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SEVERE WEATHER GUIDE MEDITERRANEAN PORTS

12. CANNES

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This handbook for the port of Cannes, 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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FOREWORD

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

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

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

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

PORT INDEX

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

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

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

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

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

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

PREFACE

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

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

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

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

RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	PAGE NUMBER	ENTERED BY

1. GENERAL GUIDANCE

1.1 DESIGN

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

1.1.1 Objectives

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

1.1.2 Approach

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

A. A literature search for reference material was performed.

B. Cruise reports were reviewed.

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

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

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

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

1.1.3 Organization

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

A. a brief narrative summary of environmental hazards,

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

C. local wind wave conditions, and

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

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

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

1.2. CONTENTS OF SPECIFIC HARBOR STUDIES

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

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

Emphasis is placed on the hazards related to wind, wind waves, and the propagation of deep water swell into the harbor areas. Various vessel locations/situations are considered, including moored, nesting, anchored, arriving/departing, and small boat operations. The potential problems and suggested 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

Cannes is located on the southern coast of France in the region known as the French Riviera (Figure 2-1), about 26 n mi southwest of the Italian border.

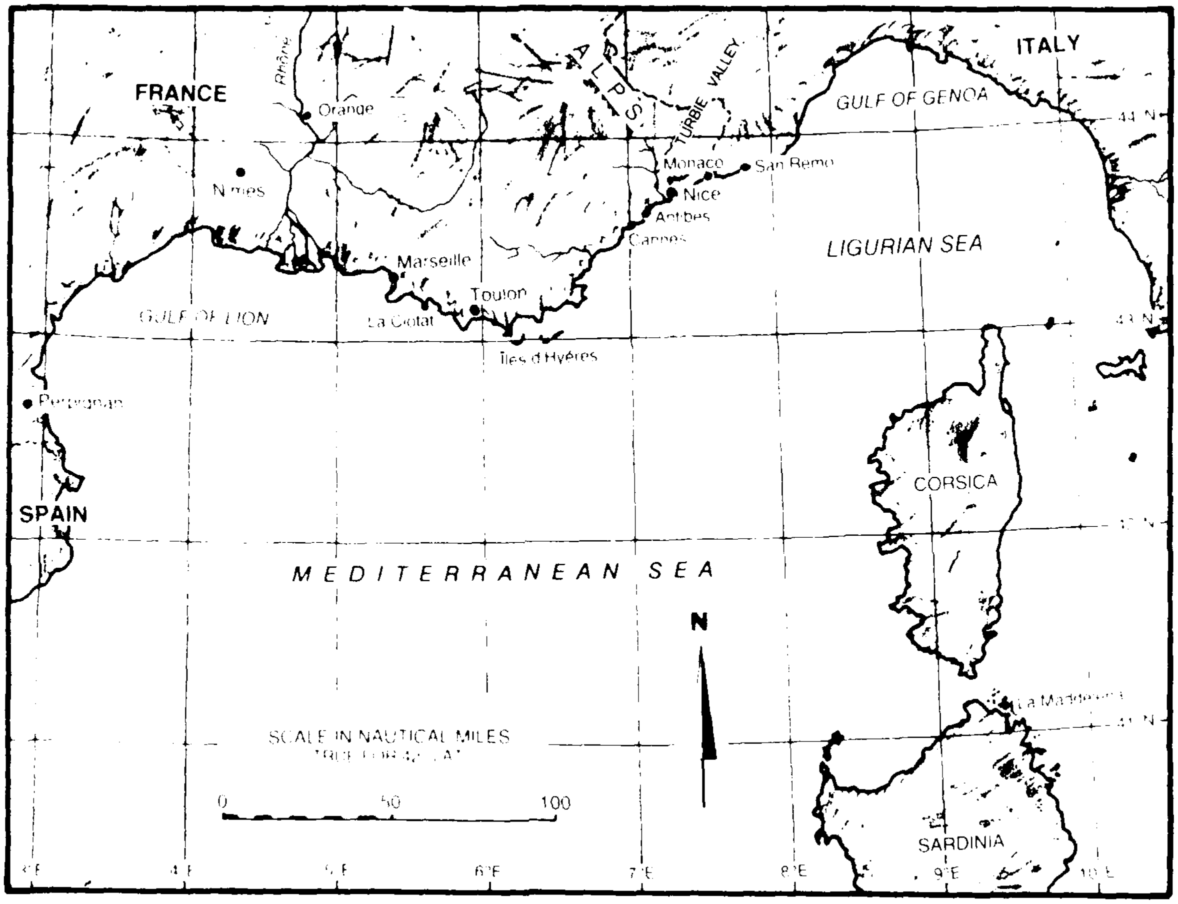

Figure 2-1. The Northwestern Mediterranean Sea.

The Port of Cannes is situated on Rade de Cannes in the northeast part of Golfe de la Napoule, about 5 n mi west of Cap D'Antibes (Figure 2-2). Iles de Lérins are just south-southeast of the Port. Hills of 800 to over 900 ft (244 to 274 m) lie close northward of the Port, while mountains with elevations to 5,827 ft (1,776 m) back the coastline about 15-20 mi inland.

Three primary anchorages are located outside the inner harbor as follows (Figure 2-2):

No. 1 - 43°32.1'N 07°01'E. Located approximately 0.5 n mi south of the end of the southernmost breakwater in the northeast portion of Golfe de la Napoule. Best in calm, east, or northeast winds. The bottom is mud and provides good holding (Hydrographer of the Navy, 1965).

No. 2 - 43°31.8'N 07°03.5'E. Situated north of Ile Ste. Marguerite in the southwestern part of Golfe Juan. Best in southeast, south, or southwest winds. Holding is moderately good on a mud or muddy sand bottom (Hydrographer of the Navy, 1965).

No. 3 - 43°32.3'N 07°03.3'E. Located east of Cap de la Croisette in the western portion of Golfe Juan. Best in northwest winds. May be used to avoid Mistral effects. Bottom type and holding properties are similar to anchorage No. 2.

The wind may change directions during a port call, making it advisable to shift anchorage location. The shift takes about 1 hour (FICEURLANT, 1985).

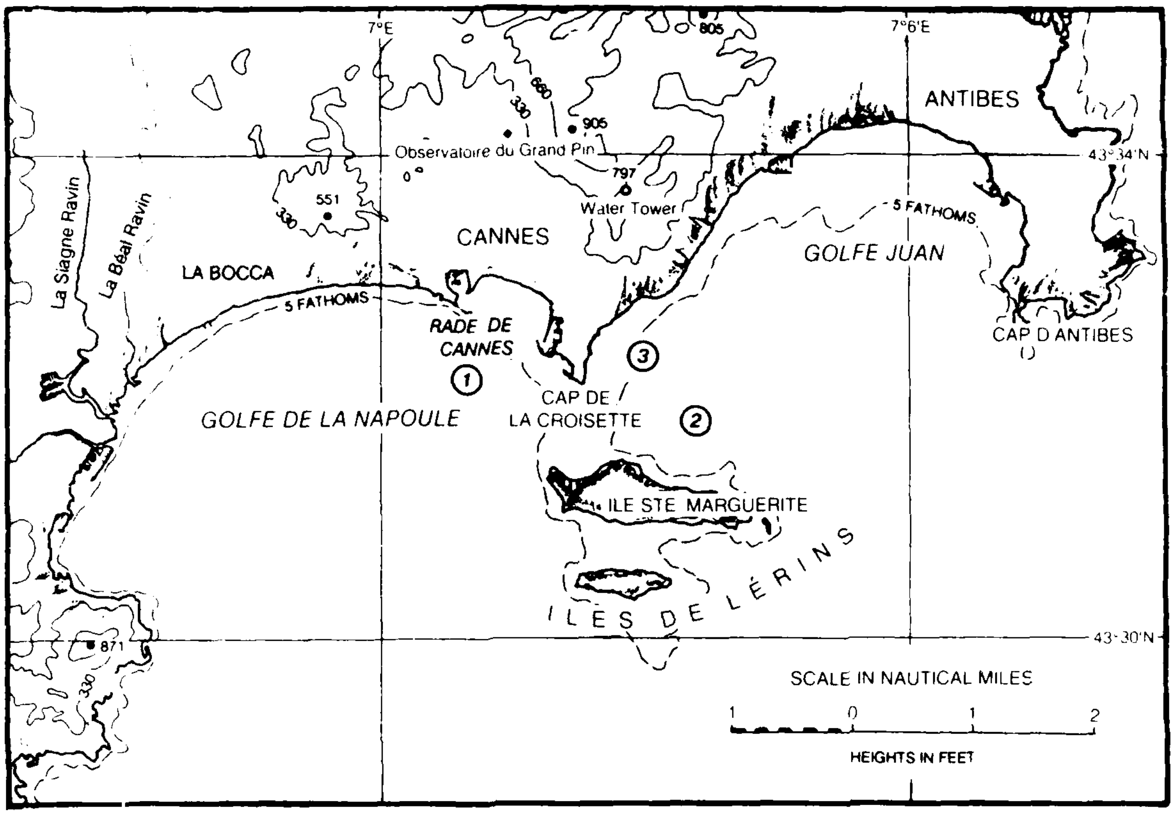

Figure 2-2. Approaches to the Port of Cannes.

The inner harbor of the Port of Cannes (Figure 2-3) is small and cannot accommodate deep draft vessels since it is dredged to only 16 ft (4.9 m) (FICEURLANT, 1985). The harbor is protected on the south and southwest by a 1150 ft (351 m) breakwater and on the southeast by 575 ft (175 m) breakwater. Navy vessels utilize the outer anchorages. A fleet landing is located inside the breakwater.

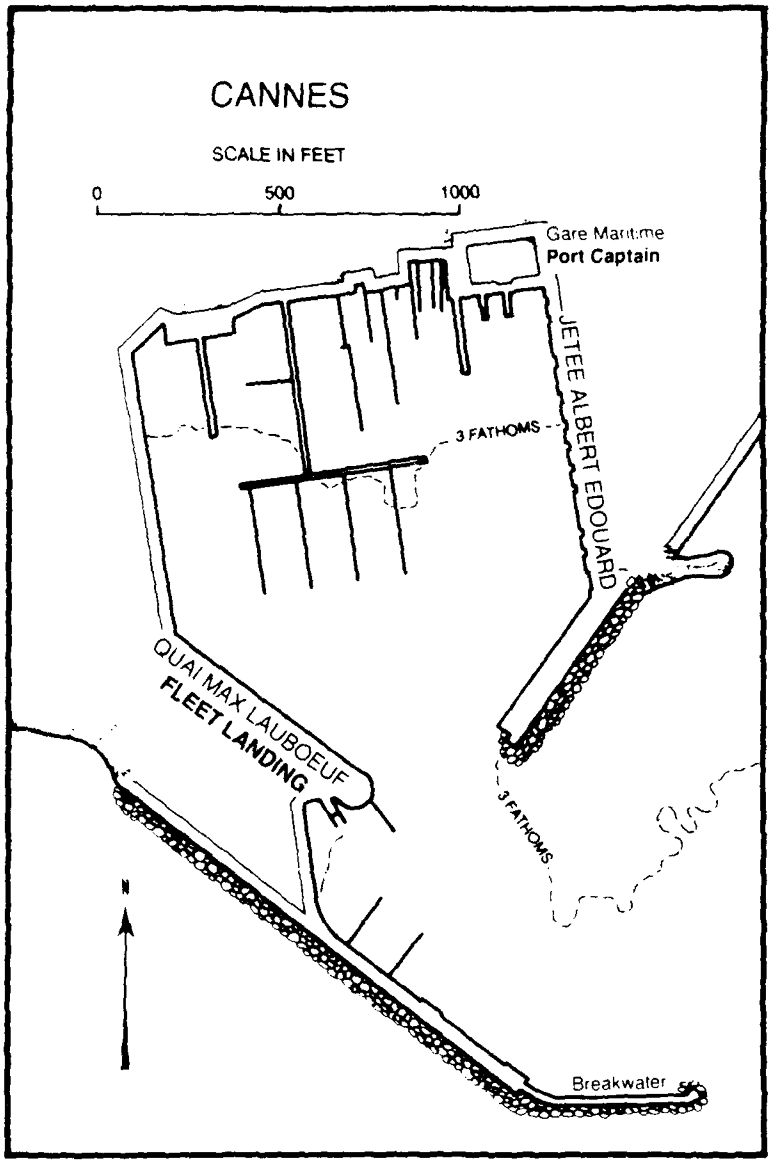

Figure 2-3. Port of Cannes.

The anchorages may be used depending on the direction of the wind as follows (FICEURLANT, 1985):

No. 1 - 43°32.1'N 07°01'E. Located approximately 0.5 n mi south of the end of the southernmost breakwater in the northeast portion of Golfe de la Napoule. Best in calm, east, or northeast winds. The bottom is mud and provides good holding (Hydrographer of the Navy, 1965). Large aircraft carriers have used this anchorage.

No. 2 - 43°31.8'N 07°03.5'E. Situated north of Ile Ste. Marguerite in the southwestern port of Golfe Juan. Best in southeast, south, or southwest winds. Holding is moderately good on a bottom of mud or muddy sand (Hydrographer of the Navy. 1965).

No. 3 - 43°32.3'N 07°03.3'E. Located east of Cap de la Croisette in the western portion of Golfe Juan. Best in northwest winds. May be used to avoid Mistral effects. Bottom type and holding properties are similar to anchorage No. 2.

The wind may change directions during a port call, making it advisable to shift anchorage location. The shift takes about 1 hour (FICEURLANT, 1985).

Currents at Cannes are negligible. With a range of only about 7 inches (18 cm), the tides are constant with very little fluctuation. Mean tide level is 1.3 ft (FICEURLANT, 1985).

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

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Table 2-1. Summary of hazardous environmental c

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VES SITU
1. E-SE'ly winds/waves - Produce worst conditions in inner harbor and at anchorages 2 and 3. * Waves pass through entrance to inner harbor. * Anchorages 2 and 3 are exposed to full force of wind/waves. * Occurs 1-2 times yearly. * Most common in winter/early spring. * May be accompanied by rain and thunderstorms.	Advance warning * Strong or strengthening high pressure cell over central Europe with low pressure south or southwest of Cannes. * Low pressure systems moving north toward Ligurian Sea or Gulf of Lion after passing through Strait of Gibraltar or forming north of Atlas Mountains. Duration * May last 18-24 hours.	(1) (2) (3) (4) (5) (6)
2. S'ly winds/waves - Produces worst conditions for anchorage no. 1. * Anchorage no. 1 offers no protection from open sea conditions. * Most common in winter/early spring. * Swell direction may differ from wind direction by 45°-90°. * Swell height may reach 8-10 ft (2.5-3 m).	Advance warning * The early stages of cyclogenesis south of the Alps commonly result in SW'ly 30-40 kt winds between the French Coast and Corsica. * Depressions moving east into the Ligurian Sea or across Corsica into Italy. Duration * Swell may persist for 2-3 days.	(1) (2) (3) (4) (5)

...onmental conditions for the Port of Cannes, France.

...RD	VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
...l over	(1) Inner harbor.	(a) Waves passing through harbor entrance create dangerous conditions in inner harbor. * Since deep draft vessels do not utilize the inner harbor, effect is limited to small boats.
...g ...rth of	(2) Anchorage no. 1.	(a) Anchorage no. 1 provides best protection of the 3 anchorages at Cannes. * Some wave energy may pass through opening between Pointe de la Croisette and Ile Ste. Marguerite. * Impact on anchored vessels would be minimal. * Two anchors may be required in strong winds. * Greatest impact is on small boats.
	(3) Anchorage no. 2.	(a) Anchorage no. 2 is exposed to full force of wind and waves. * Moving to anchorage no. 1 is recommended.
	(4) Anchorage no. 3.	(a) Anchorage no. 3 is exposed to full force of wind and waves. * Moving to anchorage no. 1 is recommended.
	(5) Arriving/departing.	(a) Heavy weather conditions may exist in unprotected waters. * Outbound units should be prepared for heavy weather. * Inbound units should utilize anchorage no. 1.
	(6) Small boats.	(a) Swell may create dangerous conditions in the inner harbor. * Operation of small boats may be curtailed until conditions abate.
...the ...nds	(1) Anchorage no. 1.	(a) Anchorage no. 1 is exposed to full force of wind and waves. * Ship may roll due to differing wind and wave directions. * Moving to anchorage no. 2 is recommended.
...Sea	(2) Anchorage no. 2.	(a) Anchorage no. 2 provides best protection of the 3 anchorages at Cannes. * Lee of Ile Ste. Marguerite shelters anchorage. * Evasion/sortie should not be required.
	(3) Anchorage no. 3.	(a) Anchorage no. 3 provides limited protection. * Moving to anchorage no. 2 will provide better protection.
	(4) Arriving/departing.	(a) Heavy weather conditions may exist in unprotected waters. * Outbound units should be prepared for heavy weather. * Inbound units should utilize anchorage no. 2.
	(5) Small boats.	(a) Conditions on waters between inner harbor entrance and west end of Ile Ste. Marguerite may preclude safe boat operation. * Boating to/from anchorages may be cancelled.

Table 2-1. (Continu

HAZARDOUS CONDITION	INDICATORS OF POTENTIAL HAZARD	VESSEL L SITUATION
3. Mistral winds/waves - Direction may vary from W to NE. * Most common in late winter/early spring. * Wave height is reduced due to lack of fetch. * Wind in harbor may be light while strong winds blow only 1 n mi W; whitecaps often visible outside harbor.	Advance warning * Mistral will start west of Cannes when the following pressure differences are achieved--highest pressure to west. * Perpignan - Marseille, 3 mb. * Marseille - Nice, 3 mb. * Perpignan - Nice, 6 mb. * For Mistral winds to affect Cannes, they will first be observed at Marseille/Toulon. * Mistral will spread as far east as Cannes if a 10 mb pressure difference exists between Toulon and Nice. With only 2 mb difference between Marseille and Toulon the Mistral will stop near Toulon. * A north to northeast pressure gradient is usually required before Mistral affects Cannes.	(1) Anchora (2) Anchora (3) Anchora (4) Arrivin (5) Small b
4. Sea breeze - SW'ly wind common on warm days. * May be expected daily in late spring and summer. * Force 4-5 (11-21 kt) usually reached by 1400-1500L.	Advance warning * Can be expected on warm days in late spring and summer. Duration * Late morning to late afternoon. * Maximum velocities observed about 1400-1500L.	(1) Small b

(Continued)

VESSEL LOCATION/ SITUATION AFFECTED	EFFECT - PRECAUTIONARY/EVASIVE ACTIONS
(1) Anchorage no. 1.	(a) Although conditions in the anchorage would likely remain moderate under strong Mistral flow, a change in wind direction could cause deterioration. * If wind direction remains NW to NE, wave generation would be restricted due to lack of fetch. * If wind direction is W, significant waves could develop. * Impact on anchored vessels would be minimal, but 2 anchors may be required in a strong event. * Moving to anchorage no. 3 is recommended. * Be aware of wind chill factor.
(2) Anchorage no. 2.	(a) Anchorage no. 2 provides better protection than no. 1, but not as good as no. 3. * Position is most vulnerable to W or NE flow. * Moving to anchorage no. 3 is recommended. * Be aware of wind chill factor.
(3) Anchorage no. 3.	(a) Anchorage no. 3 provides best protection of the 3 anchorages at Cannes. * Anchorage is sheltered in lee of Pointe de la Croisette. * Evasion/sortie should not be required. * Be aware of wind chill factor.
(4) Arriving/departing.	(a) Heavy weather conditions may exist close to coast while harbor conditions remain mild. * Inbound vessels should utilize anchorage no. 3. * Outbound units should be prepared for heavy weather. * Be aware of wind chill factor.
(5) Small boats.	(a) Small boat operation in inner harbor and close to lee shore should remain largely unaffected. * Boat runs to/from all anchorages may be jeopardized if wind has a strong W to NW component. * Boat runs to/from anchorages 2 and 3 could be hazardous if the wind direction is N to NE, but runs to/from anchorage no. 1 would be only minimally affected.
(1) Small boats.	(a) Waves raised by wind could make boating uncomfortable. * Effect could be minimized by making runs in morning or evening vice afternoon.

SEASONAL SUMMARY OF HAZARDOUS WEATHER CONDITIONS

WINTER (November thru February):

* Worst conditions due to lows moving toward Cannes from south bringing high winds, high waves and thunderstorms.
* Southerly winds cause swell which can enter harbor and winds in harbor usually from another direction causing motion problems for anchored ships.
* Mistral brings high winds and rough seas outside harbor.
* Lombarde (northeasterly) wind is cold and can cause dangerous wind chill.

SPRING (March thru May):

* Early spring similar to winter,strong Mistral events are rare after March.

SUMMER (June thru September):

* Mid-afternoon sea breeze may hamper boating operations.

AUTUMN (October):

* Short transition season with winter-like weather by end of month. Wind chill not yet a factor.

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

REFERENCES

Hydrographer of the Navy, 1965: Mediterranean Pilot, Volume II. Published by the Hydrographer of the Navy, London, England.

FICEURLANT, 1985: Port Directory. Fleet Intelligence Center Europe and Atlantic, Norfolk, VA.

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 3-2 provides a summary of vessel locations/situations, potential hazards, effects-precautionary/evasive actions, and advance indicators and other information by season.

3.1 Geographic Location

Cannes is located on the southern coast of France in the region known as the French Riviera (Figure 3-1), about 26 n mi southwest of the Italian border.

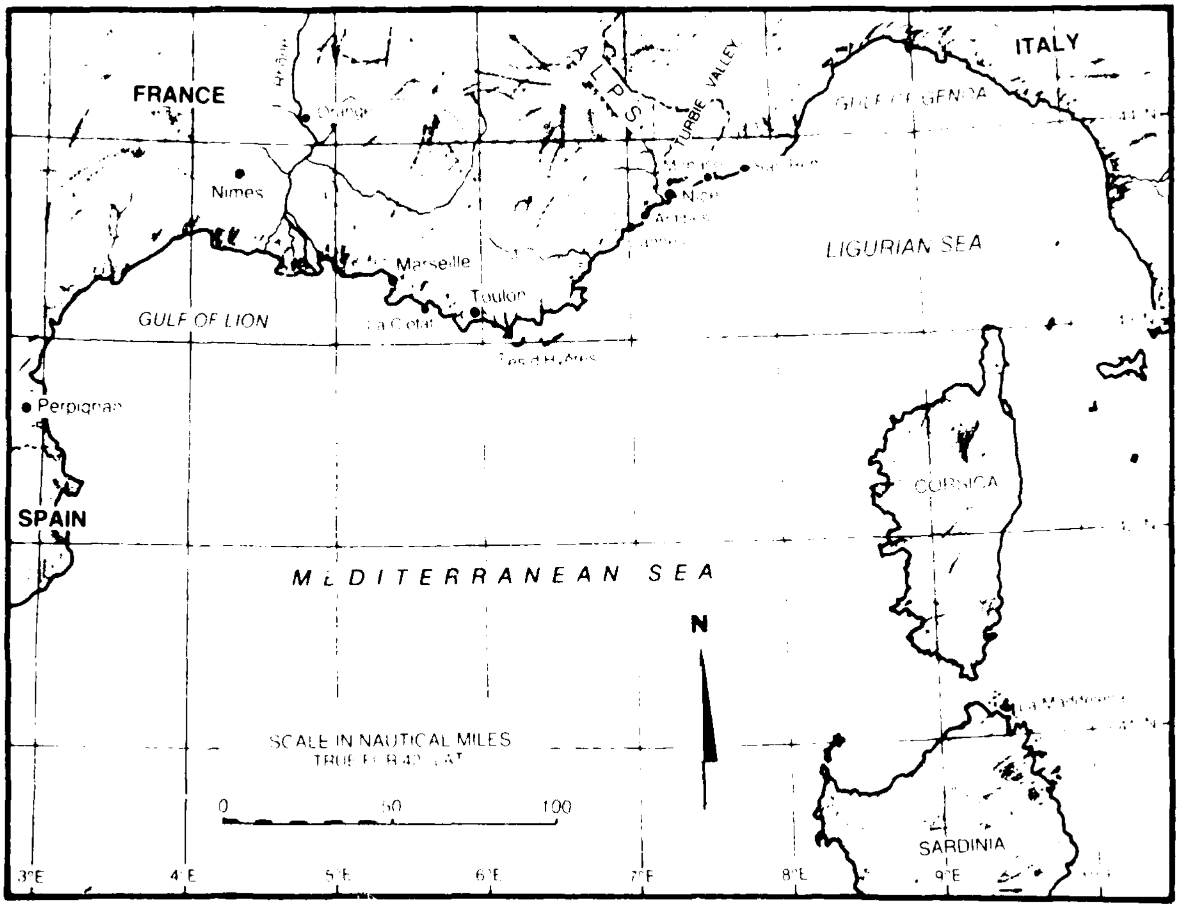

Figure 3-1. The Northwestern Mediterranean Sea.

Situated on an approximately 8 n mi long east-west section of the coast, the Port of Cannes is located on Rade de Cannes in the northeast part of Golfe de la Napoule, about 5 n mi west of Cap D'Antibes (Figure 3-2). Iles de Lérins are just scuth-southeast of the Port. Prominent landmarks include a water tower with crenellated parapets situated on the summit of a 794 ft (242 m) hill which is located about 1 1/2 mi northeast of the harbor, and the Observatoire du Grand Pin which stands on a 938 ft (286 m) summit about 1 1/2 mi north-northeast of the harbor. Mountains with elevations to 5,827 ft (1,776 m) back the coastline some 15-20 mi inland. Anchorages used by the U.S. Navy are located about 0.5 n mi south of the entrance, north of Ile Ste. Marguerite, and east of Cap de la Croisiete in the western Golfe Juan.

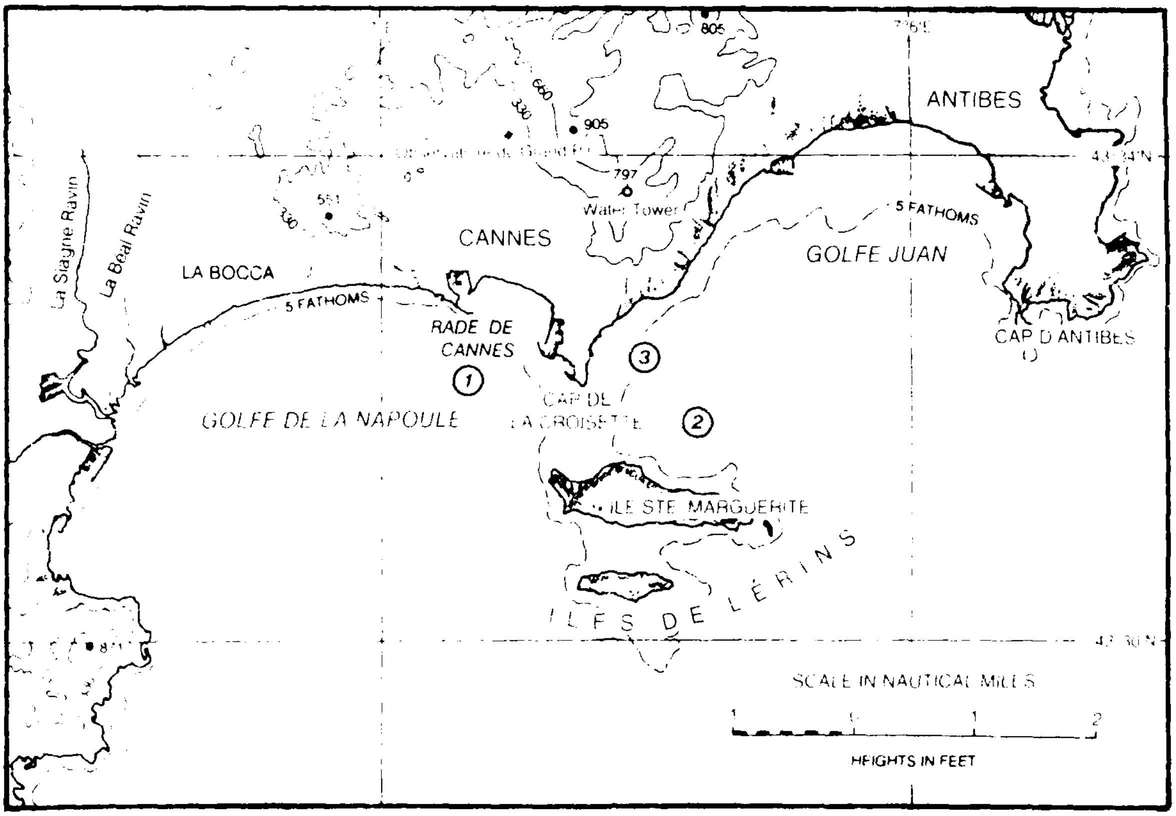

Figure 3-2. Approaches to the Port of Cannes.

The inner harbor at Cannes is small and cannot accommodate deep draft vessels since it is dredged to only 16 ft (4.9 m), (FICEURLANT, 1985). The harbor is protected on the south by a long breakwater that extends approximately 1,150 ft (351 m) southeastward from Quai Max Lauboeuf on the western side of the harbor. A 575 ft (175 m) long breakwater projects southwestward from Jetée Albert Edouard on the eastern side of the harbor. Both breakwaters have mooring facilities on the inner sides. The harbor entrance is about 345 ft (105 m) wide west of the southern end of the breakwater on the eastern side of the harbor, and has a depth of 22 ft (6.7 m). U.S. Navy ships utilize the several anchorages located outside the breakwater which have space enough to accommodate 4 or 5 DD/FF size ships. A Fleet Landing is located inside the breakwater, and is only a 10-minute ride from the anchorages by motor whale boat.

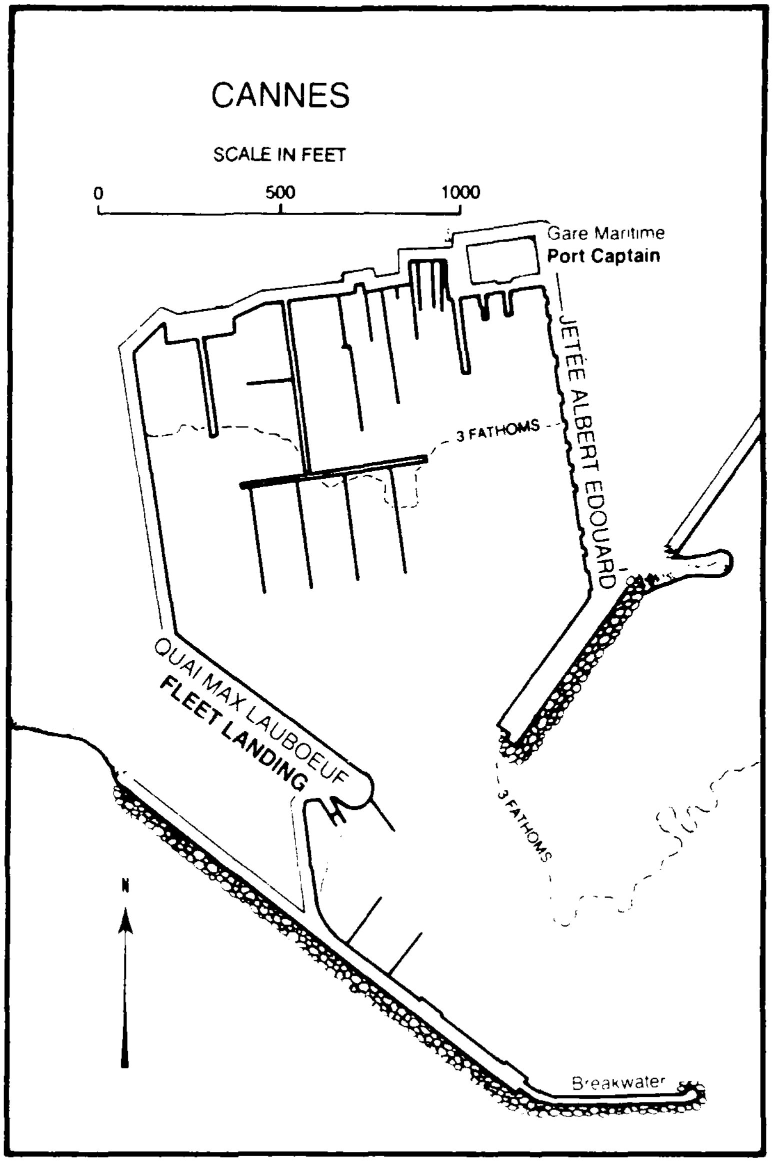

Figure 3-3. Port of Cannes.

3.2 Qualitative Evaluation of the Port of Cannes

The inner harbor at Cannes is well protected from most waves, but east to east-southeasterly winds can produce waves which create dangerous conditions in the inner harbor. Such events occur only once or twice a year but can cause cancellation of all boat traffic.

The anchorages may be used depending on the direction of the wind as follows (FICEURLANT, 1985):

No. 1 - 43°32.1'N 07°01'E. Located approximately 0.5 n mi south of the end of the southernmost breakwater in the northeast portion of Golfe de la Napoule. Best in calm, east, or northeast winds. The bottom is mud and provides good holding (Hydrographer of the Navy, 1965). Large aircraft carriers have used this anchorage.

No. 2 - 43°31.8'N 07°03.5'E. Situated north of Ile Ste. Marguerite in the southwestern port of Golfe Juan. Best in southeast, south, or southwest winds. Holding is moderately good on a bottom of mud or muddy sand (Hydrographer of the Navy. 1965).

No. 3 - 43°32.3'N 07°03.3'E. Located east of Cap de la Croisette in the western portion of Golfe Juan. Best in northwest winds. May be used to avoid Mistral effects. Bottom type and holding properties are similar to anchorage No. 2.

The wind may change directions during a port call, making it advisable to shift anchorage location. The shift takes about 1 hour (FICEURLANT, 1985).

3.3 Currents and Tides

Currents at Cannes are negligible. Tides are constant with very little fluctuation; the range is only about 7 inches (18 cm). Mean tide level is 1.3 ft (0.4 m) (FICEURLANT, 1985).

3.4 Visibility

Visibility is usually not a problem at Cannes, averaging 8 to 10 n mi (13 to 16 km). Normally, there is a light haze in morning and evening.

3.5 Hazardous Conditions

The inner harbor at the Port of Cannes has little exposure to most wind and wave conditions, but is strongly affected by specific events. The three anchorages, which are located outside the protective confines of the harbor, are each vulnerable to some conditions while being relatively protected from others. Cannes is located near the eastern limit of the area affected by Mistral winds. The configuration of the adjacent landmass minimizes the impact of the Mistral on the harbor, although strong winds and high seas may be observed just to the west.

Although rare, storms having tropical cyclone characteristics with fully developed eyes have been observed on at least three occasions in the Mediterranean Basin: 23-26 September 1969, 22-28 January 1982, and 26-30 September 1983. On the latter occasion the storm moved northwest from the Gulf of Gabes (on the southeast coast of Tunisia), through the straits of Sicily, along the east coast of Sardinia, and into the Gulf of Genoa. Winds of 100 kt were observed near the eye while Cagliari, Sardinia reported winds of 60 kt. While the probability of such a storm striking Cannes is remote, the meteorologist must be aware of the possibility.

Weather forecasts for Cannes are transmitted on VHF channels 16 (primary) and 12 (secondary).

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

A. <u>Winter (November through February)</u>

Winter weather at Cannes is similar in many respects to that experienced in other parts of the French Riviera. Unsettled weather is the rule, with precipitation and gusty winds common, although gale force (≥34 kt) winds are rare.

The most hazardous weather at the Port of Cannes is caused by low pressure systems moving from the south toward the Gulf of Lion or the Ligurian Sea (Shaver, undated). Such depressions may pass through the Strait of Gibraltar or form north of the Atlas Mountains. High winds, rough seas, rain, and thunderstorms may accompany the passage of the system and last for 18 to 24 hours. Low centers passing south of Cannes can bring east to northeast winds to the anchorages, in which case anchorage no. 1 would provide the best protection. The inner harbor may be affected by strong winds/waves with easterly components.

Winds at Cannes generally parallel the coast, and are most often northeast or southwest. Most of the winds with a northerly component (most often northeasterly) are caused by lows forming in the Gulf of Genoa or lows that have moved into the Ligurian Sea (Shaver, undated).

Cannes is near the eastern edge of the area affected by the Mistral, but strong Mistral winds blow only a mile or so to the west (Shaver, undated), likely the result of wind flow through a river valley. White caps on rough seas can be observed in open water outside Cannes' harbor. When Cannes does experience Mistral winds, the gradient is usually north to northeast (vice northwest). The wind direction at Cannes resulting from Mistral flow could vary from west to northeast. The <u>Port Directory</u> for Cannes (FICEURLANT, 1985) states that prevailing winter winds are between westerly and northerly, with the northwesterly Mistral being strong at times. Anchorage no. 3 would be the preferred anchorage during a Mistral.

Low pressure systems moving into the Ligurian Sea or across Corsica into Italy generate a southerly (160°

to 220°) swell that affects the anchorages, and with enough easterly component the swell could enter the inner harbor. Swell height may reach 8 to 10 ft (2.5 to 3 m) and persist for 2 or 3 days. According to Shaver (undated), "The biggest problem with swell waves entering the harbor is that by the time the swell arrives, winds in the local area are usually from a different direction than the swell is approaching. This frequently causes the swell to approach the ships at anchor at critical angles (say 45° to 90°)." The preferred anchorage would depend on the existing and forecast wind direction, but anchorages 2 or 3 would likely afford the best protection from southerly waves.

Precipitation is common during winter in association with transient low pressure systems and/or fronts. Snow is uncommon, but approximately 10 inches (25 cm) fell during a 24-hour period in one recent year. Antibes, a community approximately 6 mi east of Cannes, had almost 16 inches (40 cm) fall in February 1956.

Temperatures are moderate during winter, not often decreasing below the freezing point. If the cold temperatures coincide with a strong wind, such as a northeast wind called the "Lombarde," wind chill (temperature combined with wind) can be very cold. 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)

The Cannes area experiences spring weather characterized by periods of stormy winter-type weather alternating with false starts of more settled summer-type weather (Brody and Nestor, 1980).

Low pressure systems continue to transit the area, but do so with decreasing frequency as the season progresses. The transiting depressions bring associated winds and waves to Cannes, causing difficulties in those anchorages with insufficient protection.

Mistral events still occur, but become weaker and less frequent after March, and rare by the end of May. Precipitation in association with passing low pressure systems is common through April, after which amount and frequency show significant decreases. Temperatures warm appreciably throughout the season.

C. Summer (June through September)

The extratropical storm track moves north of the Mediterranean Basin for most of the summer season. Consequently, extratropical cyclones and associated wind and inclement weather are not commonly observed at Cannes. Instead, relatively warm, settled weather prevails.

Summer winds can vary from easterly to westerly, with occasional strong southerly winds occurring (FICEURLANT, 1985). Because the routes small boats must take to the anchorages are afforded little protection from these directions, it may be necessary to secure small boat operations until the winds and swells abate. Local authorities state that a southwest swell is common during summer in association with a Ponant wind which occurs during mid-afternoon at force 4 or 5 (11-21 kt). Due to the daily occurrence of the wind, it is likely the Ponant wind is a sea breeze.

Precipitation is at a minimum for the year during summer, increasing after August.

D. Autumn (October)

As is the case for the rest of the French Riviera, the Cannes area experiences a short autumn season that usually lasts for the month of October. It is characterized by an abrupt change to winter-type weather (Brody and Nestor, 1980). The extratropical storm track returns to the Mediterranean Basin from northern Europe, allowing eastward-moving extratropical storms to once again transit the area and bring unsettled weather to Cannes. Temperatures decrease during the month, but wind chill is not normally a problem until winter.

3.6 Harbor Protection

The inner harbor at Cannes is protected from the effects of most wind and wave conditions, but is vulnerable to those from certain directions. The anchorages, which are located outside the inner harbor, are each protected from or vulnerable to winds and/or waves from a wide range of directions. A description of each of the potential situations follows.

3.6.1 Wind and Weather

As is the case with most ports, wind alone causes only minor difficulty in the Port of Cannes. It is the associated wave energy that causes the biggest problems. Small boats moored in the inner harbor should experience no problems from wind if they are adequately secured and well fendered. Vessels in the various anchorages also should not experience major problems from the wind alone. But by using an anchorage that is protected from a given wind direction, they can usually also avoid the worst wave conditions. The following anchorages are recommended.

Anchorage no. 1 - Use if calm or strong east to northeast winds are occurring or forecast.

Anchorage no. 2 - Use if strong southeast, south, or southwest winds are occurring or forecast.

Anchorage no. 3 - Use if strong west or northwest winds are occurring or forecast.

FICEURLANT (1985) states that since each of the anchorages afford little protection from certain easterly, westerly, or occasional strong southerly winds during summer, conditions frequently develop which necessitate the securing of boating until wind and swells abate. As mentioned in section 3.2, a change in wind direction may necessitate a change in anchorage. The shift takes about 1 hour (FICEURLANT, 1985).

3.6.2 Waves

The inner harbor at Cannes is protected from wave action from most directions, but is vulnerable to waves from east through east-southeast. Waves from those directions can pass through the harbor entrance and create dangerous conditions for small boat operation. Past occurrences of such situations have resulted in cancellation of boat runs to/from ships in the anchorage, and necessitated having personnel on liberty sleep ashore in the Gare Maritime (Marine Station) at the harbor.

Anchorage no. 1 is exposed to the effects of waves from the south quadrant, but is well protected from any waves from west through east-northeast. The promontories of Cap D'Antibes and Pointe de la Croisette provide limited protection from waves with an east component, but some wave energy could reach the anchorage by passing through the narrow and relatively shallow passage between Pointe de la Croisette and Ile Ste. Marguerite.

Anchorage no. 2 is afforded good protection from waves with a southerly component by Ile Ste. Marguerite. It is exposed to waves with a northeastly component.

Anchorage no. 3 affords good protection to vessels during Mistral events, and also from waves with strong south components. It is exposed to waves from the east quadrant.

See section 3.6.1 regarding the desirability of shifting anchorage positions or securing boating.

3.7 Protective and Mitigating Measures

3.7.1 Moving to New Anchorage

As discussed in sections 3.2 and 3.6.1, a shift from one anchorage to another may be required due to an existing or forecast change in wind or wave directions. The three anchorages combine to provide adequate protection in most wind/wave situations, so a sortie to a different port would likely not be necessary unless a prolonged spell of hazardous weather conditions are forecast for Cannes.

3.7.2 Scheduling

During summer, when the sea breeze is most common, small boat operations should be scheduled at times that will minimize the chop raised by the wind. Where possible, runs made before noon or after sunset will avoid the worst effects. In most instances however, the sea breeze should not be of sufficient strength to pose any significant hazard to personnel or craft.

3.8 Local Indicators of Hazardous Weather Conditions

The following guidelines have been extracted from various sources and are intended to provide the insight necessary to enable the meteorologist to better understand the various weather situations that affect the

Port of Cannes. Because Cannes is not in an area normally subjected to wind during an initial Mistral onset, most of the more technical guidelines for Mistrals have been omitted from this listing. If a more comprehensive listing is desired, the reader is referred to section 3.8 of the port studies for either Marseille or Toulon, France.

3.8.1 Mistral

1. Cannes is near the eastern edge of the area affected by the Mistral, but strong Mistral winds blow only a mile or so to the west. White caps on rough seas can be observed in open water outside Cannes harbor. When Cannes does experience Mistral winds, the gradient is usually north to northeast (vice northwest). The wind direction at Cannes can vary from west to northeast (Shaver, undated).

2. Northwesterly Mistral flow is strong at times at Cannes (FICEURLANT, 1985).

3. Conditions which favor the formation of a Genoa low are conducive to the start of a Mistral at Marseille. A strong Mistral at Marseille may spread eastward to the coastal waters near Cannes.

4. For Mistral winds to affect the Cannes area, they will first be observed at Marseille and Toulon. Alongshore pressure gradient is important in predicting Mistral extent. When a 10 mb difference exists (higher pressure to the west) between Toulon and Nice, the Mistral will spread eastward. With only a 2 mb difference between Marseille and Toulon, the Mistral will cease near Toulon.

5. The Mistral will start at Marseille when one (or more) of three surface pressure differences is achieved: Perpignan-Marseille, 3 mb; Marseille-Nice, 3 mb; or Perpignan-Nice, 6 mb. A difference usually occurs from 0 to 24 hr after a closed Genoa low appears, but can occur earlier (Brody and Nestor, 1980).

6. Eastward from Iles d'Hyères there is a rapid decrease in the frequency and in the average force of the Mistral. It blows at times all along this coast but because of its reduced frequency and intensity it is not the same threat as around the Rhône delta. The general climate of the French Riviera benefits from being sheltered from the most intense form of Mistral which is experienced farther west (Hydrographer of the Navy, 1965).

7. The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy (Brody and Nestor, 1980).

3.8.2 Non-Mistral

1. The early stages of lee cyclogenesis south of the Alps commonly result in southwesterly 30-40 kt winds in the region between the southern French coast and Corsica (Brody and Nestor, 1980).

2. The most hazardous weather at the Port of Cannes is caused by low pressure systems moving from the south toward the Gulf of Lion or the Ligurian Sea (Shaver, undated). Such depressions may pass through the Strait of Gibraltar or form north of the Atlas Mountains. High winds, rough seas, rain, and thunderstorms may accompany the passage of the system and last for 18-24 hours.

3. Winds at Cannes generally parallel the coast, and are most often northeast or southwest. Most of the winds with a northerly component (usually northeasterly) are caused by lows forming in the Gulf of Genoa or lows that have moved into the Ligurian Sea (Shaver, undated).

4. Low pressure systems moving into the Ligurian Sea or across Corsica into Italy generate a southerly (160° to 220°) swell that affects the anchorages, and with enough easterly component could enter the inner harbor. Open sea swell height may reach 8 to 10 ft (2.5 to 3 m) and persist for 2-3 days. The swell may arrive

after the wind changes direction, reaching the anchorage at angles of 45° to 90° to the wind and, consequently, to the longitudinal axis of the anchored vessels, resulting in a rolling motion (Shaver, undated).

5. Weather forecasts for Cannes are transmitted on VHF Channel 16 (primary) and Channel 12 (secondary).

3.9 Summary of Problems, Actions, and Indicators

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

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Table 3-2. Potential problem situations at

VESSEL LOCATION/ SITUATION AFFECTED	POTENTIAL HAZARD	EFFECT - PRECAUTI[C
1. Inner Harbor Strongest in Winter & early Spring Also occurs in Summer and Autumn	a. E-SE'ly winds/waves - Sea and swell pass through harbor entrance and create worst conditions in inner harbor. Occurs once or twice per year. May be accompanied by rain and thunderstorms and last for 18-24 hours.	a. Waves passing through harbor create choppy, hazardous conditi draft vessels do not enter inner boats making runs to/from the an
2. Anchorage no. 1 - S of Inner harbor. Strongest in Winter & early Spring Also occurs in Summer and Autumn	a. E-SE'ly winds/waves - Although anchorage is the best of the three during such conditions, some wave energy could pass through the relatively narrow and shallow passage between Pointe de la Croisette and Ile Ste. Marguerite. May be accompanied by rain and thunderstorms and last for 18-24 hours.	a. Impact on anchored vessel wo to/from the anchorage would be a alternative for this situation. strong winds.
Occurs mainly in Winter, Spring, and Autumn Uncommon in Summer	b. S'ly winds/waves - Produces worst conditions for vessels in this anchorage position. Swell height may reach 8 to 10 ft (2.5 to 3 m) and last for 2 or 3 days. Swell direction may differ from wind direction by 45° to 90°.	b. Anchorage is exposed to full If swell and wind directions dif Moving to anchorage no. 2 is rec
Strongest in late Winter & early Spring Uncommon in Summer Also occurs in Autumn	c. Mistral winds/waves - May not significantly affect this anchorage position if vessel is far enough northward. Strong Mistral winds often blow only a mile or so to the west, likely the result of funneling through the La Beal and La Siagne Ravines. Wave generation would be minimal due to the lack of fetch.	c. Although vessel may not expe moving to anchorage no. 2 would aware of wind chill factor.

F... ...ations at the Port of Cannes, France - ALL SEASONS

...RY/	PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
anca... n th... or, ... ges...	...g through harbor entrance refract/reflect and ...hazardous conditions in the harbor. Since deep ...o not enter inner harbor, effect is limited to small ...ns to/from the anchorages.	a. A strong or strengthening high pressure cell over central Europe with a low pressure center south or southwest of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving north toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming north of the Atlas Mountains.
e m... ed. ... anch...	...hored vessel would be minimal, but small boat runs ...orage would be affected. Anchorage no. 1 is best ...this situation. Two anchors may be required in	a. A strong or strengthening high pressure cell over central Europe with a low pressure center south or southwest of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving north toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming north of the Atlas Mountains.
e of ... signi... ded.	...exposed to full f[illegible] of open-ocean conditions. ...directions differ significantly, ship may roll. ...ge no. 2 is recommended.	b. May be caused by low pressure systems moving into the Ligurian Sea or across Corsica into Italy. The early stages of cyclogenesis south of the Alps commonly result in SW'ly 30-40 kt winds in the region between the south French coast and Corsica. Swell waves seldom exceed 10 ft (3 m).
e si... de t...	...el may not experience significant heavy weather, ...ge no. 3 would provide better protection. Be ...ll factor.	c. Although the Mistral usually causes only minimal problems in the anchorage, it is prudent to be aware of forthcoming Mistral events. (1) Conditions which favor the formation of a Genoa low are conducive to the start of a Mistral at Marseille, and a strong Mistral may spread E to the coastal waters near Cannes. (2) The Mistral will start at Marseille when one of three pressure differences is achieved: Perpignan - Marseille, 3 mb; Marseille - Nice, 3 mb, or Perpignan - Nice, 6 mb. Such differences usually develops within 24 hr after a closed Genoa low appears, but it occasionally occurs earlier. (3) There is a rapid decrease in the frequency and average force of the Mistral east of Iles d' Hyères. On many occasions light E'lys are reported at Nice when strong NW'lys are blowing at Marseille. (4) For Mistral winds to affect Cannes, they will first be observed at Marseille/Toulon. Alongshore pressure gradient is important in predicting Mistral extent. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread east. With only a 2 mb difference between Marseille and Toulon, the Mistral will stop near Toulon. (5) The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy. (6) When fully established the Mistral is usually accompanied by clear skies. However, rain (or, in winter, rain and/or snow) and violent squalls commonly accompany the cold front which precedes the Mistral.

Table 3-2

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAUT
3. Anchorage no. 2 - N of Ile Ste. Marguerite. Strongest in Winter & early Spring Also occurs in Summer and Autumn Strongest in late Winter & early Spring Uncommon in Summer Also occurs in Autumn	a. Easterly winds/waves - Worst weather conditions for this anchorage. May be accompanied by rain and/or thunderstorms and last for 18-24 hours. b. Mistral winds/waves - Should not seriously affect this position. Winds may be moderately strong and gusty, but lack of fetch should significantly reduce wave height.	a. Anchorage is exposed to f Moving to anchorage no. 1 is b. Although vessel may not ex moving to anchorage no. 3 woul aware of wind chill factor.
4. Anchorage no. 3 - E of Pointe de la Croisette. Strongest in Winter & early Spring Also occurs in Summer and Autumn Occurs mainly in Winter, Spring, and Autumn Uncommon in Summer	a. E-SE'ly winds/waves - Worst weather conditions for this anchorage. May be accompanied by rain and/or thunderstorms and last for 18-24 hours. b. S'ly winds/waves - Anchorage position is fairly well protected from S'ly waves but wave energy may refract around east side of Ile Ste. Marguerite. Open ocean wave height may reach 8-10 ft (2.5-3 m).	a. Anchorage is exposed to ful Moving to anchorage no. 1 is r b. Although the anchorage is energy of S'ly waves, moving t protection.

(Table 3-2. (Continued)

AR	PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
orc nend	... exposed to full force of open-ocean conditions. ...age no. 1 is recommended.	a. A strong or strengthening high pressure cell over central Europe with a low pressure center south or southwest of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving north toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming north of the Atlas Mountains.
nc vi	...ssel may not experience significant heavy weather, ...age no. 3 would provide better protection. Be ...ill factor.	b. Although the Mistral usually causes only minimal problems in the anchorage, it is prudent to be aware of forthcoming Mistral events. (1) Conditions which favor the formation of a Genoa low are conducive to the start of a Mistral at Marseille, and a strong Mistral may spread E to the coastal waters near Cannes. (2) The Mistral will start at Marseille when one of three pressure differences is achieved: Perpignan - Marseille, 3 mb; Marseille - Nice, 3 mb, or Perpignan - Nice, 6 mb. Such differences usually develops within 24 hr after a closed Genoa low appears, but it occasionally occurs earlier. (3) There is a rapid decrease in the frequency and average force of the Mistral east of Iles d' Hyères. On many occasions light E'lys are reported at Nice when strong NW'lys are blowing at Marseille. (4) For Mistral winds to affect Cannes, they will first be observed at Marseille/Toulon. Alongshore pressure gradient is important in predicting Mistral extent. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread east. With only a 2 mb difference between Marseille and Toulon, the Mistral will stop near Toulon. (5) The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy. (6) When fully established the Mistral is usually accompanied by clear skies. However, rain (or, in winter, rain and/or snow) and violent squalls commonly accompany the cold front which precedes the Mistral.
ce nde	... exposed to full force of open-ocean conditions. ...age no. 1 is recommended.	a. A strong or strengthening high pressure cell over central Europe with a low pressure center south or southwest of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving north toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming north of the Atlas Mountains.
te ora	... anchorage is protected from most of the direct ...aves, moving to anchorage no. 2 would afford better	b. May be caused by low pressure systems moving into the Ligurian Sea or across Corsica into Italy. The early stages of cyclogenesis south of the Alps commonly result in SW'ly 30-40 kt winds in the region between the south French coast and Corsica. Swell waves seldom exceed 10 ft (3 m).

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PRECAU
5. Arriving/departing Strongest in Winter & early Spring Also occurs in Summer and Autumn	a. Easterly winds/waves - May create difficult conditions for arriving vessels. Anchorage no. 1 is only viable position, and boating to/from inner harbor may not be feasible. Heavy weather may exist on open sea. May be accompanied by rain and thunderstorms and last for 18-24 hours.	a. Utilization of anchorage vessels. Outbound vessels s
Occurs mainly in Winter, Spring, and Autumn Uncommon in Summer	b. S'ly winds/waves - Waves limit anchorage options to positions 2 or 3, with position 2 being favored. Boating to/from inner harbor may not be feasible. Heavy weather may exist on open sea, with waves to 8 to 10 ft (2.5 to 3 m).	b. Inbound vessels should c unavailable, then no. 3. Ou weather.
Strongest in late Winter & early Spring Uncommon in Summer Also occurs in Autumn	c. Mistral winds/waves - While anchorage position no. 3 is well protected, and no. 1 and no. 2 are only moderately affected by Mistral winds, inbound and outbound units will experience heavy weather at sea once the lee of the land is not a factor.	c. Inbound vessels should u vessels should prepare for h factor.

Table 3-2. (Continued)

T - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
ation of anchorage no. 1 is recommended for inbound Outbound vessels should prepare for heavy weather.	a. A strong or strengthening high pressure cell over central Europe with a low pressure center south or southwest of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving north toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming north of the Atlas Mountains.
d vessels should opt for anchorage at no. 2.If 2 is e, then no. 3. Outbound vessels should prepare for heavy	b. May be caused by low pressure systems moving into the Ligurian Sea or across Corsica into Italy. The early stages of cyclogenesis south of the Alps commonly result in SW'ly 30-40 kt winds in the region between the south French coast and Corsica. Swell waves seldom exceed 10 ft (3 m).
d vessels should utilize anchorage no. 3. Outbound ould prepare for heavy weather. Be aware of wind chill	c. Although the Mistral usually causes only minimal problems in the anchorage, it is prudent to be aware of forthcoming Mistral events. (1) Conditions which favor the formation of a Genoa low are conducive to the start of a Mistral at Marseille, and a strong Mistral may spread E to the coastal waters near Cannes. (2) The Mistral will start at Marseille when one of three pressure differences is achieved: Perpignan - Marseille, 3 mb; Marseille - Nice, 3 mb, or Perpignan - Nice, 6 mb. Such differences usually develops within 24 hr after a closed Genoa low appears, but it occasionally occurs earlier. (3) There is a rapid decrease in the frequency and average force of the Mistral east of Iles d' Hyères. On many occasions light E'lys are reported at Nice when strong NW'lys are blowing at Marseille. (4) For Mistral winds to affect Cannes, they will first be observed at Marseille/Toulon. Alongshore pressure gradient is important in predicting Mistral extent. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread east. With only a 2 mb difference between Marseille and Toulon, the Mistral will stop near Toulon. (5) The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy. (6) When fully established the Mistral is usually accompanied by clear skies. However, rain (or, in winter, rain and/or snow) and violent squalls commonly accompany the cold front which precedes the Mistral.

VESSEL LOCATION/SITUATION	POTENTIAL HAZARD	EFFECT - PREC
6. Small boats Strongest in Winter & early Spring Also occurs in Summer and Autumn	a. <u>E-SE'ly winds/waves</u> - Worst weather situation for small boats in/out of inner harbor. Waves pass through harbor entrance and create dangerous operating conditions. May be accompanied by rain and thunderstorms and last for 18-24 hours.	a. Dangerous operating boat operation. Boatin dangerous situation dev
Occurs mainly in Winter, Spring, and Autumn Uncommon in Summer	b. <u>S'ly winds/waves</u> - Makes small boat operation between the inner harbor and anchorages hazardous if not impossible due to exposed water areas outside harbor entrance. Open ocean waves may reach 8-10 ft (2.5-3 m).	b. While inner harbor outside the harbor entra anchorages.
Strongest in late Winter & early Spring Uncommon in Summer Also occurs in Autumn	c. <u>Mistral winds/waves</u> - Could raise a dangerous chop if wind direction has a direction which provides adequate fetch.	c. Small boat operation unaffected, but runs to/ the wind has a strong W 3 could be hazardous if anchorage no. 1 would be
Uncommon in Winter Most common in Summer Also occurs in Autumn and Spring	d. <u>Sea breeze</u> - Not a major problem, but may impact boat runs to/from the anchorages during afternoon hours.	d. Waves raised by the anchorages uncomfortable be minimized by making ru the afternoon.

Table 3-2. (Continued)

...ECT - PRECAUTIONARY/EVASIVE ACTIONS	ADVANCE INDICATORS AND OTHER INFORMATION ABOUT POTENTIAL HAZARD
...gerous operating conditions inside harbor may preclude safe ...eration. Boating should be cancelled if a potentially ...s situation develops.	a. A strong or strengthening high pressure cell over central Europe with a low pressure center S or SW of the French Riviera can create the wind/waves at Cannes. May be caused by low pressure systems moving N toward the Ligurian Sea or Gulf of Lion after passing through the Strait of Gibraltar or forming N of the Atlas Mountains.
...e inner harbor operations should remain safe, conditions ...the harbor entrance may preclude runs to/from the ...es.	b. May be caused by low pressure systems moving into the Ligurian Sea or across Corsica into Italy. The early stages of cyclogenesis S of the Alps commonly result in SW'ly 30-40 kt winds in the region between the S French coast and Corsica. Swell waves seldom exceed 10 ft (3 m).
...l boat operation near the lee shore should remain largely ...ed, but runs to/from the anchorages could be jeopardized if ...has a strong W to NW component. Runs to anchorages 2 and ...be hazardous if the wind direction is N to NE, while ...e no. 1 would be largely unaffected.	c. Although the Mistral usually causes only minimal problems in the anchorage, it is prudent to be aware of forthcoming Mistral events. (1) Conditions which favor the formation of a Genoa low are conducive to the start of a Mistral at Marseille, and a strong Mistral may spread E to the coastal waters near Cannes. (2) The Mistral will start at Marseille when one of three pressure differences is achieved: Perpignan - Marseille, 3 mb; Marseille - Nice, 3 mb, or Perpignan - Nice, 6 mb. Such differences usually develops within 24 hr after a closed Genoa low appears, but it occasionally occurs earlier. (3) There is a rapid decrease in the frequency and average force of the Mistral east of Iles d' Hyères. On many occasions light E'lys are reported at Nice when strong NW'lys are blowing at Marseille. (4) For Mistral winds to affect Cannes, they will first be observed at Marseille/Toulon. Alongshore pressure gradient is important in predicting Mistral extent. When a 10 mb difference exists between Toulon and Nice, the Mistral will spread east. With only a 2 mb difference between Marseille and Toulon, the Mistral will stop near Toulon. (5) The eastern boundary of the Mistral extends downwind from the western edge of the Alps through San Remo, Italy. (6) When fully established the Mistral is usually accompanied by clear skies. However, rain (or, in winter, rain and/or snow) and violent squalls commonly accompany the cold front which precedes the Mistral.
...s raised by the wind could make boating to/from the ...s uncomfortable outside the harbor entrance. Effect could ...zed by making runs in morning or evening instead of during ...noon.	d. Occurs on warm days, reaching force 4 or 5 (11-16 or 17-21 kt) from the SW at 1400-1500L.

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PORT VISIT INFORMATION

JUNE 1986. NEPRF meteorologists R. Fett and R. Picard met with Port Captain Mr. Levitre to obtain much of the information used in this port evaluation.

APPENDIX A

General Purpose Oceanographic Information

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

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

A.1 Definitions

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

A.2 Wave Spectrum

Wave characteristics are best described by means of their range of frequencies and directions or their 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 a given state of wave development, each spectrum has a band of frequencies where most of the total energy is concentrated. As the wind speed increases the range of significant frequencies extends more and more toward lower frequencies (longer periods). The frequency of maximum energy is given in equation 1.1 where v is the wind speed in knots.

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

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

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

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

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

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

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

A.4 Wave Conditions Within The Fetch Region

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

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

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

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

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

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

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

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

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

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

WIND FORECAST OR CONDITION

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

SEA FORECAST OR CONDITION

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

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

A.5 Wave Climatology

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

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

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

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

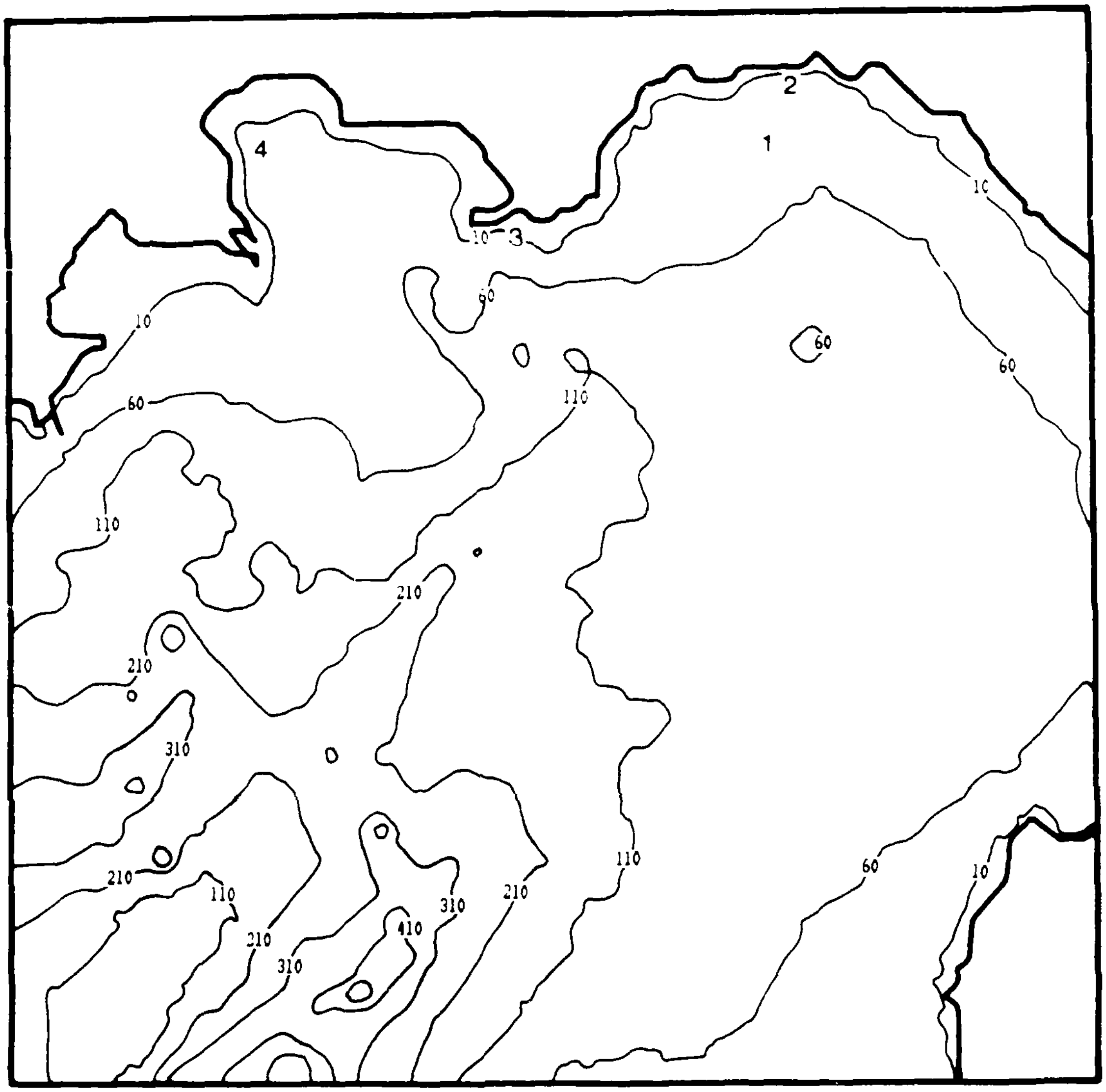

Figure A-1. Example plot of bathymetry (Naples harbor) as used in this project. For plotting purposes only, contours are at 50 fathom intervals from an initial 10 fathoms to 110 fathoms, and at 100 fathom intervals thereafter. The larger size numbers identify specific anchorage areas addressed in the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

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