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| **WMO Ice Forecaster Competency Framework** |
| The following document is providing as minimum competency requirements to effectively perform the duties of an ice forecaster (IF) for all operational ice services and institutes in the world. The competency framework identifies the knowledge, skills and behaviours that should be demonstrated.  Implicit in the background knowledge and skills for IF is the recommendation that they should have successfully completed the Ice Forecast Training Program (IFTP) or relevant parts thereof. It should, however, be recognised that national personnel qualification requirements for IF may be set at a higher level, e.g. a national requirement for an IF to also be degree qualified. |
| In general, the ice services are responsible for sea ice covered regions over Global Ocean, interior lakes and rivers and their interaction with the land and the atmosphere. There will be considerable variation in the legitimate functions of ice services worldwide. Consequently, it is not possible to write a document that exactly matches every service’s function. Therefore the performance criteria should be applied in a way that is consistent with these variations.  Once this competency framework is adopted, each ice service will define how the competencies relate to their own national operations. That is, the ice services will have to adapt the competencies, associated underpinning knowledge and performance criteria that are specific to their functions and region. Therefore, the performance criteria should be applied within the context of the following conditions:   * For the area of responsibility – http://www.gmdss.org/metareas.html * In consideration of the impact of sea and terrestrial ice phenomena, variables and parameters on marine operations; and * In compliance with marine user requirements, international regulations, local procedures and priorities.   The competency requirements are as follows:   1. Analyse and monitor continuously the ice conditions and parameters. 2. Forecasts of ice conditions and parameters. 3. Warn of hazardous ice conditions and parameters prone to damage vessels and equipment, and threaten the safety of marine navigation and fishing activities. 4. Ensure the quality of ice information and services 5. Communicate ice information to internal and external users   **Note:** As this competency framework is recommended and generic to all providers of ice forecast and warning services. Any priorities should be established by the individual ice service based on their mandate. |

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| **Format of the Framework** |
| The framework is provided under the following headings:   * The recommended competency * Competency description * Performance criteria * Background knowledge and skills   The details within each of the headings describe the aspects of each competency recommended for an effective service. The specific performance criteria for a given ice service’s program should reflect the roles and responsibilities of the office’s service.  The role of ice analysts and forecasters will continue to change in response to evolving technology and user requirements. As such, any change will require high standards of competency and underlying knowledge and skills with a focus on continuous improvement. This framework is presented in an attempt to anticipate as much as possible those changes in the future. The adoption of a quality management approach is strongly recommended. |

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| **1. ANALYSE AND CONTINUOUSLY MONITOR THE ICE CONDITIONS AND PARAMETERS** |
| **Competency Description:**  Integrate multiple remote sensing sources, meteorological and oceanographic data and auxiliary data sources to monitor continually the ice conditions. Use applicable geographical information systems and local standard operating procedures to produce timely and accurate sea ice analysis. Determine the need for issuance, cancellation or amendment/update of forecasts and warnings according to documented thresholds and regulations. |
| **Performance Criteria** |
| 1. Use effectively basic satellite data, active microwave sensors, optical, near infrared, thermal Infrared, radar and laser Altimetry, interferometric passive microwave (SMOS) and in-situ observations in monitoring and analysing the ice conditions. |
| 2. Compare current forecasts and warnings against current ice conditions. |
| 3. Based on the monitoring/analysing the ice conditions and parameters, warnings issued by other ice services, and model guidance, appraise the need for amendments to forecasts and updates of warnings against established and documented criteria. |
| **Background knowledge, skills and abilities** |
| • Knowledge of the ice products (routine and non-routine), their issue times and the priorities applied in the region. |
| • Knowledge of non-routine weather conditions and local effects that trigger ice pressure warnings, rapid closing of coastal leads warnings and special Ice warning. |
| • Knowledge of meteorological and ice analysis techniques (subjective and objective). |
| • Knowledge of relevant observing systems, platforms, and sensors that may include remote sensing (satellite altimeters, microwave sensors); radar, in-situ sensors ( moored wave buoys, drifting buoys, bottom pressure sensors, ice thickness sensors); human observing procedures (ship, shore) and how their advantages and limitations vary with respect to prevailing seasonal and meteorological/ice conditions. |
| • Knowledge of bathymetry, coastal geomorphology, marine climatology, oceanic currents, any local marine phenomena, local weather systems, and their potential impacts on ice movement, developing, melting and destruction in the area of responsibility. |
| • The ability to perform manual/subjective analyses (including techniques for analysis in data sparse areas). |
| • The ability to perform analysis on ice related images. |
| • The ability to perform statistical data analyses. |
| • The ability to apply statistical analysis and other informational techniques to data, which has a geographical, or geospatial aspect. |

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| **2. FORECAST ICE CONDITIONS AND PARAMETERS.** |
| **Competency Description**  Forecasts of ice conditions and parameters are prepared and issued in accordance with documented requirements, priorities and deadlines. Demonstrate a good working knowledge of the weather producing processes, characteristics and behaviour of synoptic and mesoscale weather systems and sea ice physics and dynamics. Use this knowledge in forecasting the ice movement, development, melting and destruction. |
| **Performance Criteria** |
| 1. Analyse and diagnose the ice conditions and parameters as required for the preparation and issue of forecasts. |
| 2. Prepare forecasts for the following ice conditions and parameters:   * ice concentration * floe size * stage of development * ice movement * freeze up time * break up time * ice deformation * icebergs and their movement   Other international/national forecast requirements as listed under Regional Variations. |
| 3. Ensure that forecasts are prepared and issued in accordance with national standard operating procedures (SOPs) including format, codes and technical regulations on content, accuracy and timeliness. |
| 4. Ensure that forecasts of ice conditions and parameters are consistent (spatially and temporally) across boundaries of the area of responsibility as far as practicable, whilst maintaining scientific integrity. This will include monitoring forecasts/warnings issued for other regions, and liaison with adjacent regions as required. |
| **Background knowledge, skills and abilities** |
| • Knowledge of methods for predicting meteorological, oceanographic and ice conditions and their application. (Including those required by the application regional variations.) |
| • Knowledge of forecasting models (deterministic models and EPS) including weather, ocean, ice and wave models. |
| • Knowledge of remote sensing applications. |
| • Knowledge of forecast preparation systems (including use of the software). |
| • Knowledge of areas of responsibility (local and regional), and in particular forecast boundaries and associated observation sites. |
| • Knowledge of forecast issue times and work priorities. |
| • Knowledge of types and characteristics of wave and swell; generation and decay of wave and swell; and shallow water wave characteristics |
| • Knowledge of sea ice physics and dynamics |
| • Knowledge of sea/ tidal currents and sea level. |
| • The ability to forecast sea ice extent, thickness, concentration, stage of development, drift, deformation, growth and melting and floe size |
| • The ability to forecast icebergs and their movement, as required. |

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| **3. WARN OF HAZARDOUS ICE CONDITIONS AND PARAMETERS** |
| **Competency Description:**  Warnings are issued in a timely manner when hazardous conditions are expected to reach documented threshold values and updated, amended or cancelled, as appropriate, according to documented criteria. These conditions and parameters are in general prone to damage vessels and equipment, and to threat the safety of marine navigation and fishing activities. |
| **Performance Criteria** |
| 1. Warn for the following hazardous ice conditions and parameters, including their spatial extent, onset/cessation, duration, an intensity and its temporal variations:   * ice pressure warnings * rapid closing of coastal leads warnings * special ice warnings * icebergs |
| 2. Ensure that warning products are prepared and issued in accordance with thresholds for hazardous ice conditions and parameters as per MarPro (Canada), national SOPs including formats, codes and technical regulations on content, accuracy and timeliness. |
| 3. Ensure that warnings of hazardous ice conditions and parameters are consistent (spatially and temporally), across boundaries of the area of responsibility as far as practicable, whilst maintaining meteorological integrity. This will include monitoring forecasts/warnings issued for other regions, and liaison with adjacent regions as required. |
| **Background knowledge, skills and abilities** |
| • Knowledge of SOPs for warnings. |
| • Knowledge of ice warning criteria and associated amendment criteria. |
| • Ability to utilize forecasting models (deterministic models and EPS) outputs. |
| • Knowledge of areas of responsibility (local and regional) and warning boundaries. |

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| **4. ENSURE THE QUALITY OF ICE INFORMATION AND SERVICES** |
| **Competency Description:**  Forecasts, warnings and related products are provided within a quality management framework. |
| **Performance Criteria** |
| 1. Apply the organisation’s quality management system and procedures as required. |
| 2. Assess the impact of known observational error characteristics (e.g. bias, achievable accuracy and limitations of observations and sensing methods) on forecasts and warnings. |
| 3. Verify and validate ice data, products, forecasts and warnings (timeliness, completeness, and accuracy), using real-time verification tools. |
| 4. Monitor the functioning of operational systems, gather and assess customer comments, suggestions and complaints, and take remedial actions when necessary. |
| 5. Identify and evaluate ice forecasting and warning related problems and determine appropriate corrective and preventive actions for continuous improvement. |
| **Background knowledge, skills and abilities** |
| • Knowledge of quality management principles, practices and procedures. |
| • Knowledge of SOPs for forecast and warning. |
| • The ability to utilize verification techniques and statistics. |
| • Knowledge of contingency plans. |
| • Knowledge of relevant stakeholder operations and needs for and applications of forecasts, including:  - Stakeholder operations (e.g., procedures, tactics, planning processes and cycles)  - Stakeholder limitations, including operating limits, legal constraints, geopolitical limits)  - Stakeholder desired outcomes from operation |
| * General knowledge of stakeholder terminology (e.g., nautical terms, acronyms, abbreviations, technical terms related to forecast variables (e.g., ice concentration, stage of development, thickness, ice movement, freeze up, ice deformation, state of the sea, currents, waves, swell, tides), customer preferred measurement units) |
| • Knowledge of stakeholder communication and security systems, if required. |
| • Knowledge of the impact of ice conditions and parameters on stakeholder operations/activities. |

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| **5. COMMUNICATE ICE INFORMATION TO INTERNAL AND EXTERNAL USERS** |
| **Competency Description:**  Ice forecasts and warnings are communicated in a timely and clear manner to meet user community needs. Participate in professional consultations. |
| **Performance Criteria** |
| 1. Ensure that all forecasts and warnings are disseminated via the authorised communication channels to user groups. |
| 2. Provide ice briefings as necessary, and provide consultation to meet specific user needs. |
| 3. Make use of forecasts and warnings of meteorological parameters, variables and phenomena to describe their impact on marine operations, safety of life and property, including the coastal environment and population. |
| **Background knowledge, skills and abilities** |
| • Knowledge of primary users and operations and their ice related sensitivities. |
| • Knowledge of available communication systems, techniques and methodologies. |
| • Ability to ask users the appropriate questions so as to better understand their needs and address them or refer them to the appropriate authority. |
| • Ability to utilize cross-boundary consistency techniques – national and international, as well as inter-disciplinary / inter-agency checks as needed. |
| • Ability to communicate effectively, orally, graphically and in writing (level of details to meet the identified needs of specific users). |

**REGIONAL VARIATIONS**

Regional variations referred to within the document may include but are not limited to the following:

* Agreed and documented criteria and thresholds
* The range of environmental factors including but not restricted to:
* Ice types
* ice related hazards
* Permanent/semi permanent local occurrences (ex. gyres and polynyas)
* tides, sea level and storm surge
* sea currents and drifting of ice
* sea surface temperature and salinity where required
* Appreciation of the types and use of forecast guidance
* Local climatology. Designated offices responsible for advice on meteorology, sea ice, lake and river ice, ice bergs, oceanography
* Regional regulations
* Boundaries of forecast and warning areas
* Communication language(s)
* Communications technology for forecast and warning transmission, and for ice briefings
* Forecast database(s) utilized – gridded/text/graphical/digital, etc.
* Extent of automation of observing and sensing systems

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