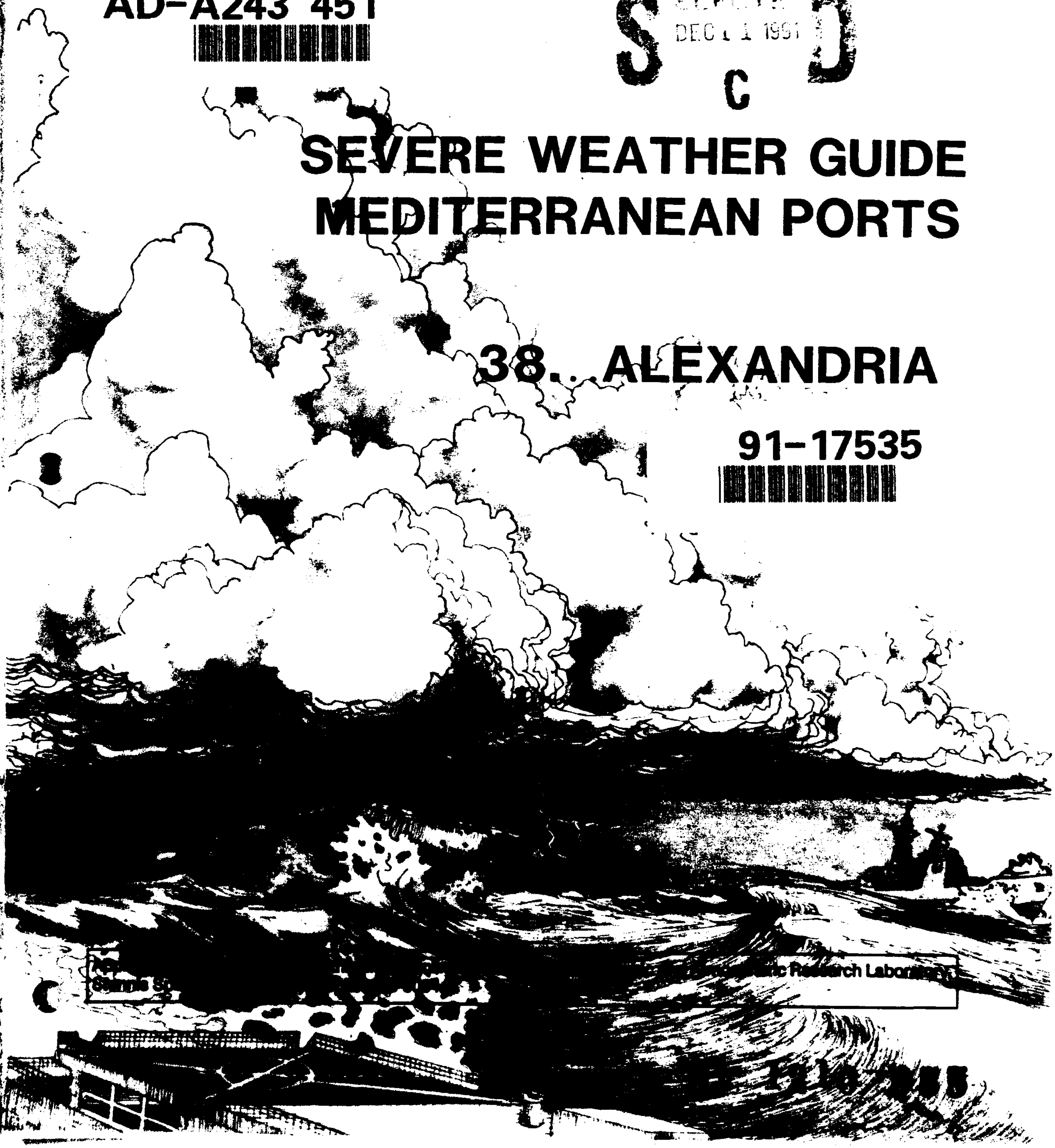
Naval Oceanographic and
Atmospheric Research Laboratory

Technical Note 114
June 1991

SEVERE WEATHER GUIDE
MEDITERRANEAN PORTS

38. ALEXANDRIA



ABSTRACT

This handbook for the port of Alexandria, 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.

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.

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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.

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
40	BIZERTE, TUNISIA
41	TUNIS, TUNISIA
42	SOUSSE, TUNISIA
43	SFAX, TUNISIA
44	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 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 NOARLW personnel; considerable information was 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 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 precautionary/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 Alexandria, Egypt (31°10'N 29°50'E) is located on the western extremity of the Nile River Delta. By sea it is about 150 n mi west of the Port of Said and entrance to the Suez Canal (Figure 2-1).

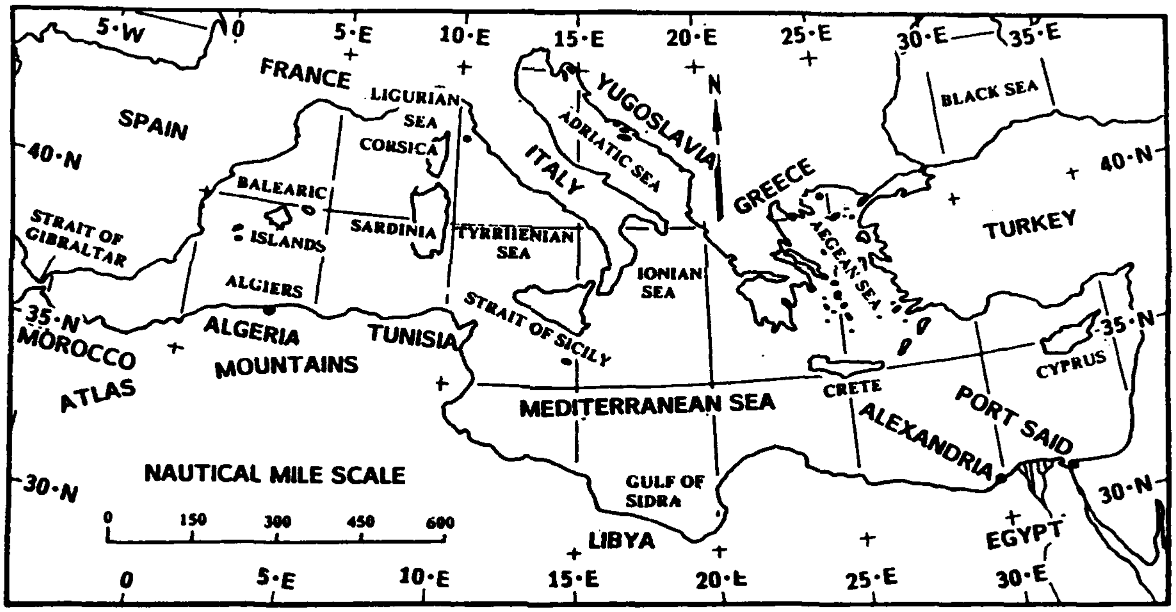

Figure 2-1. Mediterranean Sea

Alexandria is the largest seaport in Egypt. It is situated on a narrow strip of land between Lake Maryut and the Mediterranean Sea (Figure 2-2). There are two natural harbors, known as the East and West Harbors, located either side of a half-mile-wide isthmus that extends northwestward from the coast. The coastal area in the vicinity of Alexandria is very flat and featureless. The depth soundings decrease gradually towards the land. Due to the numerous shoals, land should not be approached to a depth of less than 20 fathoms (36 m) except in defined entrance passes. The Big Channel (Great Pass) is the principal channel through the reefs used for entrance to the West Harbor. The channel has a minimum width of 200 yds and can only be transited by one vessel at a time.

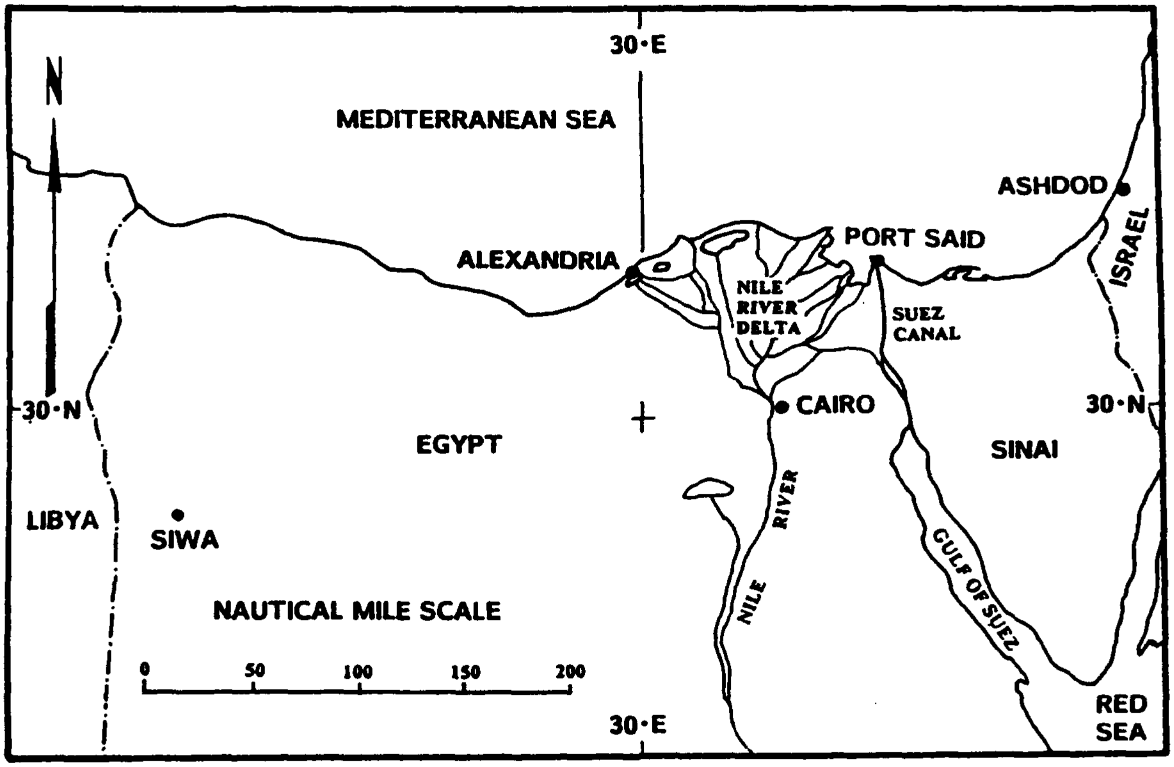

Figure 2-2. Northern Egypt and adjacent waters.

Alexandria is a sheltered harbor with a large quay wall extending the length of the Harbor (Figure 2-3). Wave conditions are limited to 2 ft (<1 m) in both the East and West Harbors. All the Alexandria harbor areas are crowded with numerous vessels at anchor throughout the approach sectors as well as within the harbors. Heavy traffic is a normal condition and local masters are very aggressive in close quarter maneuvering.

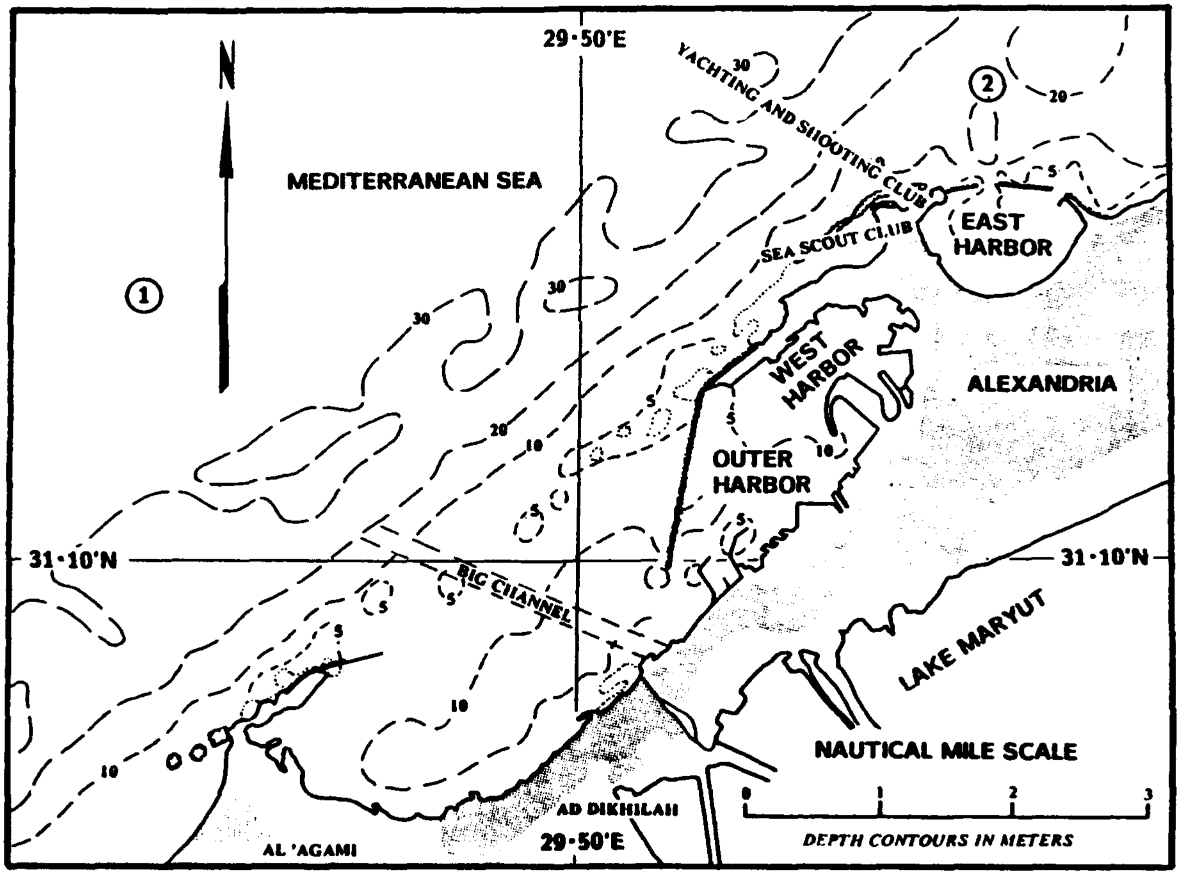

Figure 2-3. Port of Alexandria, Egypt.

The West Harbor is used by deep draft vessels. It consists of an outer and inner harbor. U.S. Navy vessels are normally berthed at the Arsenal quay in the inner harbor (FICEURLANT, 1987). The outer harbor provides several well protected free-swinging berths as well as numerous mooring buoys. Slightly less protected anchorages, but still inside the protecting reef zone, are also available southwest of the outer harbor entry.

An anchorage outside the East Harbor entrance is exposed to seaward. Fleet Landings are located inside the East Harbor at the Sea Scout Club and at the Yacht and Shooting Club (Visit Report, 1989).

Holding is considered good throughout the area in sand and mud. Tides are negligible and there is little or no current in the harbors (Hydrographic Department, 1961).

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

Table 2.1. Summary of hazardous environ

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VI SI
1. <u>Strong wind from the NW</u> - Occurs following frontal passage and/or on backside of migratory lows. * Strongest in winter, occurs in autumn and spring. * Winds of 30 to 40 kts for 12 to 18 hrs. * Winds of 20 to 30 kts may persist for 2 or 3 days when migrating low stalls in north- east Mediterranean. * Waves up to 15-17 ft (5 m) during strongest storms, 6-10 ft (3-4 m) often persist for several days. * Likely to be accompanied by showery weather. * Typically preceded by strong southerly winds (Khamsin).	<u>Advance Warning</u> * North African Depression (low) forms east of Atlas Mountains. * Depression/low/front approaching from the west. * Cirrus clouds advance from the west. * Local pressure starts to fall. * Winds veer to east, then south and southwest and increases in speed as front approaches. <u>Duration</u> * 12 to 18 hrs with normal winter migratory low. * 2 or 3 days when low stalls over northeast Mediterranean.	((2 ((4

rdous environmental conditions for Alexandria, Egypt.

	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
sion Atlas : west. ce from	(1) Moored in West Harbor	(a) <u>The West Harbor provides total protection from waves, but little protection from the wind.</u> * Buoy moored vessels may swing into fairway. * Berthings likely to require assistance.
s to then and in- front	(2) Anchored Outside Shoal Area	(a) <u>The anchorages provide no protection from NW winds/waves</u>. * Wave energy spread over wide range of periods (up to 18-20 seconds). * Causes additional hazards in alongside/well deck operations involving various length vessels. * Sortie to open ocean may be prudent action.
ormal v. v stalls	(3) Arriving/ Departing	(a) <u>Navigation hazardous in crowded harbor.</u> * Standard procedure is to close entry channel when winds exceed 20 kts and/or open sea waves are greater than 8 ft (2.5 m). * Principal entrance to West Harbor is narrow limiting transit to one vessel at a time. * Congested traffic, aggressive maneuvering by local seamen, anchored vessels fouling channels and swinging at anchor, local custom of close berthing and difficulty in making visual bearings due to traffic and flat terrain make for difficult navigation at best.
	(4) Small Boat Operations (a) Outside Shoal Areas	(a) <u>Small boat operations normally canceled.</u> * Small boat rigging should be to lee of large vessels. * Summertime sea breezes produce choppy conditions outside shoal area. * Wide range of wave periods and various length vessel responses are additional hazard for small craft alongside operations in areas outside shoal areas.
	(b) East Harbor Fleet Landings	(b) <u>Rocky shoals and minimum freeboard</u>. * Numerous rocks within 3 ft (1 m) of surface. * About 2 ft (<1 m) freeboard at Sea Scout Club seawall/Fleet Landing. Recommend use of fenders and/or floating barge for berthing.

Table 2.1 (c

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD
2. <u>Strong wind from the south</u> - Locally known as "Khamsin". * Occurs late winter early spring, strongest March and April. * Maximum wind 25 to 35 kts, increasing as they veer from east through southwest. * Average duration a day or less in February, increases to 3 to 4 days in March/April, more than 5 days rare. * Brings hot, dry, dusty conditions. * Anomalous propagation, markedly reduced radar and radio ranges, strong mirages. * Typically followed by strong northwest winds.	<u>Advance Warning</u> * North African Depression (low) forms east of Atlas Mountains. * Depression moves eastwarc pressure falling over eas ern Libya/western Egypt. * Cirrus clouds advance fr the west. * Local pressure starts to fall. * Northerly winds veering t east. * Rapid rise in tempera- ture/drop in humidity. <u>Duration</u> * Average duration increas from a day in February t or 4 days in March and April. * Wind veers to southwest increases as front approaches. * Rapid drop in temperatur increase in humidity, an end of blowing dust mark frontal passage and end Khamsin.

Table 2.1 (continued)

OF AZARD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
Depression st of Atlas es eastward, ng over east-	(1) Moored in West Harbor	(a) <u>The harbor provides little protection from high winds.</u> * Unstable buoy moorings may allow vessels to swing into fairway. * Berthing will require tug assistance.
ern Egypt. advance from starts to s veering to tempera- umidity.	(2) Anchored Outside Shoal Areas	(a) <u>Problems related to wind effects and reduced visibility, radar and radio ranges.</u> * Advisable to use extra anchor to reduce swinging. * Secure vessel and use top side covers to protect from dust penetration. * Anticipate limited radar/radio propagation ranges. * Be aware of inaccurate visual ranges due to mirages.
on increases February to 3 arch and southwest and ront temperature, midity, and dust marks e and end of	(3) Arriving/ Departing	(a) <u>Navigation hazardous in crowded harbor.</u> * Standard procedure is to close entry channel when winds exceed 20 kts and/or open sea waves are greater than 8 ft (2.5 m). * Principal entrance to West Harbor is narrow limiting transit to one vessel at a time. * Congested traffic, aggressive maneuvering by local seamen, anchored vessels fouling channels and swinging at anchor, local custom of close berthing and difficulty in making visual bearings due to traffic and flat terrain make for difficult navigation at best. * Limited radar/radio ranges and questionable visual ranges due to mirage effects. * Visibility reduced in blowing sand and dust.
	(4) Small Boat Operations	(a) <u>Minimal wave heights with offshore flow.</u> * Visibility reduced in blowing sand and dust.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

Winter (November through March)

* Northwesterly winds and waves. Associated with migratory cyclones and fronts approaching from the west over water. Winds 30 to 40 kt, waves 13 to 17 ft. Extreme conditions usually last less than a day. Most frequent December through February.

* Persistent long period swell. Results from prevailing NW'ly winds over eastern Mediterranean. Swell of 8 to 12 ft at 14 to 18 second periods may persist for several days.

* Southeasterly winds (Khamsin). Late winter SE'ly 25 to 35 kt in advance of African depressions. Increasing in frequency and duration through late winter into early spring. Averages 1 event lasting 24 hr in January to 3 events lasting 3 or 4 days each by March. Brings very hot and dry weather, strongest events likely to cause violent dust storms.

SPRING (April-May)

* Southeasterly winds (Khamsin). Most intense and most frequent through April. Violent dust storms accompany strong events. Seldom occurs after May.

SUMMER (June-September)

* Coastal weather is mild under prevailing regional N'ly winds which are enhanced by the sea breeze. Anchorages and approaches outside the reefs tend to be choppy throughout the day.

* Wave energy spread over wide range of periods. Regional N'ly wind produces long period swell, local sea breeze enhancement produces short period sea, results are additional hazards for alongside/well-deck operations outside reef zone/breakwaters.

AUTUMN (October)

* Northwesterly wind and waves. Typical Mediterranean marked change from summer to winter generally occurs in late October, early cold season storms generally moderate in strength.

REFERENCES

FICEURLANT, 1987: Port Directory for Alexandria (1987), Egypt. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

Hydrographic Department, 1961: Mediterranean Pilot, Volume V. Published by the Hydrographic Department, under the authority of the Lords Commissioners of the Admiralty, London.

PORT VISIT INFORMATION

January 1989. NOARL meteorologists R. Fett and D. Perryman met with Port Authority Officers Admiral Hamdy Mahdy and Mr. Atif Maroni and U.S. Navy husbanding agent Captain Abdel Rahman Awwa to obtain much of the information used in this port evaluation.

3. GENERAL INFORMATION

This section is intended for Fleet meteorologists/oceanographers and staff planners. Section 3.5 includes a general discussion of hazards and Table 3-1 provides a summary of vessel locations/situations, potential hazards, effect-precautionary/evasive actions, and advance indicators and other information by season.

3.1 Geographic Location

The Port of Alexandria, Egypt (31°10'N 29°50'E) is located on the western extremity of the Nile River Delta. The Port is about 150 nmi west, by sea, of the entrance to the Suez Canal and Said (Figure 3-1).

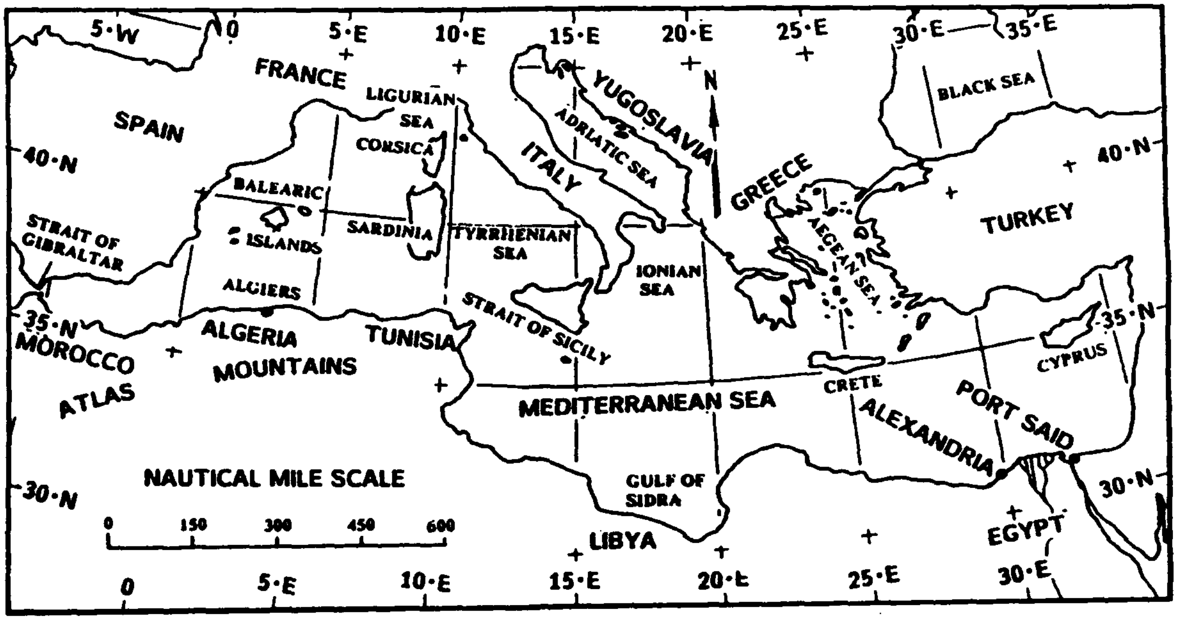

Figure 3-1. Mediterranean Sea.

Alexandria is the largest seaport in Egypt. It is situated on a narrow strip of land between Lake Maryut and the Mediterranean Sea (Figure 3-2). There are two natural harbors, known as the East and West Harbors, located either side of a half-mile-wide northwestward extending isthmus. The coastal area in the vicinity of Alexandria is very flat and featureless and the coastline is nearly straight. The depth soundings decrease gradually towards land. Due to the numerous shoals, land should not be approached to a depth of less than 20 fathoms (36 m) except in defined entrance passes. The Great Pass is the principal channel through the reefs used for entrance to the West Harbor. The channel has a minimum width of 200 yds (182 m) and can only be transited by one vessel at a time.

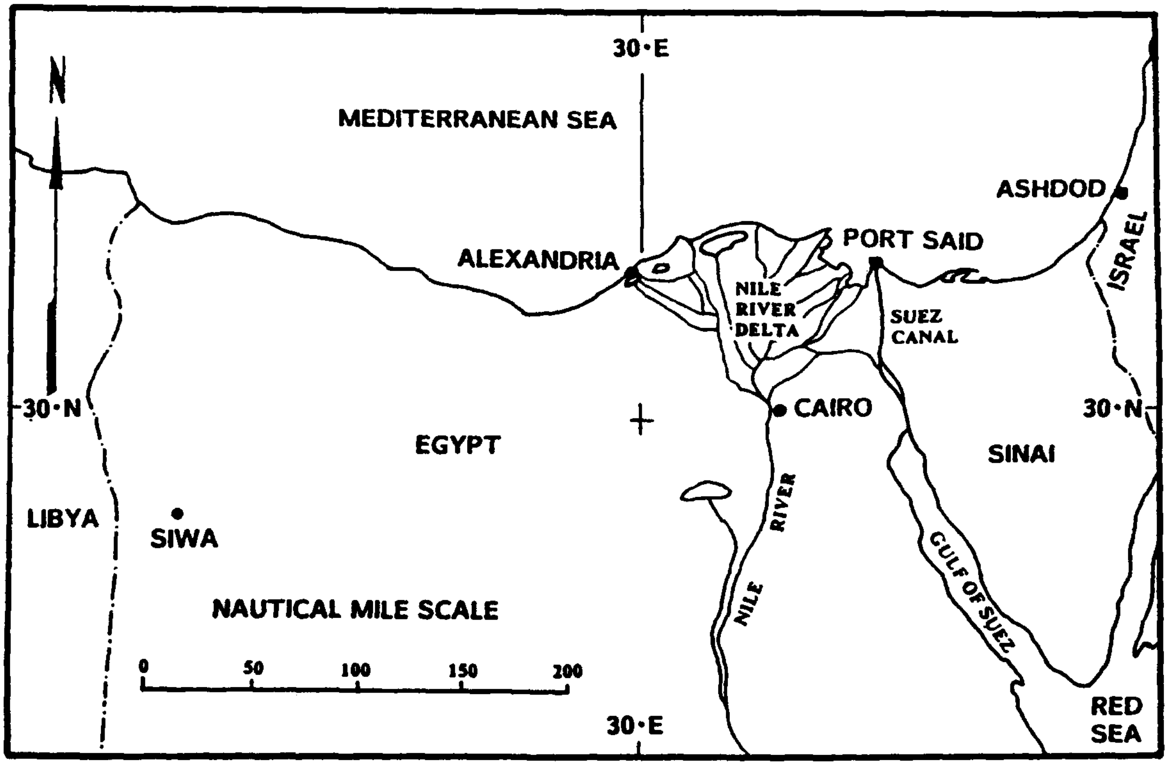

Figure 3-2. Northern Egypt and adjacent waters.

Alexandria is a sheltered harbor with a large quay wall extending the length of the Harbor (Figure 3-3). Both the East and West Harbors are crowded with numerous vessels at anchor throughout the approach sectors as well as within the harbors. Heavy traffic is a normal condition and local masters are very aggressive in close quarter maneuvering.

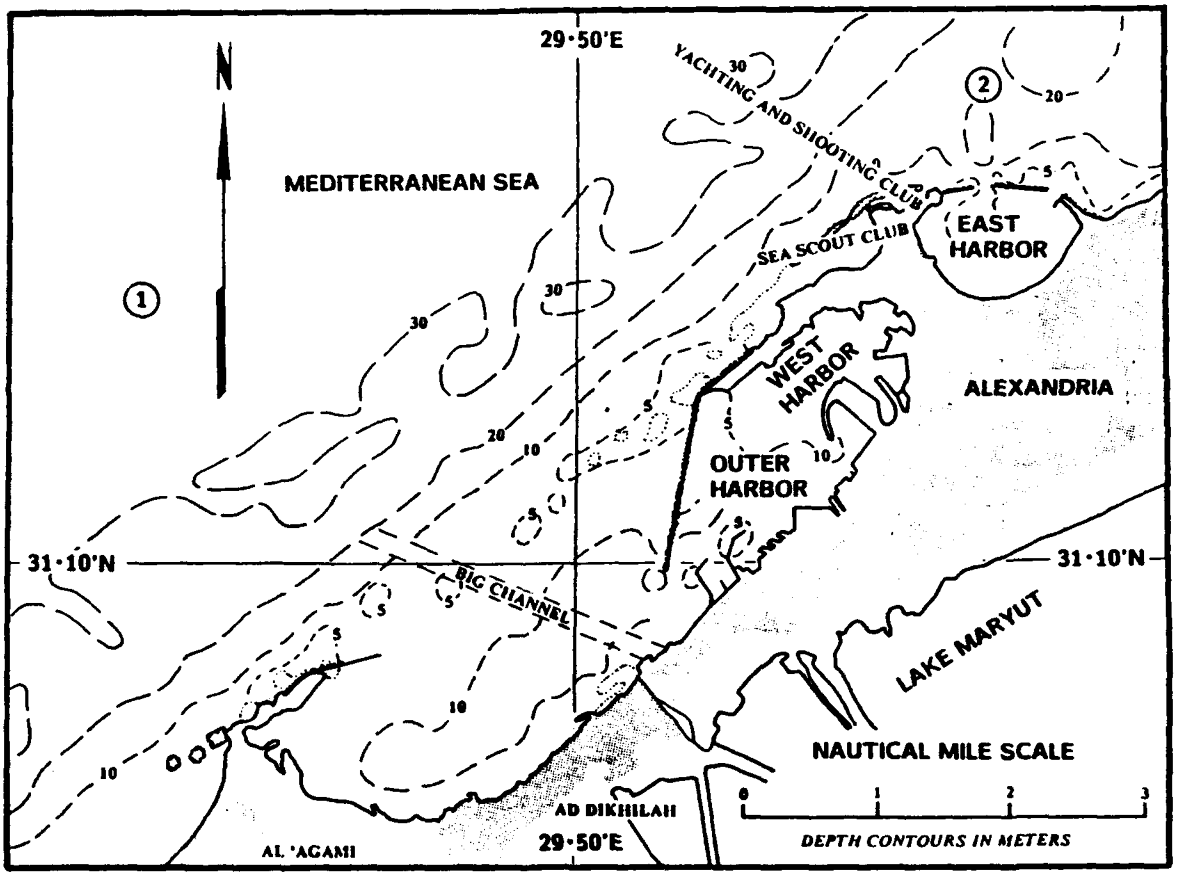

Figure 3-3. Port of Alexandria, Egypt.

The West Harbor is used by deep draft vessels. It consists of outer and inner harbors. U.S. Navy vessels are normally berthed at the Arsenal quay within the inner harbor (FICEURLANT, 1987). The outer harbor provides several well protected free-swinging berths as well as numerous mooring buoys. Wave conditions are limited to 2 ft (<1 m) in both the East and West Harbors. Less protected anchorages are available to the southwest of the outer harbor entry, but still inside the protecting reef zone.

An anchorage outside the East Harbor entrance is exposed to seaward. Fleet landings are located inside the East Harbor at the Sea Scout Club and at the Yacht and Shooting Club (Visit Report, 1989). Numerous rocks exist at 3 ft (1 m) or less below the water, especially in the proximity of the Sea Scout Club, and present a clear hazard to navigation (FICEURLAND, 1987). Any appreciable swell can cause a heavy toll on screws.

3.2 Qualitative Evaluation of the Port of Alexandria

Alexandria is a crowded port with numerous anchored vessels and congested traffic. Local masters are aggressive in close maneuvering. The harbors are well protected from wave action by a large quay wall. Wave heights are limited to a maximum of 2 ft (<1 m) inside the harbors. The deep draft vessel entrance to the West Harbor is via the narrow Great Pass which runs through a dangerous shoal area. Traffic is limited to one vessel at a time. A number of wrecks can be seen on the reef either side of the Great Pass.

Small boats using the Fleet Landings or other berths in the East Harbor should be aware of the numerous rocks within 3 ft (1 m) of the surface. This is especially a problem near the Sea Scout Club seawall. This seawall, having only about 2 ft (<1 m) of freeboard also presents the hazard of potential hull damage during even minimal wave action. Precaution should be exercised through use of fenders and/or a floating barge.

3.3 Currents and Tides

The Port Directory for Alexandria (FICEURLANT, 1987) states that tidal variation is negligible, and there is little or no current in the harbor.

3.4 Visibility

During typical late winter and spring strong southerly wind events (Khamsins) dust will reduce visibility to 3 or 4 miles. During highest wind periods visibility may be reduced to 100 m. Markedly reduced day time slant range visibility, development of mirages and anomalous restrictions of radar and radio ranges are also typical during Khamsin events (Meteorological Officer, 1962). Fog will reduce visibility to less than a mile during a few summer mornings.

3.5 Hazardous Conditions

The Port of Alexandria has a congested, but well sheltered harbor. Gradually changing water depths and numerous shoals coupled with a narrow extended entrance makes approach and entry extra hazardous. The port closes to traffic when winds are over 20 kts and/or seas are over 8-9 ft (2.5 m) Port closure threats or actual closures occur approximately 15 times a year, most always during winter. Additional navigational hazards result from poor radar and visual features due to the flat featureless shoreline with conditions further complicated during Khamsin events by visibility restrictions, anomalous radar/radio ranges and marked mirage effects.

Alexandria experiences two rather well defined seasons with short transition periods (FICEURLANT, 1987). The winter or "rainy" season lasts from November through February. The spring transition during March and April are referred to as the Khamsin. Summer conditions persist from May through September, with a short autumn transition in October through early November.

The most hazardous weather conditions occur in winter when low pressure systems or frontal systems pass through the area. Northwesterly winds of 25 to 40 kts follow the passage of winter cyclones and/or frontal systems and may persist for several days when the migratory system stalls over the eastern Mediterranean region. The strong and persistent wind events result in waves building to 12 to 15 ft (3.5 to 4.5 m) seaward of the shoal areas and at the anchorage outside the East Harbor entrance.

During the spring transition period of March and April east to eastsouth winds (Khamsin) prevail. During the strongest Khamsin events (25-35 kt), which may last for several days, significant dust will be raised. Visibility will generally be reduced to 3 to 4 miles and on a couple of days there will be periods of a few hours with reduction to 100 meters. Coastal area temperatures of 105 to 110°F (41-43°C) are reached during strong Khamsin events.

A seasonal summary of various environmental conditions that are typical of the Alexandria area follows:

A. Winter (Late November through February)

The passage of winter migratory midlatitude cyclones and fronts result in variable wind directions and nearly all the regions rainfall. Winds are generally south to southwest, averaging 10 kts. Temperatures are mild ranging from high 60's in daytime to low 50's at night. Skies are partly cloudy. The most hazardous conditions occur following frontal passages when strong northwesterly winds (25 to 40 kt) and high seas (13-17 ft) may persist for several days. This region of the Mediterranean Sea experiences longer period swell than in the western Mediterranean. Swell of 16 to 18 second periods cause greater response for longer vessels. Shorter period waves, which cause maximum response in shorter vessels, will also exist during strong local wind conditions. Therefore, alongside or well deck operations can be additionally hazardous due to differences in response by different length vessels.

B. Spring (March and April)

The Khamsin period, winter to summer transition, lasts for about 50 days. Offshore flow, east to southeast winds prevail. Strong events (25-35 kt) may last for several days during which dust will be raised reducing general visibility to 3 to 4 n mi and at times to less than 100 m. This is the hottest period along the coast with maximum temperature reaching 105-110°F (41 to 43°C). The strongest events are associated with North African depressions which form east of the Atlas Mountains and move eastward over land during the spring season rather than the over water route of winter. Hazards in addition to normal wind and reduced visibility include: dust penetration, limited radio/radar ranges and strong mirages. Low level wind shear through the strong surface based temperature inversion creates a flight hazard.

C. Summer (May through September)

Summer months experience minimum cloud cover, rain is extremely rare, northerly winds of 8-14 kt prevail, and temperatures are mild. At times the sea breeze will reinforce the gradient winds to produce 20-30 kt coastal winds. Small boat operations become marginal and the wide range of wave periods can make alongside/well deck operations additionally hazardous. Fog reduces morning visibility on a few days during summer. The sea breeze keeps temperatures moderate with highs reaching the upper 80°'s F (upper 20°'s C) and lows in lower 70°'s F (lower 20°'s C). A few miles inland, beyond the sea breeze influence, daytime temperatures typically exceed 120°F (39°C).

D. Autumn (October and early November)

The summer to winter transition is less dramatic and delayed a few weeks from the western and central Mediterranean regions. Generally there are no weather hazards during this period. Land/sea thermal contrast related winds decrease in speed and migratory baroclinic systems have not yet begun to develop.

3.6 Harbor Protection

Alexandria harbor has large quay walls protecting the total harbor complex. In addition, extensive shoaling exists along this sector of the coast and in general provides protection from the open sea waves. Anchorages outside the shoals and entrances through the shoals are fully exposed and hazardous during high wind/wave events. The congested traffic, aggressive close quarter maneuvering, anchored vessels fouling channels and swinging at anchor, close berthing customs, and difficulty in making visual bearings due to traffic make for difficult maneuvering, at best, in Alexandria Harbor.

3.6.1 Wind and Weather

The Port of Alexandria is exposed to all winds. Blowing dust and reduced visibility during the Khamsin season is particularly hazardous due to the congested harbor conditions. Wintertime northwesterlies are the strongest winds experienced. During light to moderate Khamsin events (spring transition) the onshore sea breeze may cancel the offshore Khamsin resulting in near calm conditions along the coast.

3.6.2 Waves

The West Harbor is protected from wave action by the extensive offshore shoaling and the large quay wall. Wave heights within the West Harbor are limited to about 2 ft (<1 m) in the outer harbor and even less in the inner harbor. There is a less protected anchorage area just southwest of the outer harbor. Although this anchorage is not as well protected as the outer harbor anchorages, it does not experience high waves due to the shoal area to seaward.

The East Harbor is also protected by a quay but there is an opening in the shoal zone to seaward. As a result some open sea wave energy enters the shallow East Harbor and results in wave heights to 3 ft (1 m). Due to the numerous submerged rocks, within a foot of the surface, any wave action in the East Harbor can create hazardous operations for small craft.

All anchorage areas outside the shoal zone are exposed to open sea waves. Winter wave heights can reach 12 to 15 ft. Summer wave conditions can be a problem for small craft and for alongside and/or well deck operations. Prevailing northerly winds of 8 to 14 kt over the entire eastern Mediterranean result in long period swell of 3 to 6 ft (1-2 m) height. When reinforced by the sea breeze local coastal winds may reach 25 to 30 kts and generate 5 to 6 ft shorter period wind waves superimposed on the swell. The combined heights of 5 to 8 ft will limit small boat operations outside the shoal zone. The resulting long and short wave lengths will result in differential movement, vessel response, by different length vessels and will make alongside and well deck operations additionally hazardous.

The inner and outer harbors of the West Harbor are protected from open ocean waves by breakwaters and extensive shoals. The area to the southwest of the outer harbor, but inside the shoals, is protected from swell but does experience choppy 3-5 ft waves during winter storm conditions. The waiting area outside the shoals is fully exposed to open ocean swell and sea conditions. Approach to the West Harbor entrance via the channel through the shoal area is secured about 15 times each winter due to northwesterly winds over 20 kt and/or seas over 7-8 ft (2½ m).

Winter storms with strong westerly to northerly winds of 30-40 kt can result in significant wave heights of 13-17 ft (4-5 m). Long period swell of 16-18 seconds is also experienced during winter storms. Because of the fully exposed conditions of the waiting area outside the channel ships are advised to sortie to the open ocean during winter storm conditions. There are no bays or deep anchorage areas in this region that are protected from westerly or northerly winds and waves.

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

<u>Example: Use of Table 3-1</u>.

For a <u>deep water</u> wave condition of 12 feet, 12 seconds, from 300°, the approximate shallow water wave conditions are:

<u>Point 1:</u> 11 feet, 12 seconds, from 305°
<u>Point 2:</u> 13 feet, 12 seconds, from 315°

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)

ALEXANDRIA POINT 1: Outside West Harbor Depth 120 ft

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
240°	240° 1.0	245° .9	250° .9	260° .7	265° .7	265° .6
270°	270° 1.0	270° .9	275° .9	280° 1.0	280° .8	285° .8
300°	300° 1.0	300° 1.0	305° 1.0	305° .9	310° .7	310° .7
330°	330° 1.0	330° 1.0	330° .9	330° .9	330° .8	330° .9
360°	360° 1.0	360° 1.0	355° .9	355° .8	350° .9	350° .9
030°	030° 1.0	030° .9	020° .6	015° .6	010° .5	005° .5
060°	060° .7	050° .9	045° .6	030° .4	020° .4	015° .3

ALEXANDRIA POINT 2: East Harbor Entrance Depth 55 ft

Period (sec)	6	8	10	12	14	16
Deep Water Direction	Shallow Water Direction and Height Ratio					
240°	255° .7	270° .9	280° 1.0	295° 1.0	300° .9	290° 1.0
270°	270° .8	280° 1.1	300° 1.0	295° 1.0	300° 1.0	300° 1.0
300°	310° 1.1	310° 1.2	320° .9	315° 1.1	320° 1.1	325° 1.1
330°	335° .9	335° .8	335° .9	335° .9	335° 1.0	340° 1.1
360°	005° 1.0	360° 1.1	360° .9	350° .6	350° .7	355° 1.0
030°	035° .7	030° 1.0	010° .7	015° .6	005° 1.0	010° 1.0
060°	050° .8	045° .8	035° .4	035° .6	025° .8	015° .4

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 resulting from the propagation of deep water waves into the area 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 3-2 and 3-3.

The forecast for wave conditions tomorrow (winter case) outside the harbor are:
8 feet, 10 seconds, from 330°

Expected shallow water conditions and duration:

	Point 1	Point 2
Height	7 feet	7 feet
Period	10 seconds	10 seconds
Direction	from 330°	from 335°
Duration	12 hours	13 hours

Interpretation of the information from Tables 3-1 and 3-2 provides guidance on the local wave conditions expected tomorrow at the various area 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 include 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 3-2. 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 ft (1 m) and greater than 6.6 ft (2 m) by climatological season.

ALEXANDRIA POINT 1:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	48	23	37	15
Average Duration (hr)	17	17	21	15
Period Max Energy (sec)	8	9	9	8-9
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	21	3	6	2
Average Duration (hr)	12	10	14	12
Period Max Energy (sec)	11	10	11	10
ALEXANDRIA POINT 2:	WINTER	SPRING	SUMMER	AUTUMN
>3.3 ft (1 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	49	25	36	14
Average Duration (hr)	16	17	20	14
Period Max Energy (sec)	8	9	8-9	8-9
>6.6 ft (2 m)	NOV-APR	MAY	JUN-SEP	OCT
Occurrence (%)	22	4	6	2
Average Duration (hr)	13	11	15	11
Period Max Energy (sec)	11	11	9	11

Local wind wave conditions are provided in Table 3-3. Because of the nearly straight coastline in this area there are no specific fetches that can be defined. Table 3-3 provides wind waves for a range of fetch lengths and wind speeds. 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. Alexandria. Local wind waves for fetch limited conditions (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
5	<2 ft	2/3-4 1	2-3/3-4 1	3/3-4 1-2	3-4/3-4 1
10	2/3-4 1-2	3/3-4 2	3-4/4 2	4/4-5 1-2	5/5 1-2
15	2-3/4 2	3-4/4 2	4/4-5 2	5/5 2	6/5 2
20	3/4-5 2-3	4/4-5 3	5/5 3	6/5-6 3-4	7/5-6 3
25	3-4/4-5 3	4/5 3	5-6/5 3	6-7/6 3	7-8/6 3
30	4/4-5 [illegible]	5/5-6 4	6/6 3-4	7/6 3-4	8/6-7 3

Example: Small boat wave forecasts for a location that has a 15 n mi limited fetch to the south (based on the assumption that swell is not a limiting condition).

Forecast for Tomorrow:

Time	Wind (Forecast)		Waves (Table 3-3)
prior to 1000 LST	S	8-12 kt	< 2 ft
1000 to 1400	S	16-20 kt	2-3 ft at 4 sec by 1200
1400 to 1900	S	22-26 kt	building to 3-4 ft at 4 sec by 1600

Interpretation: Assuming that the limiting factor is waves greater than 3 feet, small boat operations will become marginal by 1200 and restricted by 1600.

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 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 and Mitigating Measures

3.7.1 Moving to a New Anchorage

Movement from any outer anchorage to anchorages inside the shoal area will provide significant protection from waves.

3.7.2 Scheduling

Vessels scheduling entry or departure of the West Harbor should be aware of the standard operating procedure of closing the harbor entrance when winds exceed 20 kts and/or waves are greater than 8 ft (2.5 m). These conditions, or threat of, happen about 15 times per winter season. Small boat operations outside the shoal zone may be curtailed for several days and nights during and following winter storm events.

The strongest summer events resulting from a combination of gradient wind and sea breeze can also cause harbor closure. Summer maximum winds are most likely to occur from midmorning to sunset, resulting in curtailed small boat operations outside of the shoal zone or to/from the exposed anchorage outside the East Harbor. During the Khamsin season the afternoon sea breeze may cancel the offshore flow of weak to moderate Khamsin winds resulting in near calm coastal wind conditions during the afternoon. Calm conditions are most likely to be experienced during summer night and very early morning periods. Sea breezes are established by 0700-0800 in summer and around 1000 during spring and autumn. In winter, during periods of fair weather, the sea breeze will be established by about noon (Meteorological Officer, 1962, Vol. I).

3.8 Regional and Local Indication of Hazardous Weather Conditions

The following sequences are listed in approximate longer to shorter lead times and generally regional to local spatial scales. Determination of regional indicators will require access to outside data via communication or remote sensing systems.

North African Depression Development and Approach

- o Strong surface ridging across Morocco and Algiers station 60390 surface wind shift from southwest to northwest (Brody and Nestor, 1980).
- o Cumulonimbus/thunderstorm development over northern Africa mountain and coastal areas.
- o Falling pressure over eastern Libya and western Egypt area.

Potential Khamsin in Advance of Depression

- o Easterly wind reported by station SIWA (61416/61417)
- o Appearance of high cirrus approaching from west
- o The day before a Khamsin starts the seas will be very smooth (glassy) and the sea gulls will be more active.
- o Locally falling pressure
- o Wind veers from northerly to easterly
- o Rapid decrease of humidity
- o Wind veers from east to south
- o Blowing dust develops

Duration and Intensity of Khamsin

- o Increases with months from late winter into spring until April, rapid drop off through May into early June.
- o Approach path; February into March approaches on coastal track, duration of Khamsin about a day. March, April and May over land track south of 30°N, duration 3-4 days before cold frontal passage.

Frontal Passages. Strong Northwesterly Winds, High Seas to Follow.

- o Front approaching. Wind veers to southwest, speed increases and visibility decreases in blowing dust/sand.
- o Frontal passage. Sudden wind shift to northwest, temperature drops and humidity rises.

- o Rapid drop off of blowing sand. Dust and haze may linger for a day or so.
- o Rising pressure and gradually decreasing northwesterlies over a couple of days period. Northerly swell may persist for 2 to 4 days if associated low stalls in Cyprus area.

Anomalous Propagation, Low Level Turbulence, Mirages and Reduced Visibility

- o Indicators of onset of Khamsin events are also indicators of onset of following conditions and vice versa:
  - Strong temperature inversions between surface and 3000 ft.
  - Helicopters may be out o. radio contact at 1 to 2 mile range.
  - Anomalous radar ranges.
  - Morning Inferior mirages (distance to horizon shortened) and evening Superior mirages (distance to horizon increased).
  - Strong wind shear near top of inversion.
  - Marked reduction of slant range during daylight periods.
  - Reduced surface visibility in blowing dust/sand.

3.9 Summary of Problems, Actions, and Indicators Table 3-4 is intended to provide easy-to-use seasonal references for meteorologists or ships using the Port of Alexandria. Table 2-1 (section 2) summarizes Table 3-4 and is intended primarily for use by ship captains.

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Table 3.4. Potential proble

VESSEL LOCATION/ SITUATION	POTENTIAL HAZARD	EFFECT - PRECAU
1. Moored in West Harbor Strongest in winter occurs in Spring and Autumn	a. Northwesterly Winds/Waves - Occurs following frontal passage and/or on backside of migratory lows. Winds 30 to 40 kts for 12 to 18 hours, not uncommon for 20-30 kt winds to continue for 2 or 3 days or as long as low remains nearly stationary in NE Mediterranean. Swell waves of 15-17 ft (5 m) - occur during strong winter storms. Swell of 8-12 ft (3-4 m) often persists for a week or more. Wave energy is spread across a wide spectrum of frequencies\periods. Waves inside breakwaters limited to about 3 ft (1 m) in strongest winter storms.	a. Moored vessels ma ment will be extremely traffic, aggressive ma anchored vessels fouli anchor, local custom c culty in making visual flat terrain. Berthir assistance. Use of ha not recommended.
Occurs February through early June most intense and longest duration March and April	b. Southeasterly Winds/Waves - Locally known as "Khamsin", a regional form of "Sirocco". Winds of 25 to 35 kts may persist for 3 to 4 days in advance of approaching N. African depressions. Hot, dry, dusty winds from deserts to south. High personal discomfort, anomalous radar/radio propagation, reduced horizontal and slant range visibility, fine dust penetration all systems, strong wind shear near top of inversion. During peak season (March/April) winds may persist from the SE for a number of days but at speeds less than 25 kts and with minimum blowing dust but still hot and dry.	b. Problems similar winds. Difference wi stress will be in opp most likely recurrenc for northwesterly win strong Khamsin events

›tential problem situations at Alexandria, Egypt.

T - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
›d vessels may swing into fairway. Move- be extremely risky due to congested ›ggressive maneuvering by local seamen, ›essels fouling channels and swinging at ›cal custom of close berthing, and diffi- ›aking visual bearings due to traffic and ›in. Berthing likely to require tug ›. Use of harbor during storm periods is ›ended.	a. Strong northwesterly winds occur following frontal passage and/or on the back side of migratory lows. These wind events will persist for several days when the associated low becomes nearly stationary in the Cyprus area. Eastern Mediterranean cyclones have three general source regions: Aegean Sea/Cretan Sea, Gulf of Antalya to Cyprus, and North Africa south of the Atlas Mountains. The first two areas are active from late October through April. North African depressions that move eastward far enough to influence the Port Said area are most likely in February through early June. Strong northwesterlies are generally preceded by strong Khamsin events. Southerly wind veering to southwesterly and increasing indicates the approach of the front and with passage winds become northwesterly, blowing dust drops off rapidly, temperature drops off and humidity increases.
lems similar to those under northwesterly ›ifference will be ship movements and ll be in opposite direction and season of ly recurrence shift to spring vice winter westerly winds. Use of harbor during amsin events not recommended.	b. Khamsin, a regional name for Sirocco type winds, are hot, dry and dusty southerly flow from out of the desert. They are a late winter early spring event and are most intense in March and April. Strong Khamsin events are associated with the approach of north African depressions. North African depression development is likely with strong surface ridging across Morocco. A wind shift from southwest to northwest at Algier (60390) is an indicator of cyclogenesis east of the Atlas mountains. Cumulonimbus development over Libya and northwestern Egypt, evident in satellite imagery, indicates depression development. Falling pressure over this same area and/or an easterly surface wind report from SIWA (61416/61417) indicates eastward movement of the depression. Local indicators of depression approach and Khamsin development include: falling pressure, approach of high cirrus from the west, surface winds veering from north to easterly, rapid decrease in humidity, winds continuing to veer to south, and onset of blowing dust. The duration increases on average from less than a day in February to 2 to 3 days in March and April. These depressions/cyclones typically take an overwater track early in the Khamsin season, shifting southward to coastal and over land in spring. Due to lack of conventional data and classic cloud development the late season systems are more difficult to define and track.

Table 3.4

VESSEL LOCATION/ SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUT
2. <u>Anchored Outside Shoal Area</u> Strongest in winter occurs in Spring and Autumn	a. <u>Northwesterly Winds/Waves</u> - Occurs following frontal passage and/or on backside of migratory lows. Winds 30 to 40 kts for 12 to 18 hours, not uncommon for 20-30 kt winds to continue for 2 or 3 days or as long as low remains nearly stationary in NE Mediterranean. Swell waves of 15-17 ft (5m) - occur during strong winter storms. Swell of 8-12 ft (3-4 m) often persists for a week or more. Wave energy is spread across a wide spectrum of frequencies/periods. Waves inside breakwaters limited to about 3 ft (1 m) in strongest winter storms.	a. Worst conditions tions will be precaric storms. Sortie to ope range of wave periods in vessel responses, a tions particularly haz
Occurs February through early June most intense and longest duration March and April	b. <u>Southeasterly Winds/Waves</u> - Locally known as "Khamsin", a regional form of "Sirocco". Winds of 25 to 35 kts may persist for 3 to 4 days in advance of approaching N. African depressions. Hot, dry, dusty winds from deserts to south. High personal discomfort, anomalous radar/radio propagation, reduced horizontal and slant range visibility, fine dust penetration all systems, strong wind shear near top of inversion. During peak season (March/April) winds may persist from the SE for a number of days but at speeds less than 25 kts and with minimum blowing dust but still hot and dry.	b. Problems generall limited radio/radar ar deposition and penetr good, extra anchors ma swinging. Top side cc vessels closed up to p tion.

Table 3.4 (continued)

PRECAUTIONARY/EVASIVE ACTION	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
onditions at outer anchorages. Condi- e precarious during strong winter tie to open sea may be prudent. Wide e periods result in marked differences sponses, alongside/well deck opera- ularly hazardous.	a. Strong northwesterly winds occur following frontal passage and/or on the back side of migratory lows. These wind events will persist for several days when the associated low becomes nearly stationary in the Cyprus area. Eastern Mediterranean cyclones have three general source regions: Aegean Sea/Cretan Sea, Gulf of Antalya to Cyprus, and North Africa south of the Atlas Mountains. The first two areas are active from late October through April. North African depressions that move eastward far enough to influence the Port Said area are most likely in February through early June. Strong northwesterlies are generally preceded by strong Khamsin events. Southerly wind veering to southwesterly and increasing indicates the approach of the front and with passage winds become northwesterly, blowing dust drops off rapidly, temperature drops off and humidity increases.
s generally limited to wind effects, o/radar and visibility ranges, and nd penetration of dust. Holding is anchors may be advisable to restrict op side covers should be in place and ed up to protect from dust penetra-	b. Khamsin, a regional name for Sirocco type winds, are hot, dry and dusty southerly flow from out of the desert. They are a late winter early spring event and are most intense in March and April. Strong Khamsin events are associated with the approach of north African depressions. North African depression development is likely with strong surface ridging across Morocco. A wind shift from southwest to northwest at Algier (60390) is an indicator of cyclogenesis east of the Atlas mountains. Cumulonimbus development over Libya and northwestern Egypt, evident in satellite imagery, indicates depression development. Falling pressure over this same area and/or an easterly surface wind report from SIWA (61416/61417) indicates eastward movement of the depression. Local indicators of depression approach and Khamsin development include: falling pressure, approach of high cirrus from the west, surface winds veering from north to easterly, rapid decrease in humidity, winds continuing to veer to south, and onset of blowing dust. The duration increases on average from less than a day in February to 2 to 3 days in March and April. These depressions/cyclones typically take an overwater track early in the Khamsin season, shifting southward to coastal and over land in spring. Due to lack of conventional data and classic cloud development the late season systems are more difficult to define and track.

VESSEL LOCATION/ SITUATION	POTENTIAL HAZARD	EFFECT - PRECA
3. Arriving/Departing Strongest in winter occurs in Spring and Autumn	a. Northwesterly Winds/Waves - Occurs following frontal passage and/or on backside of migratory lows. Winds 30 to 40 kts for 12 to 18 hours, not uncommon for 20-30 kt winds to continue for 2 or 3 days or as long as low remains nearly stationary in NE Mediterranean. Swell waves of 15-17 ft (5 m) - occur during strong winter storms. Swell of 8-12 ft (3-4 m) often persists for a week or more. Wave energy is spread across a wide spectrum of frequencies/periods. Waves inside breakwaters limited to about 3 ft (1 m) in strongest winter storms.	a. Navigation haz Standard operating channel when winds waves are greater t to the West Harbor ed to one vessel at aggressive maneuver vessels fouling cha local custom of clo making wind bearing rain make for diffi
Occurs February through early June most intense and longest duration March and April	b. Southeasterly Winds/Waves - Locally known as "Khamsin", a regional form of "Sirocco". Winds of 25 to 35 kts may persist for 3 to 4 days in advance of approaching N. African depressions. Hot, dry, dusty winds from deserts to south. High personal discomfort, anomalous radar/radio propagation, reduced horizontal and slant range visibility, fine dust penetration all systems, strong wind shear near top of inversion. During peak season (March/April) winds may persist from the SE for a number of days but at speeds less than 25 kts and with minimum blowing dust but still hot and dry.	b. Problems simila winds. Differences stress, and windward and season of most l winter to spring. R ranges limited. Mir sightings to be ques

Table 3-4 (continued)

PRECAUTIONARY/EVASIVE ACTION	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
otion hazardous in crowded harbor. cerating procedure is to close the entry en winds exceed 20 kt and/or open sea greater than 8 ft (2.5 m). The entrance n Harbor is narrow and transit is limit- t essel at a time. Congested traffic, maneuvering by local seamen, anchored lding channels and swinging at anchor, bea of close berthing and difficulty in ue bearings due to traffic and flat ter- t or difficult navigation at best.	a. Strong northwesterly winds occur following frontal passage and/or on the back side of migratory lows. These wind events will persist for several days when the associated low becomes nearly stationary in the Cyprus area. Eastern Mediterranean cyclones have three general source regions: Aegean Sea/Cretan Sea, Gulf of Antalya to Cyprus, and North Africa south of the Atlas Mountains. The first two areas are active from late October through April. North African depressions that move eastward far enough to influence the Port Said area are most likely in February through early June. Strong northwesterlies are generally preceded by strong Khamsin events. Southerly wind veering to southwesterly and increasing indicates the approach of the front and with passage winds become northwesterly, blowing dust drops off rapidly, temperature drops off and humidity increases.
tos similar to those under northwesterly l erences will be ship movements and il windward will be in opposite direction el f most likely occurrence shifts from ar ring. Radar and radio propagation e ed. Mirage effects cause visual on be questionable.	b. Khamsin, a regional name for Sirocco type winds, are hot, dry and dusty southerly flow from out of the desert. They are a late winter early spring event and are most intense in March and April. Strong Khamsin events are associated with the approach of north African depressions. North African depression development is likely with strong surface ridging across Morocco. A wind shift from southwest to northwest at Algier (60390) is an indicator of cyclogenesis east of the Atlas mountains. Cumulonimbus development over Libya and north- western Egypt, evident in satellite imagery, indicates depression development. Falling pressure over this same area and/or an easterly surface wind report from SIWA (61416/61417) indicates eastward movement of the depression. Local indicators of depression approach and Khamsin development include: falling pressure, approach of high cirrus from the west, surface winds veering from north to easterly, rapid decrease in humidity, winds continuing to veer to south, and onset of blowing dust. The duration increases on average from less than a day in February to 2 to 3 days in March and April. These depressions/cyclones typically take an overwater track early in the Khamsin season, shifting southward to coastal and over land in spring. Due to lack of conventional data and classic cloud development the late season systems are more difficult to define and track.

Table 3.4

VESSEL LOCATION/ SITUATION	POTENTIAL HAZARD	EFFECT - PRECA
4. Small Boat Operations Strongest in winter occurs in Spring and Autumn	a. Northwesterly Winds/Waves - Occurs following frontal passage and/or on backside of migratory lows. Winds 30 to 40 kts for 12 to 18 hours, not uncommon for 20-30 kt winds to continue for 2 or 3 days or as long as low remains nearly stationary in NE Mediterranean. Swell waves of 15-17 ft (5 m) - occur during strong winter storms. Swell of 8-12 ft (3-4 m) often persists for a week or more. Wave energy is spread across a wide spectrum of frequencies/periods. Waves inside breakwaters limited to about 3-4 ft (1m) in strongest winter storms.	a. Small boat oper ages will be cancele Under typical southe westerly wind and wa outside harbor are h gy across wide range hazards for alongsid rigging should be to protection. Summert prevailing northerly conditions outside h Small boat operation made aware of numero surface. Some berth Landing sites due to This is especially a Club where freeboard To avoid hull damage ing barge be used fo
Occurs February through early June most intense and longest duration March and April	b. Southeasterly Winds/Waves - Locally known as "Khamsin", a regional form of "Sirocco". Winds of 25 to 35 kts may persist for 3 to 4 days in advance of approaching N. African depressions. Hot, dry, dusty winds from deserts to south. High personal discomfort, anomalous radar/radio propagation, reduced horizontal and slant range visibility, fine dust penetration all systems, strong wind shear near top of inversion. During peak season (March/April) winds may persist from the SE for a number of days but at speeds less than 25 kts and with minimum blowing dust but still hot and dry.	b. Minimal wave he Blowing dust/sand an create hazards. Dur events sea breeze ma wind providing near noon.

Table 3.4 (continued)

- PRECAUTIONARY/EVASIVE ACTION	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
boat operations to/from outer anchor- be canceled during stormy weather. al southeastern Mediterranean north- nd and wave conditions, operations rbor are hazardous. Spread of wave ener- ide range of periods causes additional alongside operations. Small boat uld be to lee side to provide maximum Summertime sea breeze will enhance northerly winds resulting in choppy outside harbor. operations in East Harbor should be of numerous rocks within 3 ft (1 m) of ome berthing may be a problem at Fleet es due to minimum freeboard at berths. ecially a problem near the Sea Scout freeboard is only about 2 ft (<1 m). ll damage suggest fenders and/or float- e used for berthing small boats.	a. Strong northwesterly winds occur following frontal passage and/or on the back side of migratory lows. These wind events will persist for several days when the associated low becomes nearly stationary in the Cyprus area. Eastern Mediterranean cyclones have three general source regions: Aegean Sea/Cretan Sea, Gulf of Antalya to Cyprus, and North Africa south of the Atlas Mountains. The first two areas are active from late October through April. North African depressions that move eastward far enough to influence the Port Said area are most likely in February through early June. Strong northwesterlies are generally preceded by strong Khamsin events. Southerly wind veering to southwesterly and increasing indicates the approach of the front and with passage winds become northwesterly, blowing dust drops off rapidly, temperature drops off and humidity increases.
l wave heights with offshore flow. t/sand and reduced visibility will rds. During light to moderate Khamsin breeze may nearly cancel out offshore ing near calm conditions during after-	b. Khamsin, a regional name for Sirocco type winds, are hot, dry and dusty southerly flow from out of the desert. They are a late winter early spring event and are most intense in March and April. Strong Khamsin events are associated with the approach of north African depressions. North African depression development is likely with strong surface ridging across Morocco. A wind shift from southwest to northwest at Algier (60390) is an indicator of cyclogenesis east of the Atlas mountains. Cumulonimbus development over Libya and northwestern Egypt, evident in satellite imagery, indicates depression development. Falling pressure over this same area and/or an easterly surface wind report from SIWA (61416/61417) indicates eastward movement of the depression. Local indicators of depression approach and Khamsin development include: falling pressure, approach of high cirrus from the west, surface winds veering from north to easterly, rapid decrease in humidity, winds continuing to veer to south, and onset of blowing dust. The duration increases on average from less than a day in February to 2 to 3 days in March and April. These depressions/cyclones typically take an overwater track early in the Khamsin season, shifting southward to coastal and over land in spring. Due to lack of conventional data and classic cloud development the late season systems are more difficult to define and track.

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PORT VISIT INFORMATION

January 1989. NOARL meteorologists R. Fett and D. Perryman met with Port Authority Officers Admiral Hamdy Mahdy and Mr. Atif Maroni and U.S. Navy husbanding agent Captain Abdel Rahman Awwa to obtain much of the information used in this port evaluation.

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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 frequencies 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.

<u>Format:</u> 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:

<u>WIND FORECAST OR CONDITION</u>

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.

<u>SEA FORECAST OR CONDITION</u>

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.

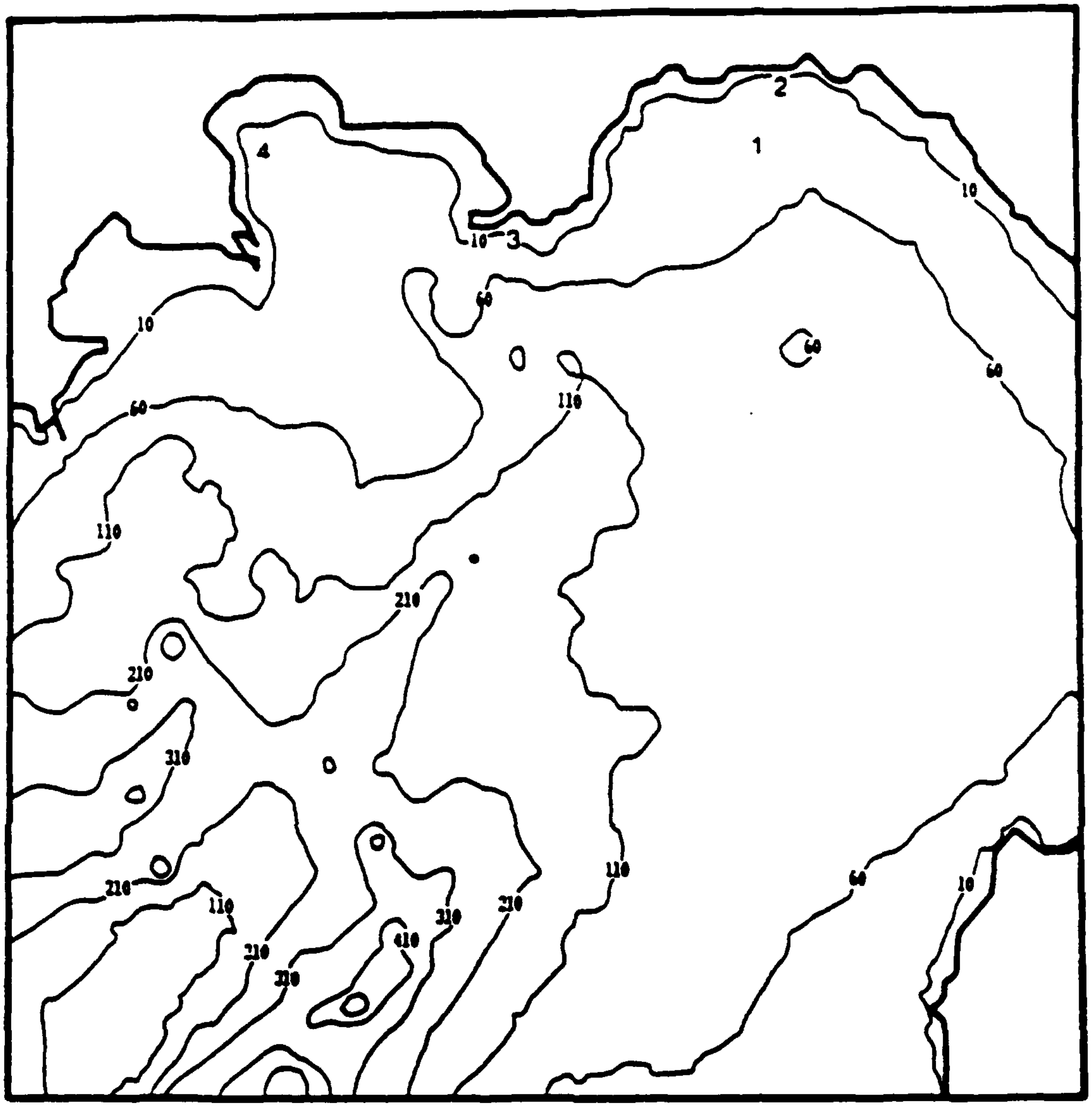

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathom contour. The larger size numbers identify specific anchorage areas addressed in the harbor study.

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