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Naval Oceanographic and
Atmospheric Research Laboratory

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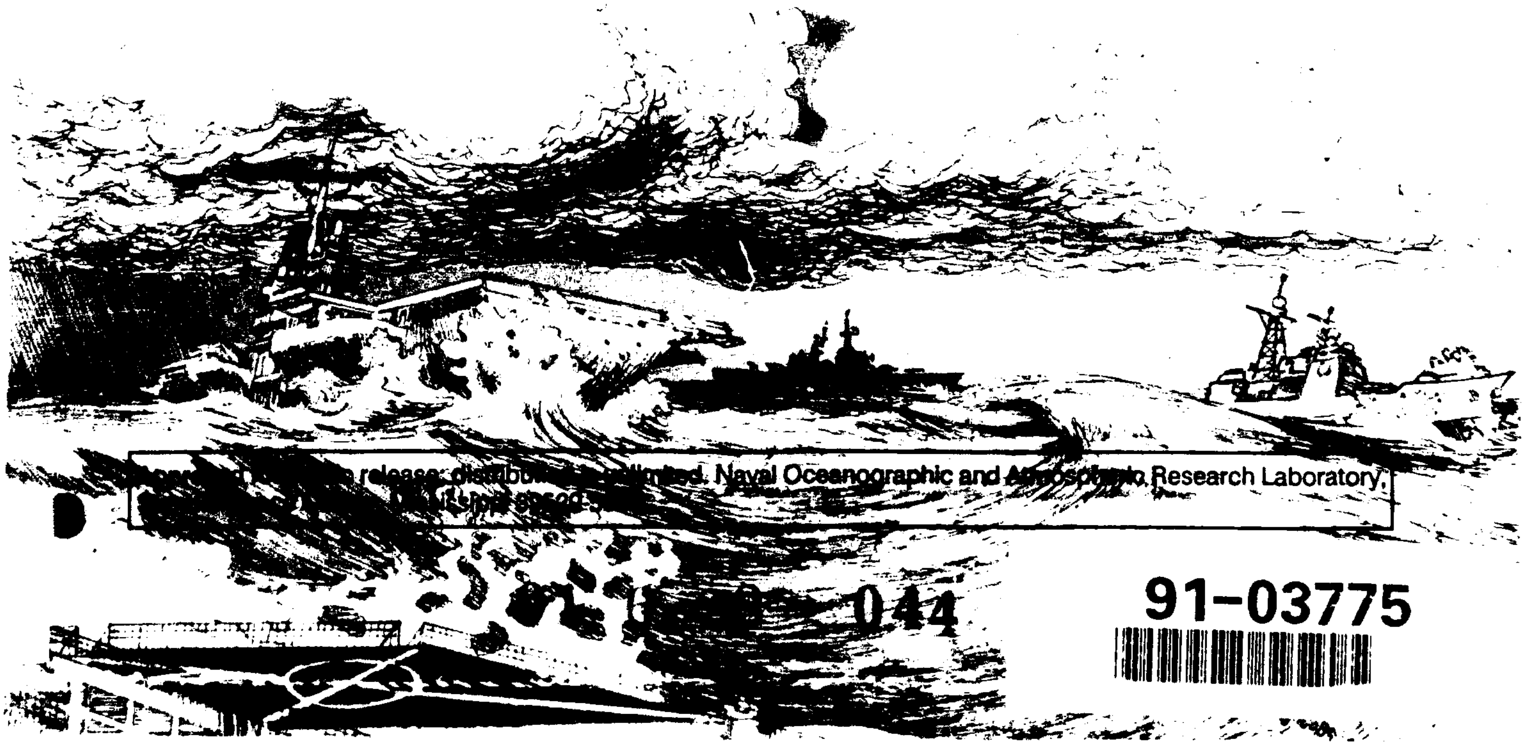
SEVERE WEATHER GUIDE
MEDITERRANEAN PORTS

32. TARANTO



CONTENTS

FOREWORD

This handbook on Mediterranean Ports was developed as part of an ongoing effort at the Atmospheric Directorate, Naval Oceanographic and Atmospheric Laboratory (NOARL), Monterey, to create products for direct application to Fleet Operations. The research was conducted in response to Commander Naval Oceanography Command (COMNAVOCEANCOM) requirements validated by the Chief of Naval Operations (OP-096).

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 Naval Oceanography Command Center (NAVOCEANCOMCEN), Rota with a copy to the oceanographer, COMSIXTHFLT. They will then be passed on to NOARL, Monterey for review and incorporation as appropriate. This document will be a dynamic one, changing and improving as more and better information is obtained.

ACKNOWLEDGMENTS

The support of the sponsors -- Naval Oceanography Command, Stennis Space Center, MS: and Fleet Numerical Oceanography Center, Monterey, CA (Program Element O&M,N) -- is gratefully acknowledged.

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. Computerized versions of these port guides are available for those ports with an asterisk (*). Contact the Atmospheric Directorate, NOARL, Monterey or NOCC Rota for IBM compatable floppy disk copies.

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
16	BARCELONA, SPAIN
17	PALMA, SPAIN
18	IBIZA, SPAIN
19	POLLENSA BAY, SPAIN
20	LIVORNO, ITALY
21	LA SPEZIA, ITALY
22	VENICE, ITALY
23	TRIESTE, ITALY
*24	CARTAGENA, SPAIN
*25	VALENCIA, SPAIN
*26	SAN REMO, ITALY
*27	GENOA, ITALY
*28	PORTO TORRES, ITALY
*29	PALERMO, ITALY
*30	MESSINA, ITALY
*31	TAORMINA, ITALY

1991	PORT
*32	TARANTO, ITALY
*33	TANGIER, MOROCCO
*34	BENIDORM, SPAIN
35	ROTA, SPAIN
36	LIMASSOL, CYPRUS
37	LARNACA, CYPRUS
38	ALEXANDRIA, EGYPT
39	PORT SAID, EGYPT
	SOUSSE, TUNISIA
	SFAX, TUNISIA
	TUNIS, TUNISIA
	BIZERTE, TUNISIA
	SOUDA BAY, CRETE
	VALETTA, MALTA
	PIRAEUS, GREECE

1992	PORT
	KALAMATA, GREECE
	CORFU, GREECE
	KITHIRA, GREECE
	THESSALONIKI, GREECE

DELAYED INDEFINITELY
ALGIERS, ALGERIA
ISKENDERUN, TURKEY
IZMIR, TURKEY
ISTANBUL, TURKEY
ANTALYA, TURKEY
GOLCUK, TURKEY

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 toographical 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 NOARL personnel; considerable information obtained through interviews with local pilots, tug masters, etc; and local reference material was obtained.
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 include 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/eparting, 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 became 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 Taranto is located in southern Italy near the head of the Gulf of Taranto at about 40° 24'N, 17° 12'E (Figure 2-1).

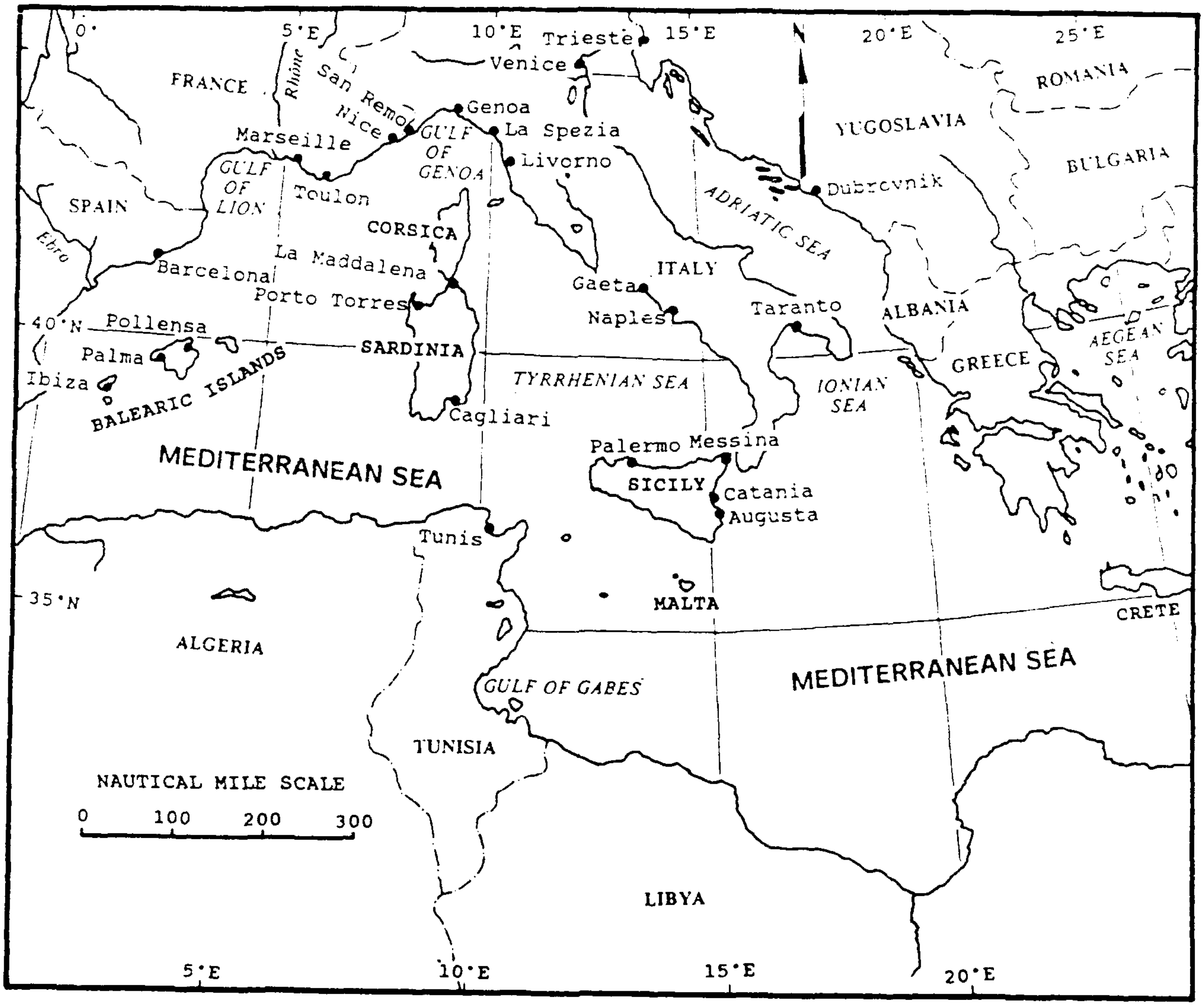


Figure 2-1. Central Mediterranean Sea.

The Port of Taranto is near the "arch of the boot of Italy" about 65 n mi north of the mouth of the Gulf of Taranto (Figure 2-2). The eastern coast of Sicily is about 225 n mi southwest of Taranto. The western side of the gulf is dominated by the mountains of the Apennino Calabrese which are visible from a considerable distance. The northeastern side is flat and low and forms the southern boundary of the large plain of Salentina. All the shores of the gulf are fringed by sandy beaches which, in general, front marshy ground (Hydrographer, 1965).

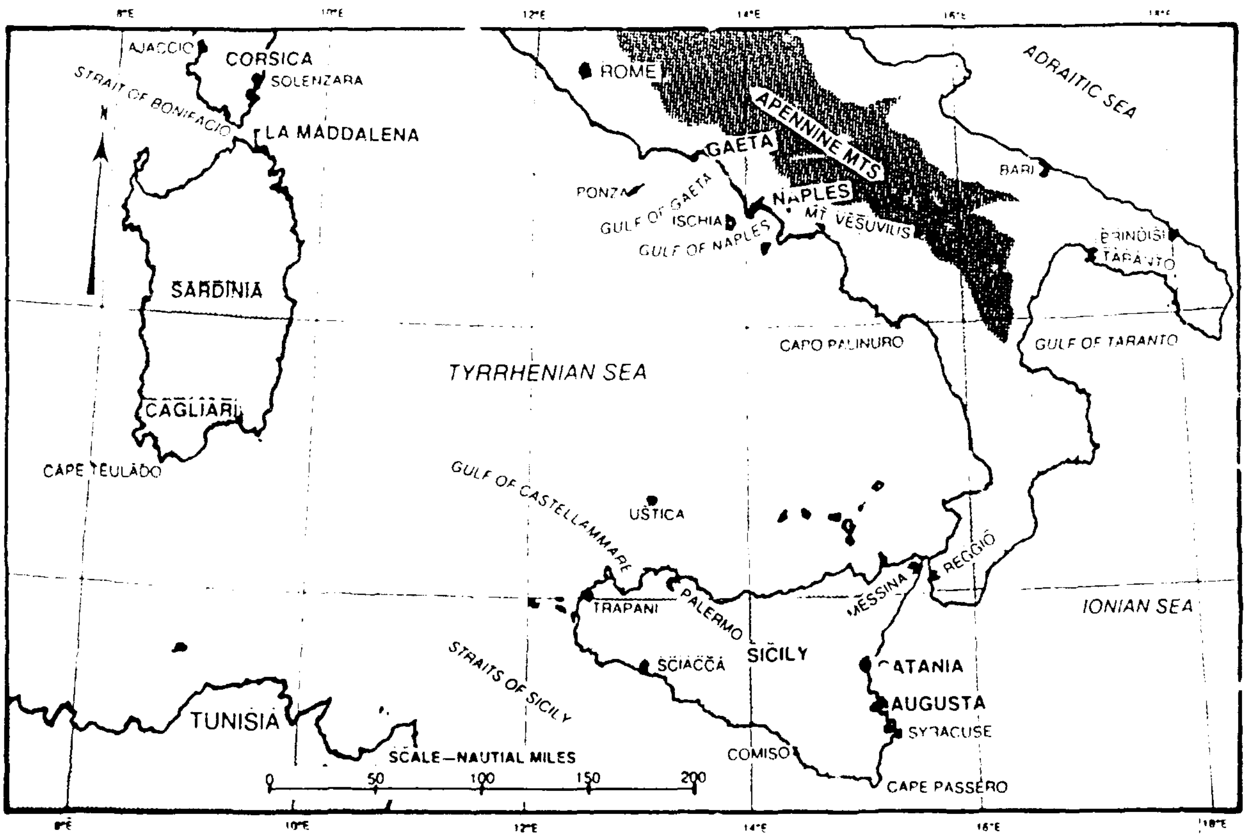


Figure 2-2. Ports of Italy, Sicily, and Sardinia.

The Port of Taranto consists of an outer harbor Mare Grande which is well protected by breakwaters and an inner harbor Mare Piccolo (Figure 2-3). The two are connected by a canal Canole Navigable (FICEURLANT, 1987). The port is nearly a closed harbor with protecting breakwaters on all sides, except for the entrance to the southwest. The surrounding land encircles the harbor area from about 350° clockwise to 170°. The western half is open to the elements, except for the breakwaters and the island of San Pietro located about one n mi northwest of the entrance. The island is at a bearing of about 280° range 1 n mi from the anchorages normally assigned to the larger USN ships (FICEURLANT, 1987). Holding in the anchorage is considered good, but vessels with large sail area and shallow draft tend to drag anchor during strong southeasterly winds (Port Visit, 1988). Access to the inner harbor is via the navigation canal which is 75 feet (23 m) wide, depth of about 39 feet (12 m) and has a drawbridge over it which must be raised to accommodate vessels taller than 65 feet (20 m). The bridge has scheduled openings at 0020-0420, 0830, 1510, and 2110 local time, openings at other times are almost impossible to arrange (FICEURLANT, 1987). Vessels transiting Canole Navigable should be particularly wary of strong crosscurrents in the immediate vicinity (last 1000 yards of approach) of the canal. Alongside berthing is available in the inner harbor at the Italian Navy base for up to large auxiliary size ships. Med mooring is the normal practice for berthing in other areas of the inner harbor. Currents are weak and tides are minimal in the Taranto area.

Specific hazardous environmental conditions, vessel situations, and suggested precautionary/evasion action scenarios are summarized in Table 2-1.

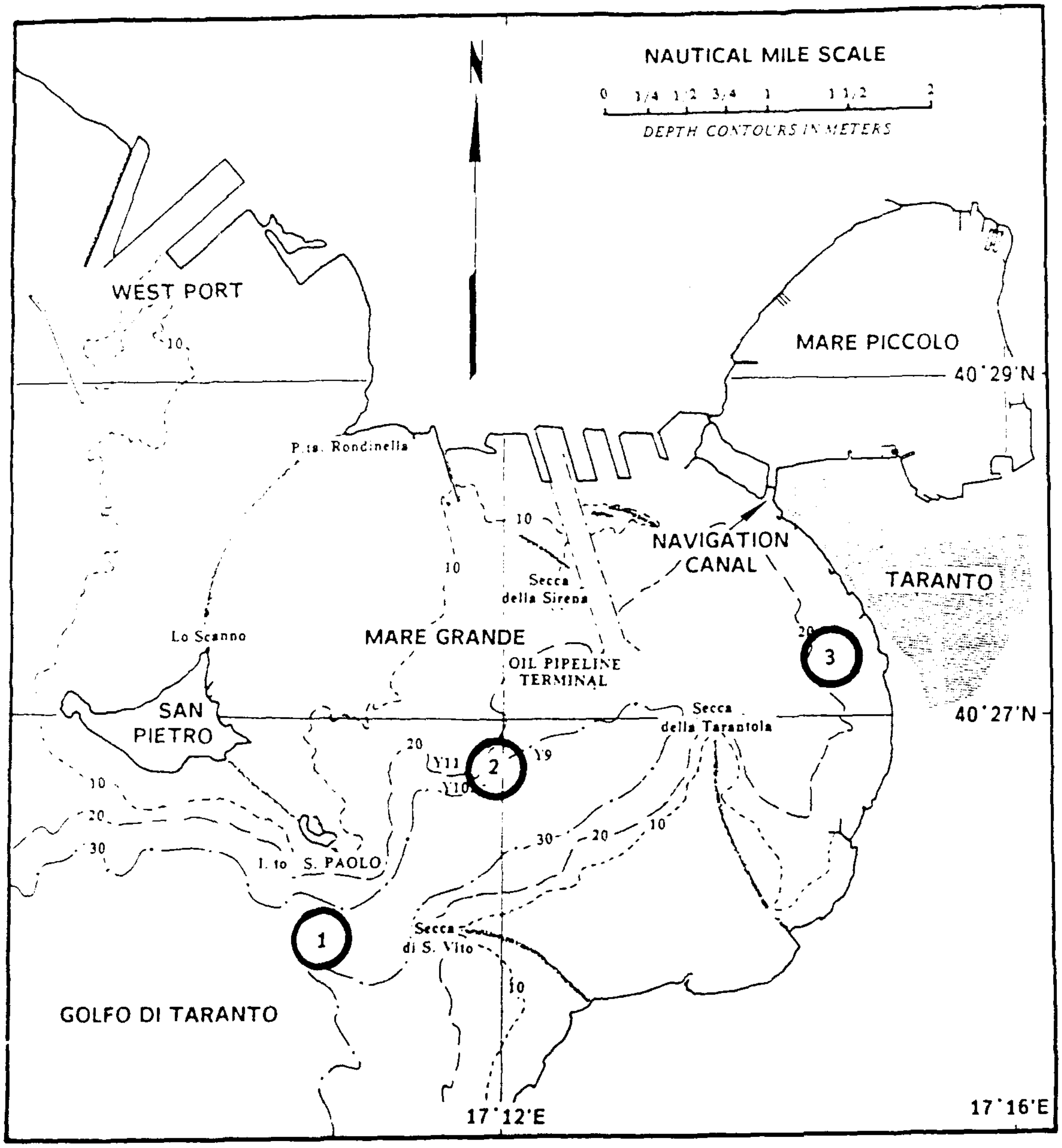


Figure 2-3. Port of Taranto, Italy.

Table 2-1. Summary of hazardous environmental conditions for the Port of T

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFEC
1. Strong SE wind. Scirocco event. * 40-50 kt * Occurs 4 to 5 times per winter * SE waves refract into outer harbor - Reach 6-10 ft (2-3 m) from the SW - Are 90° out of phase with wind * Fog and rain with east to south winds especially in May and June	Advance Warning * Abnormal rising temperature * Increasing clouds to the south * Falling barometer * Low pressure center to northwest * Rise in water level	(1) Anchored in outer harbor.	(a) Ships with la * Bet er pr * Inner harb (b) Wind and seas * Deploy se * Be aware alongside
		(2) Arriving/departing.	(a) Waves will re * Beware o (b) Visibility re * Beware o
		(3) Passage through canal.	(a) Strong cross * Passage c
		(4) Moored - inner harbor.	(a) Normally use M * Add lines
		(5) Small boat operations.	(a) Generally can * Cross win
2. Strong NW wind. Mistral event. * 40 kt, waves limited by short fetch * Occurs during January and February * Near freezing winter temperatures - Wind chill below freezing	Advance Warning * Mistral outbreak advancing from Gulf of Lion to Western Italy * Lasts for several days but light at night.	(1) Anchored in outer harbor.	(a) Winds more th * Island of * Inner harb (b) Wind chill may
		(2) Arriving/departing.	(a) Daytime winds * Early morn (b) Wind chill
		(3) Passage through canal.	(a) Cross wind an * Early morn (b) Wind chill may
		(4) Moored - inner harbor.	(a) Daytime winds * Add lines (b) Wind chill may
		(5) Small boat operations.	(a) Wind and wind * Use cauti * Issue cold

ironmental conditions for the Port of Taranto, Italy.

VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
(1) Anchored in outer harbor.	(a) Ships with large sail area and shallow draft tend to drag anchor. * Better protection in eastern outer harbor * Inner harbor offers best protection (b) Wind and seas 90 degrees out of phase with swell. * Deploy second anchor * Be aware of different responses by various length vessels during alongside/well deck operations.
(2) Arriving/departing.	(a) Waves will refract into harbor entrance. * Beware of cross winds, following seas entering, head seas departing. (b) Visibility reduced in rain and fog. * Beware of many unlighted mooring buoys.
(3) Passage through canal.	(a) Strong cross wind plus crosscurrent in vicinity of canal. * Passage during strong winds hazardous.
(4) Moored - inner harbor.	(a) Normally use Med mooring. * Add lines or move to alongside berth
(5) Small boat operations.	(a) Generally cancelled during strong events due to high waves. * Cross wind/wave patterns added hazard.
(1) Anchored in outer harbor.	(a) Winds more than waves will affect anchored ships. * Island of San Pietro may afford limited protection * Inner harbor better protected (b) Wind chill may be hazard during winter.
(2) Arriving/departing.	(a) Daytime winds biggest problem. * Early morning or after sunset lighter winds (b) Wind chill may be hazard during winter.
(3) Passage through canal.	(a) Cross wind and currents, and low SOA cause ship handling problems. * Early morning at after sunset passage reduces wind effect. (b) Wind chill may be hazard during winter.
(4) Moored - inner harbor.	(a) Daytime winds problem for Med moored vessels. * Add lines or move to alongside berth (b) Wind chill may be hazard during winter.
(5) Small boat operations.	(a) Wind and wind chill primary problems. * Use caution in boat handling * Issue cold weather gear

Table 2-1. (Continued)

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFF
3. Strong SW wind. Lebeccio event. * 30-40 kt, limited fetch (25-30 nmi) * Generally spring or fall events	Advance Warning * Strong in daytime, calming after sunset * Generally of 1 or 2 day duration	(1) Anchored in outer harbor.	(a) Exp * * * *
		(2) Arriving/departing.	(a) Fol *
		(3) Passage through canal.	(a) Fol *
		(4) Moored - inner harbor.	(a) Max *
		(5) Small boat operations.	(a) High *
4. NE wind. Flow off Adriatic Sea. * 25-30 kt with sudden onset * Lasts for several days - Strongest in afternoon - Light to calm at night * Occurs September through March - Winter freezing temperatures - Wind chills 0 to -10°F	Advance Warning * Developing high pressure over northern Italy and/or low passing eastward south of area. * Sudden onset most likely to occur in morning. * May last several days, but light at night * Belt of clouds form on hills north of inner harbor and remain for duration of event.	(1) Anchored in outer harbor.	(a) Sudd *
		(2) Arriving/departing.	(a) Sudd * *
		(3) Passage through canal.	(a) Sudd *
		(4) Moored - inner harbor.	(a) Min * *
		(5) Small boat operations.	(a) Rap * *

Table 2-1. (Continued)

.ARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
...et	(1) <u>Anchored in outer harbor</u>.	(a) <u>Exposed to wind, sea and swell</u>. * Move away from entrance * Lee of island of San Pietro may afford limited protection * Inner harbor better protected * Winds decrease after sunset
	(2) <u>Arriving/departing</u>.	(a) <u>Following/head wind and seas arriving/departing</u>. * Schedule for morning or evening passage
	(3) <u>Passage through canal</u>.	(a) <u>Following/head wind and seas entering/exiting</u>. * Schedule for morning or evening passage
	(4) <u>Moored - inner harbor</u>.	(a) <u>Maximum winds during daytime</u>. * Add lines for Med moored or berth alongside
	(5) <u>Small boat operations</u>.	(a) <u>High wind and seas in outer harbor</u>. * Operate with caution or cancel in most exposed area.
...thern ...th of	(1) <u>Anchored in outer harbor</u>.	(a) <u>Sudden onset may cause rapid swinging of ships</u>. * During morning periods be aware of potential ship swinging
...in	(2) <u>Arriving/departing</u>.	(a) <u>Sudden onset may cause handling problems</u>. * Be aware of seasonal tendency and yesterdays conditions * Early to mid morning onset most likely
...ght ...mer ...t.	(3) <u>Passage through canal</u>.	(a) <u>Sudden onset may cause handling problems</u>. * Schedule for very early morning or evening
	(4) <u>Moored - inner harbor</u>.	(a) <u>*Minimum hazard*</u>. * Note sudden onset characteristic * Be prepared for winter wind chill factor
	(5) <u>Small boat operations</u>.	(a) <u>Rapid increase of wind and dropping wind chill factor</u>. * Be aware of seasonal tendency and yesterdays conditions * Be prepared for winter wind chill factor

Shallow water wave heights resulting from the deep water waves with periods of six seconds or longer have been compiled for three points (Figure 2-3). Point 1 is just outside the entrance to the outer harbor. Point 2 is near the center of the outer harbor and Point 3 is on the easter side of the outer harbor.

Table 2-2 provides the height ratio and direction of shallow water waves to expect at the three points when the deep water wave conditions are defined.

The Taranto Point 1 conditions are found by entering Table 2-2 with the forecast or known deep water wave direction and period. In the following example, the height is determined by multiplying the deep water height (8 ft) by the ratio (.6) of shallow to deep height.

Example: Use of Table 2-2 for Taranto Point 1
Deep water wave forecast as provided by a forecast enter or a reported/observed deep water wave condition: 8 feet, 10 seconds, from 180° The expected wave condition at Taranto Point 1 as determined from Table 2-2: 6-7 feet, 10 seconds, from 185°

NOTE: Wave periods are a conservative property and, therefore, 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)

TARANTO POINT 1: Outside Outer Harbor Entrance 108 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	150° .9	155° .7	165° .5	175° .6	180° .6	185° .6
180°	180° 1.0	180° .9	185° .8	190° .7	195° .7	195° .7
210°	210° 1.0	210° .9	210° .8	205° .8	205° .7	205° .7
240°	240° 1.0	235° 1.0	230° .8	230° .8	225° .8	220° .9
270°	270° 1.0	265° .8	255° .6	250° .5	250° .5	245° .5
300°	280° .5	270° .5	265° .4	255° .4	245° .4	240° .4
330°	290° .4	285° .3	280° .2	265° .2	260° .2	250° .2

TARANTO POINT 2: Central Outer Harbor 66 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	215° .4	215° .4	215° .3	220° .2	220° .2	220° .2
180°	215° .4	215° .4	215° .2	220° .2	220° .2	220° .2
210°	215° .5	215° .4	215° .4	220° .3	215° .3	215° .3
240°	225° .5	220° .4	220° .4	220° .3	220° .3	220° .2
270°	230° .3	225° .2	225° .2	220° .2	220° .2	220° .2
300°	230° .2	225° .2	225° .1	225° .1	220° .1	220° .1

Table 2-2 (Continued).

TARANTO POINT 3: East Side of Outer Harbor 42 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	240° .2	240° .2	240° .15	245° .15	250° .1	260° .1
180°	240° .25	240° .2	240° .15	245° .15	250° .1	260° .1
210°	245° .35	250° .25	250° .2	250° .15	250° .15	260° .1
240°	235° .3	235° .2	240° .2	245° .15	250° .15	260° .1
270°	240° .2	240° .15	245° .15	250° .15	250° .15	260° .1
300°	240° .15	245° .15	250° .1	250° .1	260° .1	260° .1

The local wind-generated wave conditions for the anchorage area identified as Points 1, 2, and 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. Taranto. Local wind waves for fetch limited conditions at Points 1, 2, and 3 (based on JONSWAP model).

Point 1.

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
W 15 n mi	2-3/4 2-3	3-4/4 2	4/5 2	5/5 2	6/5 2
SW 25 n mi	4/5 4	5/6 4	6/6 3-4	8/6-7 3-4	9/7 3-4
SSW 55 n mi	5/6 5	6/6-7 4-5	8/7 4-5	9-10/7-8 4-5	11/8 4-5

Points 2 & 3.

W 2 n mi	<2 ft	<2 ft	1-2/2 1	2/2-3 1	2/3 1
SW 3 n mi	<2 ft	<2 ft	2/3 1	2-3/3 1	3/3 1

Climatological factors of shallow water waves, 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 Table 2-4. See Appendix A for discussion of wave spectrum and energy distribution. These data are provided as they occur by season for two ranges of heights: greater than 3.3 ft (1 m) and greater than 6.6 ft (2 m).

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 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

TARANTO POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	22	12	7	25
Average Duration (hr)	16	16	29	15
Period Max Energy (sec)	8-9	8-9	6-8	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	4	1	1	3
Average Duration (hr)	11	9	18	11
Period Max Energy (sec)	9	9-10	11-12	9
TARANTO POINT 2:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	5	3	0	4
Average Duration (hr)	14	10	NA	9
Period Max Energy (sec)	8	8	NA	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	<1	0	0	0
Average Duration (hr)	8	NA	NA	NA
Period Max Energy (sec)	9	NA	NA	NA

TARANTO PT 3

Deep water waves (swell) propagating into the outer harbor are not expected to reach Point 3 at heights greater than 3.3 ft (1 m). Note, however, that combined wind waves (sea) and swell can result in waves greater than 3.3 ft at Point 3. For example, if both swell and seas were 3 ft, the combined waves would exceed 4 ft ($\sqrt{3^2 + 3^2} \approx 4.2$ ft). This condition would be most likely under southwesterly flow where the open sea swell enters the harbor with minimum refraction, the fetch length within the harbor is maximum relative to Point 3, and the swell and sea waves direction are closely aligned.

SEASONAL SUMMARY OF TARANTO HAZARDOUS WEATHER CONDITIONS

Confused, rough choppy wave conditions will occur throughout the outer harbor when strong southerly wind generated swell is refracted through the harbor entrance and approaches a 90° out-of-phase direction with local wind waves.

WINTER (November through February):

* Scirocco winds: Worst conditions, SE'ly 40-50 kt, four to five events per winter. Swell and seas out of phase in outer harbor, cause great disturbance to ships, boating generally cancelled.
* Anomalous radar and radio propagation during Scirocco events. Helicopters may lose contact at 1 to 2 miles. Ship to shore communications may be disrupted even within the outer harbor.
* Winter winds generally northerly, events last for several days, strongest in daytime and light at night.
* Mistral: NW 30-40 kt, waves fetch limited.
* Bora: NE'ly 25-35 kt, sudden onsets from light to 25+ kt.

SPRING (March through May)

* Strong wind events generally from SW, short duration (1 or 2 days) and dropping off at night. Can generate unfavorable wave conditions for boating in outer harbor during early spring.
* Fog and rain with southeasterly winds, visibility near zero for a few hours during morning likely a couple times per year in May early June.
* Anomalous radar and radio propagation during Scirocco events. Helicopters may lose contact at 1 to 2 miles. Ship to shore communications may be disrupted even within the outer harbor.

SUMMER (June through September)

* Daily weak south to southwest sea breeze
* Thunderstorms two to four days per month, generally weak.

AUTUMN (October)

* Prevailing winds return to northerly directions.
* Thunderstorm activity limited to one or two days.
* Daily maximum/minimum temperature drop about 10°F from summer, now average 72° and 58°F.

NOTE: For more detailed information on hazardous weather conditions, see previous Table 2-1 in this section and Hazardous Weather Summary in Section 3.

References

FICEURLANT, 1987: Port Directory for Taranto (1986), Italy. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

Hydrographer, 1965: Mediterranean Pilot Vol. II. 9th Edition. Hydrographic Department, London.

Port Visit Information

May 1988: NOARL Meteorologists R. Fett and D. Perryman met with Chief Pilot Augusto De Bellis to obtain much of the information included in this report.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/ oceanographers and staff planners. Paragraph 3.5 provides a general discussion of hazards and Table 3-5 provides a summary of vessel locations/situations, potential hazards, effects, precautionary/evasive actions, and advance indicators and other information.

3.1 Geographic Location

The Port of Taranto is located in southern Italy near the head of the Gulf of Taranto at about 40° 24'N, 17° 12'E (Figure 3-1).

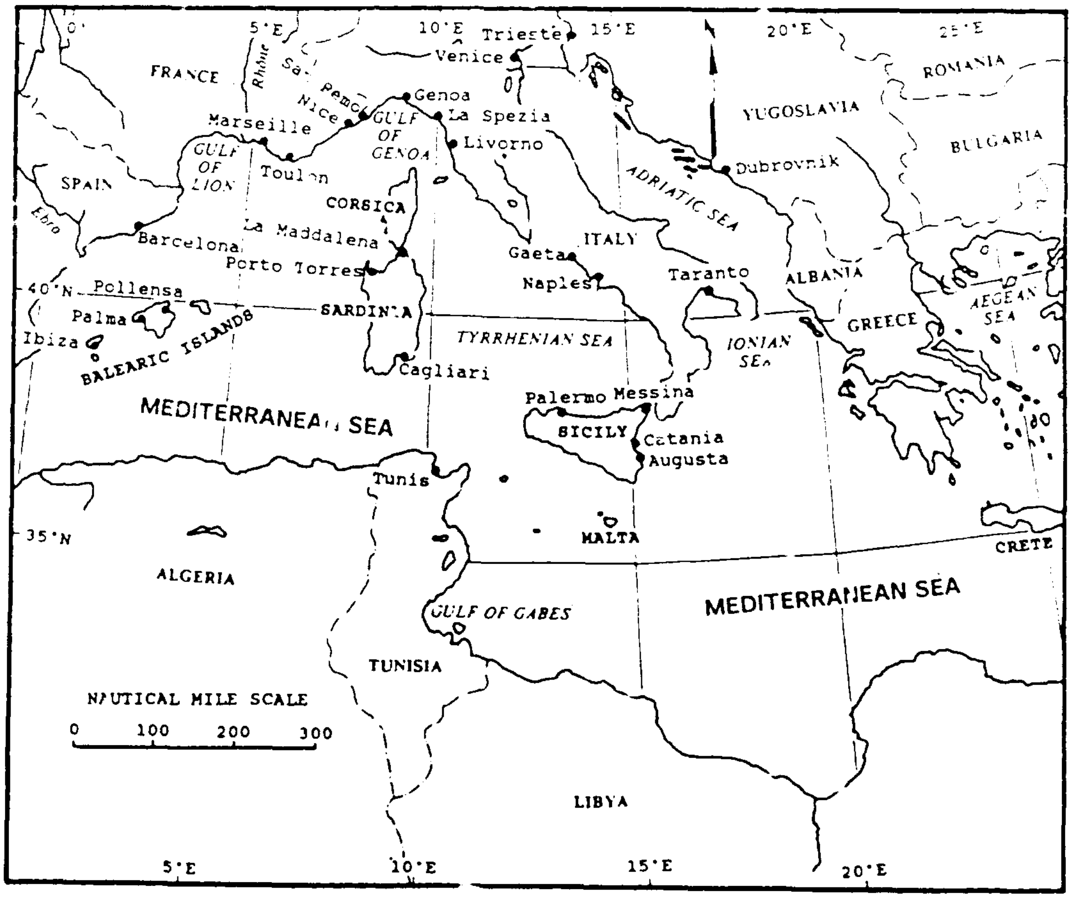


Figure 3-1. Central Mediterranean Sea.

The Port of Taranto is near the "arch of the boot of Italy" about 65 n mi north of the mouth of the Gulf of Taranto (Figure 3-2). The eastern coast of Sicily is about 225 n mi southwest of Taranto. The western side of the gulf is dominated by the mountains of the Apennino Calabrese which are visible from a considerable distance. The northeastern side is flat and low and forms the southern boundary of the large plain of Salentina. All the shores of the gulf are fringed by sandy beaches which, in general, front marshy ground (Hydrographer, 1965).

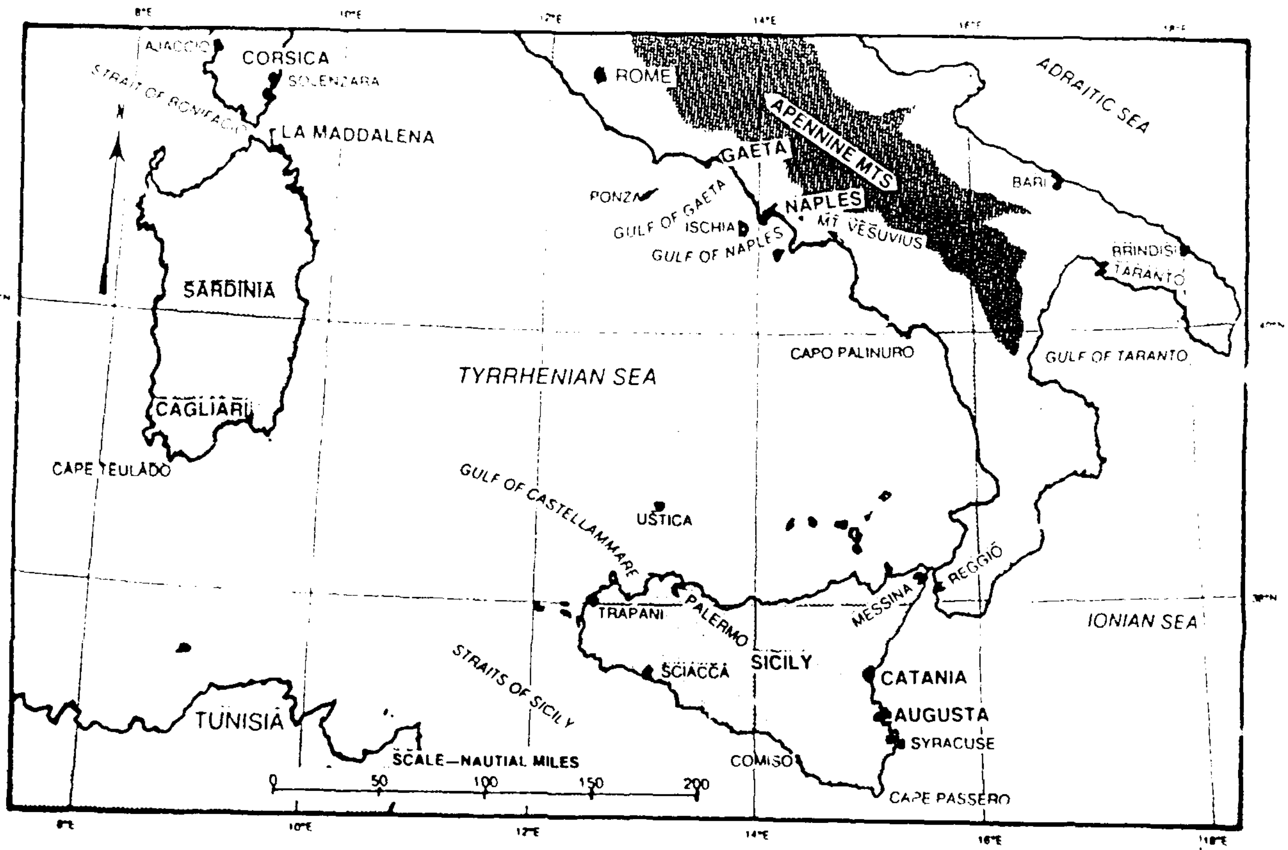


Figure 3-2. Ports of Italy, Sicily, and Sardinia.

The Port of Taranto consists of an outer harbor Mare Grande and an inner harbor Mare Piccolo (Figure 3-3). The two are connected by a narrow canal Canole Navigable (FICEURLANT, 1987). The port is nearly a closed harbor with protecting breakwaters on all sides of the outer harbor except for the entrance to the southwest. The inner harbor is surrounded by land except for the canal. The town of Taranto lies at the head of Mare Grande and extends across the neck of land separating the two harbors. The outer harbor is large, extending slightly over 3 n mi from the entrance on the southwest to the canal to the northeast. The southeast-northwest length is over 4 n mi. The port is primarily a naval base. The Italian Navy's principal southern base is in Mare Piccolo. Numerous alongside berths are available at the Italian Navy piers for ships through large auxiliary size (FICEURLANT, 1987).

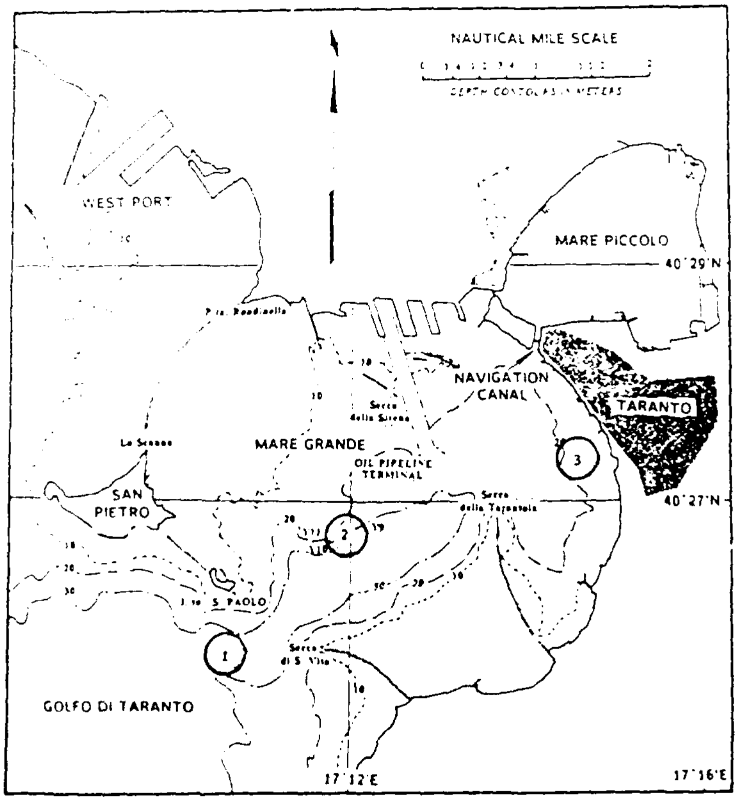


Figure 3-3. Port of Taranto, Italy.

3.2 Qualitative Evaluation of the Port of Taranto

The harbor is protected from all ocean sea waves except for the southwesterly wind-driven sea and swell which enters the outer harbor through the relatively wide entrance. The surrounding land is relatively flat so there are no significant funneling or other terrain influences on the winds. Land surrounds the inner harbor completely and the outer harbor from about 350° clockwise to 170°. The western half of the outer harbor is open to the elements, except for the breakwaters and the island of San Pietro located about one n mi northwest of the entrance. The island is at a bearing of about 280° range 1 n mi from the anchorages normally assigned to the larger USN ships (FICEURLANT, 1987). High winds can raise wind waves of 3 ft (1 m) or more in the outer harbor. Deep water swell, while significantly reduced, does propagate through the entrance as a general southwest swell in the outer harbor. With strong southeasterly winds the combination of cross swell with wind and wind waves produces conditions hazardous enough to cancel small boat operations and most other operations for anchored ships.

Holding conditions are considered good, but under 40+ kt winds ships with large sail areas and/or shallow draft have been known to drag anchor. Conditions are generally less hazardous on the east side of the outer harbor.

Entry to the inner harbor through the canal should be approached with caution. Strong cross-currents are experienced in the final 1000 yds of approach. During high wind conditions passage through the canal is not recommended. The low flat terrain surrounding the inner harbor provides little protection from winds.

3.3 Currents and Tides

Currents are weak and tides are minimal in the Taranto area. However, currents in and near the canal are irregular both in strength and direction. A rising water level of one or two feet often precedes the arrival of strong southeasterly winds.

3.4 Visibility

During spring and early summer southeasterly winds frequently bring rain and fog. Early to mid-morning visibility will be reduced to near zero two or three times each year. Conditions typically improve after about three hours. The normal Mediterranean summer-time haze conditions are to be expected. Slant range visibilities are most affected during hours of sun-light.

3.5 Seasonal Summary of Hazardous Weather Conditions

A seasonal summary of the various known environmental hazards that may be encountered in the Port of Taranto follows.

A. Winter (November through February)

The seasonal weather patterns of the Taranto area are controlled to a large extent by the monsoonal behavior of both the Eurasia land mass to the north and the Sahara Desert to the south. During winter high pressure dominates these two land masses and the storm track is found over the relatively warm waters between them; unsettled, windy weather is common (Brody and Nestor, 1980).

Strong southerly Scirocco winds are the cause of the most extreme weather conditions at Taranto. In winter, four or five Scirocco events will develop that result in 40+ kt winds and heavy southerly swell. The swell refracts into the outer harbor through the southwest entrance resulting in a near 90½ out of phase swell wave train with the southeasterly wind and wind waves. The primary synoptic pattern that causes Sciroccos is low pressure over the Mediterranean that extends southward into North Africa. Two patterns that are likely to cause a Scirocco are: 1) A cyclone forming over North Africa and tracking northward such that Taranto remains in the warm sector and 2) a cold front approaching from the western Mediterranean that extends southward over the Mediterranean into North Africa thereby placing Taranto in the warm air ahead of the front.

The prevailing winter winds are northerly over the Taranto area. The most frequent strong wind events are associated with Bora outbreaks of northeasterly wind off the Adriatic. These winds flow over the flat lands to the east of Taranto. They typically arrive with a sudden onset of 25+ kt. This is most likely to occur in mid to late morning as the offshore northerly winds tend to be strongest during the day time and quite light at night. Night time land surface cooling and development of low level inversions/stable layers are the typical cause of the drop off of northerly winds at night. Mistral events bring northwesterly 30-40 kt winds to the area. The Mistral reaches Taranto only under the strongest events. The main, necessary synoptic features are strong eastern Atlantic blocking and a deep 500 mb trough over the central Mediterranean that extends into northern Africa. With this pattern Genoa lows will move southeastward into the Ionian Sea and following their passage to the east Mistral conditions may occur. Extended periods of a week or more of bad weather will be experienced in the Taranto area when a Genoa low stalls west of southern Italy, and a series of secondary lows form over the Ionian Sea. Under this pattern Taranto will experience prolonged rainy, squally conditions with winds switching from southerly ahead of each low to northerly as it passes.

The Taranto area is somewhat arid, averaging 18 inches (483 mm) of precipitation a year. In the cold season, October through March, precipitation averages 1.3 inches per month with average frequency of occurrence being about 7 days per month. Snow showers can be expected on a couple days during January and February. Rainfall during June through mid September is at a minimum averaging less than 1/2 inch per month in the form of afternoon showers.

The Mediterranean climate is reflected in the mild temperatures. Daily mean maximum and minimum range from 54/43°F (12/6°C) in December to 86/72°F (30/22°C) in July and August. Mean annual extremes range from 95°F (35°C) to 30°F (-1°C). Several days per month for December through February will experience freezing or near freezing temperatures in the morning hours. Periods of Bora winds bring the lowest temperatures and cause for concern for personnel working in exposed areas. Table 3-1 can be used to determine wind chill for various temperature and wind combinations.

Table 3-1. Wind Chill. The Cooling power of the wind expressed as "Equivalent Chill Temperature" (adapted from Kotsch, 1983).

Wind Speed		Cooling Power of Wind expressed as "Equivalent Chill Temperature"								
Knots	MPH	Temperature (°F)								
Calm	Calm	40	35	30	25	20	15	10	5	0
		Equivalent Chill Temperature								
3-6	5	35	30	25	20	15	10	5	0	-5
7-10	10	30	20	15	10	5	0	-10	-15	-20
11-15	15	25	15	10	0	-5	-10	-20	-25	-30
16-19	20	20	10	5	0	-10	-15	-25	-30	-35
20-23	25	15	10	0	-5	-15	-20	-30	-35	-45
24-28	30	10	5	0	-10	-20	-25	-30	-40	-50
29-32	35	10	5	-5	-10	-20	-30	-35	-40	-50
33-36	40	10	0	-5	-15	-20	-30	-35	-45	-55

B. Spring (March through May)

Spring is a relatively long transition season and is characterized by the occurrence of North African cyclones that develop over the rapidly heating Sahara. These cyclones typically move northeastward across the

Mediterranean bringing Scirocco conditions to the Ionian Sea and Gulf of Taranto area. The lowest monthly average sea-level-pressure of the year, 1012 mb, occurs at Taranto in April. Scirocco events bring low stratus, fog and drizzle, with resultant poor visibilities in the northern Mediterranean. Extremely anomalous radar and radio propagations are likely because of the strong low level inversion over the water. Helicopters are liable to be out of radio contact at a range of a mile or two and ship to shore communication ranges are similarly limited. Strong turbulence associated with wind shear above the low level inversion is frequently experience. An indication of the turbulences may be deduced from barograph traces which commonly show violent "pumping" under regions with strong turbulence (Reiter, 1971).

The strongest spring wind events occur as short periods of southwesterlies, usually lasting less than a day. They drop off significantly at night. During these conditions wind driven sea and swell enter the outer harbor through the southwest facing entrance. Conditions are better within the outer harbor on the eastern side.

Precipitation drops off from winter amounts decreasing from about 1 1/2 inches in March to an inch in April and May. Precipitation in the form of light rain falls about 5 days a month. Average daily maximum/minimum temperatures rise from 58/46°F (15/8°C) in March to 72/59°F (22/15°C) in May.

C. Summer (June through September)

Scirocco events continue through June and result in hot muggy conditions in the Taranto area at this time of year. During the summer the land mass to the north is relatively warm while the Sahara is hot in comparison to the water area. Therefore weak high pressure with settled, warm, dry weather and light winds is the rule. Daily light south to southwest sea breezes prevail.

Relatively weak thunderstorms occur over the higher terrain with effects at the harbor generally limited to a shift to light to moderate northerly winds for a few hours.

Daily mean maximum/minimum temperatures reach 86/72°F (30/22°C) in July and August. Precipitation reaches a minimum in July averaging less than 1/10 inch, then increasing to a little over an inch on average in September.

Visibility is in general slightly restricted by the typical Mediterranean summer haze. Daytime slant ranges can be reduced to near zero under certain sun angle conditions.

D. Autumn (October)

Autumn usually lasts only for the month of October and is characterized by an abrupt change from settled summer-type weather to stormy winter-type weather. Long term weather parameter records, such as pressure and temperature, reflect a sharp drop on about 20 October. Prevailing winds shift to the offshore northerly directions.

Average daily maximum/minimum temperatures are 71/59°F (22/15°C), about a 8 or 9°F drop from September. Precipitation doubles from September to about 2 inches and an average of 7 days with precipitation.

3.6 Harbor Protection

The nearly closed harbor of Taranto is well protected from most wave conditions. The western portion of the outer harbor is fully exposed to wind and elements. The eastern portion provides some protection while the inner harbor is surrounded by land with only canal openings to the outer harbor. The flat low land surrounding Taranto provides limited protection from the wind. It is, however, one of the few Mediterranean ports where terrain influences of wind such as funneling or influencing the direction of flow is not a factor.

3.6.1 Wind and Weather

Strong winter southeasterlies (40+ kt) cause major disruptions to operations in the outer harbor. Ships with large sail area and/or shallow draft have caused anchor dragging problems. Southerly swell refracts through the harbor entrance resulting in a near 90° cross wave train with the wind and wind waves. Southwesterly winds of 30+ kt, most likely to occur in spring, result in wind driven swell and seas propagating into the outer harbor through the southwest facing entrance. Winter time northeasterlies flow across the low flat land to the east of Taranto and have a tendency to arrive with a sudden onset of 25+ kt winds. The onset is most likely to occur during mid to late morning. All of the winter offshore northerly winds tend to become nearly calm at night.

During spring southeasterly winds tend to bring overcast stratus and rainy foggy weather to Taranto with accompanying low visibilities. During early and late summer Scirocco events result in hot muggy weather at Taranto.

In general winters are cool with windy and highly variable weather while summer is mild with light winds and stable weather conditions.

3.6.2 Waves

Wind waves of 3 to 4 ft can be raised in the outer harbor by 40+ kt winds. Deep water swell enters the outer harbor through the entrance as southwesterly waves. Swell heights in the outer harbor near the entrance may reach 6-7 ft (2 m) under strong southerly wind conditions. Wave conditions are generally lower on the eastern side of the outer harbor and within the totally enclosed smaller inner harbor.

Table 3-2 provides the shallow water wave conditions for the three designated points when deep water swell approaches and enters the harbor.

Example: Use of Table 3-2.

For a deep water wave condition of:

12 feet, 12 seconds, from 150°

The approximate shallow water wave conditions are:

Point 1: 7 feet, 12 seconds, from 175°
Point 2: 2-3 feet, 12 seconds, from 220°
Point 3: 2 feet, 12 seconds, from 245°

Table 3-2. 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)

TARANTO POINT 1: Outside Outer Harbor Entrance 108 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	150° .9	155° .7	165° .5	175° .6	180° .6	185° .6
180°	180° 1.0	180° .9	185° .8	190° .7	195° .7	195° .7
210°	210° 1.0	210° .9	210° .8	205° .8	205° .7	205° .7
240°	240° 1.0	235° 1.0	230° .8	230° .8	225° .8	220° .9
270°	270° 1.0	265° .8	255° .6	250° .5	250° .5	245° .5
300°	280° .5	270° .5	265° .4	255° .4	245° .4	240° .4
330°	290° .4	285° .3	280° .2	265° .2	260° .2	250° .2

Table 3-2 (Continued).

TARANTO POINT 2: Central Outer Harbor 66 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	215° .4	215° .4	215° .3	220° .2	220° .2	220° .2
180°	215° .4	215° .4	215° .2	220° .2	220° .2	220° .2
210°	215° .5	215° .4	215° .4	220° .3	215° .3	215° .3
240°	225° .5	220° .4	220° .4	220° .3	220° .3	220° .2
270°	230° .3	225° .2	225° .2	220° .2	220° .2	220° .2
300°	230° .2	225° .2	225° .1	225° .1	220° .1	220° .1

TARANTO POINT 3: East Side of Outer Harbor 42 ft depth

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
150°	240° .2	240° .2	240° .15	245° .15	250° .1	260° .1
180°	240° .25	240° .2	240° .15	245° .15	250° .1	260° .1
210°	245° .35	250° .25	250° .2	250° .15	250° .15	260° .1
240°	235° .3	235° .2	240° .2	245° .15	250° .15	260° .1
270°	240° .2	240° .15	245° .15	250° .15	250° .15	260° .1
300°	240° .15	245° .15	250° .1	250° .1	260° .1	260° .1

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

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

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

10 feet, 10 seconds, from 240°

Expected shallow water conditions and duration:

	Point 1	Point 2
height	8 feet	4 feet
period	10 seconds	10 seconds
direction	from 230°	from 220°
duration	11 hours	14 hours

Interpretation of the information from Tables 3-2 and 3-3 provides 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 duration information provides insight as to how long before a change can be expected. The local wave direction information can be of use in selecting anchorage configuration and related small boat operations, including tending activities.

Table 3-3. 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 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

TARANTO POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	22	12	7	25
Average Duration (hr)	16	16	29	15
Period Max Energy (sec)	8-9	8-9	6-8	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	4	1	1	3
Average Duration (hr)	11	9	18	11
Period Max Energy (sec)	9	9-10	11-12	9

TARANTO POINT 2:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	5	3	0	4
Average Duration (hr)	14	10	NA	9
Period Max Energy (sec)	8	8	NA	8
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	<1	0	0	0
Average Duration (hr)	8	NA	NA	NA
Period Max Energy (sec)	9	NA	NA	NA

TARANTO PT 3

Deep water waves (swell) propagating into the outer harbor are not expected to reach Point 3 at heights greater than 3.3 ft (1 m). Note, however, that combined wind waves (sea) and swell can result in waves greater than 3.3 ft at Point 3. For example, if both swell and seas were 3 ft, the combined waves would exceed 4 ft ($\sqrt{3^2 + 3^2} \approx 4.2$ ft). This condition would be most likely under southwesterly flow where the open sea swell enters the harbor with minimum refraction, the fetch length within the harbor is maximum relative to Point 3, and the swell and sea waves direction are closely aligned.

Local wind wave conditions are provided in Table 3-4 for Taranto Harbor Points 1, 2, and 3. The time to reach the fetch limited height assumes an initial flat ocean. With a pre-existing wave height, the times are shorter.

Table 3-4. Taranto. Local wind waves for fetch limited conditions at Points 1, 2, and 3 (based on JONSWAP model).

Point 1.

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
W 15 n mi	2-3/4 2-3	3-4/4 2	4/5 2	5/5 2	6/5 2
SW 25 n mi	4/5 4	5/6 4	6/6 3-4	8/6-7 3-4	9/7 3-4
SSW 55 n mi	5/6 5	6/6-7 4-5	8/7 4-5	9-10/7-8 4-5	11/8 4-5

Points 2 & 3.

W 2 n mi	<2 ft	<2 ft	1-2/2 1	2/2-3 1	2/3 1
SW 3 n mi	<2 ft	<2 ft	2/3 1	2-3/3 1	3/3 1

Example: Small boat wave forecasts for Point 2
(based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)	Waves (Table 3-4)
prior to 0800 LST	light and variable	< 2 ft
0800 to 1300	SW 16-20 kt	< 2 ft
1300 to 1800	SW 28-32 kt	building to 2-3 ft at 3 sec by 1400
1800 to 2100	SW decreasing to less than 12 kt	< 2 ft

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations will become marginal by 1400 and remains so until after 1800.

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 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 with different motions to the diverse wave lengths present. The information on wave periods, provided in the previous tables, should be considered when forecasts are made for joint operations of various length vessels.

3.7 Protective/Mitigating Measures

As discussed in Sections 3.2 and 3.6 some ships are subject to dragging anchor and alongside or well deck operation may be hazardous in the outer harbor under strong wind situations. Protective and/or mitigating measures include use of a second anchor or moving to the more protected eastern side of the outer harbor. Small boat operations are likely to have to be cancelled during 40+ kt wind events. Winter time strong northerly wind events are quite frequent and tend to last for 4 or 5 days. However, the offshore northerly winds drop off to near calm at night and into early morning. Be aware of the tendency for the northeasterlies to commence with a sudden onset of 25+ kt around mid-morning. Scheduling wind critical operations/movements in early morning will likely reduce the hazards.

Highly variable and strong cross currents occur in the last 1000 yds of approach and within the canal. Strong winds will compound this problem. Med moored vessels in the inner harbor should consider moving to alongside berths when strong wind events are expected.

3.8 Indicators of Hazardous Weather Conditions

The strong wind events of Taranto all have well documented large scale circulation causative patterns. Close attention must be given to synoptic patterns particularly during the cold season when conditions are most variable and rapidly changing. All the strongest wind events are associated with cyclones, and in most cases migratory centers. Cyclogenesis in the Gulf of Genoa, Balearic Island area, over North Africa or any approaching migratory cyclone should be closely monitored. About the only local region cyclogenetic condition is when a southeastward running Genoa low stalls west of southern Italy and secondary lows form over the Ionian Sea. The 500 mb pattern should provide evidence of when this type of cyclogenetic event is likely. When the flow through the 500 mb trough is strong the surface low will most likely continue moving eastward. With diffluent flow east of the 500 mb trough or when a strong jet maximum has passed through the trough, cyclogenesis east of the trough is likely. In general cyclogenesis will always occur on the cold air side of the jetstream.

Several local and synoptic indicators of approaching high winds are severe weather conditions have been identified for the Taranto area.

3.8.1 Scirocco

Southerly Scirocco winds occur when Taranto is in the warm sector of a cyclone. A stricter definition would require the southerly flow to extend out of North Africa, but generally any strong southerly wind is locally referred to as a Scirocco. The synoptic indicators include: A deep 500 mb trough extending southward over North Africa with the trough line to the west of area of concern, plus being located in the warm sector of an approaching cyclone that has formed over North Africa or whose circulation extends from over North Africa. Lows that pass through the area, but without the southerly flow in their warm sector originating over the desert, do not cause true Scirocco conditions, hot and dusty near Africa, with development of a strong near surface inversion as the air moves northward over the relatively cooler water. As this surface layer increases in depth its moisture content increases, clouds form and the cloudy, drizzly weather of northern Mediterranean Sciroccos develops. Local indicators at Taranto of an approaching Scirocco include: rising water levels in the harbor, anomalously rising warm temperatures and increasing clouds from the south. Once under the influence of a Scirocco an indication of strong turbulence above the low level inversion is a "pumping" action shown in the pressure trace.

3.8.2 Bora

Bora winds reach Taranto as northeasterly flow across the land to the east from off the Adriatic. The basic Bora synoptic pattern has an intensive high pressure to the north over central Europe resulting in strong, cold, downslope wind along the coast of Yugoslavia. For a strong Bora to reach Taranto and southward into the Ionian Sea it usually requires the passage of a deep winter cyclone eastward across the Ionian Sea. The resulting steepened gradient between the high to the north and the low passing eastward to the south results in the maximum southward extent of the Bora wind regime. A local indicator of imminent onset of a Bora at Taranto is the formation of clouds over the low hills around the inner harbor. The clouds will persist for the duration of the Bora event.

3.8.3 Mistral

Large amplitude 500 mb flow is necessary for Mistral winds to reach Taranto. Typically this occurs with a strong eastern Atlantic blocking high and a deep trough over Europe and the central Mediterranean. Under this pattern a strong northwesterly jetstream will be found over France and the Gulf of Lion, giving further support for extensive southeastward extension of the Mistral. A southeastward movement of a Genoa low indicates the potential of both strong southerlies in advance of the low and northerlies following its passage. The following is an abbreviated list of Mistral guidelines adapted from Brody and Nestor (1980). For a more complete listing, refer to the Severe Weather Guide for Marseille (#7) or Toulon (#8), France or the original reference.

1. Causes

The Mistral is the result of a combination of the following factors:

(a) The basic circulation that creates a pressure gradient from west to east along the coast of southern France. This pressure gradient is normally associated with Genoa cyclogenesis.

(b) A wind increase over the open water resulting from the reduction in the braking effect of surface friction (as compared to the braking effect over land).

2. Onset

(a) Mistral onset in the Gulf of Lion occurs almost simultaneously with the formation of Genoa lows.

(b) If a 500 mb trough extends from central Europe southward over North Africa, a surface low from Algeria may propagate northward, intensify in the Gulf of Genoa, and initiate a Mistral.

(c) Wave clouds, such as observed on high-resolution Defense Meteorological Satellite Program (DMSP) satellite imagery, are observed over the Massif Central of southern France approximately 6 hours before the start of a Mistral.

3. Intensity

(a) Strongest winds associated with a Mistral do not occur until after the passage of the 500 mb trough. This usually occurs well after the surface cold frontal passage.

(b) Satellite observations indicating a strong Mistral will exhibit the following features: cloudy over France and clear over the water area south of the 1,000 ft water depth contour; clear over the Gulf of Lion except for a cloud mass parallel to the coast, lying 75-150 n mi offshore; and/or wispy cloud streaks extending from 315° to 360° into offshore clouds.

(c) Wave clouds extending from Sardinia to Tunisia, viewed on satellite imagery, are generally associated with gale force Mistral situations.

(d) If the 500 mb winds reported at either Bordeaux (07510) or Brest (07110) are northwesterly at 65 kt or greater, storm force winds are indicated for the Gulf of Lion.

(e) A difference in surface barometric pressure, with lower pressure to the east, between Perpignan (LFMP/07747), Marseille (LFML/07650) and Nice (LFMN/07690) will give a gauge as to Mistral intensity using the following table (Brody and Nestor, 1980); remembering Mistral winds are highly variable near the coast due to terrain effects:

Pressure Difference (mb)	Perpignan and Nice	Perpignan and Marseille	Marseille and Nice
3		30-35 kt	30-35 kt
4		40 kt	40 kt
5		45-50 kt	45-50 kt
6	30-35 kt		
8	40 kt		
10	45-50 kt		

Note: Higher pressure to west and lower pressure east.

4. Duration

(a) A strong Mistral may last for as many as 12 days without any important lulls. The most frequent length of an occurrence is about 3 1/2 days (Meteorological Office, Air Ministry, 1962).

(b) The Mistral will cease when the cyclonic regime at the surface gives way to an anticyclonic regime. Indications of this change include:

(1) The 500 mb ridge beginning to move over the Mistral area.

(2) High pressure at the surface begins to move into the western basin of the Mediterranean.

(3) There is a change that reduces the pressure difference between France and the western basin.

5. Associated Weather

Rain and violent squalls commonly accompany the cold front which precedes the Mistral. Where there is high ground sudden squalls can be expected in the lee during strong northwesterly winds.

3.9 Summary of Problems, Actions, and Indicators

Table 3-5 is intended to provide easy-to-use seasonal references for meteorologists on ships using the Port of Taranto. Table 2-1 (section 2) summarizes Table 3-5 and is intended primarily for use by ship captains.

Table 3-5. Potential problem situations at Port of Taranto, Italy -

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	
1. Anchored - Outer harbor. Occurs in Winter	a. SE'ly wind - Most hazardous conditions experienced at Taranto. Winds of 40-50 kt. Swell refracts into Outer harbor, results in swell nearly 90° out of phase with wind and wind waves.	a. Causes major disturbance to ships and traffic in outer harbor. Shallow draft/large sail area ships tend to drag anchor. Long period swell and short period wind waves cause different responses in various length vessels, alongside or well deck operations hazardous. Conditions better on eastern side of harbor. Consider deploying second anchor, moving to eastern side of harbor or if conditions permit through canal to inner harbor.	a. St fronts. Lows de high ov Mediter experie (Bora) souther prolong eastwar days), level and hi level a
Occurs in Winter late Autumn early Spring	b. NW'ly wind - Mistral events. Winds 30-40 kt. Only wave action is fetch limited wind waves generated inside harbor. Winter temperatures approach freezing, wind chill effects of concern.	b. Winds are strongest during daytime, light at night and may last for two or three days. Shallow draft/large sail area ships may drag anchor. Winter temperatures approach freezing and wind chill near 0°F. Delay daytime wind critical operations if possible. Beware of wind chill factor.	b. St when e and ce develo
Most likely in Spring Also in Autumn	c. SW'ly wind - Infrequent event during spring or fall. Open sea waves enter outer harbor. Maximum winds 30-40 kt during daytime, decrease after sunset.	c. High seas enter outer harbor through entrance. Maximum wind during daytime decreasing after sunset. Move to eastern side of harbor or to inner harbor.	c. St Genoa. Europe The tr
Occurs in Winter late Autumn early Spring	d. NE'ly wind - Frequent winter condition. Sudden daytime onset of 25+ kt wind. Strongest in daytime, light at night. Winter freezing temperatures, wind chill reaches 0 to -10°F. Light snow showers experienced a couple times a year (December, January, February).	d. Sudden onset of 25+ kt, most likely to occur during morning, can cause rapid swinging of ships and/or sudden hazardous conditions for operations in progress. Winter freezing temperatures and wind chill to -10°F with snow showers result in exposure problems for personnel. Winds become light at night but condition may persist for several days. Be aware of winter synoptic patterns that cause northeasterlies. Consider possible effects of sudden onset of winds. Prepare personnel for freezing temperature/wind chill.	d. St Winter the Ta strong the we precip hills
2. Arriving/Departing. OR Passage through Canal. Occurs in Winter	a. SE'ly wind - Most hazardous condition for arriving/departing or passage through canal. Swell refracts through entrance and into outer harbor as southwesterly waves which are nearly 90° out of phase with wind and wind waves.	a. Strong cross wind and seas out of phase with swell results in difficult ship handling. Problem compounded for canal transit due to narrow passage and restricted speed (6 kt). Be aware of conditions, adjust schedule if possible. Delay canal transit.	a. St fronts Lows d high o Medite experi (Bora) southe prolon eastwa days), level and hi level
Most likely in Spring Also in Autumn	b. SW'ly wind - Results in following/head wind and waves through entrance and canal.	b. Following or head strong winds and/or waves cause ship handling and/or ride problems. These events are of short duration and wind drops off after sunset. Use precautions or delay movement.	b. St Genoa. Europe The tr
Prevailing Condition Winter Late Autumn Early Spring	c. N'ly wind - All wave growth is fetch limited so wind is primary problem. Morning temperatures near freezing, wind chill may be near 0°F all day during winter.	c. Offshore northerly winds prevail during the cold season. Strong northerly winds are more frequent than southerly wind events. Sudden onset and cold gusty nature are the major problems. In winter watch for synoptic patterns that cause strong wind events and be prepared for winter conditions.	c. St Winter the Ta strong the we precip hills

ituations at Port of Taranto, Italy - ALL SEASONS

RECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
turbance to ships and traffic in outer harbor. area ships tend to drag anchor. Long period d wind waves cause different responses in various side or well deck operations hazardous. eastern side of harbor. Consider deploying to eastern side of harbor or if conditions to inner harbor.	a. Strong SE'lies (Scirocco) are associated with warm sector of migratory lows and fronts. The source of lows is generally the Gulf of Genoa or Balearic region. Lows develop following onset of Mistral in western Mediterranean. With blocking high over the eastern Atlantic and a deep trough over Europe and central Mediterranean, Genoa lows are likely to move SE'wrd into Ionian Sea. Taranto will experience SE'ly winds (Scirocco) while in the warm sector and north to NE''y (Bora) following eastward passage of low to south. When primary low stalls west of southern Italy and secondary lows form over Ionian Sea, Taranto experiences prolonged bad weather and alternating S'ly to N'ly winds as secondary lows move eastward. Scirocco events most frequent March through June. Periods of S'ly (2-5 days), not as strong as winter events, occur when Genoa lows move NE'wrd. Upper level trough typically over western Mediterranean, Atlantic blocking high absent and higher pressure over NE'ern Mediterranean region. Rising temperature and water level and falling pressure are indicators.
st during daytime, light at night and may last t. Shallow draft/large sail area ships may drag ratures approach freezing and wind chill near nd critical operations if possible. Beware of	b. Strong NW'lies (Mistral) occur during January and February. Reach Taranto area when eastern Atlantic blocking high is strong with deep 500 mb trough over Europe and central Mediterranean. Trough line will be over or east of Italy. A well developed NE'ly jetstream will be present over France and Gulf of Lion area.
ter harbor through entrance. Maximum wind sing after sunset. Move to eastern side of rbor.	c. Strong SW'lies (Libeicco) occur when migratory lows move NE'wd from Gulf of Genoa. Occurs with spring and autumn cyclogenesis when cold winter high over Europe is not well developed. Ridges and troughs at 500 mb have low amplitude. The trough will be located over western Europe.
kt, most likely to occur during morning, can ships and/or sudden hazardous conditions for Winter freezing temperatures and wind chill owers result in exposure problems for personnel. night but condition may persist for several ter synoptic patterns that cause north- possible effects of sudden onset of winds. freezing temperature/wind chill.	d. Strong NE'lies (Bora) follow eastward passage of cyclone across Ionian Sea. Winter anticyclone north of the Mediterranean results in prevailing N'ly winds in the Taranto area. Passage of cyclones to the south and east result in periods of strong gusty N'ly winds and squally weather. When the migratory lows approach from the west (Balearic region) or south (North Africa) the cloud cover and precipitation are more extensive than with Genoa lows. Belt of clouds form on hills north of inner harbor and last for duration of event.
and seas out of phase with swell results in g. Problem compounded for canal transit due to tricted speed (6 kt). Be aware of conditions, sible. Delay canal transit.	a. Strong SE'lies (Scirocco) are associated with warm sector of migratory lows and fronts. The source of lows is generally the Gulf of Genoa or Balearic region. Lows develop following onset of Mistral in western Mediterranean. With blocking high over the eastern Atlantic and a deep trough over Europe and central Mediterranean, Genoa lows are likely to move SE'wrd into Ionian Sea. Taranto will experience SE'ly winds (Scirocco) while in the warm sector and north to NE'ly (Bora) following eastward passage of low to south. When primary low stalls west of southern Italy and secondary lows form over Ionian Sea, Taranto experiences prolonged bad weather and alternating S'ly to N'ly winds as secondary lows move eastward. Scirocco events most frequent March through June. Periods of S'ly (2-5 days), not as strong as winter events, occur when Genoa lows move NE'wrd. Upper level trough typically over western Mediterranean, Atlantic blocking high absent and higher pressure over NE'ern Mediterranean region. Rising temperature and water level and falling pressure are indicators.
strong winds and/or waves cause ship handling hese events are of short duration and wind Use precautions or delay movement.	b. Strong SW'lies (Libeicco) occur when migratory lows move NE'wd from Gulf of Genoa. Occurs with spring and autumn cyclogenesis when cold winter high over Europe is not well developed. Ridges and troughs at 500 mb have low amplitude. The trough will be located over western Europe.
winds prevail during the cold season. Strong re frequent than southerly wind events. Sudden ature are the major problems. In winter watch that cause strong wind events and be prepared	c. Strong NE'lies (Bora) follow eastward passage of cyclone across Ionian Sea. Winter anticyclone north of the Mediterranean results in prevailing N'ly winds in the Taranto area. Passage of cyclones to the south and east result in periods of strong gusty N'ly winds and squally weather. When the migratory lows approach from the west (Balearic region) or south (North Africa) the cloud cover and precipitation are more extensive than with Genoa lows. Belt of clouds form on hills north of inner harbor and last for duration of event.

Table 3-5. (Continued)

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS	
3. Moored inner harbor. Autumn Winter Spring Rare in Summer	a. All high winds - Vessels normally Med moored, all strong winds are potential hazards.	a. Normally Med mooring is used. High winds may cause extreme strain on lines. Add lines or move to alongside berth. Be prepared for winter conditions.	a. fron Lows high Medi expe (Bor soutl prol east days leve and l leve b. when and deve c. Geno Euro The d. Wint the stro the prec hill
4. Small boat operations. Occurs in Winter (Dec, Jan, Feb)	a. SE'ly winds - Small boat operations generally cancelled during 4-5 strongest winter events. Out of phase swell, and wind and wind waves create extremely choppy confused wave conditions. Long period swell and short period wind waves cause added hazard for alongside or well deck operations between different length vessels.	a. During strong events high winds and rough choppy seas force cancelation of small boat operations in the outer harbor. Alongside or well deck operations will also be extremely hazardous due to interaction of two sets of out of phase waves, long period swell and short period local wind waves. Cancel operations during strong events.	a. fron Lows high Medi expe (Bor soutl prol east days leve and l leve
	b. SW'ly wind - Open sea waves enter outer harbor with limited refraction.	b. Open sea waves propagate into the outer harbor through the entrance under southwesterly wind conditions with little energy lost due to refraction (shoaling will reduce the wave heights). Moving to eastern side of outer harbor will result in further reduction of wave heights.	b. Geno Euro The

(A)

Table 3-5. (Continued)

PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
mooring is used. High winds may cause extreme Add lines or move to alongside berth. Be prepared tions.	a. Strong SE'lies (Scirocco) are associated with warm sector of migratory lows and fronts. The source of lows is generally the Gulf of Genoa or Balearic region. Lows develop following onset of Mistral in western Mediterranean. With blocking high over the eastern Atlantic and a deep trough over Europe and central Mediterranean, Genoa lows are likely to move SE'wrd into Ionian Sea. Taranto will experience SE'ly winds (Scirocco) while in the warm sector and north to NE'ly (Bora) following eastward passage of low to south. When primary low stalls west of southern Italy and secondary lows form over Ionian Sea, Taranto experiences prolonged bad weather and alternating S'ly to N'ly winds as secondary lows move eastward. Scirocco events most frequent March through June. Periods of S'ly (2-5 days), not as strong as winter events, occur when Genoa lows move NE'wrd. Upper level trough typically over western Mediterranean, Atlantic blocking high absent and higher pressure over NE'ern Mediterranean region. Rising temperature and water level and falling pressure are indicators.
	b. Strong NW'lies (Mistral) occur during January and February. Reach Taranto area when eastern Atlantic blocking high is strong with deep 500 mb trough over Europe and central Mediterranean. Trough line will be over or east of Italy. A well developed NE'ly jetstream will be present over France and Gulf of Lion area.
	c. Strong SW'lies (Libeicco) occur when migratory lows move NE'wd from Gulf of Genoa. Occurs with spring and autumn cyclogenesis when cold winter high over Europe is not well developed. Ridges and troughs at 500 mb have low amplitude. The trough will be located over western Europe.
	d. Strong NE'lies (Bora) follow eastward passage of cyclone across Ionian Sea. Winter anticyclone north of the Mediterranean results in prevailing N'ly winds in the Taranto area. Passage of cyclones to the south and east result in periods of strong gusty N'ly winds and squally weather. When the migratory lows approach from the west (Balearic region) or south (North Africa) the cloud cover and precipitation are more extensive than with Genoa lows. Belt of clouds form on hills north of inner harbor and last for duration of event.
e events high winds and rough choppy seas force ... boat operations in the outer harbor. Alongside rations will also be extremely hazardous due to ... sets of out of phase waves, long period swell and ... wind waves. Cancel operations during strong	a. Strong SE'lies (Scirocco) are associated with warm sector of migratory lows and fronts. The source of lows is generally the Gulf of Genoa or Balearic region. Lows develop following onset of Mistral in western Mediterranean. With blocking high over the eastern Atlantic and a deep trough over Europe and central Mediterranean, Genoa lows are likely to move SE'wrd into Ionian Sea. Taranto will experience SE'ly winds (Scirocco) while in the warm sector and north to NE'ly (Bora) following eastward passage of low to south. When primary low stalls west of southern Italy and secondary lows form over Ionian Sea, Taranto experiences prolonged bad weather and alternating S'ly to N'ly winds as secondary lows move eastward. Scirocco events most frequent March through June. Periods of S'ly (2-5 days), not as strong as winter events, occur when Genoa lows move NE'wrd. Upper level trough typically over western Mediterranean, Atlantic blocking high absent and higher pressure over NE'ern Mediterranean region. Rising temperature and water level and falling pressure are indicators.
... propagate into the outer harbor through the ...thwesterly wind conditions with little energy lost h (shoaling will reduce the wave heights). Moving to ...ter harbor will result in further reduction of wave	b. Strong SW'lies (Libeicco) occur when migratory lows move NE'wd from Gulf of Genoa. Occurs with spring and autumn cyclogenesis when cold winter high over Europe is not well developed. Ridges and troughs at 500 mb have low amplitude. The trough will be located over western Europe.

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Port Visit Information

May 1988: NOARL Meteorologists R. Fett and D. Perryman met with Chief Pilot Augusto De Bellis to obtain much of the information included in this report.

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* Formerly the Naval Environmental Prediction Research Facility.

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 spectrum 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), SEA conditions prevail. If the spectrum covers a narrow range of frequencie and directions (long crested conditions), SWELL 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 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).

$$\bar{T} = 0.285v \qquad (1.2)$$

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

$$\bar{L} = 3.41\ \bar{T}^2 \qquad (1.3)$$

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:

$$\bar{L} = .67\text{"L"} \qquad (1.4)$$

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 Depth 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 there 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.

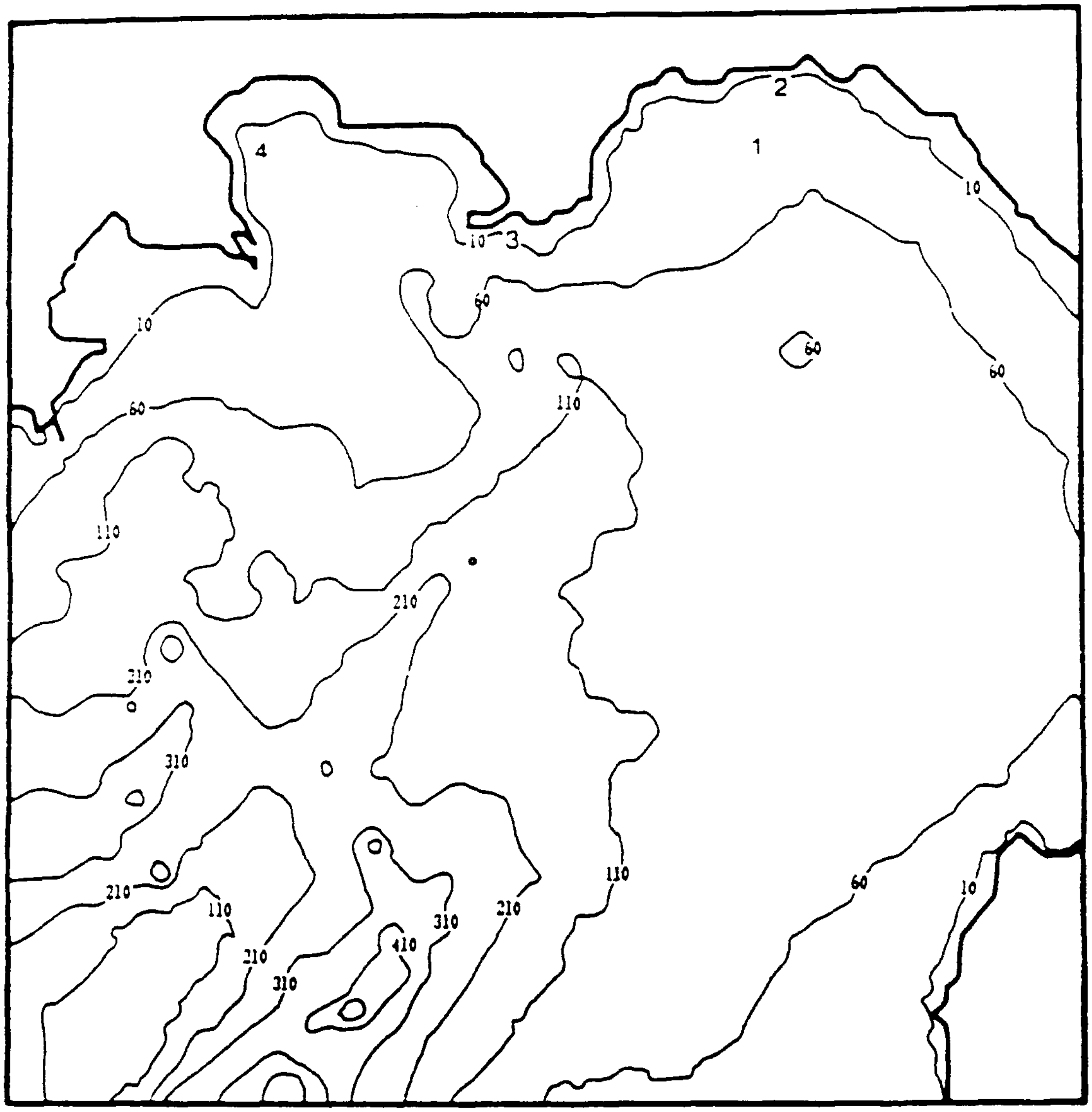

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathom contour. The larger size numbers identify specific anchorage areas addressed in the harbor study.

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R.E. Englebretson and R.D. Gilmore (SAIC)
D.C. Perryman (NOARL)

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Naval Oceanographic and Atmospheric Research Laboratory,
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This handbook for the port of Taranto, 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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