundary is protected by a breakwater, Molo di Levante, which is approximately 5,741 ft (1,750 m) long. The western half of the southern boundary of the inner harbor is formed by a mole, Molo di Mezzogiorno, which extends about 1,312 ft (400 m) eastward from the shoreline. The entrance to the port is approximately 804 ft (245 m) wide, and lies between the east end of the mole and the breakwater. The inner harbor can accommodate ships with drafts not exceeding 30 ft. The anchorage for vessels with drafts over 30 ft is located east of the breakwater. Anchorage positions relative to a green light located at the south end of the breakwater range from 272° 1,640 ft (500 m) to 248° 6,037ft (1,840 m). Good holding qualities exist at the anchorage in a mud bottom. The inner harbor has a mud and sand bottom.

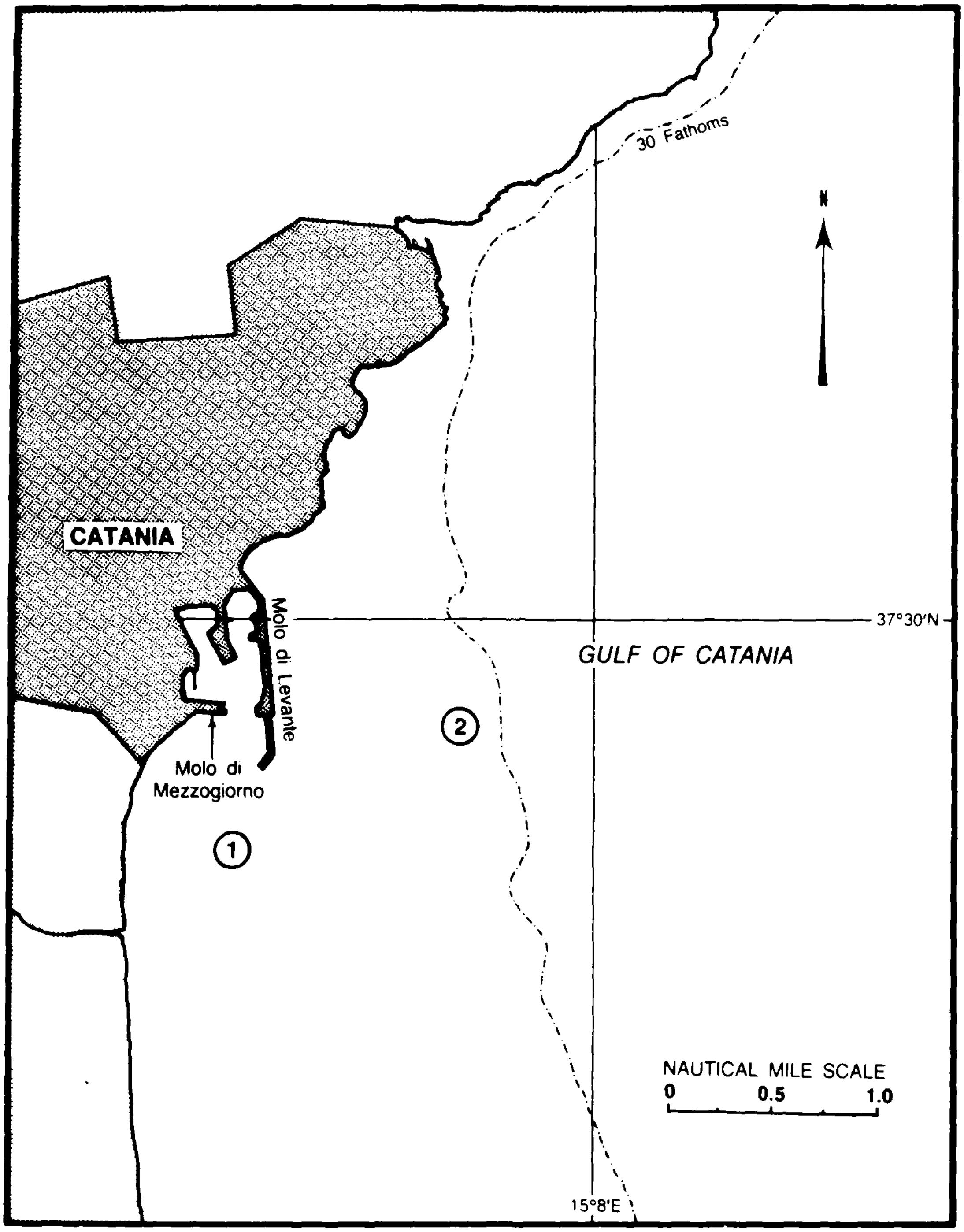

Figure 2-3. Port of Catania

Currents are generally weak and wind driven, but strong currents have been reported at the harbor entrance. A north-northeast current of about 2 kt will occur at the anchorage when the wind blows southward through the Strait of Messina. The tidal range is slight, about 1 ft, but a storm surge caused by easterly winds can flood inland.

Specific hazardous environmental conditions, vessel situations, and suggested precautionary/evasion action scenarios are summarized in Table 2-1. Hazards for both inner harbor and outer harbor are addressed.

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TABLE 2-1. Summary of hazardous environmental condit

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD
1. <u>Ash fall from Mt. Etna</u>. Caused by eruption or emission of an ash plume from Mt. Etna.	<u>Advance warning</u>. * May occur anytime Mt. Etna erupts or emits an ash plume and prevailing winds are from the NW.
2. <u>Strong wind/high sea from SE quadrant</u> - May be called Gregale, Levante, or Scirocco. * Most likely in late autumn, winter, and early spring. Uncommon in summer. * Can be accompanied by thunderstorms in late autumn or early winter. * Can generate seas to 6 m (20 ft) at anchorage. * Some wave energy will refract into inner harbor. Worst conditions occur when wind and swell are both from SE, resulting in choppy harbor conditions, worst on west side. * Mt. Etna may deflect SE winds, resulting in NE winds at harbor under SE flow situation.	<u>Advance warning</u> * Transient low pressure system south of Sicily. * Building high pressure over Europe with development of low over North Africa or Ionian Sea. * Scirocco event may be preceded by building cumulus clouds remaining over Mt. Etna when air flow is from SE. <u>Duration</u> * Transient low pressure system south of Sicily can cause winds to last for 1-2 days. * Building high over Europe with low over North Africa or Ionian Sea can produce winds lasting 5 days. * Scirocco events can last 2 weeks.
3. <u>High swell from the east</u> - Generated by "Etesian" winds over Aegean/eastern Mediterranean Seas. * Summer event, most common in August. * Waves to 8-12 ft (2.5-3.5 m) may break over top of Molo di Levante. * Causes 1 1/2 ft (1/2 m) long-period swell to refract into inner harbor. Worst on west side.	<u>Advance warning</u> * Swell will reach Catania 4-8 hours after wind begins to blow over Aegean Sea. <u>Du tion</u> * Swell will persist as long as Etesian winds are blowing. * Swell will decrease about 12-24 hours after winds diminish.

al conditions for the Port of Catania, Italy.

AZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
s an ash W.	All locations/situations.	(a) Fine, gritty particles of ash can damage delicate equipment and equipment with close tolerances. * Protect all equipment from contact with ash particles. * Change/clean air filters often on gasoline/diesel engines which must remain operating. (b) Ash may pose health hazard. * Minimize personnel exposure on weather decks to avoid ash inhalation.
cily. onian Sea. cumulus ow is	(1) Moored-inner harbor.	(a) Wind may force ship off mooring. * Mooring lines should be doubled. * Tug assistance may be necessary in strong event. * If nested, vessels may shift, depending on wind direction.
cily can orth sting 5	(2) Anchored-outer harbor.	(a) Vessels may have to depart anchorage. * Large waves may cause pitching at anchor. * Anchor dragging is possible. * To minimize effect of seas, proceed N through Strait of Messina to anchorages near Messina, at Palermo or Gulf of Castellammare on N coast of Sicily * Steaming close to W coast of Italian Peninsula will avoid worst effects of sea.
	(3) Arriving/departing harbor.	(a) Strong event may adversely impact ship maneuvering characteristics. * Adjust arrival/departure to avoid high winds. (b) Currents may be strengthened by wind. * Be alert for enhanced currents.
	(4) Small boat operations.	(a) Boating may be restricted/cancelled.
wind	(1) Moored-inner harbor.	(a) Little impact on moored vessels. * Swell refracted into harbor is not considered dangerous, but moorings should be closely monitored. * Vessels moored along Molo di Levante may experience spray from swell breaking over the top of the breakwater.
ds are ter winds	(2) Anchored-outer harbor.	(a) Vessels may have to depart anchorage. * Large swell waves may cause significant pitching at anchor. * Anchor dragging may result from swell motion. * To avoid swell, proceed N through Strait of Messina to anchorages near Messina, at Palermo, or in Gulf of Castellammare on N coast of Sicily
	(3) Arriving/departing harbor.	(a) Arrival/departure may need to be delayed. * If going to anchor, delay arrival until after swell subsides. * If going into inner harbor, turning N to approach entrance will bring swell broad on starboard beam and expose ship to excessive rolling. * Departing vessels will encounter swell broad on port beam as soon as protection of breakwater is passed.
	(4) Small boat operations.	(a) Boating may be restricted/cancelled.

TABLE 2-1. (Con'

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD
4. Thunderstorms. * May be caused by transient low pressure system south of Sicily in late autumn/early winter. * May occur with/after frontal passages in winter/early spring. * Violent storms may form over Mt. Etna in late winter/early spring and may move over the Port of Catania.	Advance warning * Rain forecast in autumn or early winter due to low pressure system south of Sicily. * Strong frontal passage during autumn, winter, or spring. Duration * Can last for 24 hours when associated with transient low south of Sicily in late autumn or early winter.
5. Sea breeze - Diurnal easterly wind reaching maximum velocities in mid-afternoon. * Most common in summer, but may occur on warm days in other seasons. * Commonly lasts from 1030L - 1800L. * Normal maximum velocities are 15-20 kt, but strong event can exceed 27 kt.	Advance warning * Routinely observed in summer, and on warm late spring and early autumn days. Duration * Typically observed between 1030L and 1800L.
6. Tropical cyclones - Although uncommon, tropical cyclones have been observed in the Mediterranean basin. * Most likely in late summer/autumn but may occur in any season. * Storm track is difficult to forecast accurately. Mariners must give wide berth to forecast track.	Advance warning * High, thin clouds in cyclonically spiralling bands, gradually thickening. * Long period swell from southern semicircle with no other reasonable explanation.
7. Atmospheric turbulence - Creates a problem for helicopters operating in the Catania area. * Occurs during summer in association with west-southwesterly winds which cancel sea breeze mechanism.	Advance warning * Low pressure trough over western Mediterranean Sea. * May be preceded by stratus clouds along the south coast of Sicily. Duration * Will last as long as west-southwesterly winds persist at Catania.

u -1. (Continued)

V I ZARD	VESSEL LOCATION/ SITUATION AFFE⁻⁻TED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
ue to low ier, or h transient iy winter.	(1) Moored-inner harbor.	(a) Possible strong winds/squalls/lightning strikes/waterspouts. * Mooring lines should be monitored closely. * Secure loose gear. * Minimize personnel exposure on weather decks.
	(2) Anchored-outer harbor.	(a) Possible strong winds/squalls/lightning strikes/waterspouts. * Personnel should be alert for anchor dragging. * Secure loose gear. * Minimize personnel exposure on weather decks.
	(3) Arriving/departing harbor.	(a) Possible strong winds/squalls/lightning strikes/waterspouts. * Ship maneuvering may be affected. * Visibility may be restricted. * Secure loose gear. * Minimize personnel exposure on weather decks.
	(4) Small boat operations.	(a) Small boat operation should be restricted. * Wind gusts/squalls may hazard small boat and occupants. * Lightning strikes are possible.
iate	(1) Moored-inner harbor.	(a) No significant problems.
	(2) Anchored-outer harbor.	(a) No significant problems. * Boating to/from anchorage may be restricted or curtailed in a strong event.
	(3) Arriving/departing harbor.	(a) Vessel control may be affected at slow SOA.
	(4) Small boat operations.	(a) Small boating may be restricted/curtailed in a strong event * 27 kt is cutoff for small craft operation to/from the anchorage.
ing bands, e with no	(1) Moored-inner harbor.	(a) Vessels should put to sea and evade storm.
	(2) Anchored-outer harbor.	(a) Vessels should put to sea and evade storm.
	(3) Arriving/departing harbor.	(a) Vessels should put to sea and evade storm. * If at sea, stay at sea and evade storm. * If departing harbor, plan to leave early to avoid the effects of the storm.
	(4) Small boat operations.	(a) Cancel small boat operations * Hoist small craft out of water and secure on deck or, if on shore, well above high tide line.
ranean Sea, the south winds	(1) Helicopter operations.	(a) Operate helicopters with caution * Delay all unnecessary flights until winds subside. * Exercise extreme caution when operating in the vicinity of Mt. Etna.

Table 2-2 provides the height ratio and direction of shallow water waves to expect at points 1 and 2 (Figure 2-3) when the deep water wave conditions are known.

The Catania Point 2 conditions are found by entering Table 2-2 with the forecast or known deep water wave direction and period. The height is determined by multiplying the deep water height (8 ft) by the ratio of shallow to deep height (.8).

Example: Use of Table 2-2 for Catania Point 2 (Carrier Anchorage).
Deep water wave forecast as provided by a forecast center or a reported/observed deep water wave condition:
8 feet, 12 seconds, from 120°.
The expected wave condition at Catania Point 2, as determined from Table 2-2:
7 feet, 12 seconds, from 115°.

NOTE: Wave periods are a conservative property and remain constant when waves move from deep to shallow water, but speed, height, and steepness change.

Table 2-2. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 2-3 for location of the points).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

CATANIA POINT 1 (Inner Harbor Entrance):

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
030°	060°	070°	080°	090°	105°	100°
	.4	.4	.4	.4	.3	.4
060°	070°	075°	085°	090°	110°	115°
	.5	.5	.6	.6	.5	.5
090°	090°	100°	110°	110°	120°	125°
	.8	.9	.9	.8	.7	.7
120°	130°	130°	120°	130°	110°	120°
	.5	.5	.5	.7	.5	.4
150°	155°	155°	120°	110°	115°	110°
	.5	.5	.5	.6	.3	.4
180°	140°	145°	140°	135°	135°	140°
	.2	.3	.3	.3	.4	.5

CATANIA POINT 2 (Carrier Anchorage):

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
030°	035°	030°	035°	040°	045°	050°
	.2	.4	.4	.3	.5	.6
060°	060°	060°	060°	065°	065°	065°
	.9	.9	.8	.8	.8	.8
090°	090°	090°	090°	090°	090°	085°
	.9	.9	.8	.8	.8	.8
120°	120°	120°	120°	115°	110°	110°
	.9	.9	.8	.8	.8	.8
150°	150°	150°	145°	135°	130°	130°
	.8	.8	.7	.6	.6	.6
180°	175°	160°	155°	150°	145°	145°
	.5	.3	.3	.5	.4	.5

The local wind generated wave conditions for the anchorage area identified as point 2 (Figure 2-3) are given in Table 2-3. All heights refer to the significant wave height (average of the highest 1/3 waves). Enter the local wind speed and direction in this table to obtain the minimum duration in hours required to develop the indicated fetch limited sea height and period. The time to reach fetch limited height is based on an initial flat ocean. When starting from a pre-existing wave height, the time to fetch limited height will be shorter.

Table 2-3. Gulf of Catania near point 2. Local wind waves for fetch limited conditions related to point 2 (based on JONSWAP model).

Format: height (feet)/period (seconds)
time (hours) to reach fetch limited height

Direction and\ Fetch \ Length \ (n mi)	Local Wind Speed (kt) 18	24	30	36	42
N 3 n mi	<2 ft	<2 ft	2/3 1	2/3 1	2-3/3 1
NE 45 n mi	4-5/5 5	6/6 4-5	7-8/7 4	9/7 4	10/7-8 4
S 13 n mi	2-3/4 2	3-4/4 2-3	4/4-5 2	5/5 2	6/5 2

Example:
To the south (180°) there is about a 13 n mi fetch (Figure 2-2). Given a south wind at 24 kt, the sea will have reached 3-4 feet with a period of 4 seconds within 2-3 hours. Wind waves will not grow beyond this condition unless the wind speed increases or the direction changes to one over a longer fetch length. If the wind waves are superimposed on deep water swell, the combined height may change in response to changing swell conditions. Wind wave directions are assumed to be the same as the wind direction.

<u>Combined Wave heights</u> are obtained by finding the square root of the sum of the squares of the swell and wind wave heights.

<u>Example</u>: Swell 10 ft, wind wave 5 ft.

$$\sqrt{10^2 + 5^2} = \sqrt{100 + 25} = \sqrt{125} \approx 11.2 \text{ ft}$$

<u>Note</u>: Increase over larger height is small. If both heights were equal, combined height would increase by a factor of 1.4. If one is half of the other, as in the example, increase over the larger of the two is by a factor of 1.12.

<u>Climatological factors of shallow water waves</u>, as described by percent occurrence, average duration, and period of maximum energy (period at which the most energy is focused for a given height), are given in <u>Table 2-4</u>. See Appendix A for discussion of wave spectrum and energy distribution. These data are provided by season for two ranges of heights: greater than 3.3 feet and greater than 6.6 feet.

Two anchorage areas have been selected for Catania (Figure 2-3). <u>Point 1</u> is near the inner harbor entrance. <u>Point 2</u> is for the outer harbor anchorage area for vessels with drafts over 30 ft.

Table 2-4. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 feet and greater than 6.6 feet by climatological season.

CATANIA POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	26	22	6	18
Average Duration (hrs)	15	15	11	13
Period Max Energy (sec)	9	9	9	8
>6.6 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	7	6	1	5
Average Duration (hrs)	13	15	12	9
Period Max Energy (sec)	10	12	10	9
CATANIA POINT 2:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	25	23	6	14
Average Duration (hrs)	12	18	9	13
Period Max Energy (sec)	10	10	9	8
>6.6 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	10	7	1	4
Average Duration (hrs)	14	11	13	10
Period Max Energy (sec)	12	12	11	10

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November thru February):

* Persistent strong winds from east thru south 20-25 kt causes swell in harbor.
* Northeasterly (Gregale) winds funnel through Strait of Messina and generate high waves at anchorage.
* Scirocco (southeasterly) can last few days to two weeks.
* Thunderstorms accompany cold front passage or lows passing to south and may last 24 hours with heavy rain.

SPRING (March thru May):

* Early spring conditions are similar to winter.
* Gregale and Scirocco are rare by season's end.
* Early morning fog/haze may reduce visibility to near 1 n mi.

SUMMER (June thru September):

* Occasionally, daily sea breeze may reach 25 kt and disrupt afternoon operations.
* West-southwesterly winds 20-25 kt cancel sea breeze and bring hot temps, reduced visibility due to dust and cause turbulence problems for helicopter operations.

AUTUMN (October):

* Short transition season with winter-like weather returning by month's end.

NOTE: For more detailed information on hazardous weather conditions see previous Summary Table in this section and Hazardous Weather Summary in Section 3.

3. GENERAL INFORMATION

This section expands on the material in the Captain's Summary. Figures and Tables are repeated with a continuation of numbering. Paragraph 3.5 provides a general discussion of hazards and Table 3-4 provides a summary of hazards and actions by season.

3.1 Geographic Location

Catania is located on the east coast of the Italian island of Sicily (Figure 3-1) about 225 n mi south-southeast of Naples.

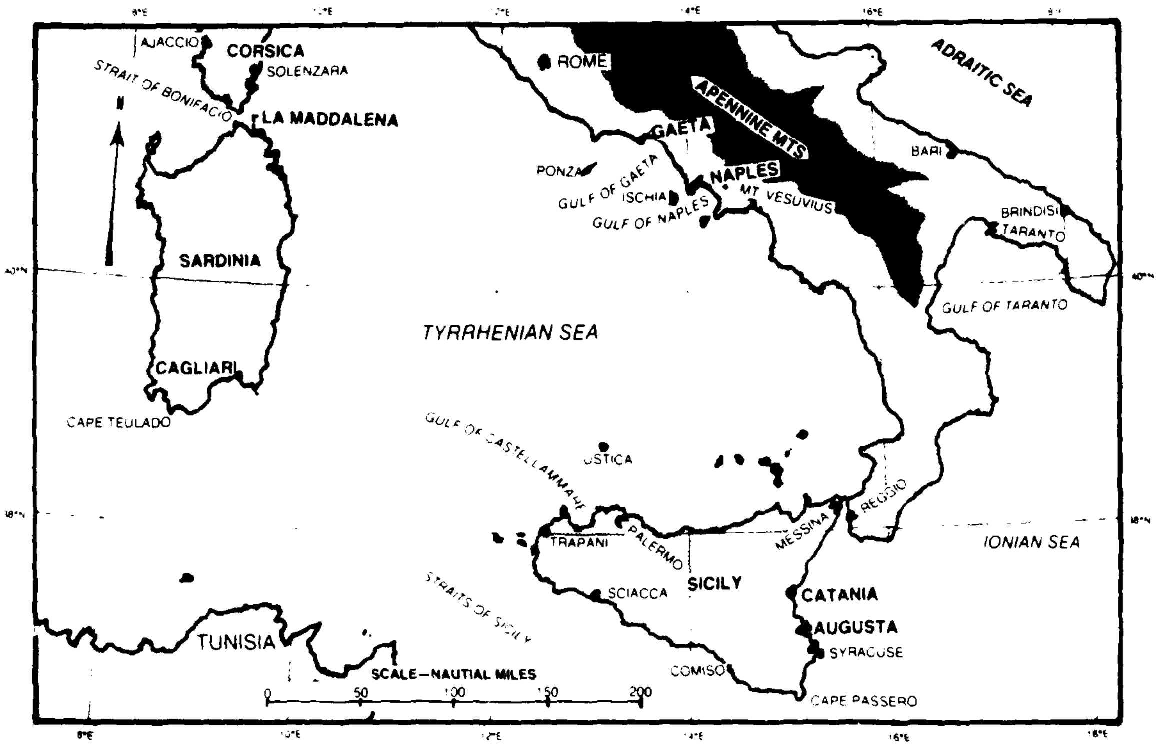

Figure 3-1. Ports of Italy, Sicily, and Sardinia.

The Port of Catania is positioned at the northwest corner of the Gulf of Catania about 55 n mi south-southwest of the Strait of Messina. Mt. Etna, an active volcano, is about 16 n mi to the north-northwest of the port (Figure 3-2).

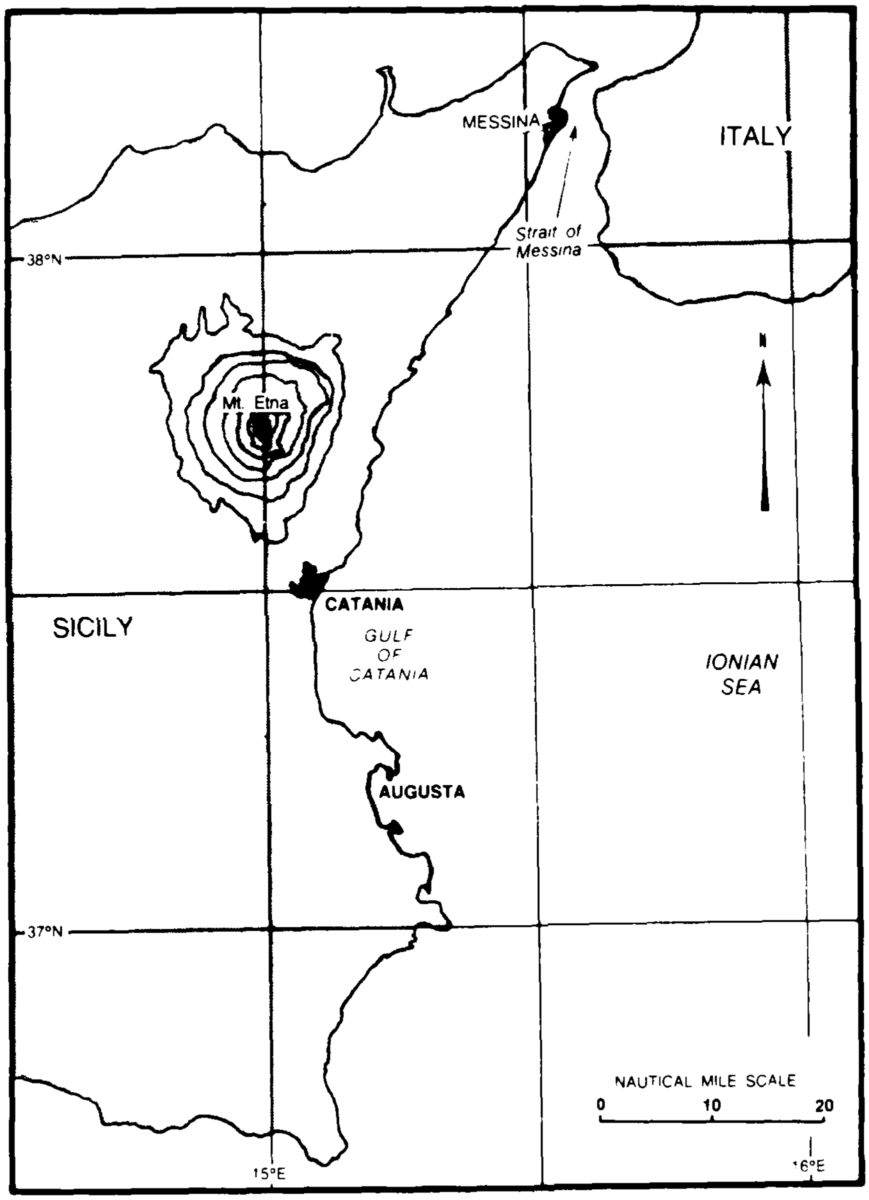

Figure 3-2. Gulf of Catania

The Port of Catania inner harbor is large and capable of accommodating ships with maximum drafts of about 30 ft (9.1 m) (U.S. Navy, 1983). Its facilities are situated within an artificial harbor formed by a long breakwater, Molo di Levante and a mole, Molo di Mezzogiorno (see Figure 3-3). Mount Etna, a 10,902 ft (3,323 m) active volcano located about 16 n mi north-northwest of the port, dominates the landscape. Other prominent landmarks include many domes on buildings in the city of Catania, a red brick chimney over 300 ft high which is surmounted by four red aircraft warning lights and located about 400 yds north-northwest of the origin of Molo di Mezzogiorno, and several grain elevator towers east of the chimney.

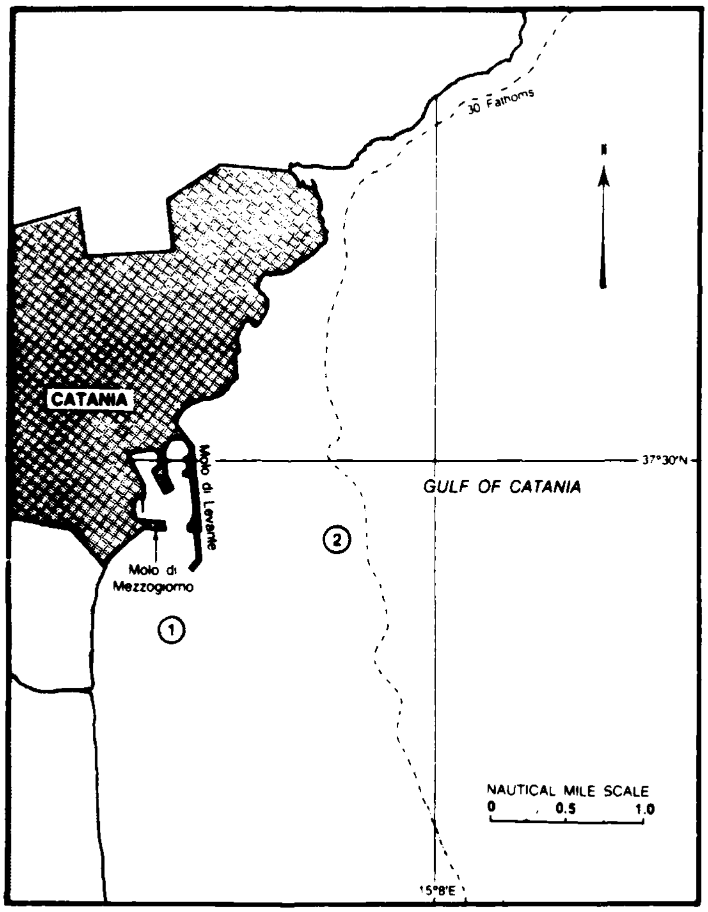

Figure 3-3. Port of Catania

3.2 Qualitative Evaluation of the Port of Catania

The Port of Catania, while well protected from the effects of sea/swell action from southwest through northeast, is adversely affected as a protective harbor when strong winds and resultant waves are from east through south. Although protected by a long breakwater, the entrance to the harbor allows refracted swell from east through south to enter the inner harbor. If a southeasterly wind and southeasterly swell coincide at Catania, choppy conditions result in the harbor.

Persistent easterly flow of 20-25 kt or more will cause 6-7 ft (2 m) and occasional 12 ft (3.5 m) swell to break over the top of Molo di Levante. Refraction allows easterly swell to enter the inner harbor, with the most pronounced effects occurring on the western side. Easterly winds 25-35 kt will produce a long period swell 1 1/2 ft (1/2 m) high in the inner harbor.

Large vessels (CV's, oilers, etc.) anchor outside the breakwater and are exposed to the brunt of all weather emanating from the eastern semicircle. The aircraft carrier anchorage is located 068° 1,840 m from a green light at the south end of Molo di Levante. Good holding qualities exist at the anchorage in a mud bottom. The inner harbor has a mud and sand bottom. The Port of Catania is subject to ash falls produced by Mt. Etna.

3.3 Currents and Tides

Currents are generally weak and wind driven, but strong currents have been reported at the harbor entrance. A north-northeast current of about 2 kt will occur at the anchorage when the wind blows southward through the Strait of Messina.

The tidal range is slight, about 1 ft, but a storm surge caused by strong easterly winds can flood inland.

3.4 Visibility

Fog is not a problem at Catania, but haze and smoke from industrial pollution can reduce summertime visibility to about 1 mi, with the poorest visibility normally occurring between 0600 and 0800 local time.

The most restricted visibility -- as low as 1/2 mi -- occurs during summer under southerly flow conditions, when air enters Sicily across the southeast tip, becoming west-southwesterly at Catania. The result is poor visibility, hot temperatures, and a "yellow-white" sky.

Visibilities are sometimes reduced to 1/2 mi in late winter/early spring in precipitation associated with thunderstorms which form over Mt. Etna.

3.5 Hazardous Conditions

Although protected from some wind/wave conditions, the Port of Catania is vulnerable to others. A seasonal breakdown of the various known environmental hazards that may be encountered in the Port of Catania follows.

A. Winter (November through February)

Persistent strong winds from east through south of 20 to 25 kt or more can cause significant problems at the Port of Catania. Although the eastern side of the inner harbor is protected by a long breakwater, the configuration of the harbor entrance allows refracted swell to enter. Southeasterly winds can produce considerable swell in the inner harbor, which is especially bad on the west side. The swell is bothersome but not dangerous. The accompanying winds can be dangerous, however.

Prolonged easterly flow will cause 6-12 ft (2-3.5 m) or greater swell to break over the top of Molo di Levante, a frequent moorage for ships. Easterly swell can also refract through the harbor entrance, causing a 1 1/2 ft (1/2 m) long-period swell in the inner harbor.

Swell generated by an easterly wind will normally diminish 24 hours after the wind stops.

Large vessels such as aircraft carriers and oilers remain outside the inner harbor, requiring about a 30 minute small boat ride into the harbor from the anchorage.

Winds from the southeast quadrant, the most adverse direction at Catania, are principally caused by the "Gregale." A Gregale results when high pressure lies or is building over central Europe or the Balkans, and a low pressure system is either over the Ionian Sea, North Africa near Libya/Tunisia, or transiting eastward south of Sicily. A transiting low may produce Gregale winds for a day or two, but winds from a low over the Ionian Sea or Libya/Tunisia may last for up to 5 days. When Gregale winds are from the northeast, they may be reinforced when passing through the Strait of Messina. The result is high waves which break over Molo di Levante. The Gregale is most dangerous for ships at anchor.

A winter "Scirocco" will also produce strong east to southeasterly wind and seas at Catania. A Scirocco is caused by a well developed low pressure system over North Africa which brings hot, muggy weather to the region. A Scirocco event usually lasts for no longer than 2 weeks, but one event on record lasted one month.

The blocking effect of Mt. Etna sometimes brings northeasterly winds to Catania in an otherwise southeasterly situation. When occurring, the northeast wind will tend to dampen southeasterly swell. Also, when northeasterly winds are blowing through the Strait of Messina, calm winds are frequently experienced in the harbor at Catania. Mt. Etna blocks winds from northwest clockwise through north. A steep gradient resulting in general northwest or north flow will produce an offshore wind at Catania but poses no problem for harbor operations except for bringing ash falls from Mt. Etna over the Port. There are no strong wind effects at Catania for winds from southwest clockwise through northwest.

Heavy rain with low cloud ceilings can occur at Catania when a low pressure system passes south of Sicily. Thunderstorms, commonly associated with low passages in early winter when SST's are still warm but air temperatures may be cool, may be constant for 24 hours. Thunderstorms may also occur with passing frontal systems.

Mt. Etna sometimes creates its own thunderstorms. The thunderstorms form on the lee side of the mountain, but steering flow sometimes carries them south over Catania. The phenomena is most violent in late winter and early spring, sometimes reducing visibility to 1/2 mi in rain. Thunderstorms can also form due to lifting caused by heat release from the volcano. Anchorage positions at the Port may experience hail and wind with gusts to 50 kt. Waterspouts are an associated phenomena.

Snow is uncommon, having occurred only once during a recent 10 year period.

Fog is not a problem at Catania. Wintertime visibilities are generally good.

B. Spring (March through May).

Early spring environmental conditions are similar to those of winter. Winds and seas generated by Gregale and Scirocco events continue with decreasing frequency as the season progresses, and are rare by the end of spring.

Thunderstorms formed over Mt. Etna occur during the early part of the season, bring reduced visibilities in rain, as well as gusty winds (to 50 kt) and possible hail and waterspouts. Thunderstorm frequency diminishes throughout the season.

Sea breezes begin to appear on warm days by late spring. Normally starting about 1030L, they reach a normal maximum strength of about 15 kt by 1500L, and die down about 1800L. A strong event will cause boating to be cancelled at the anchorage since 27 kt is the cut off for small boats to enter the inner harbor

Springtime visibility is generally good at the start of the season, but early morning haze and smog may reduce visibility to near 1 mi.

C. Summer (June through September.

The summer season in eastern Sicily has the least hazardous weather of the year. The extratropical storm track has moved northward so strong, migrating extratropical storms pose little threat to Catania.

Afternoon sea breezes are daily occurrences. Usually commencing about 1030L, the wind force increases to a maximum of about 15 kt by 1500L, and diminishes about 1800L. A strong event will cause boating to be cancelled at the anchorage since 27 kt is the cut-off for small boats to enter the inner harbor. A high pressure cell aloft can oppose the return flow of the sea breeze mechanism. The sea breeze usually dominates but velocities will be weaker than normal.

When winds are from the south over the southeast coast of Sicily, the air flows through mountain passes before reaching Catania. The air heats adiabatically as it descends the mountain slopes, and reaches Catania as west-southwesterly 20-25 kt. The winds create a turbulence problem for helicopters operating in the area. This event will cancel the sea breeze and bring very hot temperatures to the Port. Due to the dust carried from North Africa, the sky turns yellow-white and visibility may be reduced to 1/2 mi under nearly cloudless skies. Flies and other insects abound during these weather events.

Haze and smog, advected over the Port by an early morning land breeze, commonly reduces early morning (0600-0800L is the worst period) visibility to about 1 mi, but small boats operate effectively and seem to have no difficulty locating ships at anchor. The land breeze creates no appreciable wind or sea effect at Catania.

The prevailing northerly winds over the eastern Mediterranean and Aegean Seas (basically a monsoonal flow associated with a deep low pressure area which forms over northwest India) is called the "Etesian." Once established, it can generate 8-12 ft (2.5-3.5 m) westerly moving swell which will reach the east coast of Sicily in 4-8 hours. The maximum occurrence of Etesian winds and resultant swell is in August. While some of the swell may break over the top of Molo di Levante and/or refract into the inner harbor at Catania, most of the effect of the swell is experienced at the anchorage outside the breakwater.

D. Autumn (October).

As is the case over much of the Mediterranean region, the autumn season is short, spanning about one month -- October. The daily occurrence of the sea breeze is interrupted as temperatures begin to moderate. Extratropical systems begin to transit Europe as the storm track moves southward in advance of the winter season.

The threat of strong winds from the eastern quadrant caused by a Gregale or Scirocco, as discussed in section A above, increases as the autumn season progresses.

Heavy rain with low cloud ceilings can occur at Catania when a low pressure system passes south of Sicily. Thunderstorms, commonly associated with the low passages in late autumn when SST's are still warm but air temperatures may be cool, may be constant for 24 hours. Thunderstorms may also occur with passing frontal systems.

E. Tropical Storms

Storms having tropical cyclone characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean basin: 23-26 September 1969, 22-28 January 1982, and 26-30 September 1983. On the latter occasion the storm moved northwest from the Gulf of Gabes (on the southeast corner of Tunisia), through the Straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. Winds of 100 kt were observed near the eye while Cagliari, Sardinia reported sustained winds of 60 kt. The potential for a storm of this type to strike Catania is real and the meteorologist must be aware of the possibility.

3.6 Harbor Protection

The Port of Catania offers little protection from wind but the inner harbor, as detailed below, offers marginal protection from significant wave action.

3.6.1 Wind and weather

The Port of Catania is exposed to the full force of wind from northeast clockwise through south. The terrain of Sicily lying to the south through west offers only limited protection, but Mt. Etna effectively blocks winds from northwest through north. The blocking effect of Mt. Etna frequently deflects a southeasterly wind and turns it to northeasterly at Catania. A strong northwest or north flow over the region will produce an offshore flow at Catania but poses no problem for harbor operations. There are no strong wind effects at Catania for winds southwest clockwise through northwest.

3.6.2 Waves

The Harbor of Catania is protected from significant open-ocean wave action from south-southwest through northeast by the shape and orientation of Sicily and the Italian peninsula. Fetch length is near zero from south-southwest through north, and is limited to only 45 n mi to the northeast. Portions of the harbor are vulnerable to waves from east-northeast clockwise through south, however.

The anchorage is exposed to the effects of waves from east-northeast clockwise through south, making it advisable to depart the anchorage if high seas are forecast. The inner harbor is better protected, with a long breakwater oriented north-south along its eastern side, and a mole protecting part of its southern side -- see section 3.1. The entrance to the harbor is open to the south, making it possible for southeasterly (the worst direction) sea/swell to refract into the inner harbor. Easterly swell can also refract into the harbor entrance, with somewhat reduced effect in the harbor. Easterly winds of 25-35 kt will produce a 1 1/2 ft (1/2 m) long-period swell in the inner harbor. The swell is not considered dangerous, but the winds are.

Persistent easterly flow of 20-25 kt or more will cause 6-7 ft (2 m) and occasional 12 ft (3.5 m) swell to break over the top of Molo di Levante, the eastern protective breakwater where vessels are frequently moored.

Table 3-1 provides the shallow water wave conditions at the two designated points when deep water swell enters the harbor.

> Example: Use of Table 3-1.
>
> For a deep water wave condition of:
>
> 8 feet, 12 seconds, from 150°
>
> The approximate shallow water wave conditions are:
>
> Point 1: 5 feet, 12 seconds, from 110°
> Point 2: 5 feet, 12 seconds, from 135°

Table 3-1. Shallow water wave directions and relative height conditions versus deep water period and direction (see Figure 3-3 for location of the points).

FORMAT: Shallow Water Direction
Wave Height Ratio: (Shallow Water/Deep Water)

CATANIA POINT 1 (Inner Harbor Entrance):

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
030°	060°	070°	080°	090°	105°	100°
	.4	.4	.4	.4	.3	.4
060°	070°	075°	085°	090°	110°	115°
	.5	.5	.6	.6	.5	.5
090°	090°	100°	110°	110°	120°	125°
	.8	.9	.9	.8	.7	.7
120°	130°	130°	120°	130°	110°	120°
	.5	.5	.5	.7	.5	.4
150°	155°	155°	120°	110°	115°	110°
	.5	.5	.5	.6	.3	.4
180°	140°	145°	140°	135°	135°	140°
	.2	.3	.3	.3	.4	.5

CATANIA POINT 2 (Carrier Anchorage):

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
030°	035°	030°	035°	040°	045°	050°
	.2	.4	.4	.3	.5	.6
060°	060°	060°	060°	065°	065°	065°
	.9	.9	.9	.8	.8	.8
090°	090°	090°	090°	090°	090°	085°
	.9	.9	.8	.8	.8	.8
120°	120°	120°	120°	115°	110°	110°
	.9	.9	.8	.8	.8	.8
150°	150°	150°	145°	135°	130°	130°
	.8	.8	.7	.6	.6	.6
180°	175°	160°	155°	150°	145°	145°
	.5	.3	.3	.5	.4	.5

Situation specific shallow water wave conditions resulting from deep water wave propagation are given in Table 3-1 while the seasonal climatology of wave conditions in the harbor resulting from the propagation of deep water waves into the harbor are given in Table 3-2. If the actual or forecast deep water wave conditions are known, the expected conditions at the two specified harbor areas can be determined from Table 3-1. The mean duration of the condition, based on the shallow water wave heights, can be obtained from Table 3-2.

Example: Use of Tables 3-1 and 3-2.

The forecast for wave conditions tomorrow (winter case) outside the harbor are:

8 feet, 14 seconds, from 060°

Expected shallow water conditions and duration:

	Point 1	Point 2
height	4 feet	6 feet
period	14 seconds	14 seconds
direction	from 110°	from 065°
duration	15 hours	12 hours

Interpretation of the information from Tables 3-1 and 3-2 provide guidance on the local wave conditions expected tomorrow at the various harbor points. The duration values are mean values for the specified height range and season. Knowledge of the current synoptic pattern and forecast/expected duration should be used when available.

Possible applications to small boat operations are; selection of the mother ships anchorage point and/or areas of small boat work. The condition duration information provides insight as to how long before a change can be expected. The local wave direction information could be of use in selecting anchorage configuration and related small boat operations, including tending activities.

Table 3-2. Shallow water climatology as determined from deep water wave propagation. Percent occurrence, average duration or persistence, and wave period of maximum energy for wave height ranges of greater than 3.3 feet and greater than 6.6 feet by climatological season.

CATANIA POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	26	22	6	18
Average Duration (hrs)	15	15	11	13
Period Max Energy (sec)	9	9	9	8
>6.6 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	7	6	1	5
Average Duration (hrs)	13	15	12	9
Period Max Energy (sec)	10	12	10	9
CATANIA POINT 2:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	25	23	6	14
Average Duration (hrs)	12	18	9	13
Period Max Energy (sec)	10	10	9	8
>6.6 feet	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	10	7	1	4
Average Duration (hrs)	14	11	13	10
Period Max Energy (sec)	12	12	11	10

Local wind wave conditions are provided in Table 3-3 for Catania point 2. The specified fetch lengths are specifically for point 2. The time to reach the fetch limited height assumes an initial flat ocean. With a pre-existing wave height, the times are shorter.

Table 3-3. Gulf of Catania near point 2. Local wind waves for fetch limited conditions related to point 2 (based on JONSWAP model).

Format: height (feet)/period (seconds)
time (hours) to reach fetch limited height

Direction and\ Fetch \ Length \ (n mi)	Local Wind Speed (kt) 18	24	30	36	42
N 3 n mi	<2 ft	<2 ft	2/3 1	2/3 1	2-3/3 1
NE 45 n mi	4-5/5 5	6/6 4-5	7-8/7 4	9/7 4	10/7-8 4
S 13 n mi	2-3/4 2	3-4/4 2-3	4/4-5 2	5/5 2	6/5 2

Example: Small boat wave forecasts (based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)	Waves (Table 3-3)
prior to 0700 LST	light and variable	< 1 ft
0700 to 1200	NE 8-10 kt	< 4 ft
1200 to 1800	NE 22-26 kt	building to 6 ft at 6 sec by 1600

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations would become marginal by 1300 and restricted before 1400.

Combined wave heights are computed by finding the square root of the sum of the squares of the wind wave and swell heights. For example, if the wind waves were 3 ft and the swell 8 ft the combined height would be about 8.5 ft.

$$\sqrt{3^2 + 8^2} = \sqrt{9 + 64} = \sqrt{73} \approx 8.5$$

Note that the increased height is relatively small. Even if the two wave types were of equal height the combined heights are only 1.4 times the equal height. In cases where one or the other heights are twice that of the other, the combined height will only increase over the larger of the two by 1.12 times (10 ft swell and 5 ft wind wave combined results in 11.2 ft height).

3.6.3 Wave data uses and considerations

Local wind waves build up quite rapidly and also decrease rapidly when winds subside. The period and therefore length of wind waves is generally short relative to the period and length of waves propagated into the harbor (see Appendix A). The shorter period and length result in wind waves being characterized by choppy conditions. When wind waves are superimposed on deep water waves propagated into shallow water, the waves can become quite complex and confused. Under such conditions, when more than one source of waves is influencing a location, tending or joint operations can be hazardous even if the individual wave train heights are not significantly high. Vessels of various lengths may respond in different motions to the different wave lengths present. The information on wave periods, provided in various tables, should be considered when forecasts are made for joint operations of various length vessels.

3.7 Protective and Mitigating Measures

3.7.1 Moving to new anchorage

When heavy east through south wind or swell is encountered or forecast (swell often reaching heights of 20 ft (6 m) or more during winter), local mariners say it is best for ships to leave the anchorages. More protected anchorages can be found along the north coast of Sicily near Messina, or at Palermo or in the Gulf of Castellammare.

3.7.2 Sortie/remain in Inner Harbor

If strong winds or high seas from east through south are forecast, local harbor personnel advise that small vessels moored in the inner harbor should stay, but double their moorings. Ships with drafts of 30 ft or less can enter the inner harbor for protection if the winds do not exceed 27 kt. Small craft should be well secured. If a sortie is chosen, moving northward through the Strait of Messina to more protected waters along the north coast of Sicily or west coast of the Italian peninsula should be considered.

3.7.3 Scheduling

During summer, when the sea breeze is most common, and early morning visibility is worst, ship arrivals/departures and small boat operations should be scheduled at times which avoid the worst of each condition. On average, a mid to late morning evolution would be a reasonable compromise. Similarly, an early evening arrival or departure would provide light winds and increased visibility.

3.8 Local Indicators of Hazardous Weather Conditions

Strong winds and heavy seas from the southeast quadrant are the greatest threats to the Port of Catania. While not technically a "hazardous" weather condition, the uncomfortable conditions caused by southerly flow during summer can create unpleasant working environment and poor visibility.

Easterly Wind/Waves - Since strong winds from the east quadrant are caused by a steep north-south pressure gradient, one indicator of a potential Gregale event would be the forecast of a synoptic situation which includes a building high to the north while a low pressure center is forecast to remain or intensify over the Ionian Sea or the North African region of Libya/Tunisia, or transit eastward south of Sicily. A persistent strong wind condition caused by a stationary or slow-moving situation may last for up to 5 days. Winds caused by a transient low pressure system will normally last for about 1-2 days. Seas will persist for about 24 hours after the generating winds diminish. Winds which are southeasterly over the open ocean frequently become northeast over Catania due to the blocking effect of Mt. Etna.

Etesian winds in the eastern Mediterranean or Aegean Seas can produce 8-12 ft (2.5-3.5 m) westerly moving swell which will reach the east coast of Sicily in 4-8 hours. Maximum occurrence is in August.

Strong winds and hot, muggy weather accompanying a Scirocco are often preceded by cumuliform clouds forming and remaining over Mt. Etna during southeasterly flow over eastern Sicily.

Hot Weather/Poor Visibility - When winds are southerly over the southeast tip of Sicily during summer, hot, unpleasant weather with poor visibility occurs at Catania. This event is often preceded by a stratus buildup along the south coast of Sicily.

TABLE 3-4. Potential problem situa

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTION
1. Moored/Anchored. - inner harbor - outer harbor Late Autumn Winter Early Spring	a. Strong winds/heavy seas from southeast quadrant - Primarily a late autumn, winter, early spring event. Can be caused by "Gregale" or "Scirocco". May produce seas to 20 ft (6 m) in outer harbor, with lesser heights refracting into inner harbor. Southeasterly seas are worst. Southeasterly wind coincident with southeasterly swell results in a choppy inner harbor. East winds may cause 6-12 ft (2-3.5 m) seas to break over the top of Molo di Levante, and 1 1/2 ft (1/2 m) long-period swell to refract into the inner harbor. Refracted swell is worst for vessels moored on the west side.	a. Remain at mooring, doubling mooring personnel exposure on weather decks.
Late Autumn Early Winter Late Winter Early Spring	b. Rain/thunderstorms - Late autumn/early winter depressions passing south of Sicily frequently cause heavy rain and/or thunderstorms at Catania that may be continuous for 24 hours. May also occur with passing frontal systems. Violent thunderstorms form over Mt. Etna late winter/early spring and move over Catania with hail, wind gusts to 50kt and waterspouts.	b. Remain at mooring. Thunderstorms ca but the most significant are lightning s little can be done to avoid lightning st damage by high wind. Secure loose gear. weather decks.
Late Spring Summer Early Autumn	c. Sea breeze - An almost daily occurrence late spring through early autumn. An unusually strong event may reach 27 kt and cause boating to be cancelled at the anchorage, and may delay ships entering or departing the anchorage. Usually begins about 1030L, reaches a normal maximum of about 15 kt by 1500L, and diminishes about 1800L.	c. Remain at mooring. Normal strength harbor operations. A strong event -- ex to normal ship operations. Secure loose weather decks. Boating runs to/from anc 27 kt. During summer minimize afternoon
Winter Spring Summer Autumn	d. Tropical cyclone - Uncommon in the Mediterranean, but when occurring have a strong chance of developing in October. Two of the three storms recorded since 1969 have occurred in late September. High winds and seas possible.	d. Because of the potential for destruc to avoid being placed in the track of a to sea and take evasive actions at the f may strike or pass close to Catania.
Winter Spring Summer Autumn	e. Ash fall from Mt. Etna - Catania is at risk whenever Mt. Etna erupts or emits an ash plume.	e. Cover all delicate equipment. Secur Ensure all engines which must remain ope Minimize personnel exposure to ash.
Summer Early Autumn	f. Easterly swell - "Etesian" winds over the eastern Mediterranean or Aegean Seas can cause 8-12 ft (2.5-3.5 m) swell to propagate westward to the east coast of Sicily. Maximum occurrence is in August. Swell may break over top of Molo di Levante and refract 1 1/2 ft (1/2 m) long-period swell in inner harbor. Worst effect is on west side.	f. Inner Harbor: Remain at mooring. to generate a bothersome swell in the i is advised for vessels moored on the we Anchorage: If forecast swell is hig are advised to leave the anchorage and Sicily or west of the Italian Peninsula Sicily near Messina, or at Palermo or t

m situations at Port of Catania - ALL SEASONS

CAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
ing mooring lines. Secure loose gear. Minimize r decks.	a. Strong winds from the southeast quadrant result when a strong or building high pressure cell over central or eastern Europe coincides with an intensifying low pressure system over North Africa or Ionian Sea. This is primarily a late autumn, winter, early spring synoptic pattern. Prognostic charts should be reviewed with this scenario in mind. Winds associated with a Scirocco are often preceded by cumuliform clouds forming and staying over Mt. Etna during southeasterly flow over eastern Sicily.
derstorms can pose several problems to mariners, lightning strikes and strong gusty winds. Since lightning strikes, vessels are limited to avoiding loose gear. Minimize personnel exposure on	b. Thunderstorm activity can be expected when a transient low pressure system moves eastward south of Sicily late in the season. During late autumn and winter cool air moving over the relatively warmer sea surface causes instability which can result in more-or-less continuous thunderstorm activity for up to 24 hours. They may also occur with passing frontal systems or in the cold air following the front. During late winter and spring violent thunderstorms form over Mt. Etna and move over Catania when the steering flow is from the northwest.
al strength sea breezes would have little impact on event -- exceeding 20-25 kt -- could pose hazards Secure loose gear. Minimize personnel exposure on to/from anchorage will be curtailed if winds reach ze afternoon small boat operations.	c. The sea breeze should be expected daily during the warm season except under the following conditions: (1) A high aloft over Sicily can oppose the return branch of the sea breeze. The sea breeze will usually overcome the resistance but will be weaker than normal. (2) When southerly flow across eastern Sicily descends toward Catania as a west southwesterly, hot wind, visibility may be reduced to 1/2 mi, and no sea breeze occurs. Stratus buildup along the south coast of Sicily usually precedes the event.
for destruction, mariners should make every effort track of a tropical cyclone. Vessels should put ons at the first indication that a tropical cyclone Catania.	d. There is little advance indication of the formation of a tropical cyclone in the Mediterranean. Close monitoring of satellite images and synoptic reports is necessary for early detection of a developing tropical cyclone. An approaching tropical cyclone may be indicated by noting high, thin clouds in cyclonically spiralling, gradually thickening bands, or unexplained long-period swell approaching from the southern semicircle.
ment. Secure all unnecessary engine operation. remain operating have adequate air filtration. c ash.	e. Possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from the northwest quadrant.
mooring. If incoming swell is sufficiently high ell in the inner harbor, doubling of mooring lines d on the west side. swell is high enough to cause problems, vessels chorage and seek more protected waters north of n Peninsula, or anchorages along the north coast of alermo or the Gulf of Castellammare.	f. The "Etesian" occurs when a deep thermal low forms over northwest India. It creates a northerly monsoonal flow which crosses the Aegean and eastern Mediterranean Seas and generates swell which propagates westward to Sicily. Maximum occurrence is in August, when the thermal low is strongest. Observing wind reports in the Aegean and eastern Mediterranean Sea will provide advance warning of an Etesian event. Once generated, the westward moving swell reaches the east coast of Sicily in 4-8 hours.

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRE
2. Arriving/departing harbor. Late Autumn Winter Early Spring	a. Strong winds/heavy seas from southeast quadrant - Primarily a late autumn, winter, early spring event. Can be caused by "Gregale" or "Scirocco". May produce seas to 20 ft (6 m) in outer harbor, with lesser heights refracting into inner harbor. Southeasterly seas are worst. Southeasterly wind coincident with southeasterly swell results in a choppy inner harbor. East winds may cause 6-12 ft (2-3.5 m) seas to break over the top of Molo di Levante, and 1 1/2 ft (1/2 m) long-period swell to refract into the inner harbor. Refracted swell is worst for vessels moored on the west side.	a. Large vessels approachin seas are occurring or foreca 30 ft or less could proceed are less than 27 kt; otherwi Vessels scheduled to depart winds. All vessels should b entrance.
Late Autumn Early Winter Late Winter Early Spring	b. Rain/thunderstorms - Late autumn/early winter depressions passing south of Sicily frequently cause heavy rain and/or thunderstorms at Catania that may be continuous for 24 hours. May also occur with passing frontal systems. Violent thunderstorms form over Mt. Etna late winter/early spring and move over Catania with hail, wind gusts to 50kt and waterspouts.	b. Continue evolution with to mariners, but the most si winds and in the case of tho can be done to avoid lightni by high wind. Secure loose decks.
Late Spring Summer Early Autumn	c. Sea breeze - An almost daily occurrence late spring through early autumn. An unusually strong event may reach 27 kt and cause boating to be cancelled at the anchorage, and may delay ships entering or departing the anchorage. Usually begins about 1030L, reaches a normal maximum of about 15 kt by 1500L, and diminishes about 1800L.	c. Continue evolution with delay until winds subside. harbor.
Winter Spring Summer Autumn	d. Tropical cyclone - Uncommon in the Mediterranean, but when occurring have a strong chance of developing in October. Two of the three storms recorded since 1969 have occurred in late September. High winds and seas possible.	d. Because of the potential to avoid being placed in the to sea and take evasive acti may strike or pass close to
Winter Spring Summer Autumn	e. Ash fall from Mt. Etna - Catania is at risk whenever Mt. Etna erupts or emits an ash plume.	e. Cover all delicate equip Ensure all engines which mus Minimize personnel exposure
Summer Early Autumn	f. Easterly swell - "Etesian" winds over the eastern Mediterranean or Aegean Seas can cause 8-12 ft (2.5-3.5 m) swell to propagate westward to the east coast of Sicily. Maximum occurrence is in August. Swell may break over top of Molo di Levante and refract 1 1/2 ft (1/2 m) long-period swell in inner harbor. Worst effect is on west side.	f. Large vessels approachin effect of the swell would be subsides. Smaller vessels, inner harbor where the open and wave motion would be lim

BLE 3-4. (Continued)

PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
aching Catania should remain at sea if strong winds/high orecast for the harbor. Smaller vessels with drafts of ceed to the inner harbor if the winds at arrival time herwise remain at sea until the winds/seas subside. part should do so prior to onset of 27 kt or greater uid be alert for strong currents near the harbor	a. Strong winds from the southeast quadrant result when a strong or building high pressure cell over central or eastern Europe coincides with an intensifying low pressure system over North Africa or Ionian Sea. This is primarily a late autumn, winter, early spring synoptic pattern. Prognostic charts should be reviewed with this scenario in mind. Winds associated with a Scirocco are often preceded by cumuliform clouds forming and staying over Mt. Etna during southeasterly flow over eastern Sicily.
with caution. *Thunderstorms can pose several problems* st significant are lightning strikes and strong gusty r those formed over Mt. Etna, waterspouts. Since little htning strikes, vessels are limited to avoiding damage ose gear. Minimize personnel exposure on weather	b. Thunderstorm activity can be expected when a transient low pressure system moves eastward south of Sicily late in the season. During late autumn and winter cool air moving over the relatively warmer sea surface causes instability which can result in more-or-less continuous thunderstorm activity for up to 24 hours. They may also occur with passing frontal systems or in the cold air following the front. During late winter and spring violent thunderstorms form over Mt. Etna and move over Catania when the steering flow is from the northwest.
with caution unless winds are 27 kt or greater. If so, ce. Minimize summer afternoon runs to/from inner	c. The sea breeze should be expected daily during the warm season except under the following conditions: (1) A high aloft over Sicily can oppose the return branch of the sea breeze. The sea breeze will usually overcome the resistance but will be weaker than normal. (2) When southerly flow across eastern Sicily descends toward Catania as a west *southwesterly*, hot wind, visibility may be reduced to 1/2 mi, and no sea breeze occurs. Stratus buildup along the south coast of Sicily usually precedes the event.
ntial for destruction, mariners should make every effort the track of a tropical cyclone. Vessels should put actions at the first indication that a tropical cyclone e to Catania.	d. There is little advance indication of the formation of a tropical cyclone in the Mediterranean. Close monitoring of satellite images and synoptic reports is necessary for early detection of a developing tropical cyclone. An approaching tropical cyclone may be indicated by noting high, thin clouds in *cyclonically spiralling, gradually thickening bands*, or unexplained long-period swell approaching from the southern semicircle.
equipment. Secure all unnecessary engine operation. must remain operating have adequate air filtration. sure to ash.	e. Possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from the northwest quadrant.
aching the anchorage *in the outer harbor where the* d be at a maximum are advised to delay until the swell eis, with drafts of 30 ft or less, can proceed to the open ocean swell would be blocked by Molo di Levante, e limited to refracted wave energy and local wind waves.	f. The "Etesian" occurs when a deep thermal low forms over northwest India. It creates a northerly monsoonal flow which crosses the Aegean and eastern Mediterranean Seas and generates swell which propagates westward to Sicily. Maximum occurrence is in August, when the thermal low is strongest. Observing wind reports in the Aegean and eastern Mediterranean Sea will provide advance warning of an Etesian event. Once generated, the westward moving swell reaches the east coast of Sicily in 4-8 hours.

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUTIONAR'
3. Small boat operations. Late Autumn Winter Early Spring	a. Strong winds/heavy seas from southeast quadrant - Primarily a late autumn, winter, early spring event. Can be caused by "Gregale" or "Scirocco". May produce seas to 20 ft (6 m) in outer harbor, with lesser heights refracting into inner harbor. Southeasterly seas are worst. Southeasterly wind coincident with southeasterly swell results in a choppy inner harbor. East winds may cause 6-12 ft (2-3.5 m) seas to break over the top of Molo di Levanie, and 1 1/2 ft (1/2 m) long-period swell to refract into the inner harbor. Refracted swell is worst for vessels moored on the west side.	a. Small boat operations should be secured state makes their operation unsafe.
Late Autumn Early Winter Late Winter Early Spring	b. Rain/thunderstorms - Late autumn/early winter depressions passing south of Sicily frequently cause heavy rain and/or thunderstorms at Catania that may be continuous for 24 hours. May also occur with passing frontal systems. Violent thunderstorms form over Mt. Etna late winter/early spring and move over Catania with hail, wind gusts to 50kt and waterspouts.	b. Small boats should be operated with extr first indication of lightning or strong wind
Late Spring Summer Early Autumn	c. Sea breeze - An almost daily occurrence late spring through early autumn. An unusually strong event may reach 27 kt and cause boating to be cancelled at the anchorage, and may delay ships entering or departing the anchorage. Usually begins about 1030L, reaches a normal maximum of about 15 kt by 1500L, and diminishes about 1800L.	c. Minimal effect on inner harbor operations kt. Small boat operations are cancelled at 2
Winter Spring Summer Autumn	d. Tropical cyclone - Uncommon in the Mediterranean, but when occurring have a strong chance of developing in October. Two of the three storms recorded since 1969 have occurred in late September. High winds and seas possible.	d. All small boat operations should cease at cyclone. Small craft should be hoisted out c or, in the case of shore-based boats, well at
Winter Spring Summer Autumn	e. Ash fall from Mt. Etna - Catania is at risk whenever Mt. Etna erupts or emits an ash plume.	e. Cover all delicate equipment. Secure all Ensure all engines which must remain operati
Summer Early Autumn	f. Easterly swell - "Etesian" winds over the eastern Mediterranean or Aegean Seas can cause 8-12 ft (2.5-3.5 m) swell to propagate westward to the east coast of Sicily. Maximum occurrence is in August. Swell may break over top of Molo di Levante and refract 1 1/2 ft (1/2 m) long-period swell in inner harbor. Worst effect is on west side.	f. Minimal effect on inner-harbor operation anchorage may be affected if swell period is compounded by significant wind waves.
4. Helicopter operations. Summer	a. West-southwesterly winds 20-25 kt.	a. West-southwesterly winds may cause turbu operating in the Catania area.

. (Continued)

TIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
e secured in winds over 27 kt or if sea .	a. Strong winds from the southeast quadrant result when a strong or building high pressure cell over central or eastern Europe coincides with an intensifying low pressure system over North Africa or Ionian Sea. This is primarily a late autumn, winter, early spring synoptic pattern. Prognostic charts should be reviewed with this scenario in mind. Winds associated with a Scirocco are often preceded by cumuliform clouds forming and staying over Mt. Etna during southeasterly flow over eastern Sicily.
with extreme caution and secured at the trong winds.	b. Thunderstorm activity can be expected when a transient low pressure system moves eastward south of Sicily late in the season. During late autumn and winter cool air moving over the relatively warmer sea surface causes instability which can result in more-or-less continuous thunderstorm activity for up to 24 hours. They may also occur with passing frontal systems or in the cold air following the front. During late winter and spring violent thunderstorms form over Mt. Etna and move over Catania when the steering flow is from the northwest.
operations unless velocities exceed 20-25 celled at 27 kt.	c. The sea breeze should be expected daily during the warm season except under the following conditions: (1) A high aloft over Sicily can oppose the return branch of the sea breeze. The sea breeze will usually overcome the resistance but will be weaker than normal. (2) When southerly flow across eastern Sicily descends toward Catania as a west southwesterly, hot wind, visibility may be reduced to 1/2 mi, and no sea breeze occurs. Stratus buildup along the south coast of Sicily usually precedes the event.
ld cease at the approach of the tropical isted out of the water and secured on deck ts, well above the high tide line.	d. There is little advance indication of the formation of a tropical cyclone in the Mediterranean. Close monitoring of satellite images and synoptic reports is necessary for early detection of a developing tropical cyclone. An approaching tropical cyclone may be indicated by noting high, thin clouds in cyclonically spiralling, gradually thickening bands, or unexplained long-period swell approaching from the southern semicircle.
Secure all unnecessary engine operation. in operating have adequate air filtration.	e. Possible whenever Mt. Etna erupts or emits an ash plume and prevailing winds are from the northwest quadrant.
operations. Runs to the outer harbor period is short, or swell motion is es.	f. The "Etesian" occurs when a deep thermal low forms over northwest India. It creates a northerly monsoonal flow which crosses the Aegean and eastern Mediterranean Seas and generates swell which propagates westward to Sicily. Maximum occurrence is in August, when the thermal low is strongest. Observing wind reports in the Aegean and eastern Mediterranean Sea will provide advance warning of an Etesian event. Once generated, the westward moving swell reaches the east coast of Sicily in 4-8 hours.
ause turbulence problems for helicopters	a. West-southwesterly winds may result when a low pressure trough is located in the western Mediterranean Sea. Turbulence at Catania may be preceded by stratus clouds forming along the south coast of Sicily.

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PORT VISIT INFORMATION

JUNE 1985. NEPRF meteorologists R. Fett and R. Picard met with NOCD meteorologists AGC Adams and Port Captain CDR Petralia to obtain much of the information used in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

This section provides general information on wave forecasting and wave climatology as used in this study. The forecasting material is not harbor specific. The material in paragraphs A.1 and A.2 was extracted from H.O. Pub. No. 603, Practical Methods for Observing and Forecasting Ocean Waves (Pierson, Neumann, and James, 1955). The information on fully arisen wave conditions (A.3) and wave conditions within the fetch region (A.4) is based on the JONSWAP model. This model was developed from measurements of wind wave growth over the North Sea in 1973. The JONSWAP model is considered more appropriate for an enclosed sea where residual wave activity is minimal and the onset and end of locally forced wind events occur rapidly (Thornton, 1986), and where waves are fetch limited and growing (Hasselmann, et al., 1976). Enclosed sea, rapid onset/subsiding local winds, and fetch limited waves are more representative of the Mediterranean waves and winds than the conditions of the North Atlantic from which data was used for the Pierson and Moskowitz (P-M) Spectra (Neumann and Pierson 1966). The P-M model refined the original spectra of H.O. 603, which over developed wave heights.

The primary difference in the results of the JONSWAP and P-M models is that it takes the JONSWAP model longer to reach a given height or fully developed seas. In part this reflects the different starting wave conditions. Because the propagation of waves from surrounding areas into semi-enclosed seas, bays, harbors, etc. is limited, there is little residual wave action following periods of locally light/calm winds and the sea surface is nearly flat. A local wind developed wave growth is therefore slower than wave growth in the open ocean where some residual wave action is generally always present. This slower wave development is a built in bias in the formulation of the JONSWAP model which is based on data collected in an enclosed sea.

A.1 Definitions

Waves that are being generated by local winds are called "SEA". Waves that have traveled out of the generating area are known as "SWELL". Seas are chaotic in period, height and direction while swell approaches a simple sine wave pattern as its distance from the generating area increases. An in-between state exists for a few hundred miles outside the generating area and is a condition that reflects parts of both of the above definitions. In the Mediterranean area, because its fetches and open sea expanses are limited, SEA or IN- BETWEEN conditions will prevail. The "SIGNIFICANT WAVE HEIGHT" is defined as the average value of the heights of the one-third highest waves. PERIOD and WAVE LENGTH refer to the time between passage of, and distances between, two successive crests on the sea surface. The FREQUENCY is the reciprocal of the period ($f = 1/T$) therefore as the period increases the frequency decreases. Waves result from the transfer of energy from the wind to the sea surface. The area over which the wind blows is known as the FETCH, and the length of time that the wind has blown is the DURATION. The characteristics of waves (height, length, and period) depend on the duration, fetch, and velocity of the wind. There is a continuous generation of small short waves from the time the wind starts until it stops. With continual transfer of energy from the wind to the sea surface the waves grow with the older waves leading the growth and spreading the energy over a greater range of frequencies. Throughout the growth cycle a SPECTRUM of ocean waves is being developed.

A.2 Wave Spectrum

Wave characteristics are best described by means of their range of frequencies and directions or their <u>spectrum</u> and the shape of the spectrum. If the spectrum of the waves covers a wide range of frequencies and directions (known as short-crested conditions), <u>SEA</u> conditions prevail. If the spectrum covers a narrow range of frequencies and directions (long crested conditions), <u>SWELL</u> conditions prevail. The wave spectrum depends on the duration of the wind, length of the fetch, and on the wind velocity. At a given wind speed and a given state of wave development, each spectrum has a band of frequencies where most of the total energy is concentrated. As the wind speed increases the range of significant frequencies extends more and more toward lower frequencies (longer periods). The frequency of maximum energy is given in equation 1.1 where v is the wind speed in knots.

$$f_{max} = \frac{2.476}{v} \qquad (1.1)$$

The wave energy, being a function of height squared, increases rapidly as the wind speed increases and the maximum energy band shifts to lower frequencies. This results in the new developing smaller waves (higher frequencies) becoming less significant in the energy spectrum as well as to the observer. As larger waves develop an observer will pay less and less attention to the small waves. At the low frequency (high period) end the energy drops off rapidly, the longest waves are relatively low and extremely flat, and therefore also masked by the high energy frequencies. The result is that 5% of the upper frequencies and 3% of the lower frequencies can be cut-off and only the remaining frequencies are considered as the "significant part of the wave spectrum". The resulting range of significant frequencies or periods are used in defining a fully arisen sea. For a fully arisen sea the approximate average period for a given wind speed can be determined from equation (1.2).

$$\bar{T} = 0.285v \tag{1.2}$$

Where v is wind speed in knots and T is period in seconds. The approximate average wave length in a fully arisen sea is given by equation (1.3).

$$\bar{L} = 3.41\ \bar{T}^2 \tag{1.3}$$

Where $\bar{L}$ is average wave length in feet and $\bar{T}$ is average period in seconds.

The approximate average wave length of a fully arisen sea can also be expressed as:

$$\bar{L} = .67\text{"L"} \tag{1.4}$$

where "L" = $5.12T^2$, the wave length for the classic sine wave.

A.3 Fully Arisen Sea Conditions

For each wind speed there are minimum fetch (n mi) and duration (hr) values required for a fully arisen sea to exist. Table A-1 lists minimum fetch and duration values for selected wind speeds, values of significant wave (average of the highest 1/3 waves) period and height, and wave length of the average wave during developing and fully arisen seas. The minimum duration time assumes a start from a flat sea. When pre-existing lower waves exist the time to fetch limited height will be shorter. Therefore the table duration time represents the maximum duration required.

Table A-1. Fully Arisen Deep Water Sea Conditions Based on the JONSWAP Model.

Wind Speed (kt)	Minimum Fetch/Duration (n mi) / (hrs)	Sig Wave (H1/3) Period/Height (sec) / (ft)	Wave Length (ft)[1,2] Developing/Fully /Arisen L X (.5) /L X (.67)
10	28 / 4	4 / 2	41 / 55
15	55 / 6	6 / 4	92 / 123
20	110 / 8	8 / 8	164 / 220
25	160 / 11	9 / 12	208 / 278
30	210 / 13	11 / 16	310 / 415
35	310 / 15	13 / 22	433 / 580
40	410 / 17	15 / 30	576 / 772

NOTES:

[1] Depths throughout fetch and travel zone must be greater than 1/2 the wave length, otherwise shoaling and refraction take place and the deep water characteristics of waves are modified.

[2] For the classic sine wave the wave length (L) equals 5.12 times the period (T) squared ($L = 5.12T^2$). As waves develop and mature to fully developed waves and then propagate out of the fetch area as swell their wave lengths approach the classic sine wave length. Therefore the wave lengths of developing waves are less than those of fully developed waves which in turn are less than the length of the resulting swell. The factor of .5 (developing) and .67 (fully developed) reflect this relationship.

A.4 Wave Conditions Within The Fetch Region

Waves produced by local winds are referred to as SEA. In harbors the local sea or wind waves may create hazardous conditions for certain operations. Generally within harbors the fetch lengths will be short and therefore the growth of local wind waves will be fetch limited. This implies that there are locally determined upper limits of wave height and period for each wind velocity. Significant changes in speed or direction will result in generation of a new wave group with a new set of height and period limits. Once a fetch limited sea reaches its upper limits no further growth will occur unless the wind speed increases.

Table A-2 provides upper limits of period and height for given wind speeds over some selected fetch lengths. The duration in hours required to reach these upper limits (assuming a start from calm and flat sea conditions) is also provided for each combination of fetch length and wind speed. Some possible uses of Table A-2 information are:

1) If the only waves in the area are locally generated wind waves, the Table can be used to forecast the upper limit of sea conditions for combinations of given wind speeds and fetch length.

2) If deep water swell is influencing the local area in addition to locally generated wind waves, then the Table can be used to determine the wind waves that will combine with the swell. Shallow water swell conditions are influenced by local bathymetry (refraction and shoaling) and will be addressed in each specific harbor study.

3) Given a wind speed over a known fetch length the maximum significant wave conditions and time needed to reach this condition can be determined.

Table A-2. Fetch Limited Wind Wave Conditions and Time Required to Reach These Limits (Based on JONSWAP Model). Enter the table with wind speed and fetch length to determine the significant wave height and period, and time duration needed for wind waves to reach these limiting factors. All of the fetch/speed combinations are fetch limited except the 100 n mi fetch and 18 kt speed.

Format: height (feet)/period (seconds)
duration required (hours)

Fetch Length (n mi) \ Wind Speed (kt)	18	24	30	36	42
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
30	3-4/5 3	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3
40	4-5/5-6 4-5	5/6 4	6-7/6-7 4	8/7 4	9-10/7-8 3-4
100	5/6-7[1] 5-6	9/8 8	11/9 7	13/9 7	15-16/9-10 7

[1] 18 kt winds are not fetch limited over a 100 n mi fetch.

An example of expected wave conditions based on Table A-2 follows:

WIND FORECAST OR CONDITION

An offshore wind of about 24 kt with a fetch limit of 20 n mi (ship is 20 n mi from the coast) is forecast or has been occurring.

SEA FORECAST OR CONDITION

From Table A-2: If the wind condition is forecast to last, or has been occurring, for at least 3 hours:

Expect sea conditions of 4 feet at 4-5 second period to develop or exist. If the condition lasts less than 3 hours the seas will be lower. If the condition lasts beyond 3 hours the sea will not grow beyond that developed at the end of about 3 hours unless there is an increase in wind speed or a change in the direction that results in a longer fetch.

A.5 Wave Climatology

The wave climatology used in these harbor studies is based on 11 years of Mediterranean SOWM output. The MED-SOWM is discussed in Volume II of the U.S. Naval Oceanography Command Numerical Environmental Products Manual (1986). A deep water MED-SOWM grid point was selected as representative of the deep water wave conditions outside each harbor. The deep water waves were then propagated into the shallow water areas. Using linear wave theory and wave refraction computations the shallow water climatology was derived from the modified deep water wave conditions. This climatology does not include the local wind generated seas. This omission, by design, is accounted for by removing all wave data for periods less than 6 seconds in the climatology. These shorter period waves are typically dominated by locally generated wind waves.

A.6 Propagation of Deep Water Swell Into Shallow Water Areas

When deep water swell moves into shallow water the wave patterns are modified, i.e., the wave heights and directions typically change, but the wave period remains constant. Several changes may take place including shoaling as the wave feels the ocean bottom, refraction as the wave crest adjusts to the bathymetry pattern, changing so that the crest becomes more parallel to the bathymetry contours, friction with the bottom sediments, interaction with currents, and adjustments caused by water temperature gradients. In this work, only shoaling and refraction effects are considered. Consideration of the other factors are beyond the resources available for this study and, furthermore, they are considered less significant in the harbors of this study than the refraction and shoaling factors.

To determine the conditions of the deep water waves in the shallow water areas the deep water conditions were first obtained from the Navy's operational MED-SOWM wave model. The bathymetry for the harbor/area of interest was extracted from available charts and digitized for computer use. Figure A-1 is a sample plot of bathymetry as used in this project. A ray path refraction/shoaling program was run for selected combinations of deep water wave direction and period. The selection was based on the near deep water wave climatology and harbor exposure. Each study area requires a number of ray path computations. Typically there are 3 or 4 directions (at 30° increments) and 5 or 6 periods (at 2 second intervals) of concern for each area of study. This results in 15 to 24 plots per area/harbor. To reduce this to a manageable format for quick reference, specific locations within each study area were selected and the information was summarized and is presented in the specific harbor studies in tabular form.

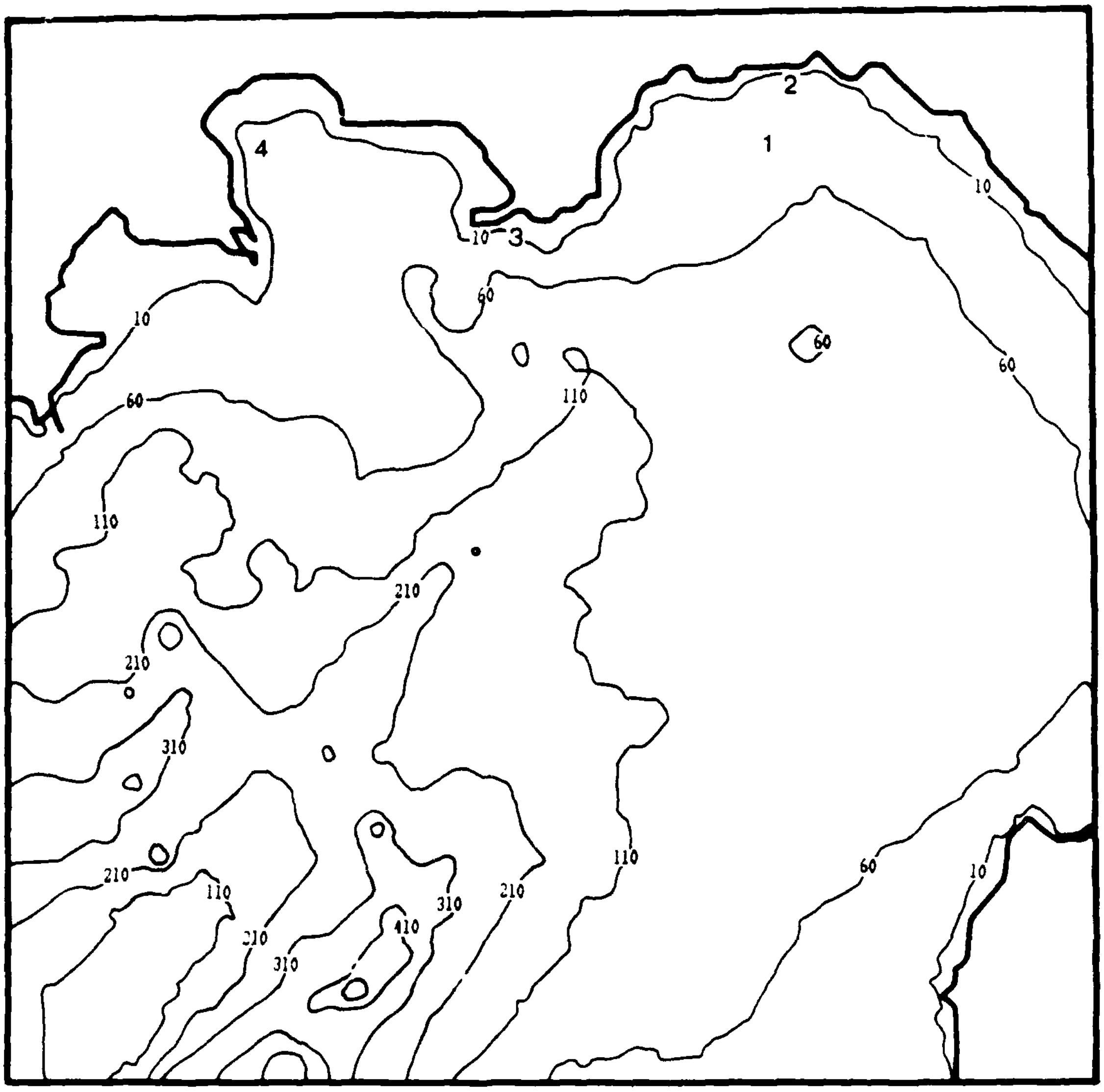

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathoms to 110 fathoms, and at 100 fathom intervals thereafter. The larger size numbers identify specific anchorage areas addressed in the harbor study.

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28D1	Destroyer Squadron LANT (2)
28J1	Service Group and Squadron LANT (2)
28K1	Submarine Group and Squadron LANT
28L1	Amphibious Squadron LANT (2)
29A1	Guided Missile Cruiser LANT
29B1	Aircraft Carrier LANT
29D1	Destroyer LANT (DD 931/945 Class)
29E1	Destroyer LANT (DD 963 Class)
29F1	Guided Missile Destroyer LANT
29G1	Guided Missile Frigate (LANT)
29I1	Frigate LANT (FF 1098)
29J1	Frigate LANT (FF 1040/1051 Class)
29K1	Frigate LANT (FF 1052/1077 Class)
29L1	Frigate LANT (FF 1078/1097 Class)
29N1	Submarine LANT (SSN)
29Q	Submarine LANT SSBN
29R1	Battleship Lant (2)
29AA1	Guided Missile Frigate LANT (FFG 7)
29BB1	Guided Missile Destroyer (DDG 993)
31A1	Amphibious Command Ship LANT (2)
31B1	Amphibious Cargo Ship LANT
31G1	Amphibious Transport Ship LANT
31H1	Amphibious Assault Ship LANT (2)
31I1	Dock Landing Ship LANT
31J1	Dock Landing Ship LANT
31M1	Tank Landing Ship LANT
32A1	Destroyer Tender LANT
32C1	Ammunition Ship LANT
32G1	Combat Store Ship LANT
32H1	Fast Combat Support Ship LANT
32N1	Oiler LANT
32Q1	Replenishment Oiler LANT
32S1	Repair Ship LANT
32X1	Salvage Ship LANT
32DD1	Submarine Tender LANT
32EE1	Submarine Rescue Ship LANT
32KK	Miscellaneous Command Ship
32QQ1	Salvage and Rescue Ship LANT
32TT	Auxiliary Aircraft Landing Training Ship

42N1	Air Anti-Submarine Squadron VS LANT
42P1	Patrol Wing and Squadron LANT
42BB1	Helicopter Anti-Submarine Squadron HS LANT
42CC1	Helicopter Anti-Submarine Squadron Light HSL LANT
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