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Guide to Marine Meteorological Services .....

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TITLE PAGE

Guide to Marine Meteorological Services

WMO-No. 471

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EDITORIAL NOTE

METEOTERM, the WMO terminology database, may be consulted at:
http://www.wmo.int/pages/prog/lsp/meteoterm_wmo_en.html.
Acronyms may also be found at:
http://www.wmo.int/pages/themes/acronyms/index_en.html.

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	1.1	All	NM, TG	Integration of NM's initial comments. Ch. 4 (Coast and Offshore) moved in.
	1.2	All	TG	Integration of Ch. 2 (High Seas) moved in. Re-organized into sections; numbered appropriately.
	1.3		NM	Major re-write
	1.4		NM	Consolidation of reviewer's comments

CONTENTS

GUIDE TO MARINE METEOROLOGICAL SERVICES ....

INTRODUCTION

Weather information has always been vital for the safety and efficient operation of marine industries, particularly transport and fishing.

Early in the twentieth century wireless telegraphy allowed regular communication between ship and shore and weather broadcasts to shipping began. The First International Convention for the Safety of Life at Sea (SOLAS) called for the coverage of all shipping lanes and fishing grounds with weather information to be broadcast by radio; governments agreed to share responsibilities for these broadcasts over the oceans. The late twentieth century saw advances in radio technology, such as narrow-band direct printing, digital selective calling and satellite broadcasting. These techniques are used in the Global Maritime Distress and Safety System, inaugurated in 1992 following the amendment of the International Convention for the Safety of Life at Sea. This requires continued international cooperation and uniformity of presentation of the information provided.

Climatological information has always been in demand from the marine community. Two global centres for the collection of climatological data derived from observations from ships were established in 1993.

The availability of marine forecasts and warnings to mariners in coastal waters are vitally important to the ability of National Meteorological Services to meet the principles of the SOLAS convention.

The internationally agreed methods of providing services to the marine community around the world are described in the *Manual on Marine Meteorological Services* (WMO-No. 558). The purpose of this *Guide* is to complement the *Manual* by:

(a) Describing the requirements for the various types of service;
(b) Explaining the rationale for the agreed methods of providing services; and,
(c) Giving guidance on how to go about setting up and maintaining marine meteorological services.

It follows the same structure as the *Manual on Marine Meteorological Services* and cross references are provided to relevant sections of the *Manual.*

1. MARINE METEOROLOGICAL SERVICES

1.1 GENERAL

Broadly speaking, marine meteorological services have two functions:

(a) To serve international shipping, fishing and other marine activities on the high seas; and,
(b) To serve the various activities which take place in coastal and offshore areas, ports and on the coast.

A marine meteorological programme embraces a wide range of activities. In the preparation of analyses, synopses, forecasts and warnings, knowledge is required of the present state of the atmosphere and the ocean surface, as well as the climate of the region. In addition, other types of forecasts which refer to special elements and phenomena, such as waves, storm surges, sea ice and ice accretion must be based on relevant observational data.

With such a strong dependence on observational data, the recruitment of voluntary observing ships and the training of shipboard and shore personnel in observing techniques comprises an important component of any marine meteorological programme. Additionally, the development of marine communication systems, along with the distribution, reception, and archiving of observations, must also be considered as a major component of a marine meteorological programme. These two components in combination thus enables the two aforementioned functions of a marine meteorological service to be fully supported and implemented.

Each part of a marine meteorological programme should also incorporate a monitoring system so that the programme can be evaluated at regular intervals. Monitoring is necessary to ensure that the services provided continue to meet the requirements of users.

1.2 ORGANIZATION OF MARINE METEOROLOGICAL SERVICES

1.2.1 General

Although a National Meteorological Service (NMS) may be organized in various ways, a general approach (based on the *WMO Strategy for service delivery and its implementation plan (WMO-No. 1129*) to the implementation of marine meteorological services can be recommended as follows:

(a) Consult the *WMO Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (*WMO-No. 1100*)", and consider how the principles of the framework could be applied;
(b) Develop and carry out programmes for the training and competency assessment of marine meteorologists and technical support personnel;
(c) Consider the types of weather sensitive marine activities such as:
    (i) Fisheries;
    (ii) Recreational boating;
    (iii) Pollution;
    (iv) Hydrofoil, hovercraft or similar services;
    (v) Oil drilling and exploration;
    (vi) Coastal structures vulnerable to high waves;
    (vii) Harbours subject to seiches and other water level changes;
    (viii) Coasts vulnerable to erosion or rising sea levels;
(d) Contact users and in consultation with them identify their requirements. Users usually include:

- Government department for fisheries;
- Recreational boating organizations;

- Fishing organizations;
- Authorities responsible for safety of life at sea, including coastal waters;
- Authorities responsible for combatting marine pollution;
- Operators of ferry, hydrofoil, hovercraft or similar services;
- Oil drilling and shipping companies;
- Authorities responsible for protection of the coastal populations from, among others, storm surges, high waves, tsunamis; and,
- Harbour control authorities;

(e) Design a service programme to provide information and products in formats that satisfy the requirements (including review of other products provided by other national meteorological services);
(f) Determine the need for any additional data and processing facilities necessary for the preparation of these service products and arrange for their acquisition (including establishment of voluntary observing ships;
(g) Arrange for the provision of service products through appropriate communication platforms;
(h) Arrange for a monitoring system to ensure that service products meet the requirements and continue to do so;
(i) Arrange for the collection and checking of meteorological records, the processing of marine climatological data and the identification of statistical tabulations to be supplied;
(j) Arrange for weather observations from ships and vessels.
(k) Identify requirements for additional research into:

  (i) Forecast techniques;
  (ii) Marine weather and ocean hazards;

(l) Ensure adequate representation of the National Meteorological Service in organizations, both national and international, in efforts to improve marine services;
(m) Ensure that adequate attention is given to meteorology and elements of physical oceanography in marine navigation schools.

1.2.2 Marine components of the WMO Global Data Processing and Forecasting System (GDPFS)

The WMO Global Data Processing and Forecasting System (GDPFS) provides a framework to support service delivery in National Meteorological Services. Members can access information from Global, Regional or Specialized Centres through the WMO Information Service. For marine forecasting, there are Centres for Wave modelling, Ocean Modelling, Numerical Weather Prediction and Tropical Cyclones. The *Manual on the WMO Global Data Processing and Forecasting System (WMO-485)* provides more specific details.

1.2.3 Service Evaluation

Service evaluation is an important requirement of the WMO Quality Management framework and Service Delivery. Service evaluation can be undertaken through:

- conversation with stakeholders;
- periodic surveys of marine users;
- measurement of performance metrics;
- review of feedback;
- benchmarking against other service providers.

Calculation of performance metrics and reporting on these performance metrics to stakeholders and clients provides accountability and transparency for the forecast and warning services provided. The following list provides guidance on useful metrics:

- Reliability of wind – calculated as the percentage of wind forecasts within 5 knots of the observed.
- Reliability of waves and sea state – calculated as the percentage of wave forecasts within 1 metre of the observed.
- Reliability of wave period - calculated as the percentage of wave period forecasts within 2 seconds of the observed.
- Success and misses for wind warnings in areas with adequate observations, such as ports and harbours.
- Success and misses for position of tropical cyclone warnings.

1.2.4 Stakeholder Engagement

It is important to provide only those services which are required, as there is no point in providing services for which there is little, if any, demand. Meteorological Services should establish consultation forums with relevant groups such as port and harbour authorities, ships' masters, pilots, dockyard personnel, port works engineers, container terminal and warehouse operators, shipping companies and insurance companies. Based on these consultations, the Meteorological Service will be able to formulate the procedures to provide services of a general nature catering for the majority of the user groups, or of a specialized nature tailored to meet any particular need of an individual user group or both types of service.

Major changes in the issue, form and content of the bulletins, or the discontinuance of a bulletin, should be announced by members well before the effective date of change to enable all users to be notified in time.

1.2.5 Education and communication with users

There is a reference in the SOLAS convention (Chapter V, Regulation 34, and within Annex A.24 Voyage Planning) about how vessels should prepare for their trip and route. The Annex specifically outlines to small vessels the importance of:

- checking the weather forecast for the journey;
- knowing the tides;
- knowing the vessel limitations for the expected weather and wave conditions.

Meteorological services should develop educational material that builds on the principles of boating and weather planning outlined in the SOLAS convention. The material should emphasize the risks associated with weather and wave conditions, and the relationship between meteorological service capability and consequences of weather impacts. For example, the likelihood of getting caught out by hazardous conditions may become lower due to improved weather forecast services, but the consequences are still high if you get caught out and into trouble.

Meteorological Services should educate mariners that not all weather developments can be predicted far in advance. Although the forecast may be favourable when they set out, they still need to listen for warnings which may be issued of imminent adverse weather.

An education programme using clear webpages and publications may be needed to educate mariners on the weather-related hazards they may face. Training courses may be run in conjunction with the rescue authorities who have to take action when these craft get into trouble.

1.3 SERVICE DESIGN CONSIDERATIONS

1.3.1 Information formats

Weather information may be provided in a number of formats to meet user requirements. The main formats include:

- Map
- Text
- Voice
- Table

Depending on the dissemination constraints for a marine user, the need to develop products in all formats may not be required. The following descriptions outline some of the benefits and constraints for each format.

- Map displays provide highly detailed information across defined spatial domains, and if provided as a time sequence, a user can study the evolution of the weather and ocean elements during specific time periods.
- Text products provide short summaries and broader detail for a defined area and time period. These text products may be simpler to interpret for most users, and can be used for marine radio broadcasts. Text products generally have a small file size for internet dissemination to mariners at sea.
- Voice products may be transmitted as audio or by video accompanied by other formats. There may be time limits imposed for radio broadcasts, and consideration should also be given to the reception quality on board vessels and impact on a mariner’s ability to interpret the information whilst doing other duties if the broadcast is too long. These constraints have an impact on the information provided in the text product that it is based on.
- Information displayed as a table is usually for a specific location, so a user will get the benefit of detailed information over a period of time for that location but may lose context of what is happening over nearby areas.

1.3.2 Dissemination Options

Consideration of the dissemination methods to reach each marine sector is important when designing a service. Some products may not be suitable for delivery to mariners operating well-offshore with communication constraints. The following list of dissemination options provides a guide:

Well-offshore (i.e. Sea Area A3, Sea Area A4)

- SafetyNet satellite transmissions
- HF NBDP
- HF radio voice services
- HF radiofax graphical services
- Internet delivered by satellite providers

Coastal areas (Sea Area A1, Sea Area A2)

- VHF/MF radio
- Navtex
- International Navtex
- Internet delivered by mobile network provider

Ports, coastlines and land-based support operations

- Internet

Internet services via satellite providers may be very expensive at sea. Consideration should be made in keeping webpage sizes to a minimum. It may be valuable to mariners that an NMHS provides a website to display simple text only versions of the products for low cost and quick download.

Mariners planning their trip may use a desktop computer or a mobile device to access internet services. Mariners operating within mobile phone coverage may also access the internet services using a mobile device or laptop. Consideration should be made to the design and layout of the information for various sized devices. Mobile phones have compact displays, whilst laptops and larger screen devices have more room to display information.

Another option is to provide a subscription based service to receive products via email, using internet or marine radio transfer platforms, for display on devices whilst at sea. The subscription service would provide small file sizes for download at sea.

Some mariners plan their activities for the next day based on television weather bulletins or AM/FM radio programs. It is important to establish relationships with media presenters to emphasize the important components of the NMS marine service. This will help ensure that mariners are receiving the same messages about weather-related hazards through all channels.

1.3.3 Consideration of time and area requirements

The service design and delivery of marine weather services should take the following characteristics into account:

- The amount of detail required for today and tomorrow versus the next few days
    - For today and tomorrow, mariners will generally require more specific details about the time of arrival of wind changes, sea-breezes, thunderstorms. This information may be presented as specific hours of the day, time periods of 2 to 6 hours, or sub-sections of the day.
    - For the next few days, mariners will generally require details about changes to wind, wave, sea-ice and weather conditions in broader time descriptors to account for uncertainty in the forecast and also their own planning detail. This information may be presented as time periods of 6 or 12 hours.

- The area coverage of the forecasts and warnings

    - Mariners often traverse large sections of the coastline or specific shipping lanes, and weather patterns can vary across coastline sections and from the coast to well offshore. It is important to cover all areas of the coastal waters with a weather service that may be used for shipping routes (to comply with SOLAS Chapter V Regulation 34).
    - It is important to consider how the forecast area can be defined, and any sub-areas to match vessel activity and density. The understanding of these areas is important for mariners reading the text forecast or listening to the forecast on marine radio.
    - The size of the forecast area is an important consideration on the amount of specific meteorological detail that can be described to match the requirements of mariners.

1.4 USER REQUIREMENTS

1.4.1 General

In general, the impact which could result from a meteorological condition depends on its severity and on the sensitivity of a particular activity or operation to that condition. Similarly, meteorological phenomena can make recreational activities and the work of fishing and shipping fleets much more difficult or hazardous.

Marine operations are sensitive to environmental conditions. Generally, extreme values of waves, wind and obstructions to visibility increase the risk to the safety of the vessel or sea structure and to the persons involved in the operation. Less extreme values, even if safety is not threatened, will affect the efficiency, effectiveness or comfort of the operation. The usefulness of a warning or a forecast depends on the accuracy of the prediction, the format and communication platform that the information is delivered, its timeliness, i.e. the number of hours or days in advance of the event that the forecast can be provided, and the ability of the user to react to the information.

For each major user group there may be significant differences in their requirements and importance of each element to their operations; the details of desired forecast; and the time required to take action based on this information. This is important information for service providers to base the design of their services on.

1.4.2 Provision of marine climatological information

The requirements for marine climatological data involve a number of activities ranging from shipping, to planning offshore mining and coastal infrastructure, to monitoring services. Climatological information can be collated into in chart, graphic and statistical form.

1.4.3 Specialized services

Meteorological Services may be requested to provide a special forecast service, either as a regular activity or to assist in a given operation at sea or on the coast. Regular services may be for a segment of the community or a large number of users, e.g. recreational boating, heavily congested shipping areas, surf beaches, fishing grounds; or they may be for specific commercial purposes, e.g. oil drilling platforms, hovercraft or hydrofoil services. Services may be required for a limited period, e.g. for construction activity on or just off the coast, or for a yacht race.

Services provided to a specific organization are usually done so on a commercial basis, whereby the precise service to be provided and the associated charges are negotiated with the client.

1.5 REQUIREMENTS FOR EACH SERVICE ELEMENT

1.5.1 Wind

Information about wind is generally considered to be the most important element to a mariner. Mariners are concerned with changes in wind speed and direction throughout the day, and for the area they are travelling through or operating within.

Critical wind speeds are sometimes lower for smaller craft than for commercial shipping. Smaller vessels are sensitive to gustiness and wind shifts as well as mean wind speed.

Depending on the special national requirements, information about lower wind speeds are important for small vessels and leisure craft. Some vessel operators restrict operations when winds exceed 15 or 20 knots, due to the development of wind waves and potential discomfort and safety of crew and passengers.

When determining warning thresholds for national requirements, the frequency of certain wind speeds needs to be considered. For example, warnings of wind speeds which are encountered on most days, will be issued so frequently as to lose their effectiveness.

The wind may exert considerable force on a structure such as a drill rig or vessel. Since the force exerted is proportional to the square of the wind speed, extreme winds are especially critical. High winds also create dangerous working conditions for personnel on exposed decks. Wind impacts on exploration platforms with respect to flaring, cargo handling, the helideck, module access and general deck operations.

The identification of a seabreeze developing along the coast is important for coastal and inland communities due to its cooling effects and improvement of human comfort levels, or even the possible development of thunderstorms along the seabreeze edge.

1.5.2 Waves

Wave information is generally the second most important element behind wind.

Information about total wave heights (the combination of swell waves and wind waves), and the individual wave components – swell waves and wind waves are of importance to a wide range of users. Consideration should be given to providing information about multiple swells of significant size as this swell information is useful for vessels and coastal activities.

Wind waves have significant effects on the headway vessels can make, how fast fish can be found and caught, how productive loading and unloading operations are, and on the transfer of fishing catches to factory ships and other operations. For example, the safety regulations on vessels of the former Soviet fishing fleet stipulated that when wind speeds reach 15 m/s or when wave heights are over 4 m, SRT-type vessels (medium fishing trawlers) should cease to make way or should stay in port.

Wind waves, especially high waves with short periods (a choppy sea), and to a lesser extent long swell, can be a danger to these small craft. In shallow water areas (lakes, island reefs), the wind wave behavior and short wavelength are particularly dangerous, due to reduced stability, to the short length, flat bottom vessels that commonly operate in these areas. Near the coast, where these boats generally operate, wind waves also depend on the irregularity of the coastline, the water depth, and surface currents or tidal streams. Combinations of strong currents, high waves and high winds may create hazardous conditions for rigs and vessels.

For large vessels, information about waves less than two metres high is normally not of concern. Smaller vessels will be concerned with all wave heights. Small vessels on lakes are vulnerable to being swamped by small wave heights with short wave periods.

The rapid arrival of a significant swell train may cause problems to port operators moving vessels into and out of port, and also for vessels who may not be able to take necessary preparatory steps in time. Rapid changes in swell conditions pose direct risks to vessel structural integrity due to enhanced loading on the vessel structure, risks to vessel stability and deck operations due to crew unpreparedness.

Some harbours become difficult of access if high seas and swells are running outside. Tourist resorts with surf beaches may need information about dangerous high swell.

The direction of wave patterns is also of concern to large vessels for fuel consumption management and ship handling. Some large vessels will find ship handling difficult when the swell direction aligns with their direction of travel and the swell height is over 4 metres. Wave breaking is also a major cause of damage at sea. High waves with very deep valleys may be called "freak or rogue waves" because they are dangerous to shipping in terms of direct risks to vessel structural integrity due to enhanced loading on the vessel structure. They are generally caused when waves move against a sea current.

Some coastal and island areas may be commonly influenced by two swell trains, and information about each individual swell train provides useful information for ports, vessels and coastal users. Information on swell systems which are crossing other systems of wind waves is also important as the confused state of the sea increases risks to vessel stability and crew operations at elevated heights.

Offshore drilling platforms are generally engineered to withstand extreme wave heights and wave periods that may be expected on average in a period of exceeding hundreds of years (i.e. very rare but statistically and physically possible). As such, companies will require information about extreme wave height and period, particularly associated with tropical cyclones or intense low pressure systems. For some oil operation purposes a complete directional spectral representation of the waves is required.

1.5.3 Wave period

Certain structures (coastal and offshore oil operations) are vulnerable to certain wave periods than others. Wave period can restrict ship handling of large vessels for long period swells, and can also cause smaller vessels to be swamped for shorter period waves. Long period swells enhance the risks for deck operations at elevated heights. Coastal foreshores may be eroded during long period swells with high energy.

Harbour Masters may close port entrances or deploy additional tugs to safely transit ships into and out of port during long period swell events. Some ports may be affected by the combined effects of wave direction and long period swell.

1.5.4 Surf and Breakers

High breaking waves can cause damage to structures built near the sea and cause coastal erosion. Surf forecasts may be required for popular surfing beaches. A prediction should include maximum height and direction of breakers, together with the wind and tides which affect the way the waves break. When high breakers are predicted, lifeguard stations may assign additional personnel or close the beach.

1.5.5 Visibility

Poor visibility is a major hazard to all vessels because of the increased danger of collision. Visibility less than two nautical miles, although not typically hazardous for most shipping operations during the day, nonetheless reduces to some degree the mariner’s ability to maneuver safely. Visibility less than one mile, however, poses a hazard to navigation and marine operations such as fishing. For visibility less than half a mile, safe navigation will require vessels to significantly reduce forward speed, or even come to a complete stop until visibility improves. In visibility approaching near-zero, it is hazardous not only for any moving vessels, but also for vessels at anchor or lying to. Reduced visibility can also increase the risk of collision between vessels, drill rigs and icebergs.

Fog and mist are the most common causes of reduced visibility, but snow, thick haze, smoke and heavy rain can also constitute a hazard. The visibility limit requiring a warning should be determined in consultation with users.

1.5.6 Cloud and Precipitation

Information about cloud cover and sunshine are an important consideration for recreational and leisure boaters in deciding whether to go boating. Generally more leisure vessels will be on the water during sunny conditions. Information about precipitation is important for recreational boating for passenger comfort, whilst heavy precipitation may significantly reduce visibility for all marine operations.

1.5.7 Thunderstorms and Squalls

Ships traversing shipping lanes are especially vulnerable to sudden changes in the weather associated with thunderstorms and violent cold fronts. The rapid development and movement of these phenomena make them an extreme hazard. Large container vessels and cruise ships in port and dense shipping lanes are particularly vulnerable to squalls and sudden thunderstorm gusts due to the long and high sides of these vessels.

Many vessels in coastal waters, particularly small craft, are vulnerable to squalls from thunderstorms and squall lines, waterspouts, and severe lightning.

The lightning associated with thunderstorms can be dangerous, since the masts and derricks tower above the water surface. Both heavy rainfall rates and lightning can cause disruption of radio transmissions. Lightning poses a serious hazard to aircraft operations, and may create problems at a drill rig if gas is being burned off at the time. Lightning would also be a serious hazard to exposed personnel in the water.

Rainfall, in general, is not a serious problem, although low visibility may result and decks may become slippery. Also, discomfort or hypothermia may result from wet clothing. Intense rainfall associated with thunderstorms, however, may cause equipment and cargo to be flooded if the drainage design is inadequate.

1.5.8 Air Temperature

Extreme temperatures, either warm or cold, can reduce the efficiency and accident-avoidance capability in workers exposed to the elements, due to incipient hypothermia or, at the other extreme, heat stroke. Heating, cooling and ventilating the working and living space is important, not only for the well-being of personnel, but also for the operation of electronic control facilities. Air temperature is also a contributing factor to wind chill and spray icing.

1.5.9 Sea temperature

Minimum, maximum and variability of sea-surface temperature (SST) and temperature gradient are important in the selection of materials for equipment used in drilling operations, since many materials lose much of their strength and toughness in very cold or very warm conditions.

Because of the risk of hypothermia, a very cold sea temperature is the critical limit for survival of personnel in the water, without adequate protection. For example, the survival time of a person in water of zero degrees centigrade is of the order of less than 10 minutes.

Water temperature plays an important factor for coastal leisure activities. It also is important for management of fisheries.

1.5.10 Ocean Currents

Information on ocean currents is used in navigation, fishing operations and search and rescue operations. The currents also have an impact on the movement of powered and sailing vessels. Fuel consumption management is an important cost factor for marine transportation companies, and details of ocean and tidal currents are a key variable. Knowledge of currents is also particularly vital in modelling the movement of possible oil spills and other contaminants.

Water currents in association with surface winds play a significant role in the movement of sea ice and icebergs.

Bottom currents are of concern for sea-bed pipelines as they can cause sediment washouts resulting in unsupported pipelines, which consequently become overstressed.

1.5.11 Rip Currents

The interaction of waves breaking along shorelines and near headlands or other coastal structures can cause rip currents. Rip currents carry water away from the shore, therefore posing a hazard to swimmers. Local lifeguard stations are best placed to identify the potential risk of rip currents due to existing beach characteristics and wave heights, wave direction, tide and wind conditions.

1.5.12 Storm Induced Water Level Changes and Seiching

These variations in water level are of great concern for the design of some coastal facilities, and for the operation of shipping in shallow waters. Storm surges and resulting flooding have caused considerable damage and loss of life in coastal communities. Governments may activate community action plans for coastal defence measures and possible evacuation of the population in areas affected.

The most common and most dangerous storm- induced water level change is the storm surge generated by a tropical cyclone. Storm surges can also be generated by intense extra-tropical depressions, particularly when the sea is being driven along a narrowing gulf. Lives are more often lost in the flooding of low-lying coastal areas from a storm surge than lost from the destructive winds of the cyclone itself. The low atmospheric pressure itself will cause a rise in water levels.

Government agencies will generally require the time and height of the maximum water level when the surge is expected to arrive. A storm surge arriving at low tide will cause less damage than one at high tide.

Harbour seiches may lead to irregular ship movements, making berthing difficult and increasing the danger of collisions. Abnormally low water levels due to the effects of wind stress — so-called negative surges — may affect marine operations in coastal areas, estuaries or at entrances to harbours. Information is also needed about such deviations in water-level.

1.5.13 Tides

Tide predictions are generally provided for the lunar influenced tides. Times of the high and low water level and height for the current day and next few days provide important planning information for vessels and coastal engineers.

1.5.14 Ice Accretion

The accumulation of ice on the superstructure and deck equipment of vessels, even large ones, may seriously affect safety and operational efficiency. Icing on aerials, for example, may make radio and radar equipment inoperative. On small vessels icing presents a much greater hazard. The weight of ice reduces freeboard and stability, and in storm conditions leads to a risk of capsizing. Fishing vessels operating in polar seas are especially vulnerable; supercooled drops of rain, drizzle or fog droplets create hazardous working conditions.

Warnings of ice accretion are given when the forecast wind force is Beaufort force 6 or more, the water temperature less than 2°C, and the air temperature well below freezing. Most cases of icing occur with high wind speeds producing sea spray or when vessels are shipping water. 'Black frost' resulting from supercooled water droplets (fog) is less frequent but far more dangerous, as the developing ice is compact and very adherent. Black frost is commonly observed with strong winds, fog, low air temperatures and relatively high water temperatures.

The planning of icebreaking operations in ports and port approaches is dependent on forecasts of wind, temperature, wave and swell conditions. Severe storms with strong winds and spray in conditions of negative air temperature may lead to rapid ice accretion and cause ships to sink.

1.5.15 Freezing spray

Freezing spray is the most dangerous form of icing encountered at sea, and accounts for around 90 per cent of ship icing reports. Spray ice can accrete at rates in excess of several centimetres per hour, and is difficult to remove because of its hardness and strong adhesion. Vessels usually generate most spray when headed into the waves, and minimum spray when running with the waves.

Vessel size is also an important factor in icing rates as the average liquid water content of wave-generated spray decreases exponentially with elevation. Most of the spray is confined in a 5-10 m range above sea-level, which means smaller vessels are exposed to considerably more spray than large ships or drilling platforms,

1.5.16 Sea Ice

Ice conditions not only hamper navigation, but can occasionally lead to damage to vessels. Sea ice can present a hazard to all classes of shipping. Vessels approaching or passing through icy regions must reduce speed, which increases costs and reduces overall voyage efficiency. Ship classifications and hull designs are based on the amount, type and thickness of ice through which a ship can safely navigate. .

Stationary structures (drill rigs and platforms) which operate in ice-infested waters must also be designed to withstand ice movement and crushing forces. Ice jamming can occur. causing bridge and harbor damage and flooding.

The most important features of sea ice which affect marine operations are:

(a) the amount of ice present, I.e. concentration usually measured as tenths of the sea surface covered by ice;
(b) ice thickness, referred to as stage of development which is related to ice age;
(c) form of ice, i.e. whether it is fast ice or pack ice, floe size, and the amount of ridging; and
(d) ice movement.

1.5.17 Icebergs

Icebergs are a major hazard for navigation. Collision may occur in limited visibility or in stormy weather with snowfall.

The position of icebergs at specified times are required with information about their estimated size; and speed and direction of movement. During the ice season the south-eastern, southern and south-western limits of regions of icebergs in the vicinity of the Grand Banks of Newfoundland are monitored for the purpose of informing passing ships of the extent of this dangerous region. The guidelines for this international ice patrol service are laid down in the International Convention for the Safety of Life at Sea (known as the SOLAS Convention).

1.5.18 Tropical Cyclones

When fully developed they are accompanied by mountainous, steep, breaking waves and winds of hurricane force. Because of the extremely low pressures in the eye of the cyclone, water levels are raised, and, when coupled with the wind-induced water-level surge together with high seas, these systems can inflict very serious damage to coastal installations, and, occasionally, to the loss of lives and ships.

The position of the centre of a cyclone (or of an extra-tropical depression) is usually given in latitude and longitude in high seas warnings designed for large ships at sea, however for coastal waters it should be given by distance and bearing from well-known coastal locations. This is because fishermen and other users of coastal waters forecasts are not so familiar with latitude and longitude. It is important to educate the community and mariners to not simply focus on the centre position of the tropical cyclone, and to be aware that the damaging effects could cover a few hundred kilometres/miles.

1.5.19 Tsunamis

Tsunamis are generated by underwater seismic activity. They can cause enormous destruction and loss of life. The warning of a significant tsunami should result in the rapid evacuation of all low-lying areas in its path.

1.5.20 Humidity

High humidity may be important in shipping for its potential damaging effect on cargo, particularly when coupled with cold sea surface temperatures, which results in hull and cargo sweating. Painting operations may be adversely affected by high humidity, and the durability of some paint coatings reduced.

Warm temperatures accompanied by high humidity can produce considerable discomfort and, in the extreme, are a hazard to health. Marine operations are affected when physical exertion becomes unpleasant and frequent rest periods become necessary under high humidity and temperatures.

1.5.21 Wind chill

Wind chill above certain thresholds are very important considerations to human comfort. Hypothermia and frostbite may result from wind chill in a very short time, impairing work efficiency and thus increasing accident likelihood. The heavy clothing necessary to withstand the cold also contributes to the possibility of accident. High values of wind chill will also reduce human survival time in the water.

1.6 REQUIREMENTS FOR SPECIFIC USERS AND APPLICATIONS

1.6.1 SOLAS vessels

SOLAS vessels are defined in the United Nations Convention for Safety of Life at Sea (SOLAS) as being of weight greater than 300 gross tonnes and all passenger vessels navigating international waters. SOLAS vessels generally undertake journeys of days and weeks in duration.

SOLAS vessels require information relating to four main activities:

- (a) Travel on the high seas;
- (b) Travel through Shipping Lanes, Pilotage areas;
- (c) Entering and exiting a port,
- (d) At berth, loading and unloading activities.

SOLAS ships are generally built to resist the forces of wind, waves and storms. However, a mechanically driven ship cannot maintain its speed and course in all weather and sea conditions. To prevent a ship from experiencing the excessive shocks of slamming into waves, or excessive rolling in adverse wave conditions, speed has to be reduced or its course changed, or both. In severe storms, speed reductions can be considerable, and a ship may have to ride out the storm without making appreciable headway.

The optimum heading on which a ship should be placed under severe weather conditions depends on the design of the ship, its size, cargo and conditions of loading. A ship with heavy deck cargo is handled differently from, say, a tanker, whilst the master of a passenger ship considers the comfort of passengers and endeavours to reduce the angle of roll. In calculating how to secure and protect the cargo, wave data and the motion of the ship must be taken into account together with the mass and position of the load.

Cargo shipped by sea-going vessels to distant destinations is always subject to some degree to the effects of meteorological conditions, which often affect the quality of the cargo by causing its deterioration. The types of damage caused by unfavourable meteorological conditions are many and varied: high humidity may cause metal parts to corrode, and when coupled with high temperatures may ruin paint coatings. Specialists in the field attribute 25 per cent of the losses experienced in freight shipments each year to meteorological conditions. More than 90 per cent of the two to three million types and varieties of freight are sensitive to meteorological factors. Humidity directly contributes 10 to 20 per cent of the losses, i.e. almost one in five or ten occurrences of spoilage is due to high humidity.

Foodstuffs in particular are extremely sensitive to environmental conditions. Approximately 90-95 per cent are temperature-sensitive, and 60 to 70 per cent are sensitive to humidity.

In all cases the expected time of arrival at the destination is of interest and will be affected by the weather conditions. Late arrival carries economic penalties for the shipping company. Some ports can only be reached at high tide, and missing a tide means a wait of 12 hours for the next available window of time. Several hours may be required to prepare a ship at sea for extreme conditions. Outlooks of possible storm developments for a period two to seven days in advance that is updated regularly are welcomed. They enable the ship's master to take any precautionary measures considered necessary, including altering course to avoid the worst of the weather, and to make appropriate assessments of the expected time of arrival.

The determination of a shipping route across the ocean to maximize efficiency and safety takes into account marine climatological data, load-line rules, ocean currents and medium- range forecasts of wind and wave conditions. One way of reducing costs is the application of meteorology to navigation; this has been applied by shipmasters for a very long time. Broadly speaking there are two applications: climatology and specific forecasts at the time of the voyage.

Routes selected for climatological reasons can be applied on ocean crossings where the weather is settled for a lengthy period. Generally speaking this will be the case in tropical and subtropical latitudes between about 30°N and 25°S. The actual weather from day to day very often agrees with that expected climatologically for the time of year. The major threat is from seasonal tropical cyclones. In these latitudes, however, there is increasing interest in routeing a ship according to the day to day variation in sea currents, as even a small saving in time can be worth a considerable amount of money.

Weather routeing services are provided in accordance with SOLAS Chapter V, Regulation 34, and IMO Resolution A.893 and IMO MSC/Circular 1063 – Minimum Standards for Provision of Weather Routeing Services, outlines the minimum characteristics for a service. The SOLAS Chapter V, Regulation 5 states that met-ocean services shall be issued by the National Meteorological Service, and this would imply that WMO and its Members should oversee weather routeing services and standards as well.

Weather Services may recommend routes based on anticipated weather conditions, sea ice, ocean determining currents, load-line zones and state of loading. The objectives of weather routeing include determining routes designed to minimize crossing time, damage or fuel consumption. For passenger cruise ships weather routeing may be used to maximize the amount of sunshine, and passenger comfort in avoiding large swells.

Weather routeing services provide the following benefits:

(a) Weather routeing for the purpose of achieving a least-time ocean crossing also reduces weather damage to ship and cargo;
(b) The greatest benefits are obtained during the winter months of December, January and February in the northern hemisphere and June, July and August in the southern hemisphere;

(c) Mean time gains on westbound voyages are larger than those on eastbound voyages as following waves, which do not have so much influence on the ship's performance, are predominant on eastbound voyages;
(d) Advised routes depend on the varying weather on, or near, the Great Circle routes. In summer when waves are predominantly low, the Great Circle is the most economic route.

The effect of routeing on the operational costs of a ship is mainly reflected in fuel and lubricating oil costs. A possible saving of 12 per cent in fuel has been calculated.

1.6.2 Non-SOLAS vessels

Non-SOLAS vessels are defined as being of weight less than 300 gross tonnes, however, the principles of voyage planning and weather risks within the SOLAS regulations still apply. In addition, the carriage of certain radio equipment is related to IMO vessel class standards, and IMO definitions for various waters and sea areas. The IMO operating limits for vessels in certain weather and wave conditions is guided by met-ocean information.

Non-SOLAS vessels require information relating to three main activities:

(a) Travel along coastal shipping routes or on the high seas;
(b) Entering and exiting a port or river entrance,
(c) At berth, loading and unloading activities.

Smaller non-SOLAS vessels are extremely vulnerable to hazardous weather and sea conditions on the high seas. In many cases of sudden deterioration in weather, there is no time to take refuge in a safe port or go to leeward coastal waters. Small vessels usually do not have a dedicated radio- telegraphy operator or satellite reception equipment, and are reliant on radio-telephony for communications. Thus weather and sea bulletins should be broadcast by voice radio-telephony for the benefit of these small craft.

Offshore yachting activities are vulnerable to intense weather patterns. Yachts may be in transit for a number of days at a time. Wind and wave information is highly important to navigation and capability of the vessel. Weather such as thunderstorms is important for safety of crew and protection of radio equipment. These vessels may not be able to avoid an intense weather pattern and a broken mast or rudder will require a rescue operation to be activated. Offshore yacht skippers access weather information on marine radio or satellite internet.

1.6.3 Fishery operations

Fishermen require information relating to the three main activities:

(a) Travel to and from fishing grounds;
(b) Locating and catching the fish; and,
(c) Care and transport of the catches.

The importance of meteorological information depends mainly upon the species fished, the fishing area and methods, and the ship's size and equipment.

Fishing vessels in coastal and offshore waters are usually small. Therefore they are very weather dependent and vulnerable to wind, waves and swell. They are at risk in poor visibility in shallow water or in dense traffic areas. Ice and ice-accretion in polar or near-polar areas may affect vessels there. Winds of Beaufort force 6 may be a hazard to small craft.

A large proportion of fishing areas are situated in northern temperate and near-polar regions, where there are great dangers in winter from storms, ice accretion on vessels and sea ice. A further danger comes from dense fog banks, mainly in the spring and summer, mostly over cold waters. Moreover, the fishing areas are generally situated far away from the general shipping routes and meteorological observations are usually very sparse.

Information about ocean surface and sub-surface temperatures and currents assist in the identification of potential fish sources.

1.6.4 Recreational boating

1.6.4.1 *General*

Recreational boating may include vessels that are powered (motor boat) or non-powered (sail-boat or yacht), and is generally a seasonal activity in the mid and higher latitudes. The principles of the SOLAS convention still apply to these vessels, and met-ocean services should consider the needs of these vessels. Recreational boating is generally undertaken for periods of a few hours, to a day or more in duration. As such, recreational boaters may be able to make decisions on where they will go boating safely, and when is the best part of the day to go boating safely. They may also choose to not go boating if conditions are too dangerous or uncomfortable.

Very small craft are usually used for recreational boating, and these are very weather-dependent. Crews of such small craft are often very inexperienced and frequently ignore the weather. While much recreational boating takes place in the comparatively sheltered waters of bays and estuaries, strong winds and squalls are still a hazard. Many accidents are due to inexperience and ignorance of the speed with which hazardous weather can arise.

Kayaking and canoeing on enclosed waters and offshore has become a popular recreational activity. These vessels require information about wind waves, winds, gusts and thunderstorms.

Forecasts and warnings for recreational boating should be given wide coverage on radio and television. Likewise, they should be included in automatic recorded telephone weather services. Proximity to wide-spread cellular telephone service along the coast now enables many recreational boaters to obtain forecasts and warnings via mobile phone and internet, therefore that means of distribution may also be taken advantage of where possible.

Warnings need to be issued of strong winds, and advanced notice of sudden increases in wind gusts, particularly squalls from thunderstorms or fronts.

During sailing regattas the crews are interested in exact wind forecasts as well as actual wind information. Sail craft are particularly sensitive to local wind effects, particularly where the coast is irregular, and very different wind conditions may exist in different areas. Wind and gust forecasts and forecasts of expected wind shifts are also of interest. Sometimes the attendance of a meteorologist is requested at a regatta coordination centre to meet specific needs.

1.6.4.2 *Winds and Waves*

Boats used for recreation come in many sizes and shapes and are manned in many instances by people relatively unfamiliar with the dangers inherent in boat operations. Critical wind speeds and wave heights are sometimes lower for these generally smaller craft than for commercial shipping. They are sensitive to gustiness and wind shifts as well as mean wind speed. Wind waves, especially high waves with short periods (a choppy sea), and to a lesser extent long swell, can be a danger to these small craft.

1.6.4.3 *Thunderstorms and Squalls*

Small craft are especially vulnerable to sudden changes in the weather associated with thunderstorms and violent cold fronts. The rapid development and movement of these phenomena make them an extreme hazard. Particularly vulnerable are the very small boats on enclosed waters such as bays and harbours.

1.6.4.4 *Fog*

As small craft usually lack radar, poor visibility in fog is a great danger in dense traffic areas such as estuaries, harbours and some coastal areas.

1.6.5 Dynamically-supported craft

Dynamically-supported craft such as hydrofoil vessels and hovercraft which are operating in coastal and offshore waters are particularly sensitive to changes in wave conditions. Wind also affects operations. The operating limits for wind and waves will vary with the type and size of craft. Because of their higher speed, information on higher ranges of visibility is required.

Fast craft such as hydrofoils, hovercraft and catamarans are more sensitive to wind and waves than ordinary craft of the same size. According to the IMO *Code for Safety of* Dynamically-*Supported Craft,* the worst intended environmental conditions should be the key threshold for operation of the craft.

Criteria of interest are wave height above 1.3 metres, wind speed above 13 metres per second (or 25 knots),and visibility less than 0.5 nautical miles.

1.6.6 Offshore oil-drilling and mining operations

1.6.6.1 General

Offshore operations require highly specialized information, tailored to a particular geographical location and to the kind of operation involved. The marine meteorologist needs to work closely with the operations manager.

Met-Ocean information is important for all four phases of offshore mining:

(a) Site identification and rig design and construction specification;
(b) The drilling from a specially constructed rig;
(c) The construction of off-shore platforms; and,
(d) Operation of the platforms.

1.6.6.2 Operations related to oil drilling platforms

The interests of the offshore hydrocarbon industry encompass a wide range of activities: geophysical surveys, operation of fixed and dynamically positioned exploration and production platforms, airborne logistic support, monitoring of sea-bed and overland pipelines, operation of liquefaction plants and port facilities, routeing of marine transportation, and possible oil-spill movement, containment and clean-up.

The requirements for information and forecasts for the platform or drilling rig site may include:

(a) Wind direction and speed at 10 metres and at the height of the helicopter deck;
(b) Direction and height of sea and swell;
(c) Periods of sea and swell;
(d) Significant weather phenomena;
(e) Ceiling;
(f) Visibility;
(g) Air temperature;
(h) Sea surface temperature;
(i) Ice accretion on constructions;
(j) Deviation of tidal heights; and,
(k) Temperature and current at different depths.

The threshold values for different phases of operations may vary considerably. Seismic survey is weather-sensitive because a vessel must make a series of transits of the area in question while towing an acoustic source and a string of hydrophones. There is an operational limit upon the wind and wave conditions which can be tolerated for both surface and deeper towing.

In addition to forecasts for the platform site, forecasts for the supply service involving helicopters and supply ships are usually needed. The requirements for these services will normally be similar to those of the general aviation and coastal transport in the area.

1.6.6.3 Waves and Wind

During drilling, the tolerance for side-to-side movement of drilling equipment as the result of wave action is approximately ten per cent of the water depth. Platforms will move up and down on the larger waves. The period of pitch and roll of a drilling ship is a critical factor, and waves with a period at or near that value can lead to hazardous pitch and roll due to resonance effects.

Wind contributes to the pitch and roll of a drilling rig, and high winds make working conditions difficult. Wind direction may also be an important element as wind shifts may necessitate careful adjustment of anchor cables.

The construction of offshore platforms is particularly vulnerable to winds and waves. Usually the platform is constructed onshore and towed to the site. Whilst underway, waves of two to three metres or higher, depending upon the design of the platform, necessitate lowering the legs or taking evasive action by moving the platform to shelter. Advanced notice of a few hours in advance is necessary to permit lowering the legs in time. Lead times of 24 hours or more may be necessary for operational decisions such as when to start the tow to the site. Once on location the legs are lowered and the structure raised above the direct influence of the waves.

Swell can be as important as wind waves in these operations and information about swell, especially from tropical cyclones, is also required. Swell may impact on the safe connection of the tanker with the oil rig. Extreme waves are a concern for structural integrity of the platform. Advanced notice of severe thunderstorms and squalls are also required, when very strong winds, although of relatively short duration, may cause damage.

Once erected, the operation of the platform usually involves the transport of personnel and equipment by helicopter, and aviation-type forecasts of wind, low cloud, visibility and altimeter setting are required. Advanced notice of gale force winds and above; and tropical cyclones are necessary as evacuation of all essential or non-essential personnel may be required (by boat or helicopter) before the occurrence of these wind conditions.

1.6.6.4 Currents and Tides

Information may be required on the sea currents at different depths during drilling in some sea areas, and when platforms are being moved into final positions. Information on bottom currents may be important to assess the pressure on cable and pipe infrastructure. Information on tidal surges may also be important.

1.6.6.5 Sea Ice and Icebergs

Strong winds and currents make icebergs a problem for pipelines and sub-sea well facilities, because these bergs scour the bottom at times and would tear out anything unprotected or even firmly attached.

In some areas with ice cover the safety of drilling and mining operations is strongly dependent on ice conditions.

If unfavourable ice conditions are expected, one of the following decisions may be taken:

(a) Dismount the drilling unit and withdraw to shelter;
(b) Continue work until some threshold ice load is reached;
(c) Continue work on a stationary platform while undertaking active methods of mitigating ice loads.

1.6.7 Coastal community activities

1.6.7.1 General

Coastal areas are often heavily populated, with people being attracted by trade, industry, fisheries, recreation, and, in some countries, retirement to a place near the sea. These communities need protection from the hazards of the sea and its storms.

Coastal community activities affected by weather conditions include:

- Swimming on the coast
- Outdoor activities
- Access to facilities or coastal pathways
- Living in houses or structures on the coast or on low lying land near the coast
- Recreational boating or transport by sea (see sections on recreational boating and transportation)

Considerable amount of engineering activity takes place in the coastal zone. Many coastlines must be protected from erosion and flooding, and this involves major construction work. The protective sea walls and breakwaters must be designed to withstand extreme wave events with relatively long return periods, so information about these extreme conditions are important for mitigation actions.

1.6.7.2 Wind

Communities located on the coastal interface with the ocean are generally exposed to the full force of wind conditions associated with cold fronts, low pressure systems and Tropical Cyclones. Activities within the community may be disrupted by these strong wind conditions.

1.6.7.3 Storm Surges

Storm surges and resulting flooding of low-lying areas have caused considerable damage and loss of life in coastal communities. When combined with large waves, there may be large impacts on coastal infrastructure and erosion of foreshore areas. Sufficient advance notice is required for coastal defence measures and possible evacuation of the population to be effected.

Abnormally low water levels due to the effects of wind stress — so-called negative surges — may affect marine operations in coastal areas, estuaries or at entrances to harbours. Information is also needed about such deviations in water-level.

1.6.7.4 Tsunamis

The warning of a significant tsunami should result in the rapid evacuation of all low-lying areas in its path.

1.6.7.5 Surf and Breakers

High breaking waves can cause damage to structures built near the sea and cause coastal erosion. Warnings will be required when such waves are expected to exceed a critical value.

Surf forecasts may be required for popular surfing beaches. A prediction should include maximum height and direction of breakers, together with the wind and tide which affects the way the waves break. When high breakers are predicted lifeguard stations may assign additional personnel or the beach may be closed.

1.6.7.6 Rip Currents

The interaction of waves breaking along shorelines and near headlands or other coastal structures can cause rip currents. Rip currents carry water away from the shore, therefore posing a hazard to swimmers. Local lifeguard stations are best placed to identify the potential risk of rip currents due to existing beach characteristics and wave heights, wave direction, tide and wind conditions.

1.6.8 Pollution of the sea

Pollution of the sea is the introduction to the sea of harmful substances resulting from human activity. Response agencies may require information on existing and predicted wind, waves and tidal or wind-generated currents to allow the prediction of the spread, movement and concentration of the pollutant. Information may also be required on the areal extent of sea ice and its drift.

The first thing that the pollution response authority will want to model is the likely movement of the pollutant. The meteorological input required by these models includes the forecast surface wind, waves and currents, air temperature and water temperature.

The wind forecast provides information on the likely natural dispersal of the oil. It may also influence the direction that any odours may travel.

If it is expected that the pollutant will ultimately affect the coast, and perhaps threaten coastal communities and installations, the on-scene commander of the clean-up operations will require forecasts and warnings related to the safe and efficient deployment of the personnel and equipment involved in the clean-up.

Tidal currents may affect the movement of the pollutant.

1.6.9 Power Generators and Industrial Plant Cooling Systems

Cooling systems on the shore discharge hot water into the sea, relying on its efficient dispersal. Anomalous tides may reduce the capability of cooling systems in the tidal reaches of a coastal area and forecasts of the wind effects on tides may be needed.

1.6.10 Requirements for long-term planning and design information

Long-term planning for marine operations is based on climatological probabilities. For example, a ferry service may not be economically viable if storms and high waves are too frequent. Ships, other marine vessels and marine structures have to be designed to withstand the strongest forces likely to be encountered.

Marine climatological data are required to provide the requisite advice and consultations should be held between designers and marine meteorologists on the use of climatological data.

1.6.11 Fisheries management

A number of environmental factors affect fish and they must be taken into account in the management and long-term planning of fishing operations. Fisheries research is largely taken up with the investigation of these factors. Environmental factors can affect:

(a) Behaviour, distribution, migration and aggregation of fish;
(b) Yield and catch;
(c) Wintering place;
(d) Fishing period;
(e) Year class-strength; and,
(f) Spawning eggs and larvae.

Among the environmental factors, the following ocean and meteorological factors are important:

(a) Sea surface temperature;
(b) Sea temperature gradient, both horizontal and vertical;
(c) Salinity;
(d) Temperature/salinity relation;
(e) Oxygen;
(f) Water quality;
(g) Currents;
(h) Water density;
(i) Swell period.

Sea temperature is an environmental factor of great importance for fishing, which in turn determines the commercial viability of fishing grounds. Both the spatial and temporal distribution of surface temperature and water temperature at depth are of great interest, as are the respective variability and any anomalous characteristics. Sudden changes in water temperature lead to stress on fish and fish quality.

Some fish live and feed close to the surface of the sea; others live for the most part on or near the bottom. Some shellfish may be dredged from the bottom. Diving operations to collect some shellfish such as abalone are very sensitive to even low swells. Swell period impacts on water quality and therefore fish quality, as well as reducing oxygen levels and resultant fish survivability.

Winds and waves may impact on operational aspects of fishery management. Currents may increase stress on infrastructure or movement of nutrient rich water.

Fishery authorities and scientists are very interested in longer range weather forecasts and climate forecasts, particularly of changes in sea-surface temperature and other meteorological and oceanographic parameters that have an impact on:

(a) Fish catches and fish quality;
(b) Fishing grounds;
(c) Distribution of fish;
(d) Fishing periods;
(e) Abundance of species;
(f) Reproductive cycles.

1.6.12 Ports

Every port or harbour is different in size, layout and the kind of weather experienced, so that there are a great variety of individual requirements for local marine meteorological services. The provision of marine meteorological services in ports usually involves different organizations which inevitably leads to different requirements from one port to another.

Marine meteorological services for main ports and harbours usually support the risks of carrying out all, or some, of the following activities:

(a) Ships' movements (entering, leaving or moving about the port);
(b) Container handling, container safety and warehousing, including the safety of cranes and lifting gear;
(c) Embarkation/disembarkation of passengers, especially by tender;
(d) Refueling operations;
(e) Loading of barges;
(f) Dredging or cleaning operations;
(g) Ship building and other construction works;
(h) Port engineering projects;
(i) Icebreaking services in ports and port entrances;

(j) Marine pollution combatting operations in port areas;
(k) Rescue operations;
(l) Industries, commerce, litigation and insurance;
(m) Waterborne recreational activities.

Knowledge of expected winds, sea and visibility helps the planning of movement of ships into, out of, or within the harbour. Weather conditions affect docking operations. When a tropical cyclone is threatening a particular port, the forecast movement of the cyclone will affect a shipmaster's decision to take evasive action by going to sea or to ride it out in the harbour.

Cargo handling is affected by high winds which can damage cranes and lifting gear. Some cargo cannot be handled in rain or in extremes of temperature. General forecasts are not always adequate because local topography tends to have considerable influence on the distribution of wind speeds and precipitation. Although the increasing use of containers has reduced the labour force at many ports, the forecasting service is still important to stevedoring companies in the rostering of their workforce.

Forecasts of wind speed, including gusts, thunderstorms, squalls, and the state of the sea are required for the planning of operations like the loading of barges, dredging and clearing operations, ship building and other construction works, port engineering projects and marine pollution combatting operations. Most of these operations require warning when wind speeds or waves are expected to exceed some critical value.

Tidal level can be operationally useful for managing under-keel clearance requirements for large ships with deep draughts moving through channels of shallow water. Abnormal water levels sometimes also affect dockyard operations. Information about tidal currents are also relevant.

The planning of icebreaking operations in ports and port approaches is dependent on forecasts of wind, temperature, wave and swell conditions. Severe storms with strong winds and spray in conditions of negative air temperature may lead to rapid ice accretion and cause ships to sink.

Harbour seiches may lead to irregular ship movements, making berthing difficult and increasing the danger of collisions.

Information on visibility or ice conditions in the different approaches to a port, for example, helps shipmasters decide the appropriate course to take.

1.6.13 Search and rescue

When a vessel is known to have sunk or to be in serious trouble (e.g. fire on board a large vessel or engine breakdown on a small craft), a search will be mounted by the appropriate authorities to rescue any survivors. On a large vessel, survivors will have taken to smaller lifeboats.

As small craft will drift with sea and tidal currents, an indication of drift is important in search and rescue operations along with forecasts of winds, waves and visibility. Sea-surface temperature may also be required, as small craft may capsize and this element is an important factor in determining survival time in the water.

1.7 INTERNATIONAL COORDINATING ARRANGEMENTS

1.7.1 General

The basis of international arrangements regarding the provision of marine meteorological services is given in the WMO *Technical Regulations (WMO-No. 49)*, Volume 1, Chapter C.1, entitled 'Meteorological services to marine activities'. It is important that shipping operators are able to obtain the same services from different countries in the same way, whether the ship is sailing on the high seas or is in port. The various procedures which must be adhered to are specified in the *Manual on Marine Meteorological Services (WMO-No. 558)* which forms part of the *Technical Regulations.* The *Manual* contains both standard practices, which are mandatory, and use the verb 'shall', and recommended practices, which use the verb 'should'. International coordination for activities in marine meteorology is shown in the following examples.

1.7.2 The WMO Voluntary Observing Ships' Scheme

Under the SOLAS Convention ships are required to report any phenomena or weather conditions which constitute a serious hazard to the safety of navigation. Selected ships also contribute, on a voluntary basis, a regular series of weather observations. These observations provide the basis of warnings and weather forecasts of benefit to shipping, and also are used in the compilation of climatological atlases. The Voluntary Observing Ships' Scheme, which is explained in detail in *WMO-1060, Manual on WMO Information Service,* demonstrates the cooperation between meteorologists and the marine community including shipping and fisheries.

1.7.3 Methods of observation of marine elements

There is no doubt that uniformity must exist in the observation of meteorological elements and those of the sea surface. Although instruments used may be different, observing sea stations (mobile ships as well as platforms) should measure exactly the same parameters which describe the state of the atmosphere or ocean at the time of measurement. It is very difficult to meet this requirement in a routine observational programme and, internationally, there must be a regular exchange of information, experiences and views to keep uniformity of measurement at an acceptable level. The requirement also applies to observing stations in coastal and offshore areas. International exchanges of information encourage the use of recent advances in instrument technology, including automation of the measurements. The subject is further explained in the *Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8)*

1.7.4 Coordination of marine meteorological broadcasts

It is important that the times of broadcast of forecasts be published and known to ships, and that only one broadcast is made to a given area at a time. The WMO coordinates the times of broadcast by satellite to various ocean areas. Broadcasts on GMDSS communication platforms (SafetyNet, Navtex, HF NBDP) and marine radio (HF and VHF) should be in accordance with a definitive timetable maintained in *WMO No. 9, Volume D, Information for Shipping.*

It is desirable that the broadcast of meteorological warnings and warnings of navigational hazards in coastal waters be coordinated, so that users receive all relevant information on hazards at about the same time. This will require coordination between the Meteorological Service, the authority responsible for issuing navigational warnings and the coast radio station(s).

1.7.5 Port Meteorological Officers

Port Meteorological Officers (PMOs) fulfil a highly important role in the liaison between NMSs and the shipping community. Their functions are truly international in nature — wherever a ship may find itself in the world, it must be able to obtain the assistance it needs to serve as a meteorological observing station, and also must be able to obtain the information about the marine meteorological services available in the country, region and abroad. International coordination is arranged by WMO, and the roles and responsibilities are described in *WMO-1060, Manual on WMO Information Service*.

1.8 WORLDWIDE MET-OCEAN INFORMATION AND WARNING SERVICE (WWMIWS)

1.8.1 General

The Worldwide Met-Ocean Information and Warning Service (WWMIWS) provides Maritime Safety Information (MSI) to mariners in the form of marine forecast and warning products. The WWMIWS is coordinated across the worlds' oceans through 21 defined areas, called METAREAs. Ships receive the MSI products via marine communication systems such as SafetyNet and NAVTEX, which form part of the Global Maritime Distress and Safety System (GMDSS). The IMO Assembly Resolution A.1051 outlines the functions of the Worldwide Met-Ocean Information and Warning Service.

The MSI products are issued by National Meteorological and Hydrographic Services (NMHS) appointed as WWMIWS Issuing Services. METAREA Coordinators are assigned to coordinate provision of the marine services for each area.

To allow mariners all over the world to understand the terminology in weather and sea bulletins, uniformity of terms is highly desirable. The multilingual list of terms used in weather and sea bulletins, given in WMO 558 Manual on Marine Meteorological Services, provides the necessary guidance to achieve the required uniformity.

1.8.2 Areas of responsibility

The establishment of areas of responsibility is coordinated by the WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), in consultation with Regional Associations and approved by the Executive Council.

An Issuing Service may arrange to receive from other NMSs forecasts and warnings for part of its area of responsibility for incorporation in the complete forecast for the whole area. These contributing services are known as Preparation Services.

The Issuing Service is responsible for composing the complete broadcast bulletins on the basis of input from the relevant Preparation Services and for monitoring the broadcasts of information to its designated area of responsibility. Where appropriate information, data or advice from a Preparation Service for a given METAREA is not available, it is the responsibility of the Issuing Service for that area to ensure that complete broadcast coverage for the area is maintained. An Issuing Service may agree with a Preparation Service on an appropriate format for the attribution of the forecast and warning information provided by the Preparation Service.

The METAREAs are identical with the NAVAREAs used by the International Hydrographical Organization (IHO) for the broadcast of navigational warnings.

An Issuing Service may extend the area of coverage of weather and sea bulletins beyond its METAREA, if it so wishes, to meet national requirements. In this case, the area of coverage has to be specified in the text of each broadcast so that ships are quite clear as to the area covered by the bulletin. Similarly, a Preparation Service may extend its area of coverage to meet national requirements, provided the area of coverage is clearly specified in the information supplied to the Issuing Service.

Whenever an Issuing Service is no longer able to provide the services for its area of responsibility, the relevant Member should inform the Secretary-General at least six months in advance. Whenever a Preparation Service is no longer able to provide forecasts and/or warnings for part of a METAREA, it should inform the relevant Issuing Service which should try to make alternative arrangements. The Secretary-General should also be informed of changes in Preparation Services.

Any amendments to the area of responsibility, or proposal for the introduction of a change in an NMSs' responsibility for an area, has to have the approval of the Executive Council based on a recommendation by JCOMM. Before drawing up any such recommendation, the Commission will obtain comments from the NMSs directly concerned with the proposed amendment as well as the comments of the president(s) of the Regional Association(s) concerned.

Because of the congruence of the METAREAs with the NAVAREAs of the IHO, it would be hoped that it would not become necessary to amend them.

1.8.3 About the Global Maritime Distress and Safety System (GMDSS)

The Global Maritime Distress and Safety System (GMDSS) has been agreed internationally within the International Maritime Organization (IMO) by amendment to the SOLAS Convention. For the purposes of the GMDSS communication equipment carriage requirements the oceans and seas of the world have been divided into four "Sea Areas" as follows:

- Sea Area A1 - sea rea within the radio-telephone coverage of at least one VHF coast station in which continuous Digital Selective Calling (DSC)* alerting is available;
- Sea Area A2 – sea area, excluding Sea Area A1, within the radio-telephone coverage of at least one MF coast station in which continuous DSC alerting is available;
- Sea Area A3 – sea area, excluding Sea Areas A1 and A2, within the coverage of an INMARSAT geostationary satellite in which continuous alerting is available;
- Sea Area A4 – sea area outside Sea Areas A1, A2, and A3, which generally comprise the polar waters.

Ships are required to carry the appropriate equipment for the sea area(s) in which they will be travelling. Most of the high seas areas of the world are in Sea Area A3.

Under the GMDSS, high seas, weather and sea bulletins are broadcast by satellite, using the INMARSAT SafetyNet service with the Enhanced Group Calling System (EGC). The EGC allows a bulletin to be broadcast to all ships with the relevant receiving equipment in:

(a) A standard METAREA or Coastal area, or,
(b) A rectangular area delineated by latitude and longitude by the sender, or,
(c) A circular area delineated by a central point and radius by the sender.

Refer to the SafetyNet Manual for further details.

1.8.4 NAVTEX

Sea Area A2 is serviced in some parts of the world (mostly in the northern hemisphere) by the NAVTEX service. This service is the coordinated broadcast and automatic reception on 518 kHz of maritime safety information by means of narrow-band direct-printing telegraphy using the English language. The messages are printed out automatically on receiving equipment on the bridge of a ship.

Refer to the NAVTEX Manual for further details.

1.8.5 Other radio communications

Provision is made for broadcast and reception by means of VHF DSC, HF DSC and MF DSC. Full details of the radio communications required internationally in the various sea areas can be found in Regulations 6 to 11 of Chapter IV of the SOLAS Convention. An NMS may have to prepare and/or issue warnings and routine forecasts for transmission by an HF-direct-printing telegraphy maritime safety information service for areas where such a service is provided for

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* DSC is a technique using digital codes enabling a radio station to establish contact with, and transfer information to, another station or group of stations, and complying with the relevant recommendations of the International Radio Consultative Committee (CCIR)

ships engaged exclusively on voyages in such areas. For Coastal waters, marine weather bulletins may be broadcast on VHF marine radio services.

As described in the GMDSS Handbook, Members should be aware of the radio call protocols for meteorological safety information broadcast on marine radio (HF and VHF).

Warnings issued between the times of routine broadcasts of bulletins should be broadcast immediately on receipt by the coast radio station. This particularly applies to the first warning of a tropical cyclone of storm or hurricane intensity. Ships need to be advised immediately of the imminence of dangerous weather.

1.8.6 Provision of information by radiofacsimile

Radiofacsimile dissemination of weather charts and plain language warnings is an effective means of serving marine users. The charts provide graphic information on the current and forecast weather situation, which aids comprehension of the forecasts and warnings contained in the text bulletins. Naturally, the positions of highs, lows and fronts on the analyses provided by radiofacsimile should agree with those described in the bulletin issued at about the same time by the same national weather service.

Detailed schedules of radiofacsimile broadcasts are contained in Information for Shipping — Volume D (WMO-No. 9). This publication gives the particulars of the radio stations, the times of broadcasts, the frequencies used and the areas covered by the charts.

The usefulness of the service depends on strict adherence to the scheduled broadcast times. Some radio- facsimile receivers need manual fine tuning adjustment to ensure optimal reception, and for this reason, ships officers expect transmission to begin at the scheduled time. Some countries use computer control of transmission to ensure accurate timekeeping.

The standard facsimile map displays intended specifically for marine use usually include:

- Surface-weather analyses;
- Surface-weather prognoses;
- Surface wind-field analyses;
- Surface wind-field prognoses;
- Wave analyses;
- Wave prognoses;
- Sea-surface temperature analyses;
- Sea-surface temperature prognoses;
- Sea-ice and iceberg information;
- Significant weather depiction;
- Ocean current information.

Suitable projections, scales and legends together with recommendations for preparation to ensure maximum clarity on reception are given.

Members should prepare map displays using the scales along the standard parallels as follows:

(a) Covering the world: 1:40 000 000;
Alternative: 1:60 000 000;

(b) Covering the hemisphere: 1:40 000 000;
Alternatives: 1:30 000 000;
1:60 000 000;

(c) Covering a large part of a hemisphere or hemi-spheres: 1:20 000 000;
Alternatives: 1:30 000 000;
1:40 000 000;

(d) Covering a portion of a continent or an ocean, or both: 1:10 000 000;
Alternatives: 1:20 000 000;
1:15 000 000;
1:7 500 000;
1:5 000 000.

The following guidelines should be considered when designing a map display for radio-facsimile:

(a) The minimum line thickness should be sufficiently large to ensure clear reproduction;

(b) Lines that are required to be reproduced uniformly should be of uniform width and intensity;

(c) Special marking in heavy print (two or three crosses) of intersections of lines of latitude and longitude should be used;

Note: This will facilitate the use of facsimile charts during periods of poor reception.

(d) The minimum separations of detail in letters, figures, symbols and the like should be sufficient to avoid the unwanted filling of spaces in the reproduction;

(e) Letters, figures, symbols and the like should be drawn as simply as possible;

(f) Models employed in plotting should be as simple as possible.

Standard symbols for the graphic representation of data, analyses and forecasts appear in the Manual on the Global Data-Processing and Forecasting System (WMO- No. 485).

2. SERVICES FOR THE HIGH SEAS

2.1 Introduction

Typical journeys undertaken on the high seas may last for many days up to a number of weeks. Cruise ships may travel to a number of port destinations with a few days on route between each port. Cargo ships may take a number of weeks between each port. The speed that these vessels travel versus the size of some weather patterns means that it might take a few days to move to safer waters. Generally, the size of vessels operating on the high seas are designed to handle reasonably rough conditions, however, extreme conditions present significant risk and danger to these larger vessels. Also operating on the high seas are cruising yachts which are more vulnerable to damage from rough conditions.

Shipmasters are interested in the synoptic weather pattern of the current and forecast positions of depressions and fronts. Although the marine forecasts describe the expected weather, wind and sea conditions, many shipmasters like to know the actual weather, wind and sea conditions experienced in nearby areas. When a storm area is approaching a ship, the shipmaster would like to know the wind speed and the sea and swell in that area so that they can navigate with greater assurance by allowing for the roll and pitch movements which are expected. Shipmasters take notice of wind warnings and will avoid such areas affected.

Similarly shipmasters like to be informed of the actual boundaries of fog areas over cold currents or advection fog near continents to help the shipmaster make some assessment of probable delays and late arrival in port.

Observations are of great interest to a shipmaster. These reports should include time of observation, cloudiness, wind, visibility, present and past weather, air temperature and pressure, and sea and swell.

SOLAS vessels require meteorological services to be disseminated on SafetyNET and NAVTEX in accordance with the GMDSS Master Plan. Members should disseminate meteorological services by marine radio frequencies (e.g. MF, HF, VHF), or High Frequency Narrow Band Direct-Printing (HF NBDP) telegraphy for areas where such a service is provided for ships engaged exclusively on voyages in those areas.

2.2 Service Descriptions

Marine meteorological services for the High Seas form part of the World-wide Met-Ocean Information and Warning Service (WWMIWS) and include provision of:

(a) Meteorological warnings;
(b) Marine forecasts;
(c) Sea-ice information services.

Refer to the Manual on Marine Meteorological Services (WMO 558) for details on procedures and format requirements.

In accordance with the principle of starting with the most important information, weather bulletins for the high seas have the following mandatory format:

- Part 1 Warnings;
- Part 2 Synopsis of major features;
- Part 3 Forecasts;

The most important element in the bulletin is the warnings, which must indicate clearly the area to which each warning applies. When there is no warning in effect, that fact must be mentioned in Part 1 of the bulletin by the statement "Warning nil" or "No warnings". Thus the recipient is in no doubt as to whether a warning is, or is not, current.

The synopsis in Part 2 usually gives a description of the position and movement of weather systems for the entire area of responsibility. The synopsis should also describe the limit of all known ice extents. In subtropical and tropical regions where the general weather situation often shows a seasonal pattern which remains unchanged for a number of days or longer, the synopsis is often reduced to a simple indication, for example "northeast trade flow". Due to the use of different units of measurement applied in various national jurisdictions for wind speed, visibility and wave heights, it is important that the quantitative unit must be included in the text of the message so that the recipient is in no doubt about the magnitude of the element.

It is usual for the area of responsibility to be subdivided, as this aids clarity to the recipient and allows concentration on the area where the ship happens to be. The subdivisions may vary with the weather situation, or be fixed in every bulletin. They may be indicated by latitudes and longitudes, or fixed areas may be indicated by names or numbers, which shortens the message and aids comprehension by the reader. Sub-areas may refer to designated areas defined by IMO such as Shipping Lanes, Particularly Sensitive Sea Areas, and Vessel Traffic Management areas. However, fixed names or numbers need to be well-publicized so that all mariners know the areas to which they refer. Sub-areas and their indications are shown for each country in, Information for Shipping — Volume D (WMO-No. 9).

Some Issuing Services divide their METAREA into subdivisions and issue a complete bulletin of Parts 1, 2 and 3 for each subdivision. This may well be the case where Preparation Services are contributing to the bulletin, as their contributions for particular areas can be incorporated into the complete bulletin with the minimum of delay.

Some Issuing Services may elect to issue a separate bulletin containing sea ice information and forecasts. This may be useful to reduce the length of a bulletin and provides flexibility for dissemination.

Warnings must be issued immediately when the need becomes apparent, without waiting for the next routine forecast. Thus warnings may be issued separately from a routine forecast.

3. SERVICES FOR COASTAL, OFFSHORE AND LOCAL AREAS

3.1 Introduction

While the major concern of marine meteorology is the safe passage of ships over the high seas, meteorological services have become increasingly important in ports and harbours. This is because many activities in ports and harbours are weather sensitive and the faster turnaround of ships in port means that delays due to weather must be kept to a minimum. Ports most in need of meteorological services are those with a relatively high proportion of adverse weather — fog, gales, swell, rain and squalls — and with a high volume of traffic leading to congestion in the harbour area and approaches.

Coastal areas geographically constitute a transition between land and sea. The areas are not defined in terms of exact geographical boundaries, as they depend on the topography inland and to sea. At many coasts the meteorological conditions are different from those experienced further inland. Coastal waters, the influence of the coast, as well as the relative shallowness of the waters, give rise to changes of atmospheric and ocean conditions which can be hazardous to the safety of shipping and small craft.

Forecasts for coastal waters not only serve the national community but also the international shipping which may make use of them as well. At the other extreme, recreational boating in very small open boats is subject to hazards from winds and waves which are of no concern to a large vessel.

Services are required not only for the coastal waters but also for people living right on the coast who are subject to a greater frequency of strong winds and gales than those living even a short distance inland. They need to be warned of storm surges and tsunamis, and are also interested in finding out about surf conditions on open beaches and conditions at harbour entrances.

3.2 Service Descriptions

The procedures which should be followed when providing marine meteorological services for coastal, offshore and local areas are described in the Manual on Marine Meteorological Services.

3.2.1 Areas and Boundaries for Bulletins

Because of the variation in winds, waves and weather in coastal waters, the weather and sea bulletins cover finer details than those issued for the high seas, which cover far greater areas. The landward boundary of an area for which a coastal bulletin is given is usually the coastline itself. But this line may be very irregular, and bays, estuaries, island barriers or reef barriers may make it hard to define just where the coastline is. A practical approach is to divide the coastal area into a number of sub-areas which are of significance to the local traffic. For instance, one sub-area could cover the approaches to an important harbour, another could cover local fishing grounds. Significant differences in meteorological conditions would also constitute an important factor in determining the sub-areas. Consideration for the number of sub-areas should also account for how the information will be disseminated through marine radio or other communication platforms. There may be time constraints on marine radio which may limit the number of feasible sub-areas to broadcast.

Seaward boundaries of coastal areas are not defined in any general way. They depend on a number of factors, such as the extent to which coastal traffic and activities extend out into the sea or ocean, the vicinity of other countries, the weather and sea conditions themselves and other considerations of a practical and sometimes legal nature. For this reason, the Manual on Marine Meteorological Services does not specify seaward boundaries, but their specification is left to the country concerned. Each Member, therefore, in notifying WMO of its programme of coastal weather and sea bulletins, should include in the specifications of this programme the exact boundaries of the area or sub-area of coastal waters for which a particular bulletin is issued. These areas are usually indicated on a map which is published in Information for Shipping — Volume D (WMO-No. 9).

3.2.2 Content of Bulletins

Although coastal bulletins may be issued primarily for national interests, they are also used by international shipping, and for this reason in the Manual on Marine Meteorological Services (WMO-No. 558), the contents of coastal weather and sea bulletins are specified. Coastal bulletins do not have to be divided into Parts 1, 2 and 3, but they should still follow the order of presentation of information: warnings, synoptic situation, forecasts. There should, as far as possible, be consistency between the forecasts and warnings for the coastal waters and the relevant high seas area. Naturally the forecast for coastal waters gives more detail for the smaller area than the high seas forecast.

Some Meteorological and Ice Services may elect to issue a separate bulletin containing sea ice information and forecasts. This may be useful to reduce the length of a bulletin and provides flexibility for dissemination.

Due to the effect of the coast itself, and its topography, winds on the coast and over near-coastal waters often differ markedly from those over the open sea, so it may be important to define the boundaries and scales to users for terms such as offshore, inshore, near shore, coastal areas.

It is not usually possible to forecast the precise wind and wave conditions in every bay or gulf along the coast, both for reasons of length of the forecast, and of inability to forecast the differences due to the topography. It is important to educate and advise small craft operator that they need to use their own local knowledge to determine the likely conditions in such areas given the general forecast for the coastal section.

It is important to determine, by consultation with representatives of user communities, the thresholds of meteorological and sea wave parameters to be used as criteria for the issue of warnings (beyond those agreed for storms and gales) or be mentioned in the forecast, e.g. wind speed, strength of gusts, wave height, swell period and direction, visibility, squalls;

Due to the use of different units of measurement applied in various national jurisdictions for wind speed, visibility and wave heights, it is important that the quantitative unit must be included in the text of the message so that the recipient is in no doubt about the magnitude of the element.

Warnings of hazardous meteorological phenomena are essential for the safety and security of all kinds of marine activities. Warnings need to give essential information, but not be overlong; most are read out over radio or automatic telephone. There is a limit on how much information can be absorbed by the listener. As stated in the Manual on Marine Meteorological Services, 'Warnings shall be as brief as possible and, at the same time, clear and complete'.

Users also like to know how long the dangerous conditions are expected to persist. Thus formulas such as 'moderation is expected tonight', or 'strong winds are expected to continue for another two days' should be included if possible.

APPENDIX 1.1

MULTILINGUAL LIST OF COMMON TERMS USED IN MARINE METEOROLOGICAL SERVICES

LISTE MULTILINGUE DES TERMES UTILISÉS DANS LES BULLETINS DE MÉTÉOROLOGIE MARITIME

LISTA MULTILINGUE DE TÉRMINOS UTILIZADOS EN LOS BOLETINES METEOROLOGICOS Y MARINOS

МНОГОЯЗЫЧНЫЙ ПЕРЕЧЕНЬ ТЕРМИНОВ ИСПОЛЬЗУЕМЫХ В МЕТЕОРОЛОГИЧЕСКИХ МОРСКИХ БЮЛЛЕТЕНЯХ

English	Français	Español	Русский
Standards of time	*Unités de temps*	*Unidades de tiempo*	*Единица времени*
Universal time coordinated (UTC)	Temps universel coordonné (UTC)	Tiempo universal coordinado (UTC)	Всемирное скоординированное время (ВСВ)
Zone time	Heure du fuseau	Zona horaria	поясное время
Summer time	Heure d'été	Hora de verano	летнее время
Local time	Heure locale	Hora local	местное время
Periods of time	*Périodes de temps*	*Períodos de tiempo*	*Периоды времеии*
Six hours	Six heures	Seis horas	шесть часов
Twelve hours	Douze heures	Doce horas	двенадцать часов
eighteen hours	Dix-huit heures	Dieciocho horas	восемнадцать часов
Twenty-four hours	Vingt-quatre heures	Veinticuatro horas	двадцать четыре часа
Thirty-six hours	Trente-six heures	Treinta y seis horas	тридцать шесть часов
Forty-eight hours	Quarante-huit heures	Cuarenta y ocho horas	сорок восемь часов
Today	Aujourd'hui	Hoy	сегодня
Tomorrow	Demain	Mañana	завтра
Next few days	Les prochains jours	Los próximos días	следующие несколько дней
Morning	Matin	Mañana	утро
Evening	Soir	Tarde, noche	вечер
Midday	Midi	Mediodía	полдень
Afternoon	Après-midi	Tarde	после полудня
Day	Jour	Día	день
Night	Nuit	Noche	ночь
Sunrise	Lever du soleil	Orto ó amanecer	восход
Sunset	Coucher du soleil	Ocaso	заход
Preliminary terms	*Termes préliminaires*	*Términos preliminares*	*Предварительные термины*
Forecast	Prévision	Previsión, pronóstico	прогноз
Further outlook	Tendance ultérieure	Evolución probable Perspectivas futuras	вероятная эволюция, дальнейшие перспективы
General inference	Situation générale et évolution	Situación general y evolución	общий вывод
General statement	Situation générale	Situación general	общее описание положения
Long-range forecast	Prévision à longue échéance	Previsión a largo plazo	долгосрочный прогноз
Medium-range forecast	Prévision à moyenne échéance	Previsión a medio plazo	среднесрочный прогноз

English	Français	Español	Русский
Short-range forecast	Prévision à courte échéance	Previsión a corto plazo	краткосрочный прогноз
Synoptic situation	Situation synoptique	Situación sinóptica	синоптическое положение, синоптическая ситуация
Warning	Avis	Aviso	предупреждение
Terms of position	*Termes de position*	*Términos de posición*	*Термины положения*
Degrees	Degrés	Grados	градусы
Latitude	Latitude	Latitud	широта
Longitude	Longitude	Longitud	долгота
Quadrant	Quadrant	Cuadrante	квадрант
Hemisphere	Hémisphère	Hemisferio	полушарие
North	Nord	Norte	север
South	Sud	Sur	юг
East	Est	Este	восток
West	Ouest	Oeste	запад
District	District	Distrito	район
Parallel	Parallèle	Paralelo	параллель
Meridian	Méridien	Meridiano	меридиан
Square	Carré	Cuadrado	квадрат
Bearing	Relèvement	Rumbo	пеленг
Direction	Direction	Dirección	направление
Track	Trajectoire,route	Trayectoria	путь, траектория
Area	Zone	Área,zona	область, район
Line	Ligne	Línea	линия
Storm warnings	*Avis de tempête*	*Avisos de temporales*	*Штормовые предупреждения*
Gale warning	Avis de coup de vent	Aviso de viento duro	штормовое предупреждение
Storm warning	Avis de tempête	Aviso de temporal	штормовое предупреждение
Hurricane warning	Avis d'ouragan	Aviso de huracán	предупреждение об урагане
Blizzard	Blizzard	Blizzard, ventisca	близзард
Tropical storms	*Cyclones tropicaux*	*Ciclones tropicales*	*Тропические штормы*
Tropical cyclone	Cyclone tropical	Ciclón tropical	тропический циклон
Hurricane	Ouragan	Huracán	ураган
Typhoon	Typhon	Tifón	тайфун
Baguio	Baguio	Baguio	багуйо
Pressure systems	*Systèmes de pression*	*Sistemas de presión*	*Барические системы*
Area of low pressure	Zone de basses pressions	Área de bajas presiones	область пониженного давления
Low	Dépression	Depresión barométrica	циклон

English	Français	Español	Русский
Trough	Creux	Vaguada	ложбина
Area of high pressure	Zone de hautes pressions	Área de altas presiones	область высокого давления
High	Anticyclone	Anticiclón	антициклон
Ridge of high pressure	Dorsale, crête barométrique	cresta de alta presión	гребень высокого давления
Belt of high pressure	ceinture de hautes pressions	cinturón de altas presiones	пояс высокого давления
Belt of low pressure	ceinture de basses pressions	cinturón de bajas presiones	пояс низкого давления
col	col barométrique	collado	седловина
Hyperbolic point	Point hyperbolique	Punto hiperbólico	гиперболическая точка
cyclolysis	cyclolyse	ciclólisis	циклозиз
cyclogenesis	cyclogenèse	ciclogénesis	циклогенез
Anticyclolysis	Anticyclolyse	Anticiclólisis	антициклолиз
Anticyclogenesis	Anticyclogenèse	Anticiclogénesis	антициклогенез
Air mass nomenclature	*Nomenclature des masses d'air*	*Nomenclatura de las masas de aire*	*Классификация воздушных масс*
Air mass	Masse d'air	Masa de aire	воздушная масса
Stable air mass	Masse d'air stable	Masa de aire estable	устойчивая масса
Unstable air mass	Masse d'air instable	Masa de aire inestable	неустойчивая масса
Cold air	Air froid	Aire frío	холодная масса
Arctic air	Air arctique	Aire ártico	арктический воздух
Antarctic air	Air antarctique	Aire antártico	антарктический воздух
Polar air	Air polaire	Aire polar	полярный воздух
Warm air	Air chaud	Aire caliente, aire cálido	теплый воздух
Tropical air	Air tropical	Aire tropical	тропический воздух
Subtropical air	Air subtropical	Aire subtropical	субтропический воздух
Equatorial air	Air équatorial	Aire ecuatorial	экваториальный воздух
Maritime air	Air maritime	Aire marítimo	морской воздух
Continental air	Air continental	Aire continental	континентальный воздух
Winter monsoon	Mousson d'hiver	Monzón de invierno	зимний муссон
Summer monsoon	Mousson d'été	Monzón de verano	летний муссон
Front nomenclature	*Nomenclature des fronts*	*Nomenclatura de los frentes*	*Классификация фронтов*
Front	Front	Frente	фронт
Polar front	Front polaire	Frente polar	полярный фронт
Cold front	Front froid	Frente frío	холодный фронт
Secondary cold front	Front froid secondaire	Frente frío secundario	вторичный холодный фронт
Warm front	Front chaud	Frente caliente	теплый фронт
Occlusion	Occlusion	Oclusión	окклюзия
Cold occlusion	Occlusion à caractère de front froid	Oclusión fría	окклюзия по типу холодного фронта
Warm occlusion	Occlusion à caractère de front chaud	Oclusión caliente	окклюзия по типу теплого фронта
Upper front	Front en altitude	Frente en altura	верхний фронт

English	Français	Español	Русский
Intertropical front	Front intertropical	Frente intertropical	внутритропический фронт
Frontal wave	Onde frontale	Onda frontal	фронтальная волна
Frontogenesis	Frontogenèse	Frontogénesis	фронтогенез
Frontolysis	Frontolyse	Frontólisis	фроптолиз
Weather	*Temps*	*Tiempo*	*Погода*
Precipitation	*Précipitation*	*Precipitación*	*Осадки*
Rain	Pluie	Lluvia	дождь
Freezing rain	Pluie verglaçante	Lluvia engelante	переохлажденный дождь
Rain and snow	Pluie et neige mêlées	Lluvia y nieve mezcladas	дождь со снегом
Supercooled rain	Pluie surfondue	Lluvia subfundida	переохлажденный дождь
Snow	Neige	Nieve	снег
Snow pellets	Neige roulée	Nieve granulada	снежная крупа
Snow grains	Neige en grains	Cinarra, gragea	снежные зерна
Drizzle	Bruine	Llovizna	морось
Hail	Grêle	Granizo	град
Diamond dust	Poudrin de glace	Polvillo de hielo	алмазная пыль
Ice pellets	Granules de glace	Gránulos de hielo	ледяной дождь
Small hail	Grésil	Granizo menudo	ледяная крупа
Shower	Averse	Chubasco	Ливень
Tornado	Tornade	Tornado	торнадо
Willy-willy	Willy-willy	Willy-willy	вилли-вилли
Visibility	*Visibilité*	*Visibilidad*	*Видимость*
Fog	Brouillard	Niebla	туман
Mist	Brume	Neblina	дымка
Haze	Brume sèche	Calima	мгла
Dust storm	Tempête de poussière	Tempestad de polvo	пыльная буря
Sandstorm	Tempête de sable	Tempestad de arena	песчаная буря
Spray	Embruns	Rociones	водяная пыль
Drifting snow	Chasse-neige basse	Ventisca baja	поземок
Blowing snow	Chasse-neige élevée	Ventisca alta	низовая метель
Miscellaneous	*Divers*	*Misceláneos*	*Дополнительные термины*
Cloud	Nuage	Nube	облако
Clearing up	Se dissipant	Despejando(se)	прояснение
Squall line	Ligne de grains	Turbonada en línea	линейный шквал
Whirlwind	Tourbillon de vent	Remolino de viento	вихрь
Water spout	Trombe marine	Tromba marina	смерч
Frost, freezing	Gelée, gel	Helada	мороз, заморозок
Rime	Givre blanc	Cencellada blanca	изморозь
Glaze	Givre transparent	Cencellada transparente	ледяной налет
Smoke	Fumée	Humo	дым
Thunderstorm	Orage	Tormenta	гроза
Thunder	Tonnerre	Trueno	гром
Lightning	Éclair	Relámpago	молния

English	Français	Español	Русский
Wind	*Vent*	*Viento*	*Ветер*
General terms	*Termes généraux*	*Términos generales*	*Общие термины*
Beaufort scale	Échelle Beaufort	Escala Beaufort	шкала Бофорта
Calm	Calme	Calma	штиль
Light air	Très légère brise	Ventolina	очень слабый ветер
Light breeze	Légère brise	Flojito (viento), brisa muy débil	слабый ветер
Gentle breeze	Petite brise	Flojo (viento), brisa débil	ветер от слабого до умеренного
Moderate breeze	Jolie brise	Bonancible (viento), brisa moderada	умеренный ветер
Fresh breeze	Bonne brise	Fresquito (viento), brisa fresca	свежий ветер
Strong breeze	Vent frais	Fresco (viento), brisa fuerte	сильный ветер
Near gale	Grand frais	Frescachón, viento fuerte	очень сильный ветер
Gale	Coup de vent	Viento duro	штормовой ветер
Strong gale	Fort coup de vent	Viento muy duro	шторм
Storm	Tempête	Tormenta, tempestad, temporal	сильный шторм — буря
Violent storm	Violente tempête	Temporal duro, orrasca	жестокий шторм
Hurricane	Ouragan	Huracán	ураган
Gust	Rafale	Ráfaga, racha	порыв
Squall	Grain	Turbonada	шквал
Sea breeze	Brise de mer	Brisa de mar	морской бриз
Land breeze	Brise de terre	Brisa de tierra	береговой бриз
Prevailing wind	Vent dominant	Viento dominante	господствующий ветер
Shift of wind	Saute de vent	Salto de viento	поворот ветра
Veering (clockwise change in direction)	Virant/Rotation du vent (dans le sens des aiguilles d'une montre)	Cambio de dirección (en el sentido de las agujas del reloj)	менять направление по часовой стрелке
Backing (anticlockwise change in direction)	Revenant/Rotation du vent (dans le sens contraire des aiguilles d'une montre)	Cambio de dirección (en el sentido contrario de las agujas de reloj)	менять направление против часовой стрелки
Local names	*Noms locaux*	*Nombres locales*	*Местные названия*
Trade winds (trades)	Alizés	Vientos alisios (alisios)	пассаты
Bora	Bora	Bora	бора
Mistral	Mistral	Mistral	мистраль
Sirocco	Sirocco	Siroco	сирокко
Gregale	Grégal	Gregal	грегаль
Levanter	Levante	Levante	левантин, южный ветер
Norther	Norther	Nortada	северный ветер

English	Français	Español	Русский
Ice	*Glace*	*Hielo*	*Лед*
(See: Sea-ice Nomenclature (WMO-No. 259) for a complete glossary)			
Bergy bit	Fragment d'iceberg	Tempanito	обломок айсберга
Brash ice concentration	Concentration en brash (sarrasins)	Concentración de escombro de hielo	ледяная каша — сплоченность
Past ice	Banquise côtière	Hielo fijo	припай
First-year ice	Glace de première année	Hielo del primer año	однолетний лед
Flaw	Brèche de séparation	Grieta	полоса тертого льда
Floe	Floe	Bandejón	ледяное поле
Frazil	Frasil	Cristales de hielo	иглы
Grease ice	Sorbet	Hielo grasoso	ледяное сало
Grey ice	Glace grise	Hielo gris	серый лед
Grey-white ice	Glace blanchâtre	Hielo gris blanco	серо-белый лед
Growler	Bourguignon	Gruñón	кусок айсберга
Hummocked ice	Glace hummockée	Hielo amonticulado	торосистый лед
Iceberg	Iceberg	Témpano	айсберг
Ice boundary	Ligne de démarcation de glaces	Frontera del hielo	ледовая граница
Ice edge	Lisière de glace	Borde del hielo	кромка льда
Ice field	Champ de glace	Campo de hielo	скопление дрейфующего льда
Ice limit	Limite des glaces	Límite del hielo	крайняя граница льда
Ice patch	Banc de glace	Manchón de hielo	пятно льда
Ice rind	Glace vitrée	Costra de hielo	склянка
Ice shelf	Plateau de glace	Meseta de hielo	шельфовый ледник
Level ice	Glace plane	Hielo plano	ровный лед
New ice	Nouvelle glace	Hielo nuevo	начальные виды льда
Nilas	Nilas	Nilas	нилас
Pack ice	Banquise	Hielo a la deriva	дрейфующий лед
Pancake ice	Glace en crêpes	Hielo panqueque	блинчатый лед
Polynya	Polynie	Polinia	полынья
Rafted ice	Glace entassée ou empilée	Hielo sobreescurrido	наслоенный лед
Shore lead	Chenal côtier	Canal costero	прибрежная прогалина
Shuga	Shuga	Shuga	шуга
Slush	Gadoue	Pasta o grumo	снежура
Young ice	Jeune glace	Hielo joven	молодой лед
Miscellaneous nautical terms	*Termes nautiques divers*	*Términos náuticos diversos*	*Разные морские термины*
Sea	Mer	Mar	море
Sea level	Niveau de la mer	Nivel del mar	уровень моря
Horizon	Horizon	Horizonte	горизонт

English	Français	Español	Русский
Tsunami	Tsunami	Tsunami	цунами
Swell	Houle	Mar de fondo	зыбь
Tide	Marée	Marea	морской прилив и отлив
Surge Storm surge	Lame de fond	Oleada / Ola de tormenta	крутое волнение
Surf	Déferlement	Resaca	прибой
Breakers	Brisants	Rompientes	буруны
Wave	Vague	Ola	волна
Wavelet	Vaguelette	Ola pequeña	небольшая волна
General descriptive terms	*Termes descriptifs généraux*	*Términos descriptivos generales*	*Общие писательные термины*
Slight	Faible (léger)	Leve	незначительный
Moderate	Modéré	Moderado	умеренный
Violent	Violent	Violento	жестокий
Heavy	Fort (gros)	Fuerte	тяжелый
Strong	Fort	Fuerte	сильный
Dry	Sec	Seco	сухой
Damp	Humide	Húmedo	влажный
In patches	Par plaques, en bancs	En bancos	в кусках, разрывной
Extensive	Étendu	Extenso	обширный, пространный
Low	Bas	Baja	низкий
High	Haut, élevé	Alta	высокий
Rough	Forte	Duro	бурный
Recurve	Se recourber	Recurvarse	поворачивать
Quickly	Rapidement	Rápidamente	скоро
Slowly	Lentement	Lentamente	медленно
Filling up	Se comblant	Llenándose	заполнение
Increasing	Croissant, augmentant	Aumentando	увеличение
Decreasing	Décroissant, diminuant	Disminuyendo	уменьшение
Breaking up	Se dissolvant	Disipándose	разрушение
Poor	Mauvais	Malo	плохой
Good	Bon	Bueno	хороший
Spreading	S'étendant	Extendiéndose	распространение
Occasional	Occasionnel	Ocasional	случайный
Continuous	Continu	Continuo	непрерывный, продолжительный
Intermittent	Intermittent	Intermitente	прерывистый
At times	De temps à autre	A veces	иногда, по временам
Immediately	Immédiatement	Inmediatamente	немедленно, непосредственно
Early	Tôt	Temprano	рано
Late	Tard	Tarde	поздно
Later	Plus tard, par la suite	Luego, más tarde	позже

4. MARINE METEOROLOGICAL SUPPORT FOR MARITIME SEARCH AND RESCUE

4.1 General

Under the GMDSS, Rescue Coordination Centres (RCCs) are responsible for coordinating search and rescue of ships in distress in each NAVAREA. The success of a search and rescue operation depends to a large extent on the meteorological information available to the RCC. Survivors may be aboard an open small boat which will drift with the wind, waves, tides and currents and search areas may be extensive if the position of the survival craft is not known with any degree of accuracy. It may be extremely difficult to see a small craft in conditions of poor visibility or choppy waves. Water temperatures provide guidance to RCC's on potential survival times of persons in the water.

The use made of meteorological information by a RCC is shown in the IMO Search and Rescue Manual.

4.2 Service Requirements

The procedures which should be followed when providing marine meteorological services to maritime search and rescue operations are described in the Manual on Marine Meteorological Services (WMO 558).

In an emergency situation, meteorological information will be required quickly and procedures should be in place for an NMS to provide the required information to an RCC as quickly as possible when a request is received. This requires the RCC to be kept informed of the addresses of relevant forecasting centres and the available means of communication. It is recommended that there is agreement between the NMS and the RCC on the standard format of the information that is required. This saves time when a request is initiated.

It is useful practice to supply the RCC with routine weather and sea bulletins, so that, in an emergency, the RCC has at least a general forecast of the weather in the area while waiting for the response to a request for more specific advice. On many occasions, when the weather is benign, the routine bulletins will be sufficient for RCC purposes.

5. SERVICES IN SUPPORT OF THE WORLD WIDE NAVIGATIONAL WARNING SYSTEM

5.1 General

Maritime Safety Information (MSI) is promulgated in accordance with the requirements of IMO resolution A.705(17), as amended. Navigational warnings are issued under the auspices of the IMO/International Hydrographic Organization (IHO) World-Wide Navigational Warning Service (WWNWS) in accordance with the requirements of IMO resolution A.706(17), as amended.

Navigational warnings are issued in response to SOLAS regulation V/4 and carry information which may have a direct bearing on the safety of life at sea. Some of the subjects of concern for navigational warnings rely on sources from NMHS. Appropriate coordination and information sharing agreements should be established with NAVAREA Coordinators to facilitate an effective warning service.

5.2 Service requirements

Full details of Navigational warnings are described in the Joint IMO/IHO/WMO Manual on Maritime Safety Information (MSI), and procedures which should be followed are described in the *Manual on Marine Meteorological Services (WMO 558)*.

Particular support arrangements are required for the following navigational hazards.

- NAVAREA Warning type (5) - Drifting Hazards
  - Icebergs
  - Volcanic activity, resulting in heavy ash or floating pumice
- NAVAREA Warning type (12) – Significant Malfunction of radio or satellite communication services
- NAVAREA Warning type (15) – Tsunamis and other natural phenomena, such as abnormal changes to sea level
  - Tsunami risk
  - Abnormal water levels

6. SERVICES IN SUPPORT OF MARINE ENVIRONMENTAL EMERGENCY RESPONSE

6.1 General

There are a number of IMO Conventions and Resolutions concerned with preventing pollution at sea. The main one is the International Convention for the Prevention of Pollution from Ships (MARPOL).

Incidents involving the spilling of oil or other pollutants constitute a hazard for coastal areas and communities. Actions necessary to contain the area of pollution, to minimize its effects and to clean up the affected area require meteorological services of a special form. Such pollution incidents usually call for immediate action and it is essential that pre-arrangements be made between the meteorological service and the pollution control authority so that the Meteorological Service can be alerted and the required information provided with minimum delay.

Maritime countries may designate a responsible authority for marine pollution, or groups of expertise which can provide the appropriate advice as required. This may be done in support of national planning for prevention of marine pollution, or for operations purposes, such as the guidance of oil tankers or to assist other marine activities constituting a pollution threat. Meteorological Services may be required to provide advice in the formulation of such national plans to prevent and control marine pollution.

6.2 Service requirements

The procedures which should be followed are described in the *Manual on Marine Meteorological Services (WMO 558)*.

A framework exists to support Members in developing and enhancing capacity to provide a consistent level of met-ocean information and drift information in the event of a range of marine environmental incidents, including;

- spills of oil and other noxious substance
- radioactive material discharges in marine and coastal zones
- other marine environmental hazards (e.g. harmful algal blooms)

Marine pollution drift and dispersal models combine the attributes of the pollutant with the environmental conditions. These models may be operated by the meteorological authority, or by the pollution control authority according to national arrangements.

7. TRAINING IN THE FIELD OF MARINE METEOROLOGY

7.1 Introduction

The types of personnel requiring training in marine meteorology are:

(a) Meteorological personnel engaged in observational, forecasting and climatological duties for marine purposes;
(b) Port Meteorological Officers (PMOs);
(c) Seafarers.

Each class of marine meteorological personnel requires training both in general and marine meteorology up to the various standards required for their particular tasks. The classification and educational requirements for meteorological personnel including the syllabi for training are fully detailed in *Guidelines for the Education and Training of Personnel in Meteorology and Operational Hydrology (WMO-No.258)*. The WMO Marine Forecaster Competency Framework can be used for assessing the suitability of forecasting staff.

7.2 Training principles and procedures

The principles and procedures governing the training of all classes of meteorological personnel engaged in marine meteorological activities together with those pertaining to PMOs and seafarers are described in the *Manual on Marine Meteorological Services (WMO 558).* Other examples include the need for special training centres, the importance of trained specialist instructors, the involvement of universities and guidance available from WMO publications. Staff involved in the provision of training should refer to the *Guidelines for Trainers in Meteorological, Hydrological and Climate Services (WMO-No. 1114)*.

In addition the standards set by the relevant international authorities for the training of ships' officers must be considered, such as the *International Convention on Standards of Training, Certification and Watch-keeping for Seafarers, 1978* (IMO publication), which sets the training requirements in marine meteorology of masters and chief mates of ships of 200 gross registered tons or more. The IMO Polar Code also provides guidelines for training of seafarers operating in polar waters.

8. SERVICES FOR MARINE CLIMATOLOGY

8.1 Introduction

8.1.1 General purpose of marine climatology and societal applications

Note: General information on the purpose of marine climatology, and societal applications can be found in the *Manual*. In addition, a comprehensive account of the uses of marine climatology can be found in the *Guide to the Applications of Marine Climatology* WMO-No. 781 (WMO 1994), and in its Dynamic Parts, *Advances in the Applications of Marine Climatology* JCOMM Technical Report No. 13 (JCOMM 2003a, 2005, 2011).

Marine climatology today provides data, information, and products about marine meteorological and oceanographic (met-ocean) conditions to a wide range of research and science applications in support of the industry and national interests in the coastal and offshore regions. Examples of applications and of their use of marine meteorological and oceanographic climatological information are detailed in Table 1.

Table 1. Examples of applications and their use of marine meteorological and oceanographic climatological data and information (additional variables not relevant to the Marine Climate Data System (MCDS) may be required).

Applications	***Examples of use of marine climatological information***	***Marine climatological data and information required***
Maritime transportation	• Ship routing (e.g. saving fuel, or making the shipping of perishable goods more expeditious), fleet management, and ship design	Winds, currents, and sea state conditions; air and sea surface temperature (SST), sea-ice, parameters of special interest (e.g. occurrence of unusual waves, underwater earthquakes)
Natural resources exploitation, including oil and gas production; Engineering and construction of coastal and offshore infrastructures	• The systems must often be capable of functioning and surviving in a variety of environments, from the tropics to ice-covered polar regions. The equipment and operations must satisfy the safety and other regulatory requirements of many nations, but also those of classification societies and insurers, whose area of operation is global. Basic to these requirements is that climate, especially extremes, should be adequately considered. • Offshore platform and coastal infrastructure architecture and design • Estimating endurance, required maintenance and operations costs of the infrastructures.	Winds, currents, and sea state conditions, SST and air temperature, sea-ice
Fisheries and aquaculture	• Fishery managers and researchers can use climate information to infer causes of changes in fish populations and to study a variety of physical, chemical and biological marine processes: o Ship and fleet operations o Identification of best aquaculture sites o Classify fish habitat o Compute fish distributions o Fish stock assessment	SST, currents, sea surface height, waves and sea state, wind direction/speed, currents, nutrients, ocean colour, chlorophyll concentration, phyto/zooplankton biomass, photosynthetic radiation, carbon, oxygen, alkalinity, salinity, turbidity
Power generation	• Sizing and design of electric power generators at sea, and estimation of the expected electric power to be generated by them based on the marine climatological conditions.	Depending on the energy source used: winds, tides or currents, water temperature gradient, and waves
Tourism	• Providing information to the tourism industry and tourists about local marine meteorological and oceanographic conditions for their activities, e.g. sailing and sea-going, beach activities, including surfing, etc.	Average climatological conditions, and probability of occurrence of extreme weather and marine meteorological events
Insurance	• Calculation of the cost of insurance against inclement weather and marine conditions for activities in the marine and coastal environment (e.g. sports and other media events, offshore infrastructure (e.g. wind turbines, oil rigs and moorings).	Probability of occurrence of extreme weather and marine meteorological events Historical record of actual occurrences of extreme weather and marine meteorological events

Applications	***Examples of use of marine climatological information***	***Marine climatological data and information required***
Coast management	• Design and maintenance of coastal infrastructures • Land management on coasts	Average climatological conditions, and probability of occurrence of extreme events
Disaster Risk Reduction	• Evaluation of the vulnerability of coastal areas which are the most impacted by extreme events • Planning of rescue operations at sea or in coastal regions potentially affected by extreme events	Probability and impact of relevant met-ocean events (e.g. extreme atmospheric and oceanic events)
Prevention and mitigation of marine pollution	• Planning of responses to environmental emergencies such as oil-spills	Average marine climatological conditions (winds, currents, sea state, waves), sea-ice, probability and impact of met-ocean events (e.g., extremes)
Search and rescue	• Planning of search and rescue operations, taking into account the marine climatological conditions	Average marine climatological conditions (winds, currents, sea state, waves), sea-ice
Climate modeling	• Data assimilation • Evaluation of ocean and atmosphere models • Calibration and validation of satellite data using in situ measurements	All marine climatological data
Climate change studies	• Studies of climate change and air-sea interaction • Climate monitoring • Climate change assessment studies • Climate reanalysis	All marine climatological data, including GCOS Essential Climate and Ocean Variables (ECVs, EOVs)

8.1.2 Modernization of the MCSS

The former Marine Climatological Summaries Scheme (MCSS) was established in 1963 by the Fourth Congress for providing international exchange of marine meteorological data and for the preparation of marine climatological summaries.

Preparation of climatological charts and atlases for oceans became possible in the second half of the nineteenth century when ships' observations, recorded in logbooks or in special "abstract" meteorological logs, started to become available in rapidly increasing numbers—and critically with increasing amounts of instrumental data recorded, following the landmark Brussels Maritime Conference of 1853 (WMO 2004, Woodruff et al. 2005). For over 100 years these charts and atlases mainly for use by shipping were prepared nationally, obliging countries to ask for observations stored in other countries to supplement their own data sets.

The objective of the MCSS was to establish a joint effort of all maritime nations in the preparation and publication of global climatological statistics and charts for the oceans. The underlying idea was that all marine meteorological observations collected from ships of whatever nationality should be included. Eight countries, each with a specific ocean area of responsibility, were designated to process the data in prescribed forms and regularly publish the climatological summaries. Two Global Collecting Centres were established in 1993 to improve the flow of the observational data, in particular concerning ship observations.

However, starting around the early 1980s, the need to take into account new sources of marine meteorological and oceanographic data (e.g. from satellites, moored and drifting data buoys, and profiling floats) increased, and with the improvement of computer power, and graphic capabilities, new techniques and practices for processing and presenting marine climatological data and products appeared, such that the preparation of climatological charts and atlases now only forms a small component of the research, educational, and commercial applications of marine climatological data (see Table 1).

This lead to the decision by JCOMM to initiate a modernization of the MCSS, which resulted in the proposal by the fourth Session of JCOMM to plan establishment of the Marine Climate Data System (MCDS). The MCDS was then formally recommended by the Fifth Session of JCOMM and established in 2018 by the Seventieth Executive Council. The MCDS replaces the MCSS which is now obsolete and will contribute to the WMO Global Framework for Climate Services (GFCS).

8.1.3 Introduction to the MCDS

Note: General information on and introduction of the Marine Climate Data System can be found in the *Manual*.

The MCDS essentially provides for standard and recommended practices and procedures, together with non-regulatory guidance assuring the collection, rescue, digitization, exchange, data processing, quality control, value adding, and data flow of marine meteorological and oceanographic climate data and products from various sources. Real-time (RT) and delayed mode (DM) data are collected through a network of specialized centres, and ultimately aggregated at Centres for Marine Meteorological and Oceanographic Climate data (CMOCs), which are meant to provide higher-level quality control, and deliver the consistent data and products needed for a wide range of marine climatological applications.

Basic sources of data include in-situ observations, for example from ships, moored and drifting data buoys, tide gauges, eXpendable BathyThermographs (XBTs), profiling floats, surface and sub-surface gliders, as well as remote sensing data from satellites, aircrafts and a few other specialized sensing systems such as land-based high frequency radars.
See section 8.3 for more information on the MCDS.

8.1.4 Other marine climatology activities

Many marine climatology activities currently fall outside the formal framework of the MCDS, largely relating to the provision of data, information, products and expert advice to serve the needs of end user applications such as those listed in Section 8.1.1 and in Table 1. Ultimately, for a complete and comprehensive MCDS, those falling outside of the current MCDS structure should look to formalize their activities under, and contribute to the MCDS.

Prominent among these activities are the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), focused on surface marine meteorological data and products; and the World Ocean Database (WOD), focused on subsurface physical oceanographic data and products—both discussed further in section 8.3.6. Owing to the central roles these two programmes play internationally, it is envisioned that their activities can be transitioned under the formalized MCDS umbrella in due time.
The International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO has established a network of Global Data Assembly Centres (GDACs), which are also contributing to the MCDS. A Centre can act as JCOMM GDAC, IODE GDAC, or both, while avoiding overlaps and providing assurance the work is complimentary to the functions of both groups.

8.2 Best Practices

8.2.1 General guidance

Note: Adherence to international standards and best practices helps ensure uniformity in data and metadata collection, quality control (QC), and the generation of community-produced observational data and climate products—which in turn helps ensure seamless user access to data and products from the full range of ocean platforms, and in support of a wide scope of operational and research applications.

In order to achieve the highest quality climate data and products, Members of the MCDS should closely follow, or propose where not available, appropriate international standards and best practices—applicable to the full range of marine-meteorological and oceanographic data processing activities including data rescue, collection, QC, documentation, archival, distribution, and mirroring of data, metadata, and products.

Note: Besides those documented in WMO Manuals and Guides, and JCOMM Technical Reports (e.g. JCOMM 2017), best practices related to ocean and marine-meteorological data and products have been established through the JCOMM-IODE Ocean Data Standards and Best Practices (ODSBP) Project, which provides guidance to international data managers. For example, ODSBP has promoted standards for 'Date and Time' (IOC 2011), and QC flag standards (IOC 2013).

Members enquiring on standards and best practices should refer to relevant WMO Manuals and Guides, JCOMM Technical Report No. 85 (JCOMM 2017), the MCDS web site (being developed), the ODSBP repository (which includes ODSBP publications), and the JCOMM Catalogue of Practices and Standards (JCOMM 2015c), and/or the JCOMM Data Management Cookbook "*The Oceanographer's and Marine Meteorologist's Cookbook for Submitting Data in Real Time and in Delayed Mode"* (JCOMM 2014) for additional information and guidance.

8.2.1.1 Retaining the original data

8.2.1.1.1 Members should record and report, in delayed mode, the original data values, where delayed-mode reports are available. Where only real-time or near-real-time reports are provided, they should be permanently preserved in their original format as well. Varying national observing practices, instrumentation, and data recording technologies frequently result in marine climate data undergoing some changes between observation time and data delivery. For example, cloud cover may be observed in oktas, but circulated over the Global Telecommunication System (GTS) in BUFR format in tenths of sky cover. Automated weather systems may measure the wind every 10 seconds, but the reported value is a 2-minute average once an hour. When discrepancies are discovered in the reported data (e.g., value varies from near neighbours, data spikes) the best method to determine the problem is to view the original observation as it was collected (manually or by an instrument). Efforts should be made to retain all source data received at all levels of the MCDS in national repositories.

8.2.1.1.2 Where records, publications, logbooks or other sources of data and metadata have been identified, efforts should be made to preserve the data in their original form, or (for original paper records) scanned into archival-quality digital forms, for eventual digitization. In cases where resources are not immediately available for data rescue or digitization, sources of data should be formally documented, to include detailed inventories as practical, and information made publically available through the International Data Rescue (I-DARE) portal (http://www.idare-portal.org).

8.2.1.2 High-resolution, and high-accuracy data

8.2.1.2.1 Many modern marine climate applications require observations to be collected at time intervals ranging from seconds to minutes. These high-resolution observations support studies of energy, moisture, and gas exchanges between the ocean and atmosphere, evaluations of numerical oceanic and atmospheric models, and calibration and evaluation of satellite observations. When deploying automated weather systems, Members should consider collecting and archiving data at high-sampling rates. High-resolution data should be provided by Members in delayed-mode, when collected.

8.2.1.2.2 The marine climate community also requires traceable observations of known uncertainty and, as much as possible, of high quality. Minimizing uncertainties relies on managing observing systems from instrument selection through the delivery of data. This starts by selecting sensors that meet or exceed standards, properly siting and exposing the instruments, and providing routine maintenance and calibration as set out by WMO No. 8 (WMO 2008). Maintaining and reporting metadata (e.g., sensor calibration, sensor type/make/model, data conversion algorithms, sensor locations) along with the data supports evaluation of uncertainty in the observations, including bias estimation. Information on metadata can be found in section 8.2.3.

Note: Examples of the need for high resolution and accurate data may be found in reports from the Workshops on the Advances in Marine Climatology (CLIMAR; JCOMM 2003b, Parker et al. 2004, Charpentier et al. 2008, JCOMM 2015a) and the Dynamic Part, *Advances in the Applications of Marine Climatology* (JCOMM 2011).

8.2.2 General guidance on the application of quality control and monitoring

In 1993, two Voluntary Observing Ship (VOS) Global Collecting Centres (GCCs) were established by WMO Resolution 11 (CMM-11) of the former WMO Commission for Marine Meteorology (CMM), to facilitate and enhance the flow and quality control of marine meteorological data. Specifically, the VOS GCCs have evolved into VOS-GDACs in the MCDS framework, and are responsible for collecting, processing and distribution of delayed mode marine Voluntary Observing Ship (VOS) data.

There is a range of activities for RT and DM quality control and monitoring.

Real-time monitoring and quality control

A set of quality control tools has been developed by Méteo France to monitor Eumetnet/ E-Surfmar observation networks[1].The QC checks are mainly based on comparisons with model outputs and can be applied to any marine observing platform that reports on the GTS. Reports are generated monthly on network data availability, timeliness, and overall quality as compared to previous months and designated targets.

Additionally, the UK Met Office hosts a Regional Specialized Monitoring Centre[2] (RSMC) for VOS data and a Real-time Monitoring Centre[3] (RTMC) for VOSClim fleet data quality monitoring which complements the duties performed by Méteo France. Monthly reports including monitoring statistics and suspect ship reports are produced and made available online.

1 http://www.meteo.shom.fr/qctools/
2 http://research.metoffice.gov.uk/research/nwp/observations/monitoring/marine/
3 http://research.metoffice.gov.uk/research/nwp/observations/monitoring/marine/VOSClim/index.html

Delayed mode quality control

Minimum Quality Control Standards (MQCS)[4] maintained by the VOS GDACs (JCOMM 2017) provide a basic level of quality control on the VOS data and assure consistency in delayed mode exchanges.

Higher Quality Control Standards (HQCS), as detailed in JCOMM 2017, are being developed to further enhance the VOS data. HQCS is a modernization of the MQCS with additional checks, such as climatological and spatial consistency checks; high resolution checks for 1-minute data and 0.01 degree land masks; and various checks for ranges and internal consistency. Referring to IOC (2011), ODSBP has established a common set of quality flags to assist with mapping between different marine-meteorological and oceanographic data set quality flags. This is a two tiered flag system. The lower tier is the quality flag system used by the particular group. There are no restrictions on this flag system as long as the flag values are well documented, although the preference is for a one-four byte alpha-numeric code. The higher tier is a one byte flag with values 1 (Good), 2 (Not evaluated or unknown), 3 (Questionable, suspect), 4 (Bad) or 9 (Missing data). This higher tier is for the general user who wants a quality control flag but is not interested in the specific reasons for the flagging. The lower tier should provide more detail on the reasons for the quality control flag. More details on the flagging system can be found in IOC (2013).

8.2.3 Metadata: Observational & Discovery

Metadata, both discovery and observational, are essential for: (a) discovering and accessing observations / data of interest; and (b) correctly interpreting those data. Similarly, metadata on the processing applied to those data are critical for ensuring data provenance and traceability, with the ability to access the original data preserved. Within the context of the Global Ocean Observing System (GOOS), Snowden et al. (2010) define and discuss the importance of these metadata. For meteorological and climate applications the minimum required set of metadata is defined within the WIGOS Metadata Standard. This includes metadata at the instrument and platform levels, basic processing information and discovery metadata.

Historically, the metadata has not been reported, or reportable, alongside the observations on the GTS nor in delayed mode due to format limitations. This began to change in 2003 with the inclusion of Voluntary Oberving Ship Climate Fleet (VOSClim) metadata within the delayed mode reporting formats. This will improve additionally with the development of BUFR marine templates. Thus, as required, Members (and other contributors) should regularly contribute and update observational metadata for all platforms that they operate to the appropriate international repository. For those programmes coordinated under JCOMM, such as under the Ship Observations Team (SOT) and Data Buoy Cooperation Panel (DBCP) the repositories are, or will be, managed by JCOMMOPS. In turn, these repositories are linked to the WMO OSCAR database. For other programmes, such as Argo and OceanSITES, the GDACS typically manage the observational metadata. Metadata at the discovery and processing levels are also of critical importance but typically stewarded at a higher level in the MCDS. Thus Members, and other contributors, should actively cooperate with DACs, GDACs and CMOCS in the generation and management of these higher-level forms of metadata.

8.2.4 Data (and metadata) rescue

National and international activities to recover data and metadata from historical ships' logbooks and other international marine meteorological and oceanographic data types (e.g. early buoy networks) remain critical to enhance climate databases, and should be promoted and further enhanced internationally. The WMO Commission for Climatology's (CCl's)

[4] http://www.wmo.int/pages/prog/amp/mmop/documents/MQCS-7-JCOMM-4.pdf

Expert Team on Data Rescue (ET-DARE) oversees an International Data Rescue web portal (I-DARE; http://www.idare-portal.org), and in the oceanographic data domain IOC/IODE'S Global Oceanographic Data Archaeology and Rescue (GODAR) programme rescues oceanographic data. Additionally, the Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative coordinates global data rescue efforts.

8.2.5 Elimination of duplicates and tracking data provenance

One of the difficult problems faced by met-ocean data providers (e.g., profile, VOS data), is to match RT and DM versions of the same original data. Typically, the RT version can contain uncertainties or inaccuracies both in positions and times and they may contain un-calibrated data. The DM data often have these errors corrected and so matching RT to DM data is not simply a matter of matching ship identifier, position and time.

Several marine climate programs have developed methods to compare RT and DM met-ocean reports to support duplicate elimination. The Global Temperature and Salinity Profile Programme (GTSPP) has developed and tested a procedure to generate unique data tags for original ocean profile data by using the cyclic redundancy check (CRC) algorithm and successfully incorporated the CRC algorithm into its daily data processing stream. ICOADS also employs a complex duplicate elimination process (ICOADS 2016) and takes advantage of unique record identifiers to track the provenance of related RT and DM reports.

In the future, WIGOS identifiers, as mentioned in section 8.2.3 will be helpful in tracking provenance of platforms providing RT and DM reports and efforts should be made to provide minimum required set of metadata as defined within the WIGOS Metadata Standards.

8.3 Marine Climate Data System

8.3.1 MCDS Description

8.3.1.1 The JCOMM Marine Climate Data System (MCDS) provides routine and standardised collection of real-time and delayed-mode climatological data and metadata. It includes both marine-meteorological and oceanographic data made available through a network of CMOCs, promoting the sharing, collection, recording, mirroring, and exchange of data and metadata for all types of end-users.

8.3.1.2 MCDS Data Acquisition Centres (DAC) receive data directly from JCOMM observing platforms within the scope of the DAC, data being in agreed formats, and provided in delayed-mode and real-time by:

(a) Receiving data from a specific data source in delayed-mode, applying agreed minimum quality control, investigating problems when required and forwarding of data to the appropriate GDAC;
(b) Receiving data from all real-time sources through existing GTS Centres , applying agreed minimum quality control, investigating problems when required and forwarding of data to the appropriate GDAC;

8.3.1.3 Select Global Data Assembly Centres (GDAC) combine agreed streams of data received from DACs within the GDACs' scope. Their role is to establish a complete dataset (including metadata), perform agreed quality checks and forward the data and metadata (both observational and discovery) with flags to the CMOC in agreed formats. Delayed mode observations should be complemented with real-time data, compared, and duplicates removed where possible. It is recommended that the GDACs be interoperable with the WMO Information System (WIS) and/or the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO Ocean Data Portal (ODP).

8.3.1.4 All data (original and QC'd) and metadata received from GDACs are forwarded to the suitable MCDS Centre for Marine-Meteorological and Oceanographic Climate Data (CMOC). CMOCs act as specialized centres, applying higher quality control standards (HQCS) and bias correction as required, making datasets and products available to the JCOMM Marine Climate Data System (MCDS) User Interface (MCDS-UI) and advising member/members states when appropriate (see CMOC Terms of Reference for further information). Data and metadata are stored in line with defined JCOMM standards to ensure data integrity and universal interoperability.

8.3.1.5 Searching, downloading, displaying and analysis of data and products will be undertaken through links provided on the MCDS-UI and additionally through the WMO WIS and/or the IODE ODP discovery portals.

8.3.1.6 CMOCs act as specialized centres ensuring integrated datasets and products are made available through the WMO WIS and/or the IODE ODP.

8.3.1.7 A detailed schematic of the MCDS dataflow, including IOC components, is shown in figure 1.

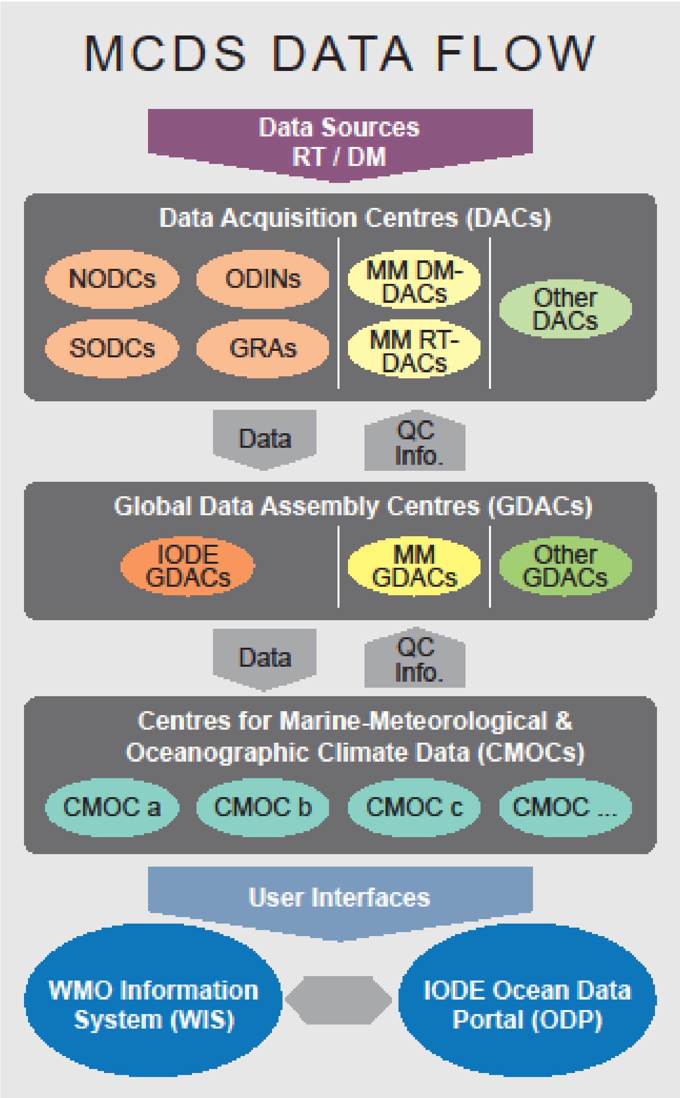

Figure 1. MCDS data flows, from source to users. NODCs = IODE National Oceanographic Data Centre; SODCs = IODE Specialized Ocean Data Centre; ODINs = Ocean Data and Information Networks; GRAs = GOOS Regional Alliances; MM = Marine-Meteorological; DM = Delayed Mode data; RT = Real-time data; DAC = Data Acquisition Centre; GDAC = Global Data Assembly Centre; CMOC = Centre for Marine-Meteorological and Oceanographic Climate Data; QC = Quality Control.

8.3.2 Ship Observations

8.3.2.1 Voluntary Observing Ships (VOS) provide meteorological and/or oceanographic observations manually, generally nowadays using electronic logbook (e-logbook) software e.g. TurboWin in delayed mode (DM) or automatically in real-time (RT). An increasing number of automated systems is installed on VOS supplying data in RT.

While most research vessels report high-resolution RT data only to archives and injected into the MCDS at the CMOC level, some low-resolution reports are distributed on the GTS and captured by GTS collection DACs.

8.3.2.2 VOS DACs are responsible for collecting VOS data from their recruited vessels, applying MQCS[4] and forwarding the quality checked data to the two VOS GDACs on a quarterly basis in an agreed data format (currently International Maritime Meteorological Tape [IMMT][5]). This comprises traditional manual DM observations as well as data received in RT from automated systems.

The members operating automated systems on board of VOS should also prepare this data by applying MQCS[4] and meta-data supplements and redistribute it in the agreed data format for delayed mode processing to the GDACs.

Additionally, a RT DAC acquires and forwards VOS observations from the GTS and prepares the data for further processing by applying MQCS[4], reformatting, and adding supplementary meta-data.

All DACs should provide feedback on any data quality issues to VOS or Port Meteorological Officers.

8.3.2.3 Within MCDS, two VOS GDACs are responsible for the data management of DM data received from VOS DACs. The VOS GDACs operate in parallel, mirroring each other.

The VOS GDACs should ensure MQCS[4] is applied to all incoming data streams notifying respective VOS DACs of any issues. Discovery metadata is made available via the WMO WIS and/or the IODE ODP. All data (original and quality controlled) and associated metadata with flags should be forwarded in an agreed data format (currently IMMT[5]) to the appropriate CMOC.

8.3.2.4 The VOS GDACs should also complement the DM data with RT data from the GTS data streams prepared by RT VOS DAC. Aggregated near-real-time data products from different data sources can then be developed at the CMOC level.

8.3.3 Data Buoys

8.3.3.1 Data buoys (DB), moored (e.g. GTMBA) or drifting Global Drifter Program (GDP), provide meteorological and/or oceanographic observations automatically. Drifting Data Buoys (DDB) transmit their data in real-time to their owner agencies via a satellite system and value-added resellers generally reformat and transmit some, or all, of the data on the GTS. Moored Data Buoys (MDB) also transmit their data in real-time, but generally store more data on-board and so may provide additional data in delayed-mode to local or national agencies, if/when recovered.

8.3.3.2 The DDB and MDB DACs are responsible for collecting data from the respective buoys type that they operate or have links to, applying quality control and forwarding the quality checked data to the DDB and MDB GDACs on a yearly basis. They should also feedback on any data quality issues to JCOMMOPS Technical Coordinator of Buoy Operations.

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5 https://www.wmo.int/pages/prog/amp/mmop/documents/IMMT-5-JCOMM-4.pdf

8.3.3.3 The DDB and MDB GDACs are responsible for the integration of all DAC data received from their respective platform types. There are two DDB GDACs that ensure quality control, notifying data quality issues to JCOMMOPS Technical Coordinator of Buoy Operations. Operating in pair, the DDB GDACs compare data holdings frequently to identify missing data streams, so that eventually they may both acquire identical data on a routine basis. All data (original and quality controlled) and associated metadata with flags should be forwarded to the appropriate CMOC. Discovery metadata is made available via the WMO WIS and/or the IODE ODP where possible.

8.3.4 High Resolution Automated Systems

Advanced technology has led to an increased number of automated weather systems being deployed on VOS, rigs, platforms, and coastal stations, along with emerging technologies such as gliders and autonomous surface vessels (ASV). In some cases, these systems are implemented by national meteorological/ocean services, (e.g., the land-based marine observing coastal stations, meteorological measurements associated with international tide gauge networks) while others are essentially implemented by the research community (e.g., ASV, gliders) or private sector industries (e.g., offshore oil platforms, wind turbines). These data may or may not be transmitted via the GTS, thus some of these data do not follow this pathway to the specialized data centres within the MCDS. Members hosting a system or data collection centre that specializes in data from high-resolution automated systems should support the submission of these data in delayed mode to an appropriate GDAC or CMOC.

8.3.5 Ocean data

Note: There are many sources for subsurface profile data. In near-real time (usually within 48 hours) data from the Argo profiling float program are made available through the Coriolis (France) and Global Ocean Data Assimilation Experiment (GODAE) DACs. Data from Expendable Bathythermographs (XBTs) through the Ship of Opportunity Program (SOOP), gliders, Conductivity Depth Temperature (CTD), pinniped mounted profilers, are pulled from the Global Telecommunications System (GTS) and uploaded to the Global Temperature and Salinity Profile Program (GTSPP) Continuously Managed Database (CMD). Data with a higher level of quality control are available through GTSPP from partners around the world for XBTs, from the CLIVAR and Carbon Hydrographic Office (CCHDO) and the Biological and Chemical Oceanography Data Management Office (BCO DMO) for CTD and bottle, the (newly formed) Animal Telemetry Network Data Assembly Center (ATN) for pinniped mounted profilers, three regional glider data assembly centres (US, European Union, Australia) for gliders, and OceanSites for deep water moored buoys. There are other sources for subsurface data, especially CTD, bottle, and XBT from research cruises, usually held by primary investigators or institutions. All of these sources are ingested, with original quality control, into the World Ocean Database (WOD). The WOD makes the data available in a uniform format with an additional set of uniform quality control flags. The WOD (and many of the sources) make their data available to the IODE ODP.

For new data sources, Centres should make efforts to distribute real-time data through the GTS so that Centres around the world have instant access to the data. For delayed-mode data collection, programs mentioned may provide a suitable archive for the new DM data source or the new program/platform should collaborate with an existing program, e.g. those mentioned in section 8.3.5, when setting up a similar data retrieval/archival process in order to learn from previous experiences and to avoid any duplication of efforts.

8.3.6 Major marine climatology programmes

The International Comprehensive Ocean-Atmosphere Data Set (ICOADS; http://icoads.noaa.gov) programme is focused on the stewardship of surface marine meteorological data and products. ICOADS is now managed via an international partnership with eight signatories from the US, UK, and Germany (Freeman et al. 2016).

ICOADS offers surface marine data spanning the past three centuries, and simple gridded monthly summary products for 2° latitude x 2° longitude boxes back to 1800 (and 1°x1° boxes since 1960)—these data and products are freely distributed worldwide. As it contains observations from many different observing systems encompassing the evolution of measurement technology over hundreds of years, ICOADS is probably the most complete and heterogeneous collection of surface marine data in existence.

Similarly, the World Ocean Database (WOD) programme WOD is a collection of QC'd ocean profile data, extending from the 1800's to present day, and updated routinely with modern and rescued data (Boyer et al. 2013).

World Ocean Atlas (WOA) products based on WOD include a set of objectively analyzed (1° grid) climatological fields of in situ temperature, salinity, and other oceanographic variables. WOA also includes associated statistical fields of observed oceanographic profile data interpolated to standard depth levels on 5°, 1°, and 0.25° grids. While linked with the IOC/IODE and the GODAR data rescue programme, the WOD and WOA activities are operated primarily by the NOAA National Centers for Environmental Information (NCEI) (https://www.nodc.noaa.gov/OC5/indprod.html).

Satellites provide an additional data source that should be included in the MCDS in order to compliment the in situ observing platforms of the MCDS and to provide additional climatological data for long-term use.

8.3.6.1 Observational data formats for archival and user access

ICOADS utilizes the International Maritime Meteorological Archive (IMMA) format. The IMMA format (Smith et al., 2016; Woodruff, 2007) is used to store and provide ICOADS observational data to users, and also to permanently archive the data and metadata in a technologically stable and readily exchanged form. The IMMA format is ASCII-based, containing a *Core* section including date, time, location and identification information along with commonly reported meteorological variables and associated metadata, followed by an arbitrary number of "attachments" to meet more specific data or metadata requirements. While the IMMA format is complex and not easily readable by the human eye, web-based user interfaces can product spreadsheet formats and other customized formats. A netCDF version of ICOADS has been developed and will be accessible in 2017.

Similarly WOD utilizes a custom ASCII format that was constructed to save space and therefore is not easily readable by the human eye. Software is publicly available to convert the native format into formats which are more easily readable and usable in common software. Additionally, WOD data can be output in netCDF format from WODselect (https://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html).

Additional agreed data formats will be used within the MCDS, and will be thoroughly documented and compatible between operating Centres to ensure harmonious flow of data through the MCDS system.

8.3.6.2 Access to data and products

ICOADS individual observations and monthly summary products are available to users from multiple access points at US partner organizations, the NCAR, NCEI and NOAA's Earth System Research Laboratory (ESRL), each with slightly different options designed to serve different user groups. The ICOADS products web page (http://icoads.noaa.gov/products.html) links to full information and data distribution websites.

WOD data and WOA products are accessible from NCEI, with current data/product versions (2013) available from these locations: https://www.nodc.noaa.gov/OC5/WOD13/ and https://www.nodc.noaa.gov/OC5/woa13/.

Additional agreed products will be generated within the MCDS, and will be thoroughly documented and accessible to ensure harmonious flow of data through the MCDS system. All data and products will be discoverable through the WMO WIS and/or the IODE ODP through the CMOC network and will contribute to the WMO GFCS.

8.3.7 Application procedure and evaluation process for establishing a Centre in the MCDS

8.3.7.1 The governance for defining the functions and adoption of each type of MCDS Centre – DAC, GDAC, or CMOC – is defined in paragraph 5.2.4 of WMO No. 558.

8.3.7.2 The application procedure for establishing an MCDS centres (i.e. DAC, GDAC, or CMOC) is detailed below:

(a) The host of the candidate MCDS Centre will describe the extent to which it will be addressing requirements of scope, capabilities, functions and data and software policy of the proposed MCDS Centre.

(b) Once the host of the candidate MCDS Centre has established that it meets the requirements to a sufficient extent, the IOC Action Addressee of the Country, or the Permanent Representative of the Country with WMO, as appropriate, writes to the IOC Executive Secretary or the WMO Secretary General respectively, to formally state the offer to host and operate the MCDS Centre on behalf of the WMO and IOC, and to request that the Centre be evaluated and added to the list of MCDS Centres. In doing so, the host of the candidate MCDS Centre also provides a statement of requirements, scope, capabilities, functions and data and software policy relevant to the MCDS Centre Terms of Reference (DAC, GDAC, or CMOC as appropriate). The letter should be copied to the appropriate JCOMM Co-President, and for CMOC applications also to the relevant President of the WMO Regional Association or Chair of the IOC Regional Subsidiary Body in the case where the MCDS Centre is only providing data corresponding to a specific geographic region.

(c) The IOC or WMO Secretariat will then request the appropriate JCOMM Co-President to take action through relevant JCOMM body to evaluate and verify compliance with requirements of the proposed Centre.

(d) The designated JCOMM body evaluates the request and advises in writing whether the MCDS Centre application should be endorsed. The designated body may wish to delegate this work to individuals and/or groups acting on its behalf (e.g. one of the component teams, depending on the nature of the proposed Centre), but any advice and proposal to JCOMM should still be assessed by and come through the designated body. JCOMM will also conduct reviews of performance and capabilities at the required intervals.

(e) If endorsed by the designated body, and depending on timing, the body makes a recommendation to the JCOMM Management Committee, and invites them to provide further advice to JCOMM.

(f) If not endorsed by the designated body or the management committee, the JCOMM Co-President should advise the candidates about areas where the candidate Centre can be improved to meet requirements. Candidates can reapply at a later date once changes have been made to meet these criteria.

(g) If endorsed by the management committee, a recommendation to include the candidate MCDS centre in the list of such centres in WMO No. 558 (for CMOCs) and WMO No. 471 (for DACs and GDACs) is passed to the next JCOMM Session, or depending on timing, directly to the WMO Congress or Executive Council and the IOC Executive Council or Assembly following JCOMM consultation in writing.

(h) If recommended by JCOMM, a Resolution for the proposed change in WMO No. 558 and/or WMO No. 471 is proposed to the WMO Congress or Executive Council and a corresponding Decision proposed to the IOC Executive Council or Assembly for including the candidate in the list of MCDS Centres.

Note: It is expected that this process, from submission of the MCDS Centre proposal to the JCOMM Co-President, to formal approval by both WMO/IOC Executive bodies, may take from 6 months to 2 years.

8.3.7.3 At times it may be necessary for a Centre to be withdrawn from the MCDS Centre role. The approach proposed by JCOMM is the following:

(a) The body designated by JCOMM should review each Centre for necessary capabilities and performance once every five years. If the review is favourable then the MCDS Centre can continue its role as before. If the review is not favourable then the DMCG must insist improvements to be made and reviewed within one year. If the second review is still not favourable then the MCDS Centre role will be withdrawn from the Centre through a recommendation by JCOMM and subsequent decision by the WMO Executive Council and IOC Assembly.

(b) If a Centre no longer wishes to carry out the functions of a MCDS Centre, JCOMM should be advised immediately through the Secretariat.

8.3.7.4 The detailed accreditation process and evaluation criteria for establishing MCDS Centres, and regularly evaluating their performances is provided in JCOMM 2017.

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Appendix 8.1
MCDS Centres (scope, designation, and evaluation)

1. Introduction

	DAC	GDAC	CMOC
Capabilities	Each Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfil the approved functions	Each Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfil the approved functions	Each Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfil the approved functions
		Each Centre is recommended to be interoperable with the WMO WIS and/or the IODE ODP	Each Centre's data system must be interoperable with the WMO WIS and/or the IODE ODP
	Each Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management	Each Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management or document current procedures as being utilized in the MCDS.	Each Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management
			Mirroring CMOCs must be able to actively and reliably "mirror" (i.e. maintain mutually consistent) data, metadata, and products, as agreed within the CMOC
	The JCOMM Data Management Coordination Group (DMCG) must assess each Centre, at least once every five years, to verify it meets the necessary capabilities and performance indicators as agreed by the Commission	The JCOMM Data Management Coordination Group (DMCG) must assess each Centre, at least once every five years, to verify it meets the necessary capabilities and performance indicators as agreed by the Commission	The JCOMM Data Management Coordination Group (DMCG) must assess each Centre, at least once every five years, to verify it meets the necessary capabilities and performance indicators as agreed by the Commission
Functions & Tasks	Each Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and/or oceanographic data and metadata (and optionally by mutually agreed CMOC-DAC products e.g. regional statistics) as documented in appropriate WMO and IOC publications	Each Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and /or oceanographic data and metadata (and optionally by mutually agreed CMOC-GDAC products) as documented in appropriate WMO and IOC publications (and to the extent that these functions are not already carried out by other existing data centres, but are complimentary to the functions of these centres)	Each Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications (if appropriate in collaboration with DACs/GDACs), for example by rescuing, collecting, processing, archiving, sharing and distributing worldwide marine-meteorological and/or oceanographic data and metadata and to the extent that these functions are not already carried out by other existing data centres, but are complimentary to the functions of these other centres

	DAC	GDAC	CMOC
Functions & Tasks			Each Centre must provide advice to Members/Member States internationally in response to enquiries regarding standards and best practices for example on data rescue, collection, processing, archival, and distribution of marine-meteorological and/or oceanographic data, metadata, and products, preferably by referring to the JCOMM/IODE Ocean Data Standards (and best practices) (pilot) project and its publications and/or the MCDS website
	Each Centre, within the confines of its agreed scope, must receive and gather meteorological and/or oceanographic data (real-time or delayed-mode) and metadata directly from the observation platforms	Each Centre, within the confines if its agreed scope, must receive and assemble meteorological and/or oceanographic data (real-time or delayed-mode) and metadata from the appropriate DAC	
		Each Centre should identify duplicates within the dataset and ensure that they are resolved	Each Centre should identify duplicates within the dataset and ensure that they are resolved, when not performed at the GDAC level
		Each Centre should compare both real-time and delayed-mode data streams, where they exist and are part of the GDAC's scope	Each Centre should compare both real-time and delayed-mode data streams, where they exist, when not performed at the GDAC level
	Each Centre must forward the data and metadata to the appropriate GDAC(s) in agreed format(s) within defined time scales	Each Centre must forward the data and metadata to the appropriate CMOC(s) in agreed format(s) within defined time-scales	
		Each Centre is recommended to be interoperable with the WMO WIS and/or the IODE ODP in order to make discovery metadata available	Each Centre must make datasets, and corresponding metadata, within the confines of its scope, available and discoverable through the WMO WIS and/or the IODE ODP
	Each Centre must communicate and liaise within the DAC network and the wider MCDS	Each Centre must communicate and liaise within the GDAC network and the wider MCDS	Each Centre must communicate and liaise closely within the CMOC network and the wider MCDS; particularly on the development and application of quality processes and procedures and on progress with their defined tasks

	DAC	GDAC	CMOC
Functions & Tasks	Each Centre must operate appropriate data processing and agreed quality control procedures within its scope as documented in appropriate WMO and IOC publications	Each Centre must operate appropriate data processing and agreed quality control procedures within its scope as documented in appropriate WMO and IOC publications	Each Centre must operate appropriate data processing and higher quality control procedures, and generate the required products within its scope
	Each Centre must provide feedback to the platform operators if data problems are encountered	Each Centre must provide feedback to the DACs on data quality issues	
			Mirroring CMOCs will mirror data, metadata, products and processes at defined time-scales The method of mirroring will be agreed upon among mirroring centres
			Data (e.g. instrumental metadata) and products managed within a CMOC will be subject to version control, and metadata history will be preserved, using procedures agreed upon within the MCDS
	Each Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC informed on the status and activities of the DAC network as a whole, and proposed changes, as required.	Each Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC Assembly informed on status and activities of the GDAC network as a whole, and proposed changes, as required.	Each Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on the services offered to Members/Member States and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC informed on the status and activities of the CMOC network as a whole, and propose changes, as required.

2. Data Acquisition Centres (DACs)

2.1 DAC Terms of Reference

2.1.1 A global network of appointed DACs will receive and gather meteorological and/or oceanographic data (real-time or delayed-mode) and metadata directly from the observation platforms and then forward onto the relevant GDAC.

2.1.2 Governance for defining the functions and adoption of DACs is defined in WMO No. 558 and paragraph 8.3.7 of this Guide.

2.1.3 To meet its MCDS requirements DACs must have the following:

Scope

(a) Each DAC will define its scope of activities, that is the types of observing platform(s) for which data shall be collected, whether these are collected nationally, regionally and/or from a specific ocean region of interest, and what quality control standard is being applied to the data;

Capabilities:

(a) Each Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfill the approved functions;
(b) Each Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management;
(c) The JCOMM Data Management Coordination Group (DMCG) must assess each Centre, at least once every five years, to verify it meets the necessary capabilities and performance indicators as agreed by the Commission.

Corresponding Functions and Tasks:

(a) Each Centre, within the confines of its agreed scope, must receive and gather meteorological and/or oceanographic data (real-time or delayed-mode) and metadata directly from the observation platforms;
(b) Each Centre must forward the data and metadata to the appropriate GDAC(s) in agreed format(s) within defined time-scales;
(c) Each Centre must have documented data processing and quality control procedures within its scope;
(d) Each Centre must provide feedback to the platform operators if data problems are encountered;
(e) Each Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and/or oceanographic data and metadata (and optionally by mutually agreed CMOC-DAC products e.g. regional statistics) as documented in appropriate WMO and IOC publications;
(f) Each Centre must communicate and liaise within the DAC network and the wider MCDS;
(g) Each Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC informed on the status and activities of the DAC network as a whole, and proposed changes, as required.

Data Policy and Software Licensing Usage Rights Requirements

(a) A DAC must be committed to make all the data, metadata, and products falling within the scope of the DAC network available to the international research community in a way consistent with WMO Resolution 40 (Cg-XII) and IOC Resolution IOC-XXII-6. Where applicable software should also be shared.

2.2 List of established DACs in the MCDS

As part of the modernization of the former Marine Climate Summaries Scheme (MCSS), now replaced by the MCDS, the following former MCSS Contributing and Responsible Members have been given the following DAC role in the MCDS. Other MCSS Members are expected to be confirmed upon approval.

DAC operated by (Country)	***Role in MCDS***
Germany	Contributing Member migrated to DAC for delayed-mode VOS data
Hong Kong Observatory, China	Contributing Member migrated to DAC for delayed-mode VOS data
India	Contributing Member migrated to DAC for delayed-mode VOS data in India's former area of responsibility in the MCSS
Japan	Contributing Member migrated to DAC for delayed-mode VOS data
Russian Federation	Polar sea ice
United Kingdom	Contributing Member migrated to DAC for delayed-mode VOS data
United States of America	DAC for VOSClim Contributing Member migrated to DAC for US delayed-mode data DAC for RT marine data from the Global Telecommunication System (GTS)

2.3 Evaluation Criteria for DACs

	Criteria	**How do you meet the requirement?**
1	Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfill the approved functions;	
2	Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management	
3	Scope of the activities of the Centre to receive and gather meteorological and/or oceanographic data (real-time or delayed-mode) and metadata directly from the observation platforms	
4	Centre must forward the data and metadata to the appropriate GDAC(s) in agreed format(s) within defined time-scales	
5	Centre must have documented data processing and quality control procedures within its scope	
6	Centre must provide feedback to the platform operators if data problems are encountered	
7	Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and /or oceanographic data and metadata (and optionally by mutually agreed CMOC-DAC products) as documented in appropriate WMO and IOC publications	
8	Centre must communicate and liaise within the DAC network and the wider MCDS	
9	Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC Assembly informed on status and activities of the DAC network as a whole, and proposed changes, as required	

3. Global Data Assembly Centres (GDACs)

3.1 GDAC Terms of Reference

3.1.1 A global network of appointed GDACs will assemble and quality control meteorological and/or oceanographic data (real-time or delayed-mode) and metadata received from the appropriate DACs and then forward onto relevant CMOC(s).

3.1.2 Governance for defining the functions and adoption of GDACs is defined in WMO No. 558 and paragraph 8.3.7 of this Guide.

3.1.3 To meet its MCDS requirements GDACs must have the following:

Scope

(a) Each GDAC will define its scope of activities, that is the types of observing platform(s) for which data shall be collected and compiled, and what quality control standard is being applied to the data before submission to a CMOC;

Capabilities:

(a) Each Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfil the approved functions;
(b) Each Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management;
(c) The JCOMM Data Management Coordination Group (DMCG) must assess each Centre, at least once every five years, to verify it meets the necessary capabilities and performance indicators as agreed by the Commission;
(d) Each Centre should be interoperable with the WMO WIS and/or the IODE ODP, where feasible.

Corresponding Functions and Tasks:

(a) Each Centre, within the confines if its agreed scope, must receive and assemble meteorological and/or oceanographic data (real-time or delayed-mode) and metadata from the appropriate DAC;
(b) Each Centre should identify duplicates within the dataset and if possible resolve under agreed processes;
(c) Each Centre, where both real-time and delayed-mode data streams exist, should compare DM with RT data sources, and rectify any differences and/or duplicates between the different sources;
(d) Each Centre must have documented data processing and higher quality control procedures within its scope;
(e) Each Centre must provide feedback to the DACs on data quality issues;
(f) Each Centre should make discovery metadata available to the WMO WIS and/or the IODE ODP, where feasible, noting that this is recommended but not mandatory;
(g) Each Centre must forward the data and metadata to the appropriate CMOC(s) in agreed format(s) within defined time-scales;
(h) Each Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and /or oceanographic data and metadata (and optionally by mutually agreed CMOC-GDAC products) as documented in appropriate WMO and IOC publications (and to the extent that these functions are not already carried out by other existing data centres, but are complimentary to the functions of these centres);
(i) Each Centre must communicate and liaise within the GDAC network and the wider MCDS;

(j) Each Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC Assembly informed on status and activities of the GDAC network as a whole, and proposed changes, as required.

Data Policy and Software Licensing Usage Rights Requirements

(a) A GDAC must be committed to make all the data, metadata, and products falling within the scope of the GDAC network available to the international research community in a way consistent with WMO Resolution 40 (Cg-XII) and IOC Resolution IOC-XXII-6. Where applicable software should also be shared.

3.2 List of established GDACs in the MCDS

The following centres have been given the following roles as GDACs in the MCDS:

GDAC	***Role in MCDS***
SOC/DB (France)	GDAC for Real-Time Drifting Buoys
RNODC/DB (Canada)	GDAC for Delayed-Mode Drifting Buoys
WMO Global Collecting Centres (UK and Germany)	GDAC for Delayed-Mode VOS data

3.3 Evaluation Criteria for GDACs

	Criteria	**How do you meet the requirement**
1	Centre must have, or have access to, the necessary infrastructure, facilities, experience and staff required to fulfill the approved functions;	
2	Centre must be able to apply defined WMO and IOC international standards applicable for Data and Quality Management;	
3	Centre should be interoperable with the WMO WIS and/or the IODE ODP, where feasible, however not mandatory;	
4	Scope of the activities of the Centre as an MCDS GDAC;	
5	Centre, within the confines if its agreed scope, must receive and assemble meteorological and/or oceanographic data (real-time or delayed-mode) and metadata from the appropriate DAC;	
6	Centre should identify duplicates within the dataset and if possible resolve;	
7	Each Centre, where both real-time and delayed-mode data streams exist, should compare DM with RT data sources, and rectify any differences and/or duplicates between the different sources;	
8	Centre must have documented data processing and higher quality control procedures within its scope;	
9	Centre must provide feedback to the DACs on data quality issues	
10	Centre should make discovery metadata available to the WMO WIS and/or IODE ODP, where feasible, however not mandatory.	
11	Centre must forward the data and metadata to the appropriate CMOC(s) in agreed format(s) within defined time-scales	

12	Centre, within the confines of its agreed scope, must contribute to WMO and IOC Applications by collecting and processing worldwide marine-meteorological and /or oceanographic data and metadata (and optionally by mutually agreed CMOC-GDAC products) as documented in appropriate WMO and IOC publications (and to the extent that these functions are not already carried out by other existing data centres, but are complimentary to the functions of these centres)	
13	Centre must communicate and liaise within the GDAC network and the wider MCDS	
14	Centre should report, on an annual basis, to the JCOMM Management Committee through the DMCG on its status and the activities carried out. JCOMM in turn should keep the Executive Councils of the WMO and the UNESCO/IOC Assembly informed on status and activities of the GDAC network as a whole, and proposed changes, as required	

4. Centres for Marine Meteorological and Oceanographic Climate Data (CMOCs)

4.1 The Terms of Reference and Evaluation Criteria of the Centres for Marine Meteorological and Oceanographic Climate Data (CMOCs) are provided in the Manual on Marine Meteorological Services, WMO-No. 558.

4.2 Governance for defining the functions and adoption of CMOCs is defined in WMO No. 558.

4.3 CMOCs (established and proposed) in the MCDS

CMOC	***Scope of duties in the MCDS***
CMOC-China	• Integrate marine-meteorological and oceanographic climate drifting buoy data, metadata, and actively conduct HLQC and produce specialized datasets of ECVs and EOVs; • Actively participate in the research and development of oceanographic and marine-meteorological products, and their related services: climate statistical products and reanalysis products; • 7X24 operation website to provide free services to users, and mirroring with other CMOCs when possible; • Provide technical training, and carry out capacity building activities for countries in the region.
CMOC-WOD (Application being prepared for submission)	• Collection, archive and management of global profile observations from multiple sources including DACs and GDACs within the MCDS. • Monthly summary statistics and climate products. • Development and advice to other Members.

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