Guide for

Vessels Operating In Low Temperature Environments

January 2024

GUIDE FOR

VESSELS OPERATING IN LOW TEMPERATURE ENVIRONMENTS
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American Bureau of Shipping
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the State of New York 1862

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Foreword *(2024)*

The operation of merchant vessels in low temperature environments presents many challenges for designers, builders, Owners, and Operators. These challenges include both hardware issues related directly to the construction, outfitting, and operation of vessels, as well as those issues pertaining to the ability of the crew to function in a difficult environment.

To assist the marine industry, ABS issued the *Guide for Vessels Operating in Low Temperature Environments* in September 2006. The 2015 version of the Guide was updated in accordance with the latest industry standards, as well as ABS plan review and survey practice.

Overall, the update consisted of a general relocating of some items to make the document easier to follow.

The particular changes to the Guide were as follows:

- Section 1, General:

  Added definitions and Plans and Particulars to be submitted.

- Section 2, Materials, Welding and Coatings:

  Added guidance for dis-similar materials and repair welding in low temperatures.

  Removal of possible confusion with material grade selection. With the ABS *Marine Vessel Rules* adopting IACS UR I6, the structural material requirements are now contained in Part 3 of the *Marine Vessel Rules*.

- Section 3, Hull Construction and Equipment:

  Requirements adjusted to align with industry practice, placing emphasis on a plan and application of technical solutions consistent with that plan.

- Section 4, Vessel Systems and Machinery:

  Revised to be more consistent with recent industry best practice and generally restructured Section for easier referencing.

  Added Subsection on electronic equipment to help address new high-tech vessels.

- Section 5, Safety Systems:

  Lifesaving appliance requirements updated to reflect recent developments in technology and knowledge.

- Appendix 1 to 9:

  Updated accordingly with corresponding Sections of the Guide, as well as additional information included to assist with low temperature operations.

- Appendix A10, Climatic Conditions:

  All new temperature data provided, including isothermal plots that may be used to help estimate the Polar Service Temperature in accordance with the IMO Polar Code.

The September 2021 edition replaced the requirements for surveys after construction with references to Section 7-9-42 of the ABS *Rules for Survey After Construction (Part 7)*.

The January 2024 edition provides requirements for new **POLAR(Category, PST)** and **POLAR Ready(Category, PST)** notations and updates references to Part 6, Chapter 1 of the ABS *Rules for Building and Classing Marine Vessels*.

This Guide becomes effective on the first day of the month of publication.

We welcome your feedback. Comments or suggestions can be sent electronically to rsd@eagle.org.

GUIDE FOR

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SECTION 1
General

1 Application *(2024)*

This guide applies to vessels for which one or several of the optional notations **CCO(TDST, TMAT)**, **CCO-POLAR(TDST, TMAT)**, **DE-ICE**, **POLAR(Category, PST)**, or **POLAR Ready(Category, PST)** have been requested.

The requirements in this Guide apply to vessels that are designed, equipped and intended to operate in low temperature environments or polar waters. Application of the requirements in this Guide is optional. When a vessel is designed, equipped, built and surveyed in accordance with this Guide, and when found satisfactory, a classification notation as specified in 1/3, as appropriate, may be granted.

Those vessels that are designed to meet the requirements of an ice class are to meet Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the ABS *Rules for Building and Classing Marine Vessels (Marine Vessel Rules)*, or other recognized ice class Rules prior to seeking the optional notation discussed in this Guide.

Noting that the regional climatic conditions may vary, this Guide provides notations directly related to the vessel's operating area. For example, for vessels intended to operate in Polar regions (Arctic or Antarctic) on a year-round basis, the requirements contained within the Guide differ from the requirements for a vessel operating in the Polar region only during the local summer period. Similarly, other vessels may be non-ice class yet operate in low temperatures. The Guide also recognizes the fact that the vessels' intended operational profile may vary as some vessels are intended to operate with the assistance of an ice breaker and others are intended to operate independently. Accordingly, the Guide provides requirements addressing the duration of emergency electrical power. This extended emergency power duration is expressed in hours and may be appended to the base optional class notations.

Within this Guide, ABS refers to relevant international regulations and standards that are considered to be applicable. It is recommended that the users of this Guide refer to the most recent text of those regulations and standards when applying the requirements of this Guide, as it is the intent of the Guide to remain consistent with the pertinent international regulations and standards developed by the maritime industry.

2 Objective *(2024)*

The objective of this Guide is to provide supplemental requirements that generally are not addressed by ice class Rules. Low temperature environments present numerous challenges related to operation of equipment, systems, structure, vessel maintenance and safety equipment. Additionally, the vessel's crew performance may be adversely affected. Vessels designed and constructed without addressing the effects of low temperatures may experience increased structural and equipment failures and nonfunctioning systems. Personnel performance will typically be reduced by the effects of low temperatures.

Vessel systems and exposed structure designed and equipped in accordance with the requirements of this Guide may obtain a class notation indicating the vessel is designed to operate in a Low Temperature Environment which may include the presence of ice and/or at a design service temperature specified by the Owner. This Guide is intended for design service temperatures of –10°C (14°F) or less, excluding ice class requirements, if specified, or vessels operating in polar waters.

It is recognized that vessels operating in low temperatures may have unique operating characteristics for which the requirements in this Guide may not be applicable. For such cases, ABS is prepared to consider alternative arrangements, provided substantiating information and/or a risk analysis is submitted for review.

Users of this Guide may refer to Appendices 2 through 9 which provide non-mandatory notes in support of the requirements in Sections 2 through 9. Section and Paragraph numbers used throughout the Appendices refer to the relevant Sections and Paragraphs of the Guide.

3 Classification Notations *(2024)*

Where requested by the Owner, vessels designed, equipped, built and surveyed in accordance with the requirements of this Guide may be assigned the following optional notations, as appropriate:

- **CCO(TDST, TMAT)** is an optional basic notation for vessels operating in a low temperature and is applicable to vessels designed, constructed, and surveyed in accordance with the requirements contained in Sections 2 through 7. The design service temperature and the minimum anticipated temperature in °C for which the vessel's structure and exposed machinery are designed respectively are annotated in place of "**TDST, TMAT**" in the parentheses.

  Included in this notation are vessels which typically operate in those low temperature environments (such as the Baltic region, Okhotsk Sea, Gulf of St. Lawrence, etc.). Vessels which operate in a Polar region during the local summer season exclusively are also eligible for this optional notation.
- **CCO-POLAR(TDST, TMAT)** is an optional notation available for those vessels intended to operate in Polar Regions on a continuous basis. The requirements contained in Sections 2 through 7 are applicable to vessels seeking this optional notation. The design service temperature and the minimum anticipated temperature in °C for which the vessel's structure and exposed machinery are designed respectively are annotated in place of "**TDST, TMAT**" in the parentheses.
- **(HR HOURS)** notation can be appended to the **CCO-POLAR(TDST, TMAT)** notation to indicate that a vessel is equipped and provided with arrangements for emergency power in excess of the minimum 18 hours specified within Regulation II-1/43 of the 1974 Safety of Life at Sea Convention (SOLAS) and Section 4-8-2/5.5 TABLE 1 of the *Marine Vessel Rules*. This notation would be expressed with the designation **HR** in parentheses with the total number of hours (i.e., **CCO-POLAR(–30, –50)(HR24)**).

Vessels receiving either the **CCO** or the **CCO-POLAR** notation will also be required to obtain the Class notation **POT**. See 3/2.4 of this Guide.

- **DE-ICE** is an optional notation available for vessels occasionally operating in low temperatures subject to ice accretion. The requirements in Section 10 are applicable to vessels seeking this optional notation.

As an option, vessels designed, built, and surveyed in accordance with the requirements for any of the previous notations may have the **+** appended to the notation to indicate the placement of additional equipment onboard for the crew and specific low temperature environment training for the crew as per Sections 8 and 9 of this Guide.

Vessels that have applied the process required to obtain a Polar Ship Certificate in accordance with the Polar Code, will be eligible for the following optional notation:

- **POLAR(Category, PST)** is an optional notation that indicates compliance with the IMO International Code for Ships Operating in Polar Waters (Polar Code). See Section 11 of this Guide. The Polar Code defined ship Category and the Polar Service Temperature (PST) will be annotated in place of "**Category, PST**".

For shipyards or owners that want to have their vessel ready for Polar Code certification but have not yet completed the Operational Assessment, and written a Polar Water Operational Manual can elect for the optional notation as follows:

- **POLAR Ready(Category, PST)** is an optional notation that indicates the owners/operators have not yet conducted an Operational Assessment and written a Polar Water Operations Manual, but all minimum required equipment is onboard for Polar Code compliance. See Section 11 of this Guide. The Polar Code defined ship Category and the Polar Service Temperature (PST) will be annotated in place of "**Category, PST**".

4 Definitions *(2024)*

The following definitions are applied to the terms used in this Guide.

Ambient Temperature: The air temperature in the vicinity of the vessel.

Anti-icing: Use of a system and/or a procedure that when in operation will keep ice from forming on the protected surfaces.

Category: The IMO Polar Code defined category of the ship. Can be either A, B or C, where Category A ship means a ship designed for operation in polar waters in at least medium first-year ice, which may include old ice inclusions. Category A = Ice Class PC5 up to Ice Class PC1. Category B ship means a ship not included in category A, designed for operation in polar waters in at least thin first-year ice, which may include old ice inclusions. Category B = Ice Class PC7 and Ice Class PC6. Category C ship means a ship designed to operate in open water or in ice conditions less severe than those included in categories A and B.

Deck Machinery: Any machinery or equipment onboard the vessel that is directly exposed to the low temperature operating environment. Some examples include winches, windlasses, cranes or other lifting appliances, hatch covers, vehicle ramps, boat davits and mooring fittings.

De-icing: Use of a system and/or a procedure that will reduce ice levels on the surfaces being protected. De-icing is commenced after ice accretion has occurred, resulting in either complete or partial removal of the ice.

Design Internal Temperature: The design internal temperature, also denoted as TDIT, is applicable for machinery located in closed, unheated spaces. It is determined from the Design Service Temperature plus 20°C (36°F) ($T_{DIT} = T_{DST} + 20$). In no case is the design internal temperature to be greater than 0°C (32°F).

Design Service Temperature: The design service temperature, also denoted by T_{DST}, is to be taken as the *lowest mean* daily *average* air temperature in the are of operation where:

- *Mean*: Statistical mean over observation period (at least 20 years).
- *Average*: Average during one day and night.
- *Lowest*: Lowest during year.

For seasonally restricted service the lowest value within the period of operation applies. 1/8 FIGURE 1 illustrates this definition graphically.

EPIRB: Emergency Position Indicating Radio Beacon

Emergency: A serious, unexpected, often dangerous event requiring immediate action.

Emergency Service Hours: The number of hours which the emergency source of electrical power can provide. SOLAS Regulation II-1/43 and Section 4-8-2/5.5 TABLE 1 of the *Marine Vessel Rules* require the minimum time to be 18 hours.

Essential: Systems or equipment necessary to maintain vessel propulsion, maneuvering, electrical services, firefighting (along with bilge system), ballasting or personnel safety.

Guide for Certification of Lifting Appliances: The latest edition of this ABS Guide.

In the notch: An operational mode in which a trailing vessel is moored in a specially constructed notch in the stern of an ice breaker.

Low temperature environment: Areas of vessel operations with ambient temperatures less than or equal to -10°C (14°F).

Machinery: Equipment and systems subject to the design requirements of Parts 4, 5C and 6 of the *Marine Vessel Rules*.

Maneuvering Mode: The lowest vessel speed necessary to maintain maneuverability.

MCR: The maximum continuous rating of the prime mover.

Minimum Anticipated Temperature: The minimum anticipated temperature, also denoted as T_{MAT}, can be specified by the Designer, Owner, or Builder. T_{MAT} may be a probabilistic temperature, taken as 2 standard deviations below the mean daily low temperature, or defined as a value below the T_{DST} such as T_{MAT} = T_{DST} -20°C, or T_{MAT} = $LMDLT$ –10°C (where $LMDLT$ is *Lowest Mean Daily Low Temperature*).

Marine Vessel Rules: The latest edition of the ABS *Rules for Building and Classing Marine Vessels*.

Polar waters: Arctic and Antarctic waters as defined by the IMO Polar Code.

PST: Polar Service Temperature. The temperature used in the IMO Polar Code. It means a temperature specified for a ship which is intended to operate in low air temperature, which shall be set at least 10°C below the lowest MDLT for the intended area and season of operation in polar waters.

5 Certification Procedure

A diagram for the procedure for vessels to be certified in accordance with this Guide is shown in 1/8 FIGURE 2.

5.1 Engineering Review

Vessels operating in low temperature environments need to be provided with certain design characteristics. These design characteristics are addressed in Sections 2 through 5 of this Guide. Certain vessel types have unique features or operating characteristics unlike other vessels. Requirements for four specific vessel types are listed in Section 6. The design characteristics and/or equipment required in Sections are assumed to be permanently installed (e.g., welded or bolted) in/on the vessel at the completion of construction.

This Guide also lists requirements for additional equipment that is not permanently installed (e.g., clothing for personnel protection, special safety equipment) and additional personnel training described in Sections 8 and 9. The Owner may indefinitely delay the implementation of the requirements of Sections 8 and 9 for those instances where vessel operations in the low temperature environment are not anticipated. Prior to the vessel operating in a low temperature environment, the Owner is to provide this additional equipment onboard and suitable personnel training together with a vessel operations and training manual.

Arrangements are to be made for an ABS Surveyor to verify the equipment is onboard and the personnel have received proper training via onboard supporting documentation.

5.1.1 Plans and Particulars to be Submitted – Winterization Plan *(1 September 2015)*

A winterization plan is to be submitted to ABS for review. The plan is to indicate measures to be taken in different conditions, and is to include at least the following items:

i) Proposed methodology for anti-icing or de-icing on:

- External superstructure horizontal surfaces (decks)
- External superstructure vertical surfaces (bulkheads)
- Radar antenna
- Navigational lights
- Search lights
- Communication antenna
- Lifesaving appliances
- Vents for tanks
- Escape Routes deck surfaces, rails, doors, and stairs (must be ice accretion prevention)
- Fueling stations
- Mooring equipment and controls
- Calculations to support the above arrangements.

ii) Means to prevent the following systems from freezing or becoming uncontrollably viscous:

- Firefighting systems in tanks, cargo spaces, or on deck
- Fresh water lines in tanks, cargo spaces, or on deck
- Sanitary drains, black and grey water lines
- Ballast lines, in tanks, cargo spaces, or on deck
- Fuel and oil lines
- Ballast tanks
- Fresh water tanks
- Fuel and oil tanks
- Any tank and associated piping containing a fluid that is susceptible to low temperatures.
- Combustion air intake
- Ventilation air intake
- Calculations to support the above arrangements

iii) Means of heating and ventilation, including calculations:

- Crew and passenger cabins
- Public areas in accommodation
- Enclosed working spaces

- Combustion air (pre heating)
- Engine room(s)
- Steering gear compartment
- Pump room

iv) Test plan(s) to demonstrate the functionality of the above systems.

v) Electrical single-line diagram of any electrical heat tracing systems (if-fitted)

vi) Piping diagrams for any thermal fluids used for heat tracing (if-fitted)

vii) Instructions for crew on how and when to exercise the various aspects of the plan.

5.2 Initial Survey

Vessels complying with the requirements of Sections 2 through 6 and confirmed by satisfactory survey may receive the **CCO** notation, which will be listed in the *Record*. The **CCO** notation may be maintained indefinitely provided the hull and machinery are to the satisfaction of the attending Surveyor at the subsequent Annual Surveys. See 1/5.3.

When ABS is notified that the implementation of the requirements in Sections 8 and 9 have also been complied with and confirmed by satisfactory survey, the **CCO** notation with **+** will be listed in the *Record*.

5.3 Annual Surveys

Simultaneously with each Annual Survey – Hull and Annual Survey – Machinery, the hull and machinery subject to Sections 2 through 6 are to be examined by the attending Surveyor. The additional equipment and personnel training requirements in Sections 8 and 9 are also to be verified by the attending Surveyor at this time, if applicable.

5.4 Notation Changes

The Owner may advise by written notice to ABS prior to or during the Annual Survey that the additional equipment and personnel training requirements described in Sections 8 through 9 will not be complied with. The notation will be changed to **CCO** without **+** in this instance. See 1/5.2.

6 National Administration Requirements

National administrations have additional requirements for vessels operating in their territorial waters. These requirements may address additional vessel features, equipment, personnel training and instruction manuals. These requirements are not included in this Guide. A list of administrations is provided in Appendix A12.

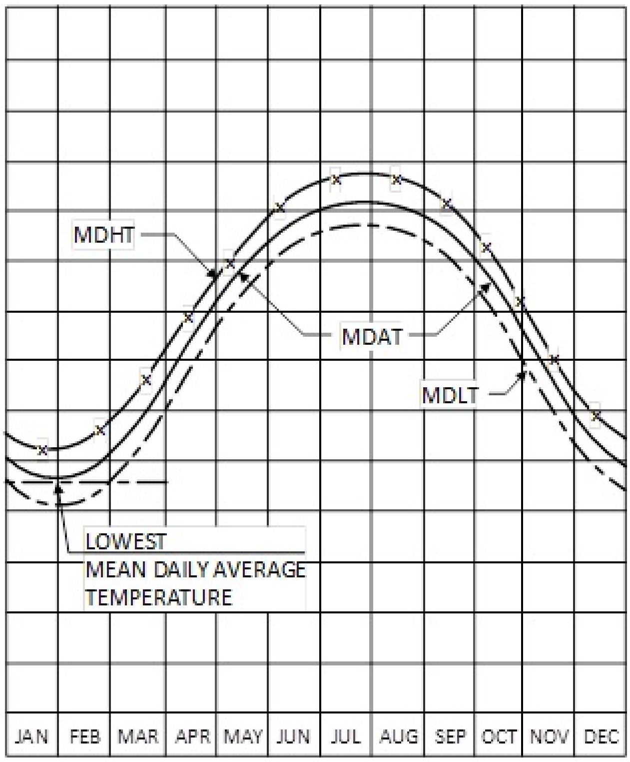
7 Design Service Temperature *(1 September 2015)*

The design service temperature is to be selected based on the months and the regions the vessel is designed to operate in. Temperature data for northern and southern areas for the 1st and the 15th of each month are provided for guidance purposes only in A10/3, "Air Temperature". A listing of various meteorological organizations is provided for guidance in Appendix A13.

8 Ergonomics

The maritime industry is aware of the important role of the human element for effective operation, safety standards and practices. For example, effective heating of accommodation spaces to an acceptable temperature, provision of proper clothing, or heated shelters on deck. Additional information is available in the ABS *Guidance Notes on the Application of Ergonomics to Marine Systems* to promote the application and understanding of ergonomic data and principles to vessel and offshore installation design. The ergonomic guidance presented in the Guidance Notes is not required although ABS urges designers, owners, and operators to adopt these principles to the greatest extent feasible.

FIGURE 1
Graphical Definition of Design Service Temperature *(1 September 2015)*



MDHT:	Mean Daily High Temperature
MDAT:	Mean Daily Average Temperature
MDLT:	Mean Daily Low Temperature
LMDAT:	Lowest Mean Daily Average Temperature - (Design Service Temperature)

FIGURE 2
Certification Procedure *(1 September 2015)*

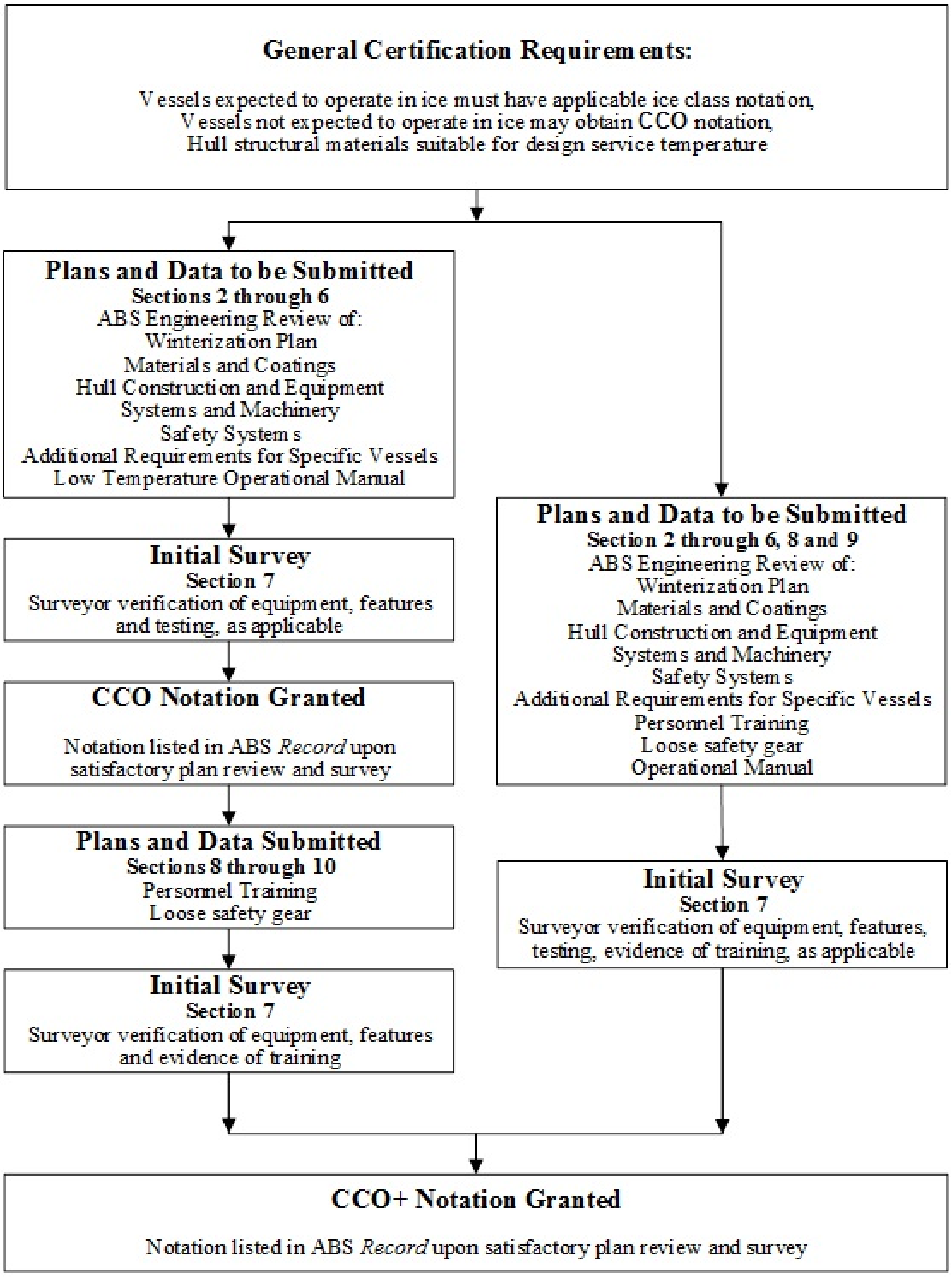


TABLE 1
Design Temperatures for Systems, Equipment and Components
(1 September 2015)

	Item	*Guide Reference*	*Temperature*[1]
1	Towing fittings	3/3.6	DST[2]
2	Anchors and anchor chain	3/6.1	DST
3	Combustion air system	4/2.2	MAT[3]
4	Turbochargers	4/2.3	MAT
5	Deck machinery	4/4	MAT
5a	Anchor windlass	4/4.2	MAT
5b	Towing winch	4/4.3	MAT
5c	Cargo Handling Equipment – cranes, hatch covers, ramp doors, side doors, cargo pumps, deck cargo securing equipment	4/4.6	MAT
5	Deck machinery	4/4	MAT
6	Piping systems	4/5	MAT
6a	Materials	4/5.1.1	MAT
6b	Flexible hoses	4/5.1.2	MAT
6c	Heating and ventilation for accommodations	4/5.1.8i)	MAT
7	Compressed air system	4/5.6	DST
8	Fire fighting system	4/6.1.1	MAT
8a	Water or foam extinguishers	4/6.1.2	MAT
8b	Fire pumps and associated equipment	4/6.1.3ii)	MAT
8c	Hydrants	4/6.1.3iv)	MAT
8d	Fire fighting system components	4/6.1.4	MAT
9	Navigation light system	4/7.1.3	DST
10a	Rotating machines – unheated spaces	4/7.2.1	DIT[4] See 4/7.2.1
10b	Rotating machines – exterior	4/7.2.1	MAT
10c	Cables	4/7.2.3	DST
10d	Electronics	4/7.3	MAT
11a	Heating and ventilation for accommodations	4/8	MAT
11b	Safety systems – heating for survival	5/2	DST
12	Navigational equipment in ice covered waters	5/3	DST
13	Lifesaving appliances and survival arrangements	5/4	30°C or DST[5]
13a	Lifeboat radio equipment and batteries	5/4.1v)	MAT
13b	Life rafts	5/4.2	DST

	Item	*Guide Reference*	*Temperature*(1)
13c	Rescue boat radio equipment and batteries	5/4.3i)	MAT
13d	Launching stations and arrangements – sheave lubricants	5/4.4	DST

Notes:

1 Equipment fitted inside an enclosure may apply DIT.

2 Design Service Temperature, (see Section 1/4).

3 Minimum Anticipated Temperature, (see Section 1/4).

4 Design Internal Temperature, (see Section 1/4).

5 Apply the lower temperature.

SECTION 2

Materials, Welding and Coatings *(1 September 2015)*

1 General *(2024)*

Materials for exposed hull structures and deck machinery are to be selected taking into consideration the intended functions in cold weather.

All hull and structural materials for ice class vessels are to be selected as follows:

- For Polar Class vessels subject to the requirements in Sections 6-1-2 and6-1-3, of the *Marine Vessel Rules*, or other recognized ice class Rules as applicable, the material requirements in these Rules are to be applied.
- For vessels subject to the requirements in Section 6-1-4 of the *Marine Vessel Rules*, the materials are to be selected in accordance with the requirements of 3-1-2/3.5 of the *Marine Vessels Rules*. When Section 3-1-2/3.5 of the *Marine Vessels Rules* is applied, the definition of temperature given in 3-1-2/3.5 of the *Marine Vessels Rules* is to be used.

For non-ice class vessels, the hull and structural materials are to be selected in accordance with the requirements of 3-1-2/3.5 of the *Marine Vessels Rules*. When 3-1-2/3.5 of the *Marine Vessels Rules* is applied, the definition of temperature given in 3-1-2/3.5 of the *Marine Vessels Rules* is to be used.

2 Dissimilar Materials *(1 September 2015)*

This paragraph is mandatory for systems and equipment in essential services, (4-8-1/7.3.3 TABLE 1 and 4-8-1/7.3.3 TABLE 2 of the *Marine Vessel Rules*, or systems included under the definition of "Essential" in 1/4 of this Guide). This paragraph is optional, but recommended, for all other systems and equipment.

The application of dissimilar materials is to be avoided where possible. Where impractical or impossible to avoid the use of dissimilar materials, tolerances are to be such that thermal expansions or contractions will not cause components to bind at the Design Service Temperature. This is applicable when components may need to be subjected to maintenance and consist of dissimilar materials. For additional information see A2/2.

The control of dissimilar materials used in construction is the responsibility of the final assembly yard and is to be covered by the yard's quality system. Components or assemblies may be enrolled in the ABS Type Approval program with specific approval on material applicability for low temperature service.

3 Material of Machinery

(1 September 2015) Machinery subject to these requirements includes any machinery associated with the function or purpose of the vessel.

Exposed machinery is to be suitable for operation at the minimum anticipated temperature if the vessel operator intends to operate the machinery in low temperatures. Safety critical systems are to be suitable for operation at the minimum anticipated temperature unless otherwise stated in this Guide. A particular machinery component/equipment can be excluded from applying requirements in this Subsection if the machinery component/equipment is not intended to be operated in low temperatures. In that case, a note will be entered in the *Record* to indicate that the specific machinery component/equipment is not reviewed to these requirements.

Section 1, Table 1 lists design temperature requirements for various systems, equipment and components.

3.1 Machinery Structural Members/Components Exposed to Weather *(1 September 2015)*

The material class and temperature of steel products used for exposed machinery foundations and load bearing components are to be in accordance with Section 2, Table 1. Material grade selection is to be selected in accordance with Section 3-1-2/3.5 of the *Marine Vessel Rules*. The Design Temperature (t_D) in Section 3-1-2/3.5 of the *Marine Vessel Rules* is to be taken as the temperature referenced in 2/5 TABLE 1 of this Guide.

3.2 Deck Machinery, Piping, Valves and Fittings *(1 September 2015)*

Deck machinery materials are to comply with material specifications in Chapter 3 of the ABS *Rules for Materials and Welding (Part 2)* or of a national or international material standard. The proposed materials are to be approved in connection with the design. All such materials are to be certified by the material manufacturers and are to be traceable to the manufacturer's certificates. Materials for piping, valves and fittings for minimum anticipated temperatures lower than -18°C (0°F) are to be selected in accordance with Section 2-3-13 of the ABS *Rules for Materials and Welding (Part 2)*.

Section 2-A1-1 of the ABS *Rules for Materials and Welding (Part 2)* contains the "List of Destructive and Nondestructive Tests Required for Materials, and Responsibility for Verifying". The listings indicate which tests require Surveyor witness, manufacturer provided data without Surveyor witness, and those tests for which data is to be provided by the manufacturer and subject to auditing by the Surveyor.

3.3 Cranes, Lifting Appliances, Vehicle Ramps, and Boat Davits *(1 September 2015)*

3.3.1 Cranes and Lifting Appliances

Certification of lifting appliances is optional.

2-1/7.21 of the ABS *Guide for Certification of Lifting Appliances (Lifting Appliance Guide)* defines the "Design Service Temperature" as "the minimum anticipated temperature at which the crane will operate as specified by the Owner, crane manufacturer or builder." For vessels seeking lifting appliance certification, the minimum anticipated temperature as defined in 1/4 of this Guide is to be applied. Having established the minimum anticipated temperature for each component, the following should be applied:

i) The material class and minimum anticipated temperature of steel products used for crane and foundation/pedestal are to be in accordance with Chapter 2, Section 3 of the ABS *Lifting Appliance Guide*.

ii) Crane structural components are to be tested in accordance with the requirements of 2-3 of the ABS *Lifting Appliance Guide*.

iii) The machinery components are to be assessed as per 2-6 of the ABS *Lifting Appliance Guide*. Therefore, it would have to be demonstrated by way of testing or analysis that such components will operate satisfactorily at the minimum anticipated temperature. In this regard, the testing requirements of 2-3 of the ABS *Lifting Appliance Guide* may also be applied to such components.

3.3.2 Vehicle Ramps

Vehicle ramps and boat davits are to be in accordance with 2/3.3.1 of this Guide as far as practicable. Where 2/3.3.1 is not applicable, items 2/3.3.2.i or 2/3.3.2.ii below are to be applied.

i) Large structural components of vehicle ramps exposed to the weather, materials are to be selected in accordance with the requirements 3-1-2/3.5 of the *Marine Vessel Rules* for material class II. T_{DIT} defined in Section 1/4 may be used instead of t_d if the structures are in an enclosed space.

ii) Large structural components of vehicle ramps exposed to the weather, materials are to be The material for machinery components of vehicle ramps, such as locks, guides, or rollers, are to be in accordance with 2/3.1 and 2/3.2 of this Guide.

3.3.3 Boat Davits

Boat davit materials are to be selected based on 2-3 of the *Lifting Appliance Guide*. The temperature to use for material selection is to be the Minimum Anticipated Temperature as defined in 1/4 of this Guide. Davits are normally not certified in accordance with the *Lifting Appliance Guide*.

3.4 Material of Exposed Outfitting *(1 September 2015)*

Steel products material class used for deck machinery are to be selected from 2/5 TABLE 1.

Material selection is to be in accordance with 3-1-2/3.5 of the *Marine Vessel Rules*.

3.5 Insulated Members

Design service temperature for insulated members will be considered upon submission of substantiating data.

3.6 Criteria for Other Steels

3.6.1 Steels with Specified Minimum Yield Strength Below 410 N/mm^2, (42 kgf/mm^2, 60 ksi)

Where steels other than those in 2-1-2/15.9 TABLE 5 or 2-1-3/7.3 TABLE 5 of the ABS *Rules for Materials and Welding (Part 2)* are intended, their specifications are to be submitted for approval. These steels are to comply with the following impact test requirements:

Yield Strength			*CVN (Longitudinal)*		
N/mm^2	*kgf/mm^2*	*ksi*	*J*	*kgf-m*	*ft-lbf*
235-305	24-31	34-44	27	2.8	20
315-400	32-41	45.5-58	34	3.5	25

At the following temperatures:

Class I: design service temperature

Class II: 10°C (18°F) below design service temperature

Class III: 20°C (36°F) below design service temperature

3.6.2 Steels with Specified Minimum Yield Strength in the Range of 410-690 N/mm^2 (42-70 kgf/mm^2, 60-100 ksi)

Where steels having this yield strength range are intended, their specifications are to be submitted for approval. These steels are to comply with the impact test requirements of 34 J (3.5 kgf-m, 25 ft-1bf) at the following temperatures:

Design Service Temperature	*Test Temperature*
0°C (32°F) -10°C (14°F) -20°C (-4°F) -30°C (-22°F) -40°C (-40°F)	-30°C (-22°F) -40°C (-40°F) -40°C (-40°F) -50°C (-58°F) -60°C (-76°F)

3.6.3 Alternative Requirements *(2024)*

As an alternative to these requirements, higher strength steels may comply with the following:

i) For transverse specimens, $^2/_3$ of energy values shown in 2/3.6.1

ii) For longitudinal specimens, lateral expansion is not to be less than 0.5 mm (0.02 in.). For transverse specimens, lateral expansion is not to be less than 0.38 mm (0.015 in.).

iii) Nil-ductility temperature (NDT), as determined by drop weight tests, is to be 5°C (9°F) below the temperature specified in 2/3.6.2.

3.7 Additional Requirements for Plates over 100 mm (4 in.) Thickness *(2014)*

In the application of this Guide, rolled steel plates of thickness over 100 mm (4 in.) for primary structural members are considered as thick plates and are subject to additional requirements in 2-1-1/16 of the ABS *Rules for Materials and Welding (Part 2)* in order to avoid possible brittle failure in cold environments.

3.8 Cast Irons

Ordinary cast iron or gray cast iron is not to be used. Nodular (ductile) iron may be acceptable (See Section 4-6-2/3.1.4 of the *Marine Vessel Rules*).

3.9 Cast Steels

Cast steel components which are not intended to be welded in construction or fabrication, are to comply with the following impact test requirements:

Yield Strength			*CVN (Longitudinal)*		
N/mm²	*kgf/mm²*	*ksi*	*J*	*kgf-m*	*ft-lbf*
235-305	24-31	34-44	20	2.0	15
305-410	31-42	44-59	24	2.4	18
410-690	42-70	59-100	27	2.8	20
>690	70	100	27	2.8	20

At the following temperatures:

Class I: design service temperature

Class II an Class III: 10°C (18°F) below design service temperature

For cast steels with yield strengths exceeding 690 N/mm^2 (70 kgf/mm^2, 100 ksi), the test temperature for all classes is to be 10°C (18°F) below design service temperature. The impact test requirement is subject to agreement between the designer/manufacturer and ABS.

3.10 Steel Forgings

Forged steel components which are not intended to be welded in construction or fabrication, are to comply with the following impact test requirements:

Yield Strength			*CVN (Longitudinal)*		
N/mm^2	*kgf/mm^2*	*ksi*	*J*	*kgf-m*	*ft-lbf*
235-305	24-31	34-44	27	2.8	20
305-410	31-42	44-59	34	3.5	25
>410	42	59	42	4.3	31

At the following temperatures:

Class I:	design service temperature
Class II and Class III:	10°C (18°F) below design service temperature

For steel forgings with yield strengths exceeding 690 N/mm2 (70 kgf/mm^2, 100 ksi), the test temperature for all classes is to be 10°C (18°F) below design service temperature. The impact test requirement is subject to agreement of the designer/manufacturer and ABS.

4 Weld Metal *(1 September 2015)*

4.1 ABS Grade Hull Steels

When the ABS ordinary and higher strength hull steels of 2-1-2/15.9 TABLE 5 or 2-1-3/7.3 TABLE 5 of the ABS *Rules for Materials and Welding (Part 2)* are applied in accordance with the vessel's ice class requirements or 3-1-2/3.5 of the *Marine Vessel Rules*, approved filler metals appropriate to the grades as shown in Section 2-A3-1 of the ABS *Rules for Materials and Welding (Part 2)* may be used.

4.2 Criteria for Other Steels

For the welding of hull steels other than the ABS grades listed in Section 2-1-2 or 2-1-3 of the ABS *Rules for Materials and Welding (Part 2)*, the weld metal is to exhibit a Charpy V-Notch toughness value at least equivalent to the transverse base metal requirements ($^2/_3$ of longitudinal base metal requirements).

4.3 Repair Welding in Low Temperatures

The procedure used for welding in low temperatures is to be agreed upon with the attending ABS Surveyor prior to work. The procedure is to specify the minimum ambient temperature, as well as pre and post weld heating temperatures. Welding materials with an ambient temperature below –10°C is not recommended and should be avoided where possible. Where welding in low temperatures cannot be avoided, the work area is to be protected from the low temperatures and wind as far as is possible by a heated temporary shelter and the weld base materials are to be pre-heated in accordance with the procedure. Post weld heating and insulation are to be applied unless otherwise specified in the procedure. It is to be noted that a vessel's hull is a large heat sink and heating of the local area to be welded will likely be required on a continuous basis during the repair. The area is to be subject to NDT in accordance with the ABS *Guide for Nondestructive Inspection* after the area has cooled to ambient temperatures.

5 Coatings

Coatings in low temperatures applied to those areas of the hull subject to contact with ice are to be durable and resistant to peeling, abrasion or other degradation. Coating product information and testing results are to be submitted for information. See A2/5 for additional information.

TABLE 1
Material Class of Machinery Structural Members/Components *(1 September 2015)*

Machinery Members		*Material Class*	*Temperature*
1.	Exposed load bearing structural and machinery components directly exposed to the weather	II	*MAT* [1]
2.	Load bearing structural and machinery components attached to and within a distance of 600 mm from the other parts which are directly exposed to the weather	II	*MAT* [1] + 10°C
3.	Load bearing structural and machinery components attached to but at a distance of over 600 mm from the other parts which are directly exposed to the weather in enclosed spaces		
3a.	Unheated space	II	*DIT* [2]
3b.	Heated space	I	0°C

Notes:

1 Minimum Anticipated Temperature, (see 1/4).

2 Design Internal Temperature, (see 1/4).

1 General

For vessels intended to navigate in ice in Polar regions or in non-Polar regions, the applicable requirements for strengthening are provided in Part 6, Chapter 1 of the *Marine Vessel Rules*. For equivalency ABS will consider other recognized ice standards.

If the intended routes in which the vessel is expected to operate are ice free, then ice strengthening classification is not required.

The materials used in the hull structural members are to be in accordance with the requirements in Section 2 of this Guide.

Information has been provided in Appendix A3 to indicate background and intent of the Guide requirements and, for some cases, recommendations or examples as to how the requirements may be complied with.

2 Tanks

2.1 Fresh Water Tanks

Fresh water tanks with boundaries including the side shell or the deck exposed to the weather are to be provided with arrangements to prevent freezing. See 4/5.2.1.

Fresh water tanks arranged such that the tank boundaries do not include the side shell or the deck exposed to the weather and are located in a heated area such as the machinery space will not require heating arrangements to be provided.

2.2 Fuel Oil Tanks

Fuel oil tanks are to be provided with heating arrangements (See 4-6-4/13 of the *Marine Vessel Rules*) if the fuel will cool below its pour point. Fuel oil tanks for residual fuels are to be maintained 10°C (18°F) above the fuel's pour point. Tank heating calculations are to be provided to show sufficient heat transfer capacity for the design service temperature.

2.3 Ballast Water Tanks *(1 September 2015)*

Ballast water tanks on vessels with design service temperatures equal to or above –30°C (–22°F) but lower than –10°C (14°F) and arranged such that the top of the tank is located above the lightest operating draft are to be provided with arrangements to prevent freezing of the ballast water. Acceptable arrangements include turbulence and convection-inducing systems, for example, bubble systems or heating coils. Other arrangements will be specially considered. See 4/5.2

Vessels with design service temperatures less than –30°C (–22°F) are to be provided with a means of heating. Tank heating calculations are to be provided to show sufficient heat transfer capacity for the design service temperature. See 4/5.2.

For ice class vessels, the capacity and arrangement of the water ballast tanks are to be sufficient to immerse the top of the propeller edges at least to the maximum thickness of level ice in the anticipated area of navigation.

Reference is made to IMO Resolution MEPC.163(56) – Guidelines for Ballast Water Exchange in the Antarctic Treaty Area.

2.4 Additional Measures for Oil Pollution Prevention *(1 September 2015)*

If the vessel's aggregate fuel and lube oil is of 600 m^3 and above, the requirements of 4-6-4/17.5 of the *Marine Vessels Rules* for the protection of fuel oil and lubricating oil tanks may be applied. The Class notation **POT** – Protection of Fuel and Lubricating Oil Tanks will also be listed in the *Record*.

Where the vessel's aggregate fuel and lube oil is less than 600 m^3, the fuel oil and lube oil tanks are to be protected, as far as is practical, from possible damage to the ships bottom and sides.

3 Superstructures and Deckhouses

3.1 Bow Area and Forecastles

The bow area is to be accessible for personnel in all weather conditions.

Forecastles are recommended so as to deflect waves and spray away from the deck areas immediately aft of the bow. If a forecastle is not provided, the shell plating is to be flared so as to deflect waves and spray away from the main deck area immediately aft of the bow. The bow area is to be designed to protect anchoring and mooring equipment and operating personnel by means of sheltered or enclosed spaces.

3.2 Deckhouses *(1 September 2015)*

The bridge wings are to be enclosed or designed to protect navigational equipment and operating personnel and to permit operating personnel observation of the ice/hull contact. [See 5/3.1.v].

We note that Bridge Visibility is a requirement of SOLAS Chapter V, Regulation 22.

External access to the navigation bridge windows is to be provided to facilitate their cleaning.

At least 50% of the total number of bridge windows are to be heated and provided with window wipers and cleaning system for de-icing purposes. The heated windows are to be located to maximize visibility assuming all non-heated windows are unusable. The window wiper blade material is to be suitable for operation at the minimum anticipated temperature.

Access to the accommodations spaces and work areas are to be provided with a means, such as two doors, to reduce heat loss from the heated space. Windows and side scuttles are to be of a type designed to minimize heat loss. An example would be double or triple glass panes.

All doors and the adjacent deck areas on emergency escape routes and navigation bridge doors and the adjacent deck areas are to be designed and arranged so that they can be maintained free of snow and ice so as to be readily functional in accordance with the winterization plan required in 1/5.1.1. See 5/4.7 for further details on escape routes.

When personnel are required to perform functions such as a lookout when underway, or security at the gangway when in port, a heated deckhouse is to be provided for sheltering purposes.

3.3 Exterior Stairs *(1 September 2015)*

All exterior stairs are to be installed at a lower angle of about 35 degrees.

Stair step and landing material is to be technically consistent with the solution selected to maintain stairways free of ice and snow. Cases where no heat is applied to the stair step, a grating type material are to be used. In all cases the walking surface of the stairs are to be of high traction.

3.4 Operating Platforms for Deck Equipment *(1 September 2015)*

Platforms for deck equipment (see 1/4) material is to be technically consistent with the solution selected to maintain the platforms free of ice and snow. Cases where no heat is applied to the platform, a grating type material are to be used. In all cases the walking surfaces are to be of high traction.

3.5 Railings

For **CCO** notation, there are no additional requirements.

For **CCO-POLAR** notation internal heating of railings exposed to low temperatures is to be provided where practicable on escape routes. See 5/4.7.

3.6 Towing Fittings for Ice Class Vessels

All ice-class vessels are to be provided with arrangements for being towed. Substantial fittings such as bollards should be well incorporated into the hull structure and should be sized for the high dynamic loads that can be experienced in ice. The towing fittings are to be suitably marked with the maximum allowable load, manufacturer, and any restrictions associated with their operation. Reference is made to MSC Circ. 1175 “Guidance on Shipboard Towing and Mooring Equipment”.

In some areas (e.g., Baltic Sea, subject to Finnish and Swedish Maritime Administrations requirements), the vessel is to be provided with arrangements to secure the anchors onboard the towed vessel. (This may be accomplished by swinging the anchor aft to prevent contact with the towing vessel, in particular for ice breakers with a notch stern. This may be accomplished with shackles and cables.)

Emergency towing arrangements are to be provided together with suitable arrangements or equipment to provide de-icing capability.

3.7 Cargo Handling

Refer to 4/4.6.2 for requirements for hatch covers, ramp doors and side doors.

Refer to 4/4.6.4 for requirements for deck cargo securing equipment.

3.8 Deck House Insulation

Additional insulation will be required in the superstructure. See A4/8 for information.

3.9 Access to Machinery on Deck

Access to the deck for personnel (e.g., doors, hatches, etc.) and to other equipment located on the main deck is to be available at all times. Access by the operating personnel is not to be obstructed by ice accumulation or endangered by overhead ice accumulation.

4 Stern

4.1 Towing Notch for Ice Breakers

When provided, towing notches are to be constructed as appendages to the main hull structure.

Fendering is to be used to reduce the possibility of damage at the towing notch, including the bow of the towed vessel. The notch is to be designed to accept various bow shapes.

See A3/4.1 for additional information.

5 Stability *(1 September 2015)*

Ice buildup is most probable in the forward parts of a vessel; however, smaller vessels can experience significant icing thicknesses in almost all areas. This can present a significant safety hazard, as the increase in topweight (aggravated by changes in trim) reduces the stability of the vessel. Stability information onboard should contain sufficient data on the vessel's stability taking into account icing to allow masters to recognize such risks as they arise and to take measures to address the situation.

The IMO Code on Intact Stability requires an allowance for ice accretion for certain vessel types. Other Administrations may have additional requirements for ice accretion.

Ice release coatings can be applied to exposed structure to minimize ice accretion and thereby reduce the effects of ice accretion on vessel stability. See A2/5.2.

The vessel is to be provided with equipment for de-icing. See 4/1.1 and A4/1.1.

Any freeing ports in accordance with the International Load Line Convention 1966 are to be equipped with means to remain operational due to icing.

Decks are to be designed to avoid stagnant water, in forms of wells or in forms of small pools of water between structural stiffening.

6 Equipment

6.1 Anchor Chain

Anchor chain is to be provided manufactured with impact resistant properties based on the design service temperature in compliance with the applicable requirements in Section 2.

SECTION 4
Vessel Systems and Machinery

1 General

Section 4 contains the Guide requirements for machinery. These requirements are organized similarly to the sections in Part 4 of the *Marine Vessel Rules*. These requirements are in addition to those listed in Part 4 of the *Marine Vessel Rules.*

Information has been provided in Appendix A4 to indicate background and intent of the Guide requirements and, for some cases, recommendations or examples as to how the requirements may be complied with.

1.1 Heat Tracing, Anti-icing and De-icing *(1 September 2015)*

Heat tracing needed to meet the requirements in 4/6, "Fire Safety Systems Requirements", are mandatory. However, requirements related to heat tracing of various systems referenced elsewhere in this Guide are optional but are to be in accordance with the winterization plan.

The vessel's superstructure surfaces and systems are to be heat traced or de-iced in accordance with the winterization plan considering:

- Open deck areas
- Gangways
- Stairways
- Superstructure areas subject to icing
- Railings

A test program for de-icing and heat tracing is to be submitted for engineering review and subsequent use by the Surveyor. The capability of the de-icing and heat tracing systems to function at the minimum anticipated temperature is to be demonstrated by onboard testing or calculations. Calculations are to be in accordance with a recognized standard or manufacturer's code of practice taking into account:

- Snowfall in the area of operation
- Ambient temperature (apply minimum anticipated temperature)
- Wind velocity in the area of operation
- Water source

The factors, for which the heating power capacity is selected, are to be clearly identified.

As the vessel arrangements differ greatly depending on vessel size, service and operating area, information for de-icing and heat tracing various systems and equipment onboard are provided in A4/1.1.

1.2 Hydraulic Systems *(1 September 2015)*

Hydraulic oil sumps are to be provided with heaters or other suitable means for heating purposes, where necessary and capable of being circulated to avoid cold spots.

The use of steam heating coils is not permitted.

The hydraulic oil is to be suitable for the minimum anticipated temperature.

If the power unit and hydraulic lines are located in a heated space, a heater is not necessary.

Thermal expansion and contraction of fixed lines is to be considered and incorporated into the design.

1.3 Overboard Discharges and Drainage *(1 September 2015)*

The use of gray cast iron material for piping, valves and fittings is prohibited.

Drains are to be protected from freezing.

Direct steam or compressed air connections to the sea chests are to be provided for de-icing purposes.

For vessels with a design service temperature below –30°C (–22°F), steam or heat tracing is to be provided on all overboard discharges.

Deck drains are to be protected from freezing or provided with means to be quickly cleared of blockage by ice and snow.

1.4 Lubricating Oil Systems *(1 September 2015)*

Lubricating oil is to be maintained at the proper minimum temperature in accordance with manufacturer's recommendations to allow equipment start-up.

The use of steam heating coils within lubricating oil tanks is not permitted.

2 Prime Movers

2.1 Prime Mover Operating Characteristics for Ice Class Vessels

The propulsion plant is to be capable of continuous operation at low power outputs and/or low vessel speeds.

If icebreaking vessels are likely to operate at or near their continuous ice breaking limit, their operation will be adversely affected by ridges, rafted ice and pressured ice conditions, and they may have to back and ram. The propulsion system should be capable of rapid and repeated variation of power and direction; and should be able to develop a significant percentage of ahead thrust when moving astern.

Ice class vessels following icebreakers should be capable of rapid and repeated variation of power and direction to avoid colliding with the icebreaker or other vessels when in a convoy. Maneuvering mode is considered to be some fraction of the full ahead speed of the vessel.

2.2 Combustion Air Systems for All Vessels

The combustion air system is to be based on the minimum anticipated temperature of the outside air.

2.2.1 Combustion Air for Internal Combustion Engines

2.2.1(a)

Means are to be provided to pre-heat combustion air for proper functioning of the main propulsion, auxiliary and emergency generator internal combustion engines in accordance with the engine manufacturer's recommendations.

2.2.1(b)

For **CCO-POLAR** notation in addition to complying with the combustion air is to be led directly from the weather to the engines having a rated power of 100 kW (135 HP) and over by way of ducting or other suitable means such that all of the combustion air is not drawn from the machinery space.

2.2.1(c)

The combustion air intakes are to be located on both sides of the vessel and arranged so as to prevent: the recirculation of engine exhaust gases into the combustion air intakes; ice accumulation; and blockage of the duct. The installation of a heat tracing system at the combustion air intakes is acceptable provided that calculations confirming the adequacy of the heat tracing system are submitted.

2.2.2 Combustion Air for Other Prime Movers

Combustion air for other prime movers, such as steam plants and gas turbines, is to be provided in accordance with the manufacturer's recommendations. The details and arrangements will be subject to special consideration.

2.3 Turbochargers for All Vessels

Turbochargers and the associated combustion air system for internal combustion engines are to be designed to obtain surge-free operation throughout the range of ambient air temperatures in which the vessel is expected to operate.

2.4 Emergency Generator Starting *(1 September 2015)*

In low temperatures the emergency generator is essential to survival. Starting of the generator is to be in accordance with 4-8-2/5 of the *Marine Vessel Rules* while the ship is in ambient temperature at the Minimum Anticipated Temperature.

The two sources of energy for starting the generator are to be selected based on minimizing the single failure mode attributed to cold temperatures.

3 Propulsion and Maneuvering Machinery

For ice class vessels, the additional requirements for propulsion and maneuvering machinery are in the applicable sections of Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Marine Vessel Rules*.

3.1 Propulsion Shafting Bearing Lubrication for All Vessels

3.1.1 Oil-Lubricated Bearings *(1 September 2015)*

Vessels with mineral-based oil-lubricated stern tube bearings are to be provided with a pollution-free oil-seal gland.

Systems are to be in accordance with 4/1.4.

3.1.2 Biodegradable Oil-Lubricated Bearings

Vessels with stern tube bearings lubricated with biodegradable lubricant may be fitted with a pollution-free oil-seal gland.

The requirements of 4/1.4 for providing lubricating oil heating arrangements are also applicable.

3.1.3 Water-Lubricated Bearings

Vessels may be fitted with water-lubricated bearings. The bearings are to be suitable for continuous operation in low temperatures.

3.1.4 Shaft Seal Type

The final selection of shaft seal type, radial or axial, must take into account the maximum diameter of the shaft itself and the speed of rotation.

3.2 Fixed Pitch Propellers for Ice Class Vessels

See A4/3.2 for non-mandatory information related to propeller blade attachment methods.

3.3 Controllable-Pitch Propellers for Ice Class Vessels *(1 September 2015)*

The controllable-pitch system is to be designed to take into account the numerous pitch reversals to be expected when operating in ice conditions. Calculations confirming the adequacy of the controllable-pitch system to withstand the additional pitch changes or service experience from the manufacturer are to be submitted for information.

For any hydraulic components exposed to low air temperatures, the requirements of 4/1.2 are applicable.

4 Deck and Other Machinery

(1 September 2015) Deck and other machinery listed in this Subsection exposed to the low temperatures or located in unheated spaces are to be suitable for operation at the minimum anticipated temperature, (see Sections 1/4 and 2/3). Note that piping and other machinery in cargo holds will be considered exposed to the design service temperature when hatch covers, ramp doors and side doors are opened to load or discharge cargo.

4.1 Anchoring Arrangements for Ice Class Vessels

4.1.1 Ice Breaking Vessels

The locations of the anchors are to be considered with respect to the waterline and anticipated ice conditions. Consideration is to be given to the height of anticipated ice ridges and rubble; and whether close towing operations will be conducted.

4.1.2 Ice Class Vessels

The locations of the anchors are to be considered with respect to towing operations with the ice breaker.

4.2 Anchor Windlass for All Vessels *(1 September 2015)*

In addition to the requirements of Section 4-5-1 of the *Marine Vessel Rules*, the anchor windlass design is to include these additional requirements:

i) It is suitable for operation at the minimum anticipated temperature.

ii) Anchor releasing arrangements are to be provided in such a manner as to reduce the effects of icing.

iii) The requirements of 4/7 apply to all electrical components of the windlass.

iv) The requirements of 4/1.2 apply to all hydraulics associated with the windlass.

v) All windlass components subject to tensile stresses are to be constructed of materials subjected to impact testing.

4.3 Towing Winch

If a vessel is expected to undertake regular towing operations, a towing winch is to be provided.

The design, construction and testing of the towing winch is to conform to an acceptable standard or code of practice. To be considered acceptable, the standard or code of practice is to specify criteria for stresses, performance and testing.

The requirements of 4/4.2.i, 4/4.2.iii, 4/4.2.iv, and 4/4.2.v are applicable.

Towing winches are to be of the electric or electro-hydraulic type, single drum, constant tensioning, and fitted with automatic spooling gear.

The winch is to be able to be controlled from the navigation bridge and an emergency override is to be located in close proximity to the winch itself.

The design load of the towing winch is to be based on the available total thrust of the vessel.

4.4 Towing Lines

The towing line breaking strength is to be determined in accordance with the requirements of the standard or code of practice discussed in 4/4.3.

4.5 Towing Fittings for Ice Class Vessels

See 3/3.6.

4.6 Cargo Handling for All Vessels

Cargo handling equipment that may be affected by low temperature environments include cranes, hatch covers, ramp and side doors, cargo pumps and deck cargo securing equipment.

4.6.1 Cranes

Cranes and any other lifting devices exposed to low temperatures are to be certified in accordance with the ABS *Guide for Certification of Lifting Appliances* at the minimum anticipated temperature. See 2/3.3.1.iii of this Guide. In addition, the operator's cab is to be able to be heated to 20°C (68°F) at the minimum anticipated temperature. If the crane is hydraulically actuated, the hydraulic oil should be suitable for the design service temperature, including an electric heater within the oil sump. If the crane is not controlled from an operator cabin, it is recommended to have, as a minimum, nylon or other synthetic material covers for all controls to keep ice/snow off the controls.

4.6.2 Hatch Covers, Ramp Doors and Side Doors *(1 September 2015)*

Arrangements or equipment is to be provided to efficiently remove ice build up around hatches and doors.

If the hatches or doors are hydraulically operated, the requirements of 4/1.2 are applicable.

Materials selected for hatch and door seals are to remain pliant at the minimum anticipated temperature. If covers are to be opened in low temperatures, a means is to be provided to de-ice the seals prior to opening.

4.6.3 Cargo Pumps *(1 September 2015)*

Cargo pumps and their auxiliary equipment (e.g., valves) exposed to the weather are to be suitable for operation at the minimum anticipated temperature. If the cargo pumps are hydraulically operated, the requirements of 4/1.2 are applicable. Electric motors driving cargo pumps are to be provided with space heaters.

4.6.4 Deck Cargo Securing Equipment

Deck cargo securing equipment (e.g., container lashings) is to be suitable for the minimum anticipated temperature.

5 Piping Systems

5.1 General *(1 September 2015)*

Piping of auxiliary machinery systems and equipment subjected to low temperatures, ice accumulation and/or ice ingestion in areas exposed to the weather or in unheated enclosed areas of the vessel are to meet the requirements of this Subsection. Piping systems are to be operable for the minimum anticipated temperature, (see 1/4 and 2/3).

All piping systems throughout the vessel should be designed to minimize exposure of crew to low temperature environmental hazards during normal operation and routine maintenance. If possible, valves and controls should be automated, and pipe tunnels should be considered if feasible.

See also Section 6, "Specific Vessel Requirements" for any additional requirements.

5.1.1 Materials

Materials subjected to the minimum anticipated temperature are to be resistant to brittle fracture and are to meet the requirements of 2/3.

5.1.2 Flexible Hoses

Seals and hoses are to remain flexible at the minimum anticipated temperature. Lubricants and working fluids are to be suitable for the design service temperature.

5.1.3 Valves

Valves and closures in exposed primary and secondary essential service systems listed in 4-8-1/7.3.3 TABLE 1 and 4-8-1/7.3.3 TABLE 2 of the *Marine Vessel Rules* are to be selected and located or otherwise protected to avoid freezing of fluids on either side of the valve and to prevent the accumulation of snow and spray ice. Moving parts may require to be heated, continuously or prior to operation.

Canvas covers with electric heating device may be considered. If a hazardous area is present, the covers are to be of a certified safe type as per 4-8-3/13 of the *Marine Vessel Rules*.

5.1.4 Pipes *(1 September 2015)*

Components, such as valves, valve control units, manifolds, vents, fittings, sounding pipes, and other piping components exposed to the minimum anticipated temperature should be protected from ice accumulation or be provided with a means to provide for continued functionality such as positioning in sheltered locations, installing trace heating or heated covers.

Horizontal runs of piping may be unavoidable on certain vessel types, such as a tanker. Effective drainage of these pipes can be accomplished by trimming the vessel aft or installing drain lines in the piping.

5.1.5 Tank Vents

The blockage of vent pipes by ice accumulation at the deck or by the freezing of plugs inside the pipe from the vapors rising from the tank contents or ingress of air into the tank can result in safety hazards, for example, due to over-pressurization. It is common to fit, or provide for, heat tracing.

If the there is a heated liquid in the tank being vented, anti-icing equipment may not necessarily be installed provided supporting calculations are provided.

5.1.6 Pipe Drainage

All piping within areas that can be expected to freeze shall be designed to prevent freezing or shall be able to be drained of contained fluids. This applies to exposed pipes, valves, pumps and fittings, including those found in areas onboard with no heating available such as voids, cofferdams, etc. Additional heat tracing and insulation should be installed on all safety-related piping exposed to extreme cold temperatures unless other means to provide for operability have been introduced.

Drain cocks (valves) should be provided as these are quick-acting devices. Drain plugs may be provided; but drainage of the piping will take much longer because the operator will have to remove each one with a tool.

5.2 Ship Piping Systems and Tanks

5.2.1 Ballast Water Tanks

Ballast water tank freeze prevention requirements are listed in 3/2.3. The piping requirements in 4/5.3.2(b) are to be applied.

Convection-inducing systems are to extend the entire length of the tank.

5.2.2 Ballast Water Tanks for Design Service Temperatures Below -30°C (-22°F)

For design service temperatures below -30°C (-22°F), each ballast water tank is to be fitted with steam heating coils.

5.3 Piping Systems for Prime Movers

5.3.1 Fuel Oil System

5.3.1(a) Fuel Oil Heating.

Fuel oil heating systems are to be designed to provide uninterrupted service of fuel oil to the prime movers.

5.3.1(b) Fuel Oil Filling Stations.

Fuel oil filling stations are to be located in an area sheltered from the weather for access and operation. For fuel oil filling pipes located on the deck, alternative arrangements to protect the filling pipes are to be provided such as a removable or hinged cover may be installed.

5.3.2 Cooling System

5.3.2(a) Seawater Systems for Ice Class Vessels. (2024)

Seawater systems draw their supply from the sea around the vessel, and therefore must be designed to reduce the risk of the inlets becoming blocked by ice or ice forming within them. Seawater system requirements for ice class vessels are provided in Part 6 Chapter 1 of the *Marine Vessel Rules*.

Alternative arrangements, such as heat exchangers integral with the hull bottom, will be specially considered.

5.3.2(b) Seawater Piping – All Vessels (1 September 2015).

The requirements of 4/1.3 are applicable.

5.3.2(c) Engine Cooling.

Main and auxiliary engine cooling lines, if exposed to freezing temperatures, are to be suitably insulated or heated. Alternatively, antifreeze may be used in the cooling water.

5.3.2(d) Non-Ice Classed Vessels.

The above requirements are applicable exclusively for ice classed vessels; accordingly, there are no requirements for non-ice classed vessels.

5.3.3 Fresh Water Systems

i) See 3/2.1.

ii) Fresh water pipe runs through void spaces are to be insulated and heat traced.

iii) All water lines exposed to freezing temperatures are to be fitted with drain cocks at the lowest part of the piping arrangement.

iv) Fresh water generation systems' inlet temperatures are to be in accordance with the manufacturer's requirements.

5.4 Other Piping Systems (1 September 2015)

Exhaust gas outlets and pressure/vacuum arrangements (e.g., for prime movers and/or their associated spaces) are to be protected from ice buildup that could interfere with effective operation.

5.5 Waste Storage and Disposal Systems (1 September 2015)

Regulations in the Baltic, Arctic and Antarctic regions vary among the administrations. See Appendix A12. Information is provided in Appendix A4/5.5.

Waste storage systems (grey and black water) including piping are to be protected from freezing by either placement into a heated compartment or insulation and heat tracing. The system is to be protected enough to prevent freezing at the minimum anticipated temperature.

5.6 Compressed Air Systems (1 September 2015)

5.6.1 General

The compressed air supplied to the control air system is to have a dew point 20°C (36°F) below the design service temperature.

5.6.2 Starting Air System – Ice Class Vessels

The requirements of 4-6-5/9 in the *Marine Vessel Rules* for diesel or turbine propulsion are applicable with the exception that the requirements in 4-6-5/9.5.1 TABLE 4 are to be replaced with the following:

TABLE 1
Required Number of Starts for Propulsion Engines

Engine Type	*Single Propeller Vessels*		*Multiple Propeller Vessels*	
	One engine coupled to shaft directly or through reduction gear	*Two or more engines coupled to shaft through clutch and reduction gear*	*One engine coupled to each shaft directly or through reduction gear*	*Two or more engines coupled to each shaft through clutch and reduction gear*
Reversible	16	20	20	20
Non-reversible	6	8	8	8

For diesel-electric or turbine-electric propulsion see 4-6-5/9.5.1(b) of the *Marine Vessel Rules.*

6 Fire Safety Systems

6.1 Fire Fighting System

6.1.1 Fire Extinguishing Design and Location *(1 September 2015)*

Fire extinguishing systems are to be designed or located so that they are not made inaccessible or inoperable by ice or snow accumulation or the minimum anticipated temperature. System configuration should take into account the need for operators to be wearing bulky and cumbersome cold weather gear. Alternative fire fighting system designs suitable for use in a low temperature environment, [e.g., aerosol fire fighting system for enclosed spaces (engine room, pump room, etc.)], will be considered upon submittal of substantiating data. The fire extinguishing system is to be such that:

i) Equipment, appliances, extinguishing agents and systems are always to be protected from freezing and operable at the minimum anticipated temperature.

ii) Precautions are to be taken to prevent nozzles, piping and valves from freezing or becoming clogged due to internal or external ice build up.

6.1.2 Water or Foam Extinguishers

Portable and semi-portable water and foam extinguishers should be located in positions protected from freezing temperatures, as practicable. Locations subject to freezing are to be provided with extinguishers capable of operation at the minimum anticipated temperature.

6.1.3 Fire Pumps and Associated Equipment

i) Where fixed fire fighting systems or alternative fire extinguishing systems are situated in a space separate from the main fire pumps and utilizing their own independent sea suction, this sea suction is to be also capable of being cleared of accumulations of ice. See 4/5.3.2(a).

ii) Fire pumps, including emergency fire pumps, are to be located in heated compartments. The pumps and their auxiliaries in the compartment are to be adequately protected from freezing at the minimum anticipated temperature.

iii) Isolating valves are to be in accessible locations. Isolating valves located in exposed locations are to be protected from freezing spray. The fire main is to be arranged so that external sections can be isolated and means of draining are to be provided.

iv) Hydrants are to be positioned or designed to remain operable at the minimum anticipated temperature. Ice accumulation and freezing are to be taken into account.

v) All hydrants are to be installed with a two-handed valve lever or hand wheels and provided with quick connects for hoses.

vi) *(1 September 2015)* Valves and hydrants exposed to minimum anticipated temperatures less than or equal to -30°C (-22°F) are not to be of cast iron.

6.1.4 Protection Against Ice Build Up

Components of the fire fighting system that may be exposed to icing that could interfere with the proper functioning of that component are to be adequately protected so as to remain operable at the minimum anticipated temperature. Portable fire fighting equipment such as portable foam applicators are to be stored in a protected space and are to be readily available.

6.1.5 Fire-fighter's Outfits

i) Fire-fighter's outfits are to be located within accommodation areas and other spaces, as appropriate, suitably protected from low temperature conditions. The outfits are to be stored in positions as widely separated as practicable and readily accessible by the crew.

ii) *(1 September 2015)* In addition to the fire-fighter's outfits required in the *Marine Vessel Rules*4-7-3/15.5, for vessels operating in remote areas one spare fire-fighter's outfit is to be provided. The spare outfit is to be stored in a location protected from low temperatures where access is provided to the open deck, such as a steering gear room.

7 Electrical Systems

7.1 System Design

7.1.1 Main Source of Electrical Power

Where central electric power plants or shaft generators are installed, the requirements in 4-8-2/3 of the *Marine Vessel Rules* are applicable.

7.1.2 Emergency Source of Electrical Power

7.1.2(a) Additional Systems, Equipment and Spaces.

In addition to those listed in 4-8-2/5.5 of the *Marine Vessel Rules*, the following systems and equipment are to be provided with an emergency source of power:

- Operation and control of the auxiliary boiler, if fitted.
- Heat tracing for any piping associated with the emergency services listed in 4-8-2/5.5 of the *Marine Vessel Rules.*

In addition to the emergency services listed in 4-8-2/5.5 of the *Marine Vessel Rules*, emergency heating is to be available for a period of 18 hours for the following spaces:

- Navigation Bridge
- Radio Room
- Engine Control Room
- Centralized Control Station
- Cargo Control Room
- Machinery Space Workshop
- Emergency Generator Room
- Battery Room
- Two common areas (e.g., Mess Room and Recreation Room)
- Hospital
- Heated Compartments for Fire Control Station and Fire Fighting Equipment

7.1.2(b) Increased Emergency Services Time.

As an option, the time periods listed in 4-8-2/5.5 TABLE 1 of the *Marine Vessel Rules* and 4/7.1.2(a) of this Guide may be increased from 18 hours or greater for vessels anticipated to operate in remote areas. This increased time is optional and will be shown in the classification notation.

7.1.3 Specific Systems

7.1.3(a) Navigation Light System.

Exposed lights are to be suitable for operation at the design service temperature and environmental conditions.

7.2 Electrical Equipment

7.2.1 Rotating Machines

7.2.1(a) Motors and Generators.

Electric motors and generators in unheated spaces are to be:

i) Fitted with means to prevent moisture condensation in the machine when idle.

ii) Provided with lubricating oil suitable for the design internal temperature if the bearings require forced lubrication or pre-lubrication.

7.2.1(b) Motors.

Electric motors in exterior locations are to be:ine when idle.

i) Fitted with means to prevent moisture condensation in the machine when idle.

ii) Provided with lubricating oil or grease suitable for the minimum anticipated temperature.

7.2.2 Switchboards, Motor Controllers, etc.

Switchboards, power and lighting distribution boards, motor control centers and motor controllers and battery charging panels located in compartments that may be subject to low temperatures are to be provided with space heaters.

These components are to be suitable for continuous operation resulting from vibrations from ice impacts and vessel maneuvering and are not to trip inadvertently. The manufacturer's certification or specification sheet is to be submitted for review.

7.2.3 Cables *(1 September 2015)*

Electric cables in exposed areas are to be suitable for operation at the design service temperature. Sheathing is to be provided to protect the cables from mechanical damage. Electric cables are to be in accordance with one of the recognized standards listed in 4-8-3/9.1 of the *Marine Vessel Rules*.

Cables on exposed decks are to be protected from the effects of mechanical ice removal.

7.2.4 Accumulator Batteries – Storage Space

A battery storage space is required to be provided with mechanical ventilation to supply heated air.

7.3 Electronic Equipment – Monitoring and Control *(1 September 2015)*

Indicators and alarms for critical systems are to be duplicated as far as possible. The use of components that have demonstrated a high level of reliability operating in low temperatures are to be used where possible.

The intended operation of the vessel and the equipment is to be considered. Vessels that are expected to enter a lay-up period in low temperatures are to have systems rated for survival at the minimum anticipated temperature while inactive. Systems that are required to operate in low temperatures are to be rated for operation at the minimum anticipated temperature. Systems to consider include but are not limited to:

- Systems used to meet the requirements of 4-7-3/9 and 4-7-3/11 of the *Marine Vessel Rules*
- System required to support ABS notations requirements
- Displays and monitors
- Computers and integrated circuits
- Human interface, including touch screen monitors
- Sensors
- Cameras

8 Heating and Ventilation

The following requirements apply to the accommodations and other spaces that are normally manned or occasionally manned for certain vessel operations.

i) The heating and ventilation systems are to be designed for satisfactory distribution of heating at the minimum anticipated temperature.

ii) Supplementary electric heaters may be used in cabins and other manned spaces. High amperage permanently installed heaters are not to be wired to the same circuit breakers as vital electronic equipment. Portable electric heaters are not permitted.

iii) The relative humidity is to be maintained in the range between 30% to 70%.

iv) *(1 September 2015)* Heating systems for accommodation spaces and the spaces listed in 4/7.1.2(a) with the following exceptions are to have a rated capacity sufficient for maintaining the temperature to 20°C (68°F) at the minimum anticipated temperature. However, the machinery space workshop, emergency generator room, battery room and compartments for fire fighting equipment are to be fitted with heating systems with a rated capacity sufficient to maintain the compartments to 10°C (50°F) at the minimum anticipated temperature.

v) Recirculation of air in the accommodation spaces is to be in accordance with a recognized standard. The standard applied is to be provided for information.

vi) Air ventilation ducting is to be insulated with non-combustible insulation.

vii) The closing apparatus for all ventilation inlets and outlets are to be located so as to be protected from snow and ice accumulation that may interfere with effective operation of the closures and recirculation of exhaust gases. Alternatively, heat tracing may be provided in lieu of a protected location.

viii) *(1 September 2015)* All other spaces that are normally manned and/or have equipment installed within are to be provided with a heating system with a rated capacity sufficient to maintain 0°C (32°F) at the minimum anticipated temperature. Consideration will be given if it is unpractical to heat the space due to its arrangement or size.

A summary of the heating, ventilation, and air conditioning calculations confirming compliance with the above requirements is to be submitted for review.

9 Remote Propulsion Control and Automation

9.1 Monitoring

Standby propulsion and auxiliary machinery are to be provided with either:

i) Low temperature monitoring with an alarm installed on each machine; or

ii) Low temperature monitoring with an alarm for the compartment.

These alarms are to alert the operator in the Engine Control Room and/or Centralized Control Station when the temperature is too low for the machinery to start.

10 Remote Control and Monitoring for Auxiliary Machinery and Systems Other Than Propulsion

No additional requirements.

SECTION 5
Safety Systems

1 General

This Section lists requirements for various equipment necessary for the protection and survival of the personnel onboard the vessel operating in low temperatures and accretion of ice. It should be noted that for vessels operating in low temperature environments, rescue and medical services may be significantly delayed because of weather conditions or remoteness of the area.

Additional information has been provided in Appendix A5.

A list of Administrations with coasts on the Arctic and Antarctic Oceans and the Baltic Sea are listed in Appendix A12.

2 Heating for Survival

Heating systems are considered essential for safety and survival. Therefore, the emergency generator is to be sized to maintain crew survivability. The spaces listed in 4/7.1.2 are to be fitted with heating systems with a rated capacity sufficient for maintaining 10°C (50°F) at the design service temperature.

3 Navigational Equipment in Ice-Covered Waters

Navigation in ice-covered waters is assisted by specialized equipment and services to support both strategic (route planning) and tactical (ice avoidance) decisions. All navigational equipment is to be capable of being operated in the environmental conditions at the design service temperature.

3.1 Equipment

The following equipment is to be installed onboard:

i) *(1 September 2015)* Equipment capable of receiving high resolution ice and weather charts.

ii) Radar systems capable of picking up ice targets.

iii) Adequate communications and signaling equipment.

iv) High powered xenon arc searchlights remotely operated and positioned to provide 360 degrees of lighting capability, if possible.

v) Sound reception system for navigation bridge with enclosed bridge wings for reception of exterior noises/signals.

vi) *(1 September 2015)* Navigation lights are to be self-heating, provided with heating or another adequate means to maintain ice-free lenses.

4 Life Saving Appliances and Survival Arrangements

(1 September 2015) This Subsection lists requirements for various life saving appliances. They are based in part on the following International Maritime Organization (IMO) documents:

- IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters or the IMO Guidelines for Ships Operating in Polar Waters.
- IMO Life Saving Appliance Code (2003) (as amended).
- IMO International Code for Ships Operating in Polar Waters (Polar Code), MSC.385(94)

The flag state administration and the administrations responsible for the coastal areas that the vessel will be operating in may have requirements in addition to those listed.

Adequate supplies of protective clothing and thermal insulating materials are to be supplied for all vessels operating in low temperature environments for all persons onboard expected to perform tasks in low temperatures.

Lifesaving appliances are to be of a type that is rated to perform its functions at the lowest temperature of:

- Its design service temperature or
- A temperature of –30°C (–22°F)

Additional rations and drinking water are to be provided onboard all lifeboats and life rafts. Extra rations (caloric intake) are required by personnel subjected to extremely cold temperatures. Drinking water containers are to be suitable to allow for thermal expansion while frozen. Consideration should be given to storing rations and drinking water, in addition to those in the lifeboats and life rafts, inside the deckhouse/ accommodations to protect them from freezing. These additional rations and drinking water are to be stored in such a space or container so as to be convenient for placement into the survival craft should evacuation become necessary. See Chapter 11 of the IMO *Guidelines for Ships Operating in Polar Waters*.

It should be understood that most EPIRBs and Personal Floatation Device (PFD) lights are automatically activated by contact with water, which may not happen when vessels are evacuated in ice-covered waters. Crews need to be aware of this fact, and are to be provided with equipment (e.g., manually activated) that facilitates other ways of transmitting distress and location information. EPIRBs and PFD lights selected are to be rated for operation at the design service temperature. Note that most EPIRBs work only down to –20°C according to manufacturers' instructions. Care must be taken to verify that the selected EPIRBs are suitable for the design service temperature. The manufacturer should be consulted for guidance.

4.1 Lifeboats *(1 September 2015)*

Partially or totally enclosed lifeboats are required for all vessels operating in low temperature environments, as they offer shelter to the occupants from the environment. Lifeboats are to meet the requirements of the IMO Life Saving Appliance Code and the flag State administration. The following additional requirements are to be complied with:

i) The capacity of the lifeboats are to be sized for 125% of crew size based on increased dimensions as crews are presumed to be dressed in bulky cold weather clothing. Lifeboat access and operations are to be based on these increased dimensions. Most lifeboats will not accommodate their SOLAS capacities when crews or passengers are dressed in bulky clothing.

ii) The lifeboat engine is to be suitable for cold starting and continuous operation at the design service temperature in lieu of the test temperature specified in the LSA Code. Engine block heaters may be considered for oil sumps. Cooling water, fuel and lubricating oils for engines are to be suitable for engine operation at the design service temperature.

iii) For ice class vessels, the engine power is to be sufficient to have ice-transit capability in thin ice with a low concentration.

iv) Lifeboat steering systems should be designed so that it does not directly transmit ice forces on the rudder to the coxwain's hands.

v) For ice class vessels, the lifeboat's keel is to be adequately strengthened to withstand an impact with ice.

vi) Lifeboats are to be provided with radio equipment and batteries suitable for operation at the minimum anticipated temperature.

vii) Lifeboat releasing gear is to be shielded or protected from freezing for ready release or reattachment.

viii) Lifeboats are to be provided with heaters and heating fans to reduce humidity and prevent icing and blockage of entrance doors. For design service temperatures less than –30°C (–22°F), heater cables are to be installed for hatches and doors to prevent freezing. Lifeboat internal spaces are to be heated both when the lifeboats are onboard as well as when the boats are operating independently, the power for these heat sources need not be the same. Heating for lifeboats when deployed is to be capable of maintaining a temperature of at least 10°C with no one onboard at the design service temperature, and be capable of temperature adjustment. Air flow inside the lifeboat is to ventilate all areas including the bow area with fresh heated air.

ix) Lifeboat windows in way of the control station are to be provided with heating or other means to prevent icing and frost.

x) Lifeboats are to be equipped so as to be capable of deterring native animal invasion (e.g., polar bears).

4.2 Life Rafts *(1 September 2015)*

Life rafts are to meet the requirements of the IMO Life Saving Appliances Code and the flag State administration.

Inflation of inflatable life rafts is to be completed within a period of 3 minutes at the lowest temperature of:

- Its design service temperature or
- A temperature of –30°C (–22°F)

After inflation, the life raft is to maintain its form when loaded with its full complement of persons and equipment.

A manual inflation pump is to be stored near the inflatable liferafts if not provided within the pack.

The hydrostatic release mechanisms are to be protected from icing.

4.3 Rescue Boat

A rescue boat, if provided, is to meet the requirements of the IMO Life Saving Appliances Code and the flag State administration. The following additional equipment is to be provided onboard the rescue boat:

i) Radio equipment with batteries suitable for the minimum anticipated temperature is to be installed.

ii) A battery charger

iii) An engine block heater

iv) *(1 September 2015)* Cooling fluid, fuel and lubricating oils for engines are to be suitable for engine operation at the design service temperature.

4.4 Launching Stations and Arrangements

The requirements of this Paragraph are applicable for lifeboats, life rafts and rescue boats.

For ice class vessels, launching appliances onboard need to be designed with the following special considerations. Free-fall lifeboats cannot be released onto ice-covered waters without risking the safety of occupants because of impact with the ice and/or surfacing under ice floes. Standard lifeboats have almost no ice-transit capability, and they should be launched into the vessel's track to maximize their ability to get clear of a sinking or burning vessel. Launching stations are to be located considering their suitability to facilitate abandoning the vessel during navigation in ice-covered waters.

Arrangements are to be provided to permit lowering life rafts onto the ice rather than into the water. Life raft storage arrangements should be provided to permit this operation.

For ice class and non-ice class vessels, the forward end of the lifeboat stations is to be shielded with a roof and wind walls to reduce ice and snow accretion on the lifeboat canopy, davits, sheaves and wires. The launching arrangements for boats and their retrieval are to be protected with a cover over the sheaves and wires.

Grease or lubricant used for the sheaves is to be suitable and is not to exhibit degraded performance at the design service temperature.

4.5 Ice Gangway, Personnel Basket and Escape Chutes for Ice Class Vessels

An ice gangway or personnel basket used in conjunction with a crane may be considered as an additional means of evacuation, subject to approval of the flag State administration.

Escape chutes, if provided, are to meet the requirements of the IMO Life Saving Appliances Code and the flag state administration. The escape chute is to provide a means of landing safely on the ice pack.

Equipment is to be provided for shelter of all personnel.

4.6 Immersion Suits and Life Jackets

The requirements in Chapter 11 of the IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters or the IMO Guidelines for Ships Operating in Polar Waters with regard to immersion suits and life jackets and the flag State administration are to be complied with.

Adequate supplies of immersion suits and life jackets are to be provided on the vessel for all persons onboard at any time.

Personal immersion suits may be stored in cabins to be used during lifeboat musters in order to avoid moisture accumulating in suits stored at lifeboat stations.

4.7 Alarms, Escape Routes, and Access Routes *(1 September 2015)*

The requirements in Chapter 4, Accommodation and Escape Measures of IMO Guidelines for Ships Operating in Arctic Ice-Covered Waters or the IMO Guidelines for Ships Operating in Polar Waters, and the flag State administration are to be complied with.

All vessels are to have arrangements or procedures to maintain escape routes free of snow and ice.

Public Announcement and General Alarms are to remain functional and audible considering snow and ice accumulation and operation at the minimum anticipated temperature.

The fog horn is to remain operational at the minimum anticipated temperature, and to be capable of being safely de-iced or designed to be anti-iced.

4.8 Lighting *(1 September 2015)*

The lighting and emergency lighting on open decks are to be designed to prevent icing.

Exterior lighting systems, including emergency lighting, are to be designed such that the decks are illuminated with consideration of fog or falling snow.

5 Drills and Emergency Instructions

Emergency and evacuation procedures including instructions for at sea and ice covered waters are to be developed with an appropriate emphasis to changes to standard procedures made necessary by operations in low temperature environments. Refer to the requirements of Chapter 13, Operational Guidelines of the IMO Guidelines for Ships Operating in Polar Waters (2009) (Resolution A.1024(26)). The procedures are to include the following topics:

i) For ice class vessels, the propeller is to be protected from contact with ice

ii) Vessel evacuation

iii) Operation of safety equipment and supporting vessel systems, such as cranes or lifting appliances during an emergency or vessel evacuation

iv) Survival at sea

v) Survival on ice/ashore

vi) Fire and damage control equipment and system

vii) Cross-training of crew members

Crew members are to be provided with proper onboard instructions and be regularly trained

6 Provisions and Spares

The flag State administration and the administrations responsible for the coastal areas that the vessel will be operating in may have additional requirements related to provisions and spares.

SECTION 6

Specific Vessel Requirements

1 Application

Many vessel types have design and operational characteristics which require special consideration. This Section of the Guide addresses those additional requirements for specific vessel types which are now operating or under consideration for operation in low temperature environment services.

Additional information has been provided in Appendix A6.

2 Vessels Intended to Carry Liquefied Gases in Bulk

2.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Liquefied Gas Carrier** or ✠ **A1 Liquefied Natural Gas Carrier** and subject to the requirements in Part 5C, Chapter 8 of the *Marine Vessel Rules*. These are additional requirements to those in the other sections of this Guide.

2.1.1 Design Loads

The requirements of this Section will only consider Liquefied Natural Gas carriers operating in waters without any significant ice cover. Loads resulting from interaction with ice and loads caused by navigation in ice are to be verified as part of the overall design development, and considered when assigning a suitable Ice Class Notation in accordance with Part 6 of the *Marine Vessel Rules*.

2.1.2 Plans and Data to be Submitted

The following systems/components are subject to the additional requirements in this Subsection for operation at the design service temperature:

- Ballast Tank Heating Arrangements
- Cargo Piping Diagram
- Cargo Pressure and Temperature Control Systems
- Cargo Tank Vent Systems
- Interbarrier and Insulation Space Venting Systems
- Environmental Control Systems (e.g., nitrogen purging systems)
- Inert Gas System
- Electrical Installations
- Additional Fire Safety Requirements, including Water Spray System
- Mechanical Ventilation in Cargo Area

- Instrumentation for Gauging, Gas Detection, and Cargo Handling Controls
- Details of the arrangements for the use of cargo as fuel and associated fuel gas piping diagrams and other arrangements for utilization of boil-off gas (BOG)
- Details and arrangements of re-liquefaction systems, if installed
- Details of additional Personnel Protection arrangements

2.2 Material Selection

Materials entering into the construction of Liquefied Gas Carriers and associated equipment and cargo containment systems are to be in accordance with the requirements in Section 2 of this Guide, Part 5C, Chapter 8 of the *Marine Vessel Rules* and the ABS *Rules for Materials and Welding (Part 2)*.

2.3 Hull Construction and Equipment

2.3.1 Ice Loads

Loads attributable to ice and snow accumulation on the containment system or any cover for the containment system are to be determined, taking into account both the static load and dynamic load from sliding or dropped ice

2.3.2 Weather Deck Equipment

Due to the nature of the cargo, many cargo-related systems and equipment are designed for operation at low temperatures. However, it is necessary to consider both external and internal low temperatures in the design and selection of materials.

For cargo piping and piping supports installed on the main deck and exposed to the weather, including ventilation piping, the design loads are to include the expected amount of ice and snow accumulation.

The supports for liquid and vapor cargo piping systems on deck are to be arranged so that free expansion and contraction of the pipes during cargo operations cannot be blocked by accumulated ice or snow.

2.3.3 Stability

Liquefied gas carriers with cargo tanks or tank covers protruding from deck and/or with many exposed piping systems and features in elevated locations are likely to accumulate large amounts of ice in the upper part of the vessel, adversely affecting stability.

Intact and damage stability calculations are to take into account the weight of ice accumulation in exposed areas by means of an allowance for ice accretion based on the specific configuration of decks, piping systems and features in the cargo area for the particular vessel.

2.4 Machinery and Electrical Equipment

Many LNG carriers utilize cargo boil-off as fuel for propulsion power. The normal rate of boil-off (NBOR) depends on the insulation of the cargo tanks and the external temperatures. For vessels capable of operating in the "gas only mode" and operating near the design service temperature, the expected boil-off volumes are to be determined to assure that the provisions for forced boil-off are adequate.

2.4.1 Valves *(1 September 2015)*

Safety Relief Valves and other valves exposed to the weather, as described in Part 5C, Chapter 8 of the *Marine Vessel Rules,* are to be arranged in such a way as to provide their local and remote activation under all circumstances. Means of ice removal and heat tracing of the valves are to be provided. Valve actuators with local position indicators are to be of the enclosed type.

Valves for cryogenic service are more susceptible to packing gland leaks at low ambient temperatures. Data is to be submitted to confirm that these valves will be suitable for service at the minimum anticipated temperature.

2.4.2 Cargo Tank and Inter-barrier Space, Venting and Pressure Regulating Arrangements

All piping and pressure/vacuum preventing systems including valves are to be provided with a heat tracing system to provide for their functionality at all times.

Operational procedures for local testing are to be provided to the operator.

2.4.3 Heating Media

The maximum temperature of heating media within the cargo area must take into consideration the temperature class associated with the auto ignition temperature of the cargoes being carried. The electrical equipment and instrumentation for heat tracing systems installed within the cargo area must be of an intrinsically safe type.

2.4.4 Cargo Control/Environmental Systems

Equipment used for the environmental control of the cargo spaces, inter-barrier spaces and other spaces that require a controlled atmosphere, either by chemical composition, temperature or air quality, are to be designed to maintain a dew point below the lesser of the design service temperature or -30°C (-22°F).

2.4.5 Mechanical Ventilation

Spaces required to be ventilated before entering are to be equipped with suitable means of pre-heating the ventilation systems to provide for their proper functioning at the design service temperature.

2.4.6 Towing Fittings

The stowage compartment for emergency towing gear is to be provided with a means for de-icing and is to be readily accessible at all times.

2.5 Access to Deck Areas and Cargo Machinery

2.5.1 Electric Motor Room and Cargo Compressor Room Access

Access to the cargo machinery room is to be available at all times. Heat tracing of the door coamings is to be provided.

2.5.2 Cargo Manifold and Cargo Vapor System

If the cargo manifold and cargo vapor areas and associated valves are enclosed from the weather, the enclosures are to be arranged in such a way as to provide for sufficient ventilation of the space when the vessel is loading and unloading. When mechanical ventilation is provided, the ventilation capacity is to be at least 30 air changes per hour based on the total volume of the space. Additional gas detectors are to be provided.

2.5.2(a) Arrangement of vent mast.

The vent mast head is to be designed to prevent blockage by ice accumulation. Drip pans for the purpose of collecting moisture in the vent mast are to be provided. Drip pans with associated drain pipes inside the vent mast head and foot are to be provided with trace heating.

2.5.2(b) Vapor heater.

A steam-operated vapor heater for the purpose of preventing vapor descending to the deck is to be installed in the vapor line before the vent riser used for controlled venting.

2.5.2(c) Boil off gas piping.

Insulation of the boil-off gas piping is required in way of areas exposed or subject to the design service temperature.

2.5.3 Access to Machinery on Deck

Access to the deck for personnel (e.g., doors, hatches, etc.) and to other equipment located on the weather deck and the bow area are required to be available at all times. Access for the operating personnel is to be arranged in such a way that they are not obstructed by ice accumulation or endangered by overhead ice accumulation.

Additional arrangements are to be made to prevent the crew from being hit by the release and sliding of accumulated ice and snow from inclined covers of the containment systems onto any walkways or passageways.

2.6 Monitoring Systems

2.6.1 Temperature Monitoring Systems

Additional temperature monitoring systems are to be installed in order to monitor the efficiency of the heat tracing systems.

2.6.2 Alarm Systems

Heat tracing and additional temperature monitoring systems are to be arranged so that any failure will result in an alarm at the manned control station.

2.6.3 Instrumentation

The following instrumentation is to be installed and fitted with heat tracing equipment as considered necessary:

- Level indicators for cargo tanks
- Overflow control
- Pressure gauges
- Temperature-indicating devices
- Instrumentation for gas detection systems

2.6.4 Other Monitoring Equipment

When remotely operated equipment, such as closed caption television (CCT), is utilized, any reduced movement of the CCT enclosure is not to impair its functionality to transmit images. Heated enclosures are to be used to provide for their continued operation.

2.7 Fire and Safety Systems *(1 September 2015)*

Additional fire and safety systems as required to be installed in liquefied gas carriers by Part 5C, Chapter 8 of the *Marine Vessel Rules* and the *International Gas Carrier Code* are to be arranged and installed so as to provide for their continued operation at the minimum anticipated temperature. The water spray deluge system is to be equipped with heat tracing and sufficient drainage to prevent freezing. Alternative arrangements for water deluge systems and possible additives to the water may be accepted based on the approval of the flag administration. Dry chemical powder systems are to be arranged to prevent clogging of the nozzles and provide for the release of the medium at the minimum anticipated temperature.

3 Vessels Intended to Carry Ore or Bulk Cargoes/Cargo Ships

3.1 General

These requirements are intended to apply to vessels with the classification ✠ **A1 Bulk Carrier**, ✠ **A1 Ore Carrier**, or ✠ **A1 Oil or Bulk/Ore (OBO)** Carrier and subject to the requirements in Part 5C, Chapters 3 or 4 of the *Marine Vessel Rules*. The requirements of 6/5 of this Guide are also applicable for vessels carrying oil. These are additional requirements to those in the other Sections of this Guide.

3.2 Material Selection

Materials entering into the construction of Bulk Carriers are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

3.3 Hull Construction and Equipment

3.3.1 Hatch Cover Sealing

Hatch cover sealing arrangements are to be suitable for the minimum anticipated temperature. Arrangements are to be provided to prevent frozen water adhering to the seals. See 4/4.6.2.

3.4 Machinery and Electrical Equipment

3.4.1 Ballast Piping

If fitted, piping connecting the upper wing tanks and lower wing tanks is to be protected from freezing. If a steam heating coil is fitted on the surface of this connecting pipe, it is to be protected so as to avoid being damaged during cargo loading and unloading operations.

If an air bubble system or heating coil system is installed and operating in the lower ballast tank to prevent freezing as per 3/2.3, the heated ballast water or air bubbles will be passing through the connecting pipe to the upper wing tank and no additional freezing protection will be required.

3.4.2 Ballast Water Tanks

With the hatch covers open for cargo loading or discharge, the ballast tanks in the double bottom and lower wing tanks may be exposed to the design service temperature. Accordingly, the requirements in 4/5.2 are to be complied with.

3.5 Access to Deck Areas and Cargo Machinery

Requirements for cargo handling equipment are in 4/4.6.

4 Offshore Support Vessels

4.1 General *(1 September 2015)*

These requirements are intended to apply to vessels with the classification ✠ **A1 Offshore Support Vessel** and subject to the requirements in the ABS *Rules for Building and Classing Marine Vessels*. Vessels with lengths in excess of these Rules will also be subject to these requirements. These are additional requirements to those in the other Sections of this Guide.

Offshore support vessels in cold regions frequently double as ice breakers and ice management vessels and should be appropriately designed for these functions. This includes selection of ice class (strengthening of hull and machinery), and also the selection of hull forms and appendages suitable for ice operations.

4.2 Material Selection

Materials entering into the construction of support vessels are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

4.3 Hull Construction and Equipment

4.3.1 Tanks

Tanks are to be arranged or provided to accept waste fluids from the drill ship.

4.3.2 Stability

If the hull form promotes ride-up onto larger ice features, stability when beached should be specially considered. Ice knives or skegs can be fitted both to reduce ride-up and to promote splitting of large floes.

Offshore support vessels can be particularly susceptible to reduced stability because of the effects of icing. These include both accumulation on equipment, making it difficult or impossible to operate, and impacts on heel, trim, and stability in general. Design features can be selected to reduce ice build up, and de-icing equipment can be installed. See 3/5.

4.4 Machinery and Electrical Equipment

Offshore support vessels typically conduct a wide range of operations that require the operation of deck machinery such as winches, cranes, etc. These, and in particular their control stations, are to be protected from cold, ice and snow, as practicable.

Drilling muds and other specialized bulk cargoes carried by offshore support vessels may be particularly susceptible to freezing and may flow less freely at low temperatures. This fact is to be taken into account at the design stage or in the selection of existing vessels for low temperature operations. Valve and control station locations are also to be considered.

Where the transfer of fuel, drilling muds and other specialized bulk cargoes to drill ships at sea is anticipated, all equipment associated with the transfer such as, hoses, valves, fittings, etc. are to be suitable for operation at the minimum anticipated temperature.

5 Vessels Intended to Carry Oil in Bulk

5.1 General *(1 September 2015)*

These requirements are intended to apply to vessels with the classification ✠ **A1 Oil Carrier**, ✠ **A1 Fuel Oil Carrier**, or ✠ **A1 Chemical Carrier** and subject to the requirements in Part 5C, Chapters 1, 2 or 9 of the *Marine Vessel Rules*. These are additional requirements to those in the other sections of this Guide.

5.2 Material Selection

Materials entering into the construction of vessels intended to carry oil in bulk are to be in accordance with the requirements in Section 2 of this Guide and the ABS *Rules for Materials and Welding (Part 2)*.

5.3 Hull Construction and Equipment

For cargo piping and piping support details, including vent piping installed on the main deck and exposed to the weather, the design loads must include the expected amount of ice and snow accumulation.

The supports for cargo and ballast piping systems on deck are to be arranged so that free expansion and contraction of the pipes during cargo operations cannot be blocked by accumulated ice or snow.

Consideration is to be given to enclosing deck piping in a tunnel or similar enclosure.

5.4 Machinery and Electrical Equipment

5.4.1 Towing Fittings

The stowage compartment for emergency towing gear is to be provided with a means for de-icing and is to be readily accessible at all times.

For ice class tankers, emergency towing fittings at the forward end required as per SOLAS Chapter II-1, Regulation 3-4 are to meet the requirements of 4/4.5.

5.4.2 Pressure/Vacuum Valves

Acceptable means for de-icing pressure/vacuum valves are to be provided so that they remain operable at all times.

5.4.3 Liquid Filled Pressure/Vacuum Relief *(1 September 2015)*

Where a liquid filled means of relieving pressure or vacuum is used, the liquid must be kept from freezing. Therefore a liquid is to have a freezing point below the minimum anticipated temperature, or the unit is to be insulated and heat traced. If an anti-freezing liquid is used, the fluid level is to be adjusted accordingly with the density of the liquid.

5.4.4 Cargo Tank Purging and/or Gas-freeing

The cargo tank purging and/or gas-freeing system is to be designed to be operable at the design service temperature.

5.4.5 Inert Gas System *(1 September 2015)*

The inert gas system scrubber is to be located in a compartment protected from the weather.

The inert gas system deck seal is to be operable under temperature conditions specified in the winterization plan.

Where a liquid filled means of pressure relief is attached to the inert gas lines, measures are to be taken to from the inert gas lines, draining into the liquid filled means of pressure relief. This may be achieved by arrangements such as a trap and drain before the liquid filled pressure relief.

5.4.6 Piping – General

All piping with contents with freezing points above the design service temperature is to be provided with a suitable means to prevent freezing. Acceptable arrangements include suitable insulation, heat tracing or continuous fluid circulation or a combination thereof.

5.5 Access to Deck Areas and Cargo Machinery

5.5.1 Cargo Manifold

Protection from the weather or anti-icing equipment needs to be provided to permit hook-up, continuous operation or disconnection when scheduled. This may be accomplished by heated covers and/or hot water wash systems.

An enclosure for the cargo manifold area is not required. If the cargo manifold area and associated valves are enclosed from the weather, the enclosures are to be arranged in such a way as to provide sufficient ventilation of the space when the vessel is loading and unloading. Additional gas detectors are to be provided.

The design of a dedicated watch station in way of the cargo manifolds should be considered for tankers that are expected to regularly load/discharge cargoes in extremely harsh environments. At many offshore terminals, tankers may be forced off their moorings by ice movement, and may need to shut down transfer operations rapidly to avoid spills. Quick disconnect and purging arrangements may need to be provided.

5.6 Monitoring Systems

5.6.1 Temperature Monitoring Systems

Additional temperature monitoring systems are to be installed in order to monitor the efficiency of the heat tracing systems. The monitoring system indicators are to be located at a manned control station. All systems provided with heat tracing are to be monitored.

5.6.2 Alarm Systems

Heat tracing and additional temperature monitoring systems are to be arranged in such a way that any failure will result in an alarm at the manned control station.

5.6.3 Instrumentation

The following instrumentation is to be installed and fitted with heat tracing equipment as considered necessary:

- Level indicators for cargo tanks
- Overflow control
- Pressure gauges
- Temperature indicating devices
- Instrumentation for gas detection systems

5.6.4 Other Monitoring Equipment

When remotely operated equipment, such as closed caption television (CCT), is utilized, any reduced movement of the CCT enclosure is not to impair its functionality to transmit images. Heated enclosures are to be used to provide for their continued operation.

5.7 Fire and Safety Systems

No additional requirements.

SECTION 7
Survey Requirements

1 General

The administrative and the certification procedures are listed in 1/5.1 and 1/5.2 and 1/8 FIGURE 2, "Certification Procedure".

These survey requirements are in addition to those listed in the *Marine Vessel Rules* and ABS *Rules for Survey After Construction (Part 7)*

Information related to survey requirements is in Appendix A7.

2 Surveys During Construction

During vessel construction, the Surveyor is to confirm that the requirements of Sections 2, 3, 4 and 5 have been complied with.

The Surveyor is to confirm that the requirements of Section 6 have been complied with for the following specific vessel types:

- Vessels intended to carry liquefied gases in bulk
- Vessels intended to carry ore or bulk cargoes
- Offshore supply vessels
- Vessels intended to carry oil in bulk

Vessels satisfactorily complying with these Guide requirements may be distinguished in the *Record* with the appropriate classification notation.

3 Surveys for Loose Equipment/Crew Training

3.1 Survey at Delivery

The Surveyor is to confirm that the requirements of Sections 8 and 9 have been complied with. Vessels satisfactorily complying with the Guide requirements may be distinguished in the *Record* with the **+** appended to the appropriate notation.

3.2 Delayed Survey Option

For vessels that are anticipated to operate infrequently in low temperature environments, the Owner may arrange for the vessel to meet the requirements in Sections 2 through 6 initially. When operation in low temperature environments is planned, the Owner is to make arrangements for the loose gear to be placed onboard in accordance with the requirements in Section 8. The vessel's crew is to be trained in accordance with the requirements in Section 9. The Surveyor is to be notified with sufficient time prior to operation in low temperature environment in order to confirm that the requirements of Sections 8 and 9 have been complied with. Vessels satisfactorily complying with the Guide requirements may be distinguished in the *Record* with the **+** appended to the appropriate notation.

4 Annual Surveys *(1 September 2021)*

See 7-9-42/1.1 and 7-9-42/3.1 of the ABS *Rules for Survey After Construction (Part 7)*.

5 Special Periodical Surveys *(1 September 2021)*

See 7-9-42/1.3 of the ABS *Rules for Survey After Construction (Part 7)*.

6 Surveys for DE-ICE Notation *(1 September 2021)*

See 7-9-42/3 of the ABS *Rules for Survey After Construction (Part 7)*.

SECTION 8
Crew Considerations

1 General

Because of the significant environmental conditions that a vessel and its crew are operating in, particular attention must be paid to the personnel so that they remain effective in performing their duties. Additional information regarding human response to cold, clothing, nutrition and accommodations is provided in Appendix A8.

2 Clothing

Adequate supplies of protective clothing and thermal insulating materials are to be provided for all persons onboard at any time. Additional information is provided in A8/3.4, “Clothing and Personal Protective Equipment”.

2.1 Hand Protection

Hand protection (mitts, gloves) is to be provided.

2.2 Head and Eye Protection

Head and eye protection gear is to be provided to reduce loss of body heat and protect vision from ultraviolet rays.

Head and eye protection is to be compatible and usable with communications equipment.

2.3 Foot Protection

Foot protection gear is to be provided.

Slip-resistant, insulated safety footwear is to be provided. For heavy work, a felt-lined (or similar insulating material) rubber-bottomed, leather-topped boot with a removable felt insole is preferred. An extra pair of safety shoes for inside work is to be provided.

2.4 Maintenance of Personnel Protective Equipment

Personnel protective equipment is to be properly maintained and stored.

2.5 Immersion Suit Protection

Immersion suits are to be provided for all members of the crew and comply with the text in Appendix A8/3.4.6. See 5/4.6.

2.6 Manual Tools

The following minimum quantities of manual tools for the removal of ice are to be provided:

i) 5 shovels

ii) 5 hammers or mallets

iii) 5 scrapers

SECTION 9

Training and Related Documentation

1 General

Vessels operating in low temperature environments are exposed to a number of unique circumstances. Weather conditions are poor and navigation charts may be unreliable or not reflect current conditions. Shipboard polar ice charts should be updated weekly upon processing of satellite images. Local ice conditions may differ significantly from those depicted on charts. Maintaining maneuverability for the avoidance of locally heavy ice conditions is an important consideration when using ice charts at the route planning level, and communication systems and navigational aids present challenges to mariners. The areas that the vessels operate in are remote, making rescue and any clean-up operations difficult. Therefore, additional crew training must be undertaken and operations manuals must be developed. Appendices A9, "Notes on Training and Related Documentation"; A10, "Climatic Conditions"; and A11, "Notes on Vessel Operations" provide additional information.

2 Training

Training in ice operations, navigation and winterization are to be provided.

Training is to address means to prevent and treat potential cold weather-related maladies of crew, including hypothermia and frostbite.

Certifications are to be recorded, where applicable, and the records updated.

3 Documentation

An operating and training manual shall be submitted to the responsible ABS Technical Office for review. The manual is to be in English and the working language of the crew. Notes for Training and Related Documentation including reference to IMO Guidelines have been provided in Appendix A9.

3.1 Operations

The operating section is to include, but not be limited to, the following:

- General arrangement showing location of equipment (including loose items) installed onboard to facilitate operation of the vessel in low temperature environments.
- Specification of the equipment installed onboard to facilitate operation of the vessel in low temperature environments together with manufacturer's recommendations of use, operational limitations, maintenance and testing procedures, as applicable.
- Relevant information related to operations in ice-covered waters, including contingency planning in the event of damage. The typical format of an operating manual is described in Appendix A9 and it is to include: Normal Operation, Risk Management, and Emergency Instructions. Various operational issues for consideration are provided in Appendix A11.

- Any special operating procedures specific to the vessel and its modes of operation.

3.2 Training

The training section is to cover at least the following subject matter areas:

- Ice recognition
- Safe navigation in ice
- Conduct during escorted operations
- Instructions for drills and emergency response
- Cold weather-related maladies

An updated listing of personnel certified (if applicable) in the use of specialized equipment carried for any type of emergency response is to be maintained.

A training log is to be maintained documenting the conduct of the training and the names of the persons attending the training.

SECTION 10
Ice Removal and Prevention Systems

1 General

Vessels operating occasionally in low temperature environments and subject to ice accretion may receive the optional notation **DE-ICE** indicating equipment and systems have been provided for ice removal and prevention of ice accretion. Additional information with regard to de-icing equipment is in A4/1.1.

2 Requirements

The following requirements are to be complied with.

2.1 Hull Construction and Equipment

3/3.2 (deckhouses)

3/3.3 (exterior stairs)

3/3.4 (operating platforms for deck equipment)

3/3.5 (railings) (Optional) If it is anticipated that ice accretion on railings will occur frequently because of the vessel's low freeboard and frequent operation in open waters in freezing temperatures, then the requirements for **CCO-POLAR** are to be applied.

3/3.6 (towing fittings)

2.2 Vessel Systems and Machinery

4/4.2.ii, 4/4.2.iii, 4/4.2.iv and 4/4.2.v (anchor windlass)

4/4.6.2 (hatch covers, ramps and side doors)

4/1.1 (de-icing and heat tracing) The requirements for **CCO** notation are to be applied.

4/6.1.1 (fire extinguishing design and location)

4/6.1.2 (water or foam extinguishers)

4/6.1.3.iii, 4/6.1.3.iv and 4/6.1.3.v (fire fighting system isolating valves and hydrants)

4/6.1.4 (protection against ice build-up)

2.3 Safety Systems

5/4.1.vii, 5/4.1.viii (lifeboats)

5/4.4 (shielding of launching stations)

2.4 Crew Considerations

8/2.6 (manual tools)

SECTION 11
Polar Code *(2024)*

1 General

Sections 2 through 10 of this Guide are not applicable for the **POLAR(Category, PST)** or **POLAR Ready(Category, PST)** optional notations.

The Polar Code requires that for vessels sailing in polar waters, the owner/operator must conduct an Operational Assessment (OA) and write a Polar Water Operational Manual (PWOM). The OA must assess the specific polar hazards for the vessel and its intended operation, propose measures to control those risks for the specified hazards, and determine the vessel's operational limitations. The risk assessments and control measures must be documented in a report as the basis for the PWOM.

The PWOM must contain vessel specific guidance (procedures and equipment identified during the OA) on how to operate the vessel for its intended operation, guidance when the vessel exceeds its operational limitations, and other important information for the crew. Both the OA report and PWOM must be reviewed by the ABS engineering office before a surveyor can verify all of the applicable equipment required by the Polar Code. Once installed and tested the Polar Ship Certificate (PSC) may be issued.

2 Applicability

Vessels that have completed the Polar Code implementation process and have been issued a Polar Ship Certificate (PSC) are eligible for a **POLAR(Category, PST)** optional notation.

Vessels that have structures, systems, and equipment designed for operations at a Polar Service Temperature (PST) but have not conducted an Operational Assessment or have a Polar Water Operational Manual may be eligible for the **POLAR Ready(Category, PST)** optional notation to indicate the vessel is Polar Code ready.

In cases where the vessel is a non-SOLAS vessel, a **POLAR(Category, PST)** or **POLAR Ready(Category, PST)** notation may be assigned provided the applicable vessel's flag Administration processes and regulations have been met.

3 Notations

3.1 Category

The "Category" designation in the notation refers to the Category in the Polar Code. The categories are defined as follows:

Category **A**: A vessel designed and built in accordance with Sections 6-1-1 through 6-1-3 of the ABS *Marine Vessel Rules* and given an Ice Class notation **PC5**, **PC4**, **PC3**, **PC2**, or **PC1**. Special consideration may be given to vessels built in accordance with other ice class rules of an approximate correspondence with **PC5** through **PC1**. For these other Ice Class notations to be considered a Category **A** vessel, an equivalent level of safety to the Polar Ice Classes between **PC5** to **PC1** is to be established.

Category **B**: A vessel designed and built in accordance with Sections 6-1-1 through 6-1-3 of the ABS *Marine Vessel Rules* and given an Ice Class notation **PC7** or **PC6**. Special consideration may be given to vessels built in accordance with the Finnish Swedish Ice Class Rules (Section 6-1-4 of the ABS *Marine Vessel Rules*) with notation **Ice Class IA** or **Ice Class IAA** or other ice class rules of an approximate correspondence with **PC7** or **PC6**. For these notations to be considered a Category **B** vessel, an equivalent level of safety to the **PC7** or **PC6** is to be established.

Category **C**: All vessels other than Category **A** and Category **B** vessels, including non-ice strengthened vessels.

3.2 Polar Service Temperature (PST)

The Polar Service Temperature (PST) is defined as being at least 10°C below the lowest Mean Daily Low Temperature (MDLT) in the intended area and season of operation, in degrees Celsius. Appendix 10 of this Guide provides information for approximating an appropriate MDLT.

The PST is typically defined in increments of 5°C but may be adusted to any whole number. If the vessel is not a low temperature service vessel (MDLT ≥-10°C), then the PST is to be marked **N/A** in the notation.

Structures, systems, machinery, and equipment are to be suitable for operation at the PST as required in the Polar Code. Hull structural steel grades are to be selected based on the more stringent of 3-1-2/3.5 of the ABS *Marine Vessel Rules* or other material requirements specific to the vessel type or Ice Class.

3.3 POLAR Ready(Category, PST)

This notation indicates that the vessel has been designed and built to comply with the Polar Code but the owner/operator has not completed the OA or the PWOM requirements. This notation indicates to an owner/operator that the hull steel grades, machinery, equipment, and systems are designed for the intended operations in polar waters, and any required equipment is installed. Note this equipment is the mandatory equipment required by the Polar Code regulations, not the equipment identified during the Operational Assessment. The shipyard typically cannot conduct the OA or write procedures for how to operate the vessel in polar waters (i.e., the PWOM). The shipyard is to provide information/procedures to guide owners/operators on the use of equipment so that the equipment will maintain functionality in the intended conditions.

In order to obtain the **Polar Ready(Category, PST)** optional notation the following requirements apply:

POLAR Ready(C, N/A)

i) Two nonmagnetic means of determining heading. [Polar Code I-A/9.3.2.2.1]

ii) Two remotely rotatable narrow beam searchlights. [Polar Code I-A/9.3.3.1]

iii) Equipment for voice communications with aircraft on 121.5 and 123.1 MHZ. [Polar Code I-A/10.3.1.3.2]

POLAR Ready(B, N/A)

i) Everything required for **POLAR Ready(C, N/A)**.

ii) An **Ice Class PC6** or **Ice Class PC7** notation.

iii) Able to withstand flooding resulting from hull penetration due to ice impact. The residual stability following ice damage shall be such that the factor s_i, as defined in SOLAS regulations II-1/7-2.2 and II-1/7-2.3, is equal to one for all loading conditions.

iv) Bridge wings shall be enclosed or designed to protect navigational equipment and operating personnel.

v) If aggregate oil fuel capacity of less than 600 m^3, all oil fuel tanks shall be separated from the outer shell by a distance of not less than 0.76 m. This provision does not apply to small oil fuel tanks with a maximum individual capacity not greater than 30 m^3.

vi) ships other than oil tankers, all cargo tanks constructed and utilized to carry oil shall be separated from the outer shell by a distance of not less than 0.76 m.

vii) Oil tankers of less than 5,000 tonnes deadweight constructed on or after 1 January 2017, the entire cargo tank length shall be protected with double bottom tanks or spaces complying with the applicable requirements of regulation 19.6.1 of MARPOL Annex I; and wing tanks or spaces arranged in accordance with regulation 19.3.1 of MARPOL Annex I and complying with the applicable requirements for distance referred to in regulation 19.6.2 of MARPOL Annex I.

viii) Oil residue (sludge) tanks and oily bilge water holding tanks shall be separated from the outer shell by a distance of not less than 0.76 m. This provision does not apply to small tanks with a maximum individual capacity not greater than 30 m^3.

POLAR Ready(A, N/A)

i) Everything required for **POLAR Ready(C, N/A)**.

ii) An ice class notation **Ice Class PC5** up to **Ice Class PC1**.

iii) Items iii through viii for **POLAR Ready(B, N/A)**.

POLAR Ready(C, PST), where PST is a temperature of -20°C or less.

i) Everything required for **POLAR Ready(C, N/A)**.

ii) All exposed structures are designed to the PST.

iii) All exposed machinery, electrical installations, radios, navigational equipment, firefighting systems, and safety and environmental protection systems are designed to the PST.

iv) Survival systems are designed to the PST and operational for the Maximum Expected Time of Rescue (minimum 5 days).

POLAR Ready(B, PST), where PST is a temperature of -20°C or less.

i) Everything required for **POLAR Ready(B, N/A)**.

ii) Items ii through iv for **POLAR Ready(C, PST)**.

POLAR Ready(A, PST), where PST is a temperature of -20°C or less.

i) Everything required for **POLAR Ready(A, N/A)**.

ii) Items ii through iv for **POLAR Ready(C, PST)**.

3.4 POLAR(Category,PST)

This notation indicates that the ship's hull, its OA Report and PWOM have been reviewed by ABS, and the vessel has been issued a Polar Ship Certificate.

APPENDIX 1

Additional Resources *(1 September 2015)*

Additional reference related to operating vessels in low temperature environments may be found in the following publications:

Bercha, F.G. (2005), Recent Developments in Arctic EER (Escape, Evacuation and Rescue). The Bercha Group.

BIMCO (2005), Ice Handbook. Jjorn Tomsen A/S. Denmark.

Canadian Coast Guard (2012), Ice Navigation in Canadian Waters.

Harrington, R. L. (Ed). (1992), Marine Engineering, Society of Naval Architects and Marine Engineers. Jersey City, NJ.

Finnish Maritime Administration (2005), Winter Navigation 2004-2005.

IACS. (2011), UR I1 – Polar Class Descriptions and Application; UR I2 – Structural Requirements for Polar Class Ships; UR I3 – Machinery Requirements for Polar Class Ships (effective for vessels contracted for construction after 1 July 2007).

International Labour Organization (2001), Ambient Factors in the Workplace. Geneva.

IMO MSC Circ. 1175 “Guidance on Shipboard Towing and Mooring Equipment”

IMO MEPC.163(56) Guidelines for Ballast Water Exchange in the Antarctic Treaty Area

IMO MSC Circular 1056/MEPC Circular 399 (2002). Guidelines for Ships Operating in Arctic Ice-Covered Waters.

IMO MSC.1/Circ.1185/Rev. 1 (2012), Guide for Cold Water Survival.

IMO Guidelines for Ships Operating in Polar Waters (2010) (Resolution A.1024(26))

IMO Life Saving Appliances (2003).

IMO Resolutions MSC.207(81), MSC.218(82) and MSC.272(85) “Adoption of Amendments to the International Life-Saving Appliance (LSA) Code”

IMO Resolution A.749(18) (1993) and updates (2002), Code on Intact Stability for All Types of Ships Covered by IMO Instruments.

IMO. (2002). MSC.152(78), Adoption of amendments to the International Convention for the Safety of Life at Sea, 1974, as amended. 5-20-04 (Lifeboats, EPIRB’s, Immersion Suits).

IMO. MSC. 385(94), International Code for Ships Operating in Polar Waters (Polar Code)

Kitagawa, H. and et al. (2000), The Northern Sea Route – The shortest sea route linking East Asia and Europe. Ship & Ocean Foundation, Japan.

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Oil Companies International Marine Forum (2010), The Use of Large Tankers in Seasonal First-Year Ice and Severe Sub-Zero Conditions.

Oil Companies International Marine Forum (2014), Offshore Vessel Operations in Ice and/or Severe Sub-Zero Temperatures.

Russian Maritime Register of Shipping. (2014), Rules for the Classification and Construction of Sea-Going Ships. St. Petersburg, Russia.

Parent, O. and Ilinca, A. (2011). Anti-icing and de-icing for wind turbines: critical review. Cold Regions Science and Technology, 65(1), 88-96.

Ryerson, C., (2009). Assessment of superstructure ice protection as applied to offshore oil operations safety: ice protection technologies, safety enhancements, and development need. U.S. Army Cold Regions Research and Engineering Laboratory. ERDC-CRREL TR-09-4, 342.

Ryerson, C., (2011). Ice protection of offshore platforms. Cold Regions Science and Technology, 65(1), 97-110.

Ryerson, C., (2013). Icing Management for Coast Guard Assets. U.S. Army Cold Regions Research and Engineering Laboratory. ERDC-CRREL TR-13-7, 288.

Santos-Pedro, V.M. (2005), Ice Regime System, Exporting Canada's Experience. Transport Canada.

Toomey, Patrick R. M., Lloyd, Michael, House, David J., (2010), The Ice Navigation Manual

Swedish Maritime Administration. (2005), Winter Navigation 2004-2005.

Transport Canada (2011), Winter Navigation on the River and Gulf of St. Lawrence: Practical Notebook for Marine engineers and Deck Officers. TP 14335 E.

Tsoy, L.G. (2002), Report on Current Regulations and Practices and Impact of IMO Regulations). Central Marine Research and Design Institute.

Tunik, A. (1998), Major Factors in Tanker Design for Oil transportation From Arctic Regions. American Bureau of Shipping.

Yang, M., Khan, F., Lye, L., Sulistiyono, H., Dolny, J., Oldford, D. (2013). Risk-based winterization for vessels operations in Arctic environments, Journal of Ship Production and Design, 29(4), 199-210.

APPENDIX 2
Notes on Materials, Welding and Coatings *(1 September 2015)*

1 General *(2024)*

The following provides additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

Material selection for the vessels with ice class requirements is to be in accordance with 6-1-2 through 6-1-4 of the *Marine Vessel Rules*, as applicable. If no ice class is specified or the ice class does not have material requirements, refer to 3-1-2 of the *Marine Vessel Rules*. However, it is recommended that Grade A steel should not be used in temperature conditions below –15°C.

Successful application of Grades A and B steels for ships of Baltic ice classes is based on the correct selection of the combinations of structure thicknesses, steel grades and appropriate operation of the vessel. For these cases there has been few reported damage incidents to such ships during winter navigation in the basin of the Baltic Sea. However, for operation in the Arctic region, under lower temperatures there have been reported occurrences of brittle cracks of vessels' structures constructed of Grade A steel. Crack development may take place even under the short-term impact of low temperatures and is related mainly to the stress in the structural element or to its vibration level (bridge wing, bulwark, etc.).

Accordingly, materials with resistance to brittle fracture are recommended for construction of exposed members.

2 Dissimilar Materials *(1 September 2015)*

Problems have been experienced in the past when a vessel is constructed or outfitted in a warm location then travels to low temperature environment. Typically these problems have been due to different thermal expansions or contractions. If an assembly is constructed in a relatively warm ambient temperature then brought into a cold temperature, the various expansion/contraction rates of the materials can cause binding or excessive internal stress. An example of this is an external light fixture, if the bulb burns out and needs to be replaced the cage and glass globe have to be removed from the steel base. If the cage and globe were installed in a warm location it is possible that the threads are locked due to thermal contraction. It is to be assumed that the component is built and installed at the normal temperature for the ship yard (+20°C or more is suggested) and maintenance assumed to be performed at temperatures down to is to be performed at the Design Service Temperature.

3 Material of Machinery

No additional information.

4 Weld Metal *(1 September 2015)*

4.1 Repair Welding in Low Temperatures

Some welding machines can be damaged by operating in low air temperatures. The operating manual of the welding machine is to be referenced before outside operation.

Post weld NDT is more important in low air temperature welding due to the rapid cooling but the low temperature may cause difficulties with the NDT. Most liquid or gels will tend to freeze on contact with the cold steel, the NDT equipment and any consumables used for the procedure is to be suitable for use in the low air temperature at the time of examination.

As with any outdoor welding, shielding from the effects of wind are important and essential where shielding gas is used in the process.

5 Coatings

(1 September 2015) The purpose of this Section is to provide ship owners and operators with general information to assist in the selection of coatings for those vessels intending to operate in low temperature environments. Whenever possible, ship owners and operators are encouraged to obtain assistance from coating manufacturers or suppliers in the selection of coatings. The physical properties of coatings applied to vessels intending to operate in low temperature environments varies and is dependent on the intended area of operation and the specific location on the vessel where the coating is to be applied. For vessels operating in low temperature environments, ABS takes note of the following coating types:

- External Hull Coatings
- Ice release Coatings
- Maintenance or Repair Coatings
- Interior Coatings

5.1 External Hull Coatings *(1 September 2015)*

External hull coatings on ships operating in ice, face different conditions than hull coatings on vessels operating in warmer, ice free waters. Therefore, the selection of hull coatings on ships operating in ice requires a different approach.

The main purpose of coatings on ship hulls is (1) protection against corrosion while the secondary purpose is (2) to provide and maintain a smooth hull with as low friction as possible when the ship is sailing. For ships operating in warmer waters it is a known phenomenon that their hulls are prone to bio fouling. Therefore, different types of anti-fouling coatings have been developed which are applied on top of the anti-corrosive coating underneath (i.e., a “Dual Coat System”).

For ships operating in ice however the fouling problem is minor. Additionally most designated anti-fouling coatings are quickly destroyed and torn from the anti-corrosion coating underneath when operating in ice. Most of the commonly used types of anti-corrosion coatings are also easily damaged by the forces of ice hitting against or scrubbing along the hull.

A “Single Coat System” having the two main functions combined; (1) Corrosion Protection and (2) remaining smooth without surface irregularities.

Today a limited number of specific ice coatings are available of which the majority is based on epoxy resins, most of them glass flake reinforced. In general epoxy based coatings perform well, but over time they tend to become brittle which may end up in cracking, chipping and finally disbonding from the steel. In general, epoxies tend not to last as long as coatings based on polyester or vinyl ester resins.

Hull coatings can be applied at a wide range of film thicknesses. For ice hull coatings in general, the thinner the coating film, the more often it has to be repaired or replaced. Typically a dry film thickness (DFT) of 500 microns (half a millimeter) or less will not provide long term protection. Particularly in the ice belt areas DFT's up to 1,000 Microns is to be considered, although coating system manufacturers is to be consulted for information on the specific system under consideration.

It is important to apply coating systems strictly in accordance with the recommendations of the manufacturers. Most important parameters during pre-treatment of the steel are roughness and cleanliness:

i) Roughness, provided by proper grit blasting and using the correct type of grit, in order to provide the required 'Anchorage'.

ii) Cleanliness to prevent poor attachment on slippery oil/grease or foreign particles underneath, as well to prevent soluble salts to eliminate osmotic blistering.

Additional Coating Selection Considerations

- Environmental restrictions on coatings, also the environmental character1 of the coating to be selected is to be considered.
- In case the coatings are to be applied in areas known to be prone to cavitation damages, an additional Test on this phenomenon is to be considered.
- For the selection of hull coatings for vessels operating in ice following Test Standards are suggested.

TABLE 1
Suggested Coating Test Standards *(1 September 2015)*

Property	*Test Standard*
Abrasion Resistance	ASTM D 4060 Taber Abrasion
Impact Resistance	ISO 6272-93
Hardness	ISO 2815
Scratch Resistance	ISO 1518
Adhesion	ISO 4624
Friction	ASTM D 4518-91
Anti-corrosion properties	as advised by NORSOK M-501
Environmental Character	A High Solids Content (preferably Solvent Free or Ultra High Solids), as a minimum to be in compliance with the VOC Regulations applicable at location of application, and not containing biocides, tin or copper compositions is to be considered.
Resistance to Cavitation damage	ASTM G 32

* election to be in harmony with the expected operation sequence and ice conditions such as type of ice and content of highly abrasive volcanic lava, gravel or sand as existing in Antarctic Regions.

5.2 Ice Release Coatings *(1 September 2015)*

The accretion of ice or snow onboard vessels can have a significant adverse effect on a vessel's operation, specifically the potential impacts of the added weight on the vessel's stability and machinery systems. Various spray-on fluids to prevent ice buildup are already on the market. Prior to use, it is advised to pre-check chemical compatibility with the coating underneath. As a means to lessen or mitigate the accumulation of ice and snow, the application of ice release coatings above the abrasion resistant hull coating and all other externally exposed surfaces (including decks, deck houses and superstructure ends and sides, guardrails, bulwarks and deck machinery) should be considered. Because of their inherent slickness, they should not be used on walkways.

These ice release coatings, which are sometimes referred to as icephobic coatings, create a slick surface. The hydrophobic (not capable of uniting with or absorbing water) surface causes the water to roll off the surface before it is able to form solid ice.

The development of these ice release or icephobic coatings within the coating industry is ongoing and is currently being explored by some coating companies as a niche product. Acceptable testing standards are under development.

5.3 Maintenance or Repair Coatings *(1 September 2015)*

It should be realized that prior to operating in arctic conditions, in most cases the ship will have been built under cover and under air conditioned conditions with favorable temperatures and humidity for the coatings to cure properly. It should be realized that most coatings used in the shipbuilding industry, the majority being so called epoxies, cure at temperatures down to minimum +5°C (+41°F). In case maintenance or repair coatings need to be applied at lower temperatures, specially formulated coatings are needed with volatile ingredients that are able to function and evaporate at such lower temperatures. Therefore, so called Winter Type or Low Temperature Type (often designated as “LT Type”) coating versions are available. It is important to know that even some of these LT coatings have to be heated prior to application. Under freezing temperatures it may be difficult eliminate all ice crystals on the steel prior to application of coatings. It is strongly advised to follow the recommendations provided by the coating producer (Coating Data Sheet). Coating producers should confirm compatibility in case a winter type or LT type coating is to be applied over a normal type coating. Finally, it should be kept in mind that maintenance coatings (See Stock) should be stored cool and dry but above freezing temperatures. For vessels operating in the Arctic, it may be wise to keep the Sea Stock at minimum and store the maintenance coatings ashore as much as possible.

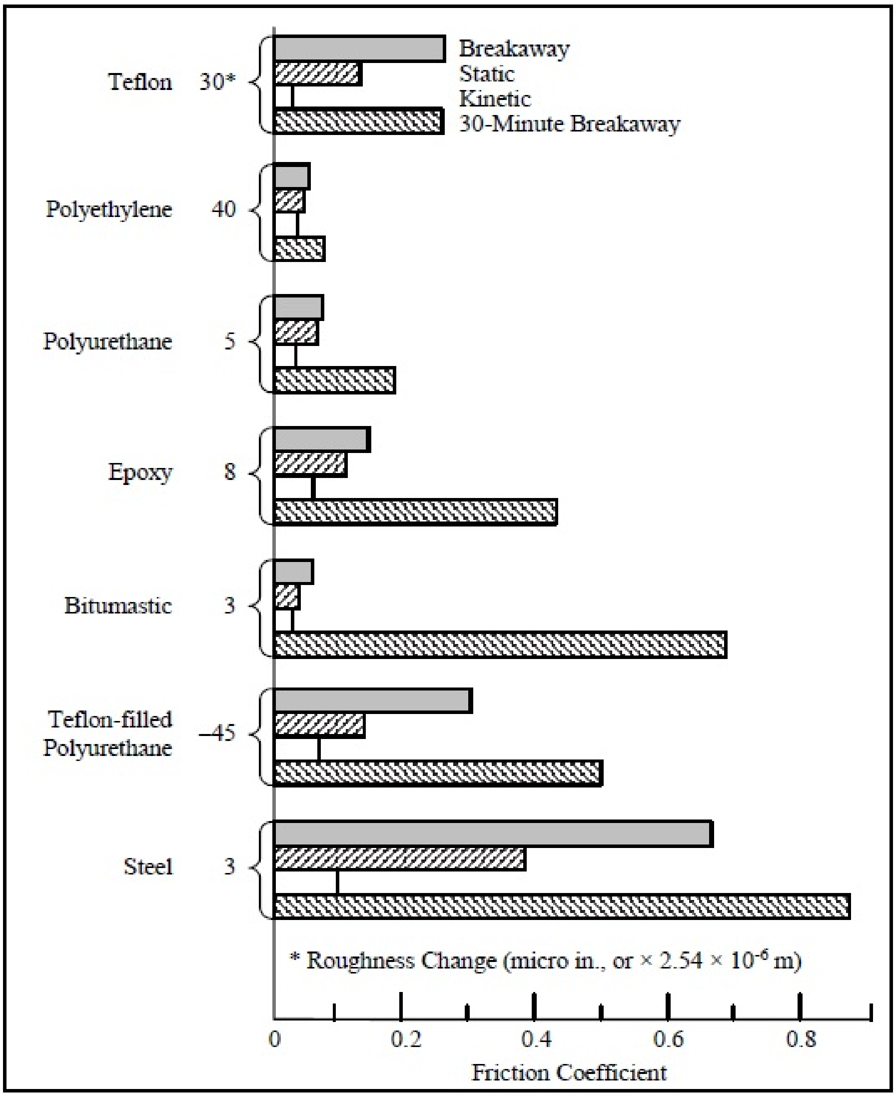
5.4 Interior Coatings *(1 September 2015)*

With regard to interior coatings, the 2014 adopted IMO Code on Noise Levels (Res. MSC.337(91) should be kept in mind. Various coating producers already are able to deliver spray-on coatings specially developed to reduce noise and/or vibration levels inside ship accommodations. Simultaneously, other coatings have been developed with special focus on warmth insulation. Some coatings also prevent condensation, which on its own helps to prevent corrosion. The use of insulating coatings may at least minimize the thickness or even completely eliminate the use of insulation materials. Good results have been realized in eliminating corrosion under insulation by applying such coatings while it may pay back itself quickly when used on deck in case of heated cargoes being transported in arctic conditions. When selecting such insulating or noise canceling coatings, it should be checked however whether they are in compliance with the IMO Fire Test Procedures (FTP-Code).

5.5 Coating Application and Maintenance

The ability of the crew or service technicians to perform repairs or routine maintenance onboard vessels operating in low temperatures is very limited. This is especially true for those coatings which are directly exposed to the weather or are on a plate or structural member that forms a boundary with the weather. As a result, the application and inspection of coatings during the construction and shipyard periods takes on an even greater importance when compared to those vessels that operate in the more temperate zones. It is recommended that owners and operators consider employing coating consultants/inspectors to confirm that all coatings have been properly applied.

FIGURE 1
Coefficient of Friction for Steel and Various Hull Surfaces on Ice



Source: Engineering and Design Ice Engineering, Manual No. 1110-2-1612, Figure 17-2, Department of the Army, U.S. Army Corps of Engineers (30 October 2002)

Note: The static friction measures the coefficient of friction from a stopped position to some relative speed between the ice and the steel. The breakaway friction accounts for specimen to ice contact, under load for a specific length of time. The kinetic friction coefficient is the value obtained during continuous movement between ice and test specimen.

APPENDIX 3

Notes on Hull Construction and Equipment

1 General

The following provides additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Tanks

2.1 Fresh Water Tanks

Fresh water tanks with a space between the tank boundary and the side shell may still be susceptible to the contents freezing. Consideration should be given to providing the tanks with turbulence-inducing systems, for example, bubble systems or heating coils.

2.2 Fuel Oil Tanks

The location of the fuel oil tanks will determine the heating requirements. For tanks located below the waterline, the seawater temperature can be assumed to be –3°C (27°F). For tanks located above the waterline in contact with the shell, the design service temperature is to be assumed.

2.3 Ballast Water Tanks

For tanks located below the waterline, the seawater temperature can be assumed to be –3°C (27°F). For tanks located above the waterline in contact with the shell, the design service temperature is to be assumed. The required heating calculations for determining heat transfer should assume seawater will be maintained at a temperature of 2°C (36°F).

2.4 Additional Measures for Oil Pollution Prevention

Vessels with a double hull design are recommended, to reduce the probability of pollution.

3 Superstructures and Deckhouses

3.1 Forecastles

Forecastles are recommended for vessels less than 50,000 DWT. Forecastles are required for all bulk carriers, ore carriers and combination carriers in accordance with IACS UR S28, Requirements for the Fitting of a Forecastle for Bulk Carriers, Ore Carriers and Combination Carriers.

A sheltered area is considered a structure enclosed on three sides with the side facing aft open to the weather.

3.2 Deckhouses *(1 September 2015)*

Present design practice is to enclose the bridge wings of vessels operating in low temperatures. If a designer elects not to enclose the bridge wings, all equipment (e.g., binnacles, propeller speed repeaters, etc.) are to be functional. Heating for personnel working on the bridge wing is to be provided.

Access to the navigation bridge windows may be provided from the navigation bridge.

The navigation bridge windows may be defrosted by the use of hot air. If all non-protected windows are considered blocked with snow and ice, the vessel's arrangements are to still meet SOLAS Chapter V, Regulation 22.

All doors on emergency escape routes and navigation bridge doors may be kept free of ice by installation of heat tracing equipment or a similar method.

The location of heated deckhouses is to be determined by vessel designer or Owner. The intent is to provide to personnel working on the deck a place to shelter and/or warm up so as to be able to continue to perform their duties. See A8/3.3.

3.3 Exterior Stairs *(1 September 2015)*

These requirements apply only to inclined stairs. They are not intended to apply to vertical ladders providing access to foam monitors, deck equipment, foremasts, etc.

Many smaller vessels or vessels with restricted deck space require the use of stairs with higher angles than 35 degrees. Exterior stairs that are adequately protected from the effects of spray or freezing rain as applicable for the area of operation may be considered at angles over 35 degrees.

See A3/3.4 for landing materials.

3.4 Operating Platforms for Deck Equipment *(1 September 2015)*

Platform material is to be selected based on the intention to keep the platforms free of ice and snow. Grating will allow most snow to fall through and makes ice removal by manual impact means easier. However, grating may not be appropriate for heat tracing application. Solid top platforms will accumulate more snow and ice. Additionally a rigid solid platform surface may be more difficult for manual removal of ice but may offer significant improvement when heat tracing is used.

3.5 Railings

It is preferable to heat railings internally. When this is not possible, heating may be accomplished by installation of exterior heat tracing.

3.6 Towing Fittings

No additional information.

4 Stern

4.1 Towing Notch for Ice Breakers

The design and characteristics of the towing notch and towing devices of ice breakers and ice class vessels are selected on the basis of the anticipated operations when navigating in ice.

The towing notch is a design feature that has been incorporated into the design of many Russian, Finnish and Swedish icebreakers but to date not included on any North American vessel. Icebreaking cargo vessels may also be equipped with a towing notch. The towing notch is installed on all Russian ice class vessels with the ULA notation. The towing notch arrangement enables a towed vessel to be drawn into the stern of the towing vessel and together the vessels work in tandem during ice breaking. This method has been used extensively in the Baltic and Russian Arctic and its effectiveness is well documented. Because of the possibility of damage to the towing notch itself, it is common to construct the notch as an appendage to the main hull structure.

In some operations, it is necessary for the icebreaker to press its bow against the towing notch of the cargo vessel. Such a method of joint operation of the icebreaker and icebreaking cargo vessel has proved to be successful in Russian practice and may be considered especially for large ice class cargo vessels because towing from the bow can be problematic.

To reduce the possibility of damage at the towing notch, including the bow of the towed vessel, various methods of fendering have been employed inside the towing notch itself. Both rubber and wood have been used successfully; while bumper wheels have been found to wear quickly. Due to the wide variety of hull shapes that are likely to be towed, the notch should be designed to accept both deep and shallow V shapes.

5 Stability *(1 September 2015)*

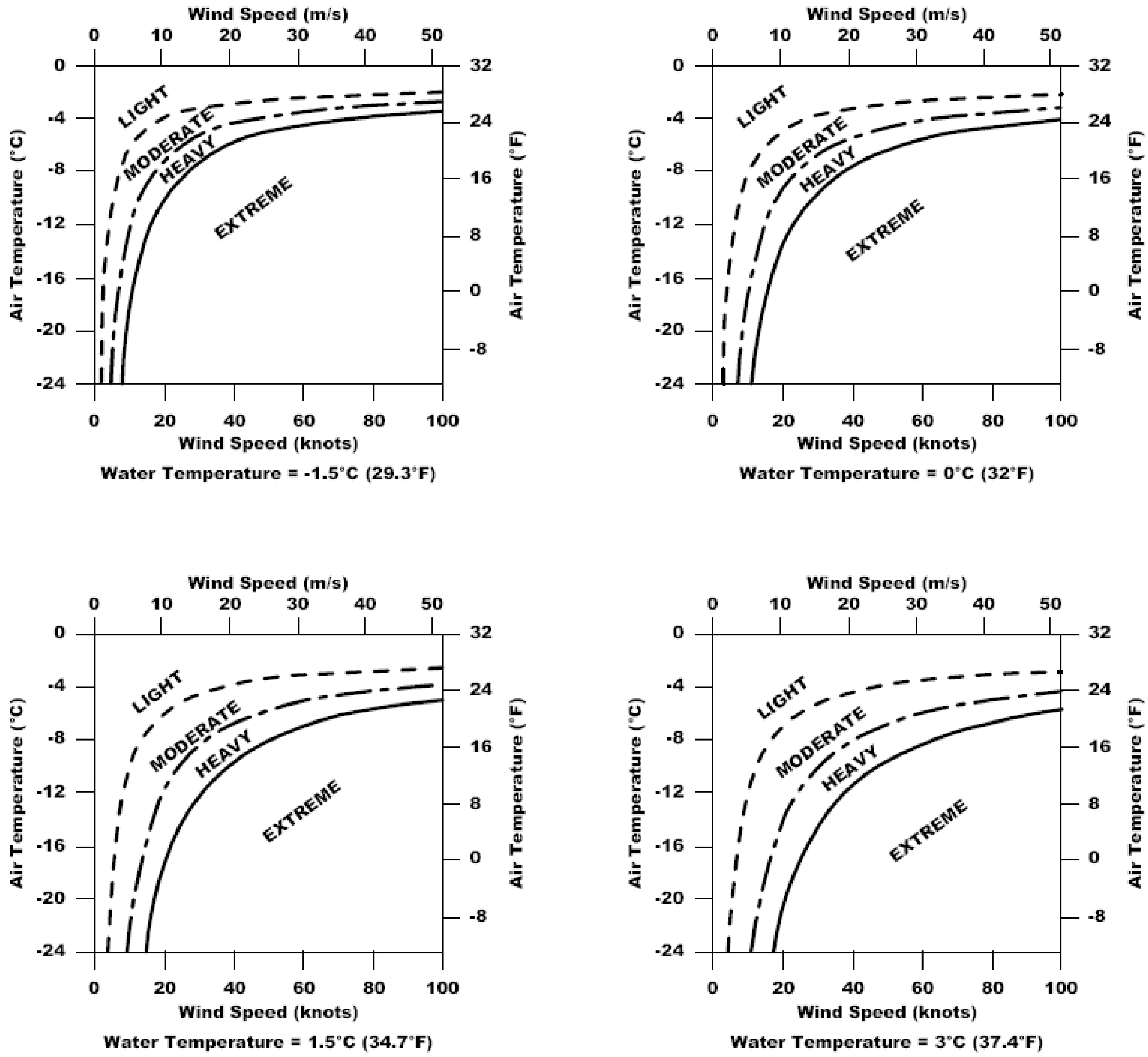
Should icing conditions develop, personnel should take all possible steps to reduce and remove ice. This may require a continuous procedure until icing conditions subside. If ice build-up cannot be controlled or removed, the vessel must be moved to a sheltered area whenever possible.

A3/5 FIGURE 1 is a grouping of icing nomographs developed by the United States National Oceanic and Atmospheric Administration (NOAA) from actual icing reports from fishing, U.S. Coast Guard and towing vessels operating in Alaskan waters. These reports were based on icing events that lasted anywhere from 1 to 26 hours but averaged 3 to 6 hours. The NOAA National Weather Service Environmental Modeling Center provides an online forecast for ice accretion at: http://polar.ncep.noaa.gov/marine.meteorology/vessel.icing/

A3/5 FIGURE 2 provides guidance for ice accretion versus wind velocity for air temperatures ranging from -34°C (-30°F) to -7°C (+20°F).

Icing may only occur when there is a source of water for wetting the deck, superstructure and other exposed parts of a vessel. Some vessel factors to consider are vessel's speed, heading (with respect to wind, waves and swell), vessel length, freeboard height, handling and the cold soaking aspect (cold soaking occurs when a vessel has been in cold conditions for two to three weeks and the hull structure remains cold for a period of time after the vessel operates in warmer temperatures). Generally, for the same environmental conditions there will be more sea spray reaching the vessel deck, superstructure, etc. when the vessel is traveling faster, into the wind and waves, and for smaller vessels and ships with less freeboard. Water waves result from the wind blowing over a vast enough stretch of the ocean. Some waves in the oceans can travel thousands of miles before reaching land. The threshold significant wave height, $h_{1/3}$, and associated wind speed, for a 200 km fetch (the distance over water which the wind blows to generate water waves) at which enough sea spray reaches the decks and superstructures to cause severe icing, assuming cold air and water temperatures are also present, are listed in A3/5 TABLE 1.

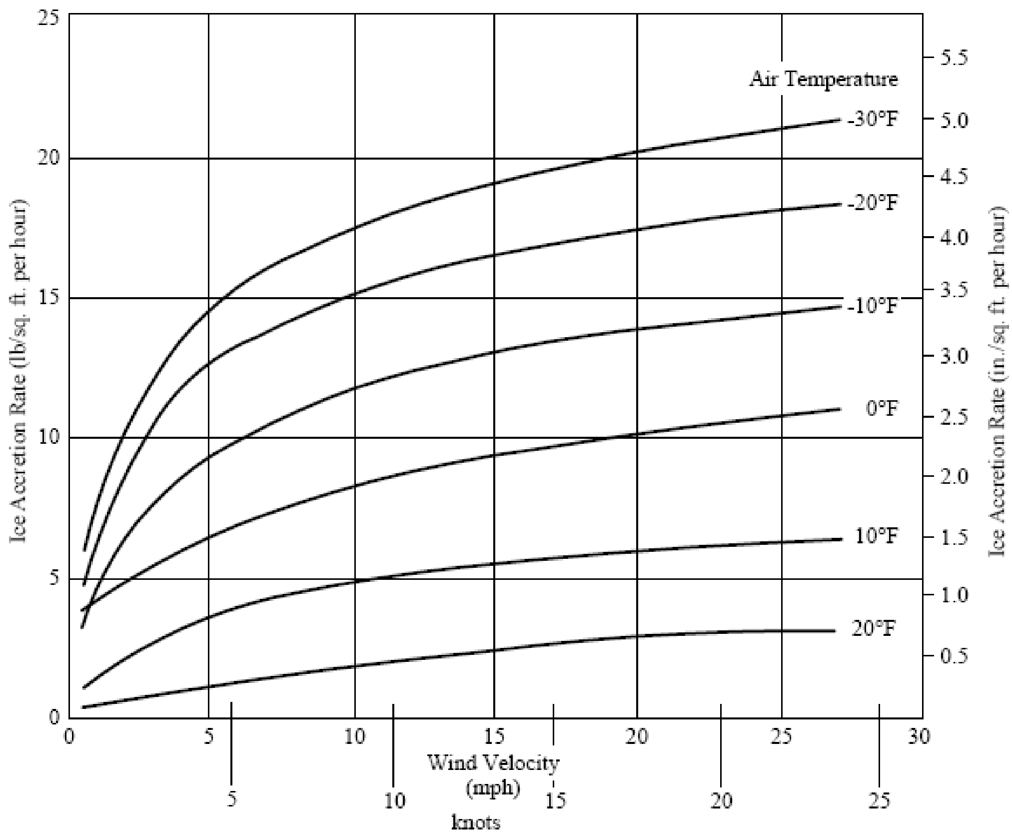
FIGURE 1
Icing Conditions for Vessels Into or Abeam of the Wind



Icing Class	*None*	*Light*	*Moderate*	*Heavy*	*Extreme*
Icing Rates (cm/hour) (inches/hour)	0	< 0.7 < 0.3	0.7-2.0 0.3-0.8	2.0-4.0 0.8-1.6	> 4.0 > 1.6

Source: Guest, P. and et al. (2005). Vessel Icing, Mariners Weather Log, Volume 49, No. 3.

FIGURE 2
Ice Accretion versus Wind Velocity for Six Air Temperatures



Source: U.S. Navy Cold Weather Handbook for Surface Ships, Figure 7-3, (May 1988)
Accreting Surface: Flat Panel; Water Spray Temperature: 41 – 48°F

TABLE 1
Threshold Wind Speeds for Icing to Occur on Various Length Ships

Parameter						
Vessel Length meters feet	15 49	30 98	50 164	75 246	100 328	150 492
Significant wave height – $h_{1/3}$ meters feet	0.6 2.0	1.2 3.9	2.0 6.6	3.0 9.8	4.0 13.1	6.0 19.7
Wind Speed at 200 km (108 nmi) fetch meters/second knots	5.0 9.7	7.4 14.4	9.8 19.0	12.5 24.3	15.0 29.3	20.0 38.9

Source: Guest, P. and et al. (2005). Vessel Icing, Mariners Weather Log, Volume 49, No. 3, Table 1. Based on Overland, J.E., (1990), Prediction of Vessel Icing for Near-Freezing Sea Temperatures, Weather and Climate, pp. 5, 62-77.

APPENDIX 4

Notes on Vessel Systems and Machinery

1 General

The following provides additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

1.1 De-icing and Heat Tracing *(1 September 2015)*

Icing can be a major issue for vessels that operate in low temperature but open water conditions. These conditions are common around northern Norway, off the east coast of Canada, and on a number of other shipping routes and fishing grounds. In ice-covered waters, icing is less of a problem, as wave-induced spray is the main source of thick ice accumulations. Ice buildup is most probable in the forward parts of a vessel, but smaller vessels can see significant icing thicknesses in almost all areas.

Spray, fog, freezing rain and snow can all also cause sufficient icing to render equipment inoperable or extremely difficult to operate, and measures should be taken to manage icing issues. Icing of safety-related equipment, exposed working areas and access routes can also lead to safety hazards, while icing of deck machinery, valve manifolds and other systems can interfere with cargo handling operations, causing delays and economic loss.

Depending on the operations of the vessel, de-icing or more permanent heat tracing equipment should be considered. Vessels intended to operate for extended periods of time in arctic climates should be designed with permanently installed equipment. Vessels normally operating in open oceans and only occasionally required to experience extreme conditions should be provided with de-icing equipment.

Smaller vessels have been equipped with pneumatically operated rubber pillows to break ice away from superstructure fronts and masts, reducing the risk of loss of stability due to ice buildup. However, for larger vessels, portable de-icing equipment is normally preferred.

Care is to be taken to provide that any de-icing equipment used is suitable for the location, particularly in hazardous locations.

It is imperative to account for the required heating load early in the design cycle. Determining the level of protection required to maintain an area ice free requires an understanding of the weather conditions the vessel is expected to encounter such as temperature, wind velocity and humidity. Equipment vendors can provide design manuals and engineering advice for the design of de-icing and heat tracing equipment. It is not practical to design a heat tracing system that is suitable for all weather conditions because the power requirements will be excessive. Likewise, the system should not be designed solely on averages as it will be underpowered. Accordingly, a decision must be made by the designer about what percentage of snowfall/icing hours the system is capable of keeping heated surfaces clear.

i) *Design Approaches*. Design approaches for de-icing and heat tracing equipment include steam, thermal oil, electric resistance heating or hot air. Combinations of these approaches are installed for some applications.

Often the desire is to employ anti-icing systems designed for the extreme condition but in reality this is often impractical. An optimal design would be one that can function as an anti-icing system the majority of the time. A risk assessment may be used to establish the time intervals acceptable for the specific vessel. This will enable the crew to focus on other duties most of the time rather than ice removal. In severe conditions operations may be suspended and crew resources can be applied to manual ice removal and the anti-icing system used as an aid to de-icing. A time based definition for de-icing has been considered by several regulatory bodies in the past but has proven an ineffective measure. It is therefore suggested that de-icing systems and procedures be evaluated based on the level of risk involved with the system being de-iced.

ii) *Steam Systems*. Equipment for de-icing includes steam generators, steam hosing, hot water and even salt water spray. Steam tracing may be considered if steam will be used onboard for cargo heating as in an oil carrier. Steam is extremely effective, but requires training to be used safely. As with all fluid lines, de-icing systems should be kept heated or drained when not in use, particularly for the more remote branches. Availability of personnel experienced in operation of steam boilers may be another factor in the decision to install a steam system. Pumps used for de-icing systems should be provided with redundant arrangements. Any equipment used for de-icing must be suitable for operation onboard, particularly when operating in hazardous areas on oil carriers, chemical carriers and liquefied gas carriers.

iii) *Thermal Oil*. Thermal oil is a substitute for steam systems as the oil will not freeze in low temperatures if suitable oil is chosen. However, the thermal capacity of oil is less than water so a greater volume of oil is required to be pumped. Protection from release of oil into the environment must be considered with thermal oil systems.

iv) *Electric Resistance Heating*. Electric resistance heating can be used for a number of applications such as exposed piping, tank heating, stairways, deck access and handrails. It can be used in cabin reheat units and areas where personnel regularly perform vessel operations. Portable units can be provided for localized areas where maintenance is performed or to meet the needs of personnel. Handrail heat tracing system design philosophy considers de-icing of those handrails in areas subject to emergency evacuation or high foot traffic so as to avoid wasting heating resources.

There are standards available such as IEEE 515.1, "IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Heat Tracing for Commercial Applications" and ASHRAE's Handbook – HVAC Applications, Chapter 45 "Snow Melting". ASHRAE 926-RP "Development of Snow Melting Load Design Algorithms and Data for Locations Around the World" is another resource. For applications in which the standards are unable to provide information, computer modeling and analysis may be performed.

v) *Hot Air*. Portable hot air generators can also be used for de-icing purposes. These units, if used, can be electric, or can operate on diesel fuel oil with a self-contained fuel system. These systems have also been effectively used for heating enclosures or shelters when exterior work is required.

vi) *Manual Removal*. Even where specialized de-icing equipment is carried onboard, manual means to remove ice and snow buildup should also be considered. This includes the use of mallets, shovels, axes, etc., and in some cases snow blowers and other mechanical equipment. Care must be taken in the operation of all these so that onboard fittings, valves and electrical components are not damaged. Storage of all de-icing equipment should be such that items can always be accessed, and that if located within exterior compartments, their access is itself protected from freezing.

vii) *Ice Prevention and Limitation*. There are also many methods that can be used to prevent icing or to limit its effect. Anti-icing methods used successfully include:

- Protective locations/covers with or without heating
- Bow form

- Electric heat trace wiring
- Heating coils
- Steam generators
- Ice resistant coatings
- Self-draining piping
- Circulation of media (e.g., hydraulic oil)

Arrangements should be made to prevent freezing of all exterior moving equipment. This includes heat tracing in way of bridge and other windows, davits, deck equipment, lifeboats and other personnel safety and rescue equipment, hatch and door seals etc. Tracing systems include electric wired tape, hot water, steam and heated glycol, although water-based systems must be kept in operation to avoid freezing themselves.

Protective covers can be a cost-effective option to protect fire hydrants, mooring equipment and other operational components exposed on open decks. Although the cover itself does not prevent ice accumulation onboard, it may provide local protection around fittings, valves and controls where ice removal may be more difficult or may risk damage to the equipment.

Special consideration may be warranted for exterior electronics equipment. Communication transmitters and receivers may require anti-icing features to provide continual functionality, although whip type antennas can usually be de-iced with a strike of a wooden mallet, or shaken to remove ice build-up. Other communications antennas with horizontal surfaces or dish shaped configurations may require built-in heat elements. Exposed rotating radar scanners normally require no special measures, even at extremely cold temperatures, due to internal heating elements. However, the smaller enclosed type arrays can become encrusted with ice and can be difficult to de-ice due to their inherent fragility of construction. Consultation with the manufacturer is recommended.

1.2 Hydraulic Systems *(1 September 2015)*

No additional information.

1.3 Overboard Discharges and Drainage *(1 September 2015)*

No additional information.

1.4 Lubricating Oil Systems *(1 September 2015)*

The lubricating oil for the main propulsion and auxiliaries, particularly for idle equipment, is to be maintained at a temperature to permit equipment start-up when demanded. Current practice is to operate a standby pump along with the lubricating oil purifier, which is fitted with a heater to keep the oil at the proper temperature.

Steam coils in lube oil sump tanks are difficult to inspect regularly and have been known to leak, rendering the equipment inoperable.

Synthetic lubricants, which have the correct viscosity at low temperatures –45°C (–50°F) without the use of heaters, may be considered on a case-by-case basis as an alternative or supplement to heating coils.

2 Prime Movers *(2024)*

Ice-strengthened and ice breaking vessels have been designed with almost all the commonly fitted propulsion plants, including direct drive and geared diesel, steam and gas turbines, and electric transmission versions. Russia operates a nuclear ice breaker fleet but nuclear power is considered highly unlikely for a commercial application in the foreseeable future and therefore is not specifically discussed within the text of this Guide.

For non-ice class vessels, the Guide assumes that the propulsion plant will be operated continuously with few changes in speed and direction when operating in low temperature environments.

2.1 Prime Mover Operating Characteristics for Ice Class Vessels

Much ice breaking takes place at very low speeds, and so it is necessary to consider bollard as well as free-running conditions in selecting propeller properties during design. Bollard and low-speed thrust can be augmented by fitting nozzles, which can also provide protection to the propeller blades. However, nozzles can be blocked or clogged by ice, in which case, rapid reversal of thrust is needed to clear the blockage.

Vessels following icebreakers will also have to reduce speed during ice breaking operations. Low power outputs for propulsion plants are considered to be in the range of 15 to 50% of MCR. During ice breaking, power output would be expected to be in the lower part of this range. There are various operational issues associated with low load operation to consider such as: incomplete combustion of fuel oil and subsequent effect on turbochargers and exhaust piping system; continuous operation of auxiliary blowers for long periods of time; effects on internal components of the prime mover; prime mover emissions; and, functioning of auxiliary systems.

Icebreakers, ice breaking support vessels, and higher ice class vessels as well as other smaller vessels are most likely to see frequent propeller-ice interaction. This effect places a range of demands on the propulsion system in addition to ensuring adequate component strength (see Appendix A4/3). Propellers may be slowed or jammed by ice blocks caught against the hull which is mitigated by increased propeller blade thickness and propulsion shaft diameter. The high torque available from certain electric transmission systems can be very advantageous for fixed-pitch systems. For controllable-pitch systems, rapid pitch changes may be required.

2.2 Combustion Air Systems

2.2.1 Combustion Air for Internal Combustion Engines

Vessels operating in low temperature environments are at risk that the engine may not operate as the low temperature of the combustion air-fuel mixture may fail to enable auto ignition when compressed in the engine cylinders. Engine cylinder pressure limits may be exceeded when using low temperature air because of the cold air's higher specific density. Protection can be achieved by installing a waste gate (blow-off valve) for either scavenge air or exhaust gas. This may lead to operating restrictions for the engine. Special features are incorporated within the combustion air system to preheat this cold air.

Some vessel designs are equipped with electric/steam heating to preheat the combustion air. Recent designs now use the diesel jacket water waste heat. Another strategy is to have an emergency air intake directly from the machinery space. It is not practical to have all combustion air taken from the machinery space because the space's temperature will become too low, affecting equipment function and personnel.

For typical diesel engines operating at reduced loads (e.g., low cylinder compression temperature), it is likely that preheated combustion air will be required. Two-stage charge air cooling/heating systems have been employed to raise the combustion air temperature for acceptable engine operation. Generally, for engine loads above 30% Maximum Continuous Rating (MCR), jacket water can be used as the heating medium. For engine loads below 30% MCR, external preheat sources may have to be installed. Typically, at engine loads near 50% MCR, charge air temperatures will rise above 0°C (32°F) and the charge air cooler can be employed.

The local operational conditions and outside temperatures should also be considered for the valve settings. Additionally, a relief valve may be installed, designed to activate (blow off) at a specific gauge pressure (typically around 2 bar). Some engine manufacturers allow the charge air blow off to be re-circulated back into air inlet ducting.

2.2.2 Combustion Air for Other Prime Movers

The manufacturers of steam plants and gas turbines, should be consulted regarding any operational restrictions imposed by low temperature conditions and for recommendations related to system arrangements and features to mitigate these restrictions.

2.3 Turbochargers

The turbocharger's pressure-volume curve with reference to the diesel engine's operating characteristics must be available. If surging is expected, special blow-off air intake systems may have to be engineered to obtain surge-free operation of the turbochargers over the entire range of operations for low design ambient temperatures. A blow-off valve installed in the charge air manifold of the engine can be used to blow off excess air to prevent turbocharger surging.

3 Propulsion and Maneuvering Machinery

This Subsection provides additional information to the requirements in the *Marine Vessel Rules*.

Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Marine Vessel Rules* applies a progressive strength approach to the propeller and propulsion shaft system. The philosophy of this approach is for the propeller blade to be the weakest link and the tail shaft the strongest. The relative strength of the components is diagrammatically shown as follows:

Propeller Blade	Weakest
Propeller Blade Palm Bolts	
Propeller Hub	↕
Propeller Hub Flange and Flange Bolts	
Tailshaft	Strongest

Propeller damage to ice class vessels is fairly common, and can result from both encounters with heavy ice and/or from operator error. The progressive strength approach is intended to lessen the frequency of catastrophic failures of tail shafts and propeller hubs from occurring.

The transmission system that delivers the power from the prime movers to the propulsors must also be able to cope with the demands of ice operation, which can include high dynamic loads due to ice impact and ice milling, vibration, and relatively frequent reversals or rapid changes in rotational speed. These considerations are most important for smaller, higher powered and higher ice class vessels, but require some attention in any ice class vessel.

Supporting structure for thrusters should be designed to withstand ice impact in addition to other operating loads imposed on the structure.

When thrusters are used for dynamic positioning, either azimuthing thrusters or variable pitch thrusters may be installed. The maximum power and maximum thrust may be developed at zero speed for station keeping purposes. For conventional hull type vessels, dynamic positioning systems are commonly direct drive. Typical drillships power systems are diesel-electric with available power capabilities usually exceeding the power requirements for transit conditions.

3.1 Propulsion Shafting Bearing Lubrication

Damage statistics indicate that problems with tail shaft seals have immobilized more vessels than any other single failure associated with propulsion systems. Both radial lip and axial face type seals have been used onboard vessels transiting through ice-covered waters. Radial lip type seals have been the preferred installation to date. Although axial face seals can accommodate larger radial and axial movements of the shaft without losing seal efficiency, the large size of shafts found onboard some icebreaking vessels tends to make these more complicated and expensive compared to radial lip seals.

Radial lip seals are, however, more sensitive to shaft speed, surface finish, shaft eccentricity, shaft vibrations and pressure differences across the seals themselves. The allowable rubbing speed limit is to prevent high lip surface temperatures that could result in seal failures and is commonly set to below 6 m/s, although slightly higher allowable speeds have been recently installed on some vessels.

Oil-lubricated bearings with pollution free sealing arrangements are seals with more sealing surfaces, or operate at reduced oil pressures, or a combination of the two. Final selection of any lubricant used for stern tube bearings should always be verified with the bearing and sealing manufacturer, as the material characteristics of the contact surfaces is of paramount importance for correct operation. Water-lubricated stern tube bearings have also been proven as a pollution mitigation strategy and have been successfully used onboard Canadian and Russian ice breaking vessels.

The selection of the shaft sealing arrangement should also consider the possibility of damage and the repair or replacement of the unit itself. Consideration should be given to the installation of split type seals.

3.2 Propellers for Ice Class Vessels

Part 6, Chapter 1, "Strengthening for Navigation in Ice" of the *Marine Vessel Rules* permits the use of solid propellers. However, since damage to ice class vessel propellers is common, consideration should be given to use of propellers with detachable blades for ease of repair.

To reduce the probability of damage to the propeller blades, especially for controllable-pitch propellers, it is advisable to operate with the top of the propeller edges below the maximum thickness of level ice.

3.3 Controllable-Pitch Propellers for Ice Class Vessels

Controllable-pitch propellers installed on ice class vessels are subjected to many more pitch changes and reversals than in seagoing service. The Guide requirement is to alert the equipment designer and Owner that the equipment design must be suitable for the service application. It is expected that fatigue calculations for the controllable pitch mechanism or service records for equipment in similar ice class service will be submitted for confirmation of suitability.

A4/3.3 TABLE 1 lists some pros and cons for the consideration of installing a controllable-pitch propeller versus a fixed pitch propeller.

TABLE 1
Considerations for Installation of CP versus Fixed Pitch Propellers

Pros	*Cons*
Operating conditions vary widely and maximum thrust is desired throughout these operating conditions.	Higher initial cost for more complex equipment.
Extensive low-speed maneuvering is required for a diesel powered vessel. Thrust can be varied continuously from ahead to astern, including zero thrust while operating in the minimum speed range of the diesel.	When constant shaft rpm is required over a wide range of operating powers the propeller pitch can be adjusted. However, a propeller efficiency penalty is incurred when operating the propeller off the design point.
Unidirectional rotation of a CP propeller subjects the blades to less ice damage because the leading edges of the blades are thicker and stronger than the trailing edges. Fouling of propeller blades by ice blocks is less likely with continuous propeller rotation.	Greater equipment complexity (e.g., hydraulic system, controls systems, additional moving parts in propulsion shafting and hub) requires additional maintenance and increases frequency of failure.

Pros	*Cons*
Improved maneuverability and a minimum vessel stopping distance. Variable thrust capability in either direction and more rapid response to thrust reversal commands improve vessel maneuverability and reduce the vessel's headreach.	
Individual blades can be replaced when damaged.	

Source: Harrington, Roy L. Editor, (1992) Marine Engineering, Society of Naval Architects and Marine Engineers

4 Deck and Other Machinery

4.1 Anchoring Arrangements

4.1.1 Ice Breaking Vessels

While operating in ice-covered waters, towing of vessels is relatively frequent, either to supplement powering capability or when a vessel suffers propulsor damage. Ice breakers and other ice breaking support vessels are most likely to conduct towing operations, but all ice class vessels should be designed to be towed on either a longer line or 'in the notch', depending on practices in the anticipated area of operation.

4.1.2 Ice Class Vessels

When ice class vessels are towed 'in the notch' of the ice breaker, the towed vessel's anchors must be lowered and the anchors moved aft and secured so as to be clear of the ice breaker's stern. Other vessels have arrangements in which the anchors are located in an enclosure over the hawse pipe.

4.2 Anchor Windlass

The deck machinery for the anchoring systems of ice breakers and ice class vessels can be either windlasses or capstans. Windlasses are fitted with a horizontal shaft used for raising and lowering the anchor while capstans are fitted with a vertical shaft to perform the same function. Anchor windlasses exposed to the weather can be expected to be coated in ice from saltwater spray and rendered inoperable if heating or some other protective device or design feature is not provided. It is preferable to have machinery fitted under cover; hence capstans offer advantages inherent in their design. It is easier to have the machinery associated with the capstan located below deck and the wildcat or wildcat and barrel above deck. Both windlasses and capstans can be located entirely below decks, but the height required for the wildcat is generally chosen so that the cable is self-stowing in the chain locker, requiring that the wildcat itself be located on an open deck. Power units located within heated spaces do not need oil sump heating.

If windlasses or other equipment are located on the exposed deck, remote release of the cable and anchor from the wheelhouse should be considered, shortening the time that crew members must spend on the open deck. The effects of icing on anchor release must be addressed and mitigated. For example, can a build-up of ice in the hawse pipe affect the ability of the anchor to be released into the water? Can icing of any of the rotating components on the anchor windlass affect release? What design modifications or operational changes would be required to mitigate the affects of ice? The vessel should be fitted with a camera for monitoring the functioning of anchor and cable, released length of cable and monitoring of sea conditions. However, the crew must still prepare the anchor for release. Sufficient supplies of suitable cold-weather clothing and, where possible, protected access and shelter stations should be provided.

Steam-driven machinery is not recommended due to inherent problems of the piping systems; the need to provide for proper draining of all lines and the consequent freezing and possible cracking of pipes.

Stressed parts of machinery shall take into account the design service temperature if exposed on open decks. It is preferable to encase all moving parts, such as reduction gears and brakes, to prevent icing or freezing spray build-up. Wildcats may be fitted with covers. In some cases, the rotating parts are provided with heaters. Bearings installed in motors/hydraulic pumps should be protected by suitable packing to prevent water/moisture entrapment.

4.3 Towing Winch

The sizing of towing winches should be based on the available thrust for the ice breaker concerned. In some cases, ice-strengthened vessels are capable of towing other vessels. Standard equipment today for towing in ice is the use of a traction winch. Depending on the ice breaker supporting the escorted vessel, the observed pull on the towing line will be some fraction of the ice breaker's available thrust. Historically, the Russian ice breakers tended to have high brake traction settings in the magnitude of 80% of available thrust. However, most other ice breakers operate in the 20% to 50% range. To limit dynamic loads originating during close towing of a vessel in ice, the towing gear is to be provided with a damping device. On Russian ice breakers there is a hydraulic damper for this purpose.

If a vessel is expected to undertake regular towing operations, it should be outfitted with a towing winch. Protection for the winch from the elements is recommended, including arrangements for the passage of the tow line. During towing, the winch, preset for a given tow pull, will reel in or pay out on the drum as the pull on the cable varies. This line action may occur quite suddenly if ice breaks and the vessel's crew should be trained for this specific hazard.

The haul in rate for most ice breakers is in the order of 9 m/min, with reel out approaching double that of the haul in.

4.4 Towing Lines for Ice Class Vessels and Ice Breaking Vessels

Each vessel is to be capable of passing an emergency towing line to the towing vessel by a line throwing appliance or similar device. A "slip" should be provided to allow the towing hawser to be disconnected rapidly from the vessel in the event of imminent danger.

The towline should, as for all mooring arrangements, break before damage to the towing winch takes place, notwithstanding the constant tension features of the winch. Towlines in ice-covered waters are considerably shorter than those often seen for open water tows. These shorter tows are carried out to prevent the channel formed by the ice breaker or ice-strengthened vessel from quickly closing and increasing the resistance of the towed vessel. Towlines generally fall between 200 to 500 meters in length, keeping the wire length to a minimum on the drum. This minimizes cable wear resulting from the outer windings depressing on the inner windings during a towing operation. The number of windings on a drum should not exceed 4 or 5 for any vessel expected to conduct regular towing operations.

4.5 Towing Fittings

Any vessel that is intended to operate in ice-covered waters should have some arrangements for being towed. Whether towed in close tandem configuration or at a distance in a more separated mode, substantial fittings such as bollards should be well incorporated into the hull structure and should be sized for the high dynamic loads that can be experienced in ice. Towing fittings are to be marked with their Safe Working Load (SWL). IMO MSC/Circ. 1175, Guidance on Shipboard Towing and Mooring Equipment provides additional information. Anchoring systems should be provided with an independent means of securing the anchor so that the anchor cable can be disconnected for use as an emergency towing bridle. When this is accomplished, the anchor chain is generally brought on deck and led out the forward chocks. The storage of the anchor has always been an issue with the tow hook-up. Previously, the anchors were lowered down onto the deck of the towing vessel. However, recent recommendations from Baltic administrations indicate that a vessel should have arrangements to secure the anchors onboard the towed vessels. For some vessels, it may become necessary to swing the anchors aft to prevent contact with the towing vessel, in particular, for ice breakers with a notch stern. This may be accomplished with shackles and cables.

Another method to secure a towed vessel is to simply secure the towing line onto the forward bollards. Most vessels are fitted with capstans or other systems such as warp ends for line hauling. However, if towing in ice is anticipated, it is advised to have a bow roller fitted to accept the towline.

A bridle is preferred to a single line hauled onboard and it is recommended that this be included within the vessel's own equipment.

4.6 Cargo Handling

4.6.1 Cranes

No additional information.

4.6.2 Hatch Covers, Ramp Doors and Side Doors *(1 September 2015)*

A thin layer of ice on the seal in way of the hatch cover contact has been known to cause trouble during opening of the cover. The ice bonding the cover to the seal may be broken by mechanical shock such as mallets, or by thermal means such as heat tracing the seal, steam or hot water spray.

4.6.3 Cargo Pumps

If the cargo pumps and their associated equipment are located in a heated space, the requirements in 4/4.6.3 are not applicable to those components in the space. If the space is not heated, then they are to be designed to function at the design internal temperature (see 1/4).

4.6.4 Deck Cargo Securing Equipment

No additional information.

5 Piping Systems

5.1 General *(1 September 2015)*

5.1.1 Materials

Materials subjected to the design service temperature are to be resistant to brittle fracture because, on occasion, it may be necessary to use hammers or axes to clear ice accumulation, making fracture a possibility.

Materials used in piping systems and equipment should be suitable for operations at the design service temperature, considering also specific circumstances such as the lay up of the vessel for extended periods. Particular attention should be paid for those components required for the prevention of pollution or the safety of the vessel. Areas of concern are the areas external to the hull and the unheated areas inside the hull and above the waterline. In all cases, these materials should not be susceptible to brittle fracture. Material requirements for piping components are listed in 4-6-1/7.1 of the *Marine Vessel Rules*.

For components manufactured from gray cast iron or other cast steels exhibiting brittle characteristics in low temperatures, refer to 2/3.8 of this Guide and 4-6-2/3.1.3 of the *Marine Vessel Rules*. Consideration may be provided for applications where a heating device is provided for the component.

Piping accessibility can be improved by providing walkways, platforms, ladders, etc., keeping in mind there could be obstructions from ice/snow. To reduce/eliminate snow/ice, heating would need to be provided. On some vessel designs, piping is enclosed in a tunnel so personnel are not exposed to the weather. Providing a tunnel may not be suitable for vessel designs where flammable fumes are present.

5.1.2 Flexible Hoses

No additional information.

5.1.3 Valves

For a list of primary and secondary essential service systems, refer to 4-8-1/7.3.3 TABLE 1 and 4-8-1/7.3.3 TABLE 2 of the *Marine Vessel Rules*.

5.1.4 Pipes

No additional information.

5.1.5 Tank Vents

No additional information.

5.1.6 Pipe Drainage

No additional information.

5.2 Ship Piping Systems and Tanks

5.2.1 Ballast Water

Cargo vessels operating in cold regions are likely to make one leg of any voyage in ballast. Ice class vessels are likely to have significant ballast capacity to reduce the range of waterlines at which ice has to be broken. Local regulations regarding the discharge of ballast water are to be considered. (See Appendix A12.) Ballast water systems, therefore, need both design and operational consideration.

Ballast water in side or hopper tanks above the waterline may freeze, starting at the top of the tank and at the side walls. In new designs, it is advisable to minimize the amount of ballast carried high in the vessel, especially in stand-alone tanks. Even where the tank itself does not freeze completely, valve and suction line freezing can occur. In extremely cold regions, thick ice formation or complete blockage within air and vent pipes has been noted.

The extent of freezing will depend on the temperatures encountered and on the duration of the voyage; and also on the salinity of the ballast water. Fresh or brackish water will freeze more easily, and so higher salinity sea water should be used where voyage routing and local or regional environmental regulations allow.

It is highly unlikely that any sizeable tank will freeze solid, as the ice itself acts as an insulating layer, reducing the rate of heat transfer. However, ice represents a weight that may not be dischargeable when the vessel is loading, reducing deadweight capacity. If ice chunks fall from the tank sides after the discharge of the liquid ballast, they may damage coatings or components. Ballast tanks should not be pressed full in any conditions when freezing is possible, as expansion during the freezing process can damage structure and pipes.

Ballast tank freezing can be prevented or minimized by adding heat. This will generally be most practical for oil tankers, where cargo heating systems can be adapted to be operated on both loaded and ballast voyages by designing the system to be able to heat either the cargo tanks or the ballast tanks depending on the voyage. In some arrangements, the heating coils in the cargo tanks operate during the ballast voyage and the radiation from these coils may be sufficient to warm the ballast water. These arrangements may be considered, provided calculations indicating sufficient heat transfer at the design service temperature are submitted for review. Circulating the water within the tanks is only effective over the short term, and on longer voyages can actually aggravate problems by increasing heat transfer from ballast water to air.

5.2.2 Ballast Water Tanks for Design Service Temperatures Below -30°C (-22°F)

No additional information.

5.3 Piping Systems for Prime Movers

5.3.1 Fuel Oil System

5.3.1(a) Fuel Oil Heating.

The fuel oil heating system must be designed for uninterrupted service so that heavy and intermediate fuels are available at all times. Steam systems are standard equipment on most ocean-going vessels. However, problems associated with freezing of the steam system have occurred. Additional problems with condensate returns and failure of heaters exposed to cold air can be eliminated with the newer thermal fluid heating systems.

It may also be necessary to add heating coils to distillate fuel tanks in order to prevent clouding or waxing of these fuels at low temperatures. These systems would normally be secured and only put into use in extreme conditions.

5.3.1(b) Fuel Oil Filling Stations.

No additional information.

5.3.2 Cooling System

5.3.2(a) Seawater Systems for Ice Class Vessels. (2024)

- Location – placing sea chest and sea bays low in the vessel, and away from ice flow lines;
- Configuration – using weirs, strainers and other means to separate ice from the water;
- Heating – normally by re-circulating hot water from cooling systems into the inlet areas.

The most cost-effective solution will depend on the type of vessel and the nature of the service. As an alternative, box coolers have been installed in recent years. In these arrangements, cooling water is forced through a U-tube-bundle, which is placed in a sea-chest having inlet- and outlet-grids. Cooling is achieved by natural circulation of the cooling water in the sea-chest or by circulation because of the vessel speed. However, ice may still accumulate during periods alongside in cold conditions, and so it is still advisable to provide heating/water recirculation to deal with possible freeze-up and associated problems during start-up. Box coolers may also become subject to damage during heavy ice conditions for vessels with "standard" hull configurations. This damage could occur during either transit or when in near-stationary dynamic positioning mode.

Relatively shallow water depths on the order of 10 m (32.8 ft) in the Arctic Ocean are common in many areas. Sea chests may be subject to mud intrusion for vessels operating in shallow waters and therefore should be provided with a means to adequately clean the sea chest of the mud.

i) *Sea Box/Bay Arrangement.* Sea inlets should be located to prevent ingestion of ice. Locations offering the best protection depend solely on the hull form and the size of the vessel. For example, larger tankers or bulk carriers of conventional ice breaking form will see very little ice at the aft end below the turn of bilge. If sea suctions are located in this area of the hull, ice ingestion during voyages is unlikely to be a serious problem. Smaller vessels with limited draft may locate the sea inlets closer to the vessel's centerline, thereby offering somewhat better protection to ice floes projected downwards along the length of the hull.

However, since ice may still accumulate during periods alongside in cold conditions, it is advisable to provide additional protection by way of heating/recirculation to avoid problems during equipment start-up.

The sea boxes should be configured to run the maximum vertical extent possible. A sea box designed with its associated tank top well above the load waterline offers a region for any ice floes that may pass through the sea grid to float clear of the sea suctions. The suctions in turn should be located as low as possible to decrease the likelihood of ice being ingested.

To improve the protection of any sea suction inlet, the use of weirs or baffle plates have been used successfully in the past. A weir type sea box will reduce the possibility of suction pipe clogging. As the suction is isolated from the sea inlet grill by way of a solid vertical plate or a perforated baffle, ice that may enter the sea box will float to the top of the sea box and in turn be prevented from being dragged down to the suction inlet. See Appendix 4, Figures 1 through 5 for example configurations. Perforations for a baffle plate are recommended to be nominally 20 mm diameter to prevent large ice particles from being ingested yet still provide sufficient cooling capacity.

There should be the capability of manually clearing the systems of all ice blockages. This can be accomplished by designing efficient access points at strainers and designing the sea box for access above the load waterline.

ii) *Piping & Valve Arrangements (1 September 2015).* Sea bays should be supplied from at least two (independent) sea suctions. For sufficient cooling water to enter the system, the area of the inlets themselves between the sea box and the sea bay should be a multiple of the total suction sectional areas of all seawater pumps.

As noted previously, the location of sea suctions is critical for adequate cooling water to the vessel's systems. Ice blockage can result in overheating of the vessel systems and has caused shut downs in the past.

Sea bays can be protected by extra capacity strainer boxes. These sea bays should have additional isolation valves installed to allow access to the strainer boxes for removing debris without the need of shutting down the vessel's systems.

iii) *Cooling and Heating.* Ice-classed vessels operating in extremely cold temperatures must consider the effects that the temperature itself may have on the vessel. Although the design of the sea bays, strainers and inlets may reduce the effects of ice ingestion or prevent some icing, these will not eliminate the possibility. There are proven practices and functional designs for heating and cooling arrangements to reduce this potential inherent for vessels operating in cold regions.

Most high ice class vessels have an emergency supply of seawater separate from the standard engine room sea bay. Ballast tanks or an entirely separate emergency sea bay have been used in the past. Many vessels have a recirculated seawater cooling system back to the sea bay. This limits the amount of cold seawater entering the vessel system and aids in reducing icing of the sea bay itself. Recirculating cooling water through ballast tanks provides an additional level of reliability. If sea boxes become blocked, these tanks may be used for cooling purposes.

De-icing systems within the sea boxes and at cooling system suctions are another feature which may be incorporated to eliminate ice accumulation and blockages. Additionally, these sea boxes and bays may be provided with steam de-icing systems. The steam system requires isolating valves, strainers, and pressure gauges sized for adequate steam capacity and supply characteristics. Hot water has also been used effectively in the past. An alternative to steam is installation of a thermal oil heating coil inside the sea chest and bay provided: 1) the heating coil is of extra heavy pipe; 2) the heating coil is all welded joints; 3) the heating coil is arranged so as to absorb the expansion and shrinkage by heat variation; 4) an isolation valve is fitted at the sea chest/bay inlet and outlet inside the engine room in an accessible location.

Examples of sea inlet design using a combination of location, configuration, and heating to prevent icing problems are shown in Appendix 4, Figures 1 through 5. Most of these designs are taken from ice breaker design practice, as these vessels face the most severe challenges due to small size, high power and aggressive operation.

FIGURE 1
Reduction of Ice Ingestion – Baffles

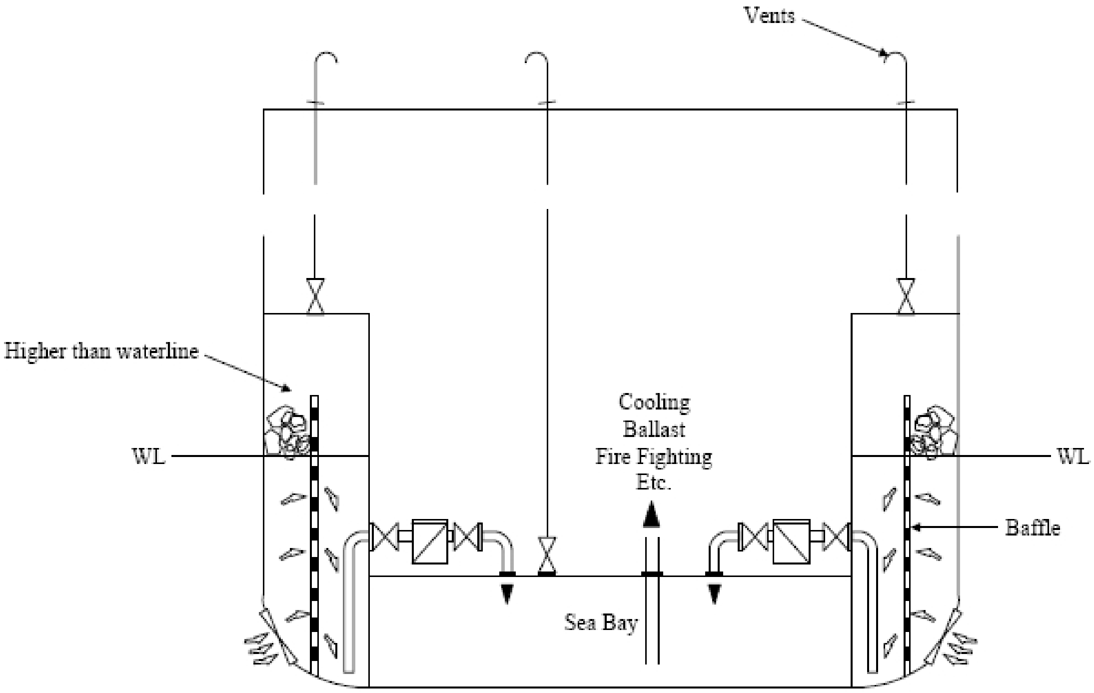


FIGURE 2
Reduction of Ice Ingestion – Weirs

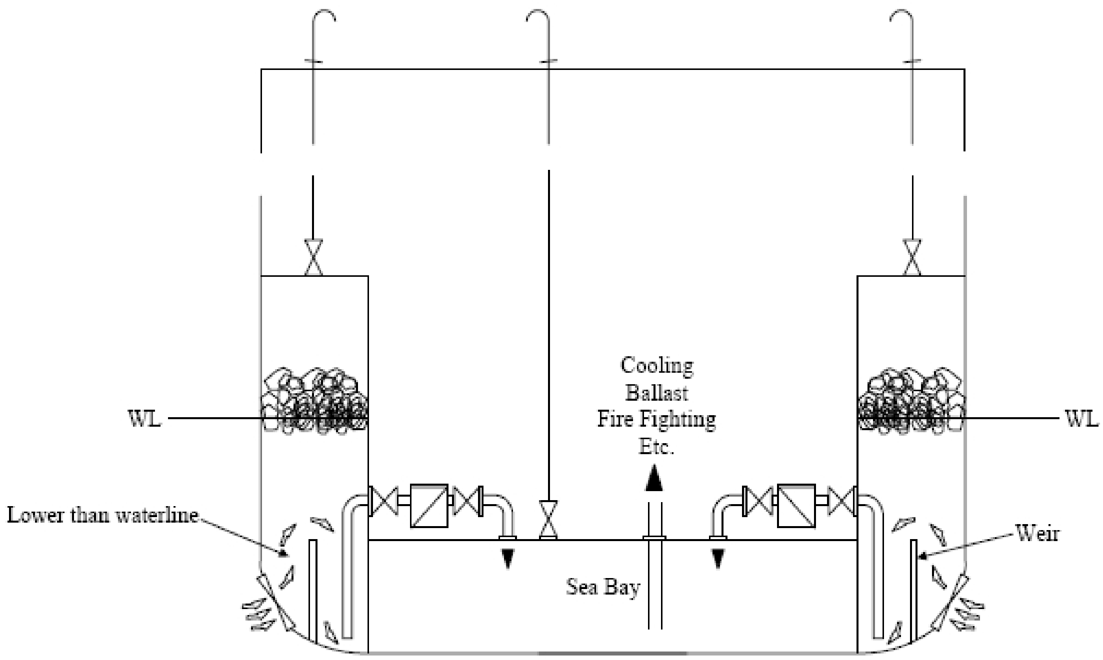
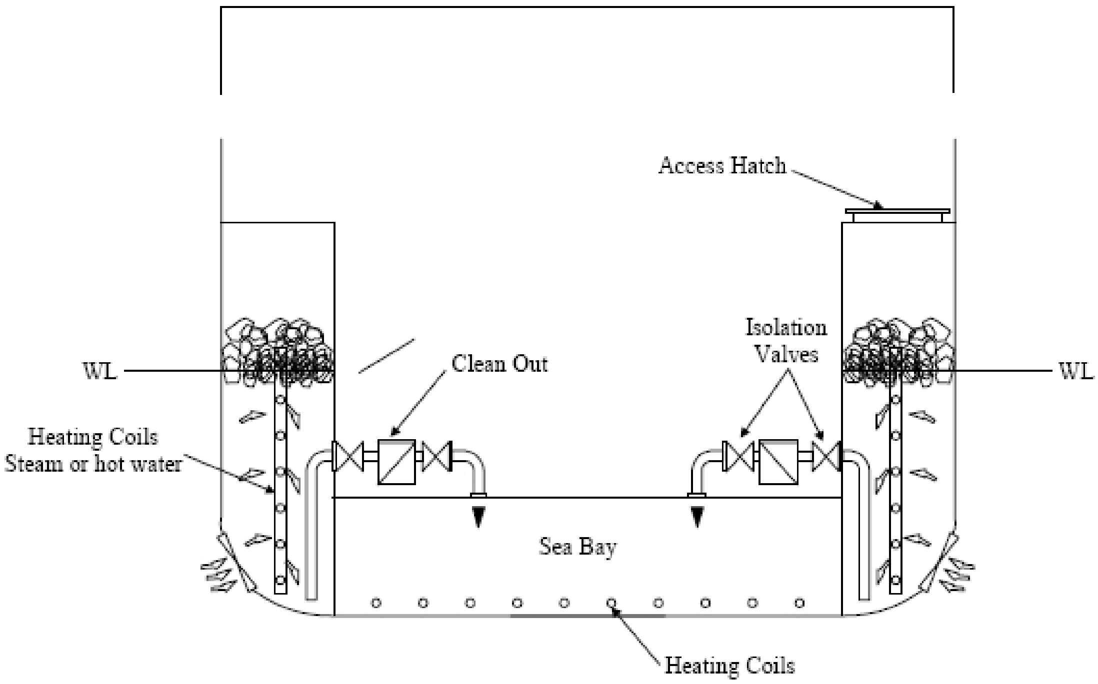
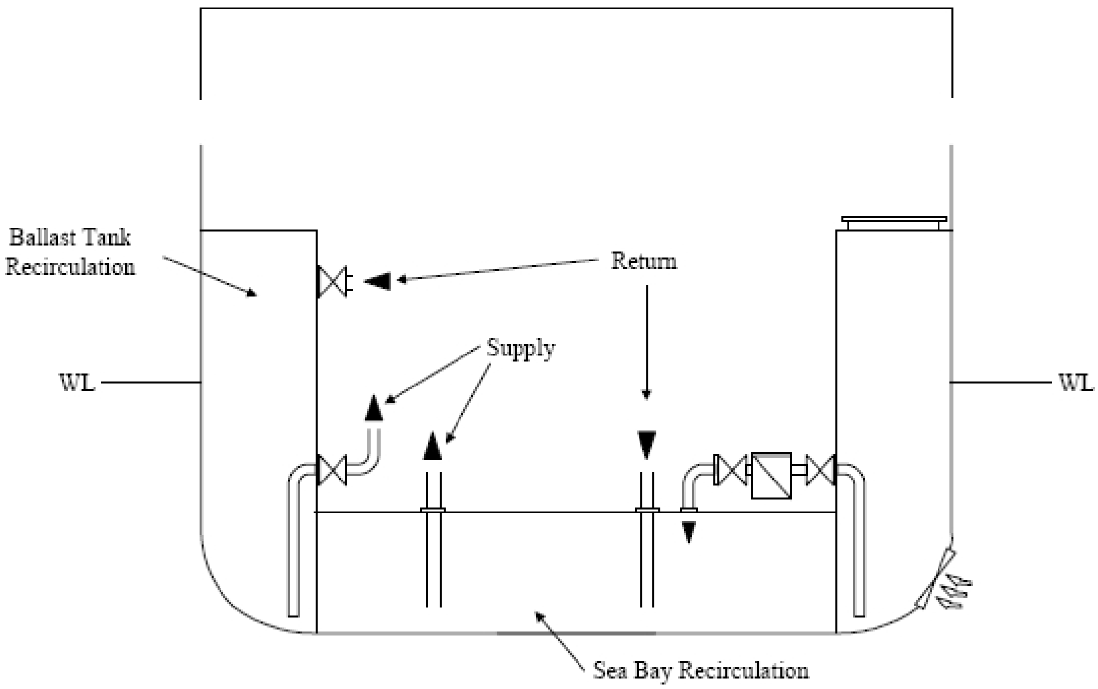


FIGURE 3
Freeze-up Prevention and Clean Outs for Ice Clearing



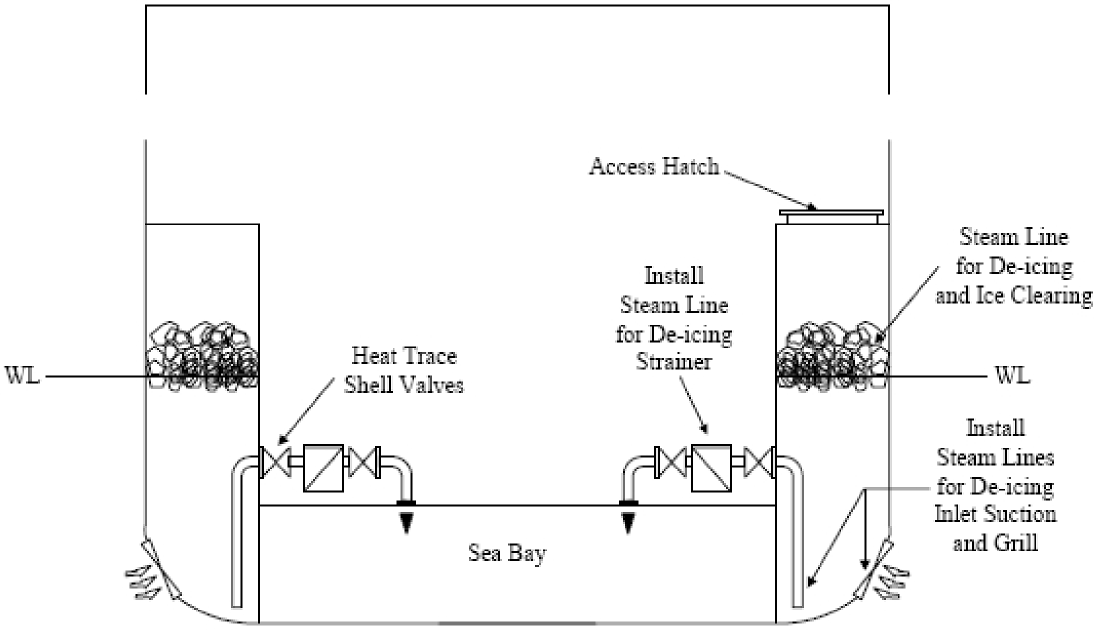
Note: Sea chest vents not shown for clarity

FIGURE 4
Recirculation – Prevents Icing and Emergency Seawater Supply



Note: Sea chest vents not shown for clarity

FIGURE 5
Recirculation – Heat Tracing and Freeze up Prevention Strategies



Note: Sea chest vents not shown for clarity

5.3.2(b) Seawater Piping - All Vessels

i) Standard piping, valves and fittings may be used in the sea water system. However, the use of cast iron material is not advised for any vessel operating in heavy ice conditions. Previous experience has shown that heavy vibrations during propeller/ice interactions may result in system failures because of fracture of this material.

ii) Overboard discharges should be kept to a minimum to reduce the possibility of ice forming in the vessel's valves, and wherever possible, water drains should not generally be discharged above the load waterline.

iii) In areas of extreme temperatures, steam or heat tracing is advised on all overboard discharges.

iv) Alternative means to de-ice sea chests and sea bays such as through electric heating will be considered.

5.3.2(c) Engine Cooling.

Main and auxiliary engine cooling is the most frequent cause of operational problems for vessels operating in cold regions and ice-covered waters. This generally results from the inlet blockage problems discussed in A4/5.3.2(a).i, but may be caused by other effects such as the freezing of cooling lines serving harbor and emergency generators.

Insulating, heating, and/or adding antifreeze to any lines exposed to freezing temperatures may be required for any engine, and particularly for those using freshwater cooling systems.

5.3.3 Fresh Water Systems

i) Fresh water tanks should be located away from the vessel's sides to prevent freezing of contents.

ii) As with all water-filled systems onboard, pipe runs within void spaces should be insulated and heat-traced to prevent freezing. Assume the void space temperature is the minimum anticipated temperature.

iii) The lowest part of the pumping arrangement and pipe runs are to be fitted with drain cocks.

iv) Fresh water generation systems may be sensitive to low sea water (inlet) temperature. The system designer must consult with the manufacturer to determine inlet temperature requirements and any other requirements necessary for satisfactory operation. In particular, reverse osmosis systems are not efficient at low temperature and will require preheat arrangements. Other auxiliary equipment may need to be considered.

5.4 Other Piping Systems

No additional information.

5.5 Waste Storage and Disposal Systems

Many voyages in ice-covered waters are prolonged by the need to maintain safe (low) operating speeds and by the long distances involved. For wastes normally stored for subsequent disposal ashore, this may impose additional space requirements. Few ports in polar regions have adequate waste disposal arrangement for shipboard wastes. These must generally be carried back to ports with better infrastructures.

Many arctic and Antarctic waters are also covered by restricted discharge requirements for waste streams such as oily, grey and black water, leading to additional requirements for onboard storage or to the installation of more capable treatment and disposal systems.

Waste compactors and incinerators can be used to reduce storage volumes and may be essential for vessels with a high number of persons onboard, including both passenger and science vessels. For other waste treatment systems, care should be taken that these will function adequately at low temperatures where both chemical and biological reactions may slow down markedly. Consult with the designer/manufacturer of these systems.

5.6 Starting Air System – Ice Class Vessels

5.6.1 General

Extremely dry control air is required to avoid condensation forming in the control air piping and ship's service air piping from freezing.

Noting that the low air temperature can result in a drop in the vessel's service air pressure, consideration is to be given to either insulating or protecting with heat tracing the service air system piping.

5.6.2 Starting Air System – Ice Class Vessels

The increase in the required number of starts for propulsion engines addresses the propulsion reliability and faster reaction time required for ice class vessels following an ice breaker. Loss of starting air after an engine shutdown increases the risk of collision when navigating in escorted formation.

6 Fire Safety Systems

6.1 Fire Fighting System

Many fixed and portable fire fighting systems can suffer from performance degradation due to low temperatures or to ice and snow accumulation at locations ranging from sea water intakes to hydrants and hoses. It is extremely important that the selection and configuration of fire fighting systems for vessels operating in low temperature environments give proper consideration to potential scenarios under extreme operating conditions.

Equipment, appliances, extinguishing agents and systems should always be protected from freezing. It is common to provide drain cocks or valves in the low points of the piping system. For water piping, if draining the system is not possible, options include charging the system with low temperature fluids (such as glycol) or maintaining continuous flow through the system.

Maintaining operability of hydrants can be accomplished by locating them in protected areas to avoid accumulation of snow and ice. Alternatively, the hydrants can be provided with a heated cover or strip heater to keep them free of snow and ice.

Fire-fighter's outfit requirements are in Sections 4-7-2 and Section 4-7-3 of the *Marine Vessel Rules*.

Some of the fire-fighter's outfits may be stored in the Fire Control Room.

7 Electrical Systems

Most aspects of electrical system design and operation can be identical to normal practice for ocean-going vessels. Some issues do, however, need to be considered as follows:

7.1 System Design

7.1.1 Main Source of Electrical Power

Where central electric power plants or shaft generators are used, speed fluctuations during ice interactions can create frequency instability, which can damage certain subsystems and components.

7.1.2 Emergency Source of Electrical Power

The initial ambient temperature in the listed spaces can be assumed to be 20°C (68°F) for calculation purposes.

The time periods listed in 4-8-2/5.5 TABLE 1 of the *Marine Vessel Rules* may need to be increased from 18 hours considering rescue times in the remote Arctic and Antarctic regions may be increased as a result of weather conditions, distances from nearby ports and proximity to other vessels operating in the area.

Heat tracing of the piping systems for the various equipment and systems listed in 4-8-2/5.5 of the *Marine Vessel Rules* is to be functional during the emergency period to permit continued system/ equipment functionality, such as heat tracing of the steering gear equipment in a very cold steering gear compartment.

7.1.3 Specific Systems

7.1.3(a) Navigation Light System.

Certain lighting designs will fail frequently in low temperature environments. Light manufacturer should certify by way of testing or service history that the lights are suitable.

It is recommended that navigation lights be of a greater intensity for improved visibility at an acceptable range. Dual filament lights would be acceptable for this purpose.

7.2 Electrical Equipment

7.2.1 Rotating Machines

No additional information.

7.2.2 Switchboards, Motor Controllers, etc.

Consult with the electrical equipment manufacturer for space heating requirements if necessary.

Vibration during ice breaking can cause circuit breakers and other components to trip.

7.2.3 Cables

No additional information.

7.2.4 Accumulator Batteries

7.2.4(a) Battery Starting Systems.

Conventional battery capacity is influenced strongly by temperature. Where batteries are installed, this should be taken into account, or battery banks should be provided with supplementary heating.

7.3 Electronic Equipment *(1 September 2015)*

No additional information.

8 Heating and Ventilation *(1 September 2015)*

Standard heating, ventilation and air conditioning (HVAC) systems (coupled with typical levels of insulation) may not have the capacity to provide adequate comfort levels during operations in extreme cold conditions. Furthermore, these standard systems may not take account of the temperature gradients that are likely to exist between the outer and inner areas of the accommodation block. An increase in the amount of approved insulation for the steel structure inside the accommodations area to support the efficiency of the HVAC system may be necessary. The associated increase in thickness and weight must be taken into account in the design. It is therefore not only important to calculate the overall heating demand accurately, but also that the layout of HVAC systems provides for a satisfactory distribution of heating.

Another consideration is relative humidity. In the world's temperate zones, the formation of condensation on the interior surfaces of those boundaries between air conditioned spaces and the weather may occur. Accordingly, vessels are insulated in such a manner as to mitigate the formation of condensation and are arranged to provide for the drainage of the condensation by leaving a channel to allow for the condensation to drain.

For vessels operating in extreme low temperature environments moisture or humidity must be added to the make-up air so as to increase the relative humidity to within a range of between 40% minimum and 70% maximum to provide for an acceptable comfort level and to prevent the build-up of static electricity. As indicated earlier in the section, an adequate amount of insulation must be provided to maintain an acceptable temperature and to reduce the energy demand required to support the heaters. In association with the increased thickness and density, the insulation is to be arranged to prevent the formation of condensation. Such an insulation arrangement may result in the need for additional space to be provided between the steel boundary and the interior lining. In general, the design of the HVAC systems for vessels intended to operate in extreme low temperatures requires a sound understanding of all the issues and therefore, must be designed accordingly.

Heating can be a major issue for propulsion and auxiliary machinery spaces when combustion air is drawn into and from the compartment. At very low external temperatures, the machinery waste heat may not be adequate to provide acceptable temperatures. Additional heating will be required, both in operation and for periods alongside when machinery is shut down or idling. Combustion air requirements and additional information are in 4/2.2 and A4/2.2.

Two-speed fans offer flexibility within the system design. For extreme cold temperatures, consideration should be given to a cross-over between the supply air inlet and the exhaust vent ducting.

Air ventilation ducting is to be insulated to prevent condensation, which leads to corrosion and mold growth.

Closing apparatus for ventilation inlets and outlets must be able to be operated at all times, particularly for closing in the event of a fire.

9 Remote Propulsion Control and Automation

9.1 Monitoring

No additional information.

10 Remote Control and Monitoring for Auxiliary Machinery and Systems Other Than Propulsion

No additional information.

APPENDIX 5

Notes on Safety Systems

1 General

The following provides additional information to the user and, in some cases, recommendations as to how the Guide requirements may be complied with.

2 Essential Services

2.1 Essential Heating for Survival

An electric or steam pre-heater should be fitted in the air-handling unit for ventilation emergency use. Alternatively, individual space heaters for the emergency service spaces may be installed. Emergency generators should be sized for additional heating loads during an emergency as per 4/7.1.2.

Special low temperature fuel may be required onboard for reliable start-up and operation of the emergency generator during an emergency. This is diesel oil that has been refined to remove “waxes” which precipitate out of the fuel resulting in fuel line clogging and subsequent engine malfunction.

Emergency generator cooling should be preferably from an air-cooled radiator with sufficiently protected coolant for the design service temperature.

Where batteries are used to provide power for emergency equipment, they should be suited and sized for low temperature operation.

3 Navigational Equipment

i) All vessels should have sufficient communications capability to download ice charts and forecasts (where available) from local ice service providers. Prior to a voyage, arrangements should be made for this information to be available, as the most useful information is frequently provided on a fee-for-service basis. Systems are also becoming available to download and display higher-resolution imagery from satellites or aircraft-based radar systems. Typically, this information requires specialized equipment and training for the user before it can be interpreted effectively; but, can be a cost-effective investment for vessels making regular polar voyages by permitting the personnel to navigate so as to avoid ice blockages, etc.

ii) Standard marine radar does not provide a good picture of ice conditions. As visibility is frequently limited by darkness, snow, or fog, other navigation aids should be considered. Cross-polarized radar systems can provide much better resolution of ice features, including bergy bits and other dangerous free-floating ice. These are now becoming available from specialized radar suppliers.

iii) Operations under escort or in a convoy can use standard navigation and communications equipment. Masters should verify that procedures and protocols are understood prior to commencing such operations, and that other vessels are made aware of any vessel characteristics that may influence their conduct and safety.

4 Life Saving Appliances and Survival Arrangements

Ice build-up in way of all lifeboats, life rafts, cradles, davits and other launching gear should be regularly removed so that launching arrangements are not hindered. This may include ensuring a wooden mallet is available at each station or in the vicinity of the lifesaving appliances.

4.1 Lifeboats *(1 September 2015)*

Air-cooled engines provide additional heating and can reduce problems associated with frozen valves, piping and water intakes.

The lifeboat's propeller is susceptible to damage from ice, particularly when operating astern because of its relatively shallow draft. Lifeboat manufacturers typically provide an ice guard for the propeller.

Lifeboat releasing gear may be provided with a heated cover to meet the requirements of 5/4.1.viii. Alternatively, the hull structure can be designed in such a way that it protects the lifeboat from the accumulation of snow and ice. Further protection can be provided to the lifeboat by providing a cover over the lifeboat.

To address the potential formation of condensation inside the lifeboat resulting from the exhalation of the lifeboat occupants, consideration should be given to installing supplementary ventilation or air circulation features and heaters within the lifeboat enclosure. The amount of condensation formed is related to the number of persons occupying the lifeboat, the physical exertion required to reach the lifeboat, and the outside air temperature.

It is recommended that lifeboats on vessels operating in ice infested waters be of a type with enhanced maneuvering and acceleration capability.

Lifeboat engine distillate fuel should have a cloud point well below the design service temperature.

Lifeboat engine lubricating oil should have the correct viscosity at the design service temperature without the use of a heater. For vessels trading between temperature extremes, it may be necessary to provide instructions to vessel personnel to replace lubricants and other fluids when operating in a different temperature.

During lifeboat testing in ice an ice block struck the boats steering nozzle causing an uncontrolled spin of the steering wheel. This spin could cause serious injury to the coxswain.

Most lifeboats are manufactured from a composite material that may change properties with changing temperatures. The hull of the lifeboat at any temperature between +10°C and T_{DST}, must be able to withstand impacts with large ice floes. Ice strength varies greatly depending on ice type and temperature, therefore the ice strength used in the hull calculations is to be justified based on operation season, location, and ice class.

With regard to deterrence of native animal populations, this refers to polar bears, which are the greatest threat to personnel, particularly in the Arctic. Refer to the IMO documents referenced in 5/4.

4.2 Life Rafts *(1 September 2015)*

Life rafts are designed to be manned *after* deployment. Davit launched life rafts are manned prior to launching.

See A5/4.4 for additional information regarding storage and launching considerations.

4.3 Rescue Boat

Refer to A5/4.1.

4.4 Launching Stations and Arrangements

Lifeboats should be capable of being launched into the vessel's track because it is assumed there will be little room to transit between the vessel side and the ice cover. This is applicable when relatively thin, open, floating ice is present.

The IMO Life Saving Appliance Code (2003) (as amended), requires free-fall craft be provided with a secondary means of launching. This secondary means may be by gravity or stored mechanical power whose function is not to be impaired by low temperature. Arrangements are to be provided to enable personnel to enter the lifeboat after it is lowered onto the ice.

In some cases, the ice may be of sufficient thickness to allow the crew to descend upon the ice instead of launching lifeboats.

Regarding the requirement to permit lowering life rafts onto the ice, it is better to do this with the life raft in an un-inflated condition to allow the raft to be dragged clear of the vessel. This may be accomplished through the use of a davit. An inflated life raft can act as a tent on the ice surface, protecting survivors from the worst of the cold and wind.

4.5 Ice Gangway, Personnel Basket and Escape Chutes

No additional information.

4.6 Immersion Suits and Life Jackets

Refer to A8/3.4.6 for additional information.

4.7 Alarms, Escape Routes and Access Routes *(1 September 2015)*

Escape routes are to be clearly marked. External escape routes such as walkways are recommended to be kept free of ice and snow. This may be accomplished by heating the surface, protecting the route with an enclosure or a combination of the two. Escape routes through hazardous areas are to be well marked and lighted. The use of abrasive coatings on escape routes should be considered.

4.8 Lighting *(1 September 2015)*

Energy saving lighting sources such as fluorescent or LED (Light Emitting Diode) typically do not generate as much waste heat as incandescent, therefore icing and snow accumulation is more likely.

Some light sources such as fluorescent lights may not illuminate at lower temperatures.

5 Drills and Emergency Instructions

No additional information.

6 Provisions and Spares

Refer to the requirements for Personal Survival Kits and Group Survival Kits in Chapter 11 "Life-Saving Appliances and Survival Arrangements" and Paragraph 13.4.5 of the IMO Guidelines for Ships Operating in Polar Waters (2009) (Resolution A.1024(26)). See A8/3.5 concerning nutrition considerations in cold climates.

The flag State administration may have additional requirements.

APPENDIX 6

Notes on Specific Vessel Requirements

1 General

The following provides additional information to the user and, in some cases, recommendations as to how the Guide requirements for specific vessel types may be complied with.

2 Vessels Intended to Carry Liquefied Gases in Bulk

Liquid Natural Gas carriers, due to the nature of the cargos carried onboard, are constructed with containment systems specifically designed with cryogenic insulating characteristics. Many other systems and equipment are also designed with materials and equipment capable of operating at low temperatures. However, it is necessary that both external and internal low temperatures are taken into consideration. In particular, safety systems such as venting arrangements need to be protected from ice and snow accumulation.

2.1 General

No additional information.

2.2 Material Selection

No additional information.

2.3 Hull Construction and Equipment

Some concerns have been expressed about the robustness of different gas containment systems under the acceleration loads that may result from ice impact. There are no inherent reasons why any system capable of open water operation and meeting gas carrier damage tolerance standards cannot be used in vessels intended for navigation in ice. Ice breaking loads should be verified as part of the overall design development.

Ice loads on the containment systems or any cover for the containment systems may be estimated by applying the allowance for ice accretion in accordance with the IMO Code on Intact Stability or the requirements of the flag state Administration. See 3/5 and A3/5.

2.4 Machinery and Electrical Equipment

No additional information.

2.5 Access to Deck Areas and Cargo Machinery

2.5.1 Electric Motor Room and Cargo Compressor Room Access

No additional information.

2.5.2 Cargo Manifold

The design of a dedicated watch station in way of the cargo manifolds should be considered for vessels that are expected to regularly load/discharge cargoes in extremely harsh environments.

Note:

Emergency disconnection is performed by the terminals (without purging) to protect their terminal loading arms. The vessel provides the Emergency Shutdown System (ESDS). When an ESDS is activated, the manifold valves close (under all service conditions within 30 sec), thus discontinuing loading or unloading operations.

During the discharge/loading operation, some operators will pump seawater over the decks and manifold areas to act as a thermal barrier should there be an LNG leak.

The cargo loading platform drip tray should be so designed that filling with seawater during the discharge/loading operation is not required. Seawater for the water curtain may be preheated to avoid excessive ice build up at the side shell plating.

Vent masts – It is extremely important that the vent mast is drained of any accumulation of water. The purpose of this is to ensure that the relief valves operate at their correct settings, which would otherwise be altered if any water were to accumulate in the vent mast and flow onto the valve assembly.

Vapor heater – LNG carriers are generally fitted with vapor heaters for use during controlled venting of vapor. Controlled venting is rarely done. At low ambient temperatures a vapor heater is mandatory, preventing the cold gas vapor to fall directly on deck. However, individual tank vents are not designed to be routed to the heater. In the instance of an individual tank relief valve lifting, uncontrolled venting occurs and cold vapor will be released to the atmosphere.

2.5.3 Access to Machinery on Deck

No additional information.

2.6 Monitoring Systems

No additional information.

2.7 Fire and Safety Systems

No additional information.

3 Vessels Intended for Dry Bulk Cargoes and OBOs

3.1 General

No additional information.

3.2 Material Selection

In cold conditions, the chance of brittle cracking will be increased with frequent impact loading associated with cargo and by mechanical handling equipment. Accordingly, consideration may need to be given to using tougher materials in the cargo hold bottom and side plating, particularly if the vessel has the **GRAB** notation.

3.3 Hull Construction and Equipment

3.3.1 Hatch Cover Sealing

The selection of hatch sealing material should be specially considered in light of their reduced ductility in extremely cold temperatures. Sealing problems of the main hatches may result in seawater entering the hold increasing risk of cargo contamination and release of products.

3.4 Machinery and Electrical Equipment

No additional information.

3.5 Access to Deck Areas and Cargo Machinery

No additional information.

4 Offshore Support Vessels

4.1 General

No additional information.

4.2 Material Selection

No additional information.

4.3 Hull Construction and Equipment

4.3.1 Stability

With regard to vessels' stability, it is important for masters to have a full understanding of the special challenges of cold weather operations and of the operating limits of their vessels.

4.4 Machinery and Electrical Equipment

No additional information.

5 Vessels Intended to Carry Oil in Bulk

5.1 General

Arctic maritime administrations and intergovernmental organizations recognize that pollution of polar waters can lead to severe consequences for the environment, aggravated by the limited availability of response infrastructure and the specific challenges of spill treatment in the presence of ice. Consequently, tankers are frequently subjected to additional design and operational requirements.

Specific regulations and guidelines may include oil transfer requirements, restricted operations and routing, carrying dedicated ice navigators or observers and, in some circumstances, arranging for mandatory ice breaker support.

Equipment and outfit issues particularly relevant to tankers include arrangements to prevent the freeze-up of vent lines, measures to protect valves and manifolds from icing, and special consideration of ballasting arrangements. Tankers intended for operations in ice may need additional ballast to immerse vulnerable elements such as propellers and rudders, which are near or above the waterline in some standard open water designs.

5.2 Material Selection

No additional information.

5.3 Hull Construction and Equipment

Vessels should be designed so that they are provided with double sides and a double bottom.

5.4 Machinery and Electrical Equipment

5.4.1 Towing Fittings

No additional information.

5.4.2 Pressure/Vacuum Valves

Some vessel operators fill the pressure/vacuum valves with anti-freeze fluid. Other operators regularly de-ice pressure/vacuum valves using an on-deck steam supply. Some valve manufacturers permit a certain amount of icing on the valve before de-icing must be performed. The valve manufacturers should be consulted for instructions.

5.4.3 Cargo Tank Purging and/or Gas-Freeing

No additional information.

5.4.4 Inert Gas System

The inert gas system deck seal is either filled with anti-freeze or heat traced to keep the seal operable.

5.4.5 Piping – General

Insulated piping should be properly installed and maintained to prevent moisture becoming entrapped between the insulation and the pipe and causing corrosion.

5.5 Access to Deck Areas and Cargo Machinery

No additional information.

5.6 Monitoring Systems

Monitoring of heat tracing systems may be accomplished by installation of lamps which indicate the line current flow through detection of line current or voltage.

5.7 Fire and Safety Systems

If additional fire and safety systems are installed they are to be suitable for continuous operation at the design service temperature. For example if a water spray deluge system is installed, it is to be equipped with heat tracing and sufficient drainage to prevent freezing. If the water spray deluge system is in an enclosed space and the piping is normally dry until service is activated, heat tracing will not be necessary. Alternative arrangements for water deluge systems and possible additives to the water may be accepted based on the approval of the flag administration. Dry chemical powder systems are to be arranged to prevent clogging of the nozzles and release the medium at the design service temperature.

APPENDIX 7

Notes on Survey

1 General

At this time there is no additional information related to survey requirements. As additional experience is gained, this Appendix will be revised.

2 Damages

2.1 Controllable Pitch Propellers – Pitch Actuation System

In the event of propeller blade damage, the pitch changing mechanism of the controllable pitch propeller is recommended to be inspected.

APPENDIX 8
Notes on Crew Considerations

1 Introduction

Working in cold weather environments has significant implications on human capabilities and unless proper precautions are made can be hazardous to a person's health. In recognition of these implications on human health and performance due to working in cold climes, this Appendix is offered to provide:

- Basic information on human performance and health hazards
- Information for design or selection of clothing
- Design of equipment to be operated in cold conditions
- Information that can be used to help generate cold weather operations' safety and operating procedures
- Information that can be used to preserve the health of persons working in cold environments

The information that follows is simply information and carries no weight as Rules or requirements leading to Notations or Certifications. The information is provided for those Owners, designers, or operators that would like information of the sort provided as a reference to consider in the course of ship design and operation. The material in this Appendix is applicable to extreme cold weather working conditions. Some of the hazards discussed here are a concern under exceptional circumstances which force personnel to stay in cold temperature for extended periods.

2 Definitions

Atrium: A body cavity or chamber, especially either of the upper chambers of the heart that receives blood from the veins and forces it into a ventricle

Chilblains: An inflammation followed by itchy irritation on the hands, feet, or ears, resulting from exposure to moist cold

Clo-units: The rate of a person's heat loss as measured in watts per square meter of skin area per kelvin of temperature difference across the clothing; the value of insulation is measured by the reciprocal of this rate, in square meter kelvins per watt (m^2-K/W)

Ergonomics: The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort

Fibrillation: Rapid uncoordinated twitching movements that replace the normal rhythmic contraction of the heart and may cause a lack of circulation and pulse

Hypothermia: Abnormally low body temperature

Melatonin: A hormone that plays a role in sleep

Physiologic: Being in accord with or characteristic of the normal functioning of a living organism

Raynaud's Sign: A bluish discoloration of the extremities; can occur when a spasm of the blood vessels is caused by exposure to cold or by strong emotion

Triglyceride: A naturally occurring ester of three fatty acids and glycerol that is the chief constituent of fats and oils

Ventricle: The chamber on the right side of the heart that receives venous blood from the right atrium and forces it into the pulmonary artery; any of the interconnecting cavities of the brain

Wind Chill: A still-air temperature that would have the same cooling effect on exposed human flesh as a given combination of temperature and wind speed; called also *chill factor, wind chill factor, wind chill index*

3 Human Response to Cold and Arctic Exposure

The core (trunk) of the human body should remain within a small temperature range for healthy function. Excessive cooling or excessive heating will result in abnormal cardiovascular and neurological function. The skin is the organ through which a person regulates body temperature. With an average skin temperature of 33°C (91.4°F), conductive heat loss occurs at temperatures below this value. Therefore, it is easy to see how cold weather performance can significantly influence normal body function. As a person cools:

- Metabolism is increased to generate more body heat – as cooling continues a person will begin to "shiver" – a visible sign that body cooling has progressed beyond a comfortable level. Increased metabolism will reduce the amount of time a person can sustain work.
- Safe manual materials handling tasks require the use of tactile senses, hand dexterity, strength, and coordination. Decreases in the ability to produce force, exhibit fine control over objects, and sustain muscular work loads occur in cold working environment.
- Work in cold environments is related to an increased risk for musculoskeletal injury.
- Motor function impairments of the arms and hands will occur long before cognitive or hypothermic-related disabilities occur. Impaired cognitive performance will lead to poor decision-making and increased risk for accident.
- Persons suffering from arthritis or rheumatism will generally experience increased levels of pain during cold weather operations.

3.1 Decreases in Cognitive/Reasoning Ability Due to Cold Exposure

According to Pilcher, Nadler and Busch's "Effects of hot and cold temperature exposure on performance: A meta-analytic review", Ergonomics, (2002) 45 (10), moderately cold conditions [below 10°C (50°F)] created an average decrease of 14% in cognitive performance (reasoning, learning and memory tasks) across 22 studies chosen for the analysis. As operational temperatures decrease, the frequency of cognitive error will increase.

Tasks requiring vigilance may be hampered after prolonged exposure to cold. Decision verification procedures should be implemented.

Cold weather operations, coupled with other physical distracters, such as noise or motion environments, will influence the quality of perception, memory and reasoning and compound the risk of decision-making error.

3.2 Health Hazards Related to Cold Exposure

The list of potential injuries and issues for occupational work in cold environments is lengthy. Personnel should have adequate training to enhance preparation for work in cold environments. Proper planning and precaution can deter the potential risks of cold work.

3.2.1 Non-freezing Tissue Injury

In nonfreezing tissue injuries, parts of the skin are chilled but not frozen.

- *Frostnip* is a cold injury in which the chilled areas of skin become numb, swollen and red. The only treatment needed is warming the area for a few minutes. During warming, the area may hurt or itch intensely. No permanent damage results, although sometimes the area is particularly sensitive to cold for months or years afterward.
- *Immersion foot (trench foot)* is a cold injury that develops when a foot is kept in wet, cold socks and boots for several days. The foot is pale, clammy and cold. After warming, the foot becomes red and painful to the touch. Sometimes blisters develop, which may become infected. Rarely, this type of injury occurs in the hands. Treatment consists primarily of gently warming, drying and cleaning the foot; elevating it; and keeping it dry and warm. Medical doctors (aboard or ashore) should be consulted regarding need for treatment with antibiotics to prevent infection or whether a tetanus booster is recommended if the person's tetanus vaccination is not current. Trench foot can often be prevented by changing socks and drying the feet at least daily.
- *Chilblains (pernio)* is an uncommon reaction that may occur with repeated exposure to cold. Symptoms include itching, pain and, in rare cases, discolored areas or blisters on the affected area (usually the leg). The condition is uncomfortable and recurrent. Preventing exposure to cold is the best treatment. Treatment includes re-warming, using blankets, lukewarm baths or heating pads positioned at low heat setting, which will allow blood flow to return to the peripheral tissues.

3.2.2 Freezing Tissue Injury

Damage to tissue during cold exposure is commonly caused by freezing of the tissue and surrounding area. Tissue freezing is more commonly referred to as frostbite, and is a common occurrence in colder climates. Frostbite occurs most often at ambient temperature below –20°C (–4°F). Frostbite occurs as a result of limbs and facial areas being exposed to low ambient temperatures and wind. Generally, frostbite is accompanied with discoloration of the skin, along with burning and/or tingling sensations, partial or complete numbness, and possibly intense pain. Hands, feet, noses and ears are more commonly affected by frostbite. If the nerves and blood vessels have been severely damaged, gangrene may follow and amputation may eventually be required. If left untreated, frostbitten skin gradually darkens after a few hours. Skin destroyed by frostbite is completely black and looks loose and flayed, as if burnt.

The crucial factor in the development of frostbite is not necessarily the ambient temperature and wind, but whether the tissue reaches a temperature of -4.8°C to -7.8°C (23.4°F to 18°F). Cellular structural damage occurs when cells freeze. There are four levels of frostbite.

- First-degree frostbite results in vesicles (blisters) that damage only the outer skin.
- Second-degree frostbite is associated with full thickness skin loss.
- Third-degree frostbite involves the skin and underlying tissue.
- Fourth-degree frostbite is the worst and results in freezing to the bone. This level of frostbite typically results in amputation of the affected tissue.

Diagnosis of whether superficial or deep tissue was damaged involves analysis of blisters; superficial injury will have clear blisters, while deeper tissue injury will have blisters filled with blood as a result of damage to vascular tissues.

Frostbite requires emergency medical care. Procedures should be in place to provide first aid for victims of frostbite. Means to get medical advice (from physicians either aboard or ashore) should be in place as part of these procedures. A person who has frostbite should be covered with a warm blanket and given a hot beverage because people with frostbite may also have hypothermia. Rubbing the area (particularly with snow) leads to further tissue damage. Because the area has no sensation, it should not be warmed in front of a fire or with a heating pad or electric blanket. The frostbitten area becomes extremely painful on warming and medical attention likely will be urgently needed for pain management. Blisters should not be broken. If blisters break, they should be covered with antibiotic ointment.

It is common for individuals who experience severe frostbite to later experience such problems as: hypersensitivity to cold, cold feet, burning/prickling/itching or tingling sensations, chronic pain, loss of sensation of touch, white fingers, excessive sweating, pain when walking, and other such problems causing a hindrance to work performance. Causes are generally thought to be related to permanent nerve and tissue damage, and in severe frostbite there can even be degeneration of bone and onset of arthritis.

3.2.3 Raynaud's Sign (White Finger)

Raynaud's sign represents a disease and relates to the body's hypersensitivity to cold, causing the arterial musculature to spasm and constrict peripheral blood flow at a much higher level than typical for a given ambient temperature. Less severe cases of Raynaud's sign, referred to as primary Raynaud's, are idiopathic (a medical condition of unknown origin), while secondary cases occur as a result of an underlying physiologic condition or environmental exposure. Secondary Raynaud's sign often occurs as a result of thickening in underlying tissue and vascular beds through mechanisms such as previous severe frostbite or exposure to vibrating tools. The term most often associated with vibration-induced impairment in hand-arm circulation is termed vibration-induced white-finger. White-finger describes the loss of color, increased numbness, and decreased tactile sense associated with circulation impairment for individuals exposed to vibration and/or cold. At the end of a white-finger attack, blood flow returns to the area causing redness, swelling and pain. In severe cases, the symptoms can cause debilitation of performance. The condition may take a few months or several years to develop, depending on the individual physiologic tolerance and the level of cold. With the decreased ability for blood to be delivered to the peripheral areas, there are often symptoms of burning/throbbing pain, numbness, stiffness, diminished sensations and swelling from fluid pooling. These symptoms, even at mild levels, are likely to make manual performance uncomfortable and unreliable.

There is no known cure for Raynaud's sign. However, there are known intervention techniques to alleviate symptoms. Exercise and using warming devices to increase blood flow to affected areas has been successful.

3.2.4 Hypothermia

Hypothermia is a rapid, progressive mental and physical collapse due to the body's warming mechanisms failing to maintain normal body temperatures.

While hypothermia is often associated with immersion in cold water, it can also occur in air when suitable cold weather protection is not employed. Conditions of extremely low dry-ambient temperature or mildly cold ambient temperatures with wind and dampness can lead to a general cooling effect on the body. If metabolic heat production is less than the gradient of heat loss to the environment, hypothermia becomes an issue.

As a result of loss of core temperature, damage to more central organs and systems presents a problem. As the temperature of the core body decreases, so does the heart and associated tissue, which ultimately results in a reduction in heart rate and therefore blood output to the body's tissues and organs. A natural protective mechanism occurs where the brain progressively shuts down cerebral (brain) areas. As core temperature drops, more areas of the brain shut down, leading to reports of amnesia during hypothermic situations, and eventual loss of consciousness in severe hypothermia. At core temperatures less than 34°C (93°F), cognitive function begins to become impaired and at temperatures below 28°C (82.4°F), there is a risk of ventricular fibrillation ("twitching" of the heart and loss of pulse) and cardiac arrest.

People with diabetes, injuries, kidney problems, epilepsy and arthritis are at a higher risk of hypothermia in comparison to healthy people.

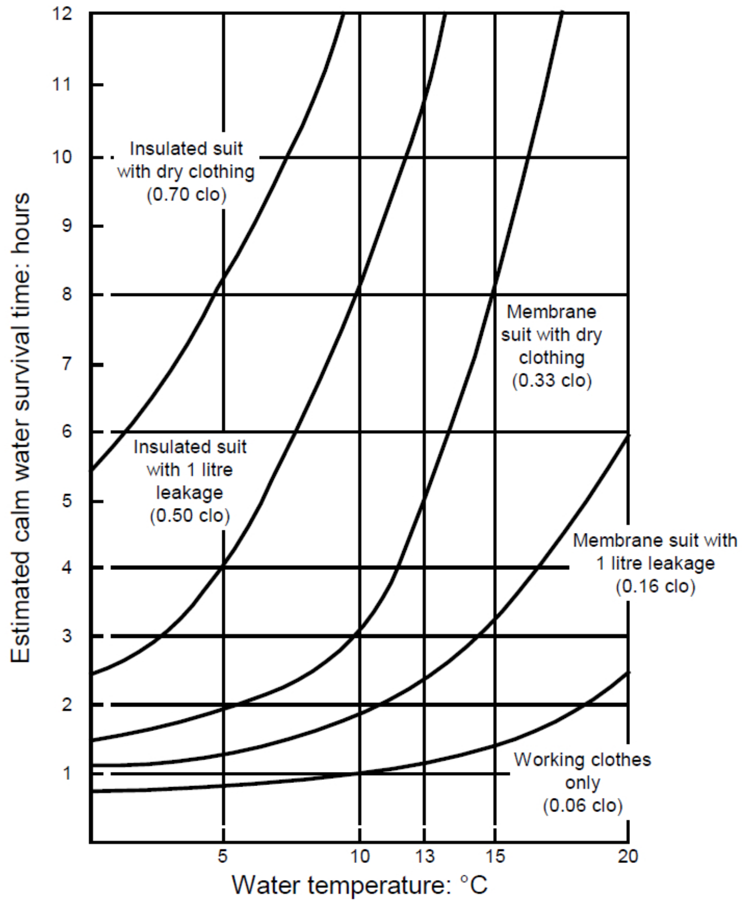
Classification of hypothermia ranges from mild to severe. Mild hypothermia involves core body temperatures between 32°C and 35°C (89.6°F and 95°F), moderate involves temperatures between 28°C and 32°C (82.4°F and 89.6°F), and severe hypothermia involves core temperatures below 28°C (82°F). A8/3.2.4 TABLE 1 presents the symptoms of hypothermia.

TABLE 1
Symptoms of Hypothermia

Mild Hypothermia	*Moderate Hypothermia*	*Severe Hypothermia*
Increased heart rate, resulting from venous return increase Shivering Excessive discharge of urine - resulting from central pooling of blood flow and resulting in rapid delivery to the kidneys Increased muscular tone Decreased nerve conduction	Impaired respiration Decreased heart rate, blood pressure Blue-gray lips, nail beds or skin color Muscle spasms Loss of feeling in or use of arms and legs Loss of muscle function Slurred speech Blurred vision Impaired cognition Confusion Shivering stops (resulting of used energy in prior stages)	Limited or no cognitive ability Twitching of the heart muscles (atrial and ventricular fibrillation) Possible cardiac arrest Unconsciousness Death

A8/3.2.4 FIGURE 1 presents the relationship between clothing and water survival time.

FIGURE 1
Relationship between Clothing and Water Survival Time



Source: Information originally developed by the United States Air Force School of Aerospace Medicine and presented by Reeves (no date)

Procedures devised in consultation with physicians should be in place to guide treatment of a hypothermic person. Means to access medical advice should be in place (aboard or ashore access to physicians). The guidance contained in MSC.1/Circ 1185/Rev. 1, "Guide for Cold Water Survival" is also applicable to the treatment of hyperthermia.

Treating the hypothermic victim generally involves the following:

i) Immediate treatment is much more important than any later action in reviving victims of immersion hypothermia.

ii) Get the person out of the cold, wind, rain or water.

iii) Be gentle with the victim, restricting their movements.

iv) Do not allow him or her to walk unless absolutely necessary.

v) Take precautions to warm the victim up slowly.

Note:

Rapidly applying heat to a hypothermia victim can send the person into shock and cause permanent brain and organ damage *vi)* Replace the victim's wet clothes with dry clothes.

vii) If the victim is conscious and alert, you can allow him or her to drink warm liquids that do not contain alcohol or caffeine.

viii) Re-warm the victim:

a) Cover the person in a blanket or any other material such as trash bags that will help heat retention.

b) A hot bath (the temperature no higher than the immersed hand will tolerate) is the most effective method of achieving re-warming.

c) As the only non-invasive hospital treatment suitable for active core re-warming in the field, inhalation re-warming donates heat directly to the head, neck, and thoracic core (the critical core) through inhalation of warm, water-saturated air at 43°C to 45°C (107°F to 122°F). This method also warms the hypothalemus, the temperature regulation center, the respiratory center, and the cardiac center at the base of the brainstem.

d) In more severe cases of hypothermia, non-clinical attempts to re-warm the body should revolve around passive re-warming – covering the body to prevent any additional heat loss and letting the body's metabolism gradually raise internal temperature. Rapid re-warming can cause immediate changes in peripheral blood distribution, cardio-pulmonary function, perfusion ratio, and nervous control of circulation; with the impaired cardiac output associated with moderate and severe hypothermia, sudden changes in peripheral blood flow can force the individual into cardiovascular shock

ix) If the victim is semi-conscious, keep the person awake.

x) If the victim is unconscious and shows no signs of life, then begin CPR immediately.

xi) Severely hypothermic individuals have a greater chance of survival if greater travel time is taken to reach a facility with appropriate treatment equipment, rather than settling for the closest facility and relying on more primitive re-warming methods.

3.2.5 Cardiovascular Function and Cold Exposure

Sudden changes in cardiovascular function occur every day when individuals are exposed to cold weather after previous exposure to a thermo-neutral climate. These changes cause a sudden increase in the workload placed on the heart and may cause subsequent cardiovascular problems.

Systolic blood pressure can increase by about 30 mm Hg, and diastolic blood pressure can increase about 20-22 mm Hg in older subjects and increases by 23 mm Hg in systolic and 12 mm Hg in younger subjects. In both populations there is a significant increase in blood pressure, and for individuals who are hypertensive, the strain on the heart may result in a cardiovascular incident. Blood pressure can be easily monitored and should be recommended for persons with existing coronary and respiratory disorders.

Cardiovascular problems associated with cold exposure rarely occur upon the initial exposure; usually a resultant case of heart attack or stroke will occur 24 to 54 hours after severe cold exposure.

3.2.6 Respiratory Function and Cold Exposure

Cold air has an influence on airway resistance and pulmonary function. This response can cause significant problems for individuals with asthma.

There is evidence of long-term occupational exposure to cold causing chronic obstructive pulmonary disorders. The increased constriction of the bronchial air passages causes an increase in airway resistance and thus greater effort in breathing. These effects are not seen in thermo-neutral air, and even when present, they are not likely to cause performance limitations, but the increased constriction may further complicate symptoms of asthmatic individuals.

3.2.7 Physiologic Changes in Arctic Environments Unrelated to Cold

Seasonal changes in circadian rhythms are common and result in changes in melatonin release. Melatonin (a hormone that plays a role in sleep) is released in response to decreased light exposure, and release is depressed with greater light. A change in melatonin release can cause disruption in the physiologic sleep-wake cycle, and this effect can reach extremes in Arctic and Antarctic environments where there are prolonged periods of light or darkness.

There is also evidence of work schedules and daily routine having an influence on sleep-wake cycles; in arctic environments where light conditions persist several months followed by months of darkness, the melatonin-mediated control of circadian rhythm can clash with the social and work-mediated sleep-wake cycle. Interruptions in sleep patterns are common in arctic regions for this reason, often leading to increased fatigue and sleep deprivation.

To counteract the physiologic reaction to decreased light, a strategy of matching lighting conditions to work patterns, using blinds and artificial lighting, has shown success. Releasing melatonin by natural or artificial conditions to match work schedules will allow for matching circadian rhythms to social demands and an overall improved sleep pattern. Shift work on ships is suspected to cause both physiological and psychological problems with crew, and these problems are expected to be amplified in arctic conditions. Suntan beds have been employed in vessels operating at near-polar locations to counteract light deprivation periods of the year.

Sleeping areas should be capable of being well “blacked out” to reduce problems in falling asleep due to excess light in the sleeping quarters.

In snow-covered environments, the snow can act as a reflective surface for sunlight without absorbing the light in the same manner as pure-water reflective surfaces. Exposure to direct sunlight for more than 10 minutes requires use of protective eyewear. Using glass lenses for protective eye equipment to filter UV and IR light from entering the retina and using brimmed hats to reduce sun exposure is recommended.

3.3 Monitoring Environmental Conditions *(1 September 2015)*

Working in cold environments requires an understanding of the interaction between ambient temperature, wind speed, relative humidity, personnel protective equipment and task being performed. In order to limit the risk during operational activities due to cold stress and further prevent local cold injuries and general freezing, specific preventative measures should be evaluated and introduced during the planning and execution of the daily work activities.

A plan for monitoring exposure to cold should be devised and should take account of variations in thermal conditions.

Ship managers should, if practicable, eliminate the need for extended work in cold conditions (for example, by rescheduling work to be performed in a warmer season, or by moving the work from outdoors to indoors, or separating the cold parts of a process from the workers, as far as practicable). If elimination of such work is impracticable, other measures to reduce risk from cold conditions should be devised.

Employers should ensure that workers are not positioned near very cold surfaces or, if this cannot be avoided, that the workers are protected by radiation shields. For standing tasks, the floor should, where practicable, have an insulating surface.

Climatic metrics such as temperature, wind speed and humidity should be regularly monitored in the locations where outside work is to be performed. Of primary importance is a regular reporting of the wind chill or equivalent temperature.

Regular communications should be maintained regarding allowable time to work outside. Indoor personnel should regularly monitor outside workers so that best work-to-rest/warming schedules are maintained.

A8/3.3 TABLE 2 presents information regarding the relationship of wind chill and exposure danger.

A8/3.3 TABLE 3 presents threshold limit values for work/warm-up schedule for four-hour shifts/watches.

TABLE 2
Relationship between Wind Chill and Exposure Danger

WIND CHILL CHART

		Ambient Temperature (°C)								
		4	-1	-7	-12	-18	-23	-29	-34	-40
Wind km/h	Velocity mph	Equivalent Chill Temperature (°C)								
Calm 0	0	4	-1	-7	-12	-18	-23	-29	-34	-40
8	5	3	-3	-9	-14	-21	-25	-32	-38	-44
16	10	-2	-9	-16	-23	-30	-35	-43	-50	-57
24	15	-6	-13	-20	-28	-36	-43	-50	-58	-65
32	20	-8	-16	-23	-32	-39	-47	-55	-63	-71
40	25	-9	-18	-26	-34	-42	-51	-59	-67	-76
48	30	-16	-19	-22	-36	-44	-53	-62	-70	-78
56	35	-11	-20	-29	-37	-46	-55	-63	-72	-81
64	40	-12	-21	-29	-38	-47	-58	-65	-73	-82

Source: Threshold Limit Values (TLV™) and Biological Exposure Indeces (BEI™) booklet; published by ACGIH, Cincinnati, Ohio	Little danger in less than one hour exposure of dry skin	DANGER – Exposed flesh freezes within one minute	GREAT DANGER – Flesh may freeze within 30 seconds

Source: Canadian Center for Occupational Health and Safety, 1999

TABLE 3
Threshold Limit Values Work/Warm-up Schedule for Four-Hour Shift

THRESHOLD LIMIT VALUES WORK/WARM-UP SCHEDULE FOR FOUR-HOUR SHIFT*

Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
° C (approx)	° F (approx)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26° to -28°	-15° to -19°	(Norm breaks) 1		(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4
-29° to -31°	-20° to -24°	(Norm breaks) 1		75 min.	2	55 min.	3	40 min.	4	30 min.	5
-32° to -34°	-25° to -29°	75 min.	2	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease	
-35° to -37°	-30° to -34°	55 min.	3	40 min.	4	30 min.	5	Non-emergency work should cease			
-38° to -39°	-35° to -39°	40 min.	4	30 min.	5	Non-emergency work should cease					
-40° to -42°	-40° to -44°	30 min.	5	Non-emergency work should cease							
-43° & below	-45° & below	Non-emergency work should cease									

Source: Adapted from Threshold Limit Values (TLV) and Biological Exposure Indices (BEI) booklet: published by ACGIH, Cincinnati, Ohio, 2000.

3.4 Clothing and Personal Protective Equipment

For appropriate protection/isolation against cold climate conditions, adequate clothing should be selected and used onboard during cold periods. Such optimal clothing should be able to mitigate water and humidity during work and at the same time insulate sufficiently to maintain thermal comfort during rest. The insulating effect of the clothing is influenced by different factors including temperature, wind and humidity.

The measure of clothing insulation is determined by clo-units. The rate of a person's heat loss is measured in watts per square meter of skin area per kelvin of temperature difference across the clothing; the value of insulation is measured by the reciprocal of this rate, in square meter kelvins per watt (m^2-K/W). One clo is equal to 0.155 m^2-K/W attire, which allows an individual to remain comfortable at an ambient temperature of 21°C (70°F).

Garments are to be labeled with exposure protection information (for example, hours of protections at a particular temperature).

Appendix 8, Table 4 presents protective and functional properties for outdoor work garments.

TABLE 4
Protective and Functional Properties for Outdoor Work Garments

Parameter	*Limit*	*Basis**	*Method**
Thermal insulation (T < -20°C)			
• Long-term cold exposure • Short term cold exposure • Gloves	≥ 3 clo ≥ 2.5 clo 2.5…3.0 clo	ISO 11079:2007 ISO 11079:2007 Frostbites	BS DD ENV 342 BS DD ENV 343 BS EN 511
Air permeability			
• In wind. Rest (100 W/m^2) • Heavy work (> 300 Wm^2)	< 20 l/m^2-s 20…150 l/m^2-s	Preventing of cooling Evaporation	BS EN 31092 BS EN 31092
Ventilation			
• Heavy work (> 300 Wm^2)	≥ 300 l/min		
Water vapor permeability			
• Cold weather clothing • Cold/foul weather clothing	≤ 13 m^2Pa/W ≤ 20 m^2Pa/W	Evaporation Evaporation	BS EN 31092 ISO 11092:1993 BS EN 31092 ISO 11092:1993
Resistance to water penetration			
• Light rain • Heavy rain	≥ 2200 Pa ≥ 33000 Pa	Protection against moisture Protection against moisture	BS EN 20811 ISO 9073-16:2007 BS EN 20811 ISO 9073-16:2007

Source: Adapted from a collaboration of information by Biem, Koehncke, Classen, & Dosman, 2003; Giesbrecht, 2000; and Golden, & Tipton, 2002

**Note:* List of Standards names noted in the "Basis" and "Method" columns:

- ISO 11079:2007: Ergonomics of the Thermal Environment - Determination and Interpretation of Cold Stress when Using Required Clothing Insulation (IREQ) and Local Cooling Effects
- British Standard DD ENV 342: Protective Clothing – Ensembles for Protection against Cold (1998)
- British Standard DD ENV 343: Protective Clothing – Protection against Foul Weather (1998)
- British Standard EN 511: Specification for Protective Gloves against Cold (30 June 2006)
- British Standard EN 31092: Textiles - Determination of Physiological Properties – Measurement of Thermal and Water-Vapour Resistance Under Steady-State Conditions (Sweating Guarded-Hotplate Test) (1994)
- ISO 11092:1993: Textiles - Physiological Effects – Measurement of Thermal and Water-Vapour Resistance Under Steady-State Conditions (Sweating Guarded-Hotplate Test)
- British Standard EN 20811: Textiles - Determination of Resistance to Water Penetration. Hydrostatic Pressure Test (15 November 1992)
- ISO 9073-16:2007: Textiles – Test Methods for Nonwovens – Part 16: Determination of Resistance to Penetration By Water (Hydrostatic Pressure)

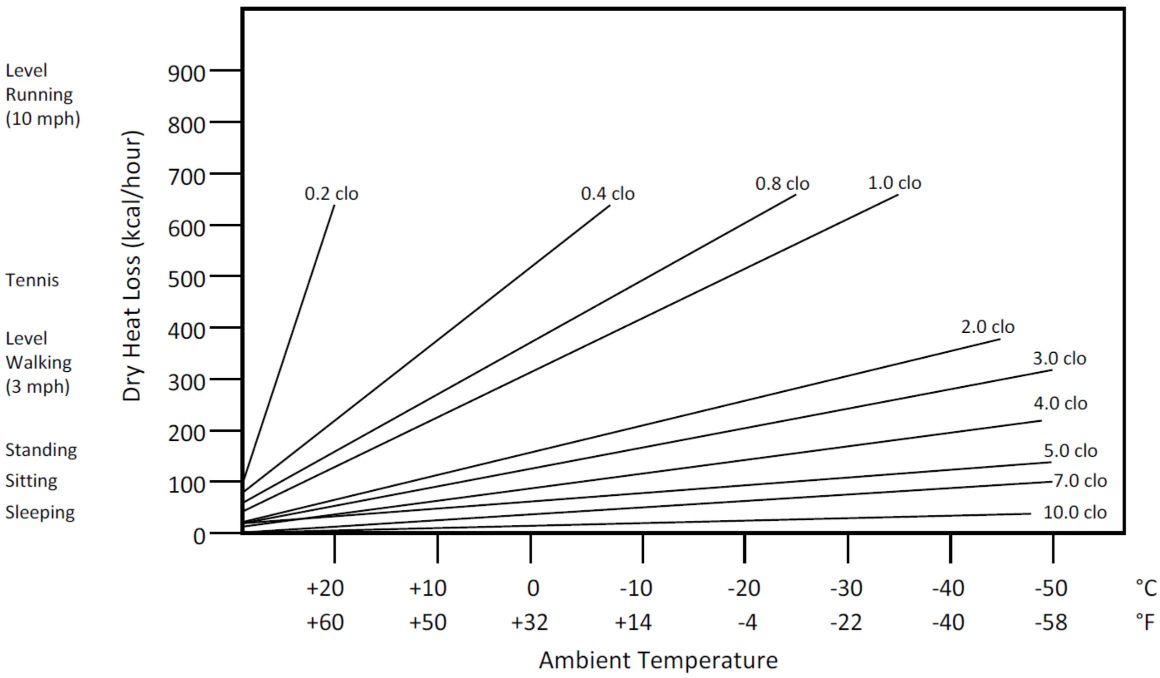
3.4.1 General Recommendations for Clothing

It is important that the clothing be as comfortable as possible. It needs to provide optimal transportation of humidity from the body to the environment, good insulation and sufficient dexterity.

Each garment in the clothing ensemble is important and all pieces should be considered part of the protective system.

A8/3.4.1 FIGURE 2 presents heat loss versus clo factor at a comfortable skin temperature. For example, a person at rest, generating 100 kcal per hour of metabolic heat at this activity, will require about 1.0 clo unit of insulation to be in thermal balance at 20°C (68°F). If the temperature were to drop to 0°C (32°F), he or she would require approximately 3.3 clo. With a further temperature drop to –20°C (–4°F), the requirement would be approximately 4.8 clo. However, an active person generating 300 kcal/hour would only need approximately 1.8 clo at –20°C (–4°F).

FIGURE 2
Heat Loss vs. Clo Factor at a Comfortable Skin Temperature



Source: Reproduced from: Forgey, W. (1999) Basic Essentials Hypothermia, 2nd Ed.

With the addition of wind and humidity to low ambient temperature, greater clo units are required. Wind has an effect of compressing clothing, decreasing the overall amount of trapped air that creates an insulating layer.

General body protection from cold should be provided.

For optimal protection, the following three (3) clothing protection layers are recommended for outdoor work activities onboard (for an effective insulation of 2.6 clo):

- Inner Layer of two layer underwear effectively absorbing and transporting perspiration:
  - "Super" underwear or similar products against the skin

    Wool as second layer

- Middle Layer which provides an isolating effect:
  - Fiber/fleece (pants and sweater/jacket), wool sweater, woolen socks
- Outer Layer which protects against the environment and should be waterproof

Sufficient amount of appropriate skin protective cold cream should be available at all times onboard, located at the assigned heating huts, common rooms and sickbay. Someone should be designated to be responsible for ensuring that cold creams are available as required onboard. Dispensers should be used instead of jars containing cold cream.

Clothing should have adjustable neck and sleeves to influence air exchange when internal temperature becomes unfavorable and to prevent sweating/moisture build-up under the clothing.

Cotton or polypropylene long underwear is recommended for all-over warmth.

Multiple layers of light, loose-fitting clothes are recommended.

Use suspenders instead of belts (tight belts can constrict blood circulation).

3.4.2 Hand Protection

Do not wear gloves or scarves that can get caught in moving parts of machinery.

While glove use is always recommended for outside work, the use of cold-protective gloves likely impairs the ability to carry out fine motor skills, while gross motor skills are less affected.

Mittens or gloves provide sufficient insulation to prevent frostbite. Mittens will retain heat for a longer period of time compared to wearing gloves. However, mittens can interfere with a person's ability to grasp and manipulate objects.

3.4.3 Head and Eye Protection

As much as 40% of body heat can be lost from an uncovered head. Use an appropriate hard hat liner to reduce heat loss when wearing protective headwear.

It is often noted that the choice of safety hat takes priority over the choice of its insulating properties. This is not a desirable principle procurement criterion for cold weather operations.

Wear a warm hat with ear protection to prevent heat loss from the head.

Protect vision from UV rays by wearing appropriate sunglasses while working in snow and ice on a bright day.

3.4.4 Foot Protection

The surface contact area of the sole is important for frictional force on ice. It is suggested that shoes/boots with rounded heels increase the contact with the surface and reduce the risk of slipping. When there is a layer of water along icy surfaces, the contact with the sole of the shoe is reduced. Therefore, the addition of sharp cleats to shoes is suggested. However, wearing shoes/boots with steel cleats on steel decks can be quite dangerous because of the loss of frictional force.

Boot selection should involve procuring a boot with proper insulation for the duration of the activity, required protection and the intensity of the work.

Woolen, polypropylene, or other thermal socks should be worn to protect ankles and feet. Keep snow and water out of footwear and replace damp socks with a dry pair.

3.4.5 Maintenance of Personnel Protective Equipment

Dirty and oily clothing loses much of its insulation value, and wearing of dirty/oily clothing should be avoided.

Do not keep cold weather clothing stored or compressed in a duffle bag for long periods of time. Fluff waterfowl down garments when removing them from the duffle bag following initial boarding of vessel.

Keep garments dry; brush off snow and frost before entering warm buildings or vehicles.

Follow manufacturer's guidelines for cleaning clothing. Failure to do so may reduce the protective capacity of the clothing.

Do not leave rips or tears unmended. Temporary repairs can be made with electrical or duct tape.

3.4.6 Immersion Suit Protection

In work where there is a risk of accidental immersion or abandonment into cold-water, specific protective equipment is recommended:

- Dry-suits and marine anti-exposure suits are commonly worn during marine operations and have been found not to impair working ability. These provide both protection and buoyancy in the water.
- A fully insulated dry suit has a clo value of approximately 0.7, leading to survival time up to 15 hours of immersion at 12°C (53.6°F), compared to 1-6 hours without the suit.
- Protective suits should be checked regularly for wear and accidental rips. In some cases, replacement of the suit is recommended

There are marine immersion suits available that protect the wearer from wind and cold in a dry environment and have isolative properties and buoyancy in water as well. While on land, these suits also have the ability to increase ventilation by opening collars and sleeves as needed, thereby accounting for individual variation in thermal comfort.

3.5 Nutrition Considerations in Cold Climates

The added weight of protective clothing and the limitations in mobility created by protective equipment will increase the mobility demands of the operator, thus increasing the metabolic needs for a given task.

A mixed diet of protein, carbohydrates and fats combining for a caloric intake of 4500 kCal for an average man is recommended for demanding labor in the cold.

Normal physiologic water loss is unavoidable in cold environments. There is a loss during physiologic activities such as metabolism, from sweat production inside protective equipment, and from increased urination related to cold-induced excessive discharge of urine. It is recommended that 3-6 liters of daily intake of water be maintained. For warming purposes, hot non-alcoholic beverages or soup are suggested. Caffeinated drinks such as coffee should be limited because it increases urine production and contributes to dehydration.

Generally, tobacco prevents the periodic blood vessel dilation needed for preventing tissue injury. The risk of frostbite and peripheral injury may increase with tobacco use.

Alcohol use should be avoided. The use of alcohol increases the flow of blood to the skin, and can lead to rapid loss of body temperature, increasing the likelihood of hypothermia.

Frequent, small meals will allow a constantly high metabolism to help maintain body temperature, whereas large meals served only 2-3 times per day will result in a decreased metabolic rate after digestion and decrease the "heat production to heat loss" ratio.

In the event of ship abandonment, a food stores carry-off kit should be provided, containing water and nonperishable foods. The carry-off kits should be stored in areas not subject to freezing temperatures. The carry-off kits should be stored in immediately accessible locations.

3.6 Workstation Design and Operational Considerations

The analysis of outdoor work situations should be performed early in design/layout development and should be updated when design changes are made that will influence personnel's exposure to cold stress.

Outdoor operations analyses (an examination of the tasks to be carried out in cold conditions) should be carried out for open work areas and semi-open work areas. The objective of these analyses is to identify and remedy task performance issues due to overall exposure to temperature, wind, icing and precipitation, including investigation of the weather protection necessary to comply with exposure limits.

Environmental measurements and assessments (air temperature, humidity and wind speed and direction) should be performed on a routine basis and at regular intervals throughout the day during cold periods with temperatures below zero degrees. All personnel working in exposed locations should be monitored at regular intervals. A person is usually unable to recognize their own signs and symptoms of hypothermia. As a precaution, use of the "buddy system" to detect signs of cold injury in coworkers is recommended.

Crew should be allowed sufficient time to acclimatize to an extremely hot or cold environment, including major changes in climatic conditions.

Monitoring of thermal conditions should be performed and should take account of:

- All stages of work cycles and the range of temperature and humidity under which tasks are performed,
- The range of clothing worn during the tasks,
- Major changes in physical activity level (metabolic heat production),
- Occasional tasks such as cleaning and maintenance of hot equipment and cold areas, and renewal of hot or cold insulation.

A log that is to be maintained by the onboard Safety Officer during operations in cold periods to keep records of the specific areas and work activities where administrative measures are introduced is recommended. Work areas where administrative measures are introduced on a regular basis should be identified by periodical review of such records.

Workers in the cold will often need to urinate more frequently, and employers should ensure that suitable arrangements are available, where feasible, and that the design of protective clothing allows easy urination.

Suitable protection should be given to the hands and fingers, particularly where dexterity is needed, as well as other exposed parts of the body. Employers should provide:

- Facilities for warming the hands, for example, by warm air, where appropriate,
- Tools with insulated handles, especially in temperatures below the freezing point,
- Measures to prevent the bare hand touching surfaces below –7°C (19°F) (workplace design or protective clothing)
- Measures to prevent bare skin touching liquids below 4°C (39°F)
- Appropriate measures to be taken in the event of insulating clothing getting wet,
- Face and eye protection, as appropriate, for outdoor work and working in snow (e.g., safety goggles against glare),
- Adequate facilities for changing,
- Arrangements for cleaning such clothing and drying clothing and footwear between shifts.

Slips and falls are much more common in winter seasons.

- Walk slowly on slippery, icy surfaces to prevent danger of slipping. Stop occasionally to break the momentum.
- Avoid carrying heavy loads or loads that obstruct vision during transportation.
- Use approved snow removal compounds.
- Use mats at entrances to prevent slippery conditions indoors caused by melting snow or ice.
- Stairs, ladders and walking surfaces should be provided with non-skid surfaces
- Hand railings should be provided with non slip surfaces or should be heated to prevent formation of ice
- Exterior stairs should be made of grated material to aid in snow and ice removal

Post visible signage emphasizing the risk for cold-related injuries at all outdoor workstation locations. Knowledge of the work area at risk for slippery conditions, augmented with proper hazard signage, is important. If individuals are aware of the cold weather conditions, they will rely on additional muscle-based reflexes (i.e., reaction time), postural control, and muscular strength to adjust to the environment and prevent slipping and falling.

Consider providing enclosed bridge wings.

Consider providing a temperature transition area (such as a heat vestibule) at exit/entry points to soften the often harsh transition from bitter cold to warmth, and vice versa)

Assess possibility for temporary local shielding around working area(s) if permanent shielding is not possible.

Clearly post locations for nearest re-warming or break areas.

Power tools and other equipment generally require specific maintenance schedules for usage in cold weather.

Cold tool handles reduce grip force. Therefore, tools with larger handles may be required for cold weather usage to accommodate the protective hand wear and reduced grip capacity.

Cold exposure aggravates the effects of mechanical vibration, making manual work more difficult and painful. Effort should be made to minimize exposure to vibration at its source.

Hospital/medical kits should be stocked with materials appropriate to treat cold weather illnesses and maladies.

Cold weather illnesses training and procedures should be provided with emphasis on both symptom identification and treatment of the cold-related illness.

3.7 Accommodations and Environmental Control

Personnel accommodations should be designed and arranged to protect the occupants from unfavorable environmental conditions and minimize risk of injury during normal (including ice transiting or ice breaking) operations and emergency conditions.

A8/3.7 TABLE 5 and A8/3.7 TABLE 6 provide guidance on exposure standards for vibration and vibration effects on various personnel functions.

Personnel accommodations, public spaces and the equipment installed in them should be designed so that each person making proper use of them will not suffer injury during normal open water operations and emergency maneuvering conditions.

Facilities should include non-slip decking, three rigid sides, handholds and insulation from exposed hot water pipes.

Personal quarters should have sufficient room to dry and store cold weather protective equipment.

Cabin heating systems should be thermostat controlled and have shielded elements, if appropriate.

- Protective clothing should not be dried directly upon heating system equipment or fittings
- Protective skin cream dispenser should be supplied in each room

Consideration should be given for providing a sauna for crew recreational use and for re-warming cold persons.

Additional accommodations and environmental control guidance is available in the ABS *Guide for Crew Habitability on Ships.*

TABLE 5
Exposure Standards and Action-Limits for Vibration

	Hand-transmitted Vibration		*Whole-body Vibration*			
	Exposure Action Value	*Exposure Limit Value*	*Exposure Action Value*		*Exposure Limit Value*	
Exposure Duration	*R.M.S. Method*		*R.M.S. Method*	*VDV Method*	*R.M.S. Method*	*VDV Method*
1 s	424.26	848.53	84.85	6.51	195.16	14.98
10 s	134.16	268.33	26.83	3.66	61.72	8.42
1 m	54.77	109.54	10.95	2.34	25.20	5.38
10 m	17.32	34.64	3.46	1.32	7.97	3.03
1 h	7.07	14.14	1.41	0.84	3.25	1.93
2 h	5.00	10.00	1.00	0.71	2.30	1.63
4 h	3.54	7.07	0.71	0.59	1.63	1.37
8 h	2.50	5.00	0.50	0.50	1.15	1.15
12 h	2.04	4.08	0.41	0.45	0.94	1.04
16 h	1.77	3.54	0.35	0.42	0.81	0.97
24 h	1.44	2.89	0.29	0.38	0.66	0.87

Source: Adapted from Griffin M. J. (1990). *Handbook of human vibration*. London: Academic Press

TABLE 6
Vibration Effects on Function and Performance

Vibration Induced Effect	*Frequency (Hz) at Which There is Occurrence*
Decreased tactile sensation	0.1 to 1 000 000
Motion Sickness	0.1 to 1
Vibrating Hand Tools Diseases	5-10
Respiration Difficulties	1.5-15
Abdominal Pain	5-15
Increased Muscle Tone	10-20
Lower Back Pain	7-20
Head Sensations	10-20
Disturbance of Speech	1-100
Urge to Defecate and Urinate	10-20
Speech Difficulties	7-20

Source: Source: Wilson, & Corlett, 1990

APPENDIX 9

Notes on Training and Related Documentation

1 General

Operations in ice require special skills if they are to be accomplished safely and efficiently.

The importance of having an experienced Ice Master or Ice Navigator has been recognized for centuries, on voyages of discovery and for commercial operations. Ice breakers and other vessels that spend much of their time in ice-congested waters may have masters and officers with sufficient expertise to provide the ice navigator function. For many other vessels, it is necessary to supplement the regular crew with supernumerary ice advisors or ice navigators, either to provide a basic capability or to comply with national regulations for local experience. Where such personnel are used, the number carried should be matched to the nature of the service and the anticipated nature of the operation.

The terminology used to describe personnel with ice-related expertise is not standardized, and so its usage may lead to some confusion. In these Guidance Notes, the following definitions apply:

- *Ice Advisor*: an individual with expertise in the interpretation of ice information and in forecasting future ice conditions
- *Ice Navigator*: a mariner (usually a master mariner) with extensive experience in the operation of vessels in ice who can provide guidance to the vessel's master and other watchkeepers
- *Ice Pilot:* a mariner individual with similar qualifications and experience to an ice navigator who may be required in some areas and jurisdictions to undertake pilotage duties
- *Ice Master*: a vessel's master with sufficient ice-going expertise to undertake the functions of ice navigator

While these personnel require extensive specialized training, some level of training should be given to all officers and crew of vessels involved in ice operations. It should also be recognized that operations in remote regions may have very limited support from shore-based infrastructure, and sufficient skills should be available onboard to cover both normal and emergency situations.

General guidance on training and crewing is offered in the IMO Guidelines; MSC Circular 1056, MEPC Circular 399. National administrations, including those of Canada and Russia, have specific requirements that must be respected in waters under their jurisdiction. This Guide aims to provide additional useful information that Owners, operators and vessels' crews can utilize in the planning and conduct of cold climate operations.

2 Training

Mariners exposed to cold and their supervisors should be trained:

- To recognize symptoms which may lead to hypothermia in themselves or others, and the steps to be taken to prevent onset and/or emergencies,

- In the use of rescue and first-aid measures, ice control equipment and procedures, personal protective equipment, and other devices and procedures intended to counter the effects or working in cold conditions,
- About action to be taken in the event of increased risks of accidents because of low temperatures.

Mariners should be advised of:

- The importance of physical fitness for work in cold environments,
- The importance of drinking sufficient quantities of liquid and the dietary requirements providing intake of salt and potassium and other elements that are depleted due to sweating,
- Effects of drugs which can reduce their tolerance to thermal extremes.

Mariners normally use classroom training, self-study, and operating experience to develop competencies and achieve certifications. Until recently, there have been very limited formal training resources for developing ice-operational knowledge. Now, several training institutes around the world can offer some level of course for ice advisors, ice navigators and/or ice masters. There are also some simulator facilities that offer training in ice recognition and other aspects of ice operations. However, these still have very limited fidelity in representing ship-ice interaction. On-board training remains the most valuable means of developing expertise, and minimum durations of operation and watchkeeping experience are specified by most national administrations before personnel can be qualified as ice navigators.

There are no formally mandated requirements for the content of training courses in ice navigation. However, any comprehensive training program needs to address the demands of Strategic, Tactical and Close Quarters navigation. Strategic navigation is concerned with the general routing of a vessel in the geographic region in which a vessel will operate, for example, the Baltic, Northern Sea Route, Northwest Passage, etc. At the tactical level, considerations include the selection of way points according to current and forecast ice conditions. At the close quarter level, active navigation evaluates the local ice conditions and the maneuvering of the vessel around and through ice floes.

Strategic Level (voyage planning) decision-making includes:

- Obtaining relevant ice information from ice maps, satellite imagery and medium-term forecasts;
- Evaluating ice conditions and environmental forecasts to verify the feasibility of the voyage and its probable duration;
- Optimizing route to minimize the time that will be spent in the ice and to avoid potentially dangerous ice features

Tactical Level (transiting) decision-making includes

- Obtaining more local ice information from enhanced satellite imagery, airborne radar images and visual reports, reports from other vessels in the area, etc;
- Optimizing the route to minimize encounters with ice that will impede vessel’s progress or cause structural damage.

Close Quarters Level (maneuvering) decision-making includes

- Using radar and visual data to assess the properties of the ice cover;
- Selecting safe speeds to reduce the risk of structural or mechanical damage;
- Maneuvering in a manner that minimizes impacts against vulnerable regions of the hull, steering gear, etc.

As can be seen from the above, an essential area of expertise – and, therefore training – is the ability to interpret various ice information ranging from charts and imagery to direct visual observation. Several good pictorial guides to ice recognition have been developed, examples of which are included in the reference list. Simulators with high quality graphics can also be valuable training aids. Ice advisors will have received training in these areas, but not necessarily in navigational skills.

A key element of expertise for an ice navigator, pilot or master is the ability to relate the ice conditions to the capabilities of a vessel, based on its ice class, powering and other features. This can be taught in general terms by training institutes, though all vessels have their own specific capabilities that will influence performance and safety.

The ice navigator and all deck officers should have some level of understanding of the relationship of the vessel's ice-strengthening class and the limiting safe ice conditions. For the IMO/IACS Polar Classes, the general definitions provided in A9/2 TABLE 1, "IMO/IACS Polar Classes," offer some information (see Appendix A10 for additional information on ice types and conditions). Vessels operating in many Russian waters are provided with an Ice Certificate which provides more detailed information on safe speeds in different ice conditions. However, it is also necessary for operators to understand how the overall ice strengthening of any vessel can vary within the hull; and, for example, how operating in ballast conditions may expose weaker areas of the hull or appendages to ice impacts. The sides and stern of most vessels are considerably less strong than the bow area and vessels should not be operated in ways that expose these areas to significant ice impact loads.

TABLE 1
IMO/IACS Polar Classes

Polar Class	*Ice Description (based on WMO Sea Ice Nomenclature)*
PC1	Year-round operation in all Polar waters
PC2	Year-round operation in moderate multi-year ice conditions
PC3	Year-round operation in second-year ice which may include multi-year ice inclusions.
PC4	Year-round operation in thick first-year ice which may include old ice inclusions
PC5	Year-round operation in medium first-year ice which may include old ice inclusions
PC6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

The maneuverability of most vessels is reduced dramatically by the presence of any ice, and as ice cover thickens, it may become almost impossible to alter course by conventional maneuvers. This is particularly true of vessels with long parallel midbodies and no side flare (i.e., most commercial vessels). However, even ice breakers may find it necessary to change course by backing into a broken track in order to generate a change in heading. This type of maneuver is known as the Captain's Maneuver, or Star Turn, due to the appearance of the track.

Another situation that may require a vessel to reverse course is the need to make repeated rams to traverse thick ice or pressure ridges. Only vessels with reasonably high levels of ice capability should attempt to ram, and great caution is required during the backing phase of any maneuver to avoid damage to propellers. It is particularly dangerous for propellers to hit ice when the shaft is stopped, which can exert very high bending loads on the blades. Ramming speeds should be selected to avoid beaching the vessel in an attitude that creates stability problems, or that will lead to problems of extrication.

Ice navigators should be able to recognize the onset of pressure events, which can cause a vessel to become beset and may pose both direct and indirect safety hazards. This pressure can be sufficient to damage the hull, and general ice drift may carry the vessel into shallow or dangerous waters. Pressure can be managed to some degree by ice breaker intervention, or if time permits, the vessel can be oriented into rather than across the direction of compression. As pressure events are usually of reasonable short duration, stronger vessels may find it best to wait them out. The ice navigator should therefore also be sensitive to signs of reducing pressure.

A significant number of high ice class vessels incorporate unusual design features ranging from azimuthing propulsors to bubbler, water wash and heeling systems. Ice navigators and other personnel should have an understanding of why such systems are used and how they can be operated for maximum effectiveness.

Training for deck officers should address ice breaking procedures and the conduct of escorted operations. While these differ somewhat in different national waters, many general principles apply. These include ensuring that communications are established and protocols understood. Potential problem areas for escort include maneuvering (if the ice breaker makes too close a turn); stopping (if the ice breaker is brought to a halt by heavy ice); the risk of damage due to impact with track sides for a wide vessel escorted by a narrower ice breaker; and the risk of damage due to bow or bottom impact with large ice pieces submerged below the ice breaker. Masters should understand that an escort does not take over responsibility for the safety of the escorted vessel.

The points covered above are not intended to represent a complete listing of subject areas for training courses, but rather an illustration of the types of knowledge that training should aim to provide. They are also amongst the type of material that should be covered in a vessel's onboard documentation, as discussed further below.

3 Documentation

Under the IMO Guidelines, "all ships operating in Arctic ice-covered waters should carry onboard at all times an operating and training manual for all Ice Navigators onboard the ship." The IMO Guidelines provide a basic overview of the type of content that each manual should cover. Manuals and other documentation should conform to the intent of other requirements, such as those of the International Safety Management (ISM) Code, Contingency Planning for Shipboard Emergencies (IMO A852(20)), and other international and national standards. As such, they need to address the information needs of all crew members and procedures for making any passengers aware of specific requirements and challenges.

3.1 Operating Manual

This manual should contain relevant information directly related to operations in ice-covered waters including contingency planning in the event that the vessel suffers damage. The typical format of any operating manual should include the following sections, tailored to operations in ice and in cold temperature conditions: Normal Operation, Risk Management, and Emergency Instructions

3.1.1 Normal Operation

This should include measures to be taken when planning a voyage into cold or ice-infested waters, including:

- Contacting maritime administrations well in advance to confirm if special requirements, crewing or personnel are required onboard
- Arranging for the availability of ice and weather data and forecasts
- Identifying any loading restrictions that may be required for safety or pollution prevention reasons
- Providing that the vessel is adequately outfitted and supplied for the voyage.

As the vessel approaches the cold region, additional checks should be undertaken, such as:

- Contact the vessel traffic control services for the area
- Verify operation of VHF radio including confirming channel used by ice breakers operating in the area

- Take measures to prevent freezing damage; (e.g., piping on deck, sounding pipes and air vents, etc., are to be drained of water) (see Appendix A11)
- Check drafts and trim to verify that the ice belt covers the waterline area and that propeller and rudders are adequately submerged
- Verify the operation of searchlights and signaling devices
- Ready anchors and towlines
- Position protective covers on exposed equipment
- Configure HVAC and other systems (where possible) for cold weather operations
- Implement any other measures required for safe navigation.

The completion of checklists should be recorded. Once the vessel is operating in cold and ice, other issues that should be covered by the Operations Manual (as applicable) may include:

- Use of special features and systems installed on the vessel, such as water wash and bubblers, etc
- Cold start and run-up of systems, including preheating of lubricating and hydraulic oils
- Procedures for clearing ice and snow accumulations without damage to equipment
- Recording and reporting local conditions to assist in forecasting and to comply with regulatory requirements.

3.1.2 Risk Management

Risk Management for cold regions should cover all hazards that may result from or be accentuated by the cold temperature environment, and by operations in ice-infested waters. This includes ensuring the operability and checking the functionality of all operational and safety systems, including firefighting and lifesaving, as discussed in previous chapters. Other issues that should be addressed include monitoring of:

- Hull integrity, by sounding tanks and voids at regular intervals
- Water temperatures in tanks and systems, to provide warning of freeze-up problems
- Performance of pollution prevention systems, to prevent the discharge of wastes.

In general, risk management requires an understanding that many systems and components will be operating at or near their design limits, and their performance may degrade rapidly. Monitoring and testing should be conducted more frequently than is the case in normal operations.

3.1.3 Emergency Instructions

Emergency instructions should address the unique aspects of certain types of incidents in cold and/or ice-infested regions. These range from communicating with support and search and rescue organizations to abandoning ship in the presence of ice. Emergency instructions cannot take the place of proper training in emergency response management, but can be extremely valuable in reminding crew members of the procedures to be followed. As with all other elements of the Operating Manual, the instructions must be tailored to the specifics of the vessel and its modes of operation. They should also be integrated with the drills and exercises covered by the Training Manual and onboard training procedures, as discussed in A9/3.2.

3.2 Training Manual

A training manual should be provided onboard all vessels. The contents of a manual for vessels operating in cold regions should be an informational and educational tool for personnel and a guide for the types of training exercise that should form part of risk management for cold regions operation. As such, it should cover at least the following subject matter areas:

- Ice recognition
- Safe navigation in ice
- Conduct of escorted operations
- Instructions for drills and emergency response

Drills are covered in some detail by the IMO Arctic Guidelines, which addresses lifesaving, firefighting, damage control and other exercises. These should be carried out under as realistic conditions as possible consistent with maintaining the safety of those onboard. Crew members should all be given the opportunity to undertake drills while wearing cold weather survival gear to gain a proper appreciation of how this will affect their mobility and dexterity.

Where specialized equipment is carried for any type of emergency response, an adequate number of crew members should be trained in advance (and certified as necessary) in its use.

APPENDIX 10

Climatic Conditions

1 Overview

The dominant factor for operations in polar and sub-polar regions is the occurrence of extremely low temperatures and the associated formation of ice. In low temperatures, any precipitation will be in the form of snow, or at closer to the freezing point as freezing rain, sleet or ice pellets. Visibility in any of these conditions can be very limited and ice build up can produce a range of hazards, as described earlier. Ice accumulation due to spray is most likely in air temperatures below 2°C (36°F), and wind speeds of above 20 knots (10 m/s). It will worsen as wind speeds increase beyond this, and in higher sea states.

In very low temperatures, sea ice can form quite rapidly once the water temperature itself falls below –1.8°C (28.8°F). Vessels with little or no ice capability can find themselves at risk if caught in these conditions, which are most likely to occur towards the onset of winter.

More generally, most vessels can be put at risk by ice movement, which can occur with considerable rapidity under conditions of high wind or currents. Conditions reported on ice charts or by remote imagery can change fast, particularly the reported positions of the ice edge and the location of leads through the pack. It is important for mariners to be able to recognize the conditions in which such changes can occur, and signs of the proximity of ice. These can include:

- "Ice blink" – a reflection of ice from the underside of cloud cover; most apparent when there is snow cover on the ice
- The onset of fog, which is often present near the ice edge
- The appearance of small ice floes, which can indicate that larger amounts are present nearby
- Rapid moderation of waves, when approaching the ice edge from downwind

2 Ice Types

For vessels intended to operate in ice, it is important to be able to distinguish between the different ice types that may be encountered, both for efficiency and or safety. The two most fundamental properties of ice cover are thickness and age, both of which are reported on standard ice charts using World Meteorological Organization (WMO) terminology and symbols, as outlined in A10/2 TABLE 1. Other terminology is also used, particularly for the initial freezing stages, including frazil, grease, shuga, and slush ice. These are all thin forms of ice cover that will normally be reported as new ice.

Ice services use a number of techniques to derive the thickness of ice cover but all of these are approximate. The symbols on ice charts should always be treated with some caution.

Old ice is ice that has survived one or more melt seasons. It encompasses both second-year and multi-year ice but the term multi-year is frequently applied to either old ice form. Multi-year ice becomes much stronger than first year ice, due in part to its reduced salinity. Floes also tend to have much more variable thickness than younger ice, as they incorporate weathered ridges and other features. This and other features help experienced ice navigators to distinguish between first-year and multi-year ice.

Ice "of land origin" is generally glacial ice, formed over thousands of years by the accumulation and re-crystallization of packed snow. Ice islands and icebergs enter the sea from glaciers and ice sheets and may in turn 'calve' smaller bergy bits and growlers as they degrade. Glacial ice is very hard, and represents a major hazard for vessels with even the highest level of ice capability. Growlers and bergy bits have small freeboards, and can be very difficult to detect either when part of the general ice cover or in open water with moderate sea states. Due to their origin, they are usually found in proximity to icebergs, whose own presence is a good indicator of the potential risk of encountering these smaller fragments.

TABLE 1
Sea Ice Stages of Development

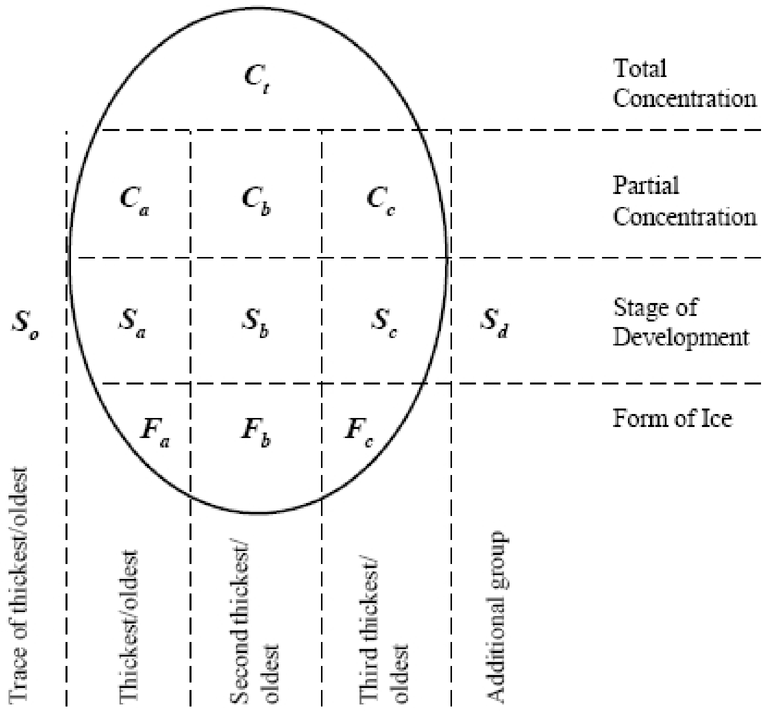
Description	*Thickness*	*WMO Code*
New ice	< 10 cm	1
Nilas; ice rind	0 – 10 cm	2
Young ice	10 – 30 cm	3
Grey ice	10 – 15 cm	4
Grey-white ice	15 – 30 cm	5
First-year ice	30 – 200 cm	6
Thin first-year ice	30 – 70 cm	7
Thin first-year ice first stage	30 – 50 cm	8
Thin first-year ice second stage	50 – 70 cm	9
Medium first-year ice	70 – 120 cm	1.
Thick first-year ice	120 – 200 cm	4.
Old ice		7.
Second-year ice		8.
Multi-year ice		9.
Ice of land origin		.
Undetermined or unknown		x

Ice cover is very rarely uniform or homogeneous. Near the coast, ice may be 'land fast', anchored in place by the shoreline and possibly by grounded pressure ridges. Land fast ice tends to have relatively consistent properties, but may still include ridges and rubble piles. At the edge of the land fast ice, shear zones may occur where the free-floating pack and land fast ice collide. The shear zone can be a chaotic amalgamation of ridging and rubbling. It can be both difficult and dangerous to transit, especially if the pack is in motion at the time. Even the most powerful ice breakers have become trapped, and less capable vessels have suffered damage or been sunk by pressure events in shear zones. Shear zones should be transited, where necessary, with extreme caution.

The general ice pack is typically a mix of ice types, thicknesses and floe sizes at various total ice concentrations. Patches or stretches of open water can be found even in the winter polar pack as floes move relative to each other. In some areas, more or less permanent polynyas of open water exist due to water upwelling. When ice floes move against each other, they may raft, increasing local thicknesses, form rubble, or generate ridging. All of these increase the difficulty of ice transit. Ridges may have sail and keel heights totaling in the tens of meters which can only be penetrated by repeated ramming.

Ice charts consolidate all available information on ice cover using the "ice egg", which in most sea areas will be developed using WMO principles and terminology. An example of how the ice egg is developed is shown in A10/2 FIGURE 1. Each of the fields is filled out using codes, of which the 'stage of development' code given in A10/2 TABLE 1 is one example. More complete explanations can be found in sources such as the Canadian government's MANICE, available on line at http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=4FF82CBD-1.

FIGURE 1
The Egg Code



3 Air Temperature *(2024)*

Traditionally, many operations in polar regions have been conducted in the summer and autumn seasons when air temperatures are not normally as low as may be encountered in mid-winter. In sub-polar areas such as the Baltic and Gulf of St. Lawrence, all-year operations are the norm. For all of these services, air temperatures below -20°C (-4°F) are relatively rare; though they can be experienced.

Midwinter operations are becoming increasingly common on some Arctic routes, and here, temperatures can be considerably lower, with -30°C (-22°F) to -35°C (-31°F) not uncommon. Year-round temperature data can be obtained for coastal sites throughout the Arctic and for most sub-polar regions. Temperatures at sea (in the ice) are on average slightly above those on the adjacent land, therefore, port temperature data will normally represent the worst case for equipment functionality and crew comfort. A few examples of land based temperature data sets are given below in A10/6 FIGURE 2 and the following pages. In these pages the temperatures for the location are given as four values for the 1st and the 15th of the month.

- MDAT = Mean Daily Average Temperature
- MDLT = Mean Daily Low Temperature
- Rec Lo = Lowest recorded temperature, for the given day, in the data set

- StDev(MDLT) = Standard Deviation of daily lows for that calendar day

Isotherms for the surface air temperature for latitudes north and south of roughly 50 to 60° are presented in Appendix 10, Figures 3 through 50. These isotherms represent the Mean Daily Average Temperature in °C.

The Mean Daily Average Temperature T_{DST} as defined in Section 1 of this Guide can be estimated from these maps.

Appendix 10, Figures 51 through 98 represent the Mean Daily Low Temperature in °C. These plots should not be used for determining temperatures in this Guide, but are included here for guidance with the estimation of the Polar Service Temperature (PST) in the IMO Polar Code. The Polar Code defines the PST as Lowest Mean Daily Low Temperature (Lowest MDLT) – 10°C.

These isotherms are developed using NOAA National Climatic Data Center hind cast data obtained from the National Operational Model Archive & Distribution System (http://nomads.ncdc.noaa.gov/). The data used was the Global Forecast System (GFS) 'Analysis-Only' with 4 data points per day and ranging from January 2004 to January 2014 and taken at the 2 m above surface level. The values on the isothermal plots compared to the station values may vary for the same location. If a station with temperature measurement data is available, the measured data is preferred over the hind cast data.

This data is provided for information only in determining the design service temperature for the vessel.

4 Humidity

As noted earlier, at extremely cold temperatures, the relative humidity in the air drops to well below that found typically elsewhere. Unless moderated by the vessel's HVAC system, dryness may cause crew discomfort. It may also increase the probability of static electricity build up and discharge, which can damage sensitive equipment and increase fire and explosion risk.

5 White Outs, Blizzards and Fog

Fog is commonly observed in areas of sea ice. Advection fog is a common occurrence in summer months when warm air masses pass over cold water areas and sea ice and the air mass cools below the vapor dew point.

Evaporation fog or steam fog is formed when water vaporisadded to air which is much colder than the vapor's source. This most commonly occurs when very cold air drifts across relatively warm water.

Blowing snow has a significant impact on visibility. Depending on grain size and compaction, visibility in snow at wind speeds over 35 knots becomes extremely limited, to a few meters in most cases.

6 Hours of Darkness

Although not strictly a weather condition, the extended hours of darkness at the higher latitudes during the winter months should not be ignored. Extra lighting capacity for deck operations and additional searchlight capability for safe navigation results from this limiting visibility. Additional deck watches for areas where sea ice and glacial ice may be encountered can cause crew fatigue and should be considered when operating in any ice-covered waters.

An opposite problem is the effect of almost continuous daylight during the summer months. Crew fatigue needs to be considered when operating for extended periods in ice conditions. Additional blinds for crewing quarters will provide proper resting periods. Ice blindness may be a risk for lookouts and bridge crew, who should be provided with appropriate eyewear.

Navigation lights should be of sufficient brightness to be visible in arctic lighting conditions.

FIGURE 2
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Aasiaat, Qaasuitsup, Greenland

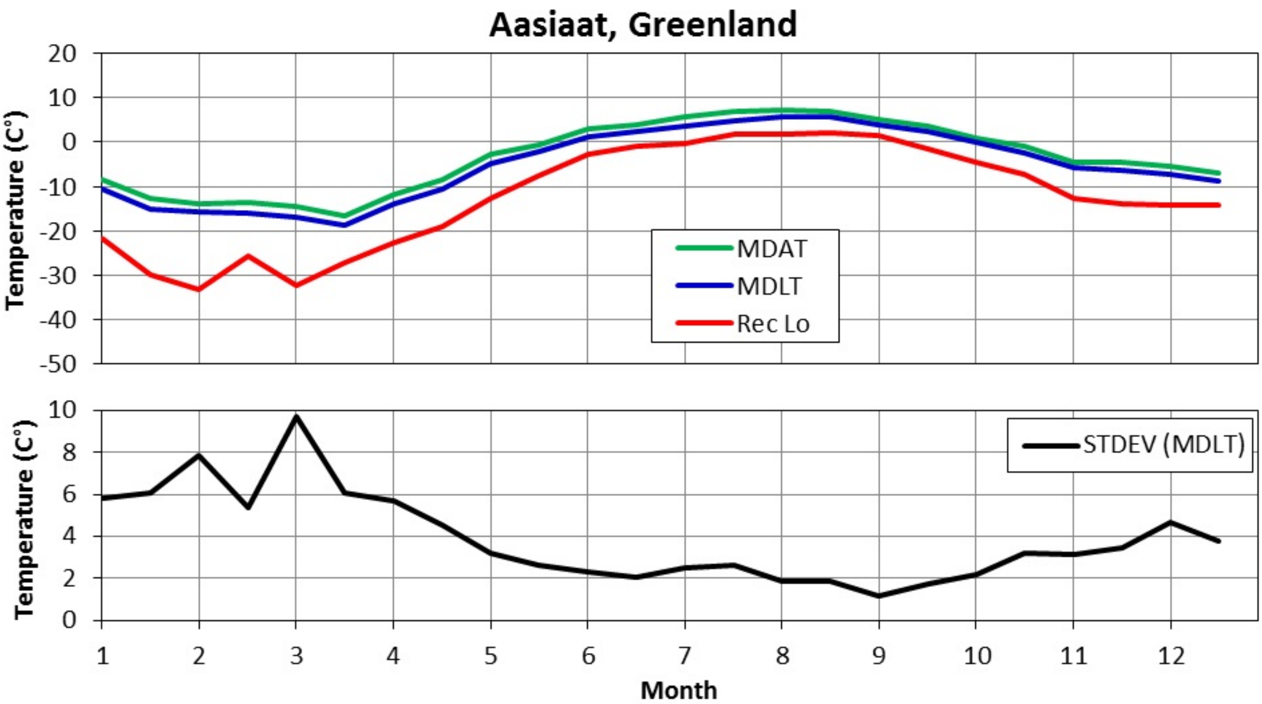
Coordinates: 68.7° N, 52.85° W

Elevation of Station: 41 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Jan. 1 1993 - Dec. 31, 2012



Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-8.61	-12.67	-13.82	-13.62	-14.58	-16.59	-11.93	-8.33
MDLT	-10.54	-14.97	-15.82	-16.16	-16.97	-18.75	-13.93	-10.61
Rec Lo	-21.80	-30.00	-33.20	-25.73	-32.20	-27.20	-22.60	-19.10
StDev (MDLT)	5.84	6.11	7.86	5.40	9.71	6.06	5.73	4.57

Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-2.83	-0.64	3.10	3.89	5.68	6.80	7.30	6.93
MDLT	-4.95	-2.16	1.20	2.35	3.71	4.85	5.82	5.56
Rec Lo	-12.80	-7.60	-2.60	-0.80	-0.30	1.90	1.80	2.00
StDev (MDLT)	3.23	2.63	2.29	2.06	2.53	2.62	1.88	1.83
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	5.01	3.56	0.88	-0.92	-4.48	-4.57	-5.56	-6.98
MDLT	3.77	2.48	-0.01	-2.36	-5.83	-6.32	-7.19	-8.70
Rec Lo	1.60	-1.50	-4.50	-7.40	-12.80	-13.87	-14.07	-14.20
StDev (MDLT)	1.17	1.74	2.19	3.19	3.14	3.49	4.65	3.79

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Alazeja River, Russia

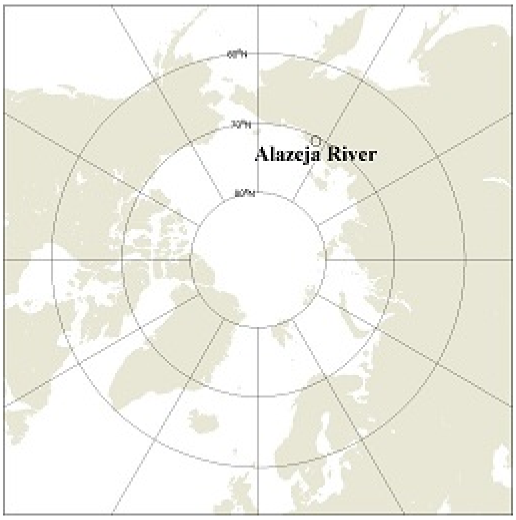
Coordinates: 70.55° N, 154.15° W

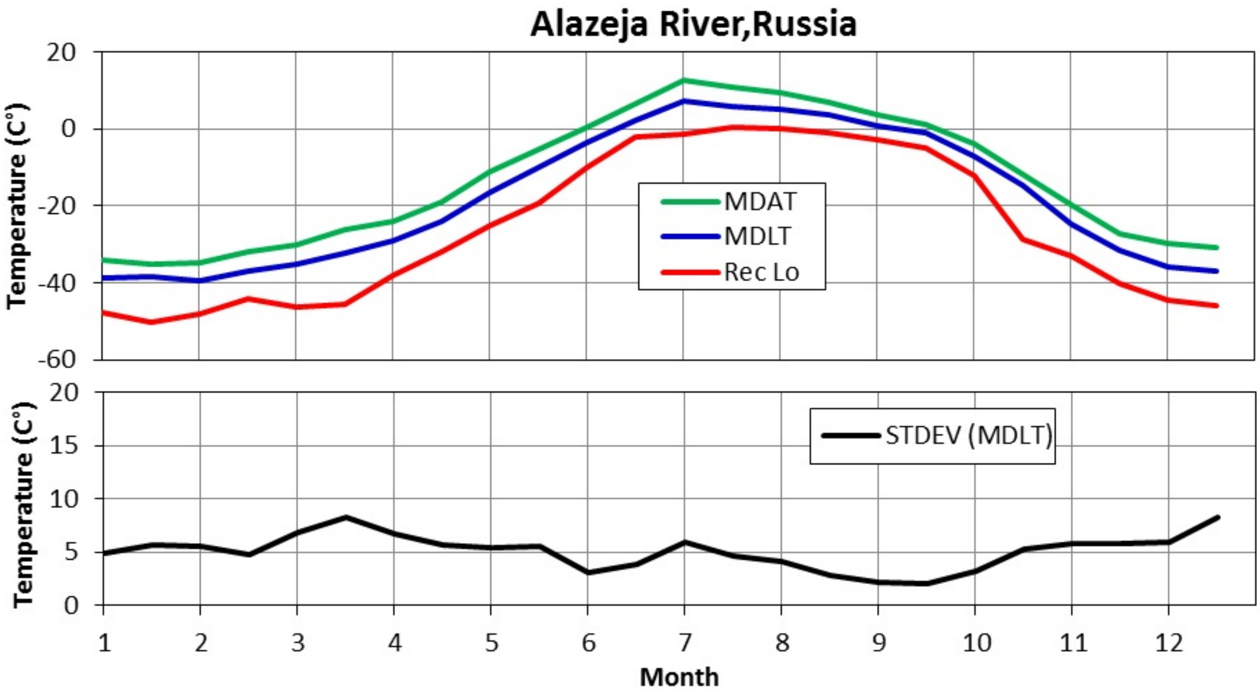
Elevation of Station: 2 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Full year of 1963, 1969-1981, & 1983-1990

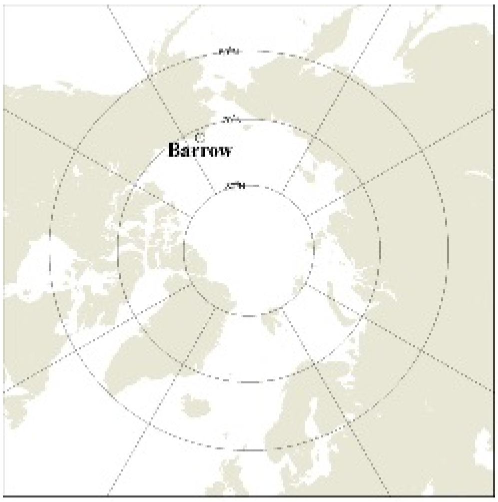


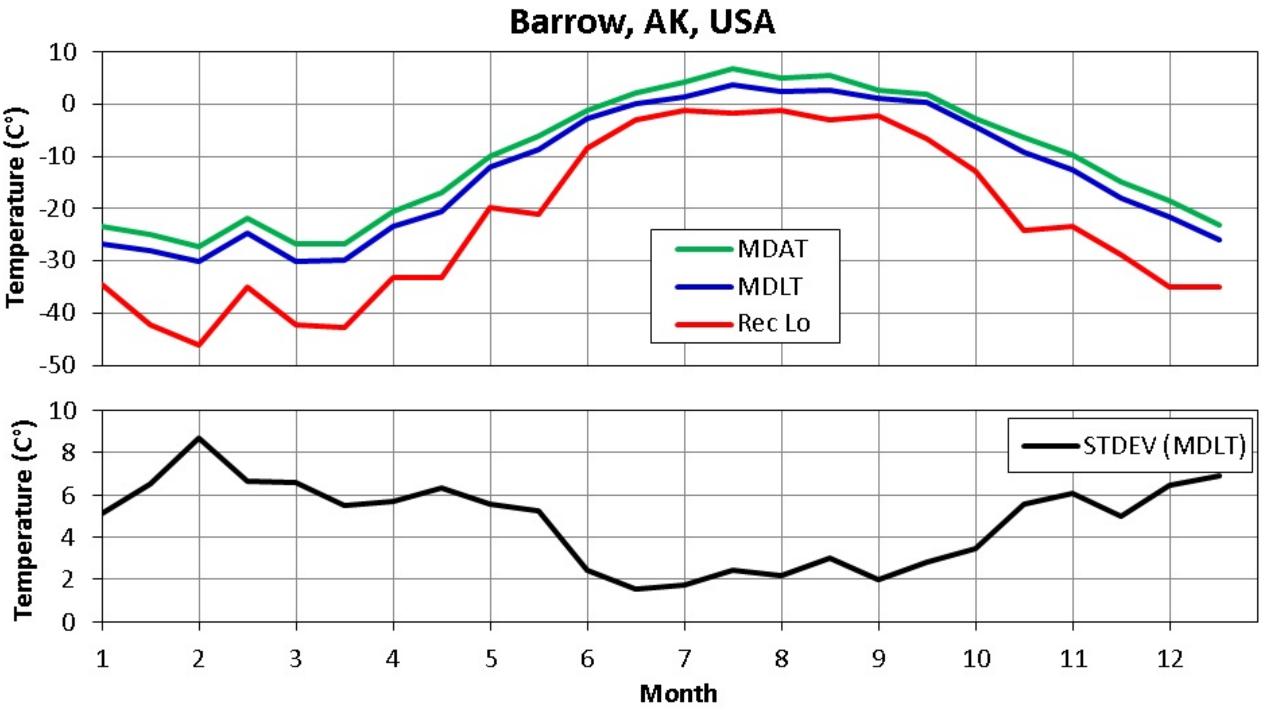


Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-34.11	-35.04	-34.79	-31.98	-30.02	-26.22	-23.97	-18.86
MDLT	-38.79	-38.51	-39.33	-36.76	-35.25	-32.20	-29.15	-24.11
Rec Lo	-47.70	-50.30	-48.00	-44.00	-46.40	-45.40	-38.00	-32.00
StDev (MDLT)	4.91	5.69	5.60	4.81	6.85	8.24	6.65	5.65
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-11.04	-5.39	0.46	6.38	12.65	10.88	9.26	6.88
MDLT	-16.52	-9.89	-3.54	2.11	7.11	5.99	5.13	3.49
Rec Lo	-25.00	-19.20	-10.00	-2.20	-1.20	0.30	0.00	-1.00
StDev (MDLT)	5.37	5.51	3.05	3.89	5.99	4.66	4.12	2.87
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	3.76	1.33	-4.02	-11.83	-19.69	-27.07	-29.91	-30.89
MDLT	0.96	-0.88	-7.09	-14.53	-24.59	-31.45	-35.67	-37.00
Rec Lo	-2.80	-5.00	-12.20	-28.50	-33.00	-40.10	-44.50	-46.00
StDev (MDLT)	2.23	2.08	3.23	5.28	5.83	5.84	5.87	8.23

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station:	Barrow, AK, USA
Coordinates:	71.283° N, 156.782° W
Elevation of Station:	4 m
Data Source:	NOAA CDO
Data Frequency:	Hourly
Data Time Span:	Jan. 1 1993 - Dec. 31, 2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-23.43	-24.81	-27.34	-21.91	-26.87	-26.66	-20.55	-16.81
MDLT	-26.71	-28.11	-29.99	-24.71	-30.05	-29.80	-23.32	-20.62
Rec Lo	-34.40	-42.20	-46.10	-35.00	-42.20	-42.80	-33.10	-33.30
StDev (MDLT)	4.97	6.55	8.19	7.14	6.62	5.13	5.70	5.36
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*

MDAT	-10.07	-6.19	-1.14	2.31	4.25	6.90	5.00	5.48
MDLT	-11.99	-8.60	-2.63	0.11	1.40	3.71	2.39	2.73
Rec Lo	-19.80	-21.00	-8.40	-3.00	-1.10	-1.70	-1.10	-3.00
StDev (MDLT)	5.22	4.02	2.71	2.16	3.00	3.03	2.45	3.07
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	2.80	1.83	-2.74	-6.36	-9.71	-14.79	-18.39	-23.00
MDLT	1.22	0.35	-4.27	-9.27	-12.56	-17.98	-21.46	-26.04
Rec Lo	-2.20	-6.70	-12.80	-24.20	-23.40	-28.90	-35.00	-35.00
StDev (MDLT)	2.51	2.96	2.79	4.78	5.17	4.42	5.76	6.44

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Clyde, Nunavut, Canada

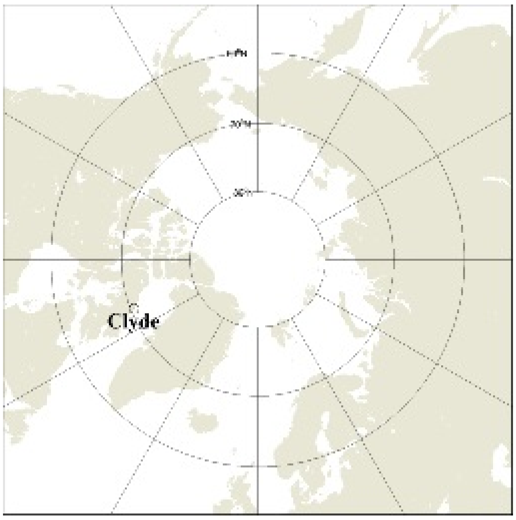
Coordinates: 70.483° N, 68.517° W

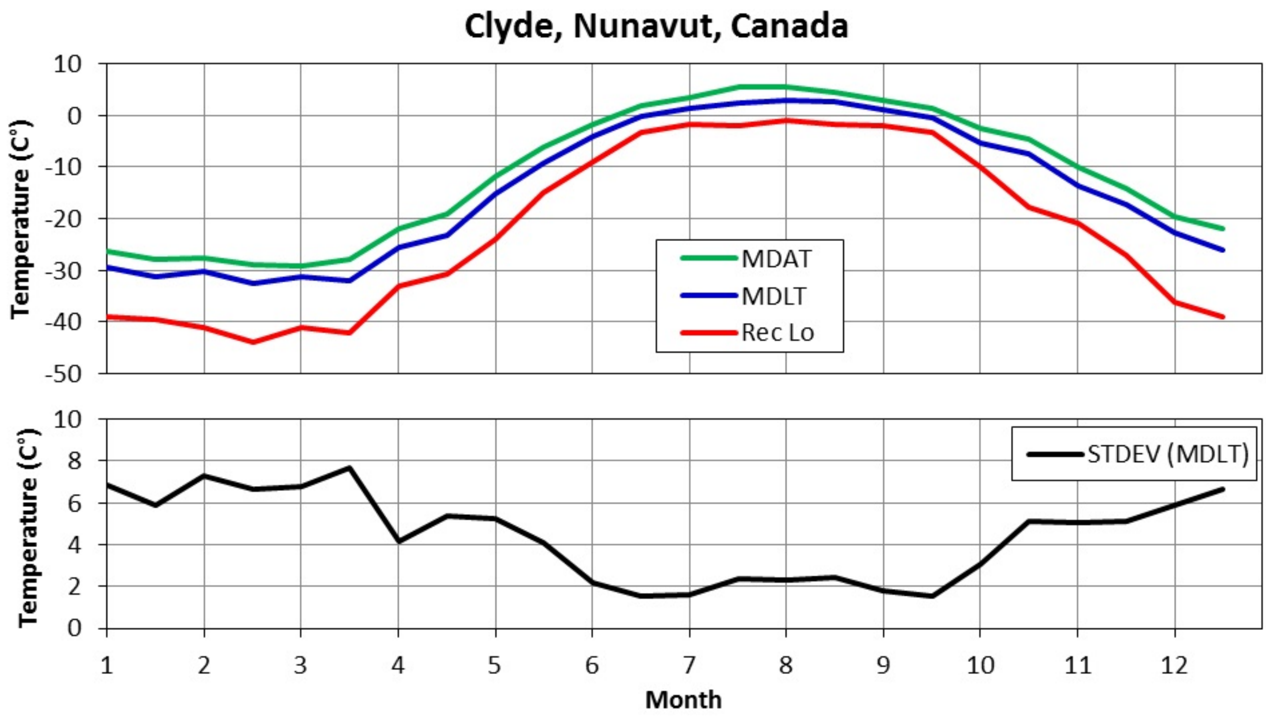
Elevation of Station: 27 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1992-1996 & 1998-2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-26.34	-27.97	-27.48	-28.99	-29.08	-27.91	-22.02	-18.99
MDLT	-29.37	-31.17	-30.32	-32.51	-31.25	-31.90	-25.52	-23.33
Rec Lo	-39.00	-39.60	-41.00	-44.00	-41.00	-42.00	-33.00	-30.80
StDev (MDLT)	6.85	5.89	7.32	6.63	6.81	7.71	4.18	5.37
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-11.80	-6.09	-1.85	1.78	3.45	5.62	5.57	4.53
MDLT	-15.13	-9.24	-4.00	-0.20	1.39	2.28	2.97	2.64
Rec Lo	-24.00	-15.00	-9.00	-3.40	-1.70	-1.90	-1.00	-1.70
StDev (MDLT)	5.22	4.13	2.18	1.55	1.60	2.38	2.30	2.44
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	2.86	1.45	-2.62	-4.70	-10.07	-14.17	-19.59	-21.88
MDLT	1.19	-0.42	-5.43	-7.53	-13.51	-17.15	-22.70	-26.05
Rec Lo	-2.10	-3.20	-10.00	-17.70	-21.00	-27.00	-36.20	-39.00
StDev (MDLT)	1.83	1.56	3.09	5.13	5.08	5.12	5.89	6.67

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Golomjannyj, Russia

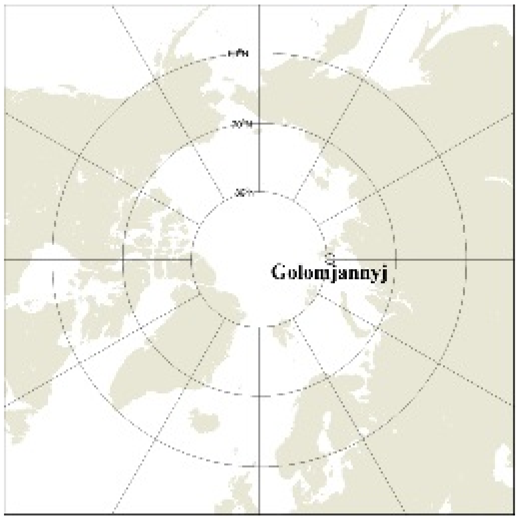
Coordinates: 79.55° N, 90.567° E

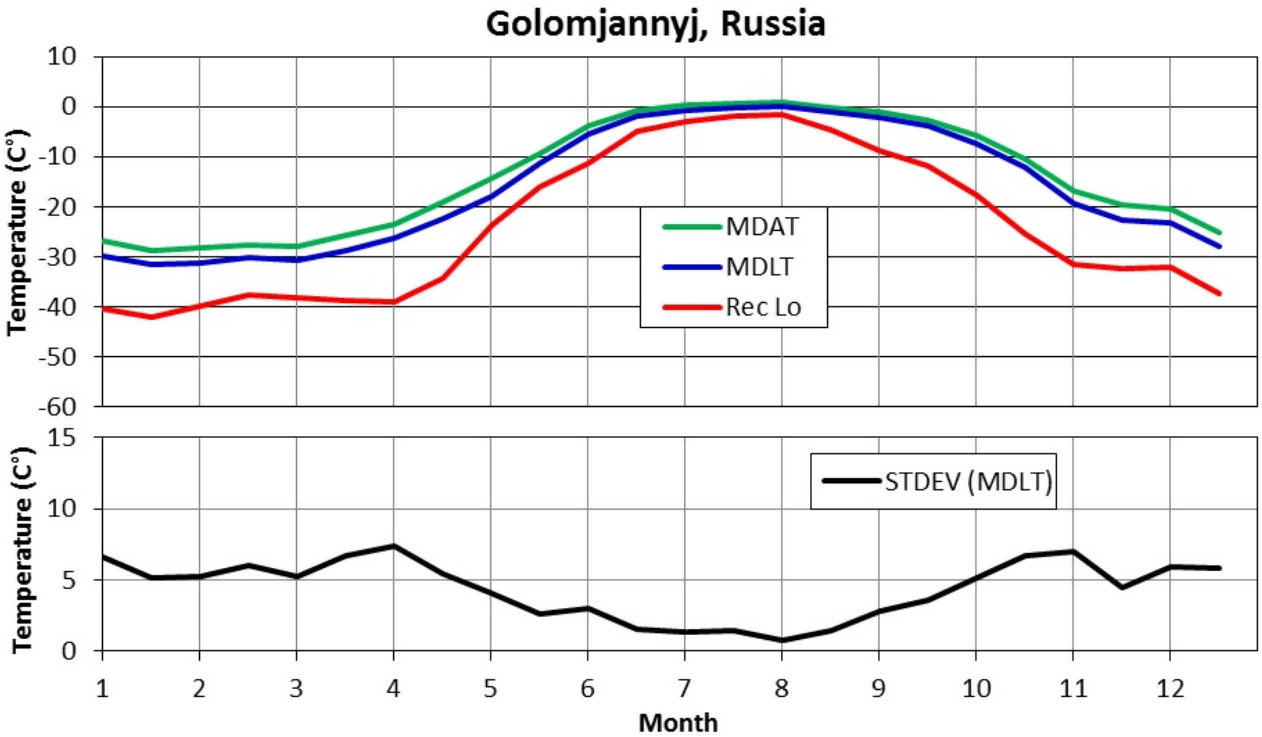
Elevation of Station: 8 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1991-1999, 2001-2007, & 2009-2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-26.81	-28.91	-28.09	-27.68	-28.06	-25.86	-23.39	-19.20
MDLT	-29.99	-31.42	-31.30	-30.27	-30.60	-28.70	-26.26	-22.50
Rec Lo	-40.40	-42.20	-40.00	-37.70	-38.20	-38.90	-39.00	-34.37
StDev (MDLT)	6.61	5.16	5.20	6.05	5.28	6.70	7.38	5.42

Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-14.44	-9.33	-3.87	-0.80	0.39	0.50	0.87	-0.12
MDLT	-18.07	-11.27	-5.49	-1.99	-0.72	-0.14	0.04	-1.01
Rec Lo	-23.90	-15.90	-11.40	-4.80	-3.10	-2.00	-1.50	-4.60
StDev (MDLT)	4.06	2.62	3.00	1.57	1.33	1.44	0.79	1.43
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	-1.11	-2.62	-5.88	-10.38	-16.83	-19.68	-20.58	-25.30
MDLT	-2.21	-3.89	-7.39	-12.10	-19.35	-22.78	-23.25	-27.82
Rec Lo	-8.80	-11.80	-17.70	-25.57	-31.47	-32.40	-32.20	-37.30
StDev (MDLT)	2.76	3.53	5.16	6.73	6.97	4.45	5.93	5.79

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: IM. M.V. Popova, Russia

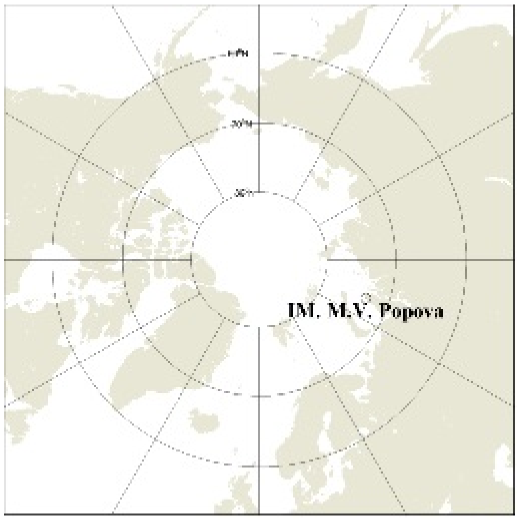
Coordinates: 73.333° N, 70.05° E

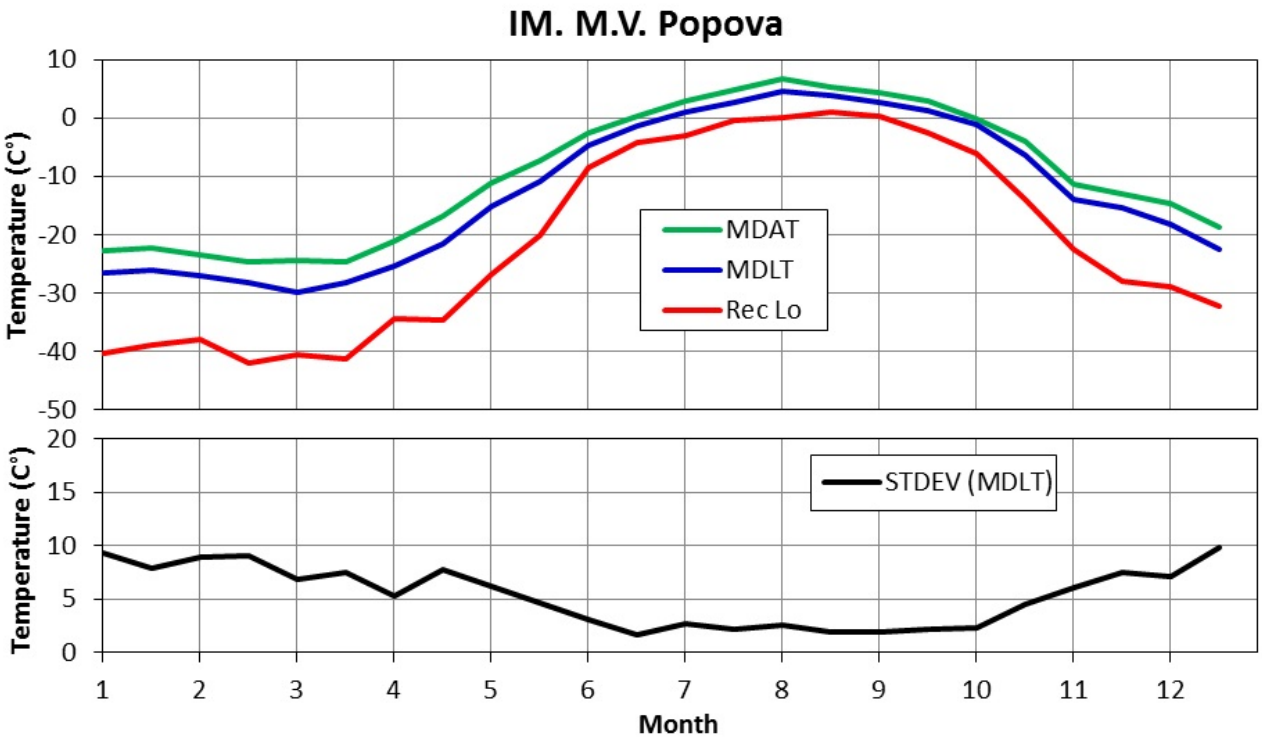
Elevation of Station: 7 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1980-1990 & 2004-2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-22.70	-22.24	-23.40	-24.69	-24.54	-24.56	-21.09	-16.72
MDLT	-26.58	-26.20	-27.04	-28.16	-29.87	-28.35	-25.47	-21.57
Rec Lo	-40.43	-38.90	-38.07	-41.97	-40.70	-41.33	-34.33	-34.63
StDev (MDLT)	9.31	7.88	8.86	9.09	6.83	7.51	5.34	7.73
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-11.05	-7.24	-2.61	0.22	2.84	4.78	6.61	5.39
MDLT	-15.11	-10.97	-4.60	-1.26	0.97	2.78	4.68	3.78
Rec Lo	-26.90	-20.20	-8.60	-4.20	-3.00	-0.50	0.00	1.00
StDev (MDLT)	6.25	4.65	3.03	1.62	2.63	2.20	2.53	1.90
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	4.34	2.80	-0.12	-3.93	-11.29	-13.03	-14.60	-18.62
MDLT	2.75	1.28	-1.05	-6.25	-13.90	-15.49	-18.19	-22.63
Rec Lo	0.30	-2.50	-6.10	-14.03	-22.53	-27.93	-29.00	-32.38
StDev (MDLT)	1.86	2.17	2.32	4.56	6.01	7.47	7.11	9.79

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Malye Karmakuly, Russia

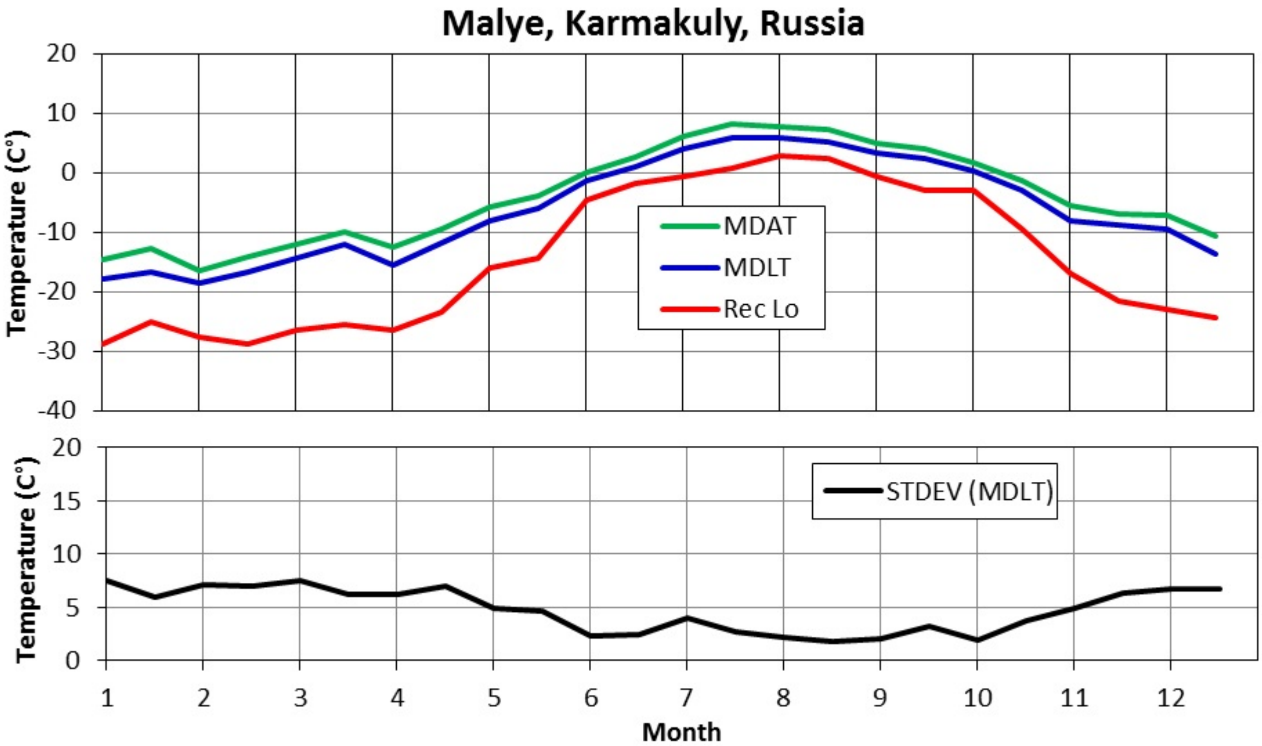
Coordinates: 72.367° N, 52.7° E

Elevation of Station: 15 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1987-1996, 1998-1999, 2002-2003 & 2007-2012



Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-14.55	-12.81	-16.42	-14.10	-12.09	-10.03	-12.59	-9.45
MDLT	-17.78	-16.69	-18.69	-16.79	-14.30	-12.17	-15.62	-11.87
Rec Lo	-28.90	-25.10	-27.63	-28.90	-26.50	-25.50	-26.50	-23.43
StDev (MDLT)	7.55	5.93	7.07	6.94	7.47	6.20	6.18	6.96

Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-5.83	-3.87	-0.06	2.70	6.11	8.27	7.70	7.14
MDLT	-8.22	-5.92	-1.38	1.01	4.06	5.97	5.97	5.20
Rec Lo	-15.97	-14.50	-4.70	-1.90	-0.60	0.70	2.87	2.39
StDev (MDLT)	4.92	4.68	2.26	2.46	4.00	2.69	2.19	1.72
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	4.89	4.00	1.76	-1.39	-5.65	-6.86	-7.15	-10.68
MDLT	3.23	2.35	0.37	-2.97	-7.99	-8.71	-9.43	-13.66
Rec Lo	-0.67	-3.00	-3.07	-9.40	-16.83	-21.70	-23.00	-24.30
StDev (MDLT)	2.09	3.25	1.95	3.70	4.91	6.30	6.68	6.77

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: MYS Uelen, Chukotka Autonomous, Russia

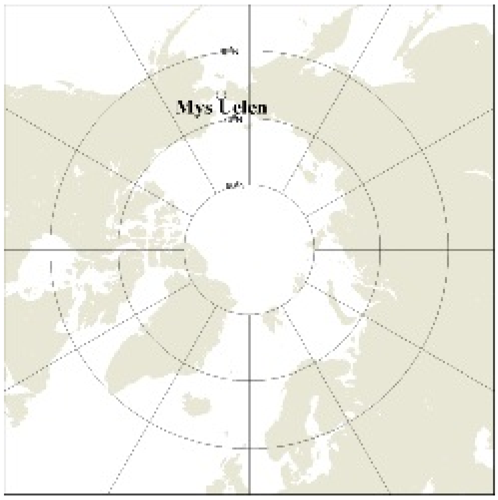
Coordinates: 66.15° N, 169.833° W

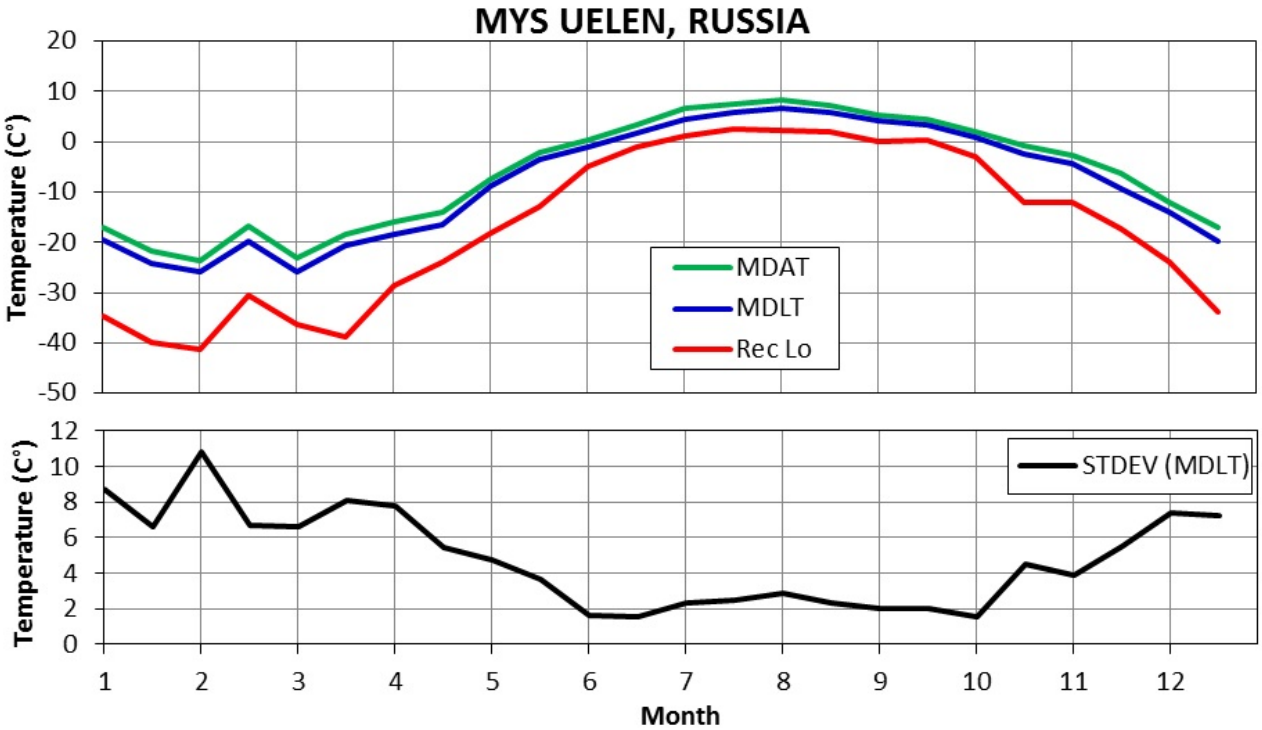
Elevation of Station: 3 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Jan. 1, 1993 - Dec. 31, 2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-16.94	-21.71	-23.61	-16.91	-23.07	-18.43	-16.06	-14.10
MDLT	-19.55	-24.25	-25.76	-19.91	-25.93	-20.62	-18.49	-16.63
Rec Lo	-34.67	-39.83	-41.40	-30.50	-36.30	-38.70	-28.50	-23.80
StDev (MDLT)	8.69	6.63	10.84	6.67	6.60	8.09	7.80	5.43
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-7.46	-2.13	0.24	3.25	6.60	7.37	8.21	7.24
MDLT	-8.84	-3.52	-1.03	1.56	4.49	5.84	6.57	5.72
Rec Lo	-18.10	-13.00	-4.90	-1.20	1.10	2.60	2.20	2.00
StDev (MDLT)	4.71	3.65	1.65	1.55	2.33	2.48	2.83	2.32
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	5.18	4.55	1.85	-0.89	-2.72	-6.28	-11.98	-16.92
MDLT	4.19	3.36	0.90	-2.42	-4.27	-9.21	-14.02	-19.67
Rec Lo	0.00	0.20	-3.00	-12.00	-12.00	-17.40	-23.80	-33.80
StDev (MDLT)	2.00	2.02	1.55	4.53	3.90	5.47	7.35	7.26

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Ostrov Kotelnyj, Russia

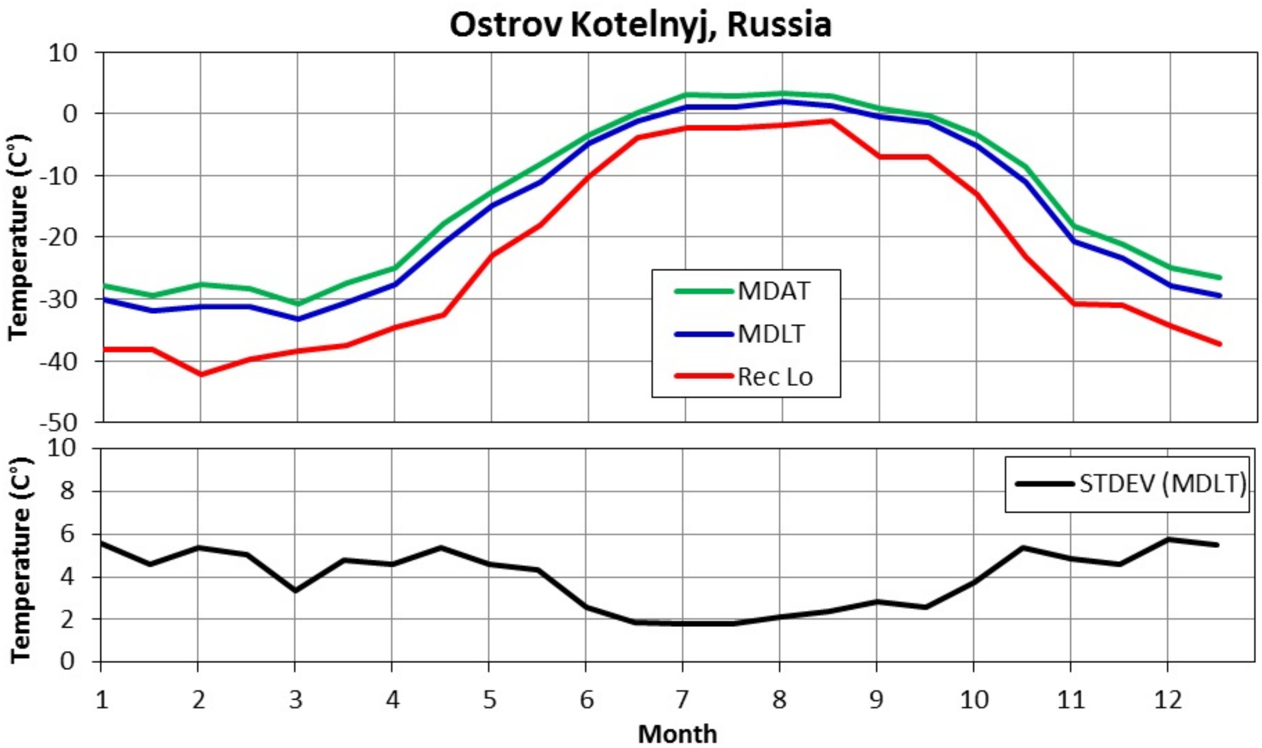
Coordinates: 76° N, 137.867° E

Elevation of Station: 8 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1987-1997 & 2004-2012



Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-27.76	-29.52	-27.57	-28.25	-30.78	-27.30	-24.84	-17.68
MDLT	-30.15	-31.89	-31.24	-31.18	-33.19	-30.53	-27.60	-20.88
Rec Lo	-38.20	-38.10	-42.30	-39.80	-38.30	-37.50	-34.60	-32.50
StDev (MDLT)	5.59	4.56	5.35	5.02	3.35	4.76	4.61	5.35

Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-12.58	-8.18	-3.35	0.22	3.14	2.77	3.20	2.86
MDLT	-14.95	-10.95	-4.69	-1.14	1.06	1.15	1.89	1.34
Rec Lo	-22.90	-18.00	-10.10	-3.80	-2.40	-2.20	-1.80	-1.20
StDev (MDLT)	4.60	4.34	2.55	1.86	1.77	1.77	2.12	2.38
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	0.94	-0.33	-3.41	-8.56	-18.20	-21.17	-24.93	-26.40
MDLT	-0.50	-1.45	-5.14	-10.98	-20.64	-23.34	-27.95	-29.31
Rec Lo	-6.90	-6.90	-13.10	-23.20	-30.70	-31.00	-34.30	-37.30
StDev (MDLT)	2.81	2.59	3.76	5.38	4.82	4.62	5.73	5.52

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Pelly Island, Northwest Territories, Canada

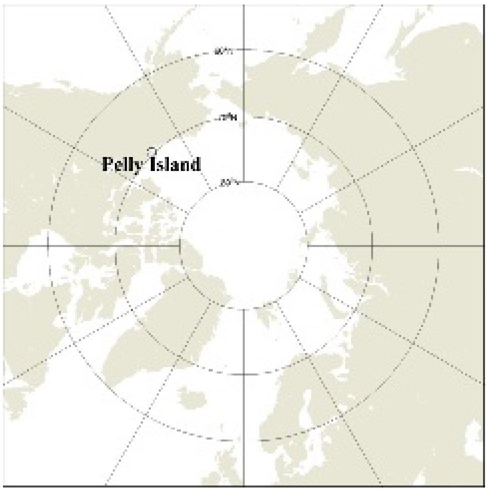
Coordinates: 69.633° N, 135.433° W

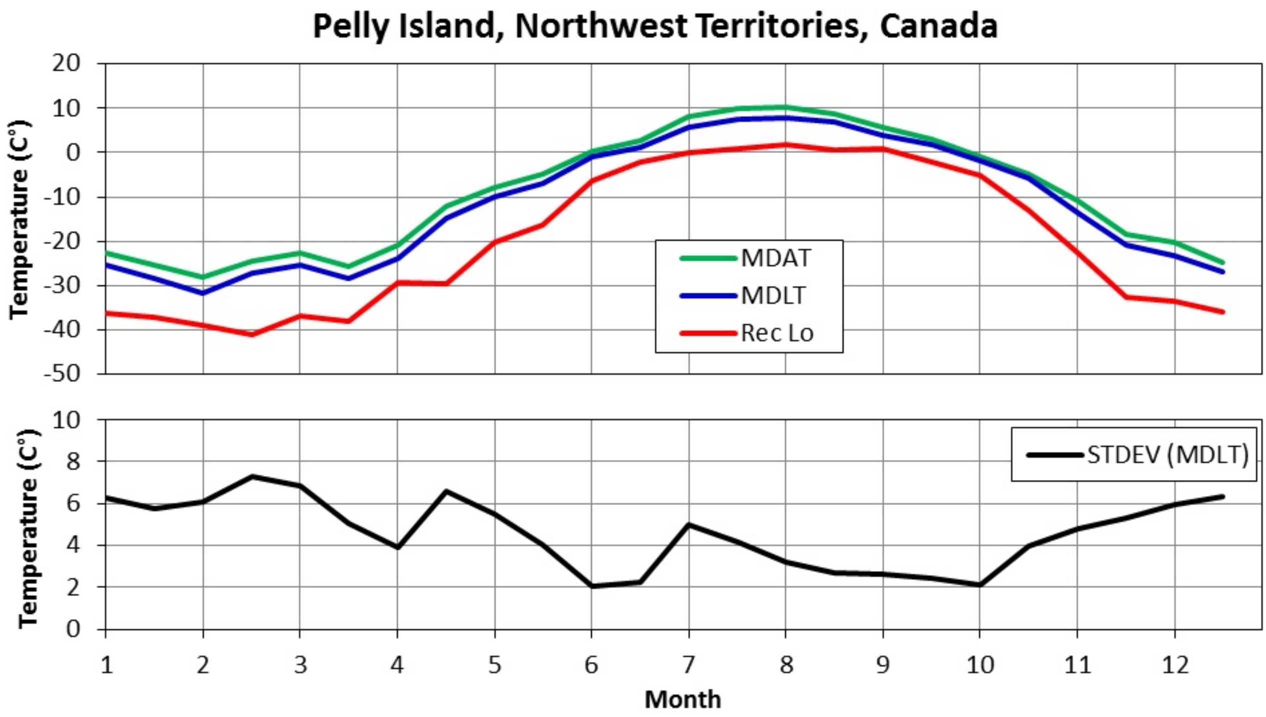
Elevation of Station: 12 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: 1987-1995, 1998-2003, 2008-2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-22.59	-25.42	-28.20	-24.51	-22.78	-25.82	-20.81	-12.01
MDLT	-25.53	-28.42	-31.68	-27.07	-25.28	-28.44	-23.88	-14.92
Rec Lo	-36.30	-37.20	-39.00	-41.10	-37.00	-38.00	-29.30	-29.60
StDev (MDLT)	6.25	5.76	6.09	7.31	6.83	5.04	3.88	6.56
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-7.77	-4.87	0.35	2.64	8.11	10.07	10.22	8.69
MDLT	-9.91	-6.86	-0.89	1.14	5.56	7.61	7.72	6.92
Rec Lo	-20.30	-16.40	-6.30	-2.00	0.00	1.00	1.90	0.70
StDev (MDLT)	5.53	4.02	2.03	2.22	5.01	4.16	3.20	2.67
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	5.74	3.12	-0.81	-4.89	-11.00	-18.42	-20.33	-24.69
MDLT	3.82	1.92	-1.80	-5.72	-13.72	-20.72	-23.16	-26.94
Rec Lo	0.80	-2.00	-5.10	-13.00	-22.60	-32.50	-33.48	-35.90
StDev (MDLT)	2.62	2.45	2.14	3.96	4.81	5.30	5.96	6.34

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Resolute, Nunavut, Canada

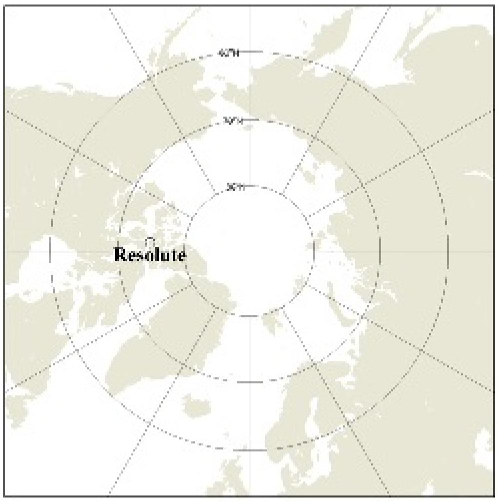
Coordinates: 74.717° N, 94.983° W

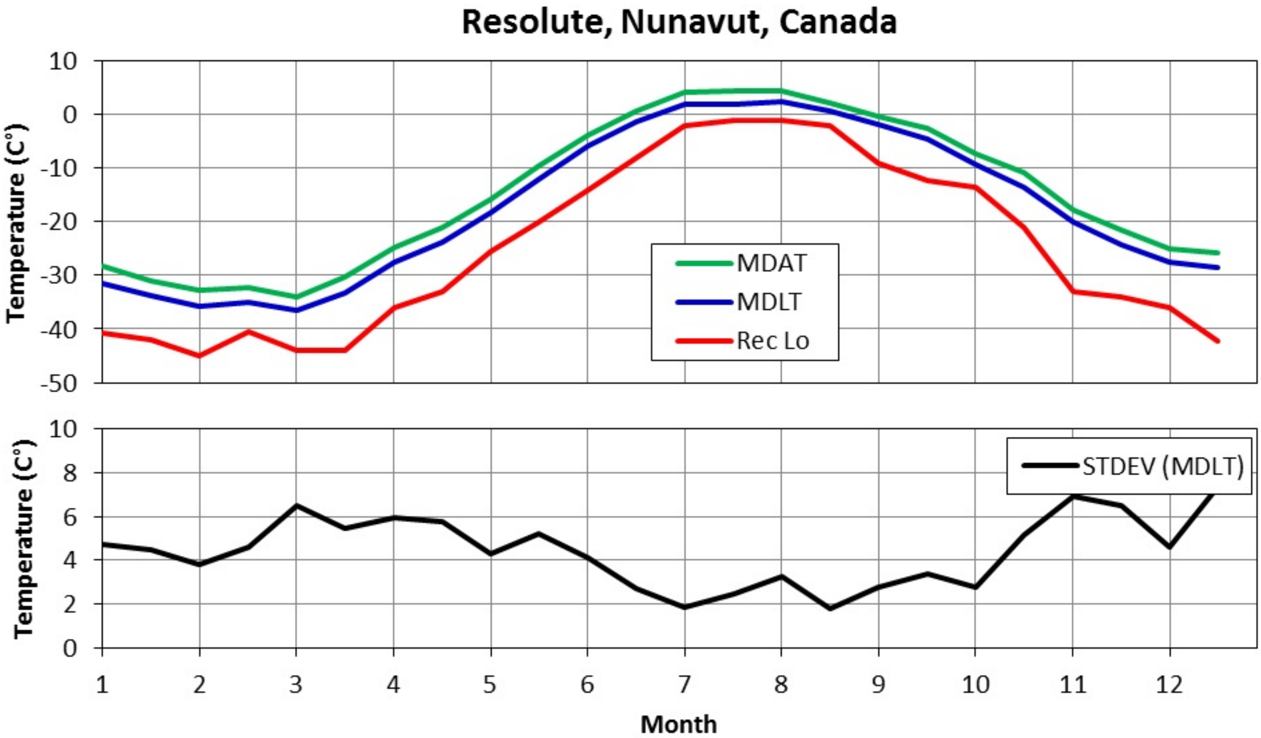
Elevation of Station: 67.7 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Jan. 1, 1992 - Dec. 31, 2011





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-28.30	-31.14	-32.66	-32.37	-34.03	-30.38	-24.86	-20.94
MDLT	-31.49	-33.87	-35.82	-35.10	-36.56	-33.16	-27.55	-23.71
Rec Lo	-40.80	-42.00	-45.00	-40.50	-44.00	-44.00	-36.00	-33.00
StDev (MDLT)	4.74	4.47	3.79	4.60	6.52	5.43	5.98	5.75

Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	-15.77	-9.45	-3.89	0.60	4.31	4.35	4.33	2.24
MDLT	-18.32	-11.96	-5.87	-1.21	2.01	2.03	2.47	0.57
Rec Lo	-25.60	-20.00	-14.00	-8.00	-2.00	-1.00	-1.00	-2.00
StDev (MDLT)	4.27	5.23	4.14	2.71	1.83	2.45	3.25	1.79
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	-0.21	-2.66	-7.22	-10.91	-17.81	-21.58	-25.07	-25.79
MDLT	-1.92	-4.62	-9.29	-13.56	-20.00	-24.38	-27.44	-28.63
Rec Lo	-9.00	-12.20	-13.50	-21.00	-33.00	-34.00	-36.00	-42.30
StDev (MDLT)	2.75	3.39	2.79	5.14	6.93	6.47	4.59	7.36

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Reykjavik, Iceland

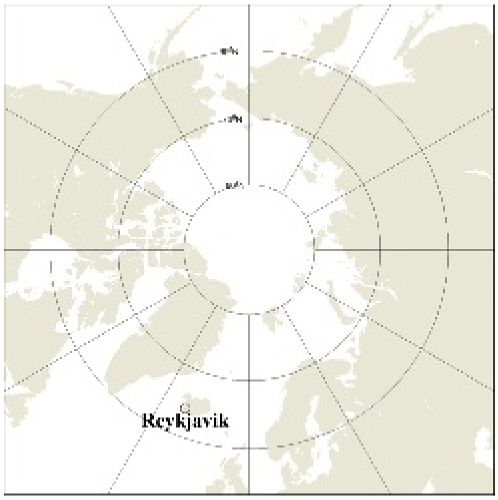
Coordinates: 64.132° N, 21.933° W

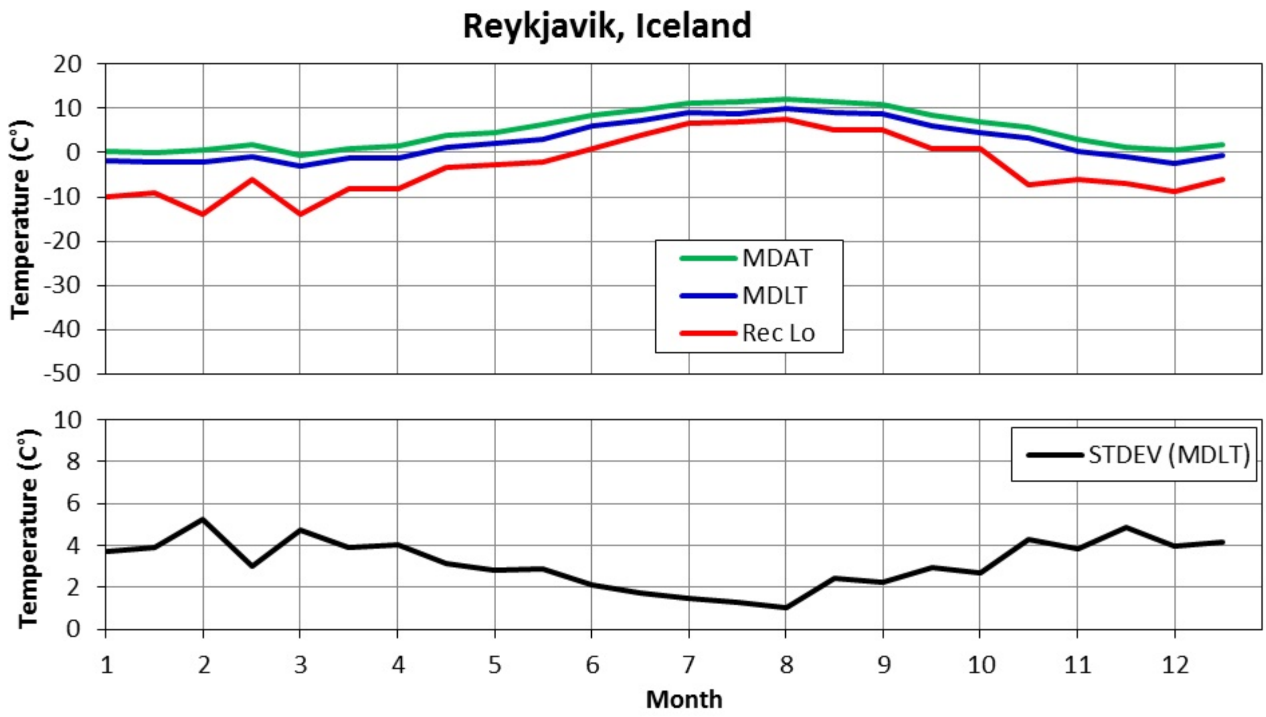
Elevation of Station: 61 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Jan. 1, 1993 - Dec. 31, 2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	0.25	-0.02	0.60	1.87	-0.58	0.85	1.55	3.82
MDLT	-1.94	-2.07	-2.17	-0.82	-3.13	-1.38	-1.21	1.25
Rec Lo	-10.00	-9.00	-14.00	-6.00	-14.00	-8.30	-8.30	-3.40
StDev (MDLT)	3.69	3.90	5.24	2.99	4.73	3.88	4.04	3.13
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	4.57	6.21	8.50	9.70	11.20	11.36	12.19	11.43
MDLT	1.96	3.04	6.00	7.10	9.00	8.71	9.86	8.92
Rec Lo	-2.70	-2.20	1.00	4.00	6.60	7.00	7.40	5.00
StDev (MDLT)	2.85	2.87	2.14	1.71	1.51	1.27	1.06	2.45
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	10.83	8.48	6.98	5.67	3.09	1.26	0.51	1.93
MDLT	8.61	6.09	4.39	3.21	0.35	-1.04	-2.46	-0.54
Rec Lo	5.00	1.00	1.00	-7.20	-6.20	-7.00	-8.70	-6.00
StDev (MDLT)	2.22	2.96	2.67	4.31	3.82	4.88	3.98	4.14

FIGURE 2 (continued)
Arctic Locations for Land Based Temperature Data Sets *(1 September 2015)*

Station: Tromso, Langnes, Norway

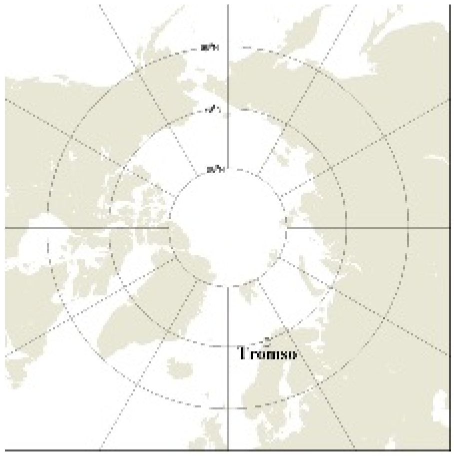
Coordinates: 69.683° N, 18.917° E

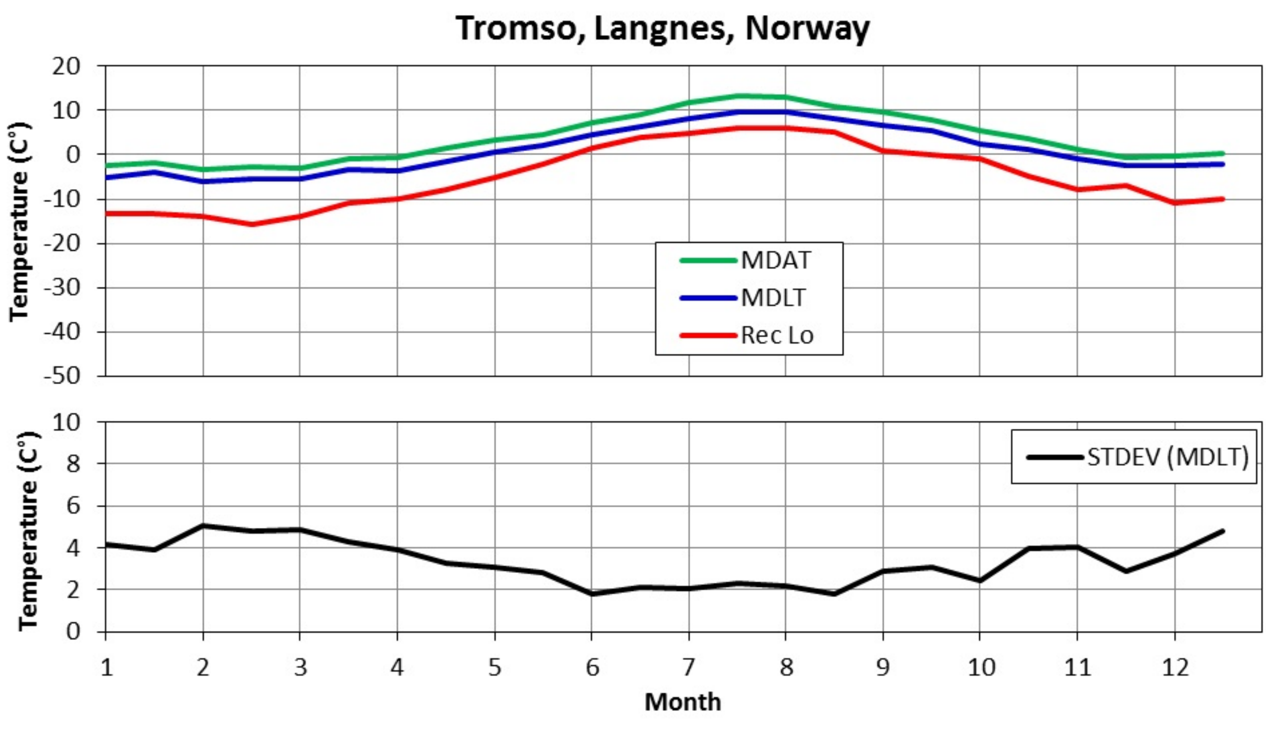
Elevation of Station: 10 m

Data Source: NOAA CDO

Data Frequency: Hourly

Data Time Span: Jan. 1, 1993 - Dec. 31, 2012





Parameter	*1-Jan*	*15-Jan*	*1-Feb*	*15-Feb*	*1-Mar*	*15-Mar*	*1-Apr*	*15-Apr*
MDAT	-2.40	-1.69	-3.20	-2.65	-3.09	-0.92	-0.58	1.46
MDLT	-5.20	-3.97	-6.04	-5.35	-5.44	-3.27	-3.69	-1.49
Rec Lo	-13.30	-13.30	-14.00	-15.80	-14.00	-11.00	-10.00	-8.00
StDev (MDLT)	4.17	3.92	5.08	4.83	4.84	4.32	3.93	3.27
Parameter	*1-May*	*15-May*	*1-Jun*	*15-Jun*	*1-Jul*	*15-Jul*	*1-Aug*	*15-Aug*
MDAT	3.32	4.62	7.07	8.91	11.77	13.32	12.88	10.99

MDLT	0.50	1.98	4.45	6.46	8.10	9.69	9.78	8.13
Rec Lo	-5.10	-2.00	1.60	4.00	4.70	6.00	6.00	5.00
StDev (MDLT)	3.05	2.82	1.77	2.09	2.06	2.30	2.16	1.83
Parameter	*1-Sep*	*15-Sep*	*1-Oct*	*15-Oct*	*1-Nov*	*15-Nov*	*1-Dec*	*15-Dec*
MDAT	9.75	7.86	5.37	3.70	1.24	-0.63	-0.21	0.20
MDLT	6.77	5.38	2.37	1.17	-0.92	-2.56	-2.54	-2.19
Rec Lo	0.80	0.00	-1.00	-5.00	-8.00	-7.00	-11.00	-10.00
StDev (MDLT)	2.91	3.09	2.45	3.95	4.00	2.88	3.74	4.83

FIGURE 3
Arctic Mean Daily Average Temperature (MDAT) in °C for January 1st
(1 September 2015)

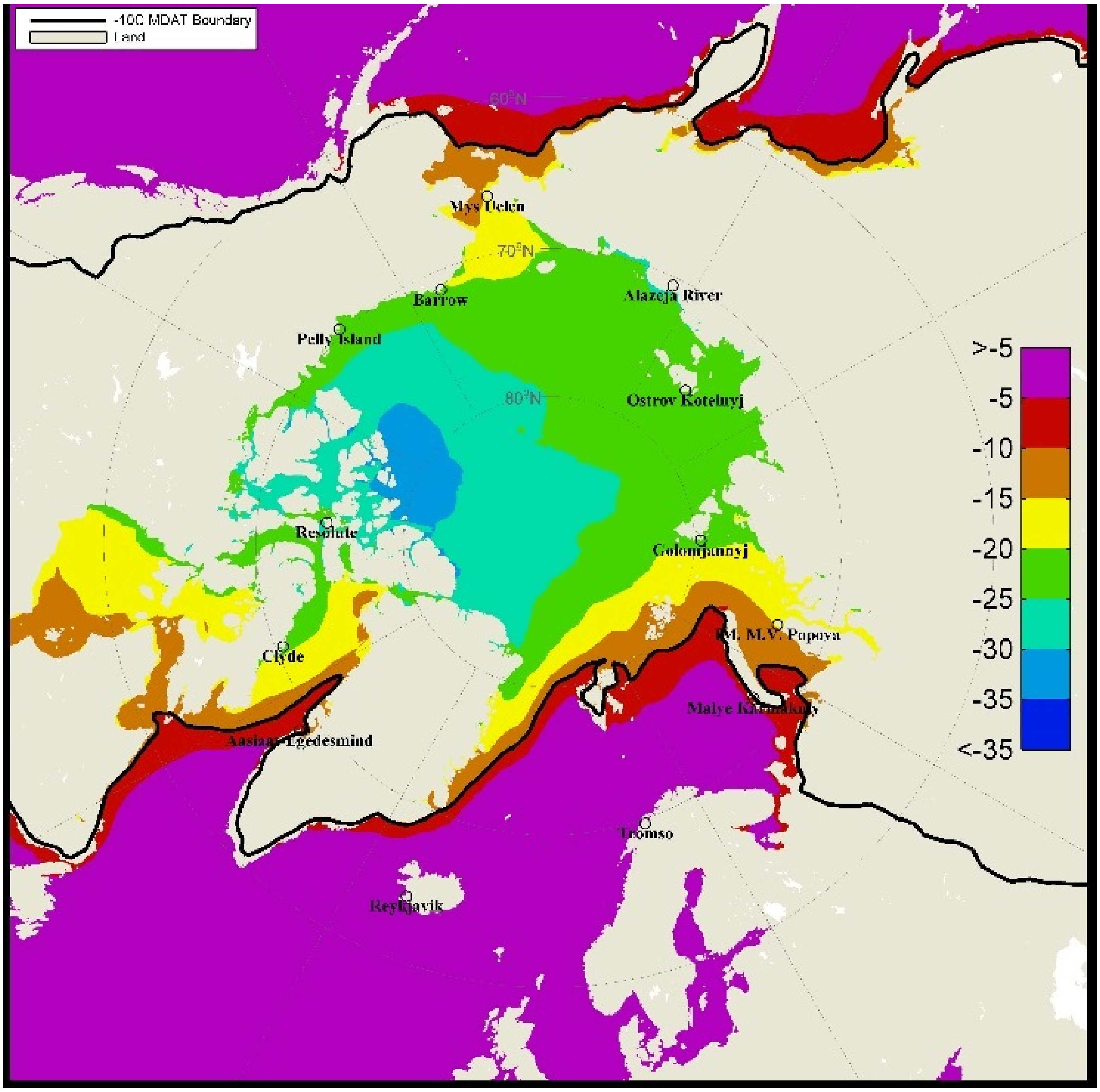


FIGURE 4
Arctic Mean Daily Average Temperature (MDAT) in °C for January 15th
(1 September 2015)

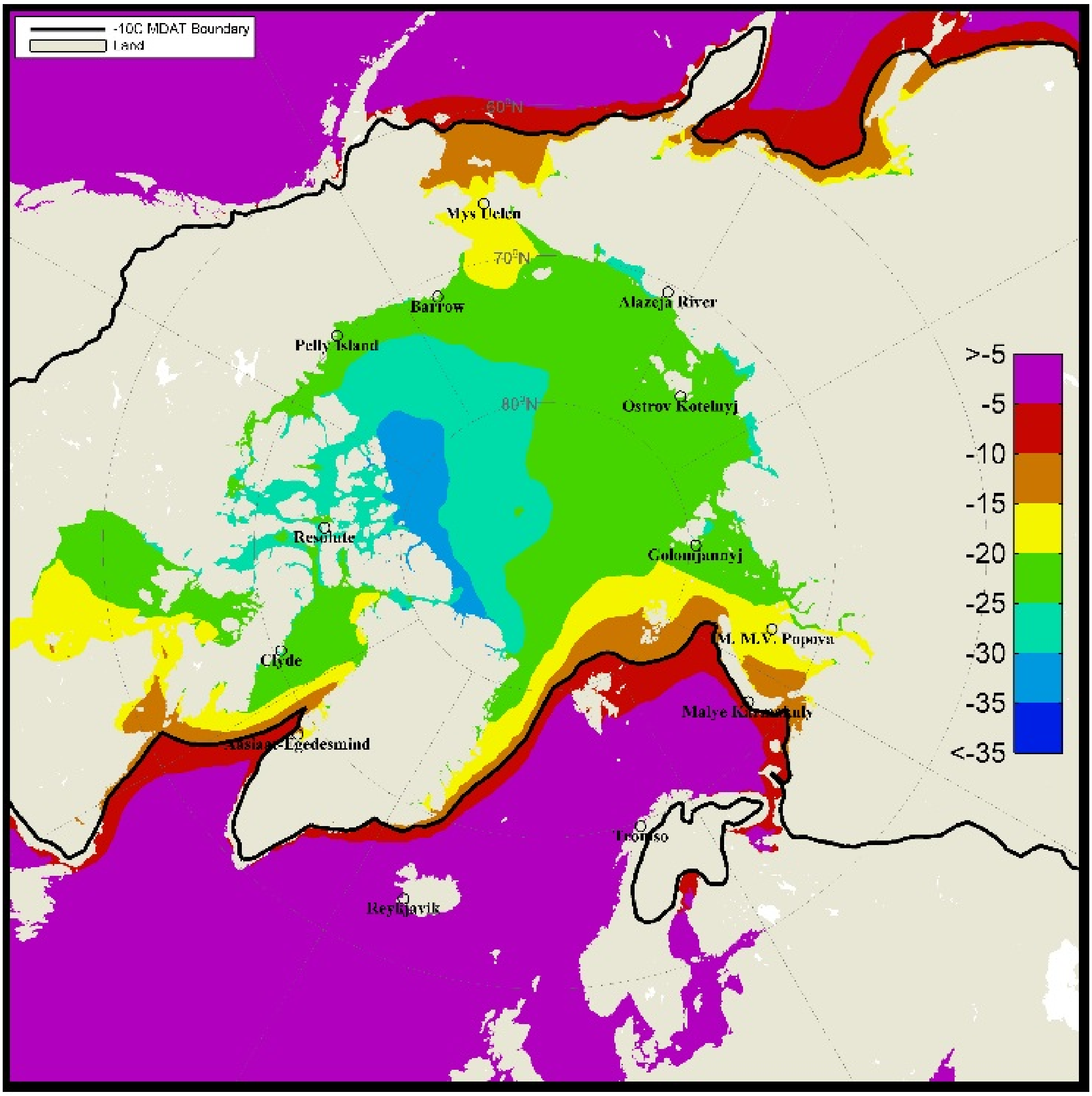


FIGURE 5
Arctic Mean Daily Average Temperature (MDAT) in °C for February 1st
(1 September 2015)

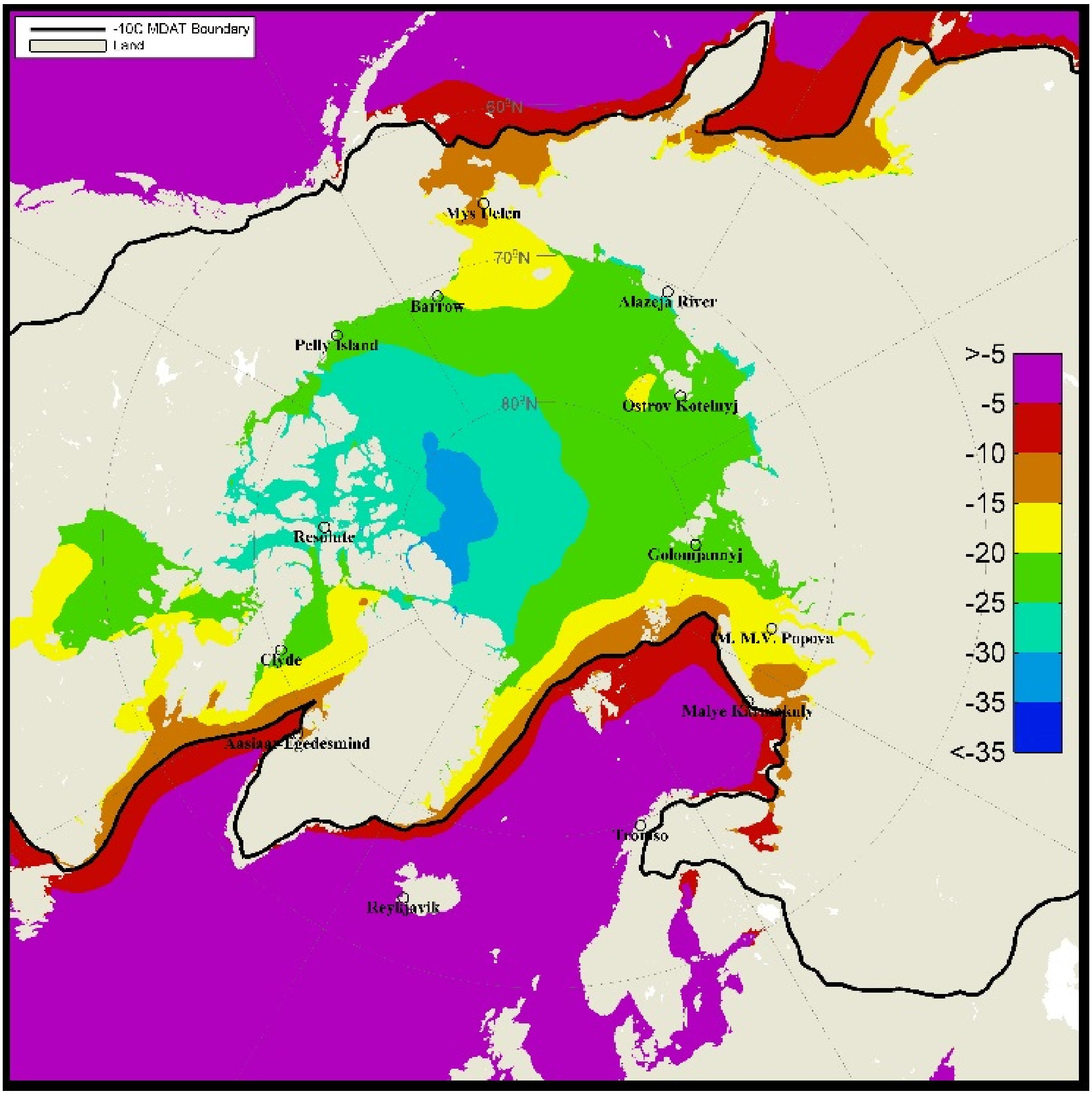


FIGURE 6
Arctic Mean Daily Average Temperature (MDAT) in °C for February 15th
(1 September 2015)

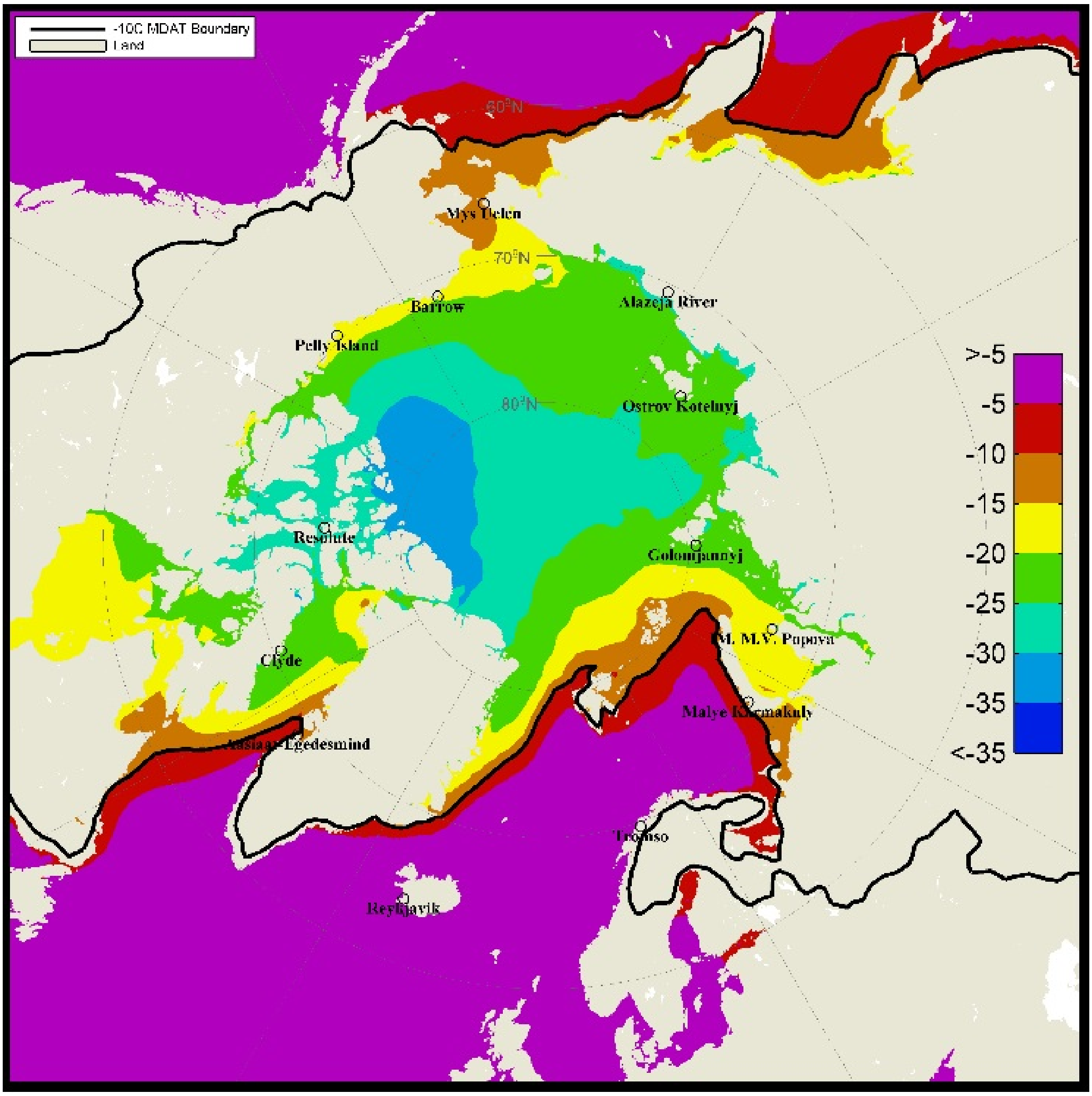


FIGURE 7
Arctic Mean Daily Average Temperature (MDAT) in °C for March 1st
(1 September 2015)

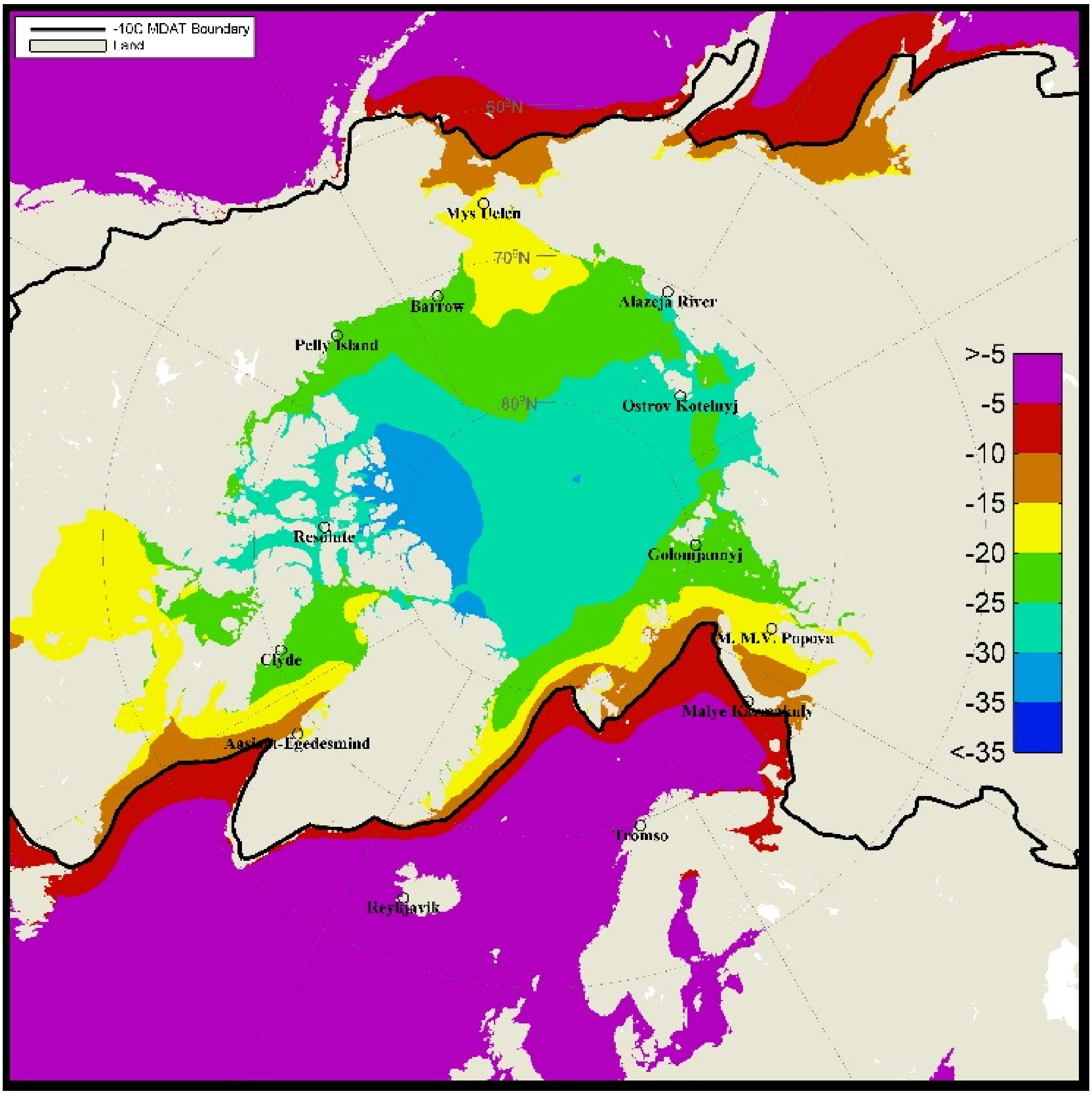


FIGURE 8
Arctic Mean Daily Average Temperature (MDAT) in °C for March 15th
(1 September 2015)

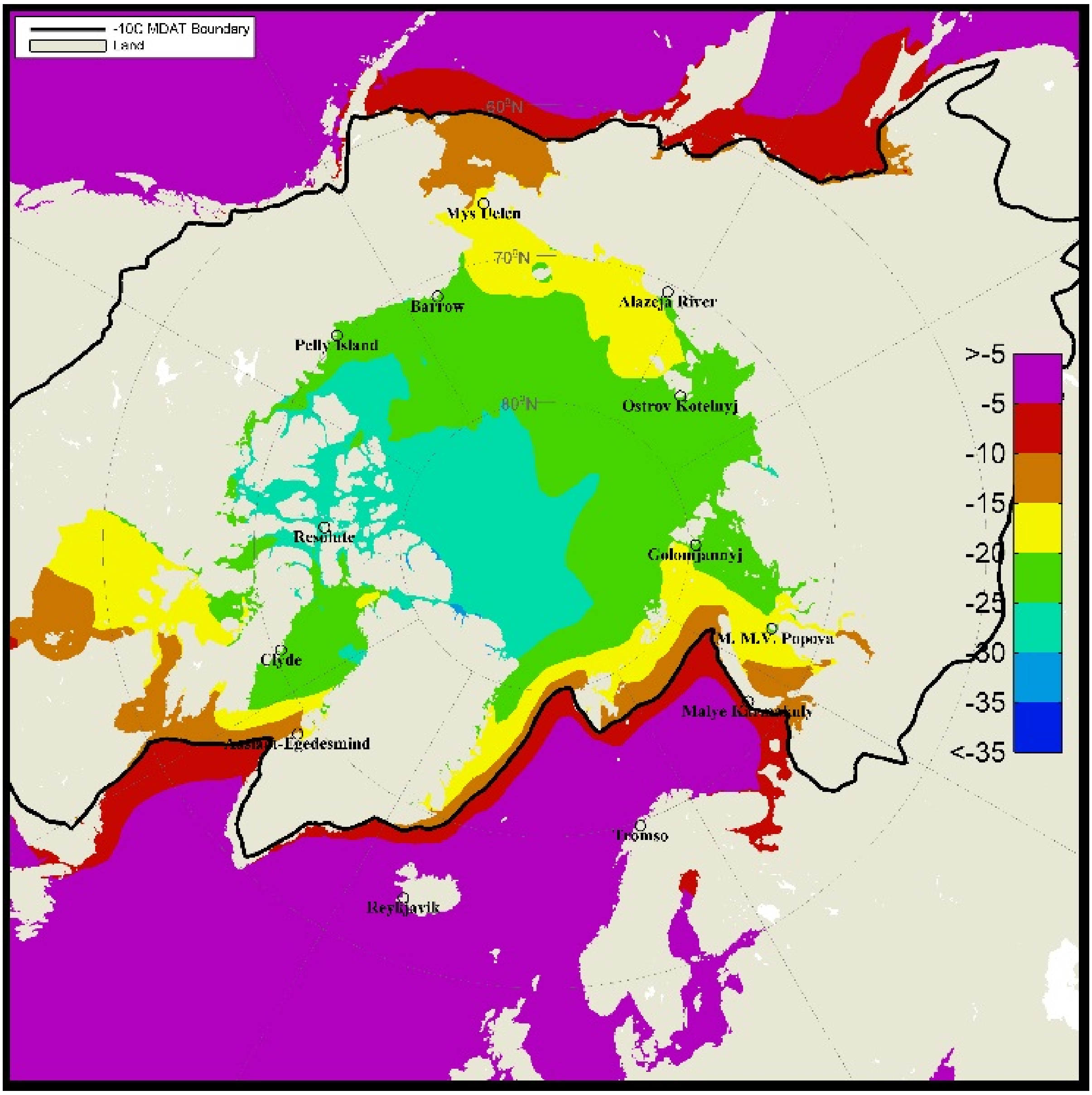


FIGURE 9
Arctic Mean Daily Average Temperature (MDAT) in °C for April 1st
(1 September 2015)

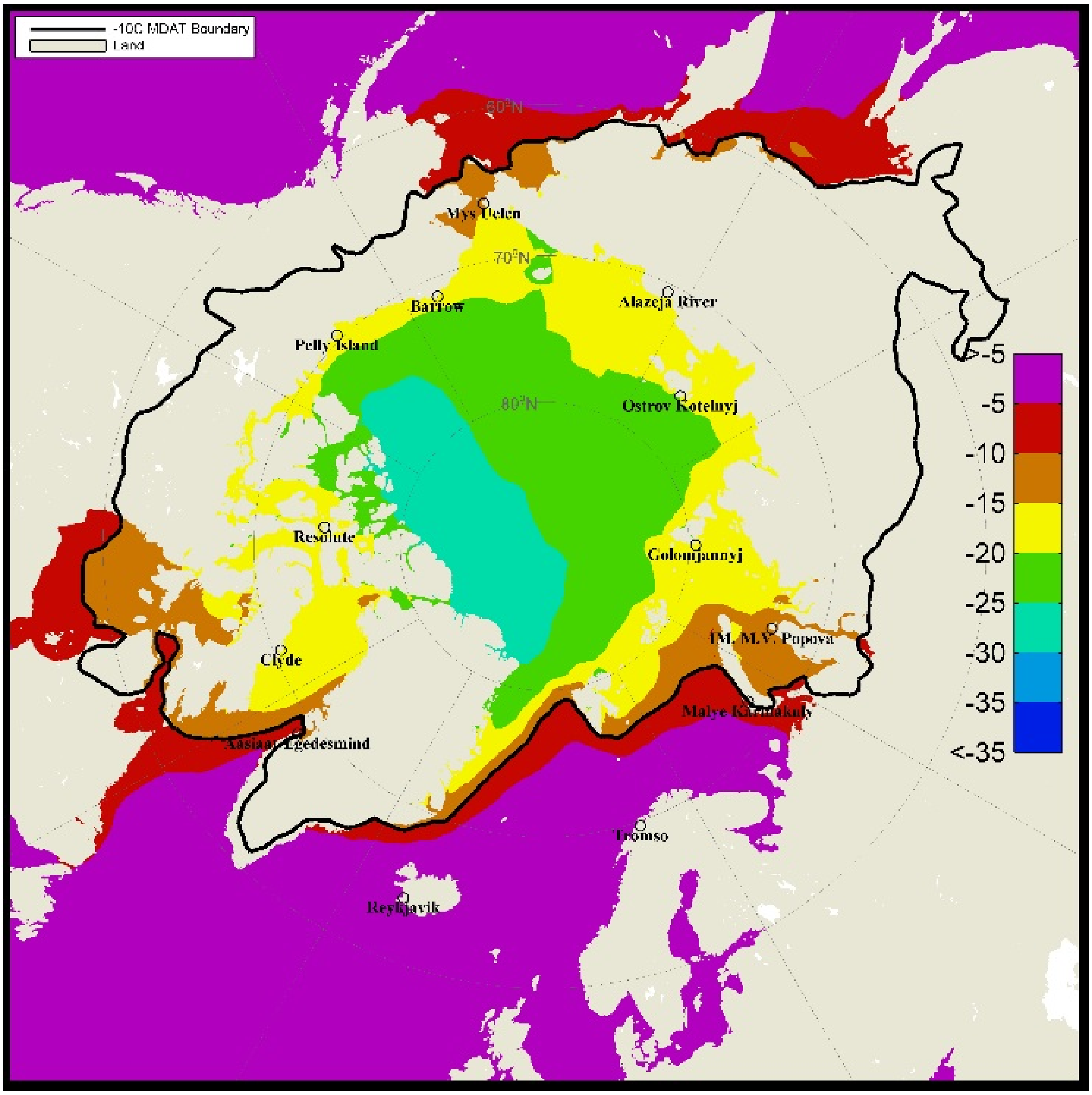


FIGURE 10
Arctic Mean Daily Average Temperature (MDAT) in °C for April 15th
(1 September 2015)

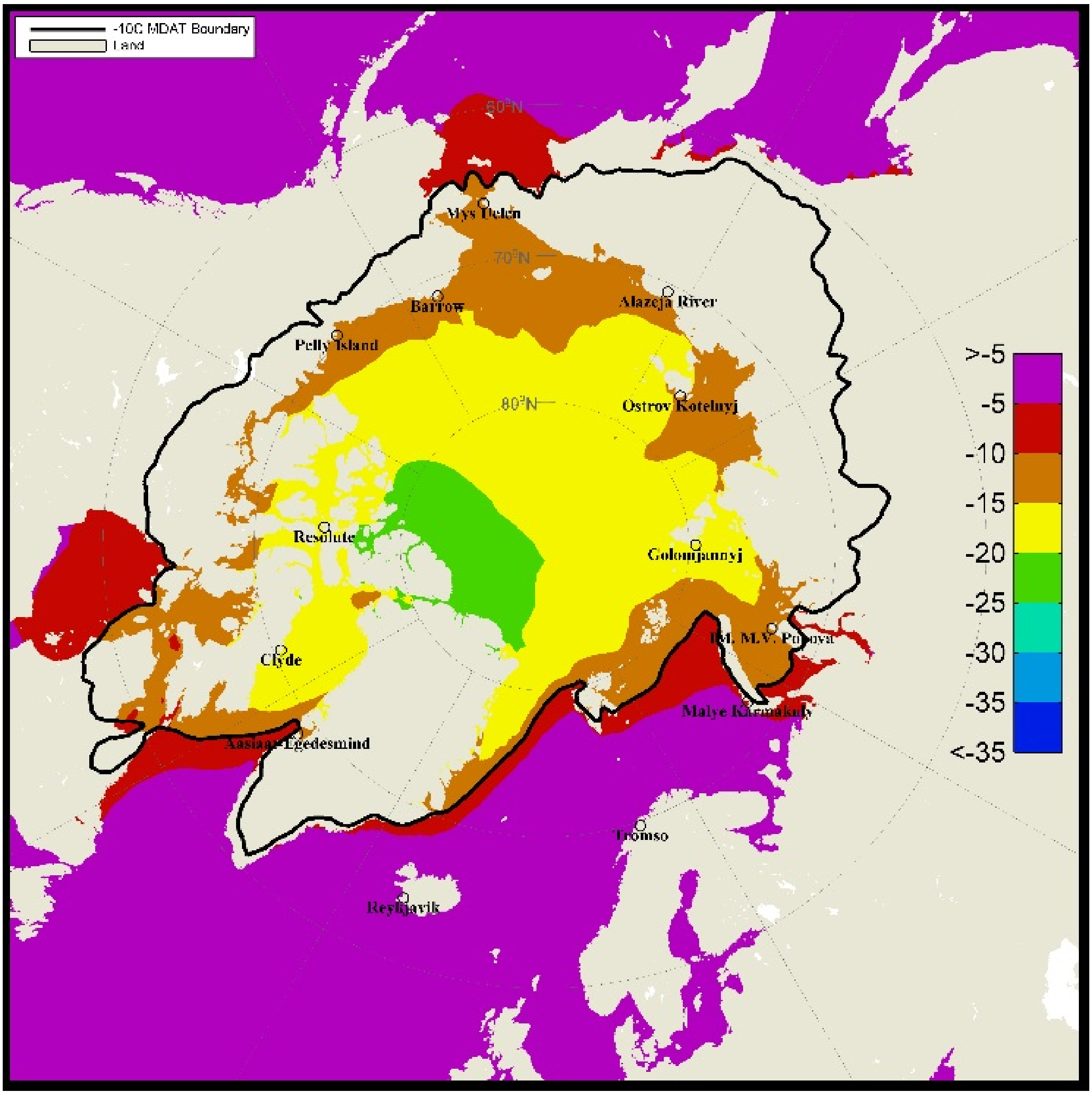


FIGURE 11
Arctic Mean Daily Average Temperature (MDAT) in °C for May 1st
(1 September 2015)

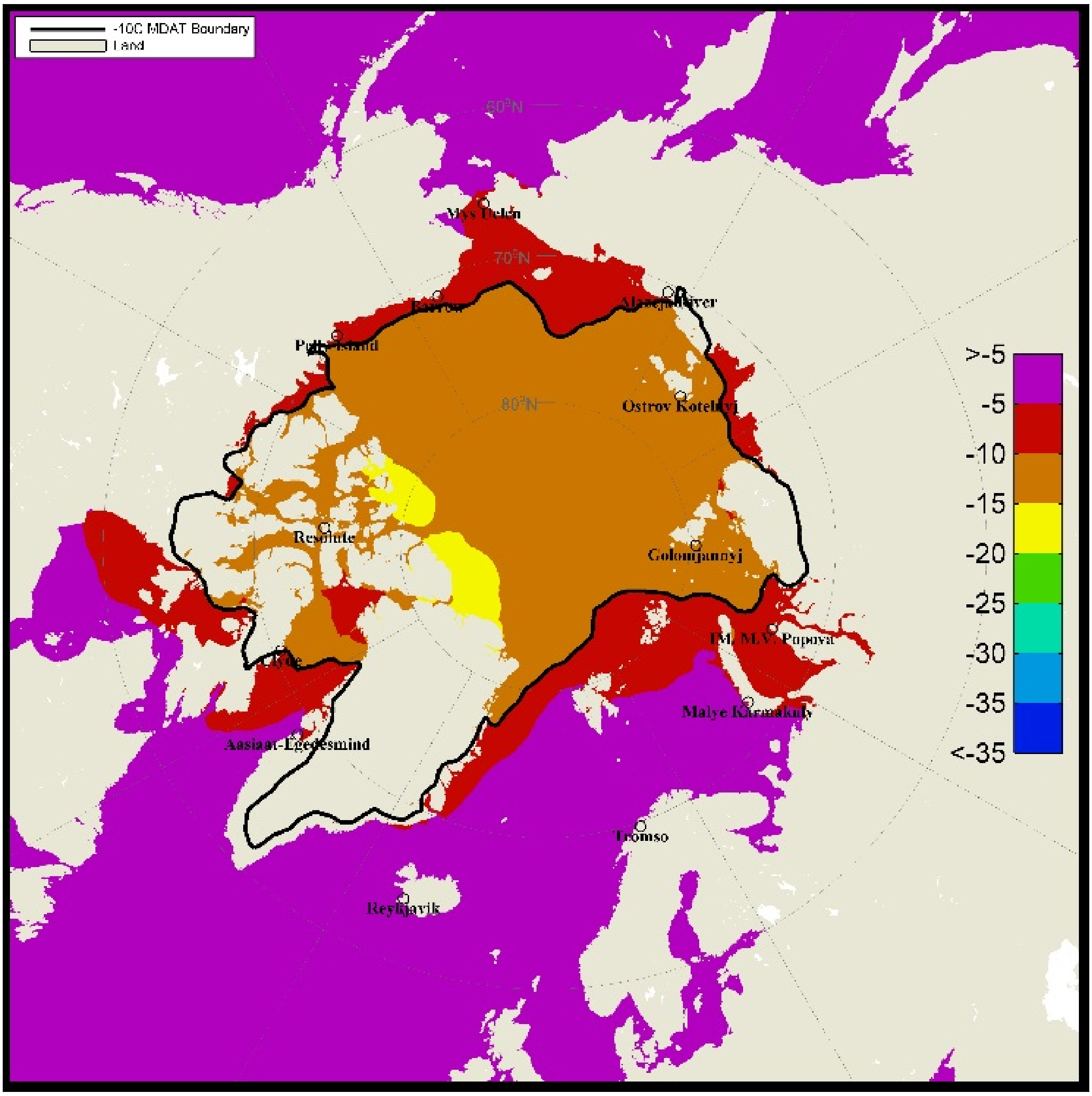


FIGURE 12
Arctic Mean Daily Average Temperature (MDAT) in °C for May 15th
(1 September 2015)

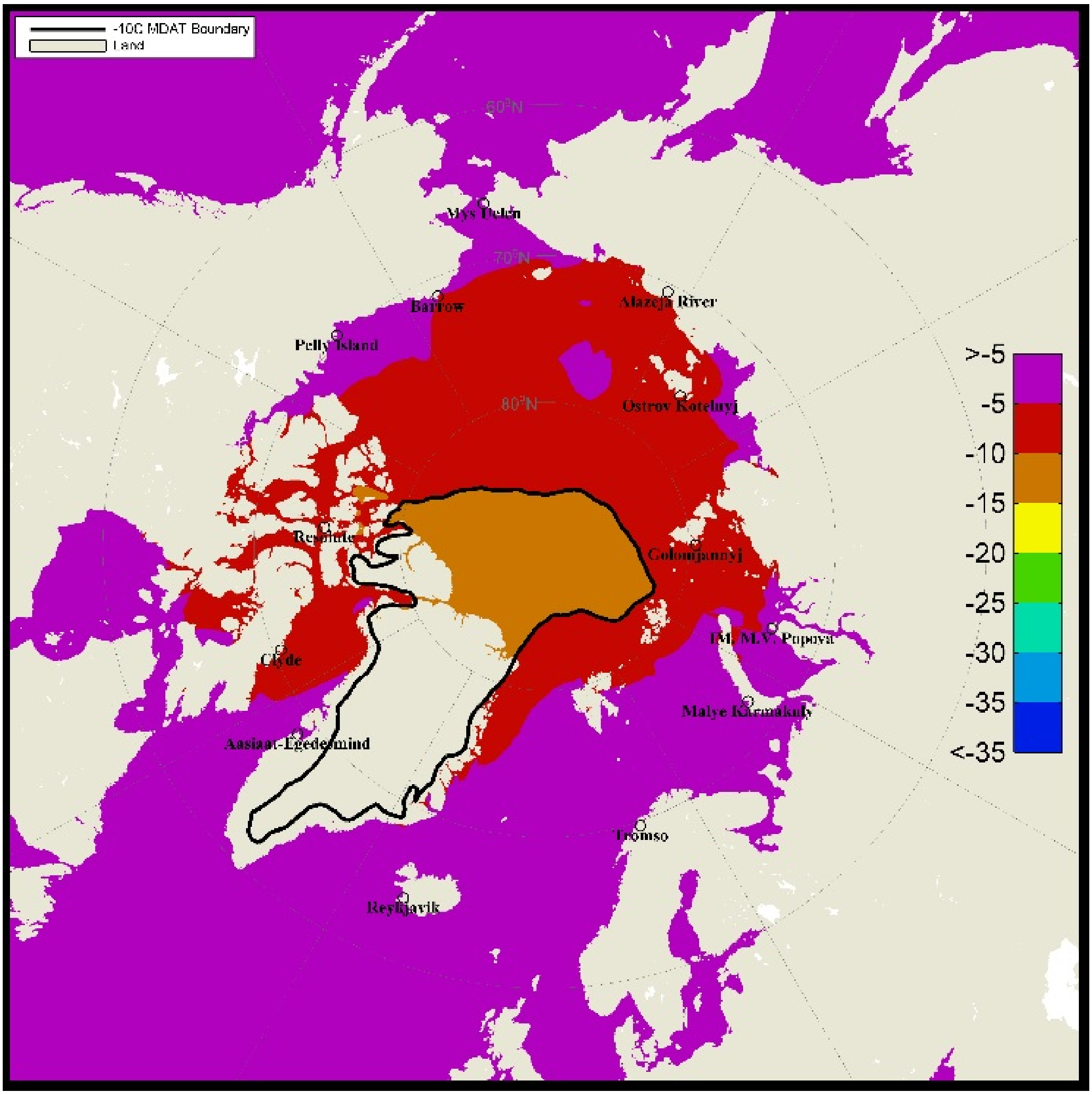


FIGURE 13
Arctic Mean Daily Average Temperature (MDAT) in °C for June 1st
(1 September 2015)

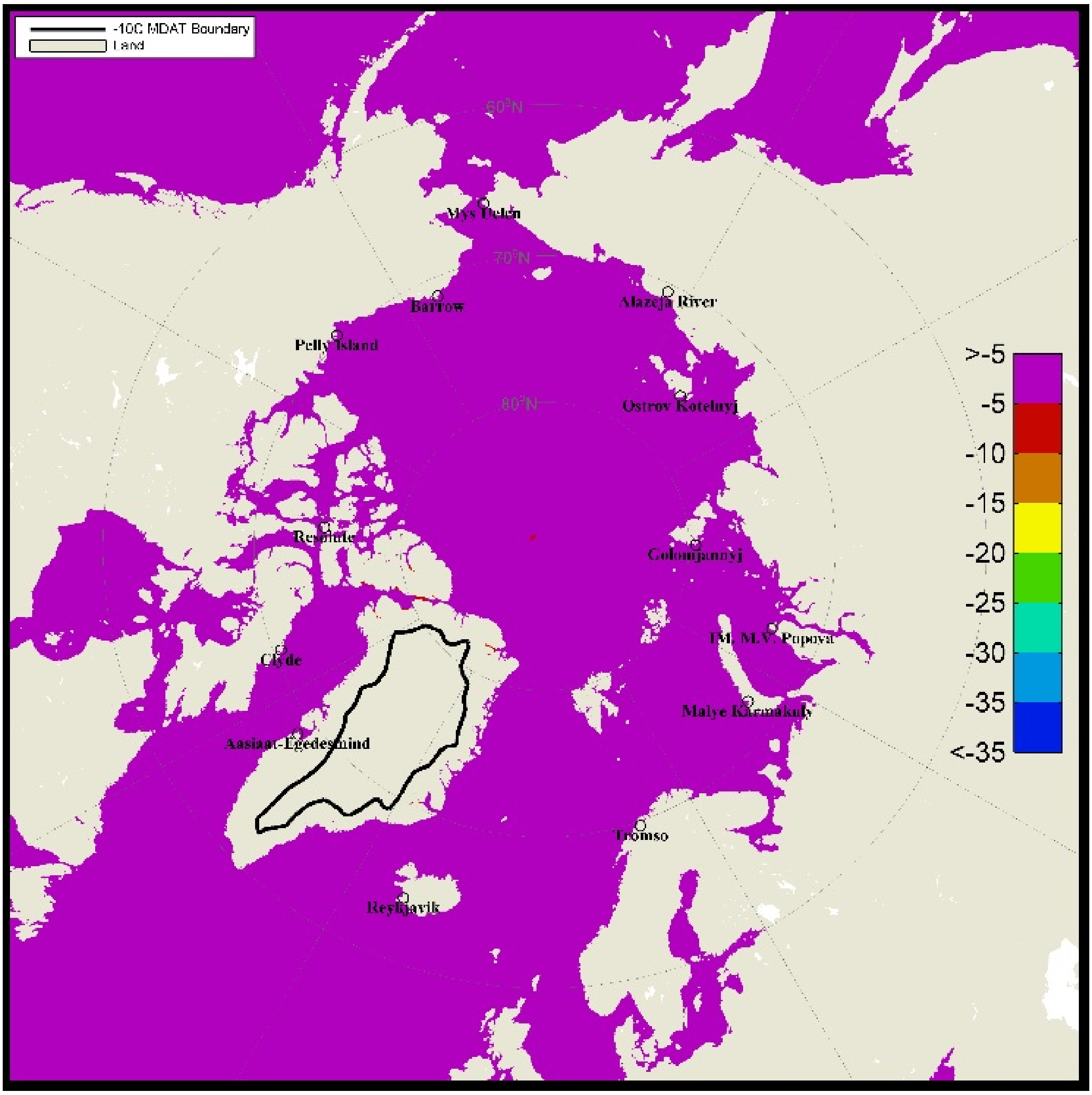


FIGURE 14
Arctic Mean Daily Average Temperature (MDAT) in °C for June 15th
(1 September 2015)

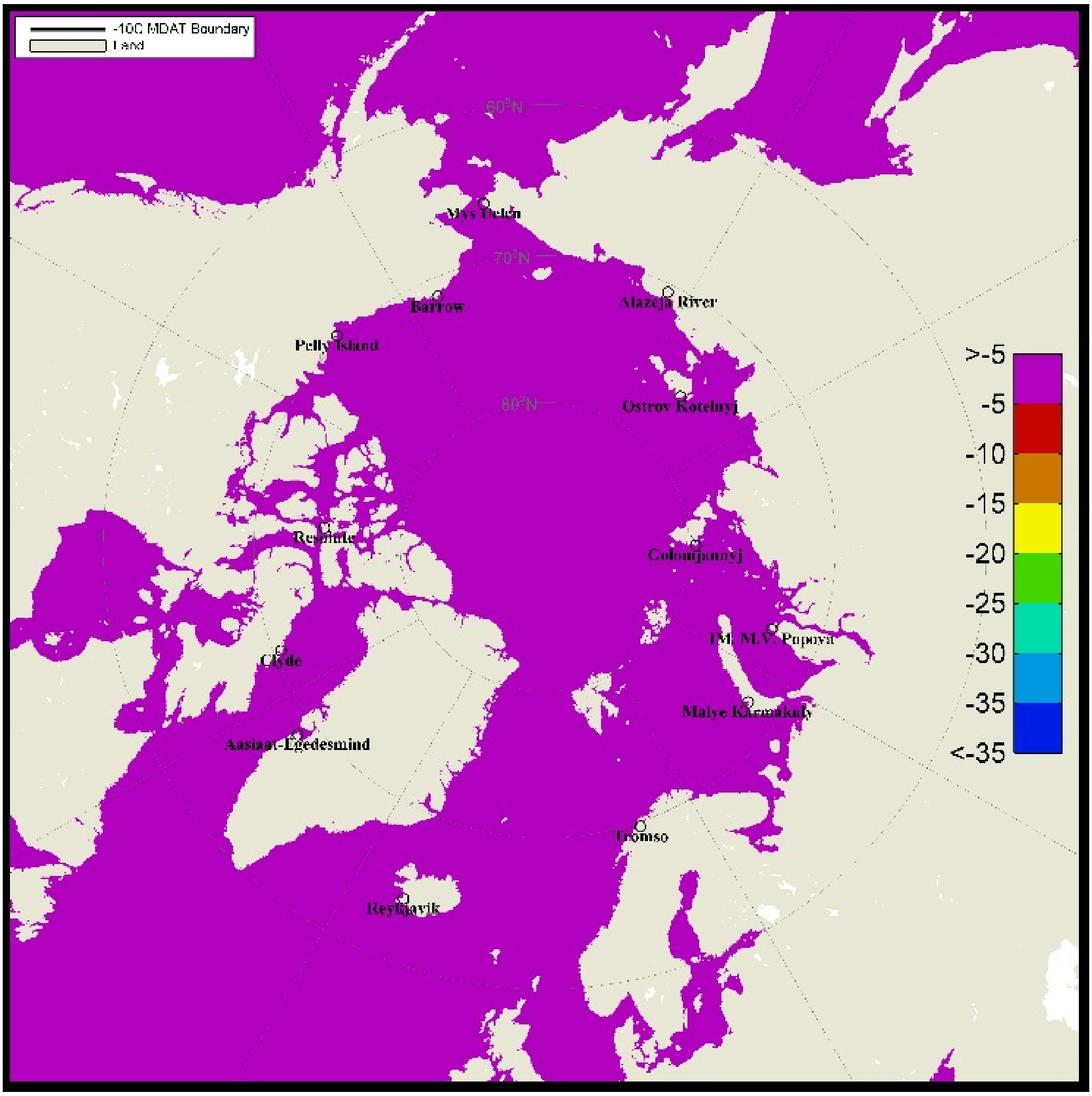


FIGURE 15
Arctic Mean Daily Average Temperature (MDAT) in °C for July 1st
(1 September 2015)

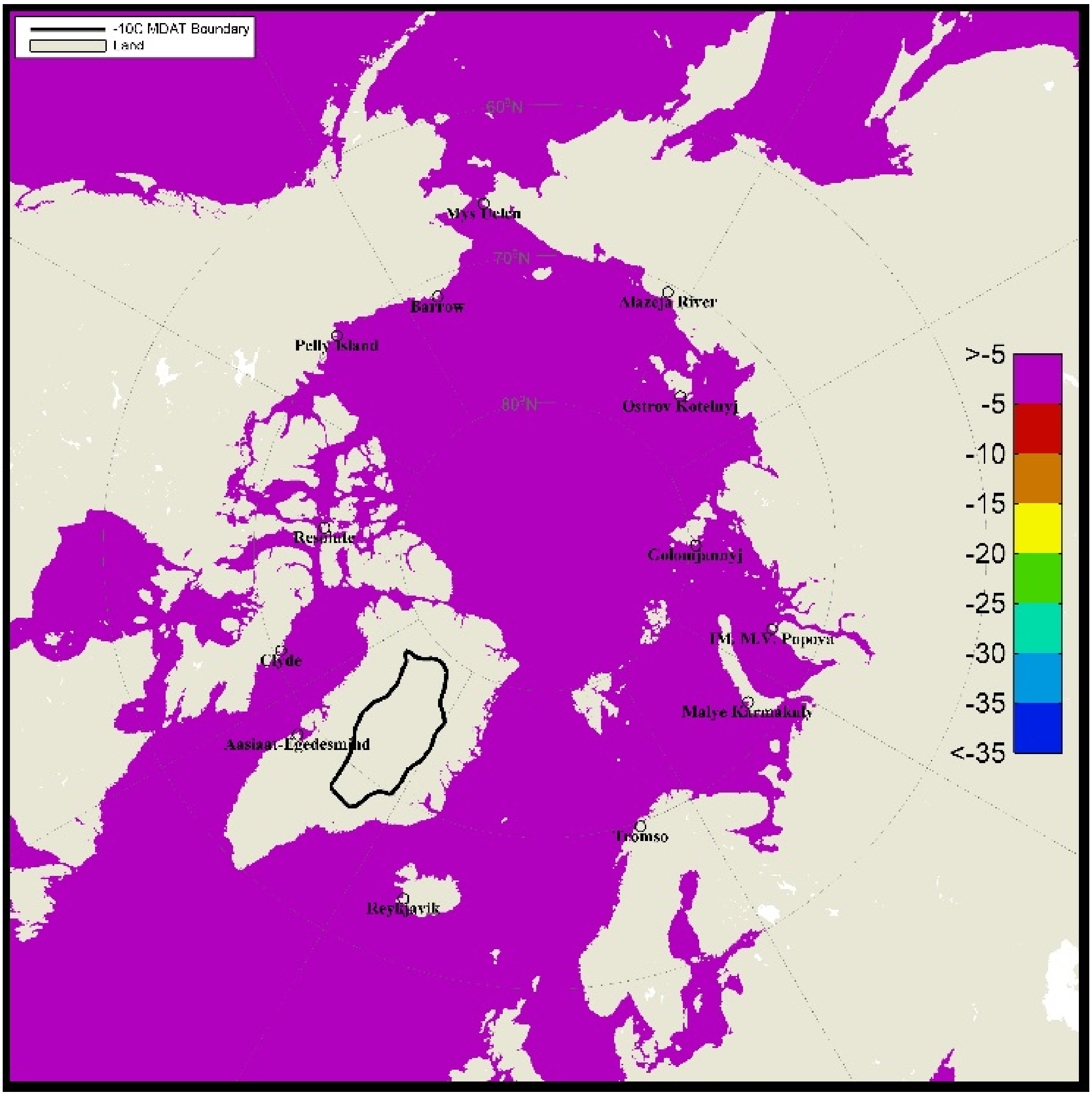


FIGURE 16
Arctic Mean Daily Average Temperature (MDAT) in °C for July 15th
(1 September 2015)

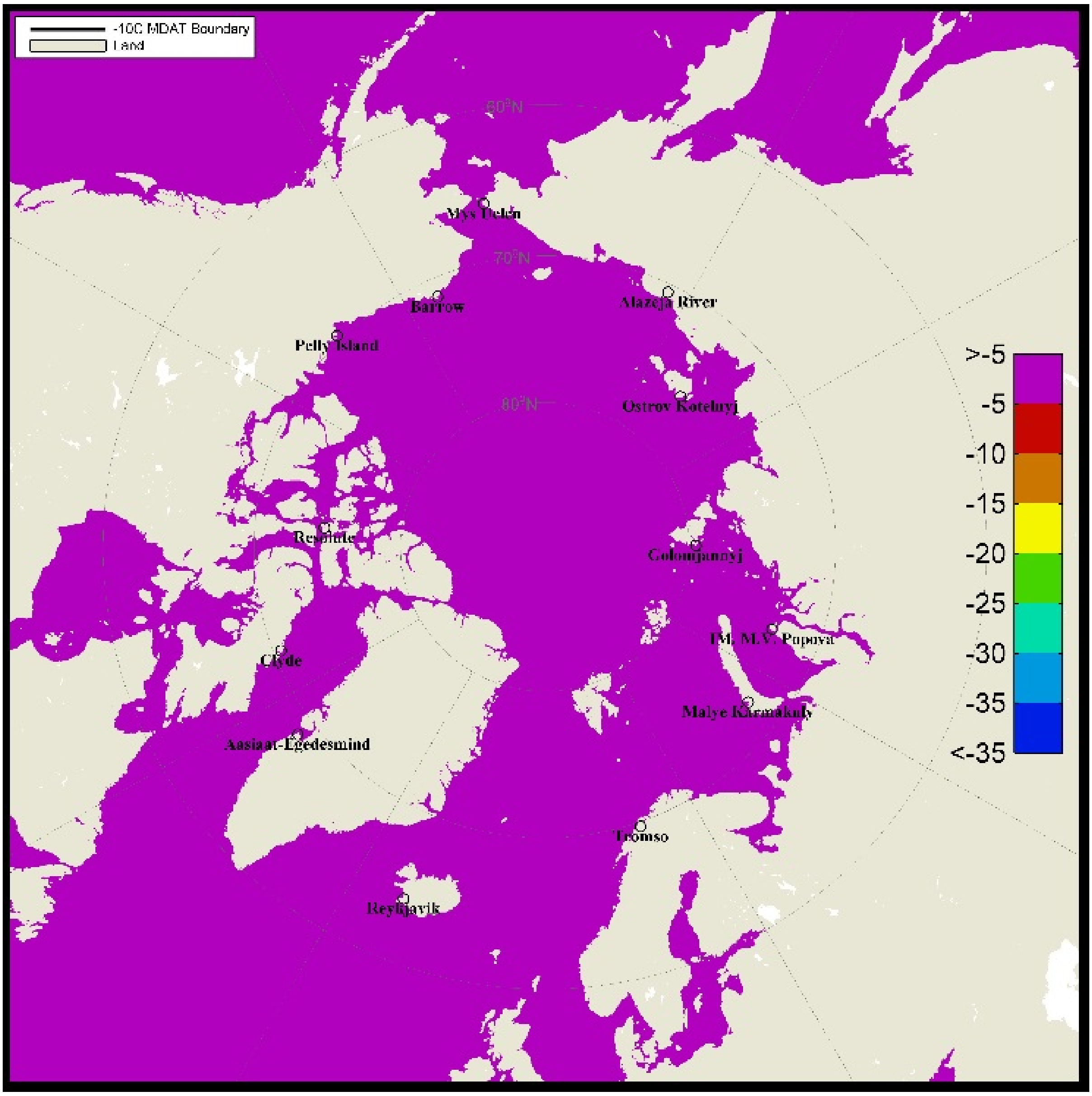


FIGURE 17
Arctic Mean Daily Average Temperature (MDAT) in °C for August 1st
(1 September 2015)

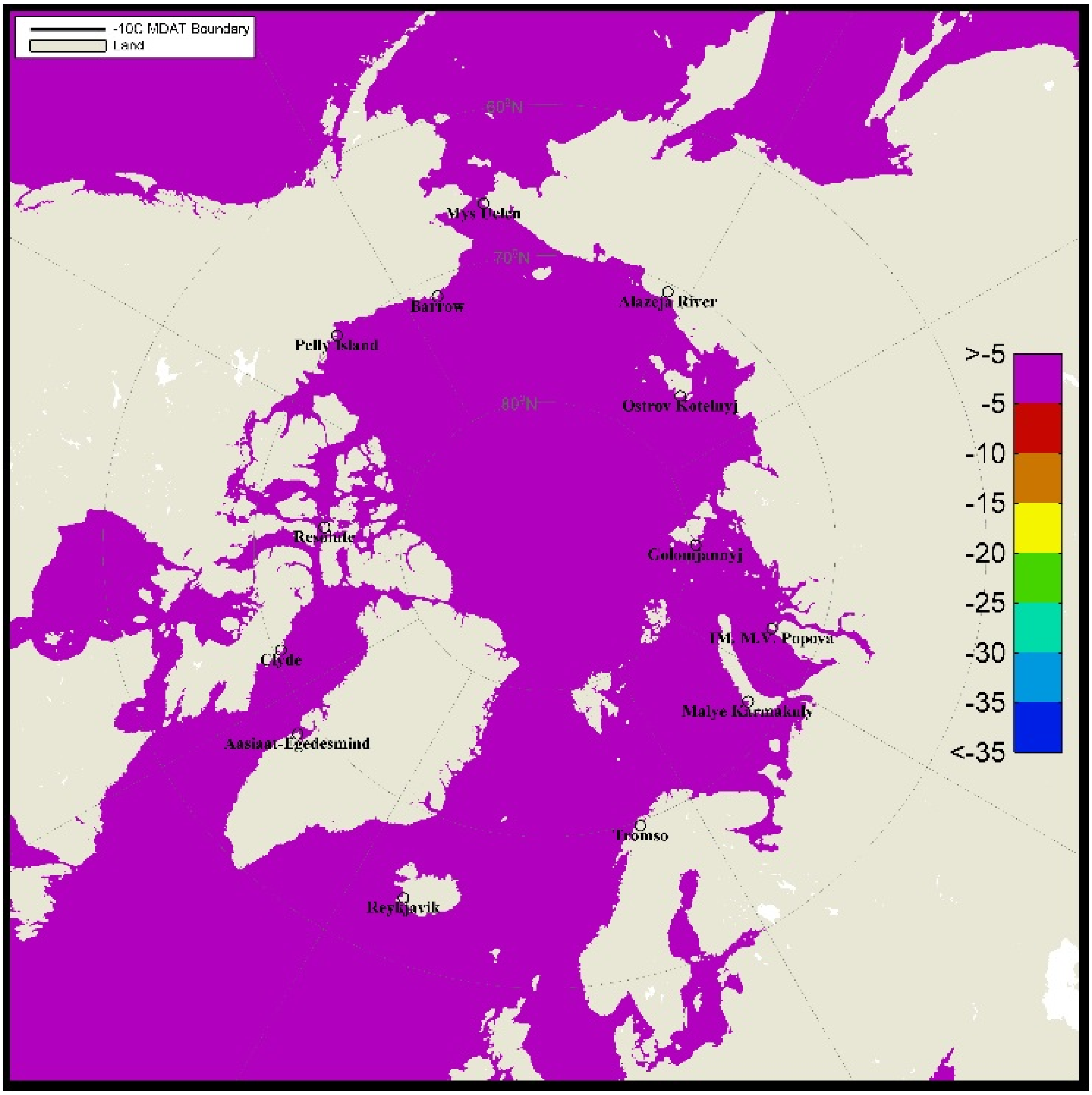


FIGURE 18
Arctic Mean Daily Average Temperature (MDAT) in °C for August 15th
(1 September 2015)

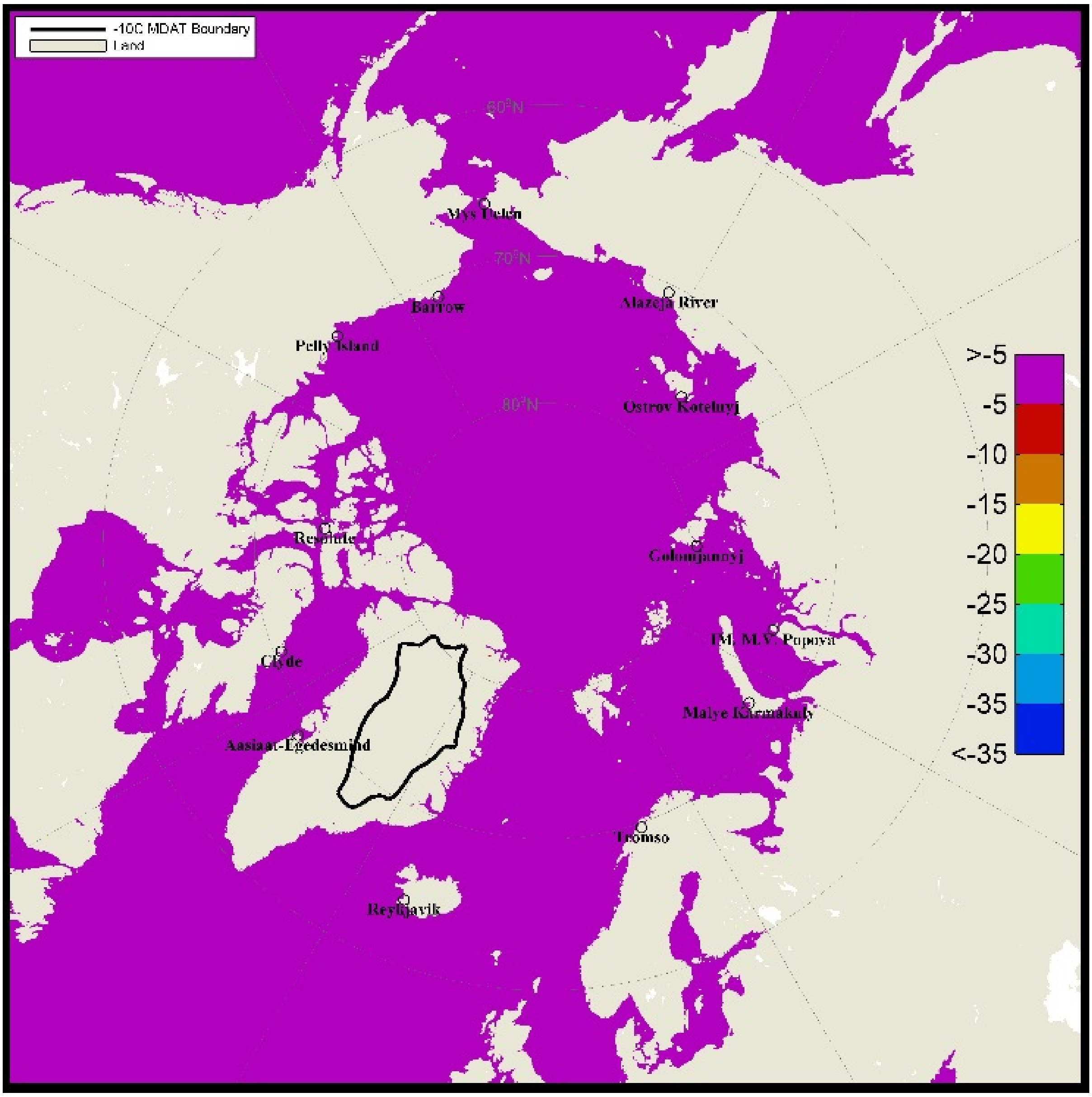


FIGURE 19
Arctic Mean Daily Average Temperature (MDAT) in °C for September 1st
(1 September 2015)

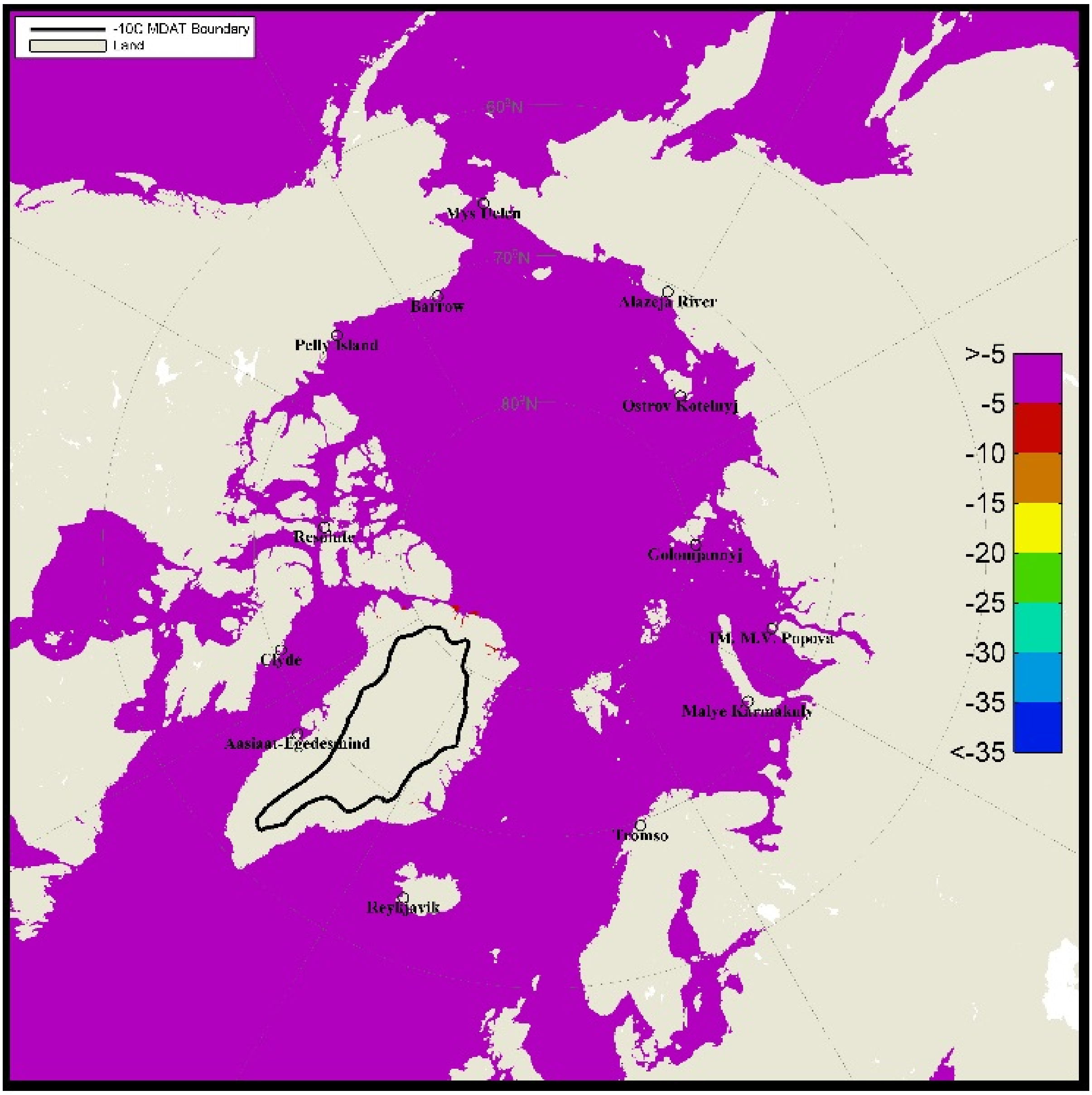


FIGURE 20
Arctic Mean Daily Average Temperature (MDAT) in °C for September 15th
(1 September 2015)

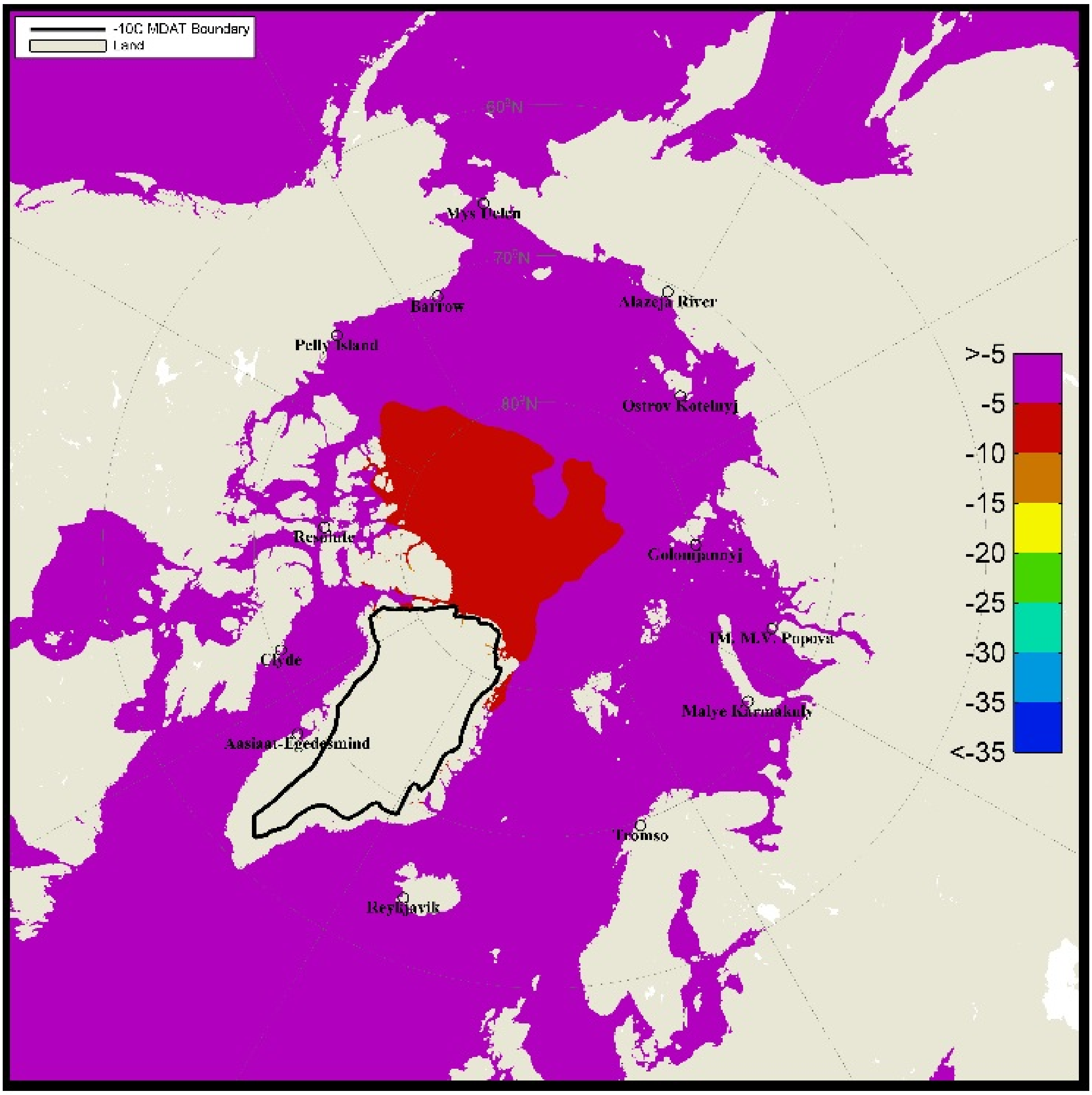


FIGURE 21
Arctic Mean Daily Average Temperature (MDAT) in °C for October 1st
(1 September 2015)

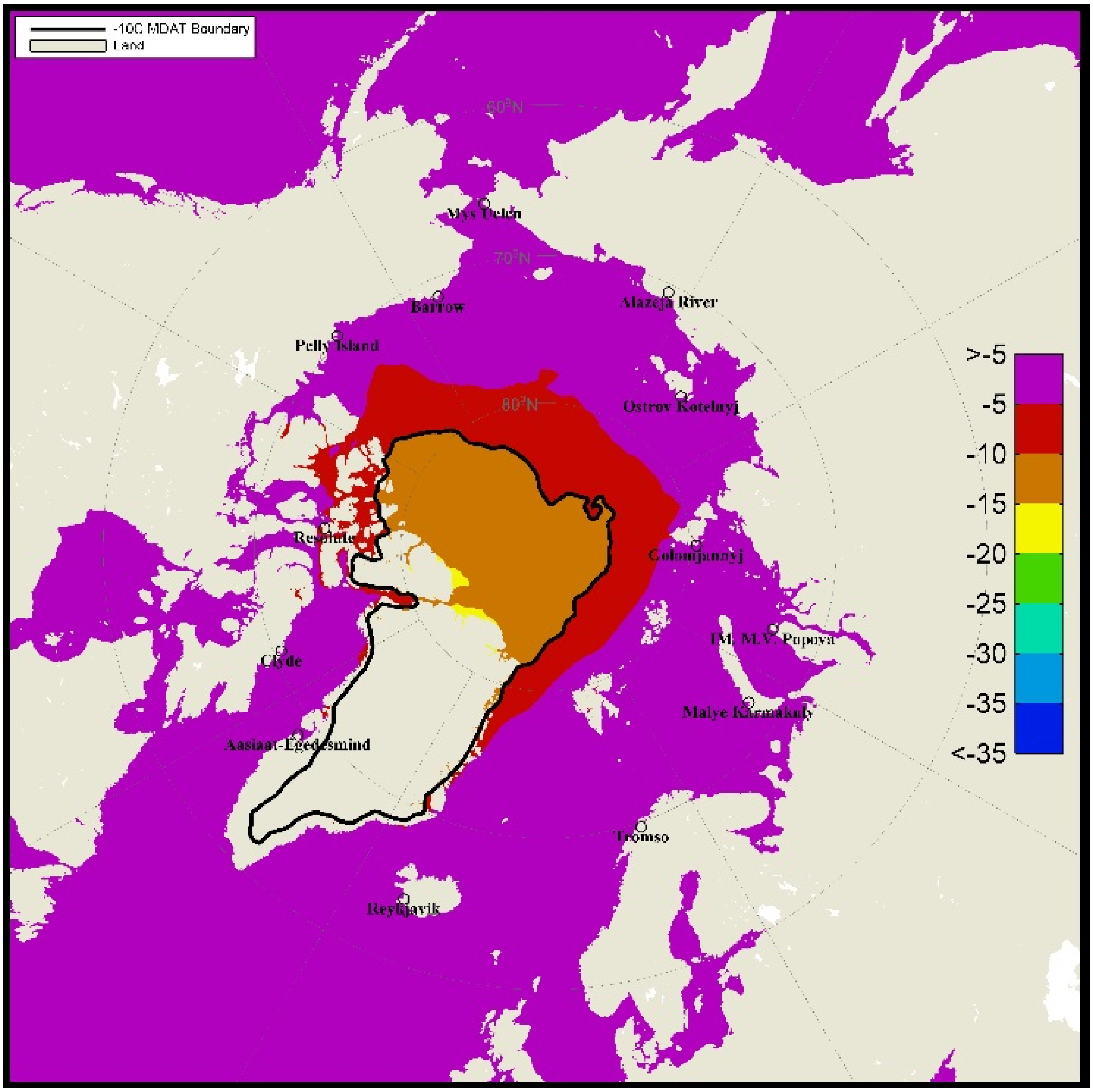


FIGURE 22
Arctic Mean Daily Average Temperature (MDAT) in °C for October 15th
(1 September 2015)

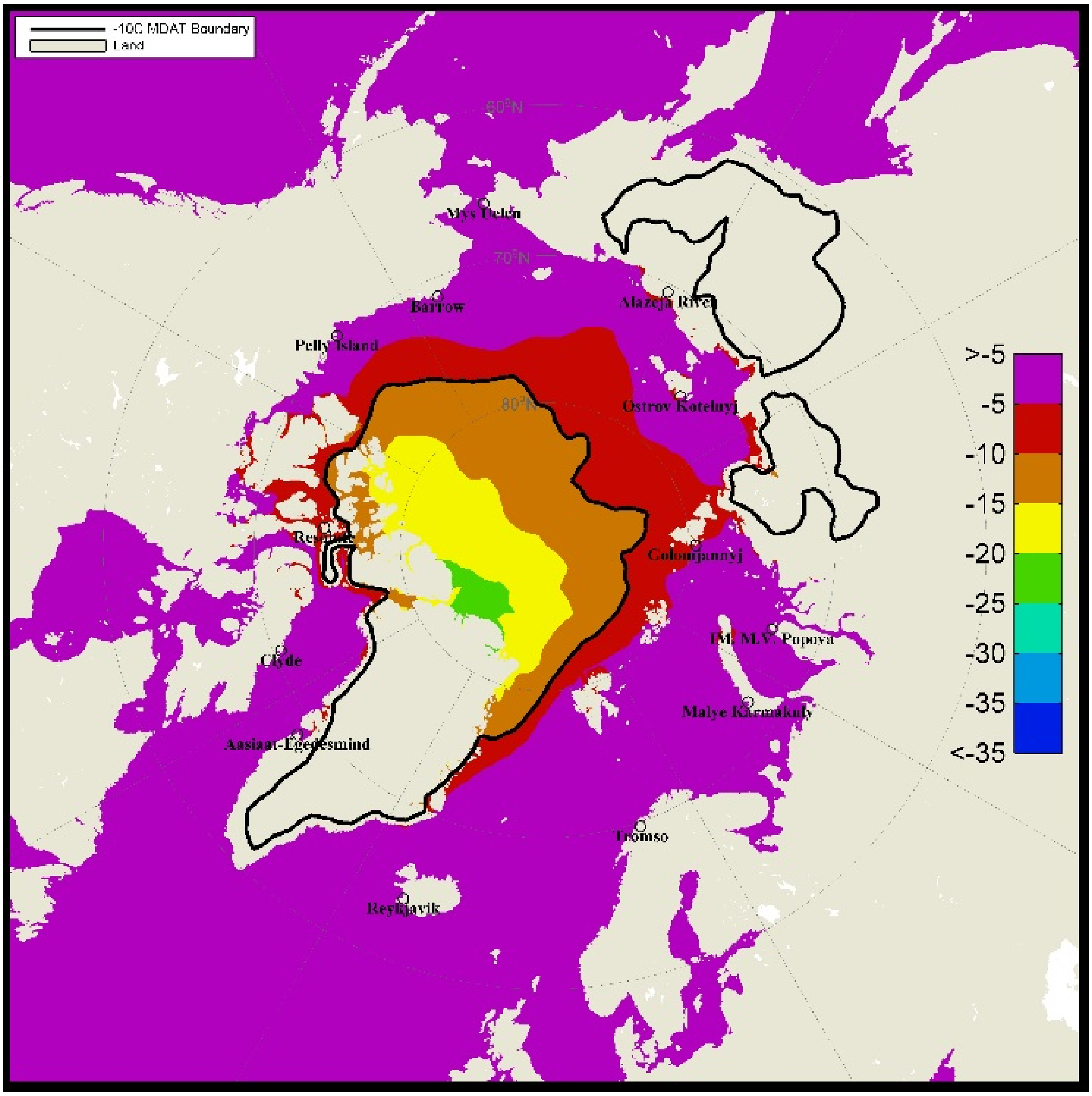


FIGURE 23
Arctic Mean Daily Average Temperature (MDAT) in °C for November 1st
(1 September 2015)

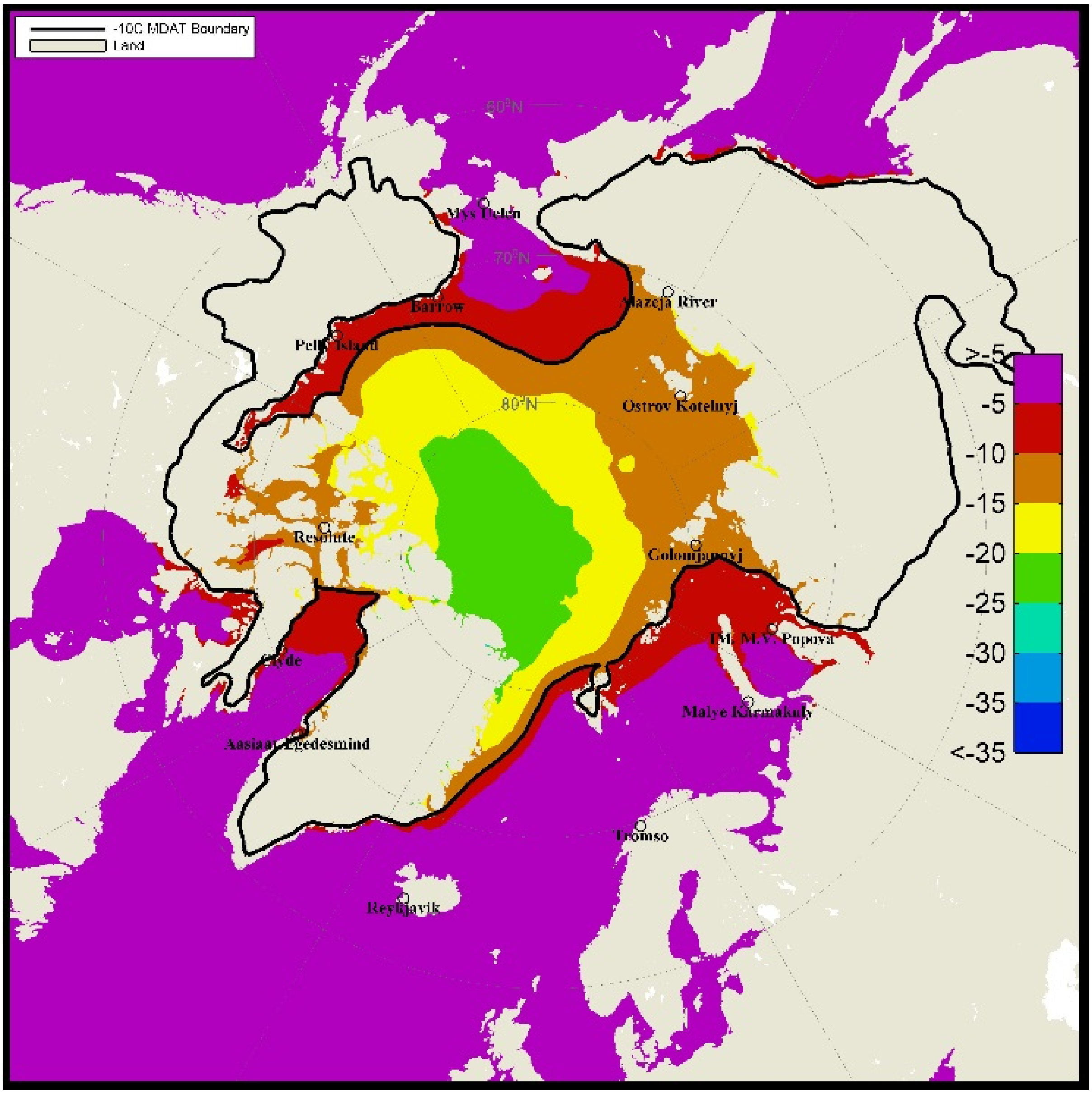


FIGURE 24
Arctic Mean Daily Average Temperature (MDAT) in °C for November 15th
(1 September 2015)

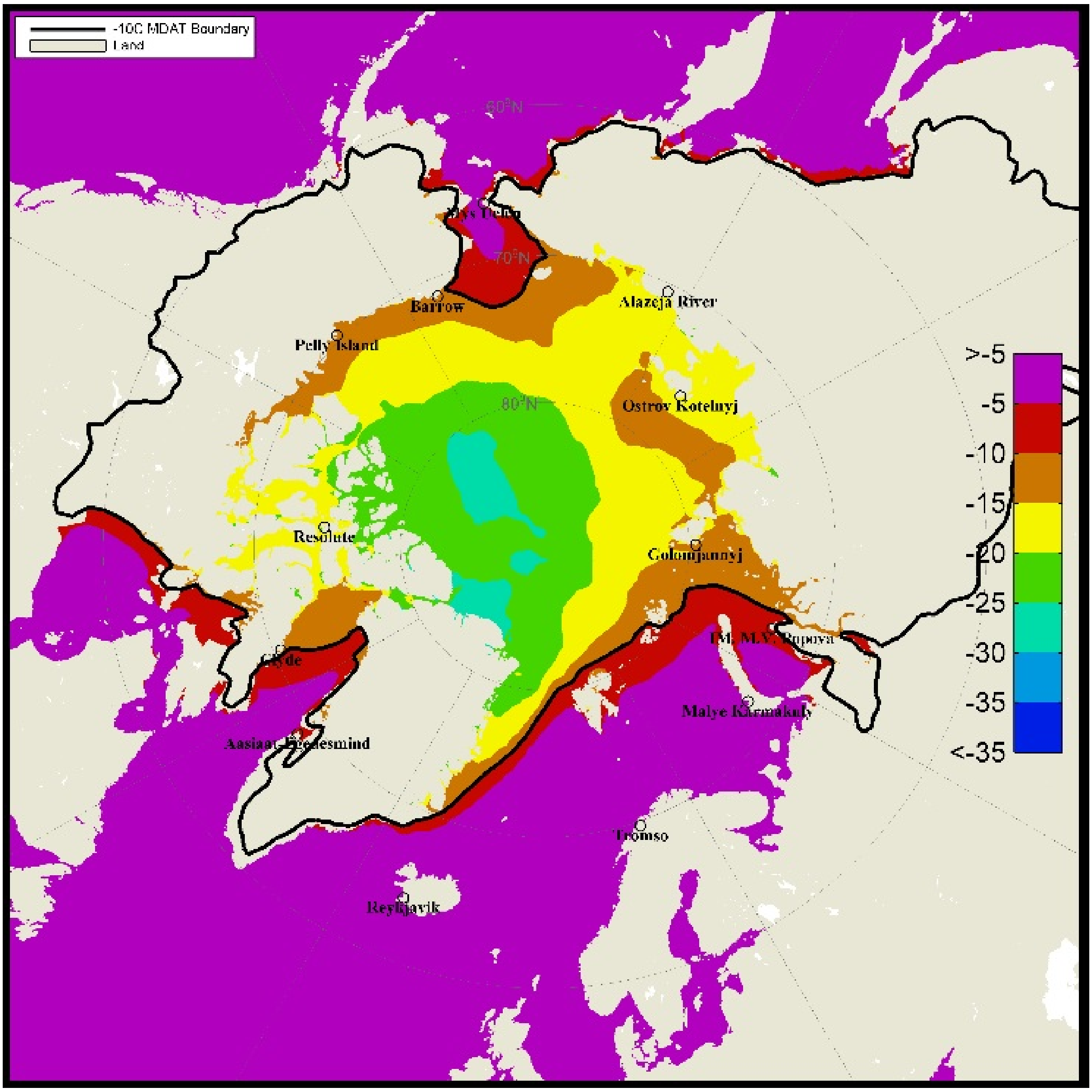


FIGURE 25
Arctic Mean Daily Average Temperature (MDAT) in °C for December 1st
(1 September 2015)

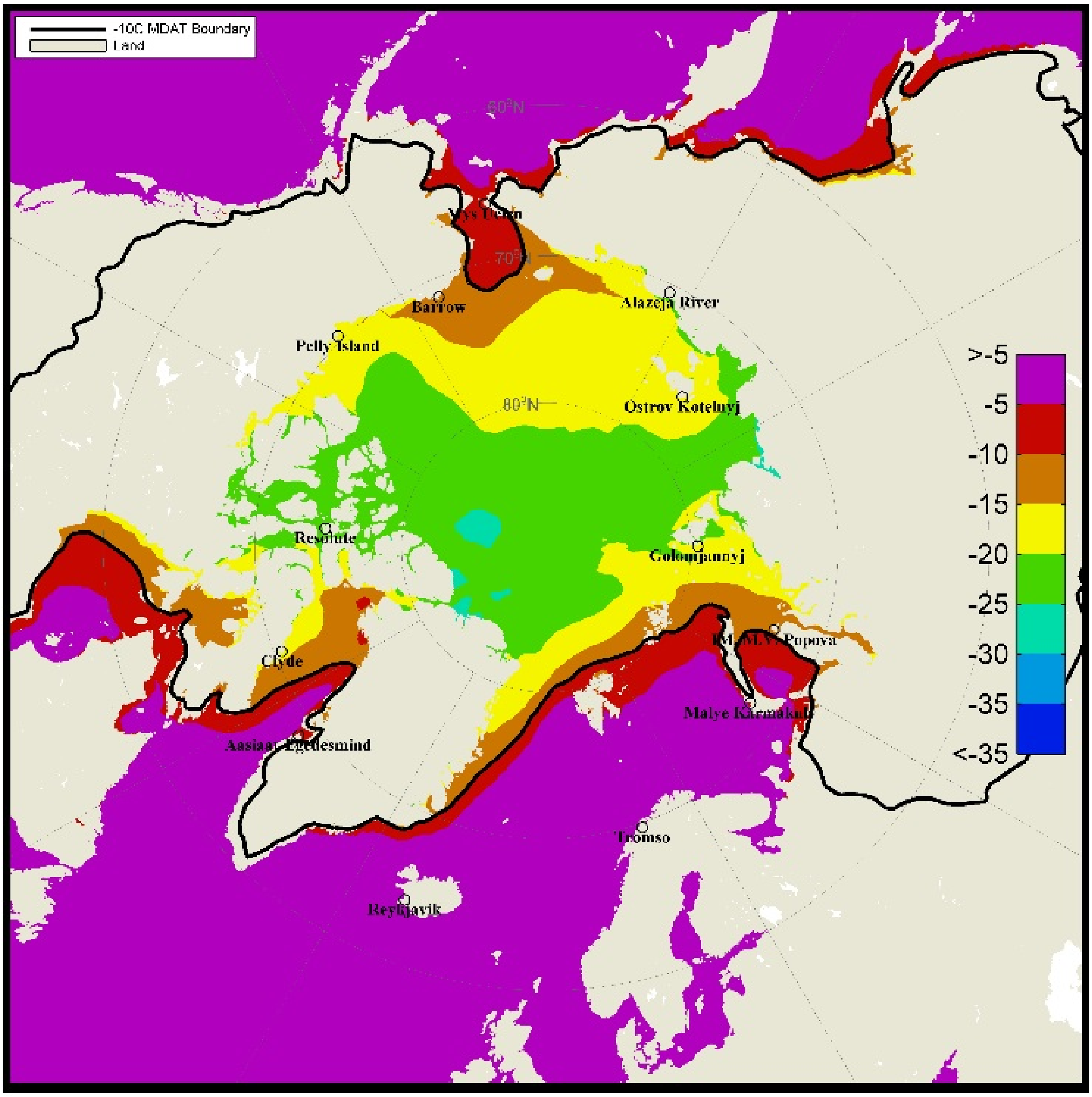


FIGURE 26
Arctic Mean Daily Average Temperature (MDAT) in °C for December 15th
(1 September 2015)

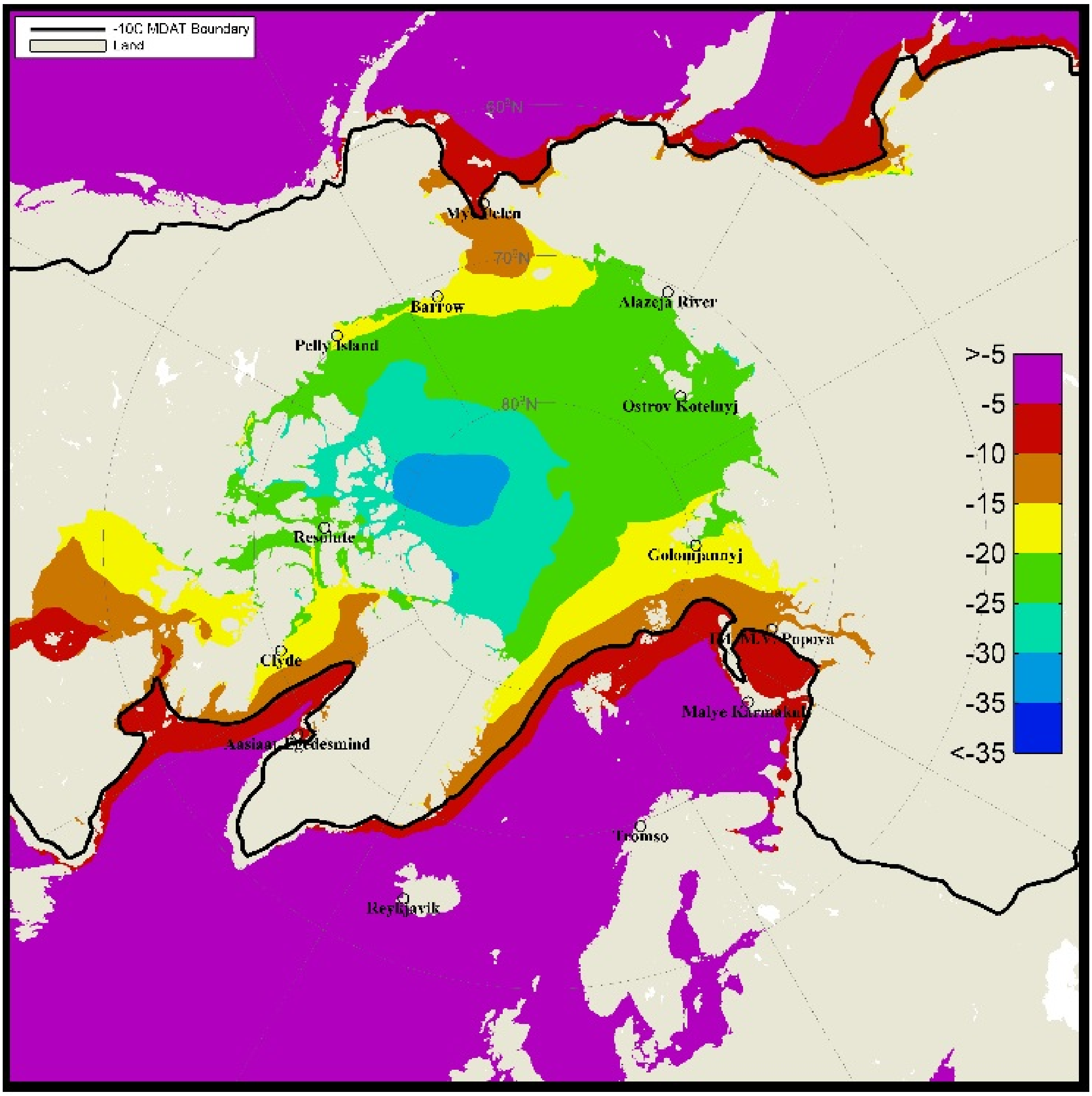


FIGURE 27
Antarctic Mean Daily Average Temperature (MDAT) in °C for January 1st
(1 September 2015)

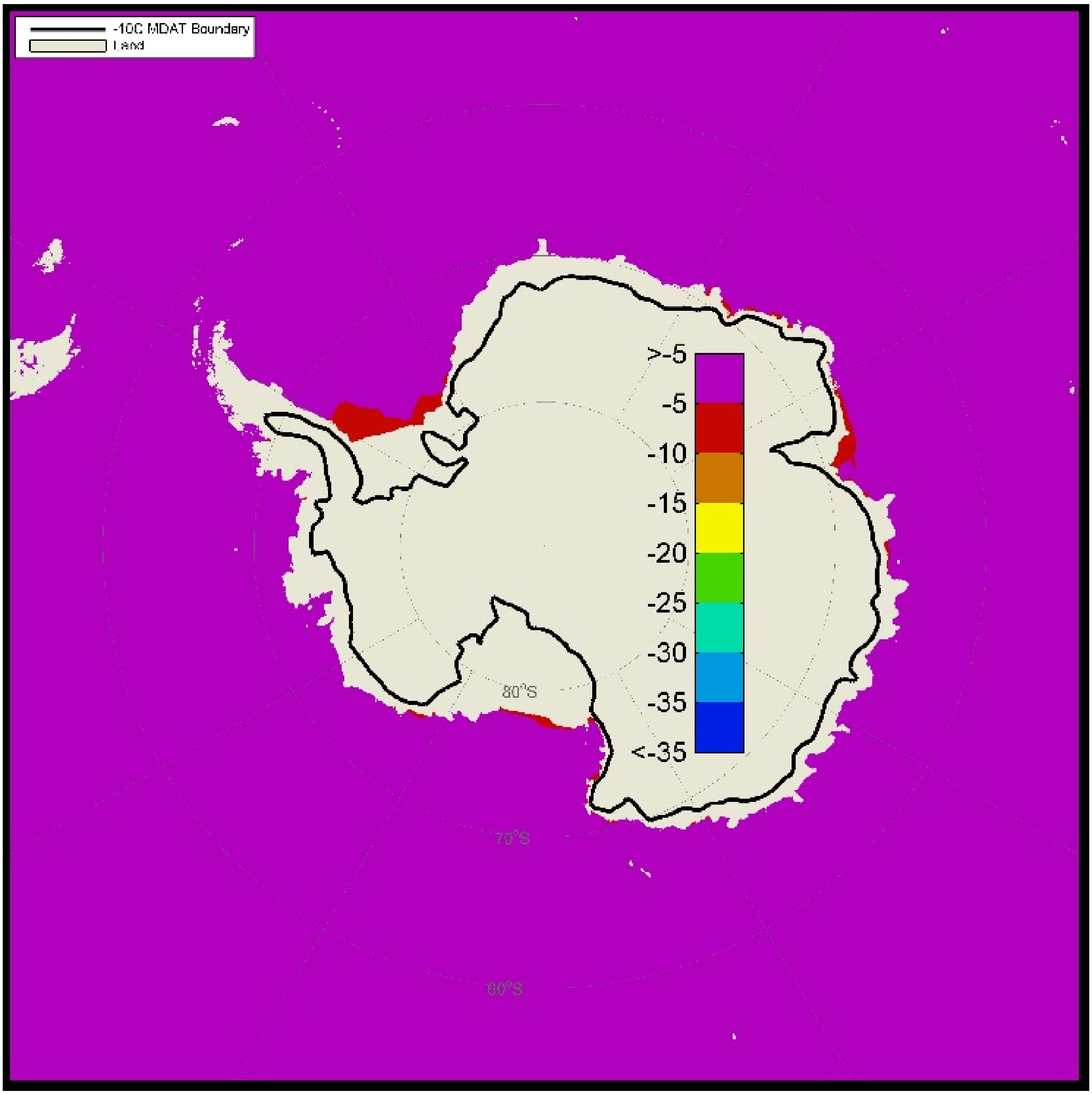


FIGURE 28
Antarctic Mean Daily Average Temperature (MDAT) in °C for January 15th
(1 September 2015)

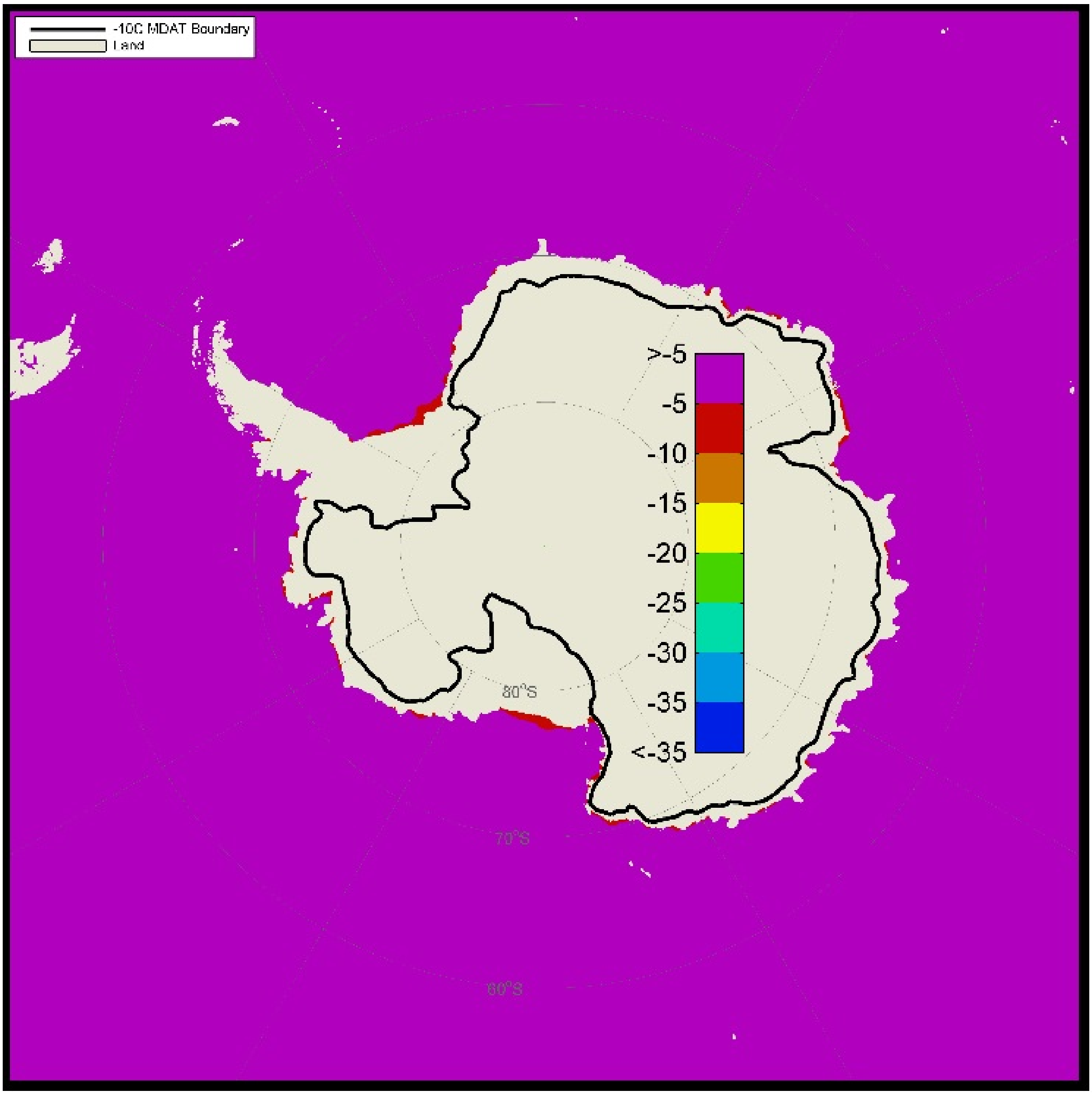


FIGURE 29
Antarctic Mean Daily Average Temperature (MDAT) in °C for February 1st
(1 September 2015)

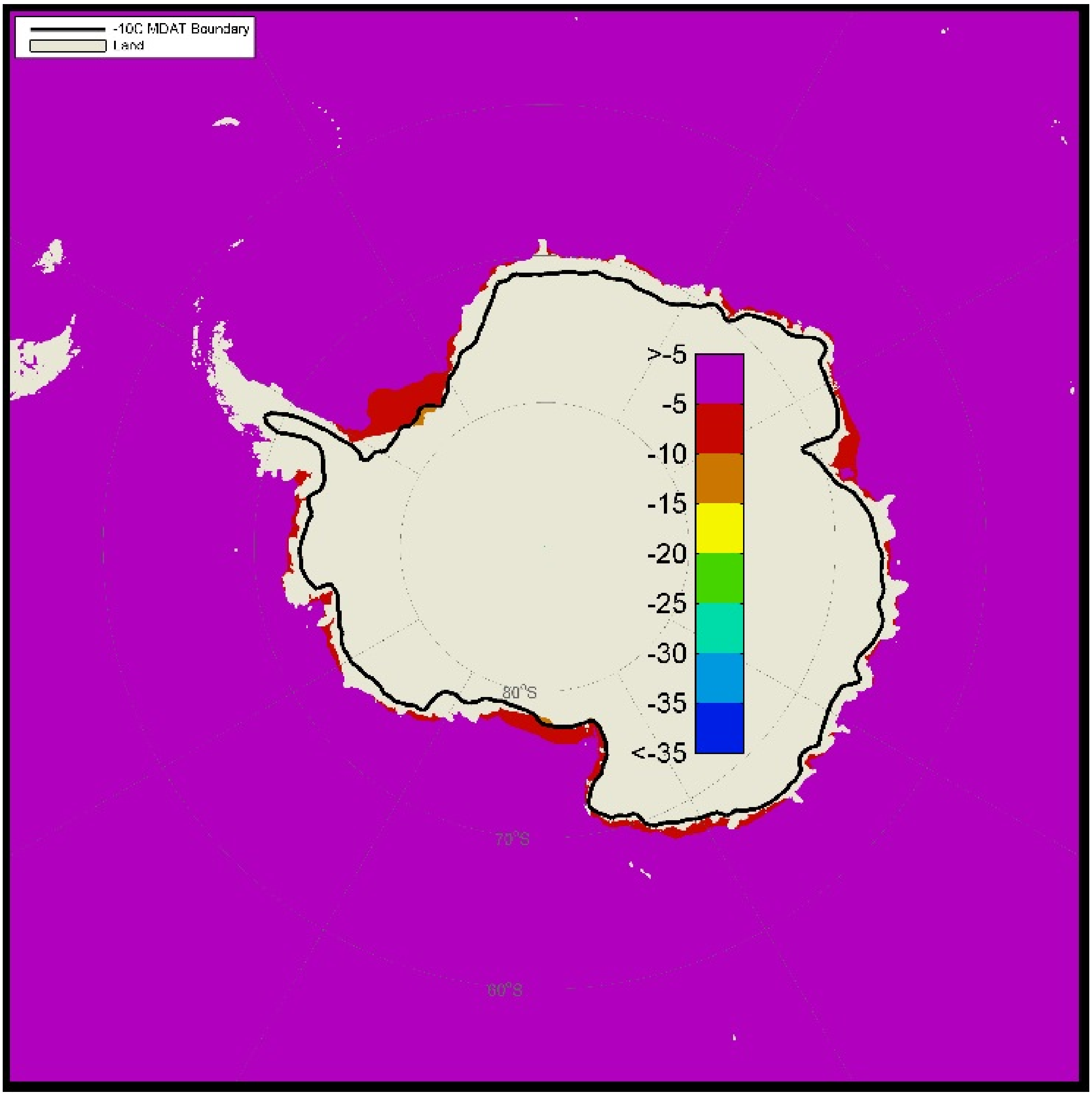


FIGURE 30
Antarctic Mean Daily Average Temperature (MDAT) in °C for February 15th
(1 September 2015)

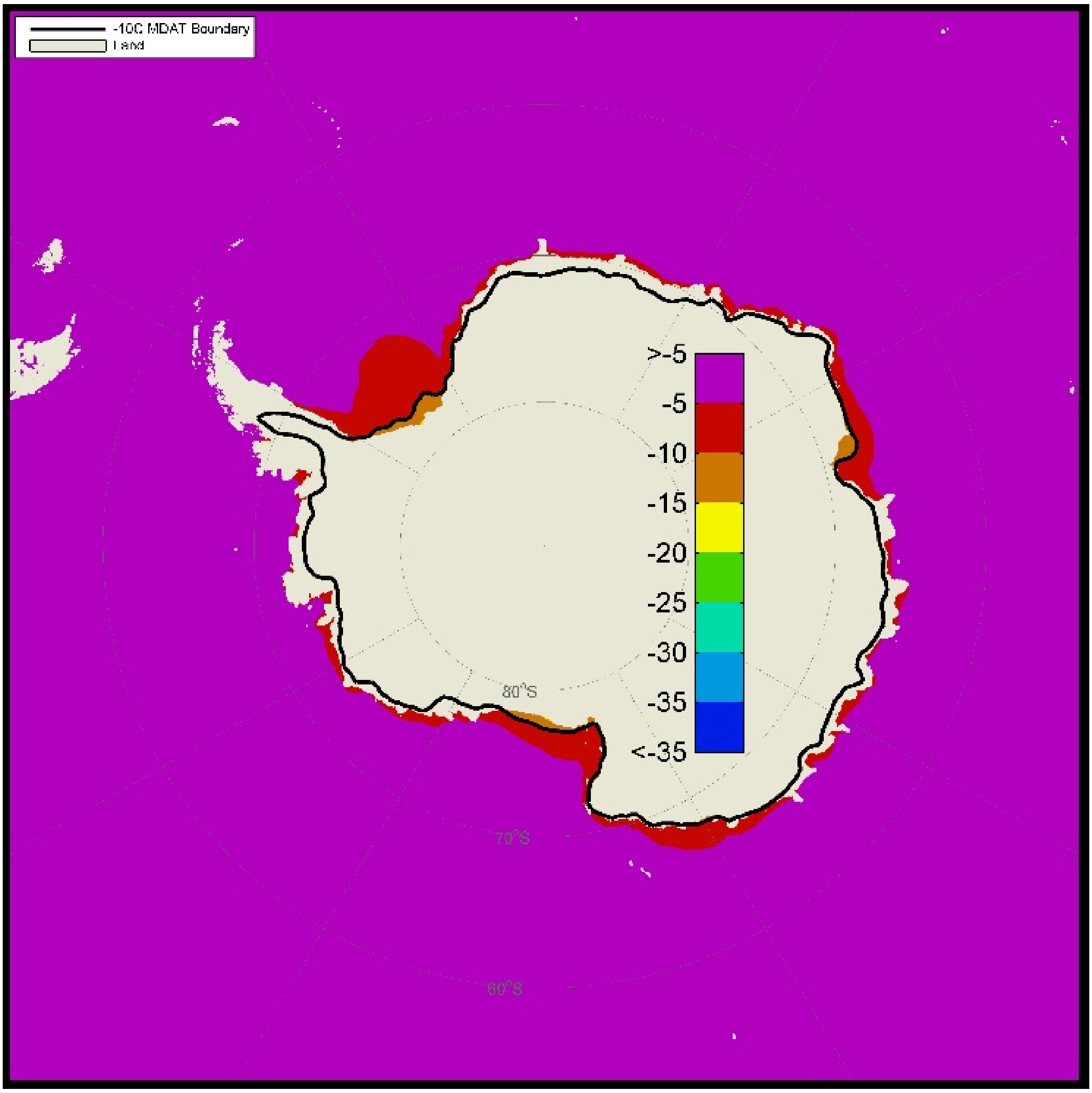


FIGURE 31
Antarctic Mean Daily Average Temperature (MDAT) in °C for March 1st
(1 September 2015)

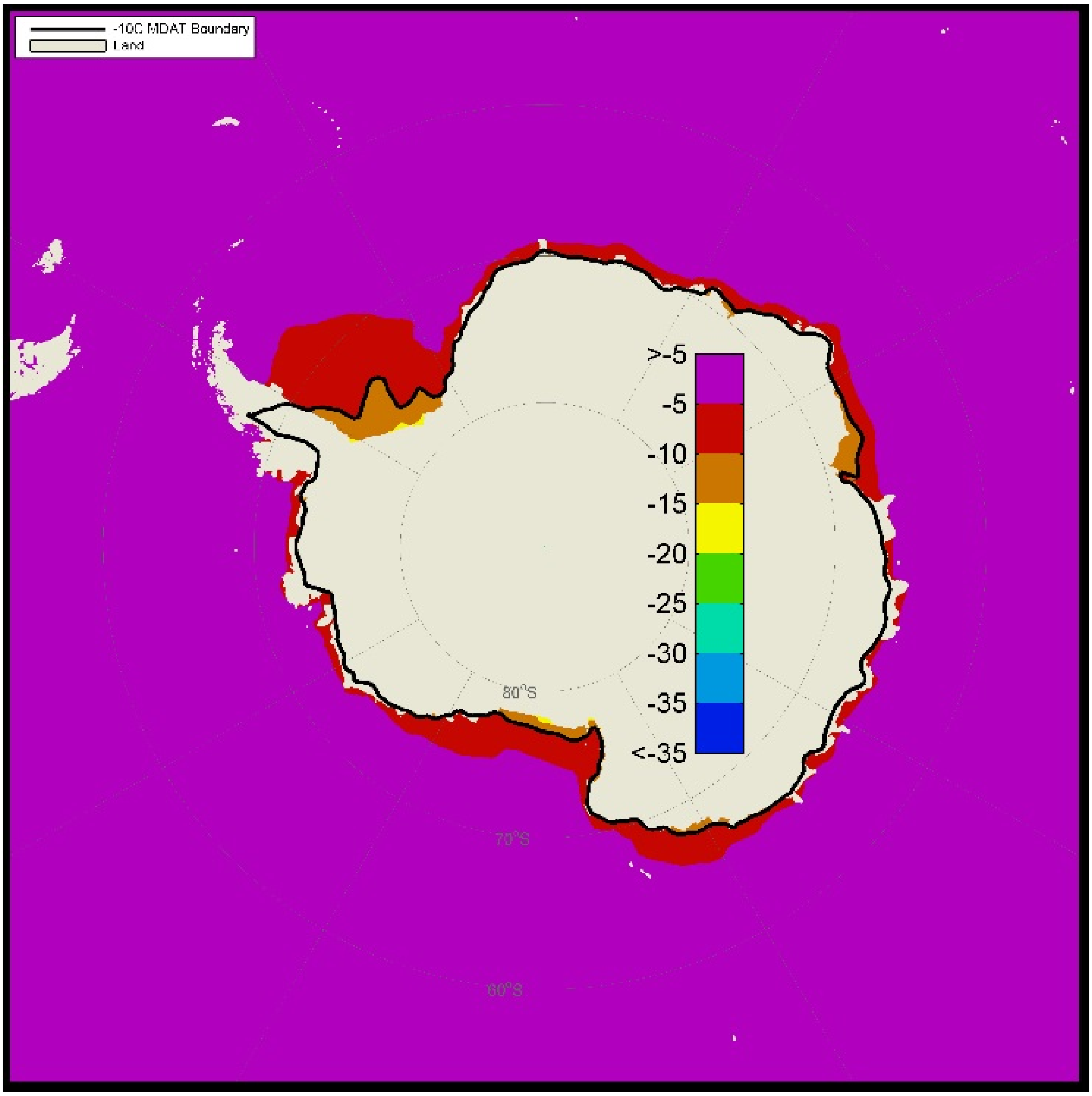


FIGURE 32
Antarctic Mean Daily Average Temperature (MDAT) in °C for March 15th
(1 September 2015)

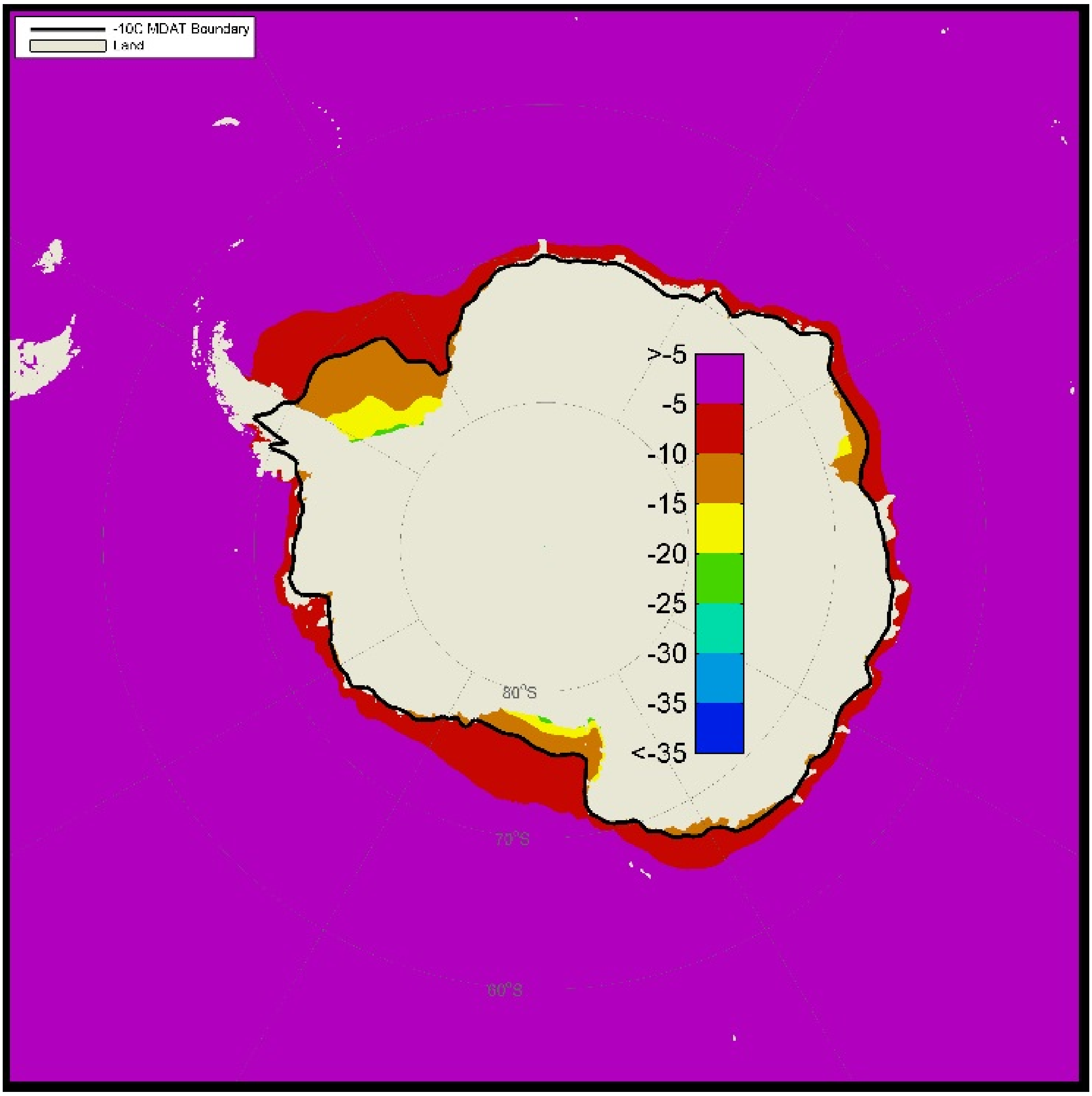


FIGURE 33
Antarctic Mean Daily Average Temperature (MDAT) in °C for April 1st
(1 September 2015)

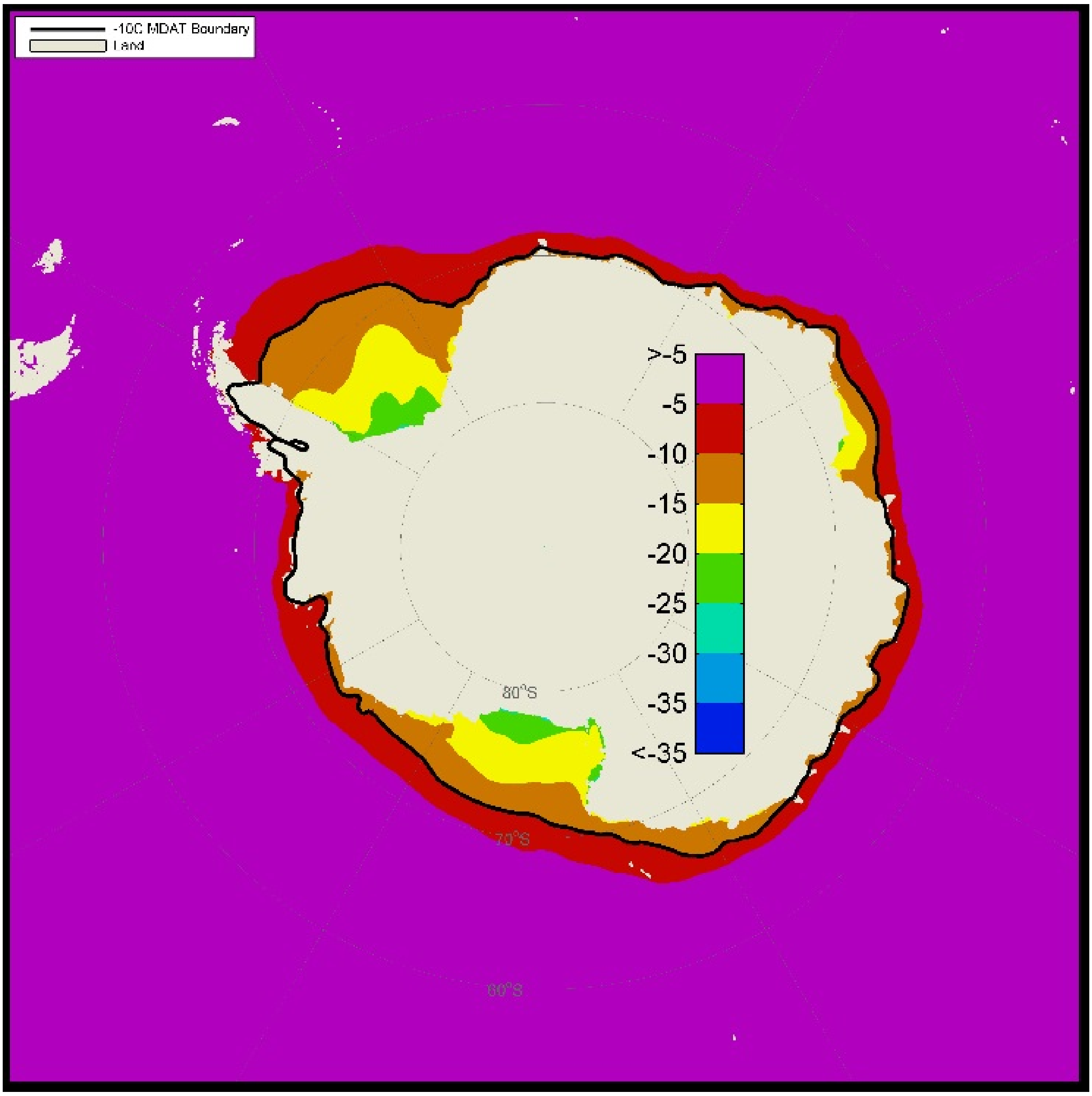


FIGURE 34
Antarctic Mean Daily Average Temperature (MDAT) in °C for April 15th
(1 September 2015)

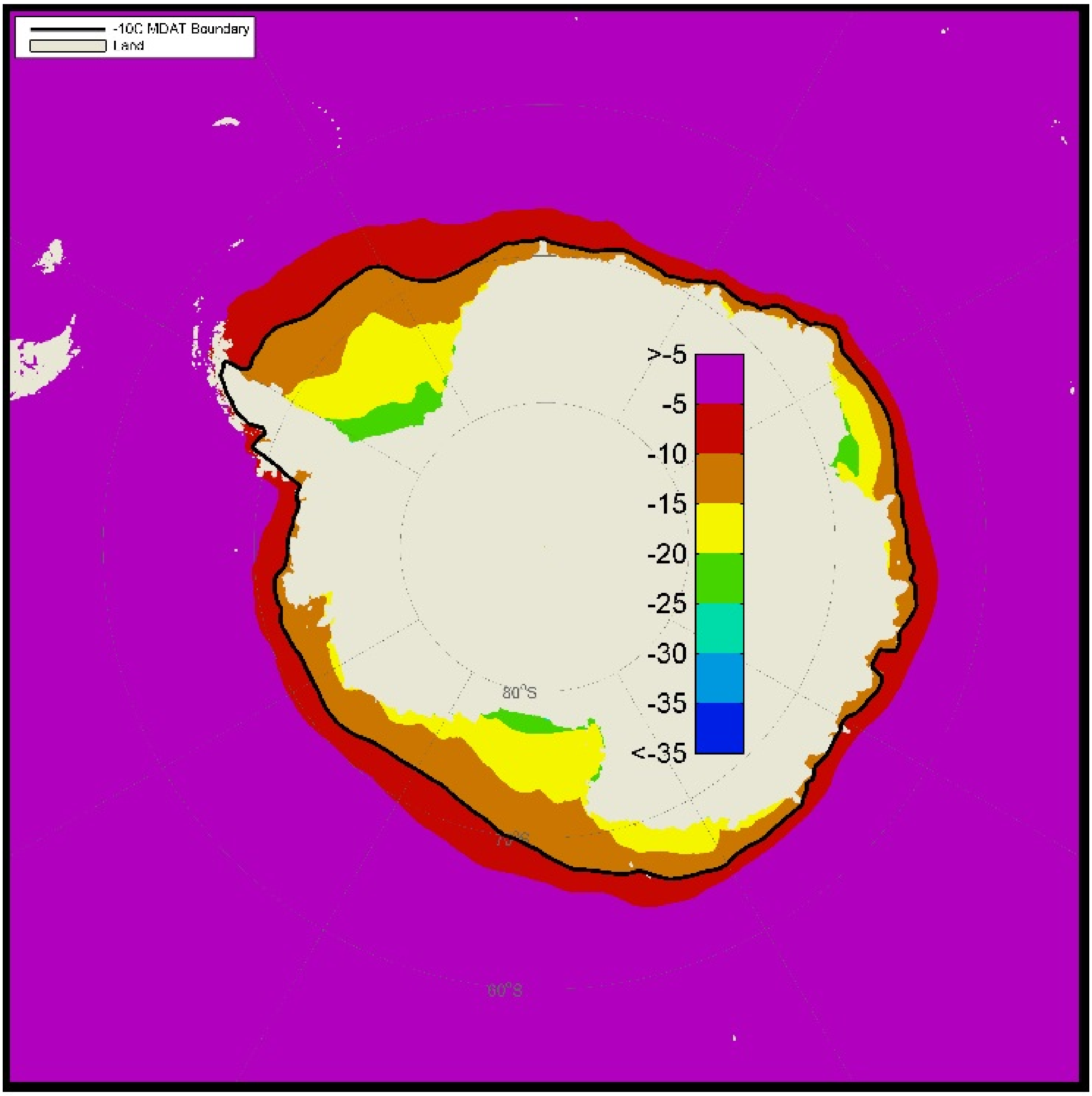


FIGURE 35
Antarctic Mean Daily Average Temperature (MDAT) in °C for May 1st
(1 September 2015)

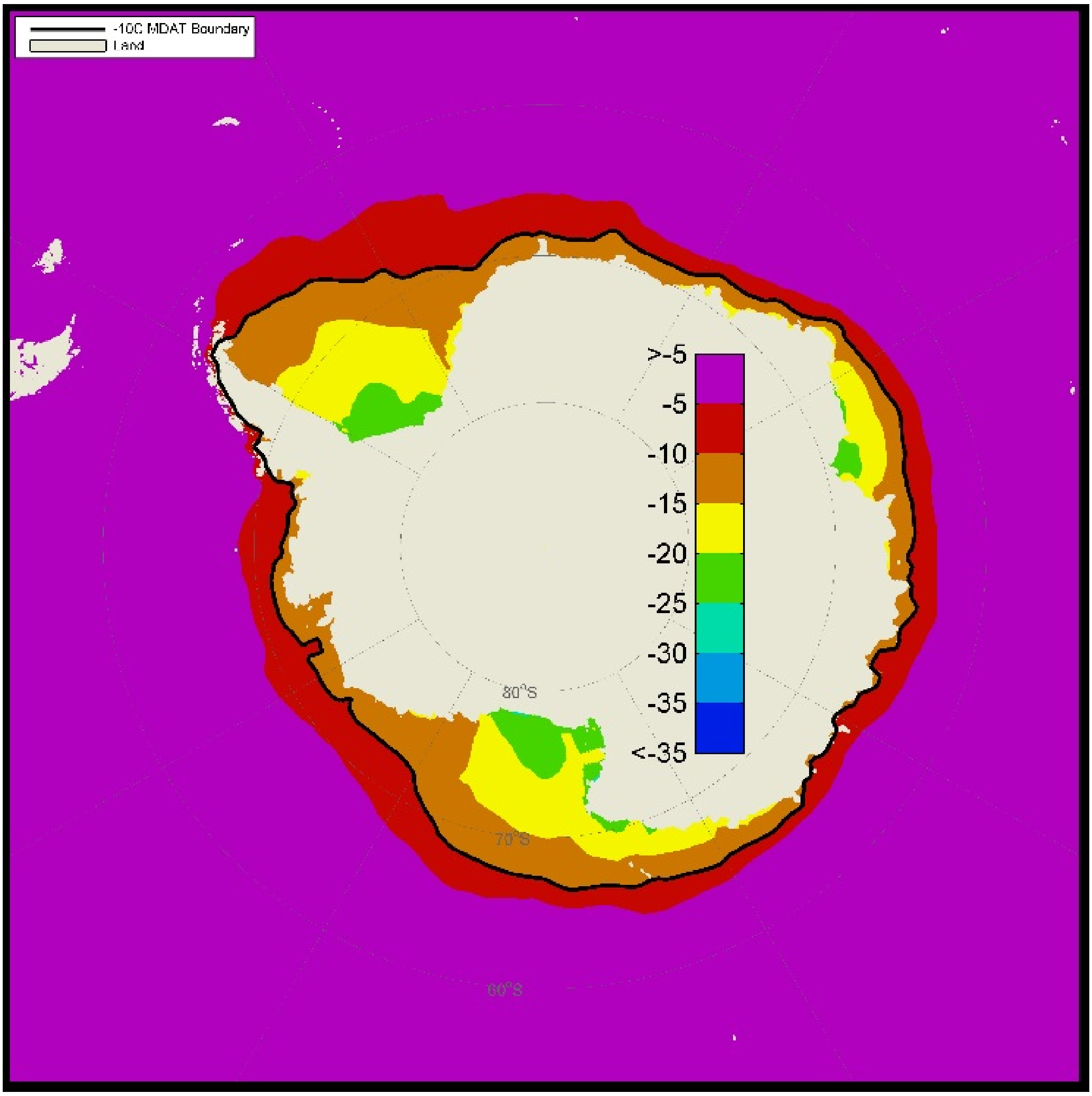


FIGURE 36
Antarctic Mean Daily Average Temperature (MDAT) in °C for May 15th
(1 September 2015)

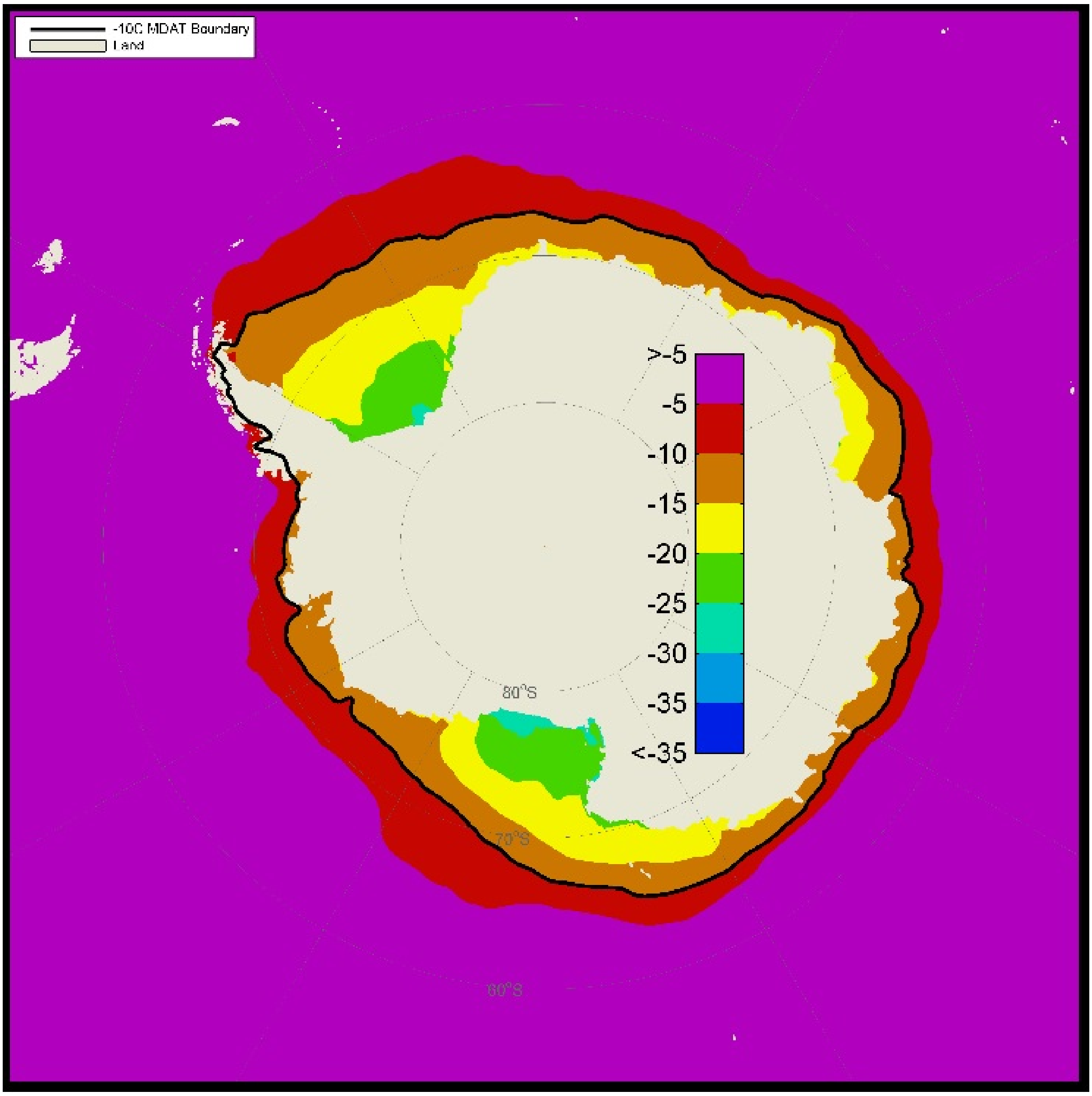


FIGURE 37
Antarctic Mean Daily Average Temperature (MDAT) in °C for June 1st
(1 September 2015)

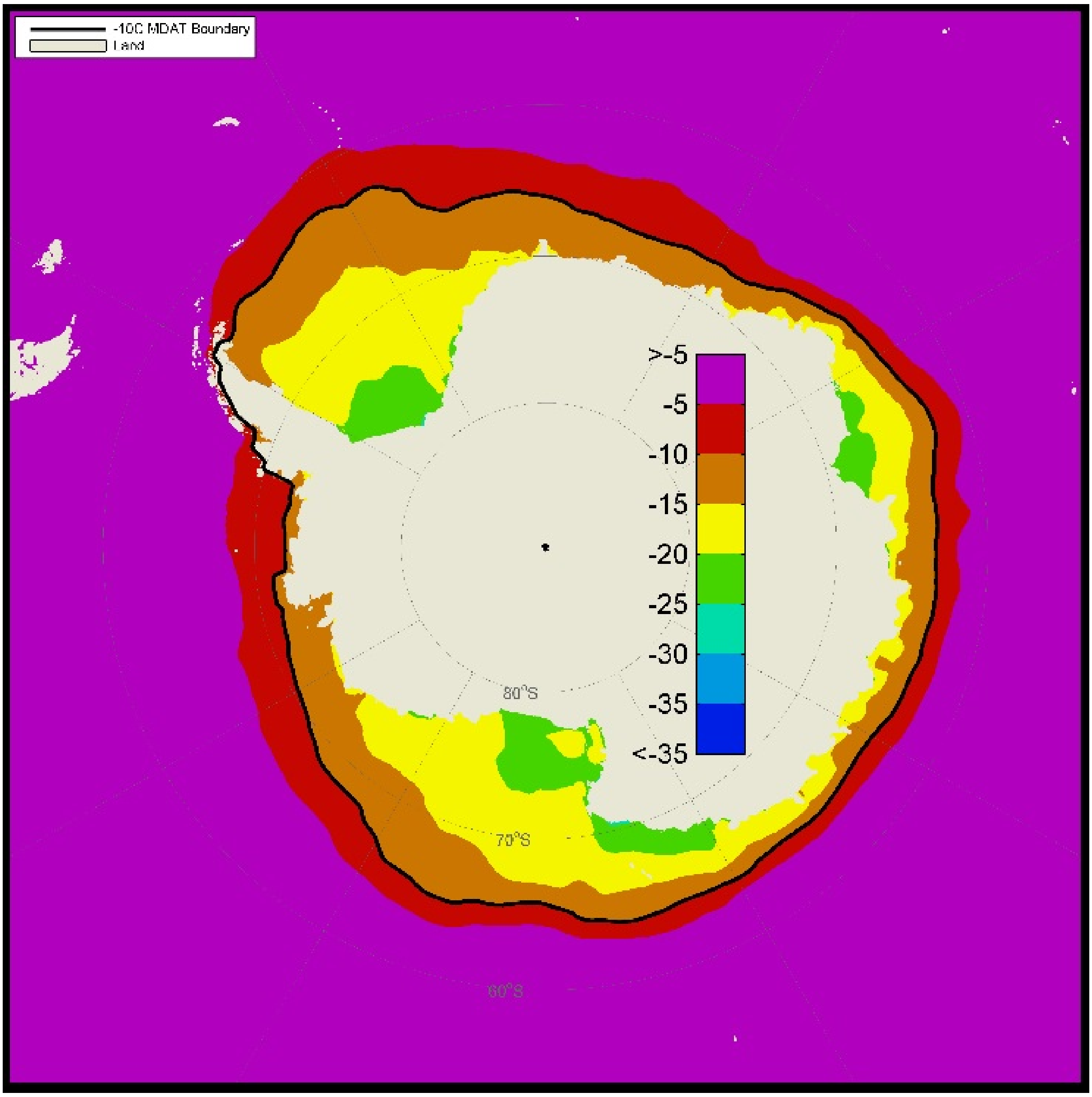


FIGURE 38
Antarctic Mean Daily Average Temperature (MDAT) in °C for June 15th
(1 September 2015)

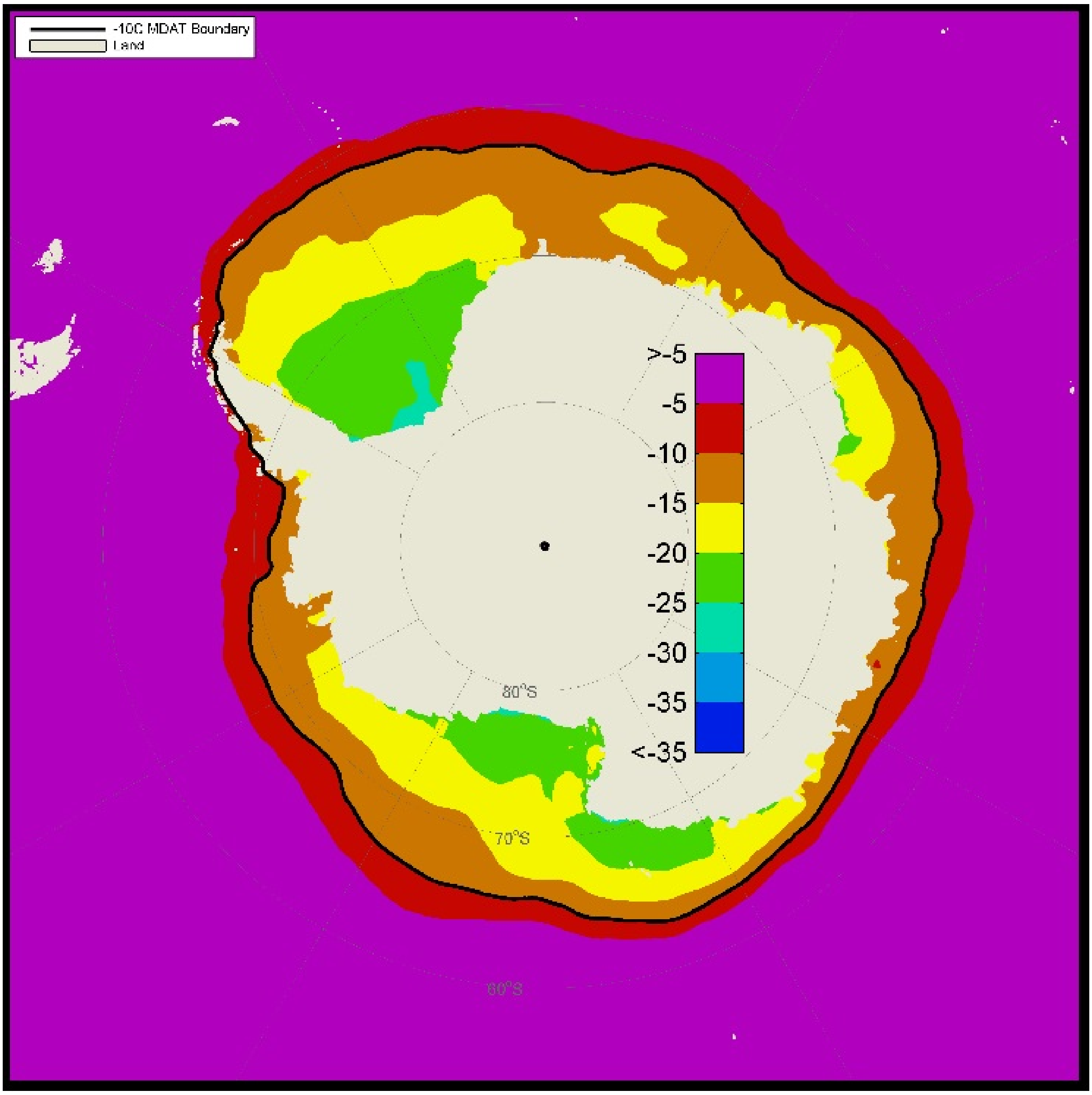


FIGURE 39
Antarctic Mean Daily Average Temperature (MDAT) in °C for July 1st
(1 September 2015)

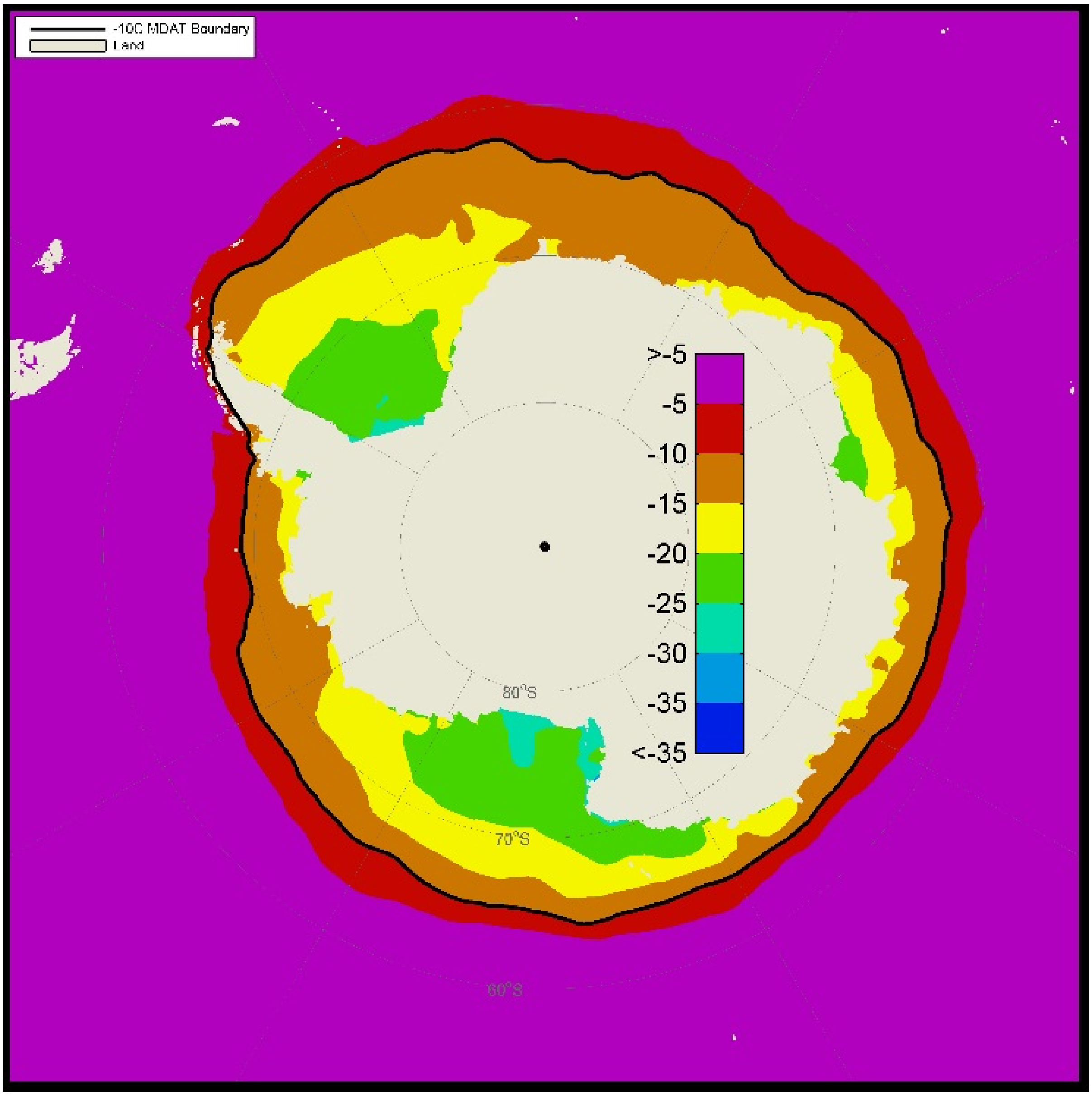


FIGURE 40
Antarctic Mean Daily Average Temperature (MDAT) in °C for July 15th
(1 September 2015)

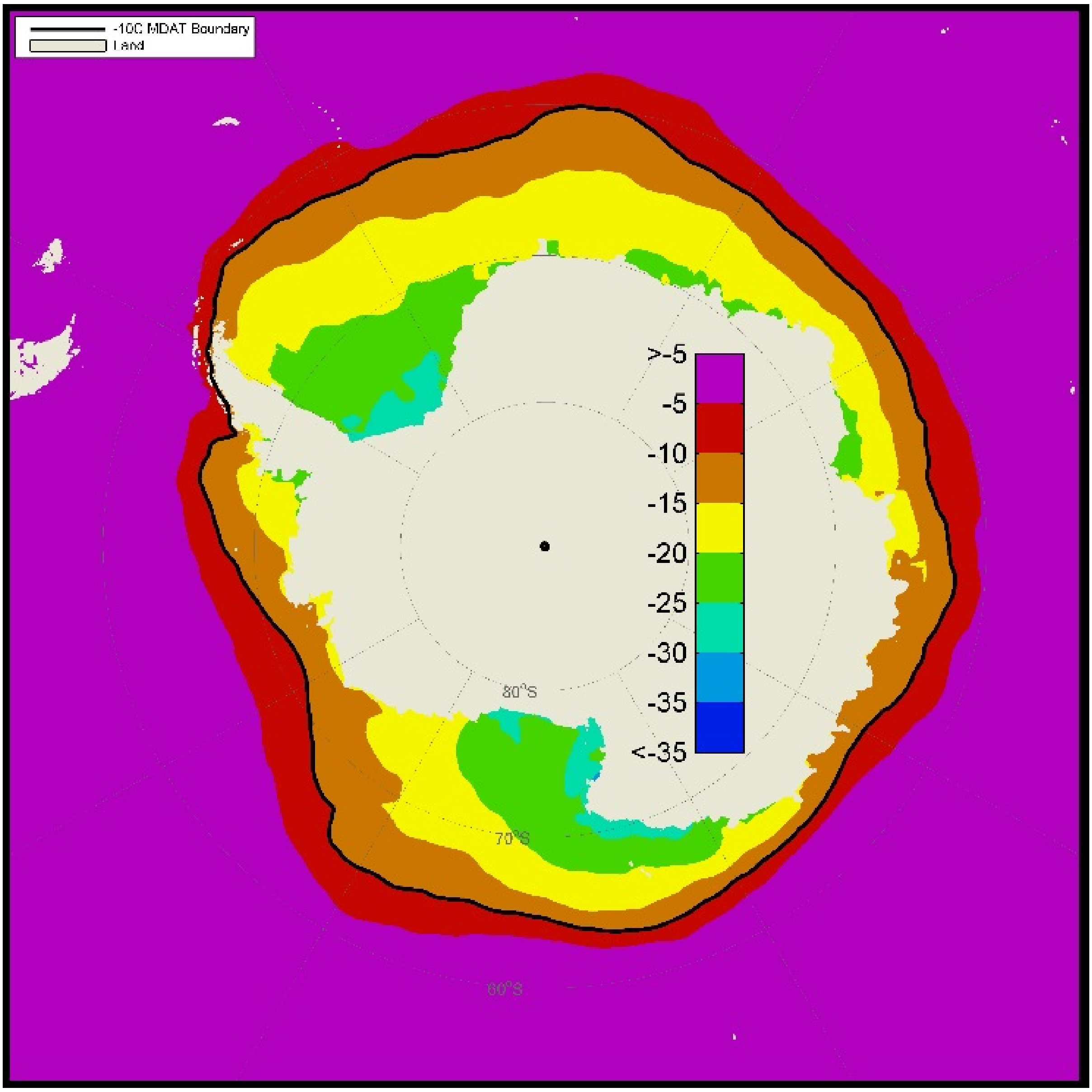


FIGURE 41
Antarctic Mean Daily Average Temperature (MDAT) in °C for August 1st
(1 September 2015)

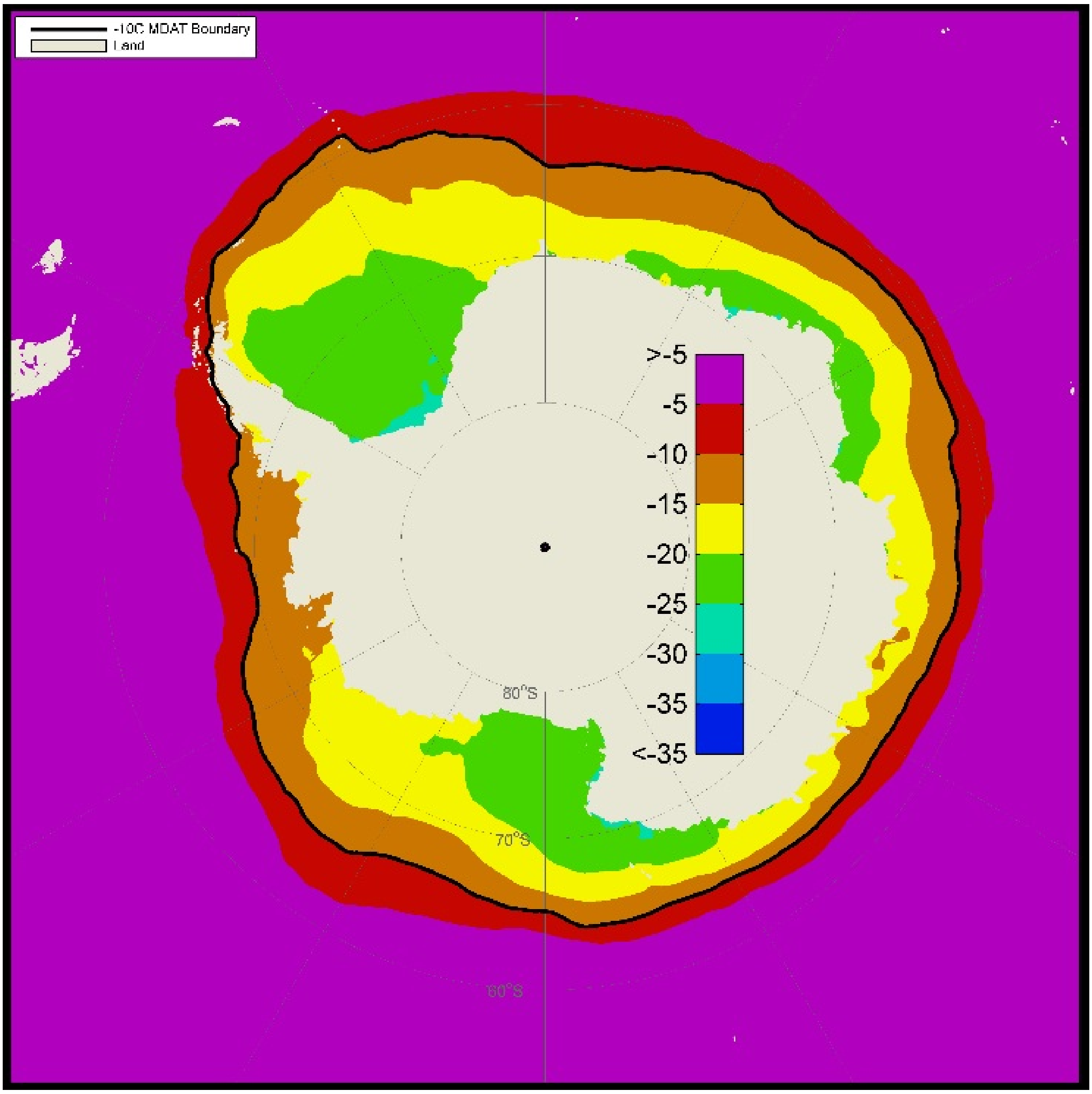


FIGURE 42
Antarctic Mean Daily Average Temperature (MDAT) in °C for August 15th
(1 September 2015)

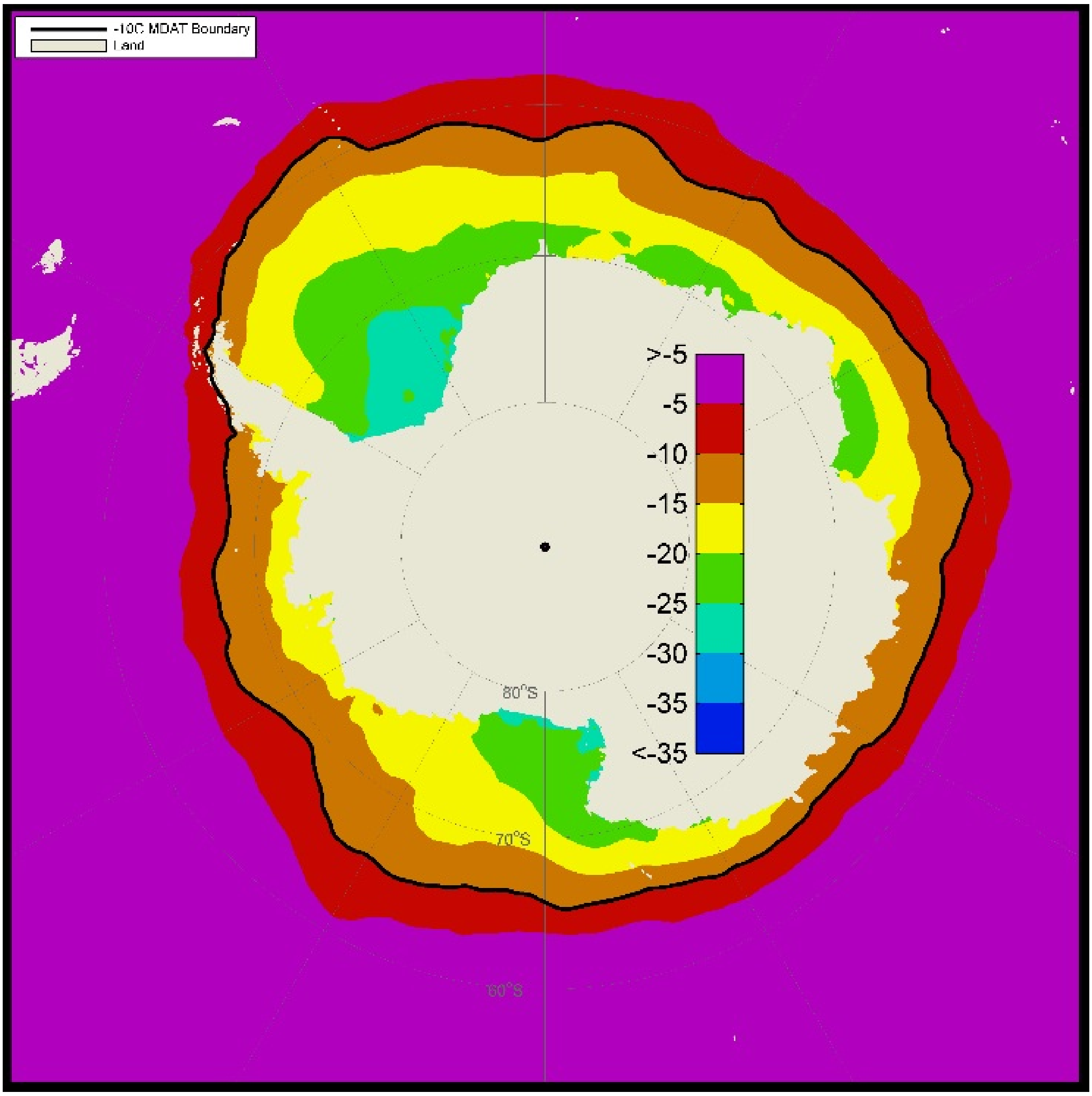


FIGURE 43
Antarctic Mean Daily Average Temperature (MDAT) in °C for September 1st
(1 September 2015)

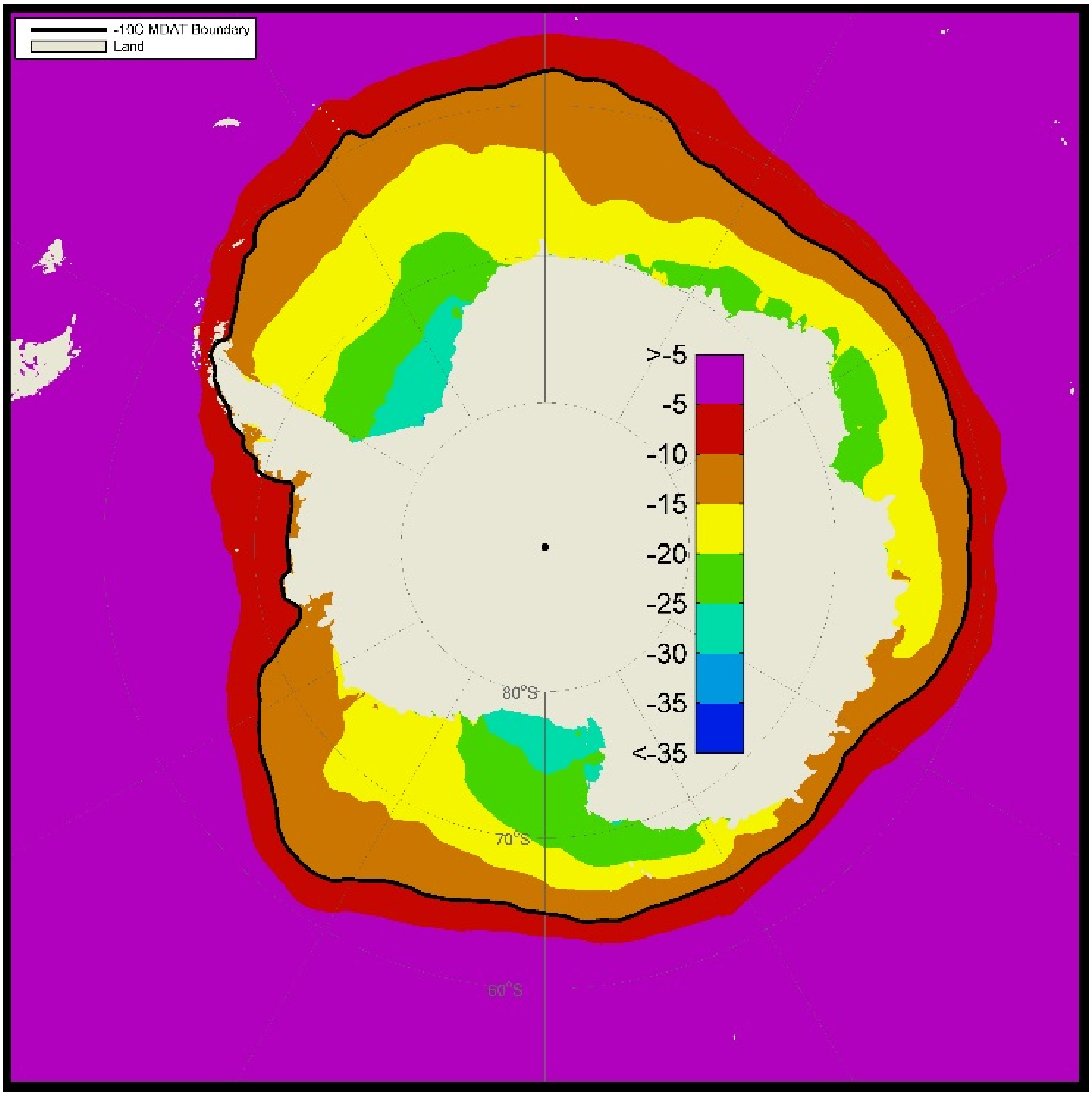


FIGURE 44
Antarctic Mean Daily Average Temperature (MDAT) in °C for September 15th
(1 September 2015)

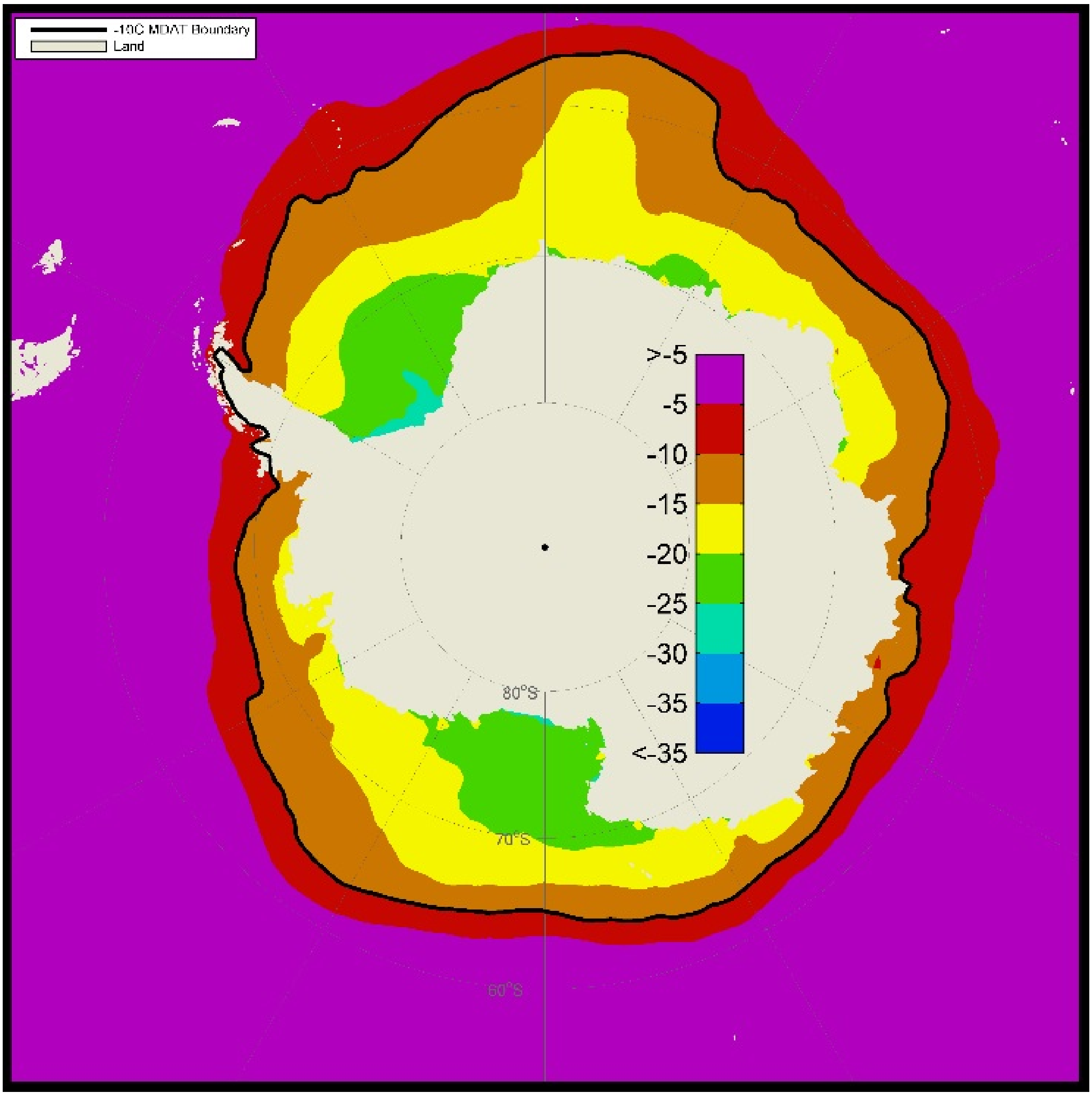


FIGURE 45
Antarctic Mean Daily Average Temperature (MDAT) in °C for October 1st
(1 September 2015)

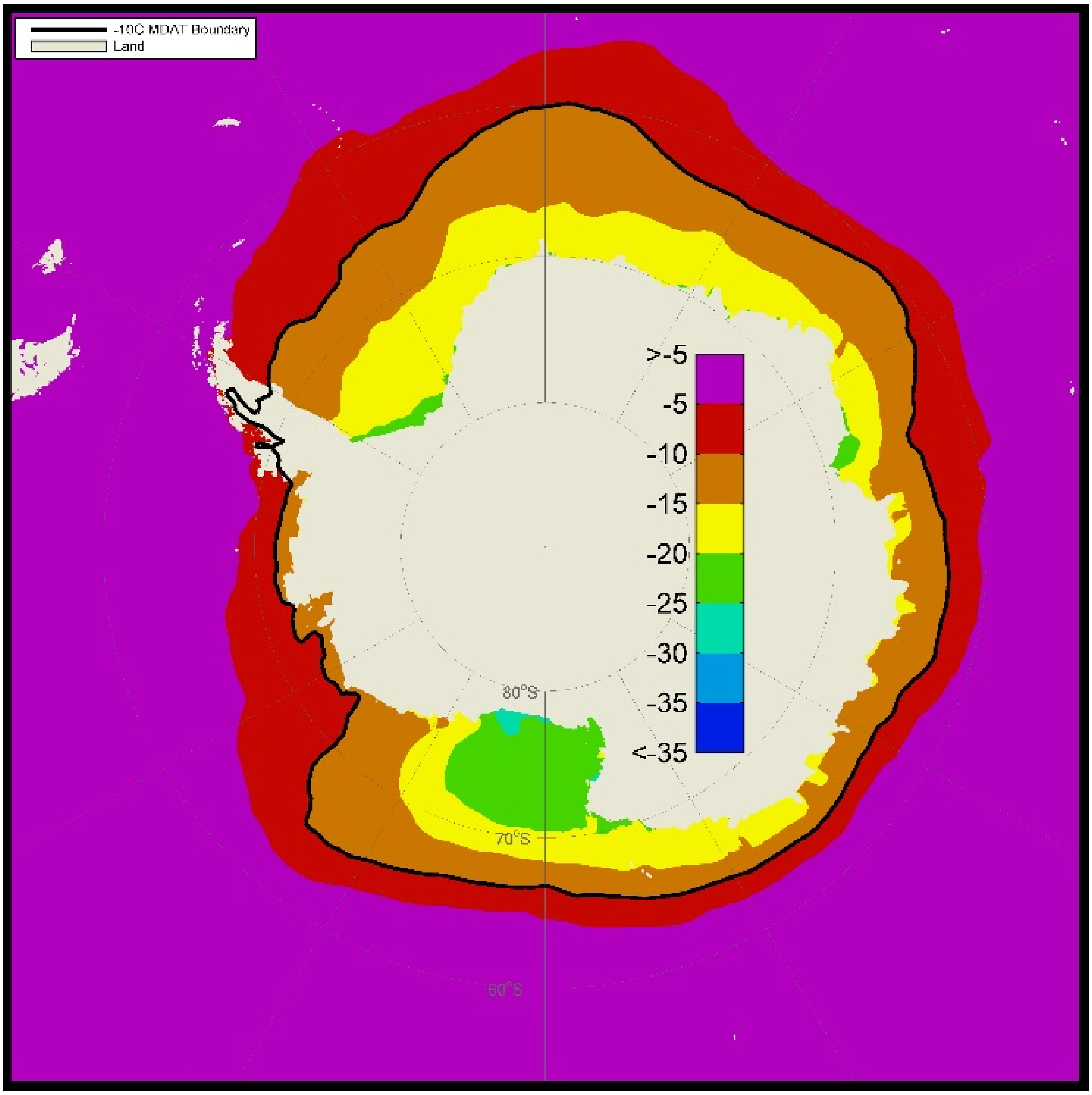


FIGURE 46
Antarctic Mean Daily Average Temperature (MDAT) in °C for October 15th
(1 September 2015)

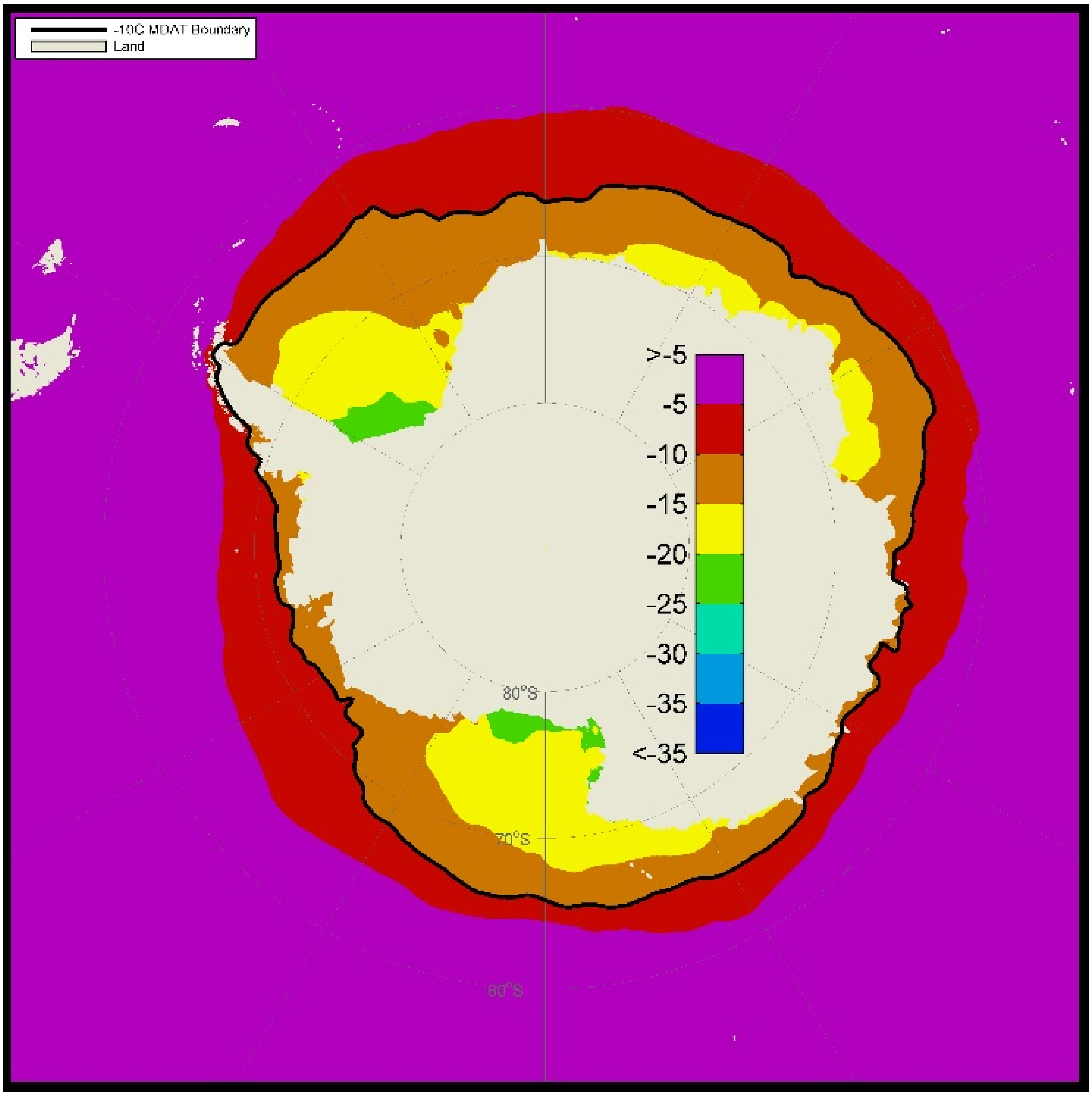


FIGURE 47
Antarctic Mean Daily Average Temperature (MDAT) in °C for November 1st
(1 September 2015)

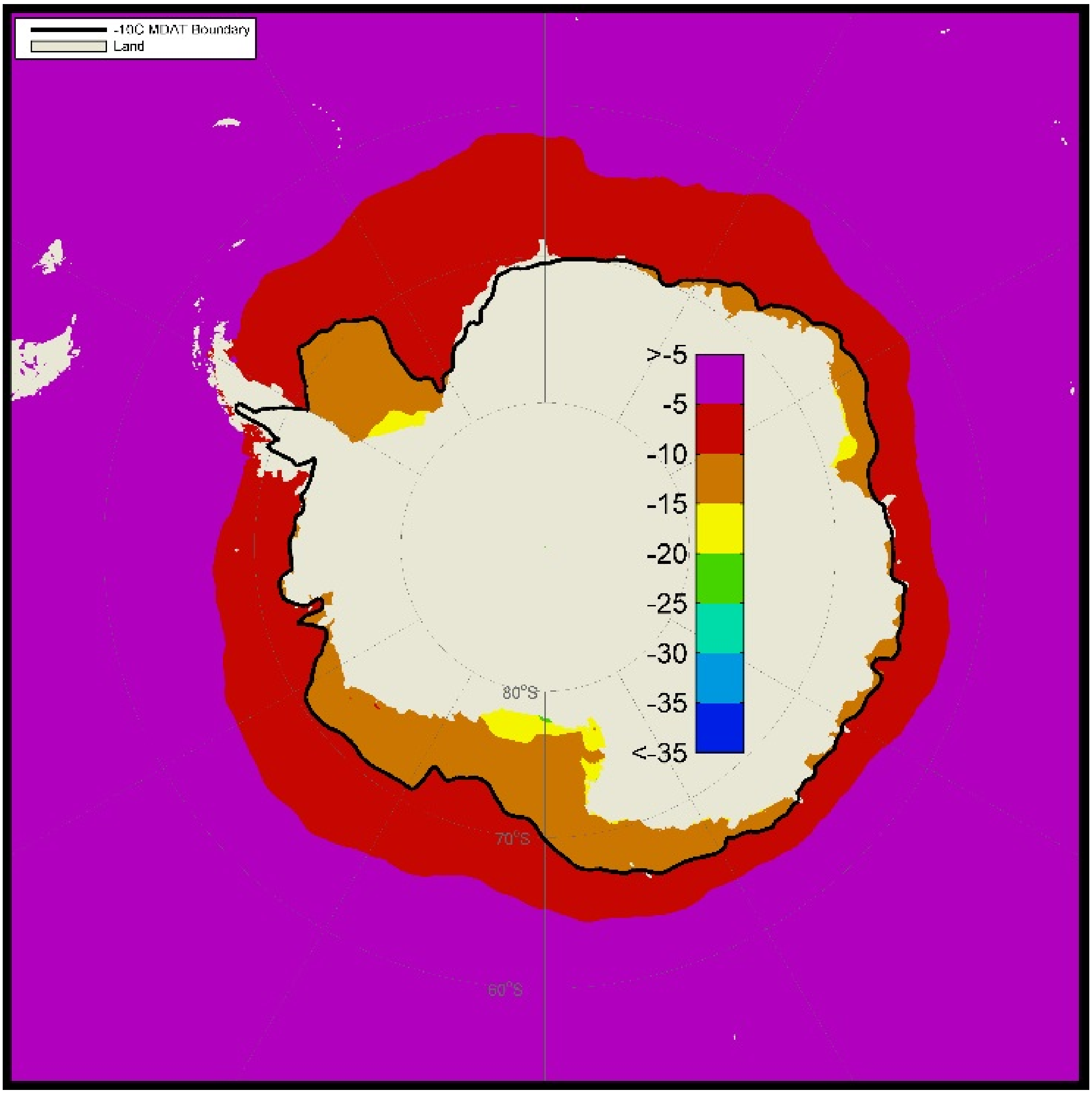


FIGURE 48
Antarctic Mean Daily Average Temperature (MDAT) in °C for November 15th
(1 September 2015)

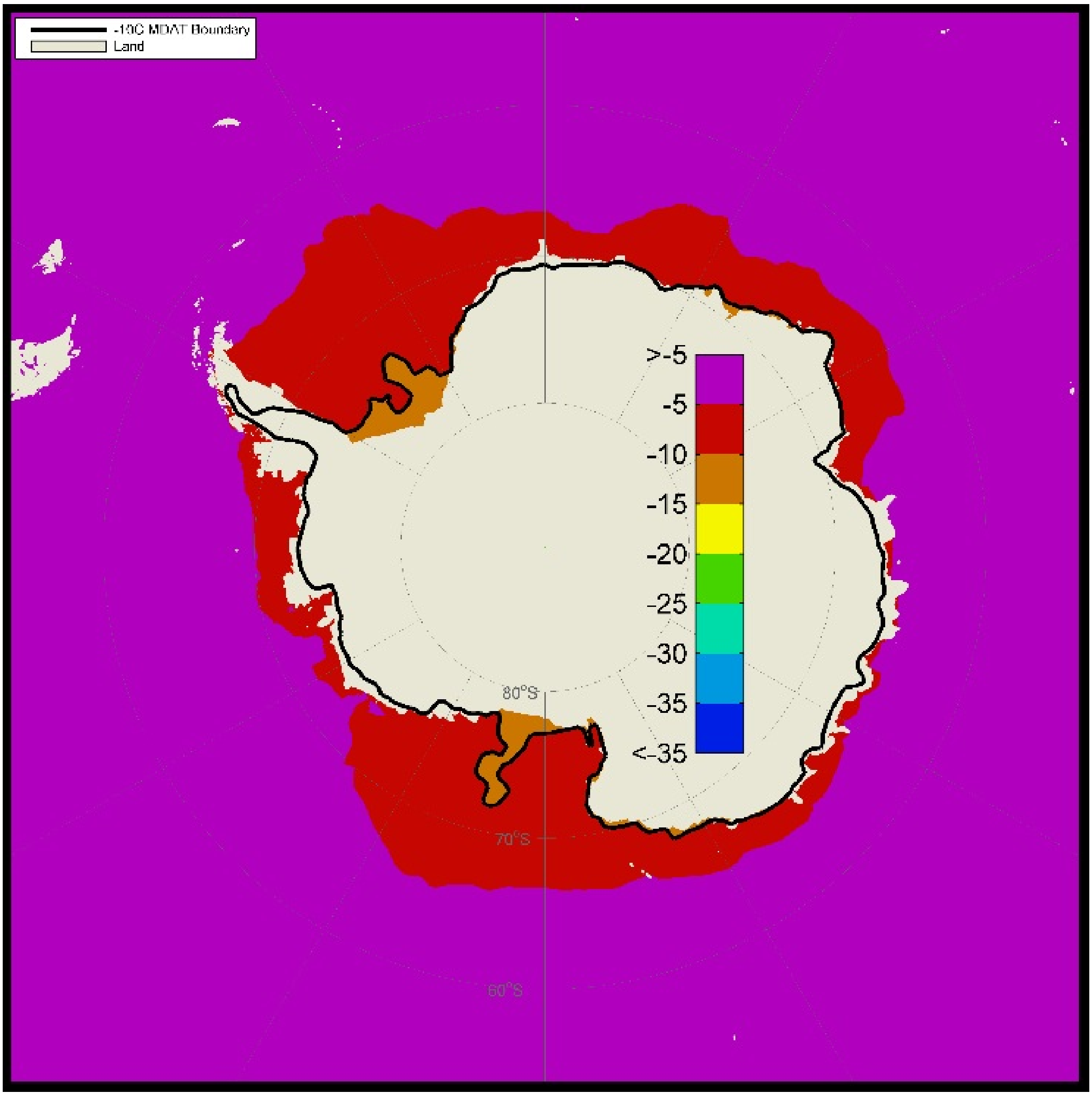


FIGURE 49
Antarctic Mean Daily Average Temperature (MDAT) in °C for December 1st
(1 September 2015)

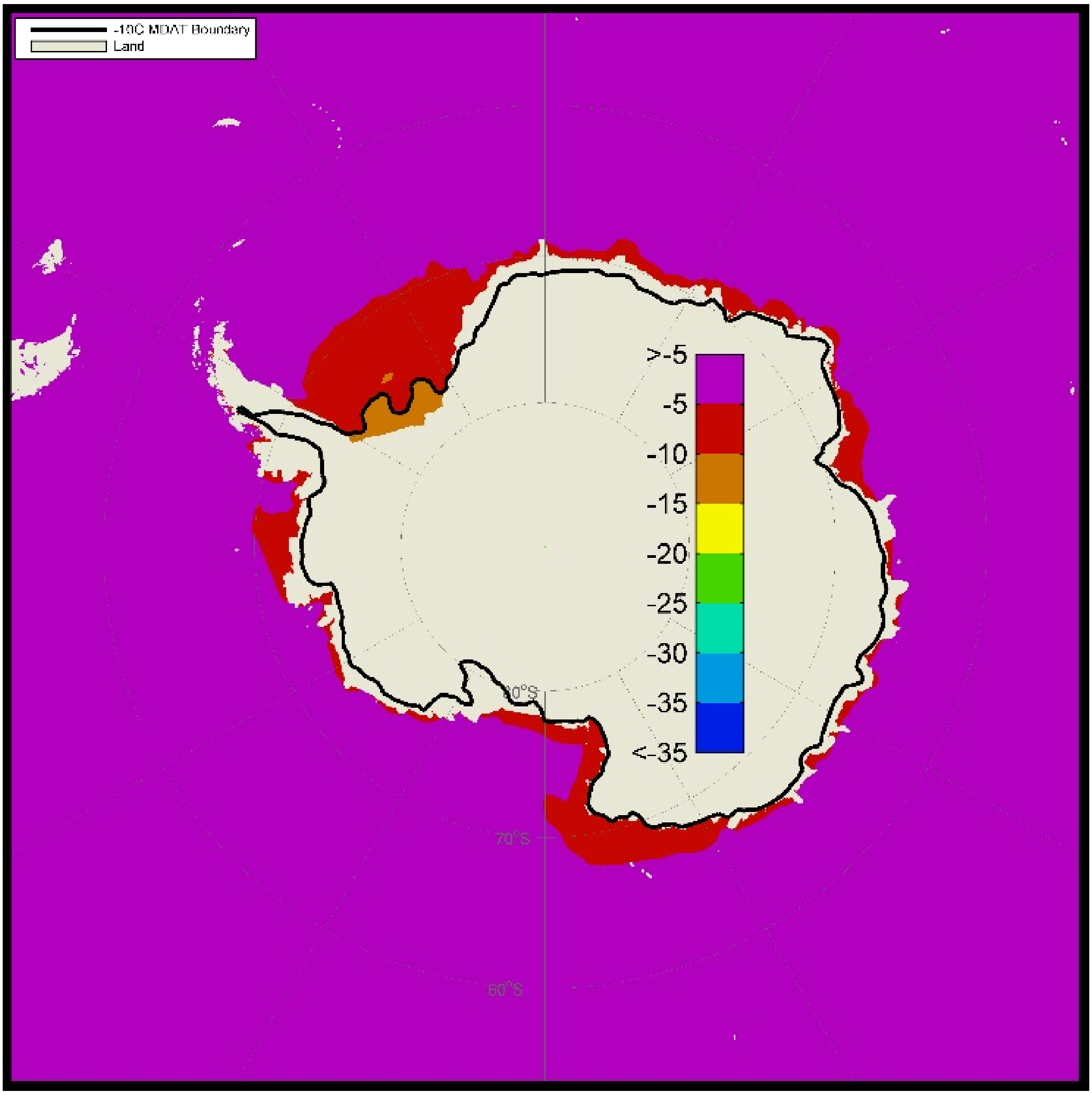


FIGURE 50
Antarctic Mean Daily Average Temperature (MDAT) in °C for December 15th
(1 September 2015)

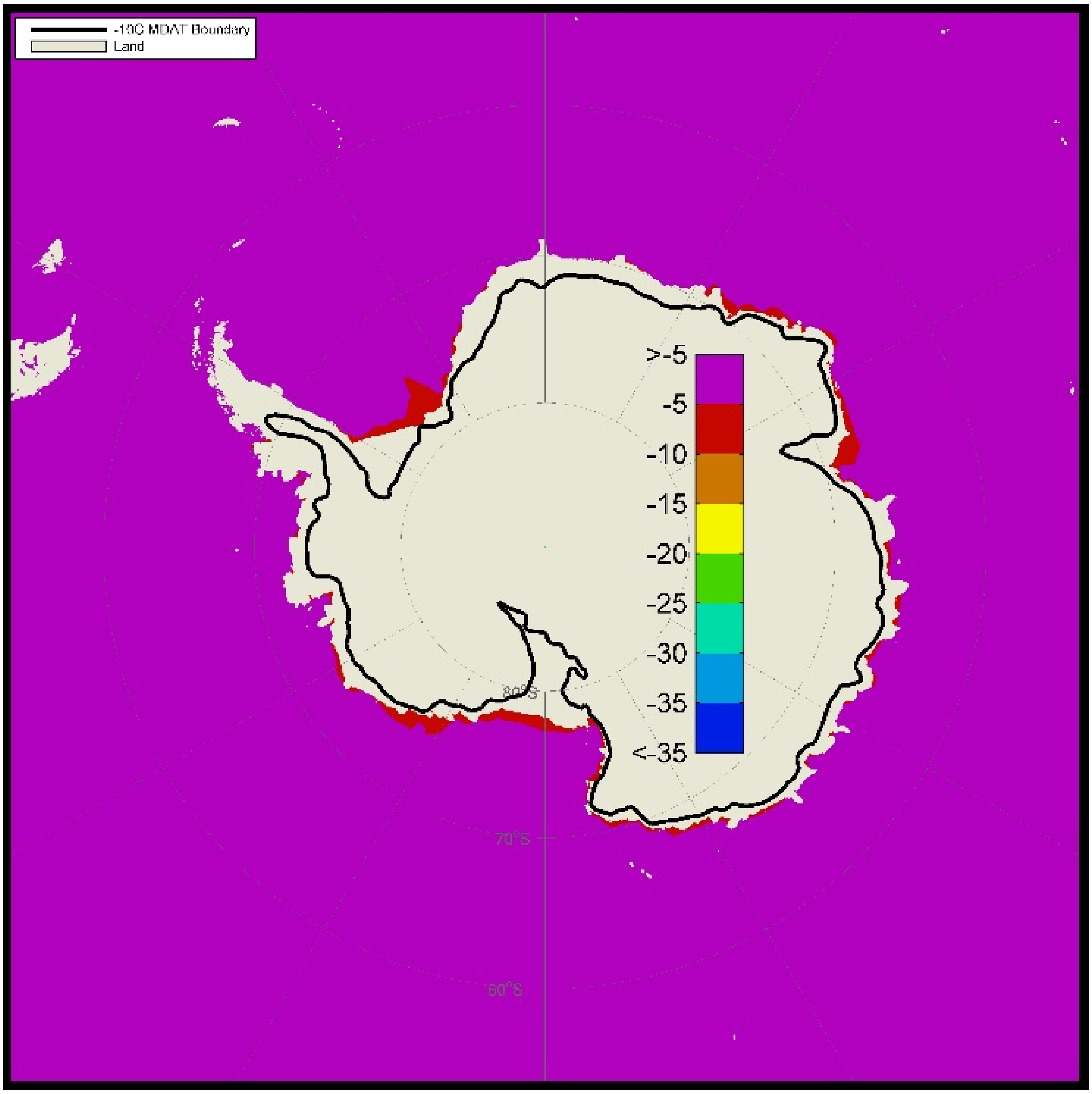


FIGURE 51
Arctic Mean Daily Low Temperature (MDLT) in °C for January 1st
(1 September 2015)

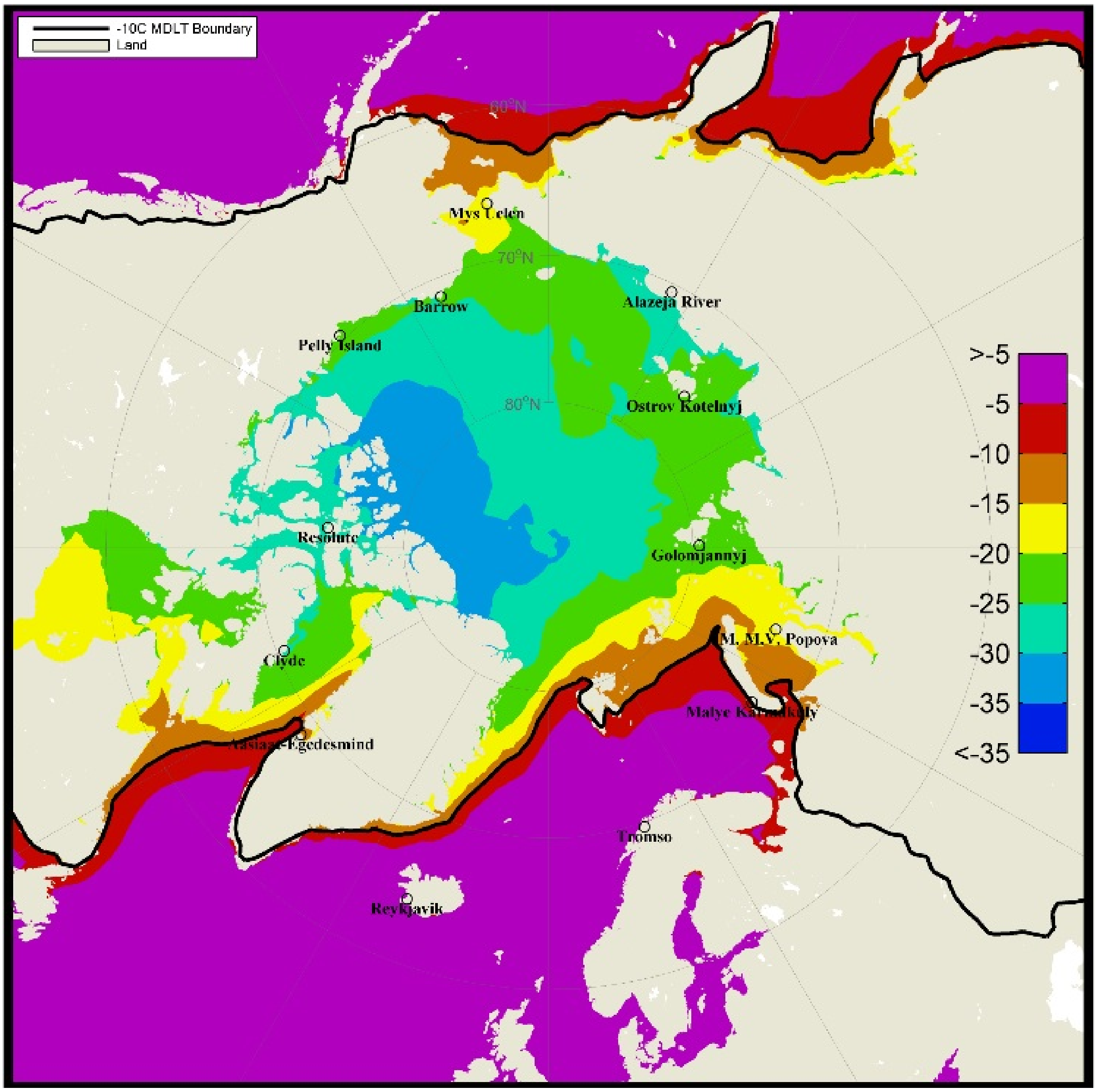


FIGURE 52
Arctic Mean Daily Low Temperature (MDLT) in °C for January 15th
(1 September 2015)

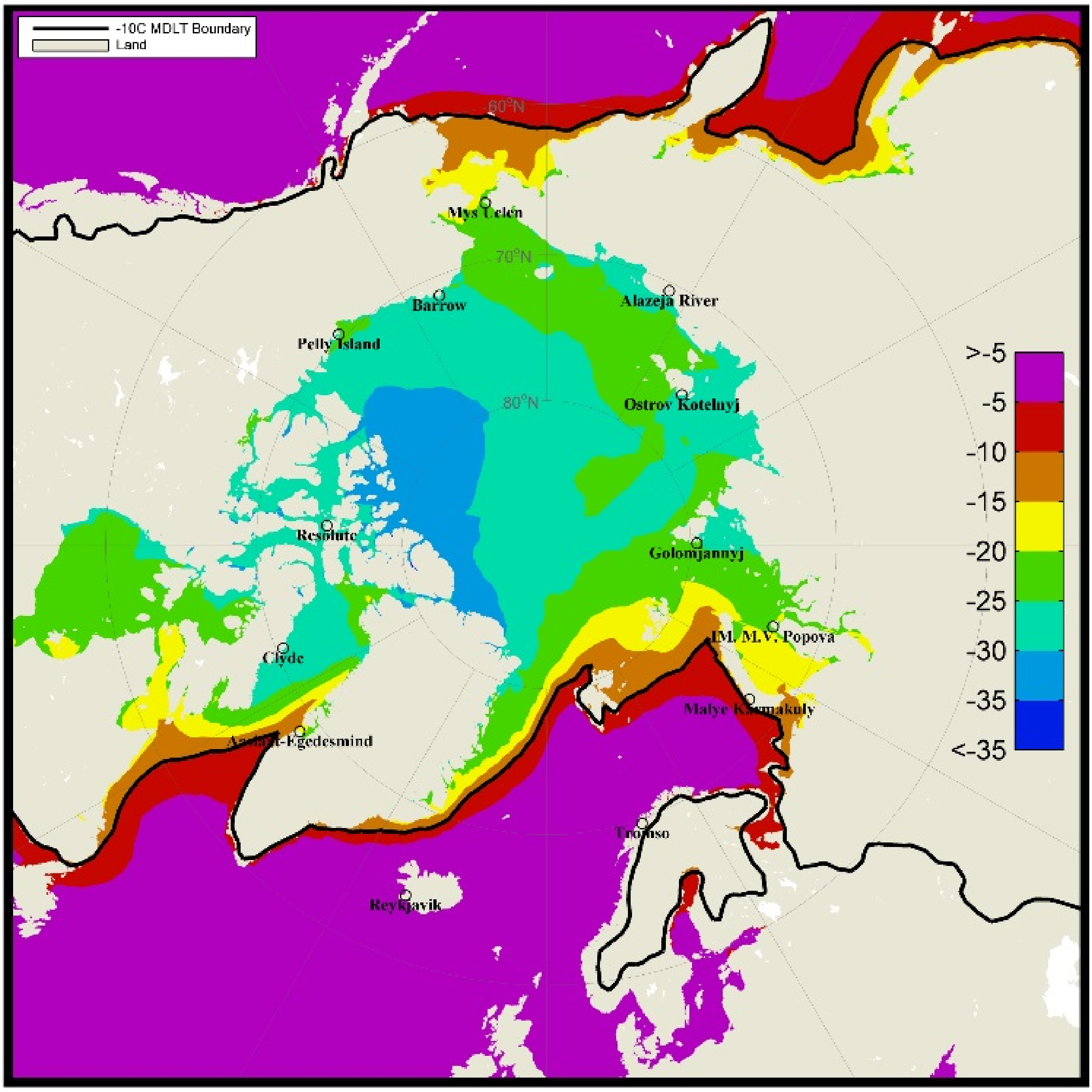


FIGURE 53
Arctic Mean Daily Low Temperature (MDLT) in °C for February 1st
(1 September 2015)

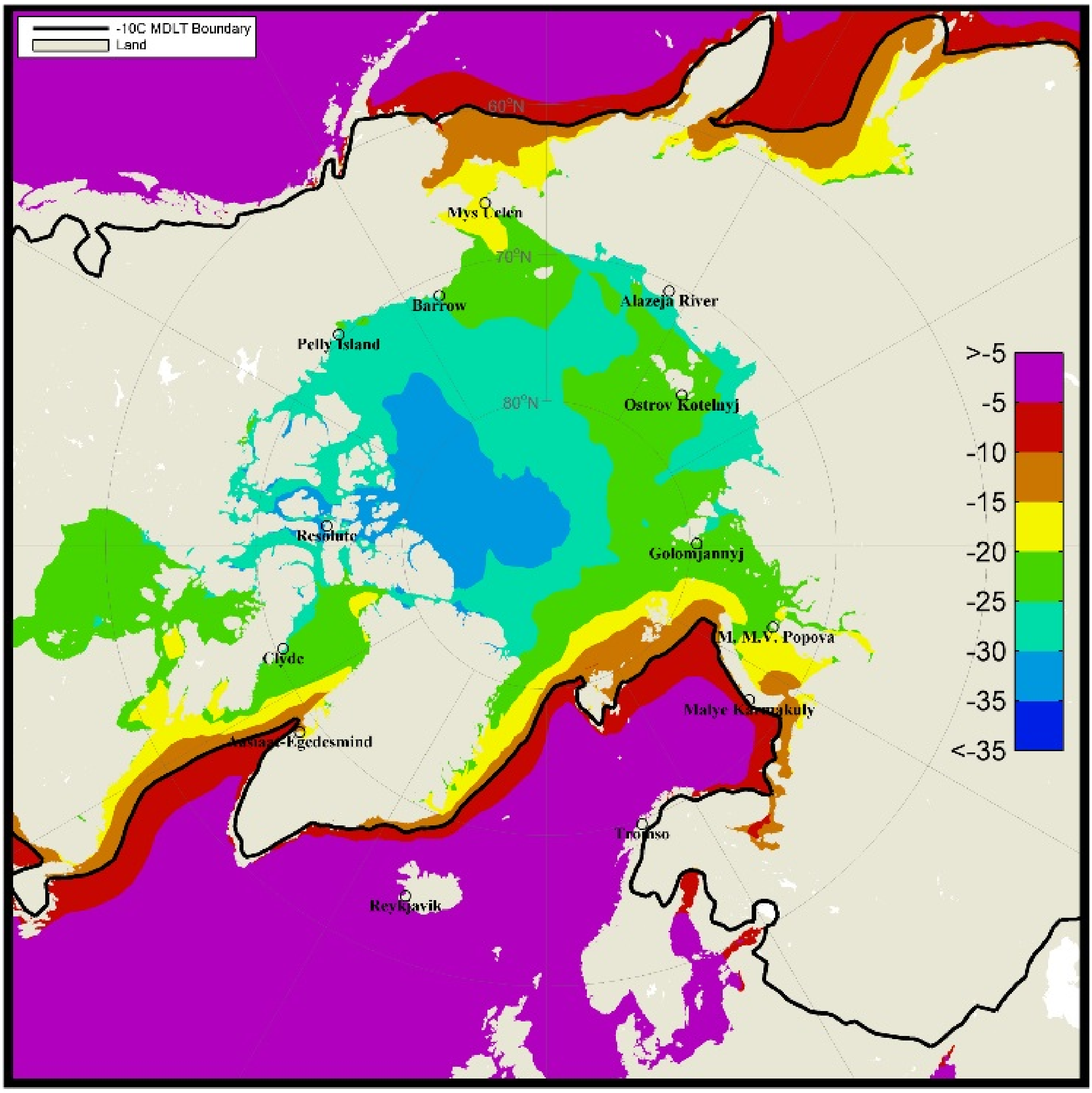


FIGURE 54
Arctic Mean Daily Low Temperature (MDLT) in °C for February 15th
(1 September 2015)

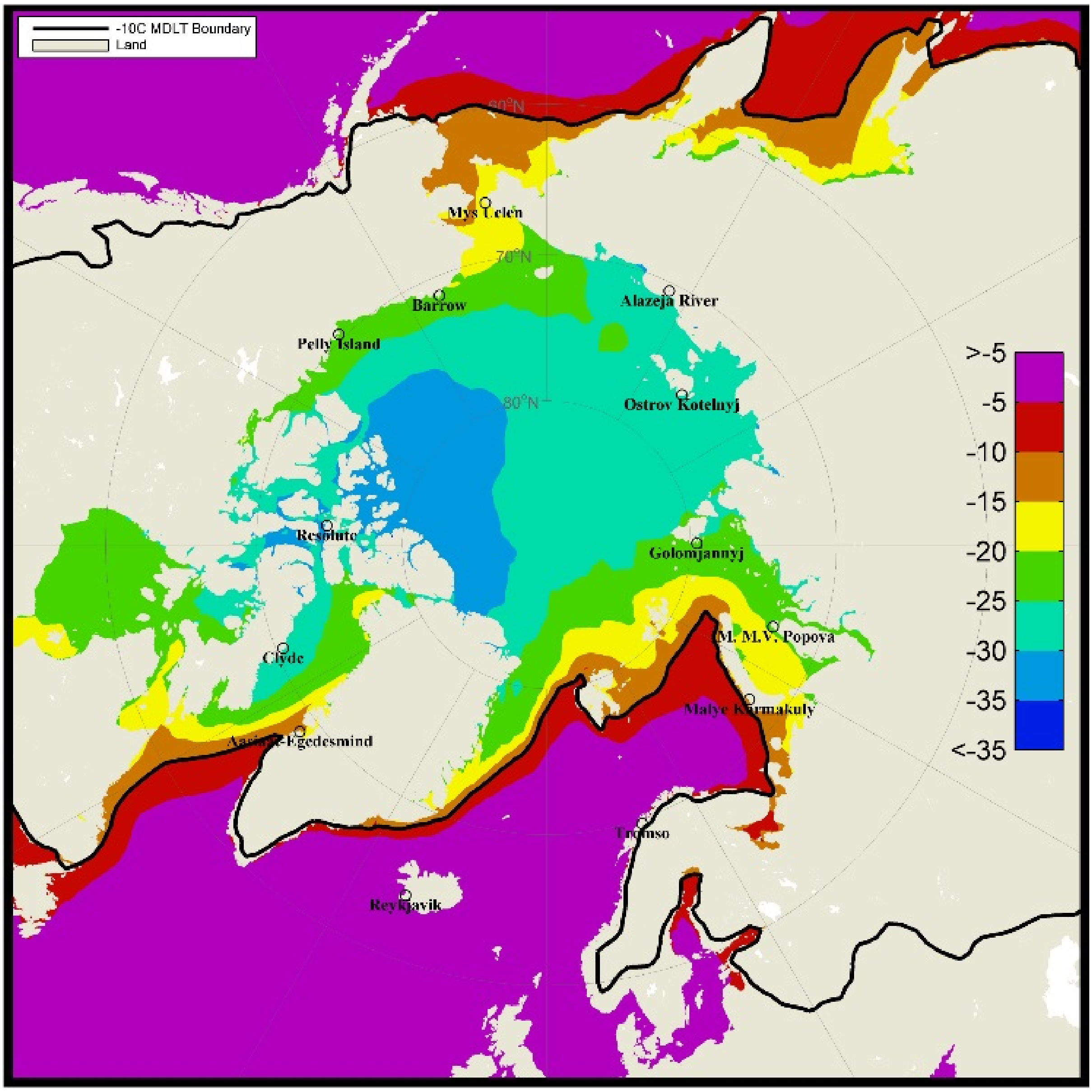


FIGURE 55
Arctic Mean Daily Low Temperature (MDLT) in °C for March 1st
(1 September 2015)

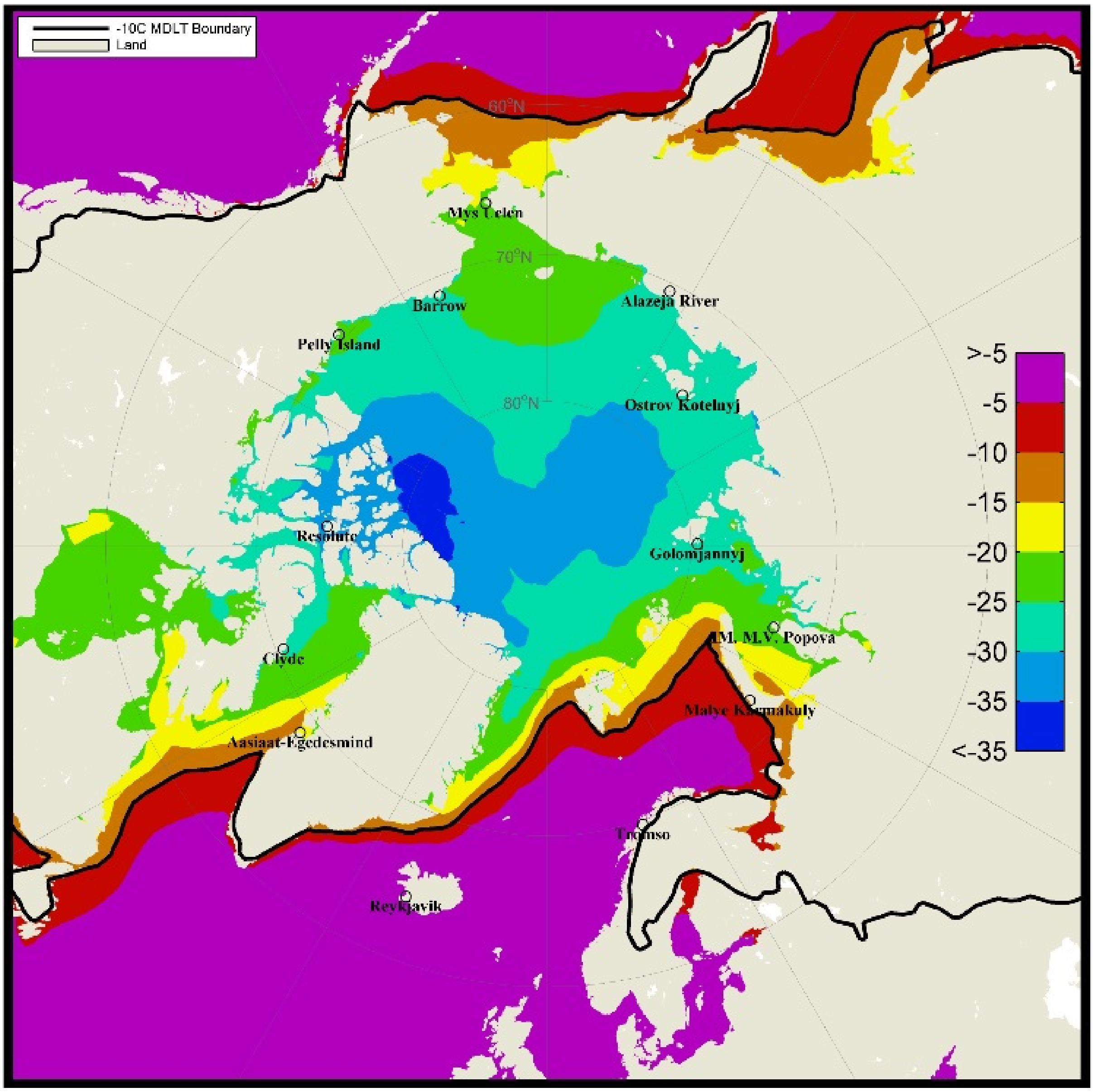


FIGURE 56
Arctic Mean Daily Low Temperature (MDLT) in °C for March 15th
(1 September 2015)

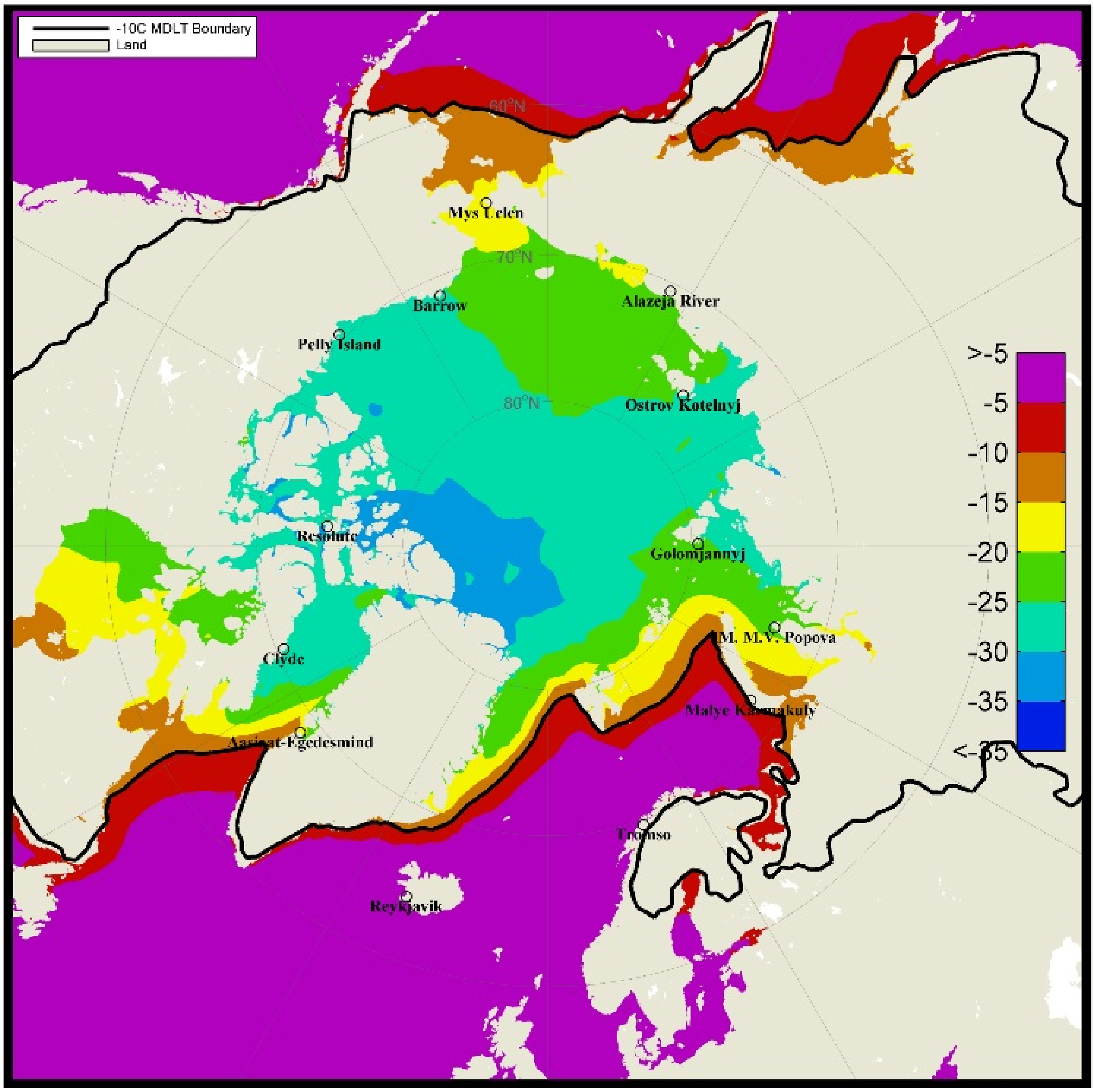


FIGURE 57
Arctic Mean Daily Low Temperature (MDLT) in °C for April 1st
(1 September 2015)

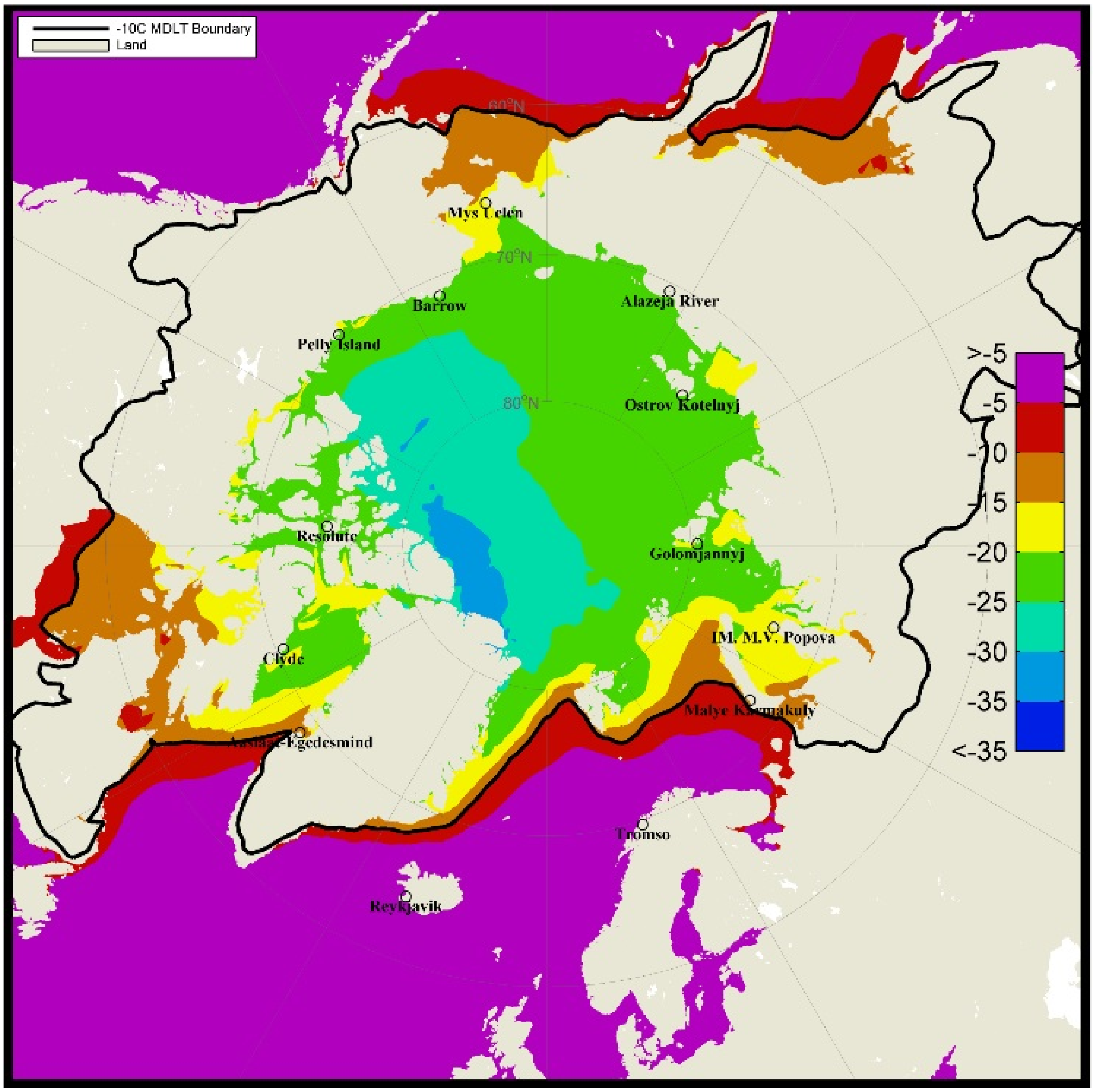


FIGURE 58
Arctic Mean Daily Low Temperature (MDLT) in °C for April 15th
(1 September 2015)

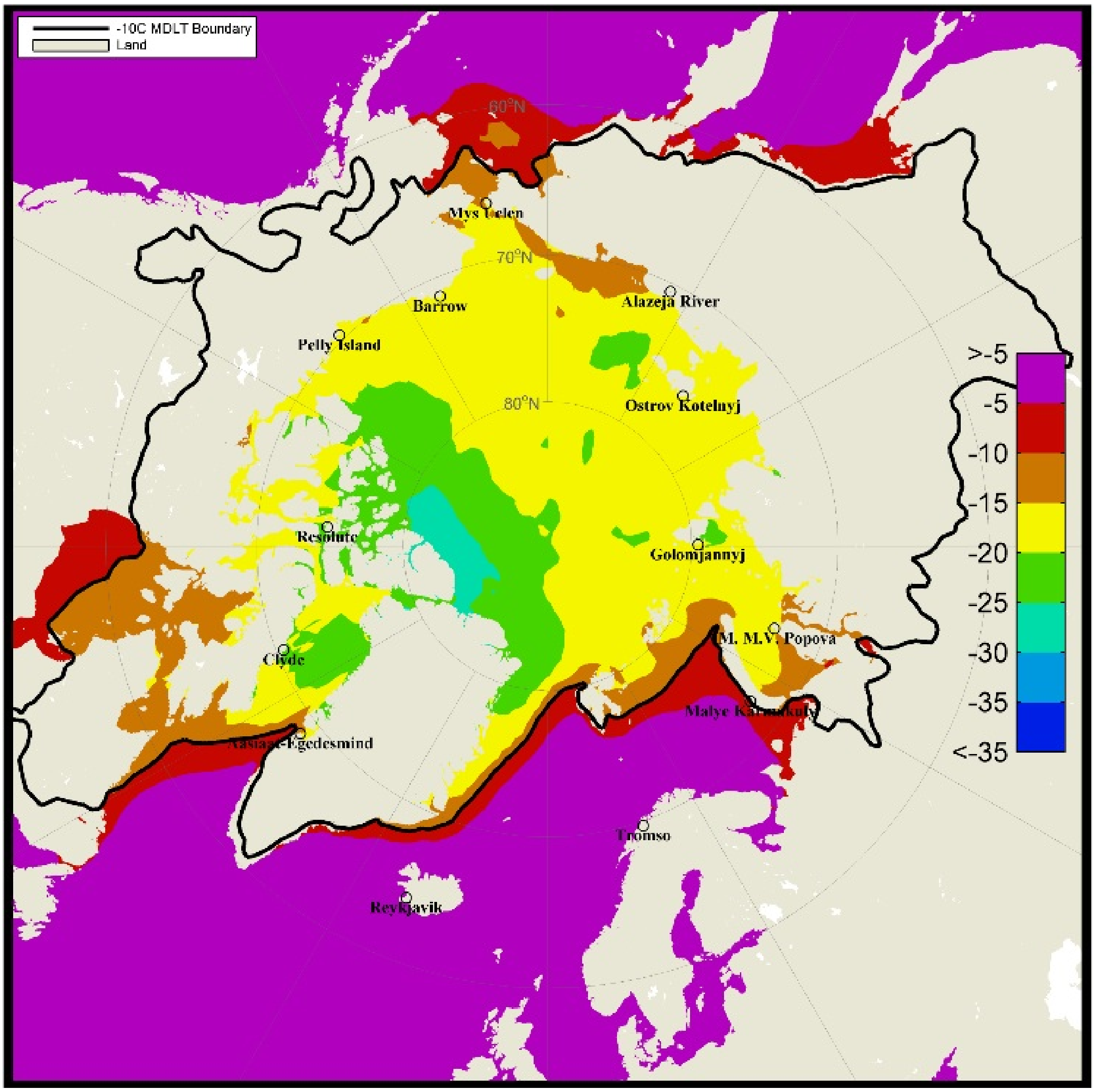


FIGURE 59
Arctic Mean Daily Low Temperature (MDLT) in °C for May 1st
(1 September 2015)

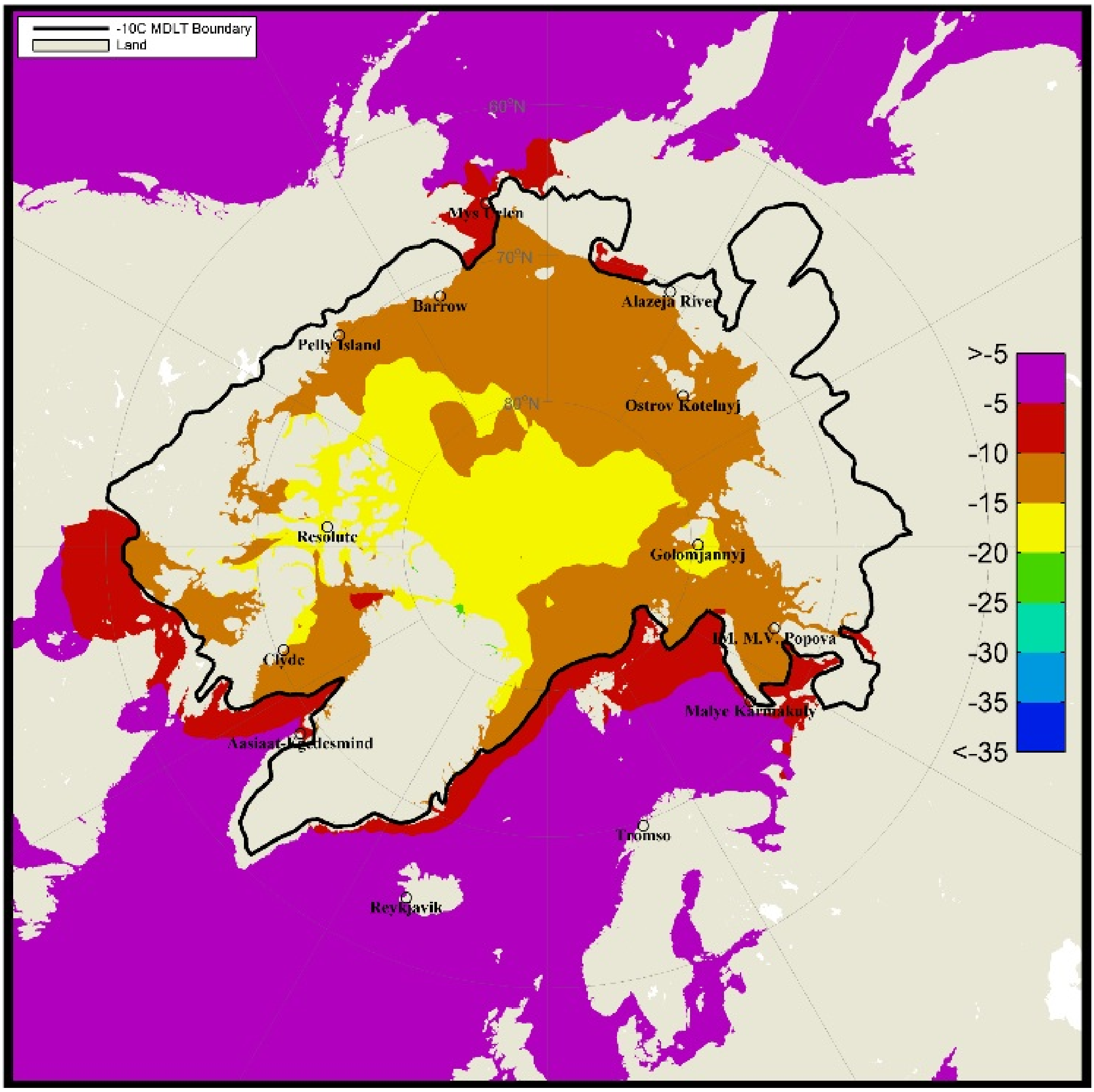


FIGURE 60
Arctic Mean Daily Low Temperature (MDLT) in °C for May 15th
(1 September 2015)

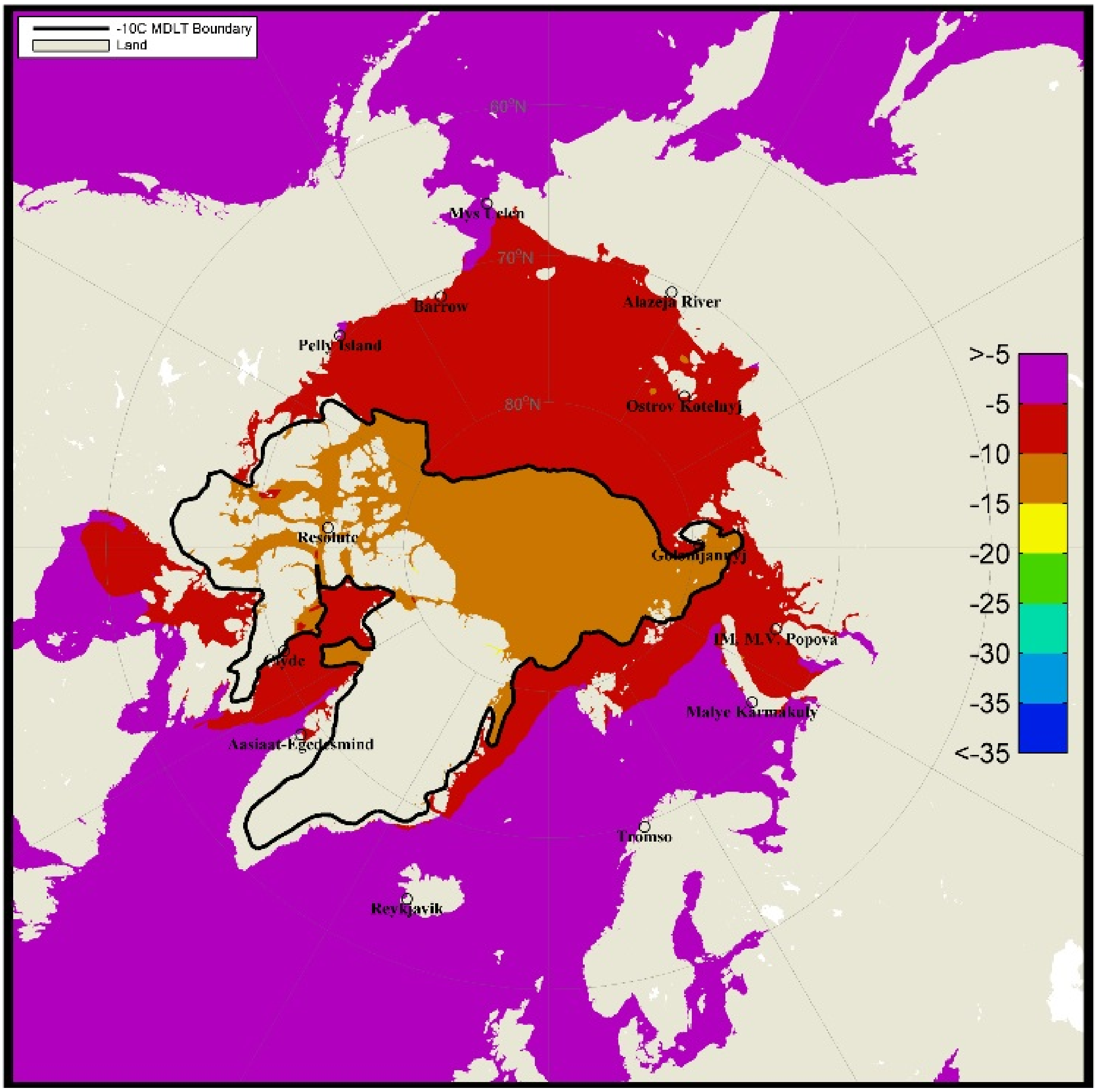


FIGURE 61
Arctic Mean Daily Low Temperature (MDLT) in °C for June 1st
(1 September 2015)

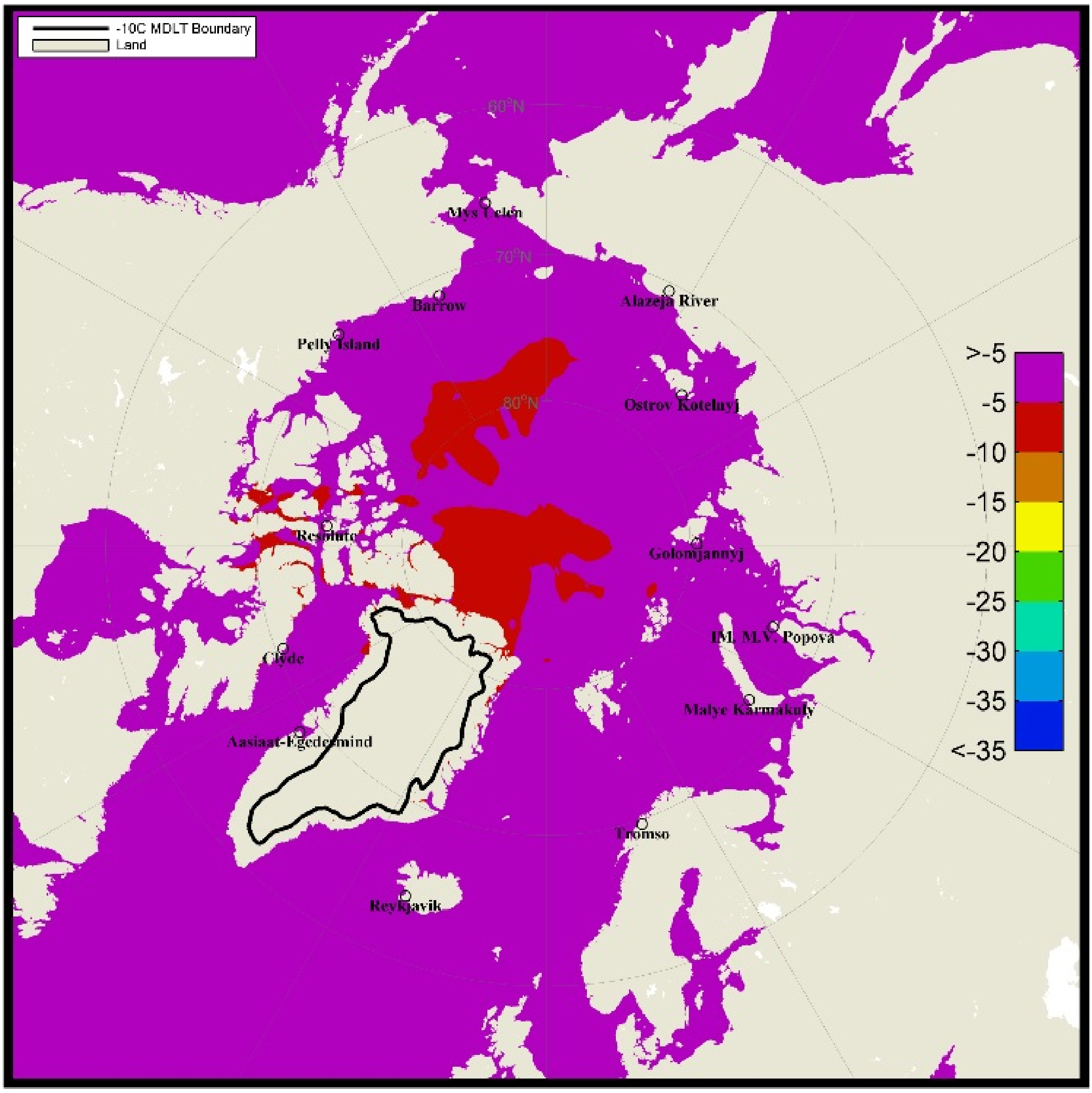


FIGURE 62
Arctic Mean Daily Low Temperature (MDLT) in °C for June 15th
(1 September 2015)

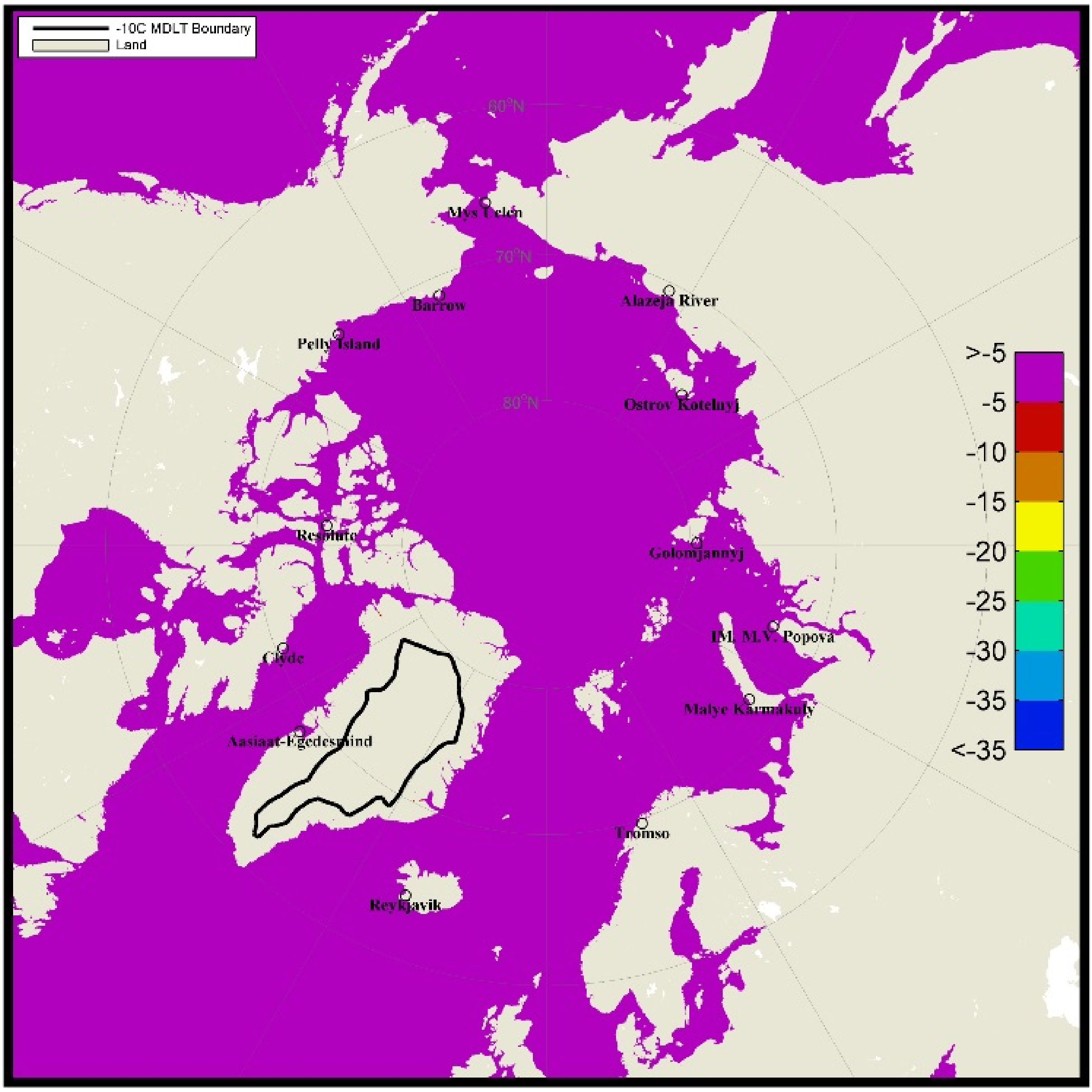


FIGURE 63
Arctic Mean Daily Low Temperature (MDLT) in °C for July 1st
(1 September 2015)

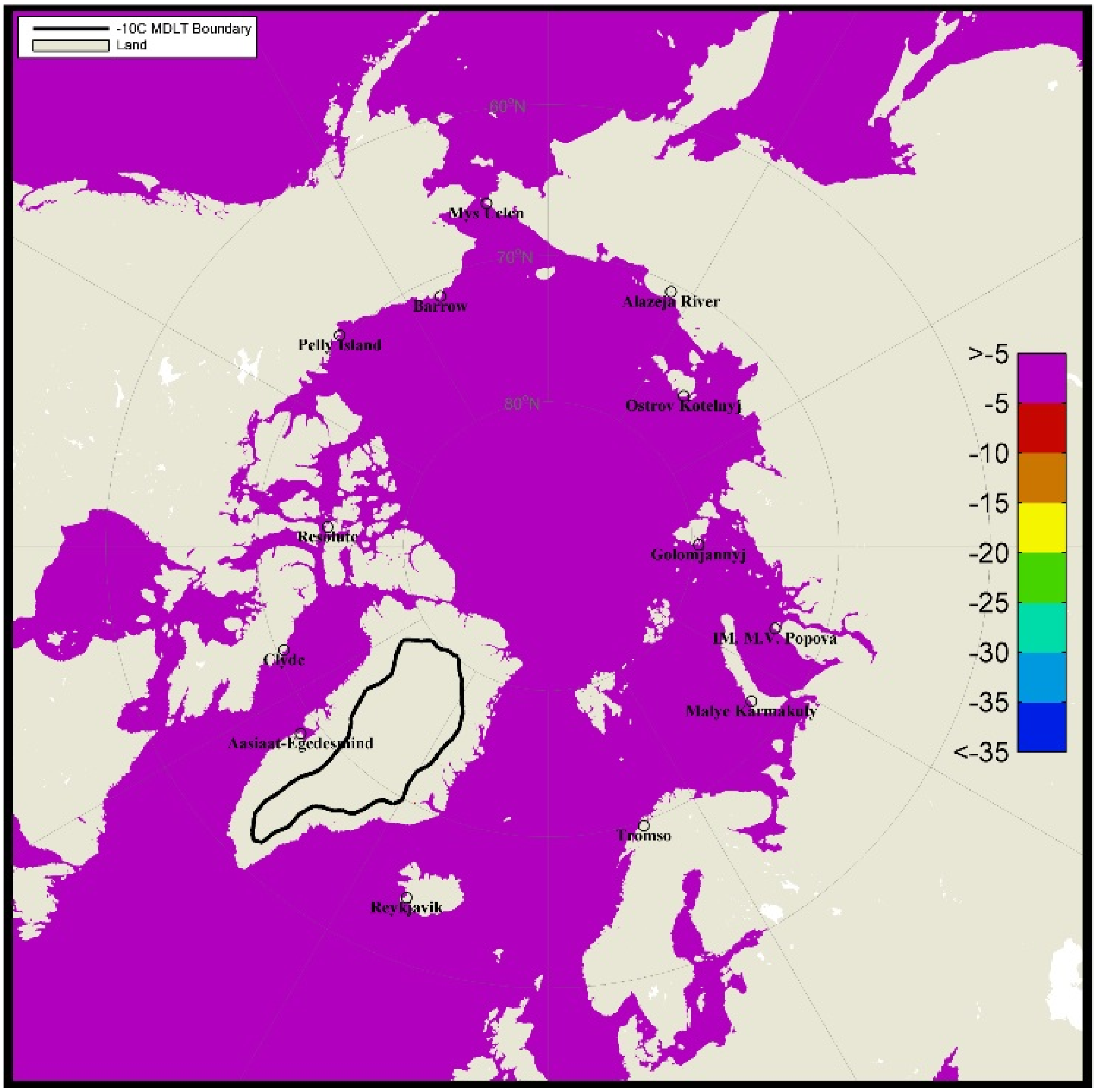


FIGURE 64
Arctic Mean Daily Low Temperature (MDLT) in °C for July 15th
(1 September 2015)

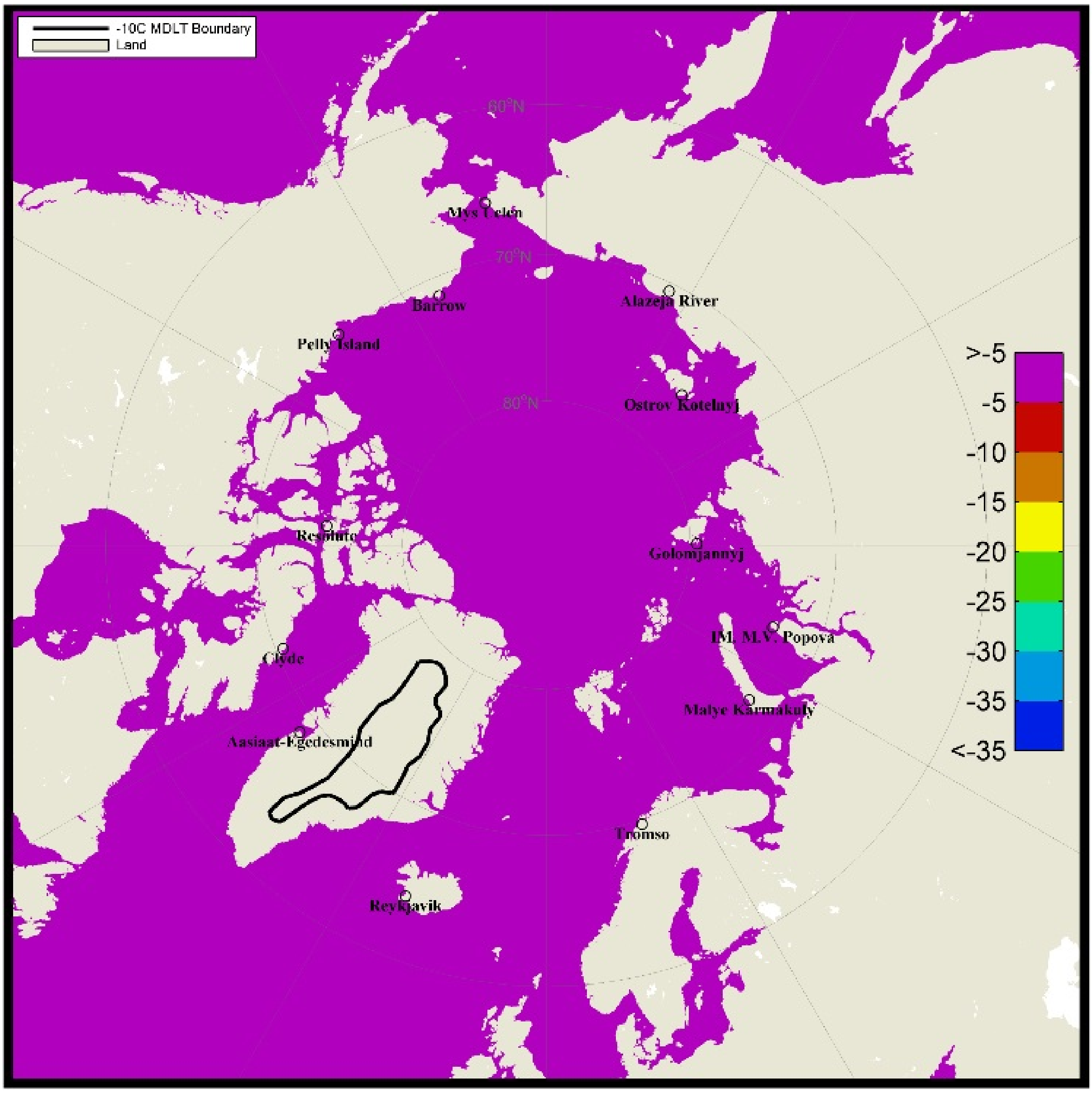


FIGURE 65
Arctic Mean Daily Low Temperature (MDLT) in °C for August 1st
(1 September 2015)

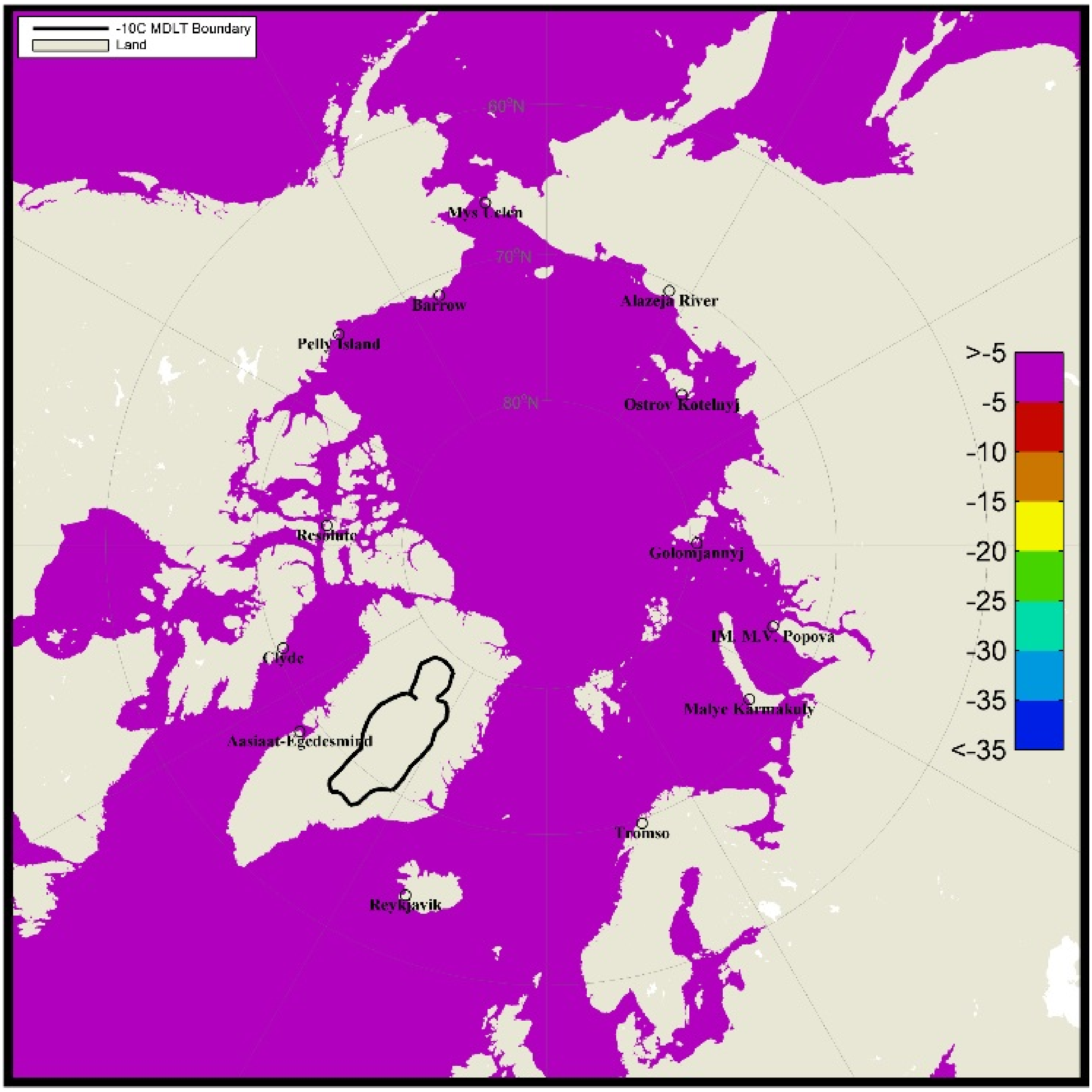


FIGURE 66
Arctic Mean Daily Low Temperature (MDLT) in °C for August 15th
(1 September 2015)

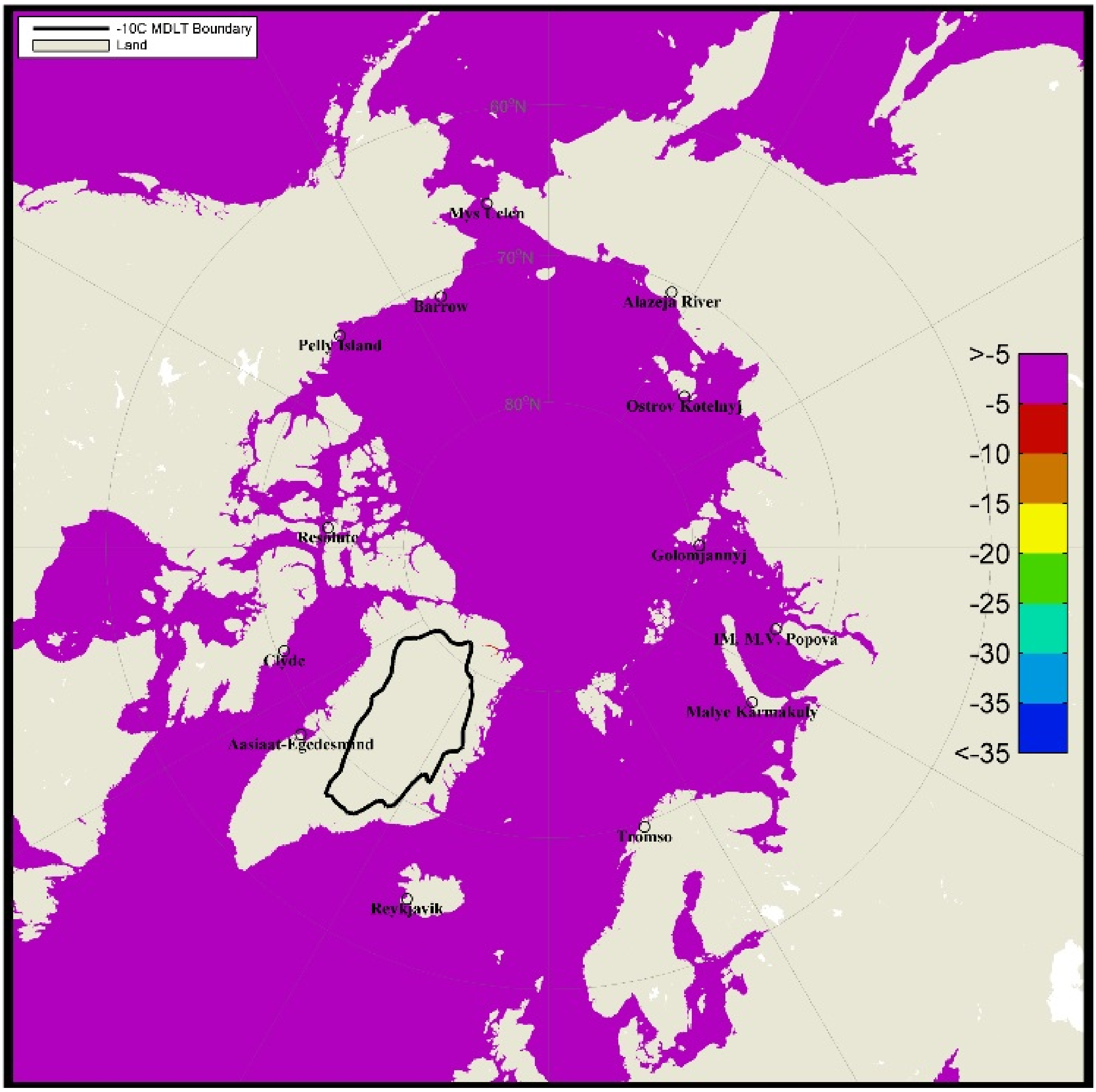


FIGURE 67
Arctic Mean Daily Low Temperature (MDLT) in °C for September 1st
(1 September 2015)

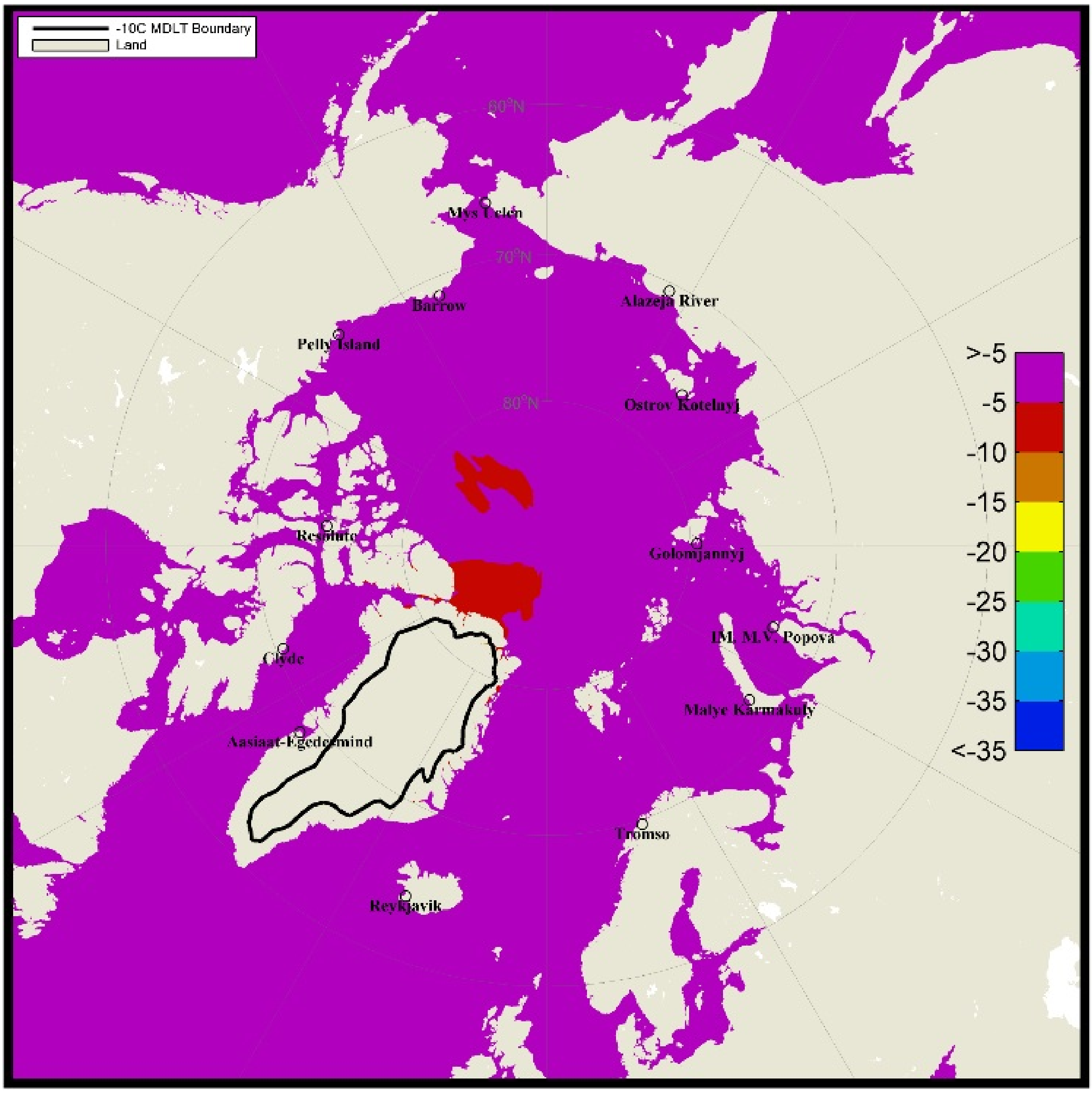


FIGURE 68
Arctic Mean Daily Low Temperature (MDLT) in °C for September 15th
(1 September 2015)

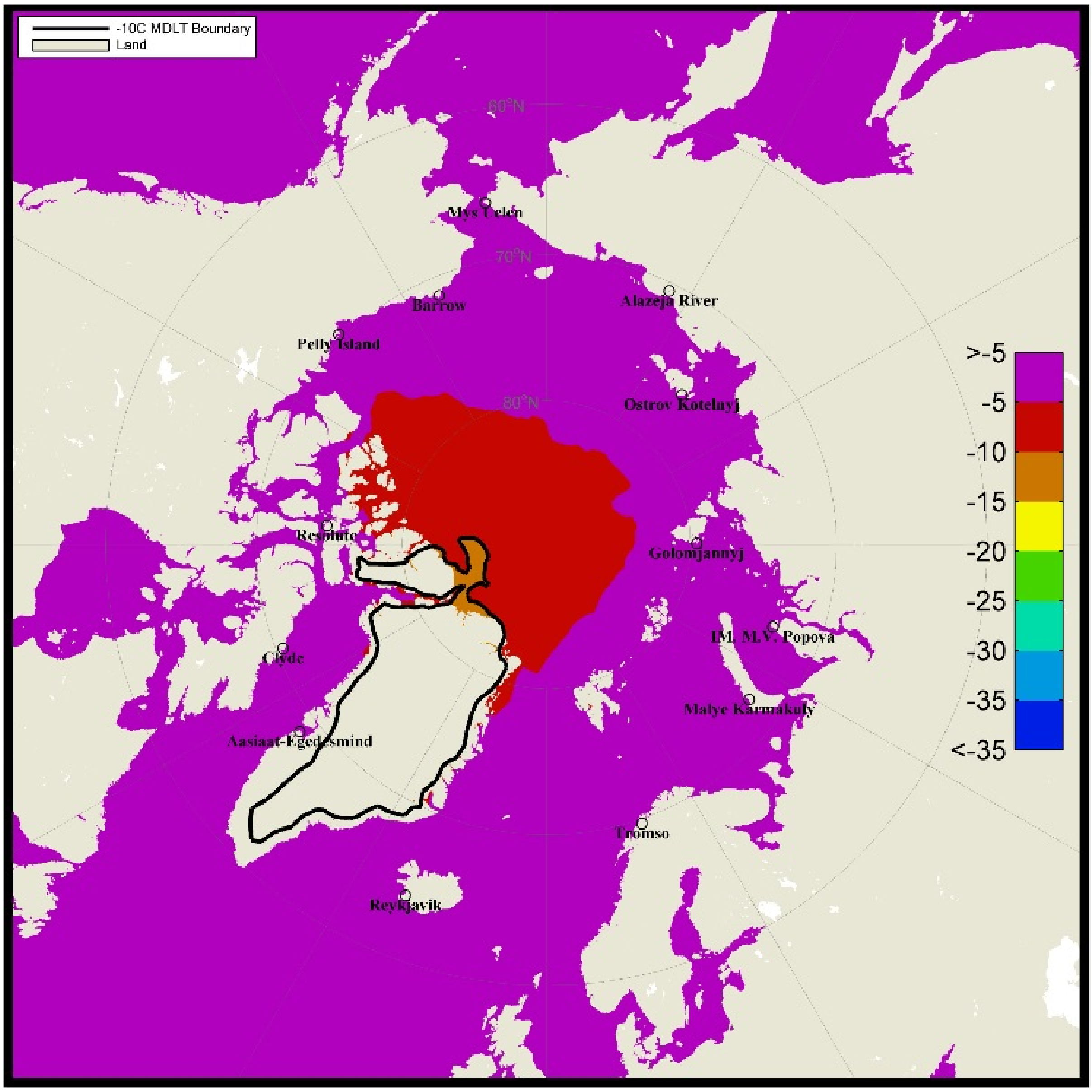


FIGURE 69
Arctic Mean Daily Low Temperature (MDLT) in °C for October 1st
(1 September 2015)

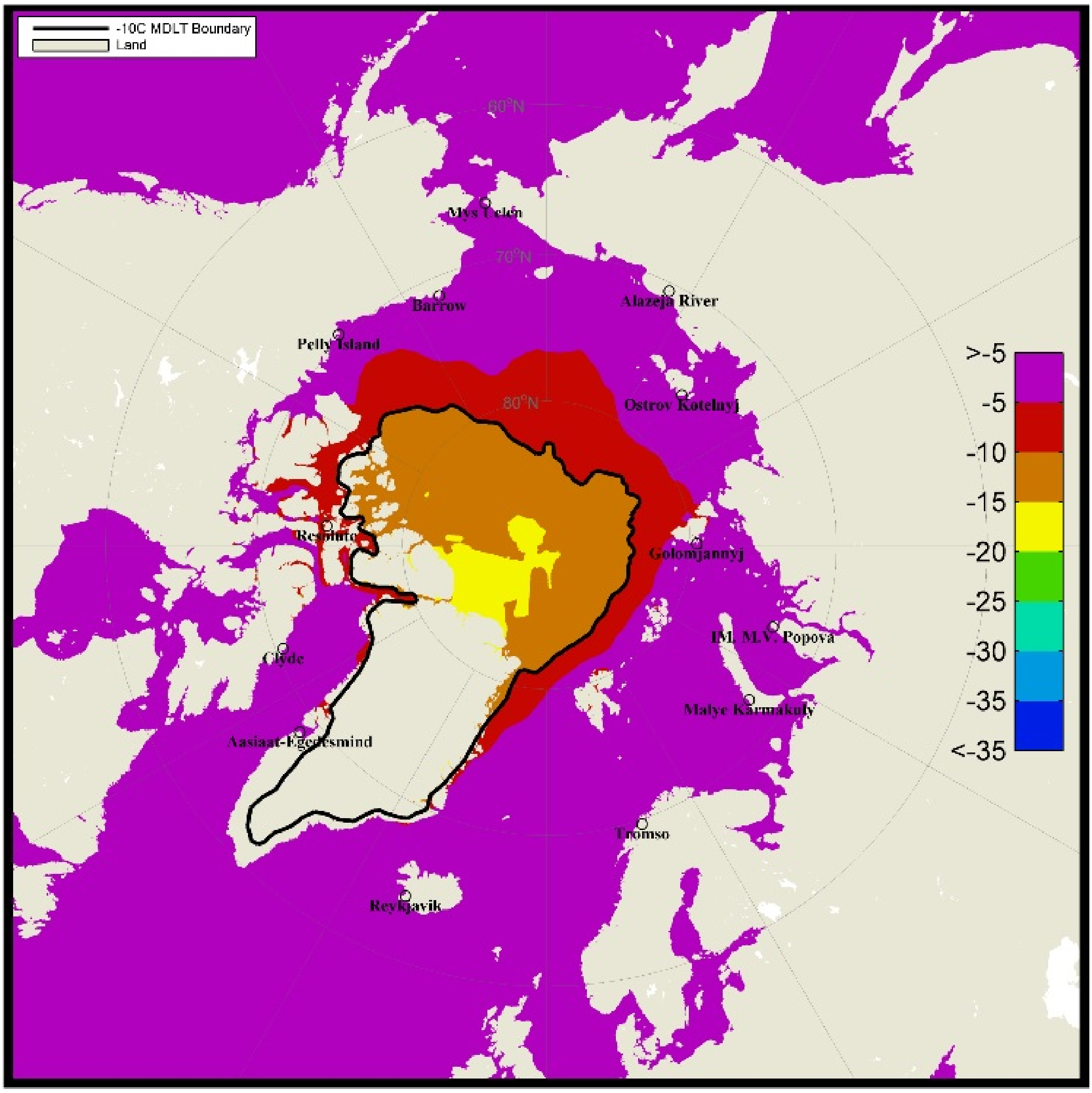


FIGURE 70
Arctic Mean Daily Low Temperature (MDLT) in °C for October 15th
(1 September 2015)

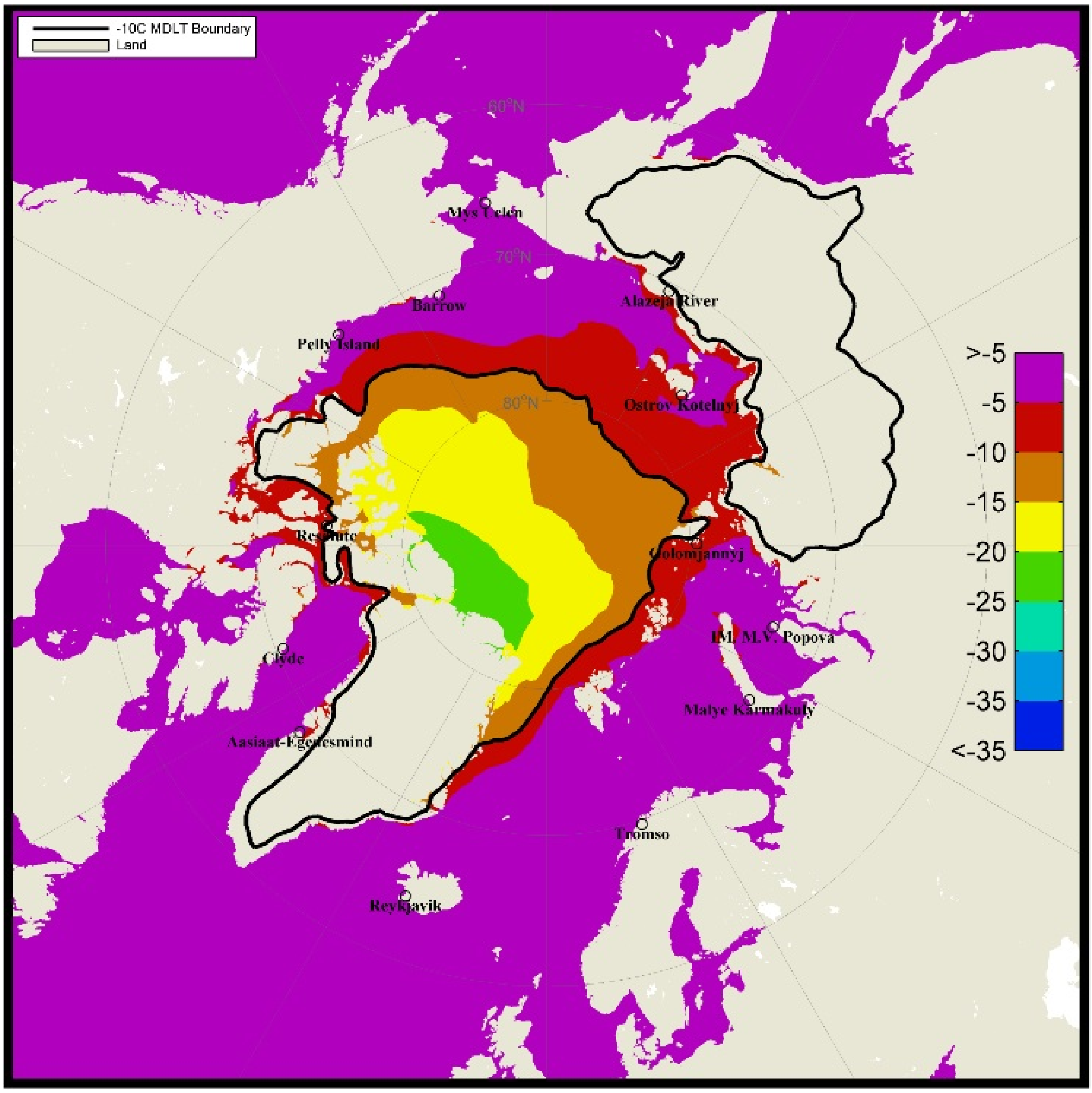


FIGURE 71
Arctic Mean Daily Low Temperature (MDLT) in °C for November 1st
(1 September 2015)

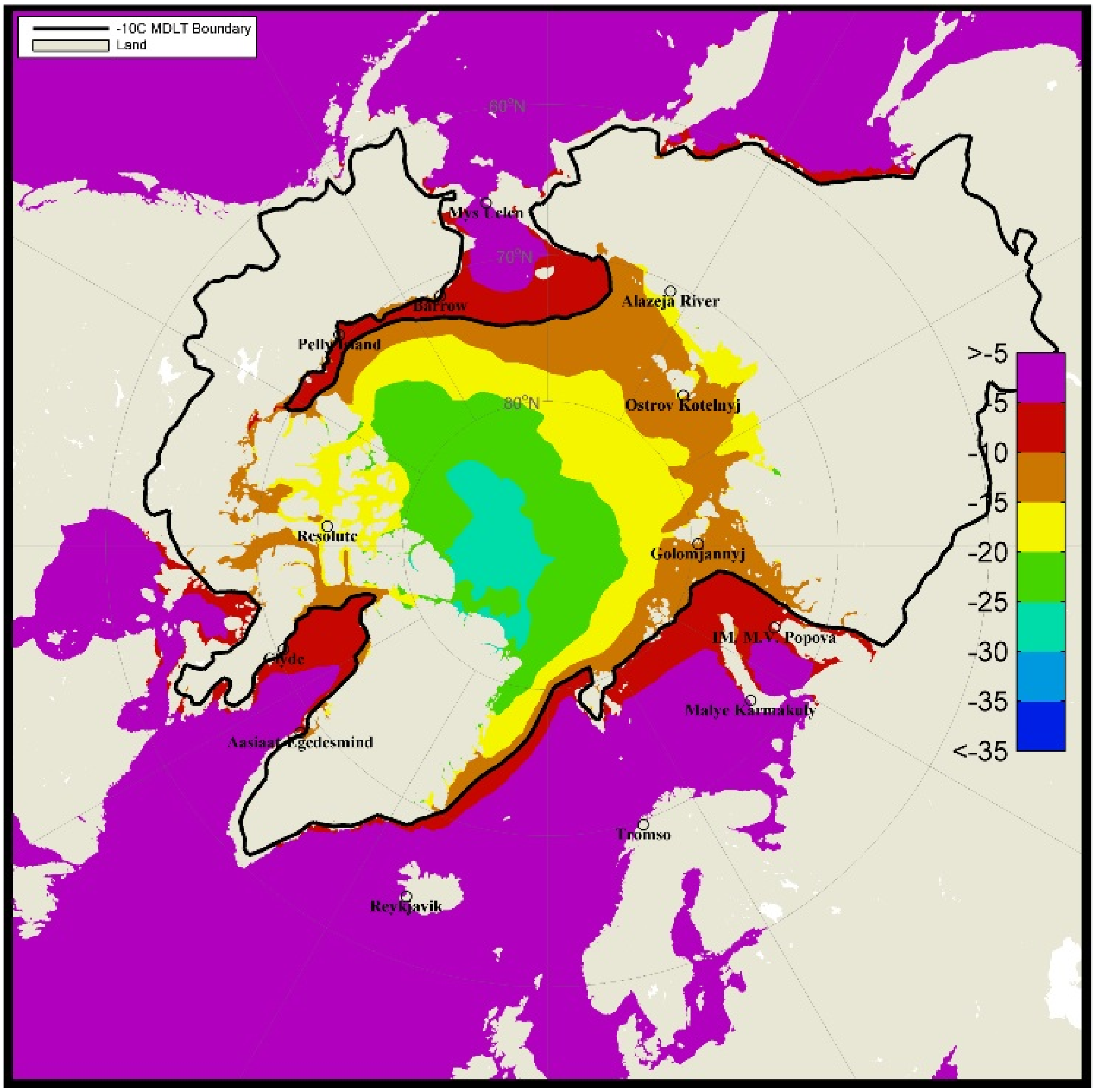


FIGURE 72
Arctic Mean Daily Low Temperature (MDLT) in °C for November 15th
(1 September 2015)

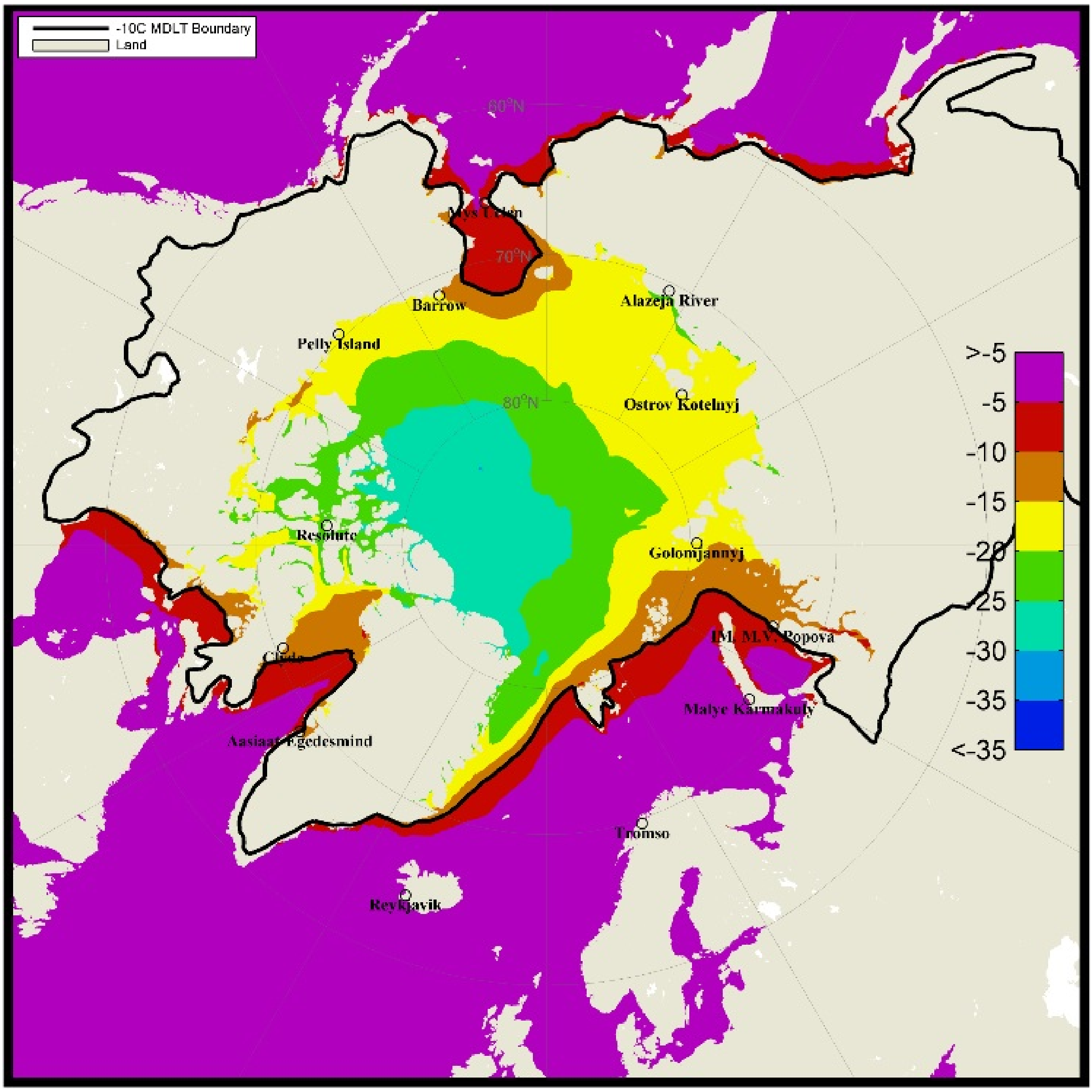


FIGURE 73
Arctic Mean Daily Low Temperature (MDLT) in °C for December 1st
(1 September 2015)

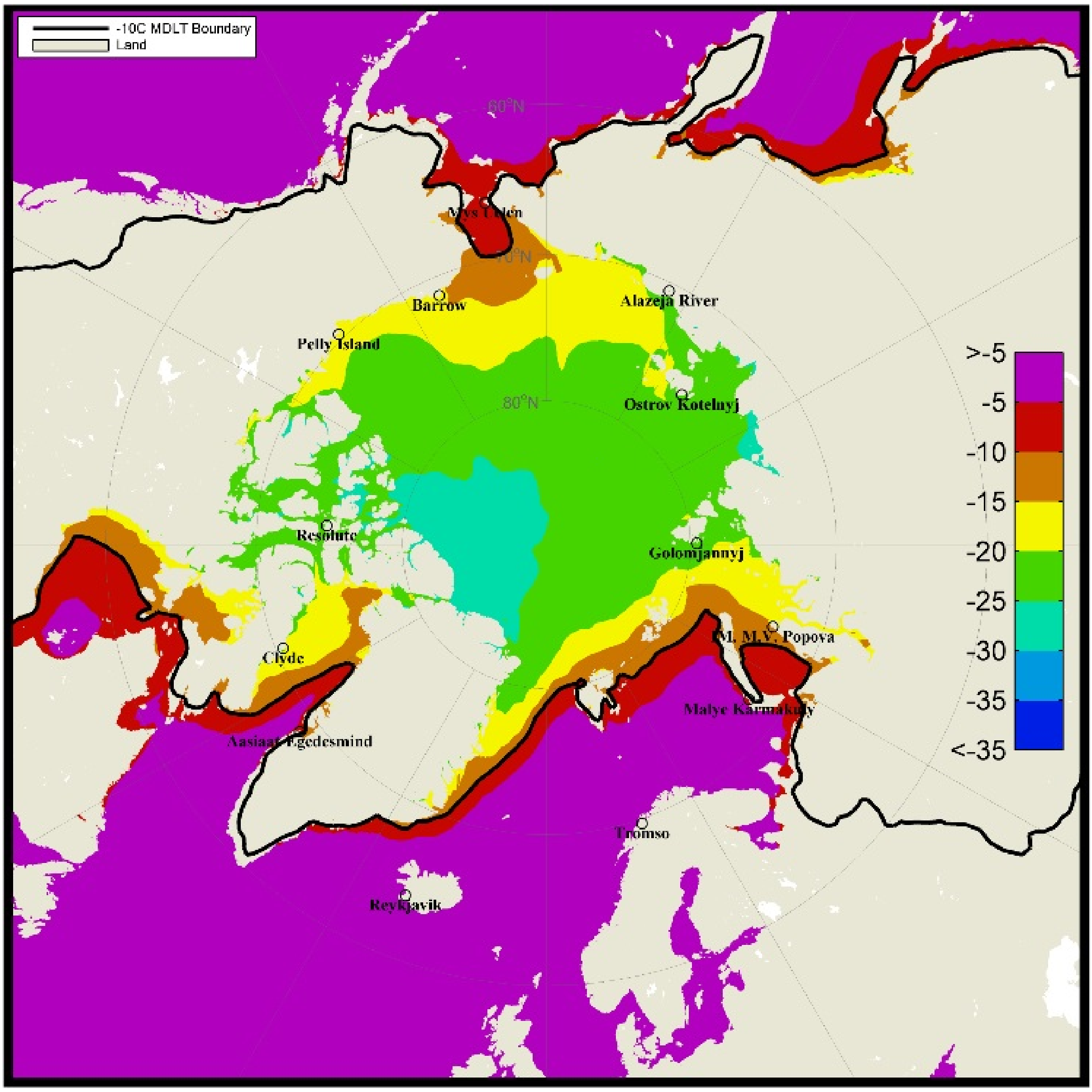


FIGURE 74
Arctic Mean Daily Low Temperature (MDLT) in °C for December 15th
(1 September 2015)

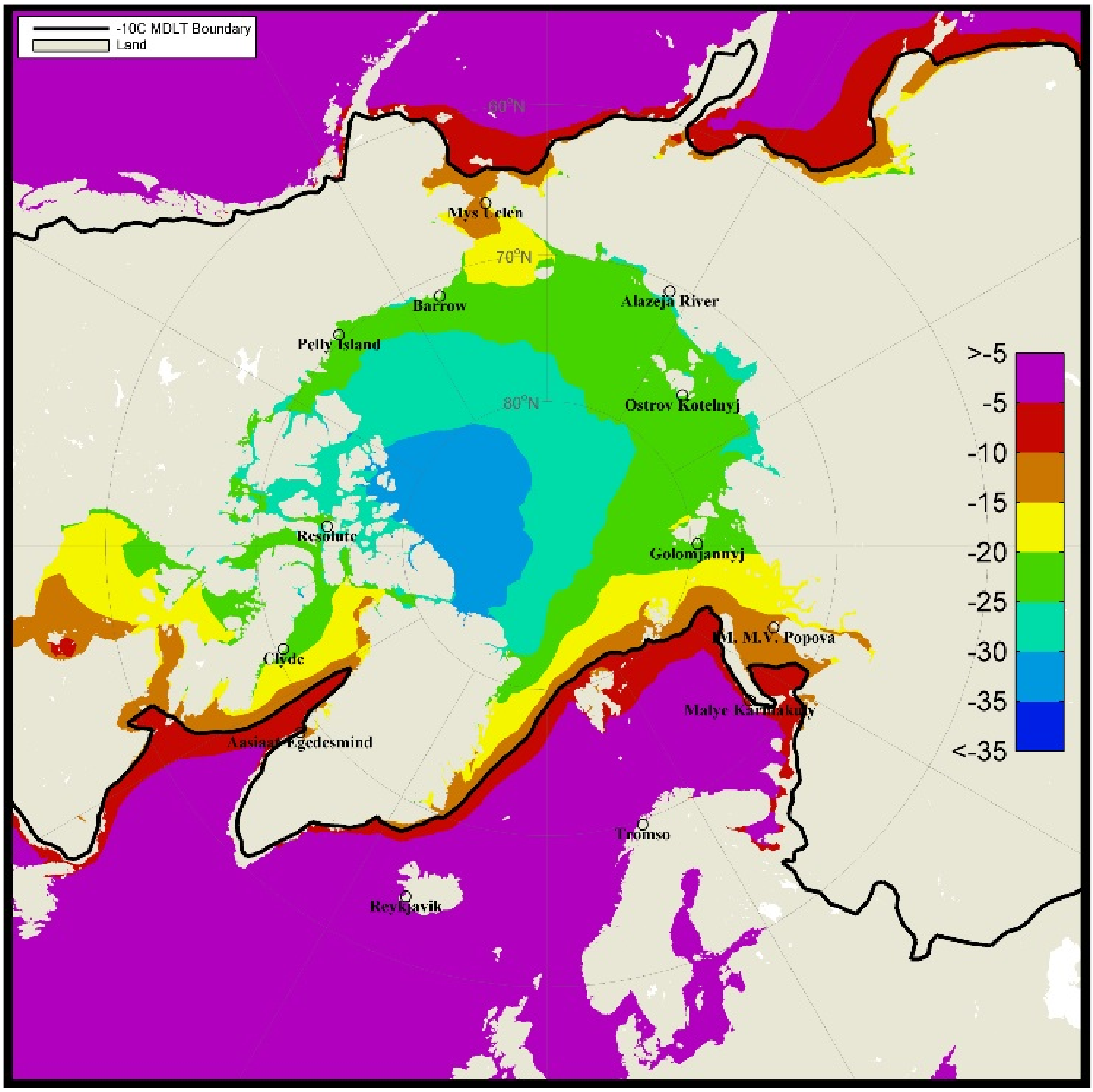


FIGURE 75
Antarctic Mean Daily Low Temperature (MDLT) in °C for January 1st
(1 September 2015)

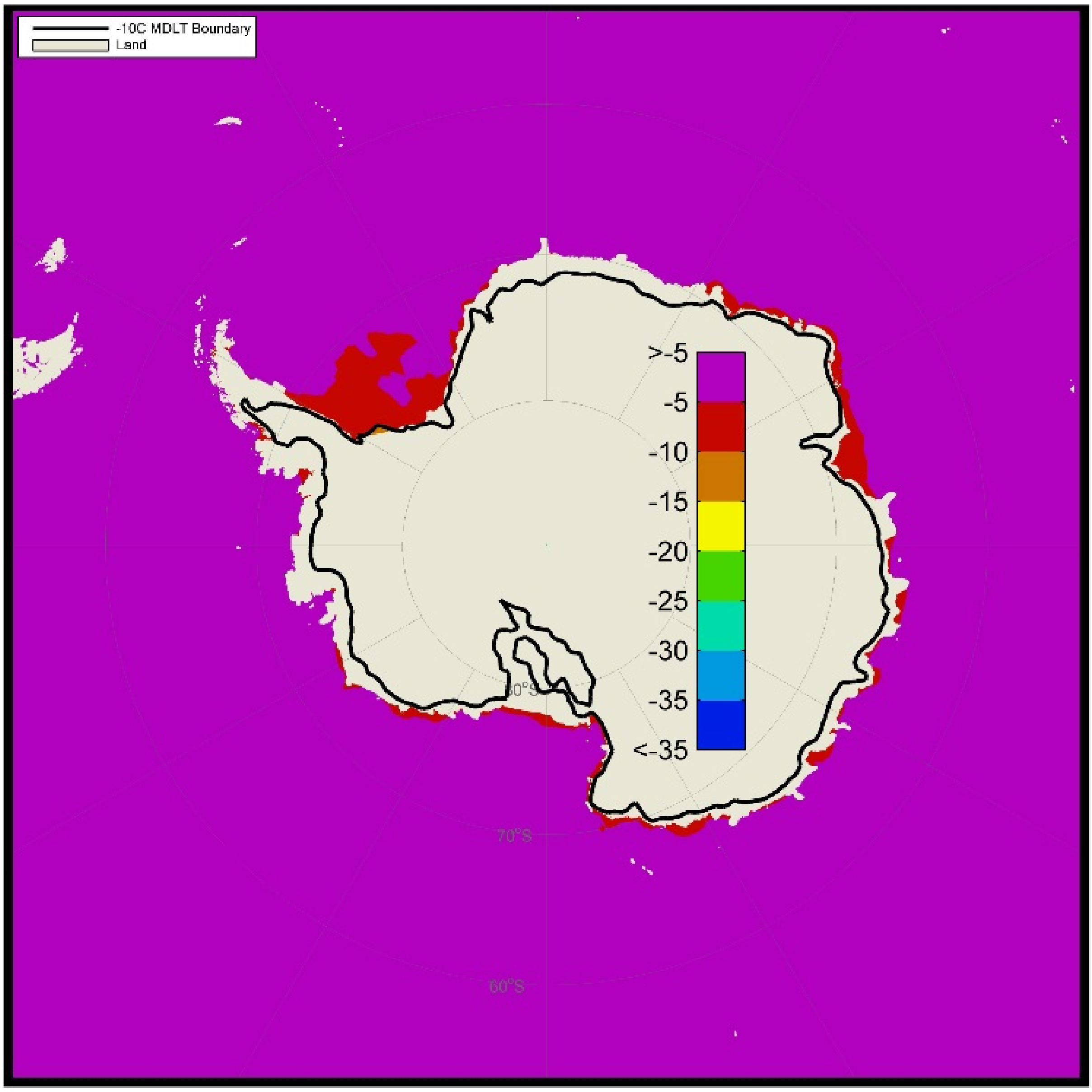


FIGURE 76
Antarctic Mean Daily Low Temperature (MDLT) in °C for January 15th
(1 September 2015)

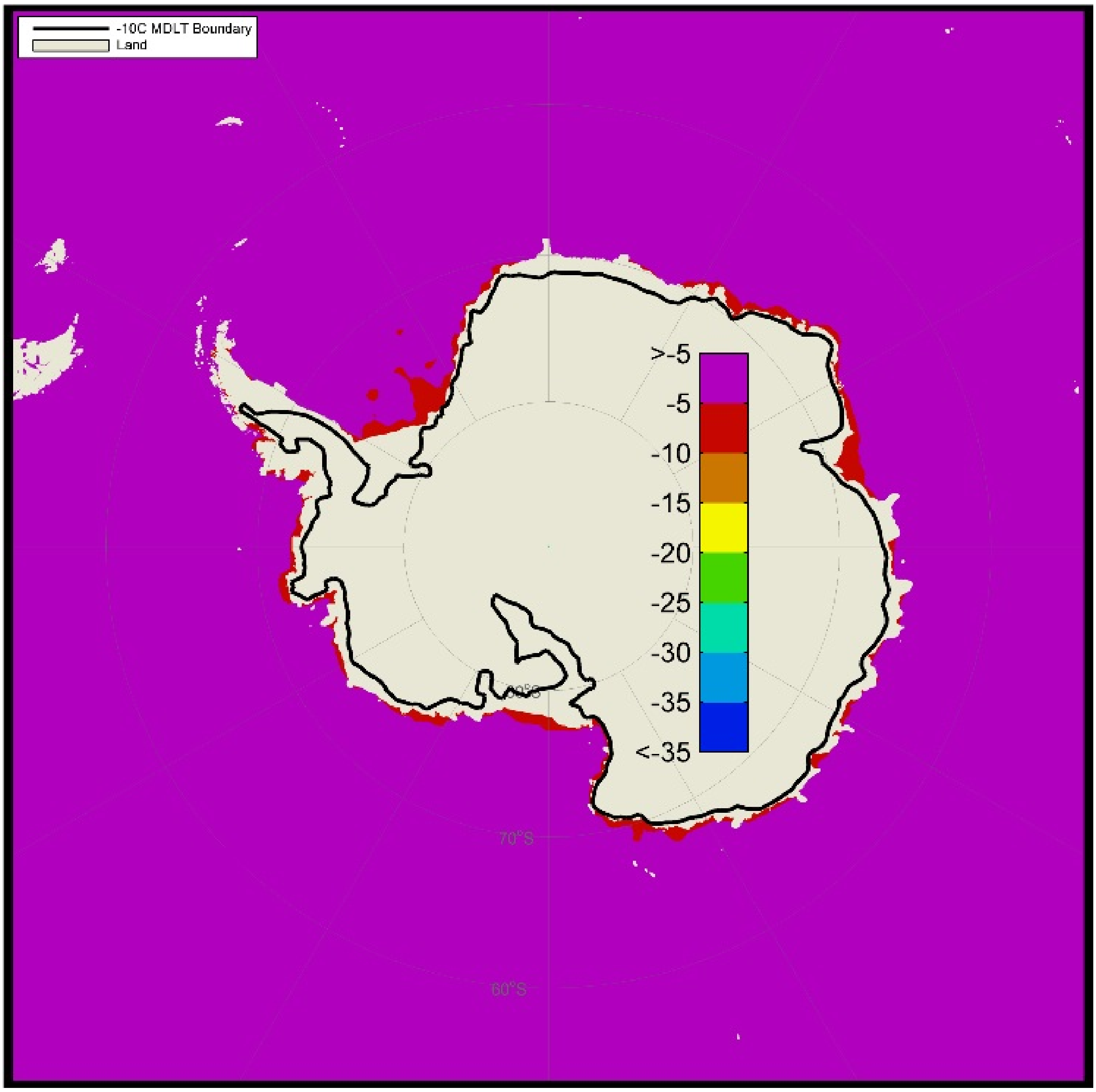


FIGURE 77
Antarctic Mean Daily Low Temperature (MDLT) in °C for February 1st
(1 September 2015)

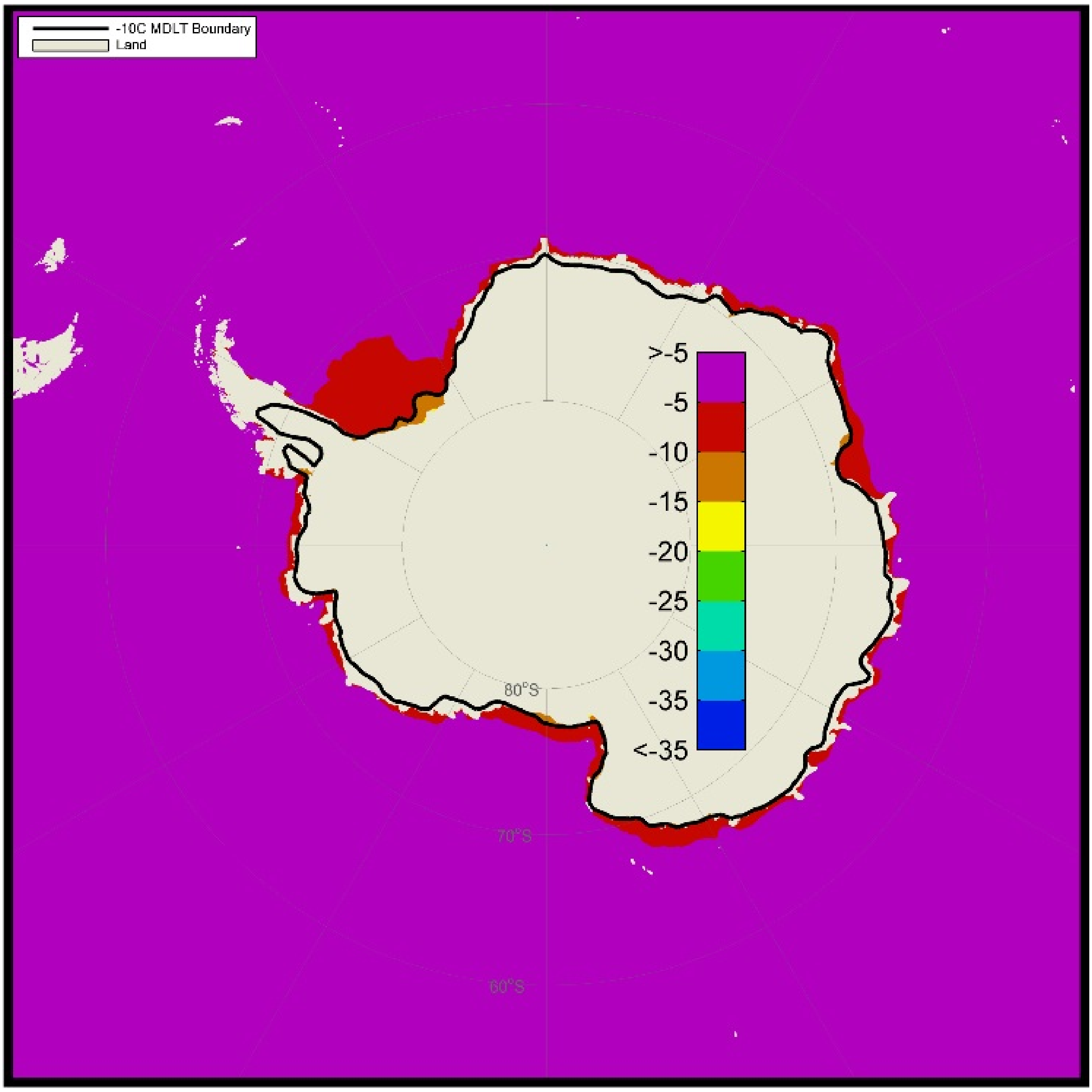


FIGURE 78
Antarctic Mean Daily Low Temperature (MDLT) in °C for February 15th
(1 September 2015)

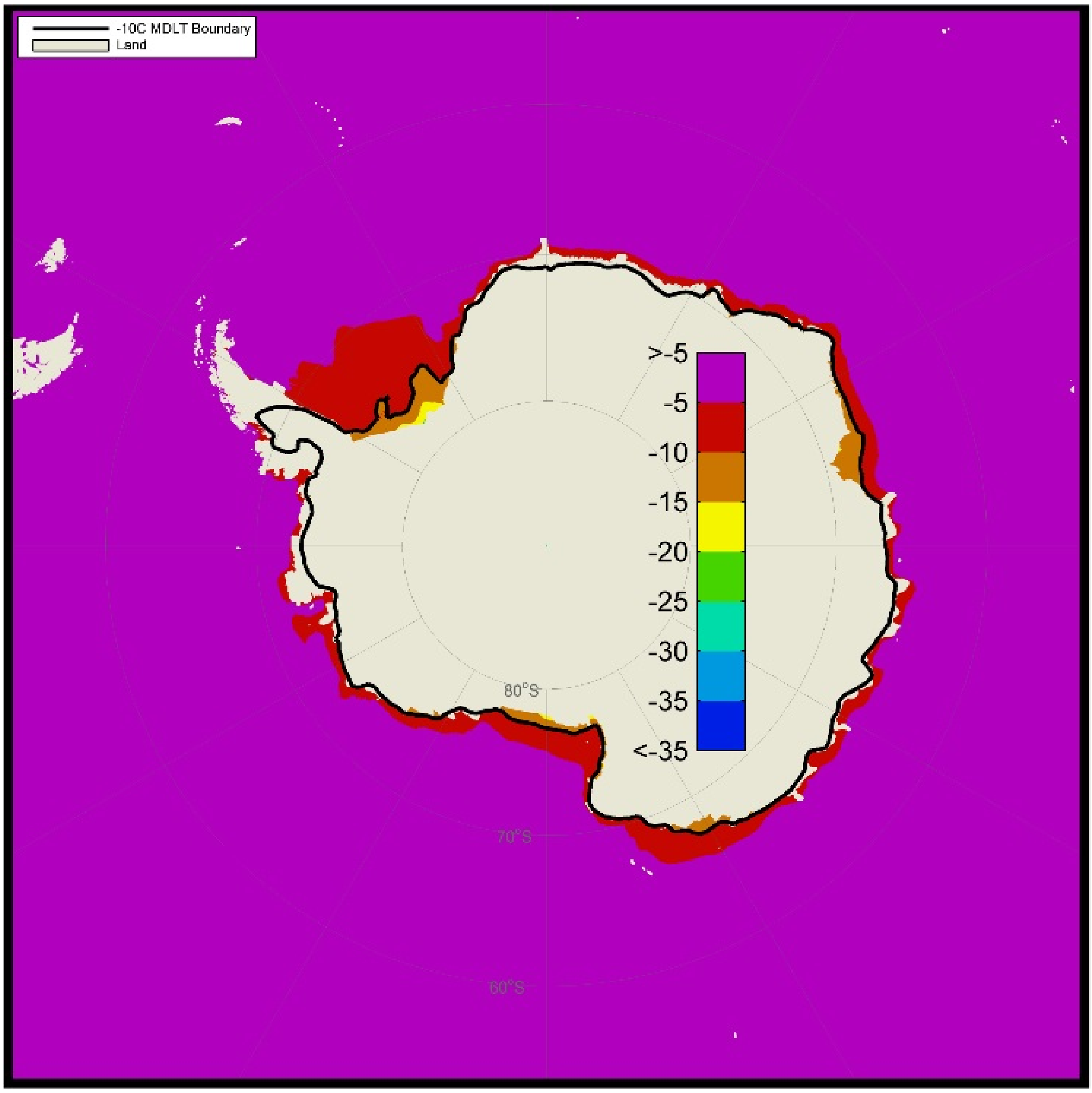


FIGURE 79
Antarctic Mean Daily Low Temperature (MDLT) in °C for March 1st
(1 September 2015)

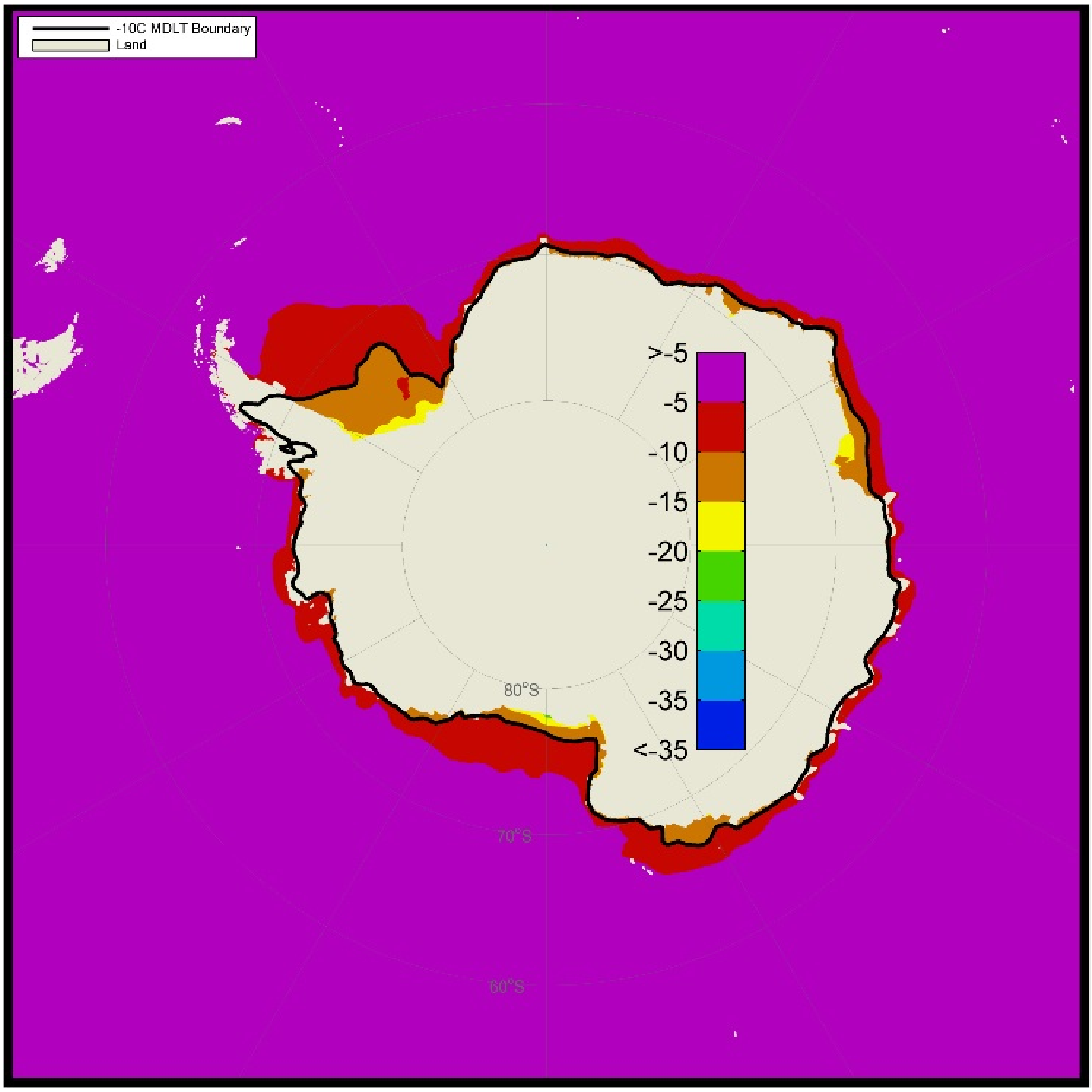


FIGURE 80
Antarctic Mean Daily Low Temperature (MDLT) in °C for March 15th
(1 September 2015)

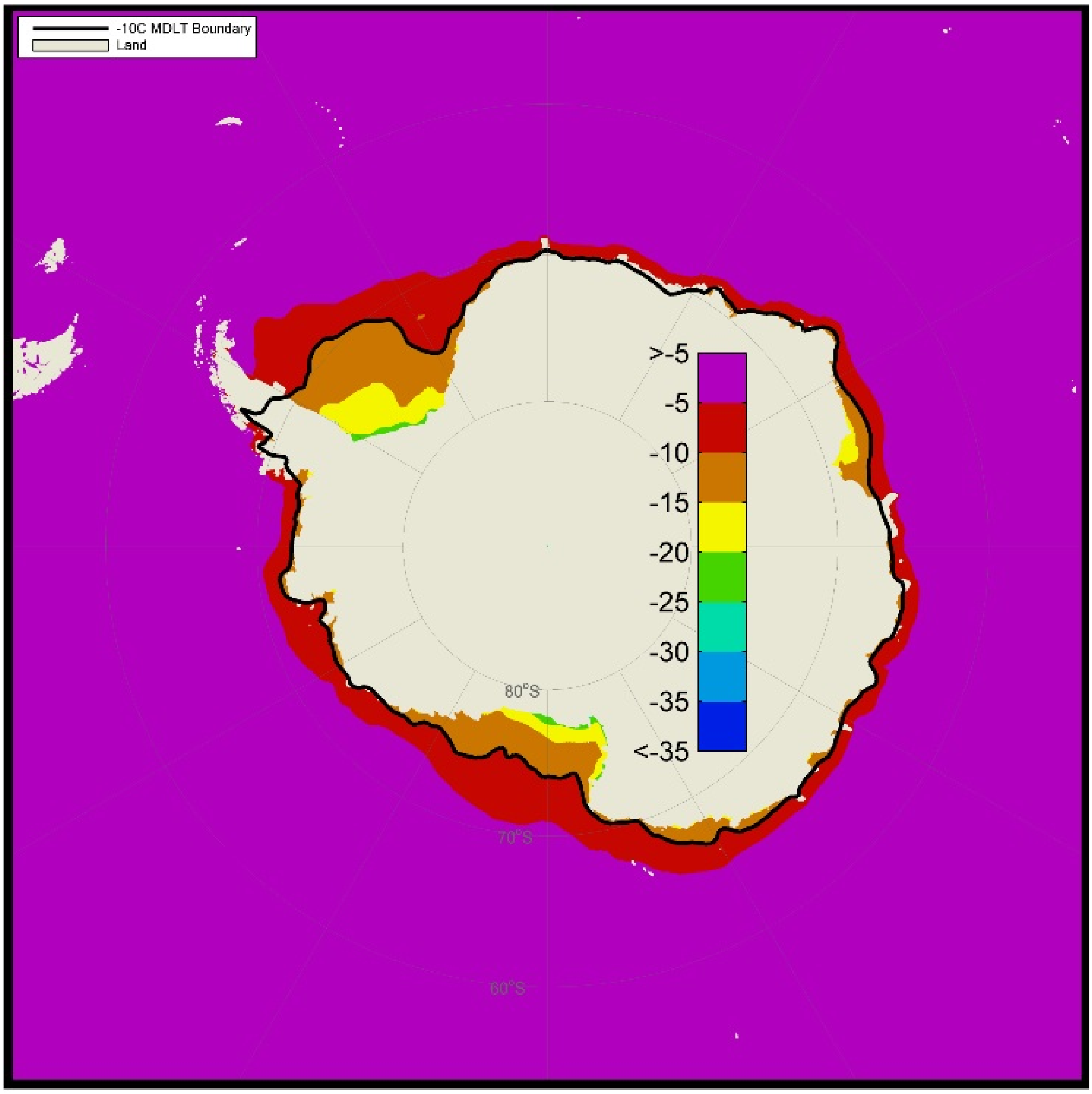


FIGURE 81
Antarctic Mean Daily Low Temperature (MDLT) in °C for April 1st
(1 September 2015)

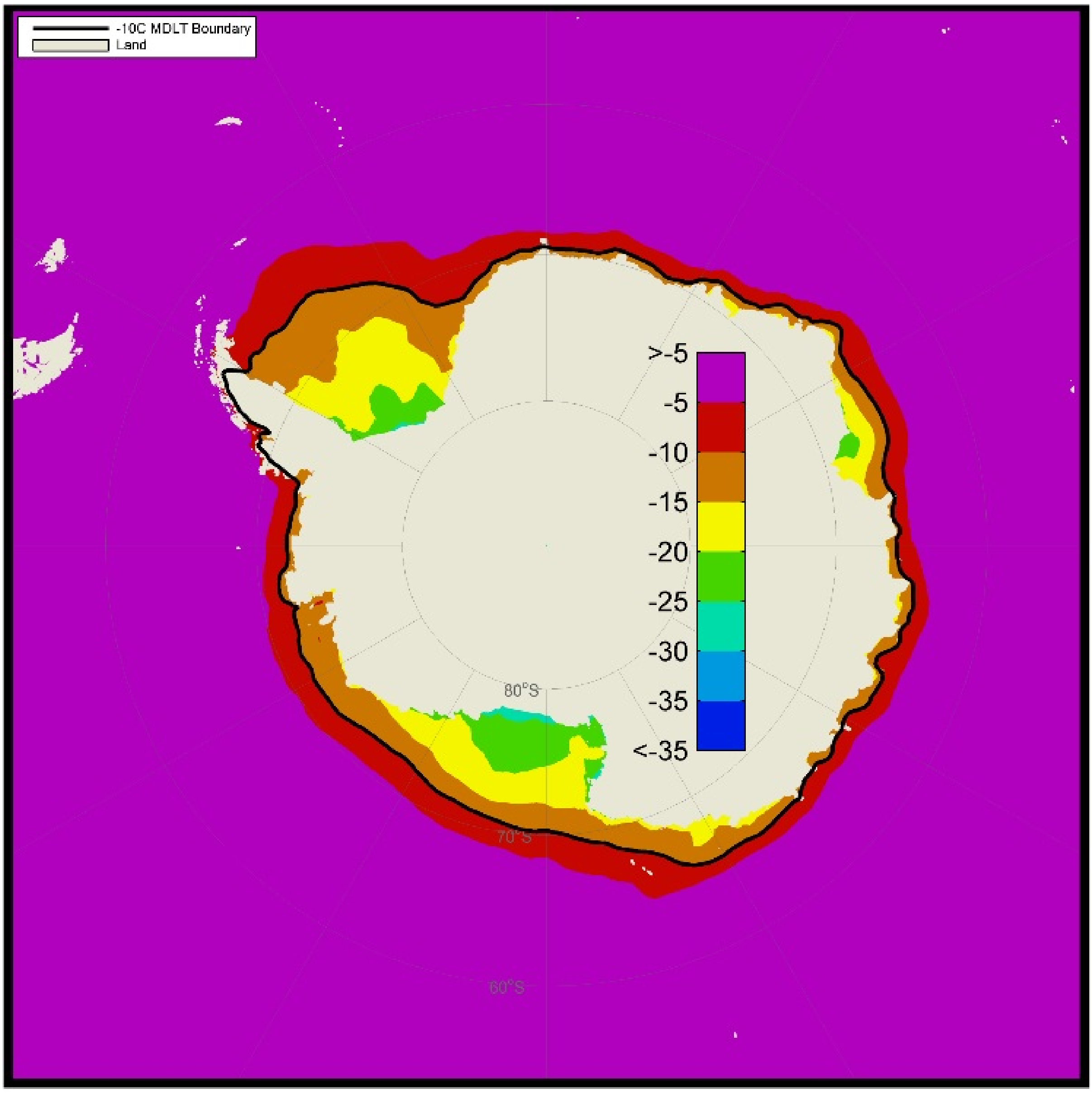


FIGURE 82
Antarctic Mean Daily Low Temperature (MDLT) in °C for April 15th
(1 September 2015)

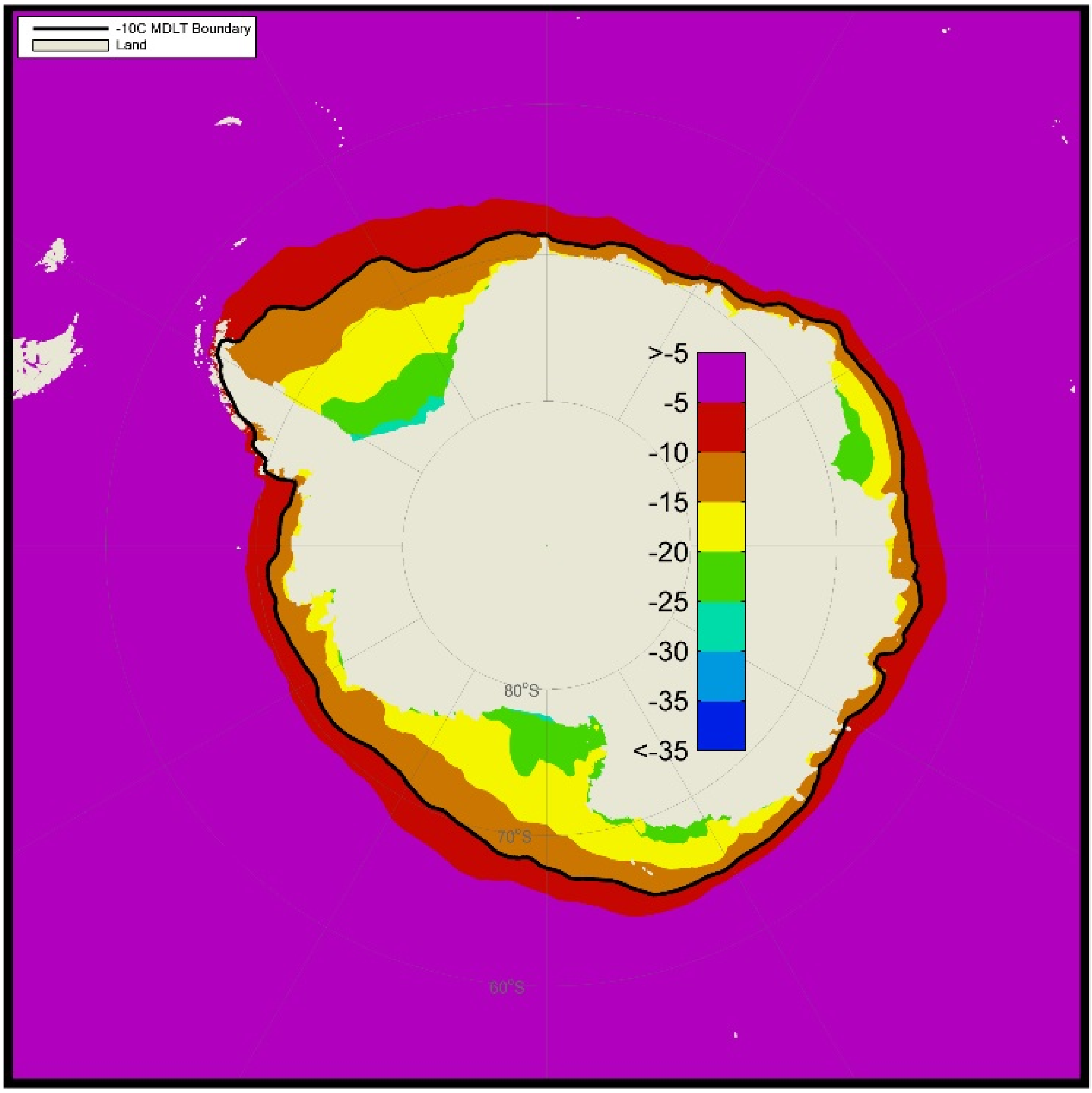


FIGURE 83
Antarctic Mean Daily Low Temperature (MDLT) in °C for May 1st
(1 September 2015)

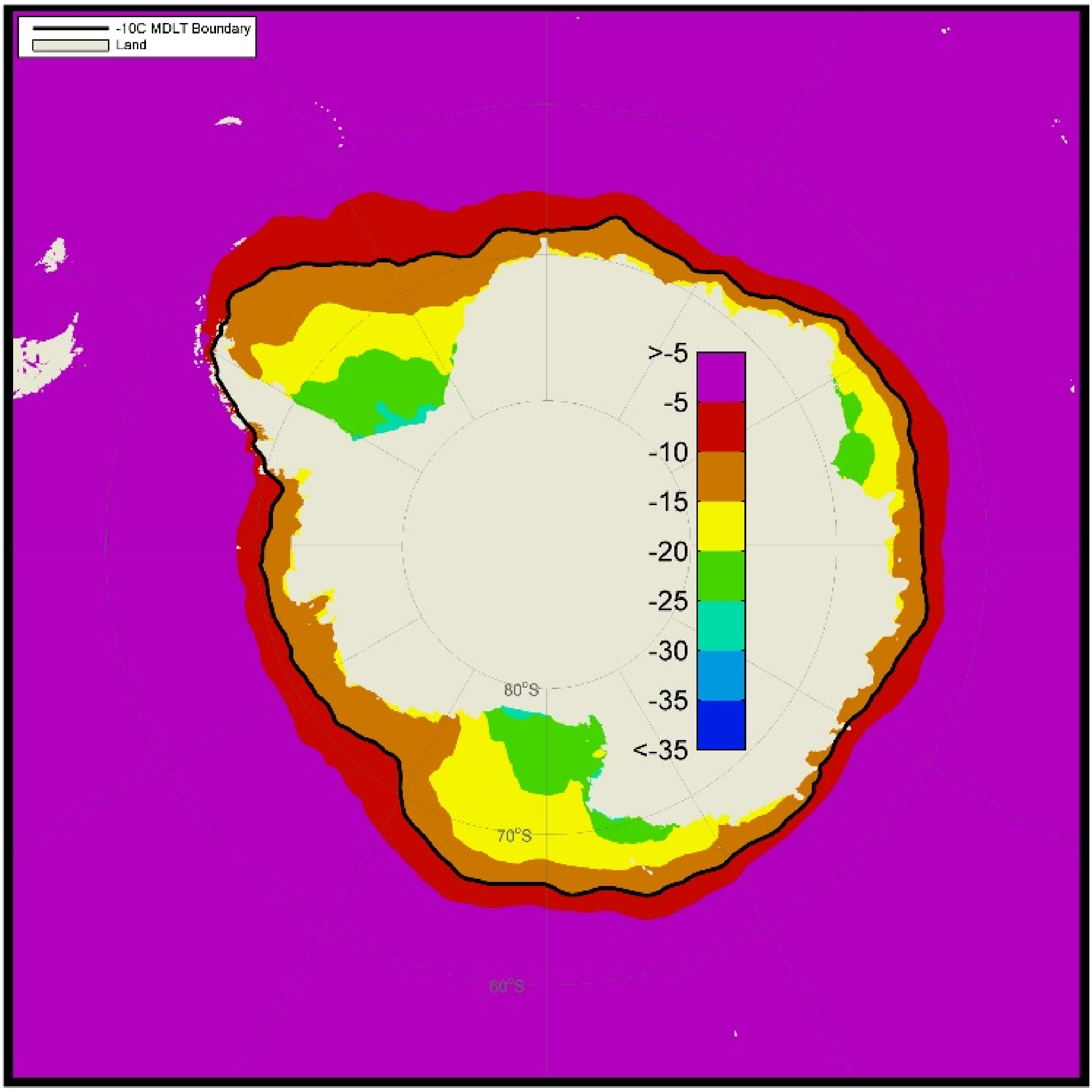


FIGURE 84
Antarctic Mean Daily Low Temperature (MDLT) in °C for May 15th
(1 September 2015)

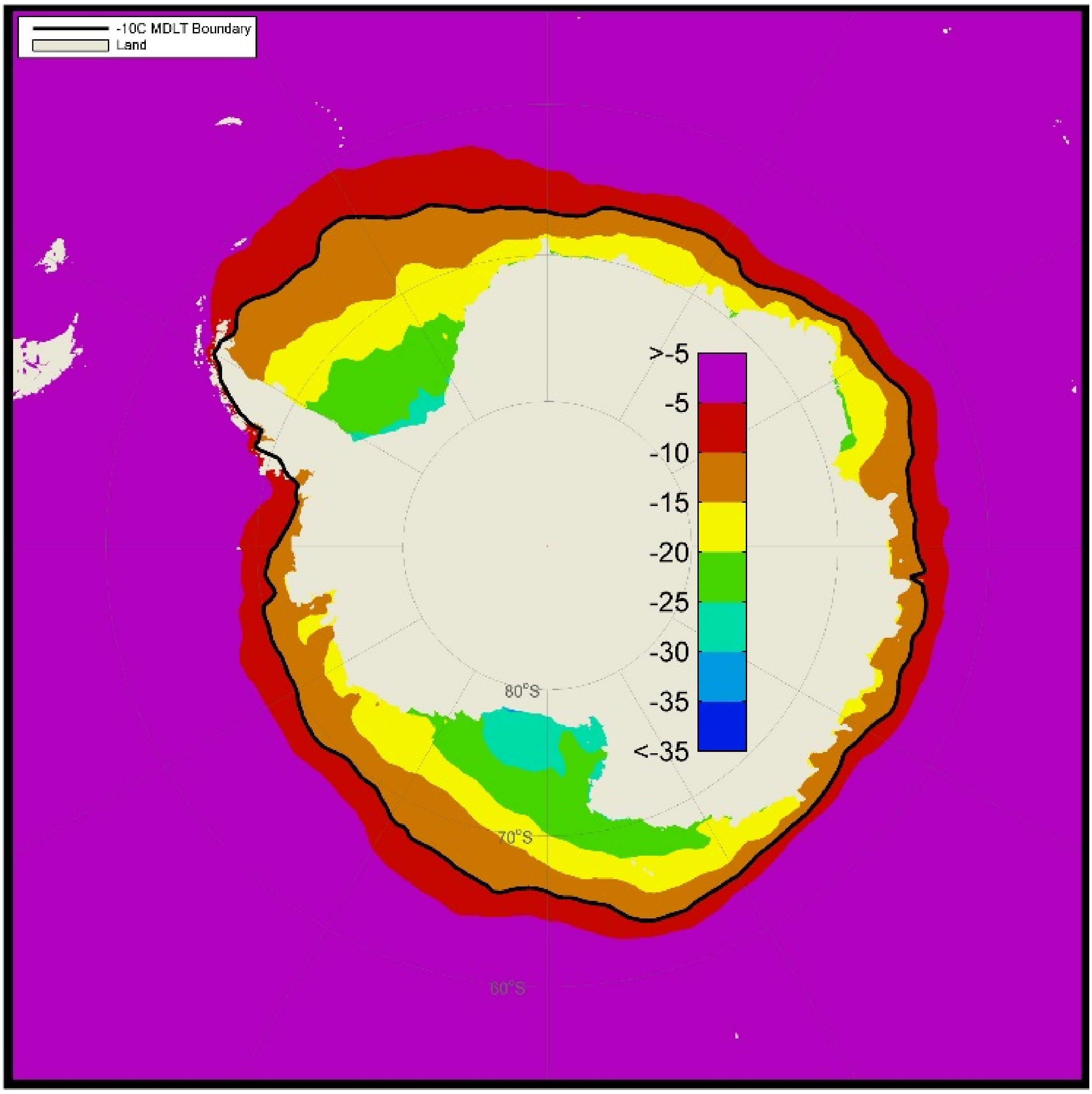


FIGURE 85
Antarctic Mean Daily Low Temperature (MDLT) in °C for June 1st
(1 September 2015)

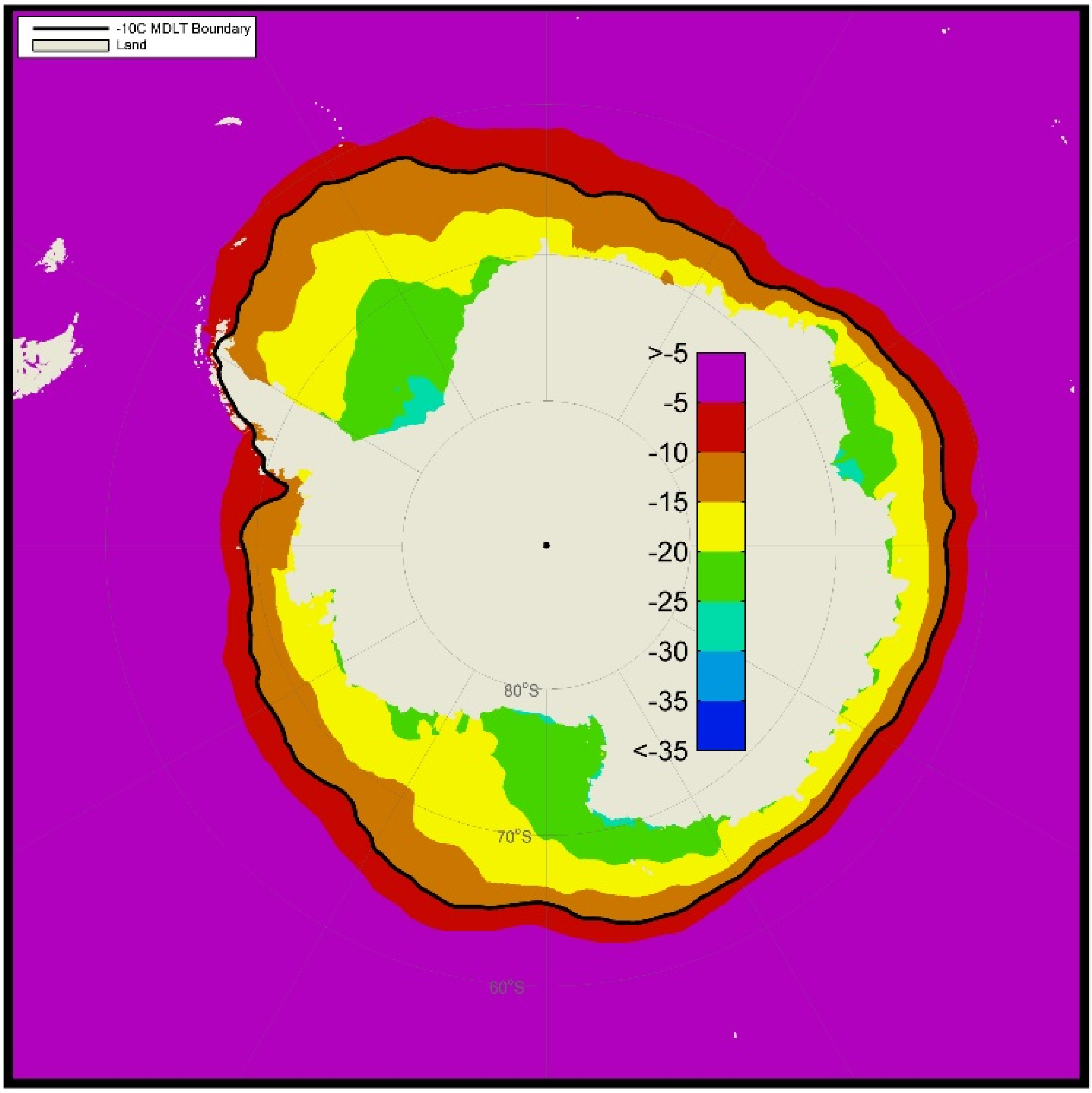


FIGURE 86
Antarctic Mean Daily Low Temperature (MDLT) in °C for June 15th
(1 September 2015)

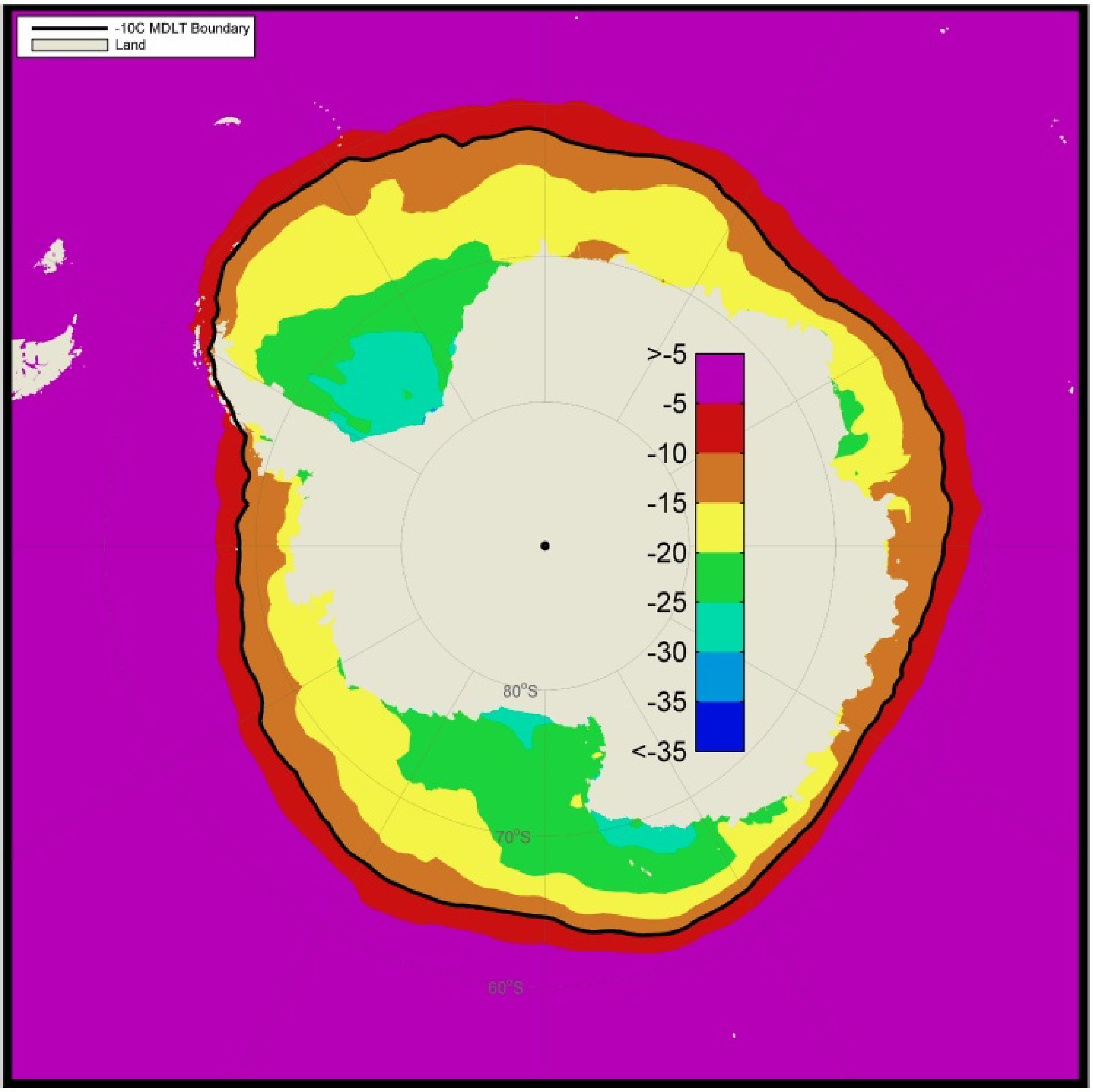


FIGURE 87
Antarctic Mean Daily Low Temperature (MDLT) in °C for July 1st
(1 September 2015)

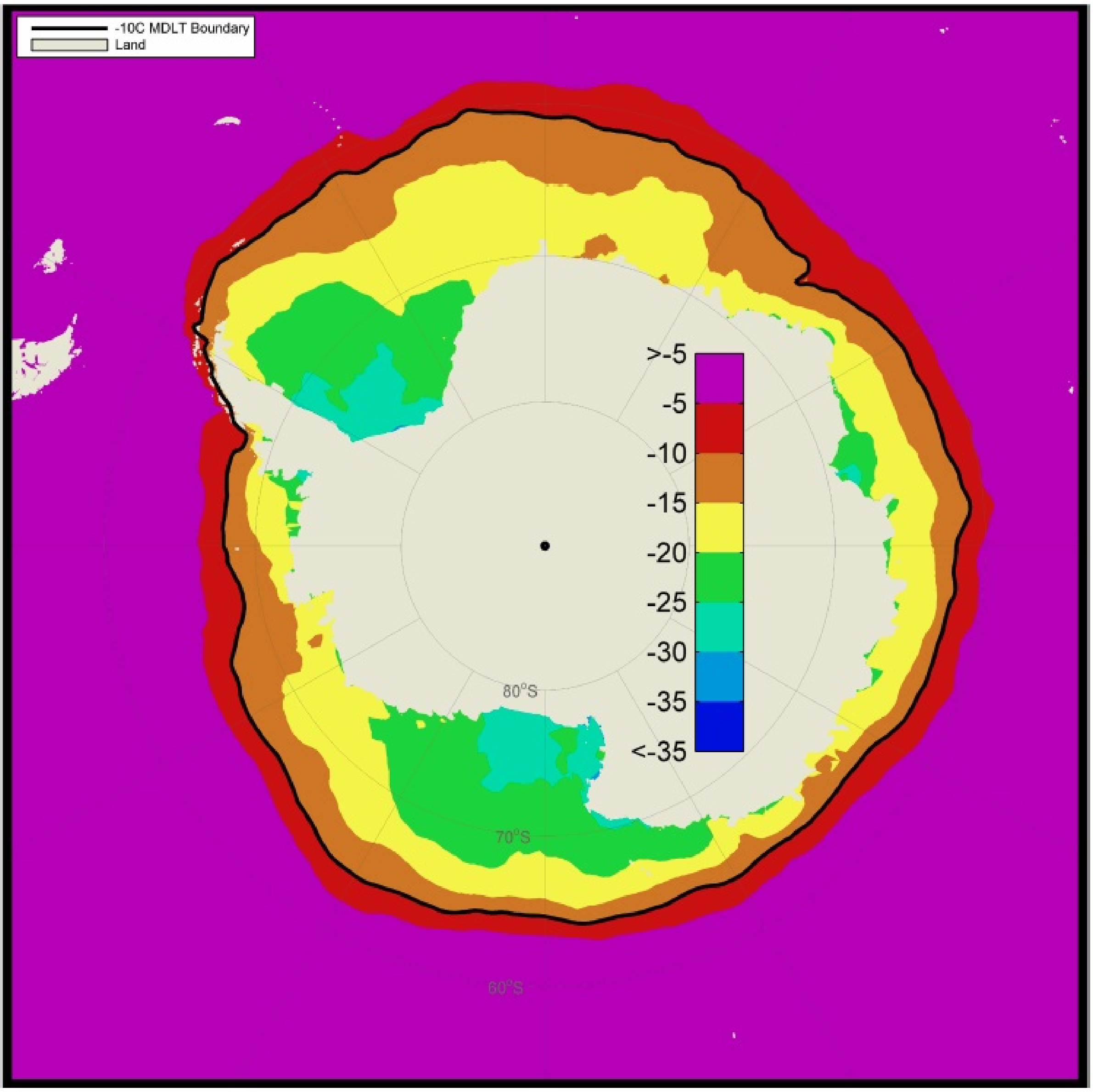


FIGURE 88
Antarctic Mean Daily Low Temperature (MDLT) in °C for July 15th
(1 September 2015)

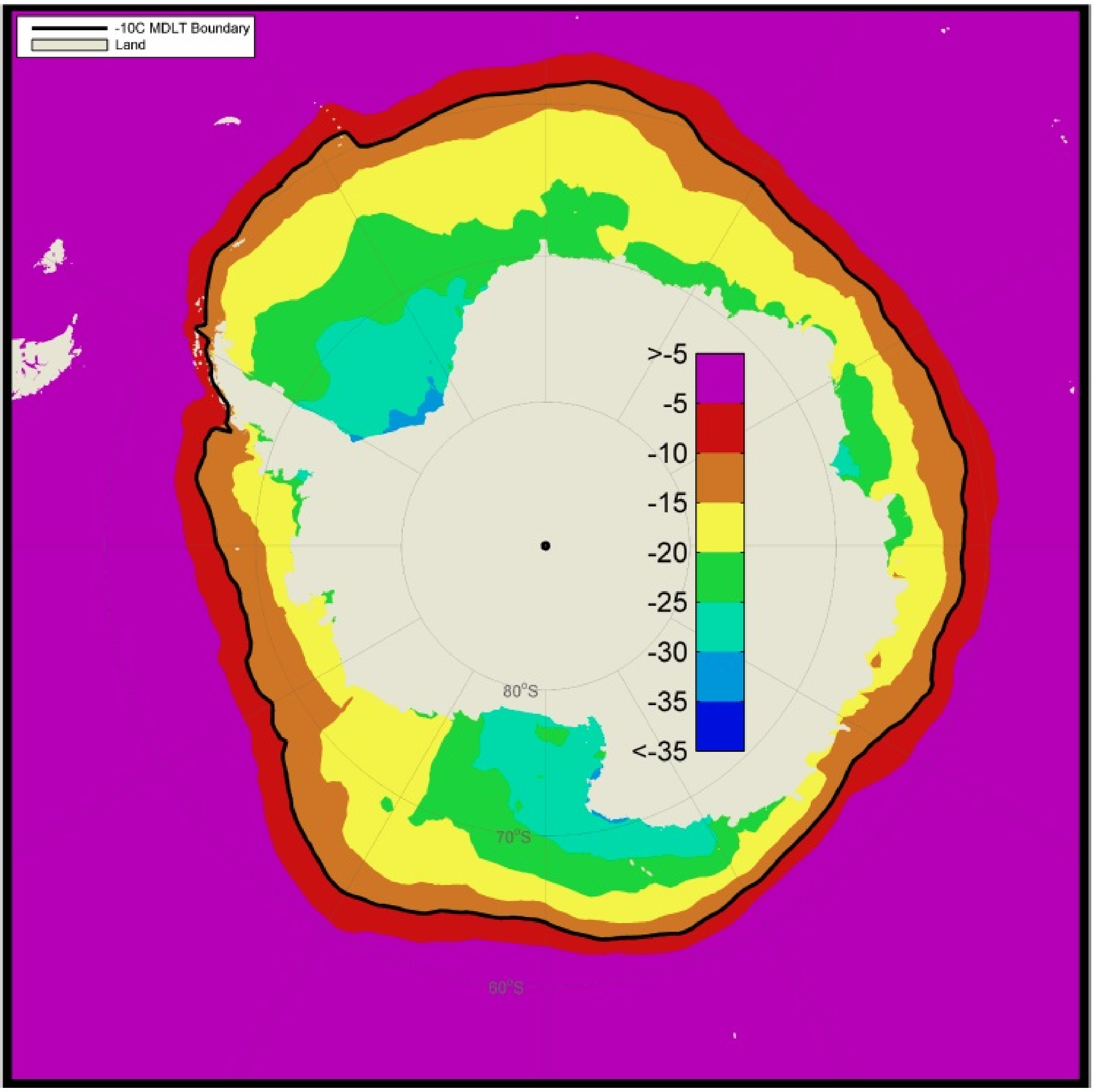


FIGURE 89
Antarctic Mean Daily Low Temperature (MDLT) in °C for August 1st
(1 September 2015)

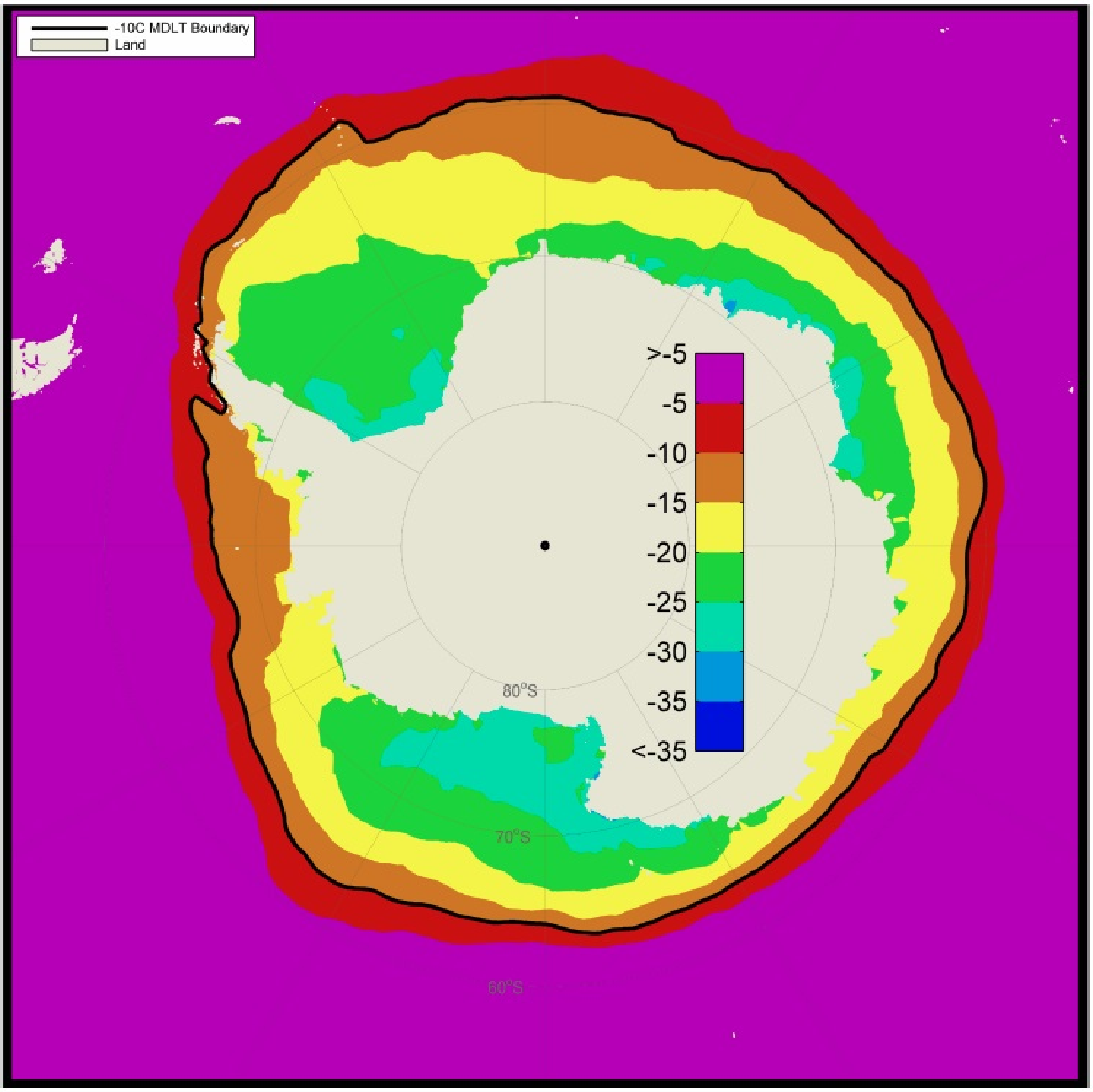


FIGURE 90
Antarctic Mean Daily Low Temperature (MDLT) in °C for August 15th
(1 September 2015)

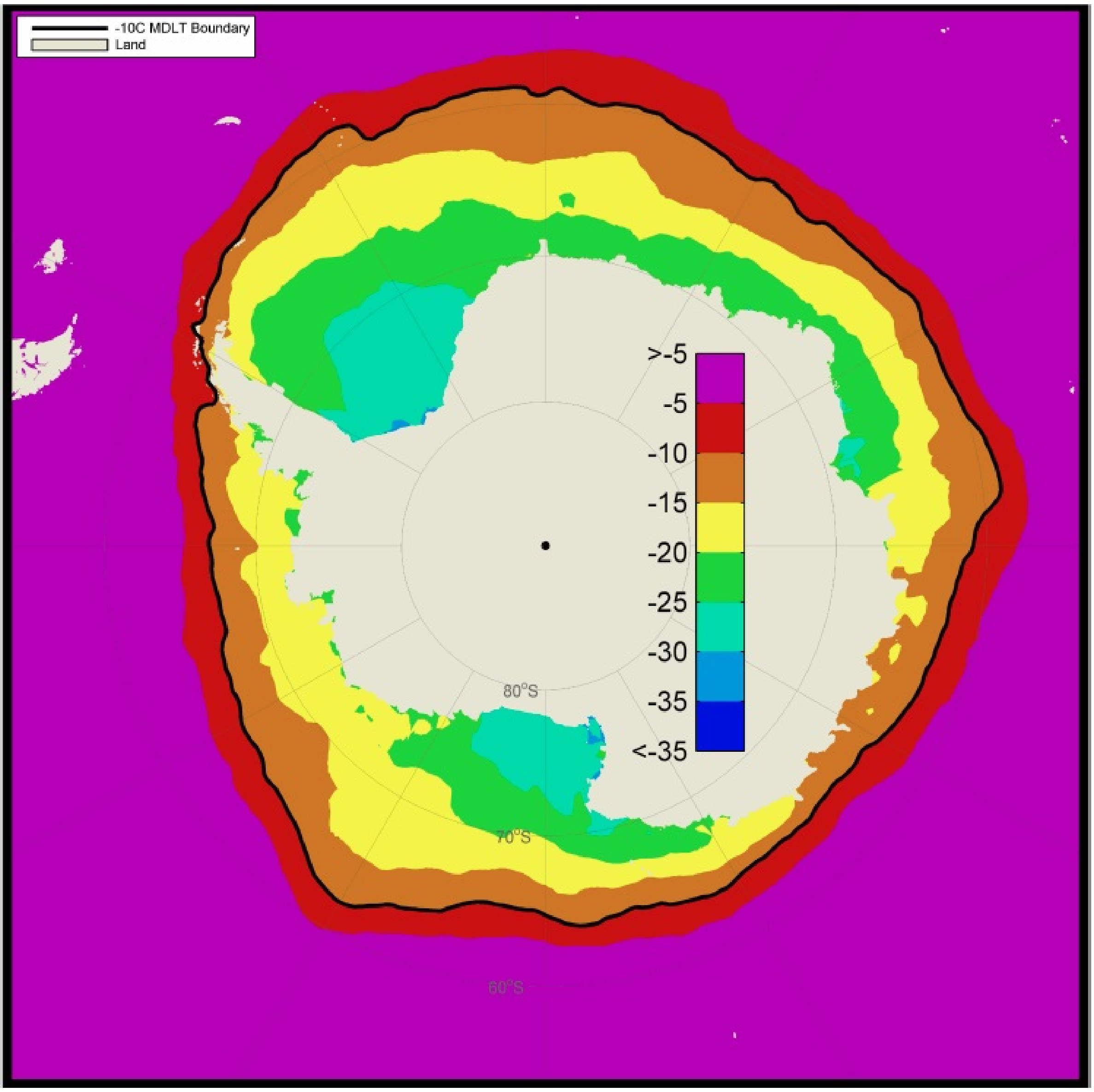


FIGURE 91
Antarctic Mean Daily Low Temperature (MDLT) in °C for September 1st
(1 September 2015)

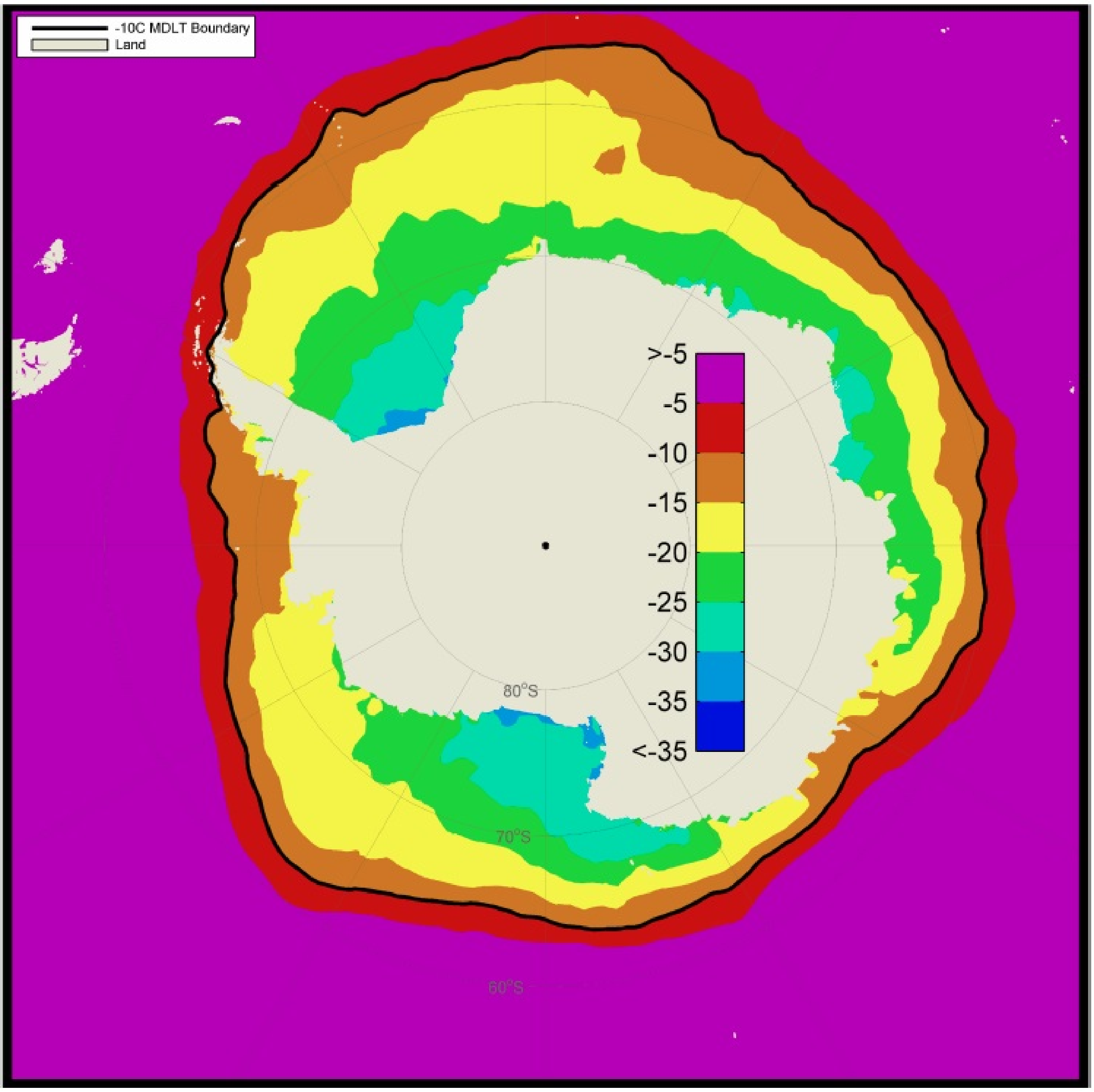


FIGURE 92
Antarctic Mean Daily Low Temperature (MDLT) in °C for September 15th
(1 September 2015)

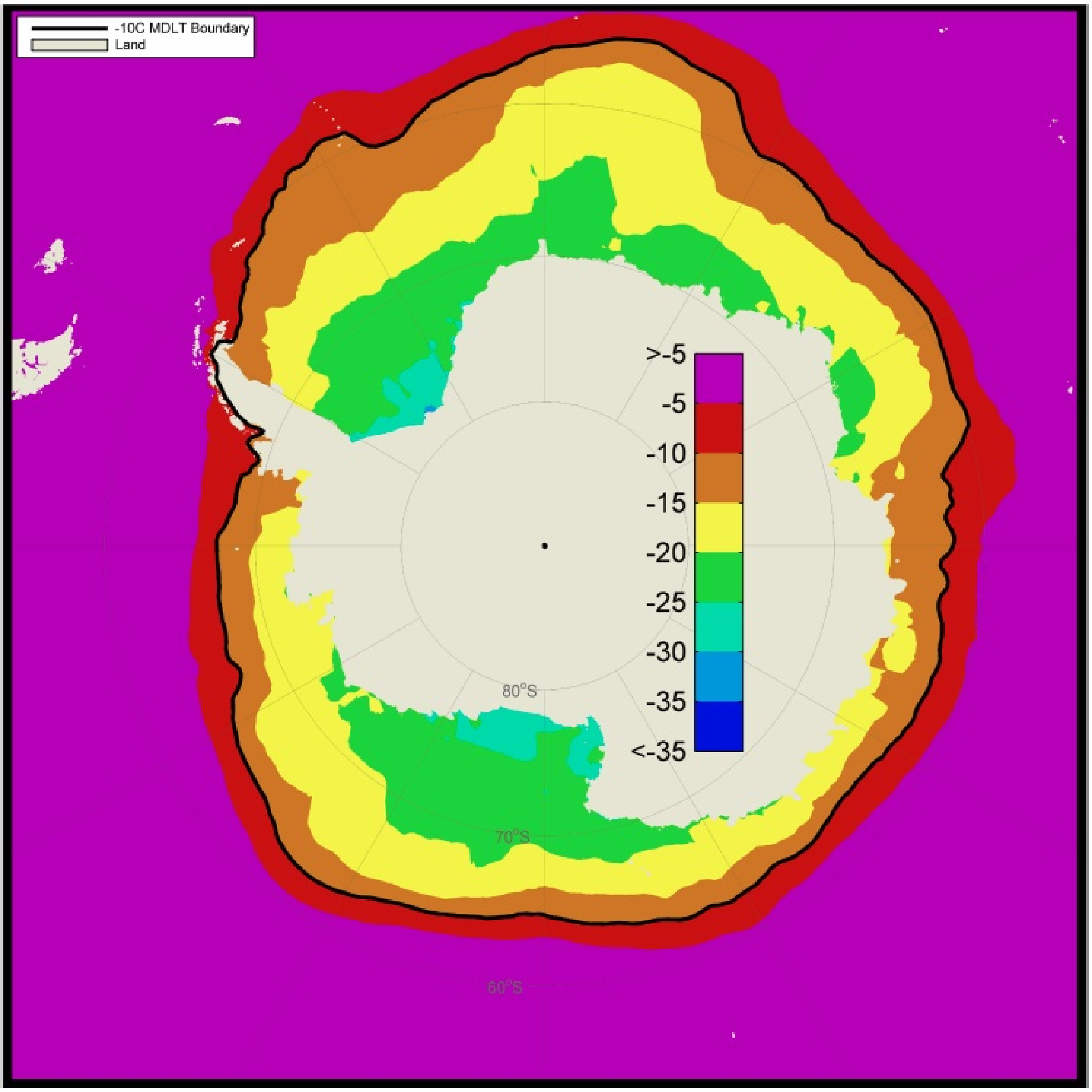


FIGURE 93
Antarctic Mean Daily Low Temperature (MDLT) in °C for October 1st
(1 September 2015)

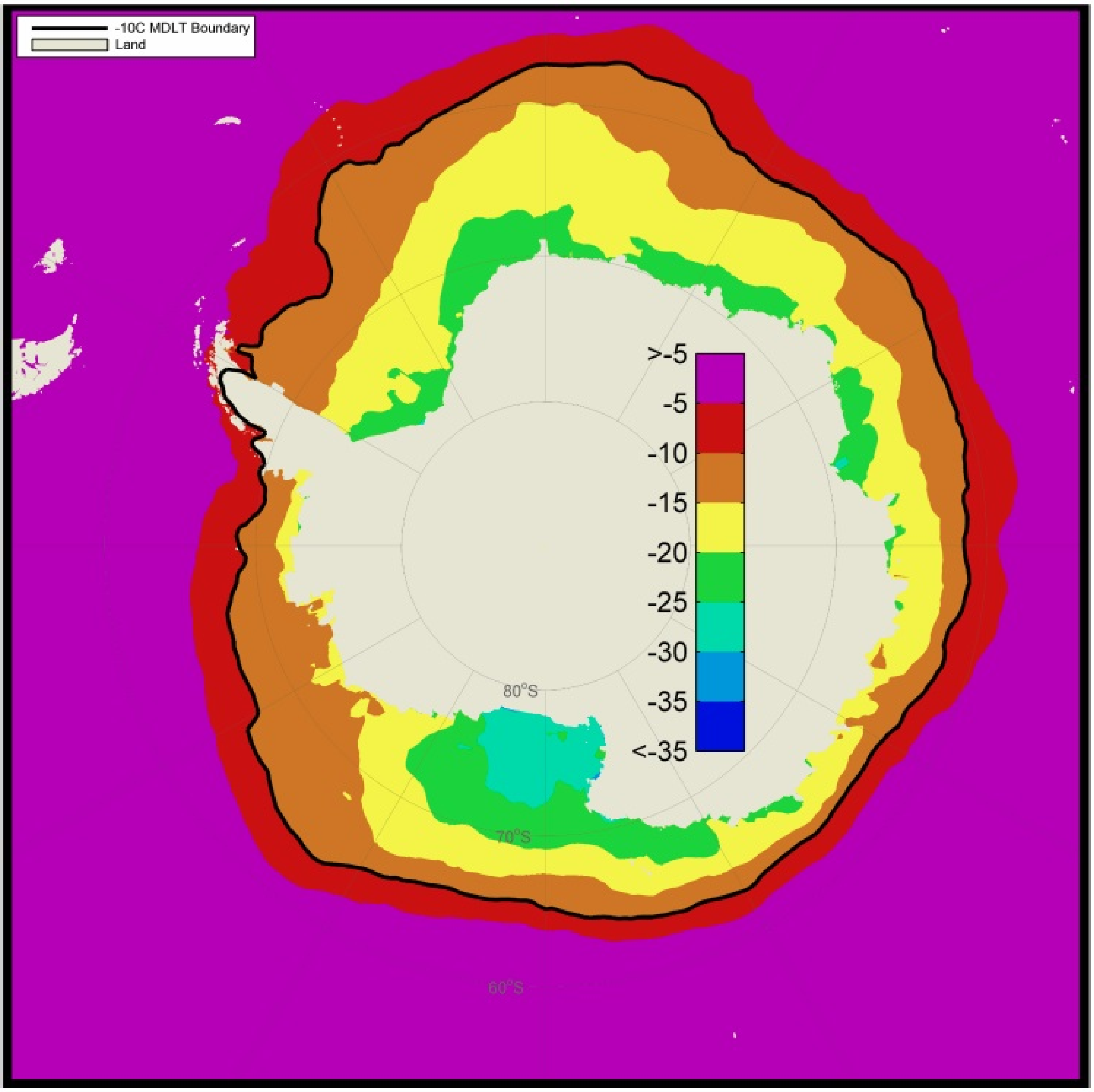


FIGURE 94
Antarctic Mean Daily Low Temperature (MDLT) in °C for October 15th
(1 September 2015)

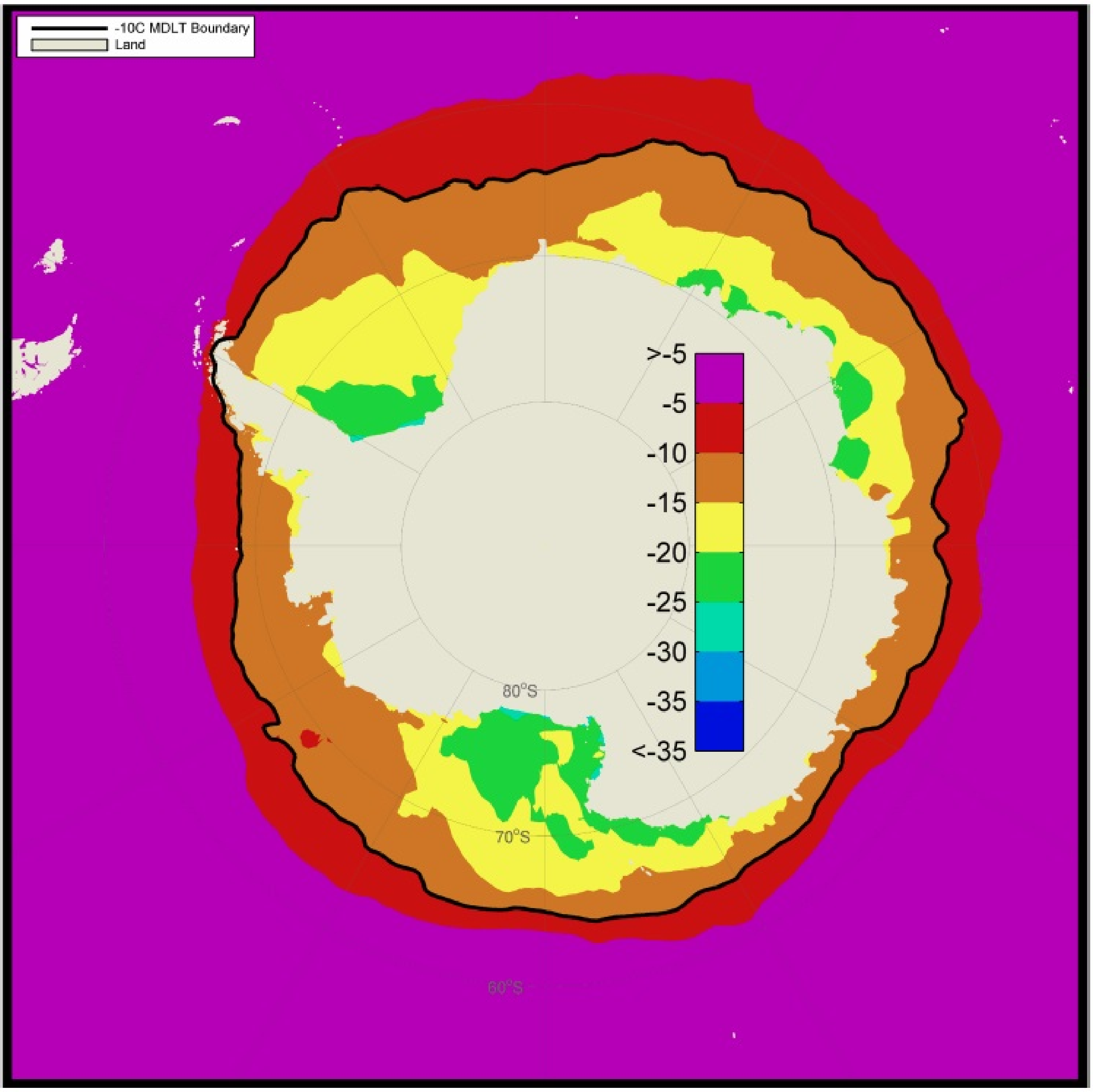


FIGURE 95
Antarctic Mean Daily Low Temperature (MDLT) in °C for November 1st
(1 September 2015)

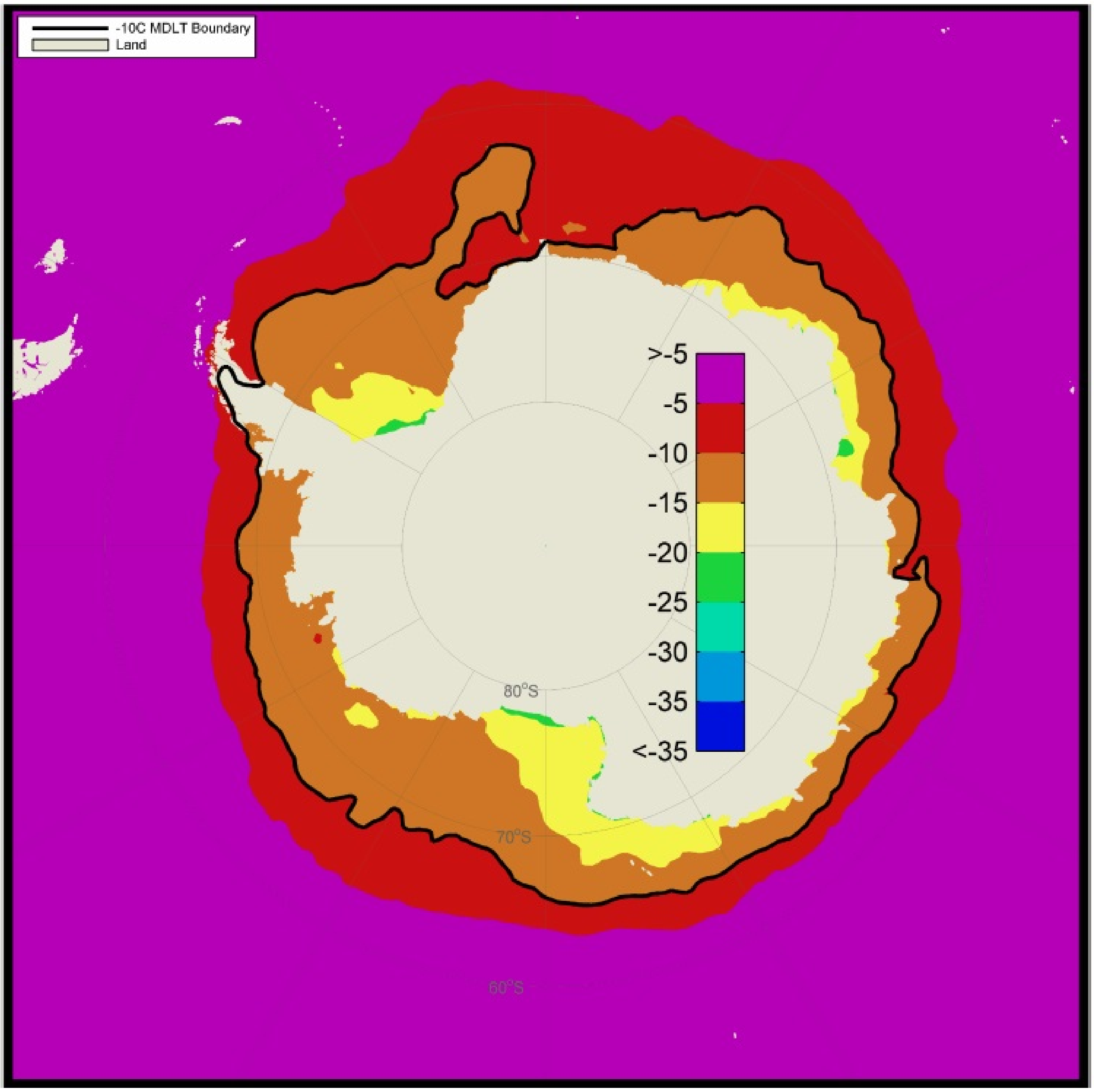


FIGURE 96
Antarctic Mean Daily Low Temperature (MDLT) in °C for November 15th
(1 September 2015)

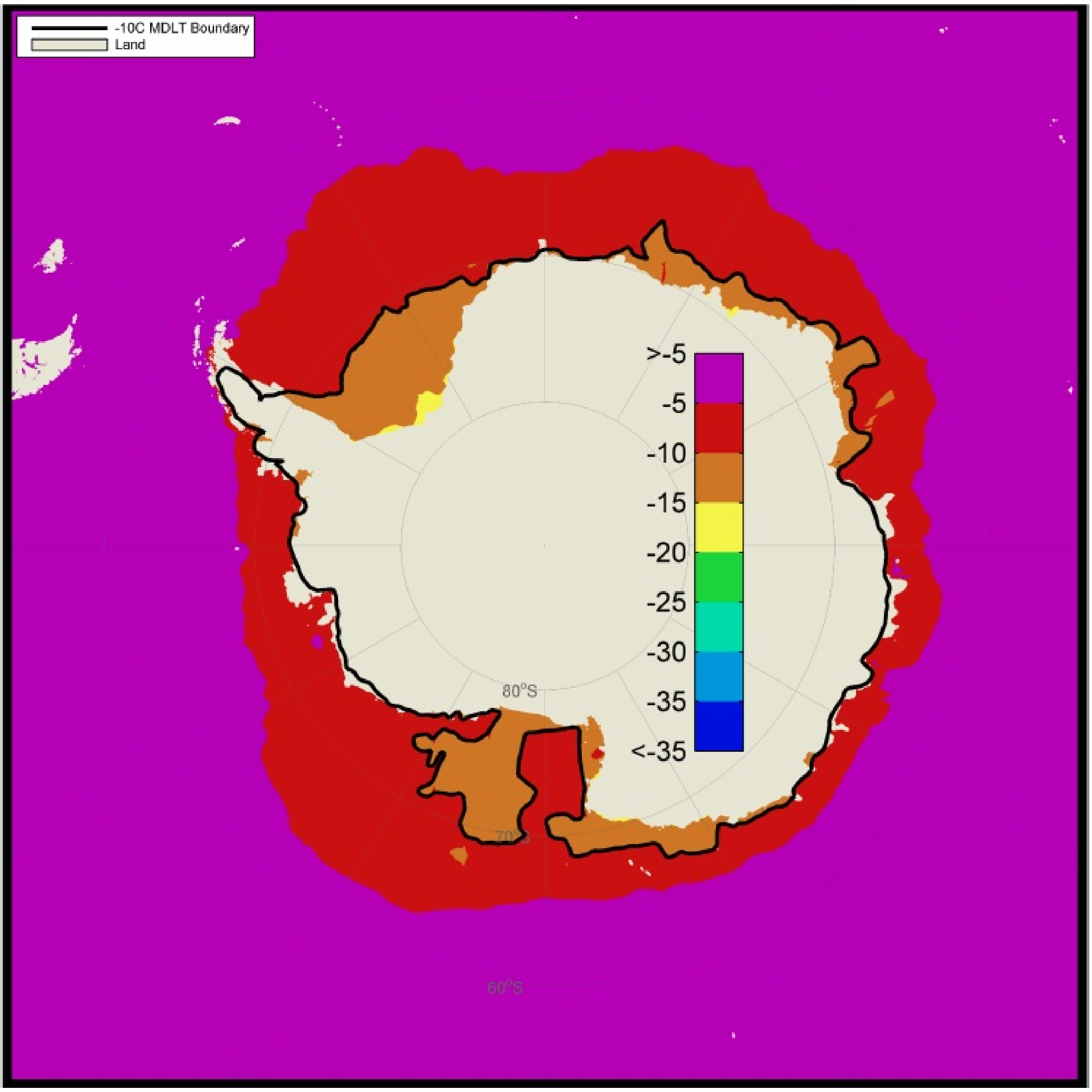


FIGURE 97
Antarctic Mean Daily Low Temperature (MDLT) in °C for December 1st
(1 September 2015)

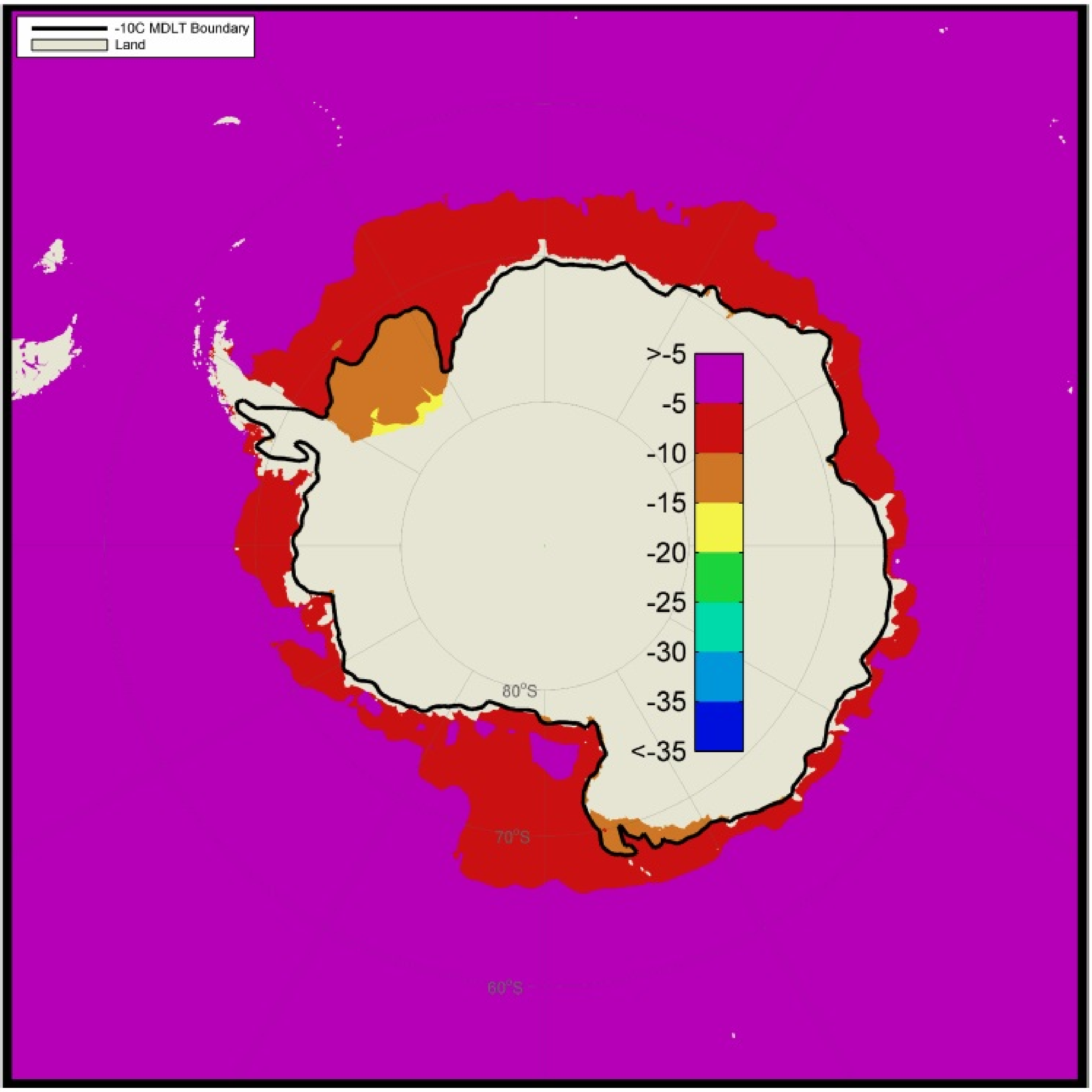
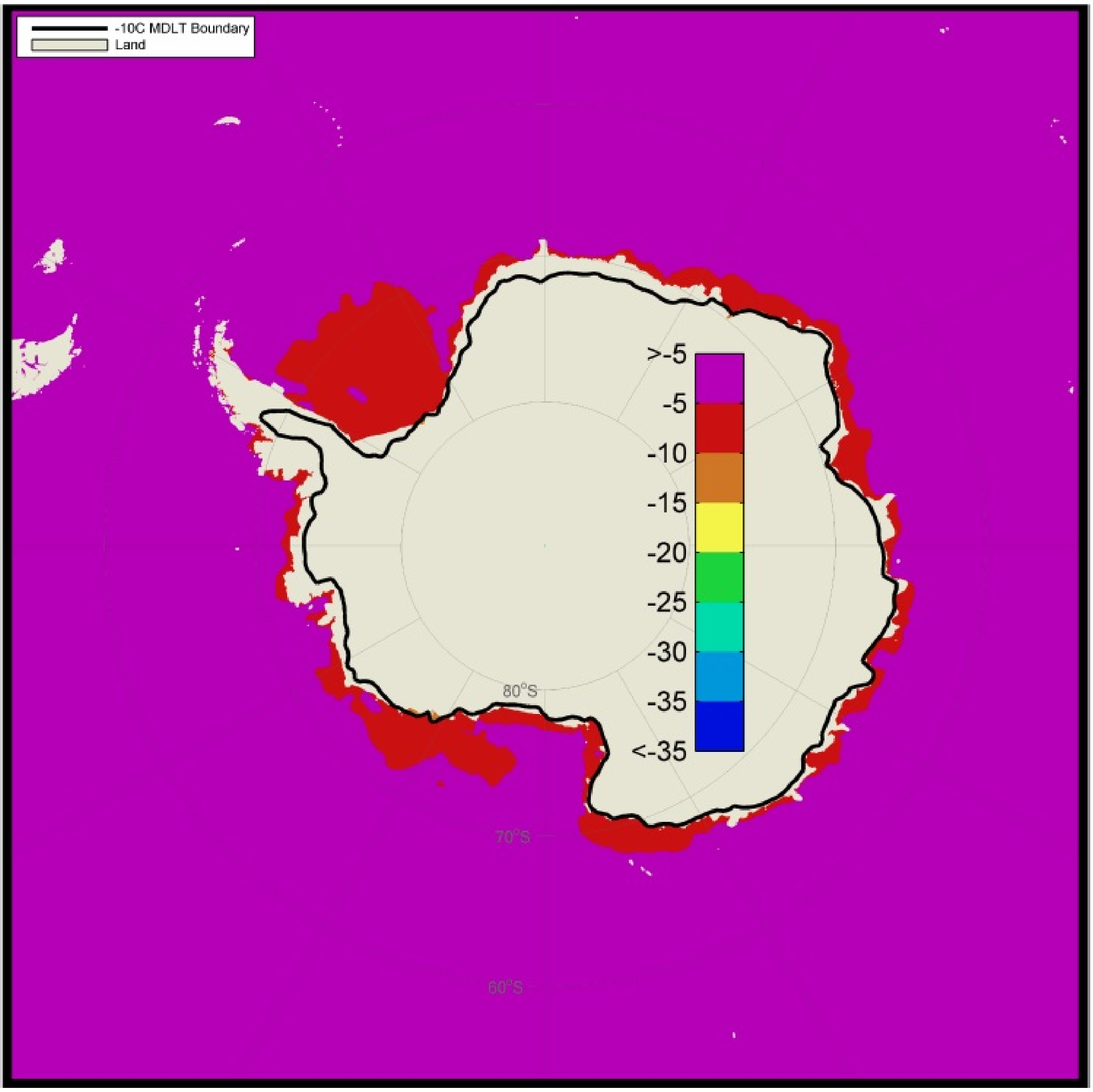


FIGURE 98
Antarctic Mean Daily Low Temperature (MDLT) in °C for December 15th
(1 September 2015)



APPENDIX 11

Notes on Vessel Operations

1 Overview

The following relates to vessel operations in low temperature environments and are recommendations only and cannot possibly list all operating scenarios or equipment types that a vessel may encounter or have installed onboard. The vessel's crew will need to make regular checks of safety-critical systems and equipment so that these are still functioning or capable of functioning as intended. The vessel's Owner and Operator are responsible for developing relevant and appropriate operational guidelines and keeping these procedures up to date.

This Appendix is organized similarly to the Guide's Sections: deck (hull), machinery, and safety systems. Within each Subsection is a list of operational issues that should be considered when developing the operations manual.

2 Deck Recommendations

2.1 Ice/Snow Removal

The deck and associated piping should be cleaned up periodically, particularly due to spray and bad weather. Ice can quickly build up on the vessel, affecting safety of the crew's movement and vessel stability.

2.2 Crew Access

2.2.1 Access Routes

Access ways should be checked each day when snow or under-cooled rain occurs and any accumulation removed.

De-ice chemical mix (glycol mix) should be applied to deck plating when freezing occurs.

Deck drains should be opened using steam, pressure air and/or de-ice chemical mix

Snow and ice should be removed by use of shovels, hardwood clubs, steam or equal.

When freezing temperatures and icing are anticipated, heated walkways are activated at 5°C (41°F) with increasing heat as further temperature drops occur.

Where necessary, additional safety lines should be run and crew members instructed on tethering themselves.

2.2.2 Escape Routes

Escape routes should be clearly marked, checked and kept clear of debris, snow and ice accumulation at least once a day or more often when required.

2.2.3 Emergency Exits

Gaskets, hinges, dowels and locks should be checked and treated with approved de-ice chemicals before the temperature drops below 0°C (32°F).

Exits should be checked and kept clear of debris, snow and ice accumulation once a day or more often when required.

Snow and ice should be continuously removed using shovels, hardwood clubs, steam and/or compressed air.

Pre-treatment with de-ice chemicals should be applied at least each month or when required.

For drilling rigs, the Derrick man's escape (Geronimo Chutes) should be checked and treated with de-ice chemicals before the temperature drops below 0°C (32°F). The chute should be function tested every day when the temperature is 0°C (32°F) or below.

2.2.4 External Emergency Lights

External emergency lights should be operative at all times and kept free from snow and ice.

The lights should be checked daily when the temperature is below 0°C (32°F).

3 Vessel Systems and Machinery Recommendations

Weather forecasts should be monitored closely. In the event forecasts predict temperatures approaching the Minimum Anticipated Temperature, deck machinery should be periodically operated (barred) and any hydraulic systems' oil heaters turned on.

3.1 Fire Fighting Equipment Readiness

Door gaskets should be treated with de-ice treatments at least each month or when required.

All snow and ice accumulation on equipment should be removed by using steam, compressed air or equal as necessary to maintain system readiness at all times.

Fire water hoses that have been used should be drained and dried immediately after use or stored at a frost-free location.

Fire mains should be drained until needed when the temperature is 0°C (32°F) or below.

When the temperature drops below 0°C (32°F), all external fire equipment should be checked daily or more often when required for snow and ice accumulation.

Portable fire extinguishers at anchor stations should be kept in operator's cabins when the temperature is -15°C (5°F) or below.

All the fire dampers directly exposed to the weather are to be checked and function tested every day when the temperature is 0°C (32°F) or below.

Exposed deck machinery should be checked frequently to verify correct operation.

3.2 Tanks

Any tank, its associated piping system and venting condition should be checked prior to loading or discharging operations.

3.3 Exterior Alarms

All external alarm equipment should be inspected daily when temperature is below 0°C (32°F).

3.4 Helicopter Deck

3.4.1 General

Foam monitors should be properly drained when the helicopter deck operations are completed.

De-ice chemical mix should be applied to the helicopter deck.

Deck border lights and floodlights should be treated with de-ice chemical mix.

Portable fire extinguishers should be kept in a heated area close to the helicopter deck.

Drains should be checked daily to verify heat tracing is working.

3.4.2 Procedures When Operating in Snow and Freezing Rain

In addition to the items above, the following procedures should be performed:

Snow should be removed from helicopter deck and access/escape ways, when required, by using shovels, steam and/or pressure air.

De-ice chemical mix should be applied to deck when required.

Ice should be removed from deck border lights and floodlights. Steam and compressed air can be used. De-ice chemical mix should be applied at least every month or when required.

3.4.3 Procedures Before Landing and Take-off

Helicopter deck should be checked before landing for debris, snow and ice accumulation.

Snow and ice should be removed. Special attention should be paid to landing area of helicopter deck and to walkways/escape routes.

Ice should be removed from deck border lights and floodlights.

Helicopter deck fire fighting system (foam monitors) should be activated.

Personnel should be kept in protected spaces until departure to avoid cold exposure.

4 Safety Systems

4.1 Evacuation Systems

4.1.1 Launching/Lifeboat Stations

De-icing equipment should be deployed and ready for use at stations when the temperature drops below 0°C (32°F). Steam hoses should be rigged and ready for use at stations.

Lashings on life jacket and survival suit boxes should be checked daily or more often when required for snow and ice accumulation. Ice can be removed by de-icing equipment. De-ice treatments should be applied at least each month or when required.

Means to de-ice (e.g., glycol/water mix or salt) should be applied on deck plating as required to prevent icing when the temperature drops below 0°C (32°F).

Lifeboat stations should be checked daily or more often for snow and ice accumulation when required.

Ice and snow should be removed from decks, gratings, handrails, rope escape ladder, life vest and survival suit boxes using shovels, hardwood clubs, steam or compressed air.

4.1.2 Lifeboats

Lifeboat heaters in all lifeboats should be switched on when the temperature drops below 0°C (32°F).

Hooks, latches and hinges should be checked daily or more often when required for snow and ice accumulation and treated with de-ice treatments.

Radio equipment with batteries should be thoroughly checked every second day.

Lifeboats should be checked two times a day or more often when required.

Engine heaters, lifeboat heating fans and battery chargers should be checked for functionality each day.

Snow and ice should be kept removed.

Hooks, lashes and hinges should be checked two times a day or more often when required for snow and ice accumulation if required. Ice should be removed using de-icing equipment.

De-ice treatments should be applied at least each month or when required.

Lifeboat engine should be run each day until it reaches operation temperature.

Lifeboat engine fuel should be checked daily for clouding or waxing.

Lifeboat engine lubricating and hydraulic (starting) oils should have correct viscosity at design service temperature without the use of heaters.

4.1.3 Launching Arrangements

Hooks, latches and hydrostatic release couplings should be checked daily or more often when required for snow and ice accumulation. and treated with de-ice treatments.

Brake guide wire and sheaves should be checked daily or more often when required for snow and ice accumulation and properly greased, if necessary.

Lifeboat launching arrangements should be checked daily or more often when required for snow and ice accumulation or more often when required.

Winches should be maintained in a snow and ice free condition at all times.

Ice on hooks, latches and hydrostatics release couplings should be removed using de-icing equipment. De-ice treatments should be applied at least every month or when required.

Winches should be operated daily.

4.1.4 Life Rafts

Latches/hydrostatic release couplings should be checked daily or more often when required for snow and ice accumulation and treated with de-ice treatments.

Snow and ice should be kept removed.

De-ice treatments should be applied at least every month or when required.

4.1.5 Life Raft Launching Arrangements

Winch should be checked and greased according to lubrication chart if required.

Brake guide wire and sheaves should be checked daily or more often when required for snow and ice accumulation and properly greased if necessary.

Life raft launching arrangements should be checked daily or more often when required for snow and ice accumulation.

Snow and ice should be kept removed.

Ice on lashes/hydrostatic release couplings should be kept removed using de-icing equipment.

Ice should be removed from release hooks using de-icing equipment and should be treated with de-ice treatments at least each month or when required.

4.2 Rescue Boats

4.2.1 Rescue Boat

Radio equipment with batteries should be thoroughly checked for operability every second day.

Rescue boat should be inspected two times a day or more often if required for snow and ice accumulation.

Engine heaters and battery charger should be checked for operability each day.

Ice and snow should be kept removed using de-icing equipment.

Engine should be run daily until operating temperature is reached.

Rescue boat engine fuel should be checked daily for clouding or waxing.

Rescue boat engine lubricating oil should have correct viscosity at design service temperature without the use of heaters.

4.2.2 Rescue Boat Launching Arrangement

Brake guide wire and sheaves should be checked and properly greased if necessary.

Quick release hook should be checked for snow and ice accumulation and treated with de-ice treatments.

Rescue boat launching arrangement should be test run each week or more often if required.

Brake guide wire should be thoroughly checked daily or more often when required for snow and ice accumulation.

Snow and ice should be kept removed from winches.

Ice on quick release hook should be removed using de-icing equipment. De-ice cure should be applied at least every month or when required.

Launching arrangement should be checked three times a day or more often when required for snow and ice accumulation.

4.3 Escape Systems

4.3.1 Escape Chutes and Life Raft Stations

De-icing equipment should be deployed and ready for use at stations when the temperature drops below 0°C (32°F).

De-icing treatments should be applied to deck plating to prevent snow and ice accumulation.

Life raft station should be checked two times per day or more often if required for snow and ice accumulation.

Ice and snow should be removed from deck handrails, raft and launching arrangements using de-icing equipment.

4.4 Personal Safety Equipment

4.4.1 Immersion Suits and Life Jackets

If immersion suits are stored at stations, they should be checked for moisture and dried if necessary.

Personal immersion suits should be stored in cabins to avoid moisture accumulating in the suits.

4.4.2 Life Jackets

Life jackets should be free from moisture when returned back into boxes after use.

APPENDIX 12

List of Administrations

1 Overview

Various national Administrations have additional regulations for vessels operating in their territorial waters beyond those listed in this Guide. It is recommended that vessel designers, owners and operators contact these Administrations directly regarding these regulations. A12/1 TABLE 1 provides a list of Administrations in areas subject to low temperatures.

TABLE 1
Administration Contact Information

Country	*Address*	*Contact/Telephone*	*Web Site Address*
ARGENTINA, REPUBLIC OF Prefectura Naval Argentina	Av. Eduardo Madero, 235 (C1106 CCA) Buenos Aires, Rep. of Argentina	Director Policia Seguridad de la Navegacion Jefe Departmento Reglamentacion de la Navegacion: (54-11) 4318-7475 ext 2411 or (54-11) 4318-7467	http://www.prefecturanaval.gov.ar
AUSTRALIA, COMMONWEALTH OF Australian Maritime Safety Authority	GPO Box 2181 Canberra City ACT 2601 Commonwealth of Australia	Principal Adviser Technical: (61-2) 6279 5049 or (61-2) 6279 5966	http://www.amsa.gov.au/
CANADA Transport Canada Safety & Security	Tower "C", Place De Ville 11th Floor 330 Sparks Street Ottawa, Ontario K1A 0N8, Canada	Director of Ships and Operations Standards: (1-613) 991-3131 or (1-613) 993-8196	http://www.tc.gc.ca/en/menu.htm
CHILE Direccion General del Territorio Maritimo y de Marina Mercante Armada de Chile	Avenida Errazuriz 537 Valparaiso, Chile	Director General: (56-32) 2208102 or (56-32) 2208097 (fax)	http://www.directemar.cl/

Country	*Address*	*Contact/Telephone*	*Web Site Address*
DENMARK Danish Maritime Authority	Skibsregistret 38C, Vermundsgade P. O. Box 2605 DK-2100 Copenhagen O, Denmark	Chief Ship Surveyor (45-39) 17 44 00 or (45-39) 17 44 01 (fax)	http://www.dma.dk/
ESTONIA Estonian Maritime Administration	Valge 4 11413 Tallinn, Estonia	Director General: (372) 6205 700 or (372) 6205 706 (fax)	http://www.vta.ee/atp/?lang=en
FINLAND Finnish Transport Agency Maritime Department	Finnish Transport Agency P. O. Box 33 FIN-00521 Helsinki, Finland www.fma.fi	Technical Approval (358-20) 448 4249 or (358-20) 448 4336 (358-20) 63 7373 (Operator)	http://portal.fma.fi/ sivu/www/ fma_fi_en/ services/ winter_navigation
GREENLAND Danish Maritime Authority	Skibsregistret 38C, Vermundsgade P. O. Box 2605 DK-2100 Copenhagen O, Denmark	Chief Ship Surveyor (45-39) 17 44 00 or (45-39) 17 44 01 (fax)	http://www.dma.dk/
ICELAND Icelandic Maritime Administration	Vesturvor 2 P. O. Box 120 202 Kopavogur, Iceland	Head of Technical Regulations Section: (354) 560 0000 or (354) 560 0060 (fax)	http://www.sigling.is/English
LATVIA Ministry of Transport of Latvia, Maritime Administration	Trijadibas iela 5 Riga, LV-1048, Latvia	Director: (371) 67062101 or (371) 67860082 (fax)	http://www.jurasadministracija.lv/ index.php?pid=211
LITHUANIA Ministry of Transport and Communications of the Republic of Lithuania	Gedimino Av. 17 Vilnius 2679, Republic of Lithuania	Director: 370 46 469657	http://www.msa.lt/index.php/en/ 27717
NETHERLANDS Inspectorate Transport and Water Management	Netherlands Shipping Inspectorate Gebouw Prinsenpoort 's-Gravenweg 665 (PO Box 8634, 3009 AP) Rotterdam, The Netherlands	Director: (31-10) 266 8500 or (31-10) 202 3424	http://www.ivw.nl/en/water/ koopvaardij/
NEW ZEALAND Maritime New Zealand	Level 8, gen-i Tower 109 Featherston Street (P. O. Box 27006) Wellington, New Zealand	General Manager, Maritime Operations: (64-4) 4730111 or (64-4) 4941263	http://www.maritimenz.govt.nz/
NORWAY, KINGDOM OF Norwegian Maritime Directorate	P.O. Box 2222 N-5509 Haugesund, Norway	Vessels and Seafarers 47 52 74 50 00 47 52 74 50 01	http://www.sjofartsdir.no/en/
POLAND Ministry of Transport and Maritime Economy	Department of Maritime and Inland Waters Administration U1. Chalubinskiego 4/6 00-928 Warsaw, Poland	Ships inspection – Head Office (48-22) 621 1448 or (48-22) 621 9437	http://www.en.mi.gov.pl/ 2-482076faaa403.htm

Country	*Address*	*Contact/Telephone*	*Web Site Address*
RUSSIAN FEDERATION Ministry of Transport of the Russian Federation Russian Northern Sea Route Administration	Maritime Administration ul. Rozhdestvenka, 1/4 103759 Moscow, Russia	Head of Maritime Administration (7-495) 926 10 00 or (7-495) 978 91 70	Ministry of Transport http://www.mintrans.ru/ Northern Sea Route http://www.morflot.ru/
SWEDEN, KINGDOM OF Swedish Maritime Administration	Maritime Safety Inspectorate Slottsgatan 82, SE-601 78 Norrkoping Kingdom of Sweden	Director of Maritime Safety: (46-11) 19 10 00 or (46-11) 10 19 49	http://www.sjofartsverket.se/
UKRAINE Ministry of Transport of Ukraine	State Department of Maritime and Inland Water Transport 14, prospect Peremogy Kyiv 01135, Ukraine	Director General: (380 44) 461 5320 or (380 44) 461 5304 (Emergency Officer)	http://www.mintrans.gov.ua/# http://www.kmu.gov.ua E-mail: security@morrechflot.gol.ua
UNITED STATES OF AMERICA U. S. Coast Guard	Commandant (G-MOC) 2100 Second Street, SW Washington, DC 20593-0001 Federal Communications Commission Wireless Telecommunications Bureau 445 12th Street SW Washington DC 20554	Chief, Office of Vessel Activities (202) 372-1210 (202) 372-1918 (fax) Public Safety and Private Wireless Division (202) 418-2771 (202) 418-2643	http://www.uscg.mil

APPENDIX 13

List of Meteorological Organizations

1 Overview

Various government organizations provide readily accessible climatic, environmental and meteorological data sets and historic atlases. A13/1 TABLE 1 provides a list of these organizations along with their contact information.

TABLE 1
Meteorological Organization Contact Information

Country	*Address*	*Contact/Telephone*	*Web Site Address*
All Russian Research Institute- of Hydrometeorological Information – World Data Centre	RIHMI-WDC, 6, Korolev St., Obninsk, Kaluga Reg., Russia	Tel: (7-495) 255-21-94 Fax: (7-495) 255-22-25 E-mail: wdcb@meteo.ru	http://www.meteo.ru/
Arctic and Antarctic Research Institute;	38 Bering str., St.Petersburg, Russian Federation, 199397	Tel: (7-812) 352 1520 Fax: (7-812) 352 2688 E-mail: aaricoop@ aari.nw.ru	http://www.aari.nw.ru/ default_en.asp
Argentine Navy Meteorological Service (SMARA) of the Naval Hydrographic Service	Av.Montes de Ocal 2124, 1217 Buenos Aires, Argentina	E-mail: cnhsmara@ rina.ara.mil.ar	
Australian Bureau of Meteorology	GPO Box 1289 Melbourne VIC 3001 (700 Collins Street Docklands) Australia	Tel: (61-(0)3) 9669 4000 Fax: (61-(0)3) 9669 4699 E-mail: webclim@bom.gov.au	http://www.bom.gov.au/
British Antarctic Survey;	High Cross, Madingley Road Cambridge CB3 0ET United Kingdom	Tel: (44 (0)12) 2322 1400 Fax: (44 (0)12) 2336 2616 Email: basweb@bas.ac.uk	http://www.antarctica.ac.uk/
Canadian Ice Service	373 Sussex Drive Block E, Third Floor Ottawa, Ontario K1A 0H3 Canada	Tel: (1-613) 996-1550 Fax: (1-613) 947-9160 Email: cis-scg.client@ec.gc.ca	http://www.ice-glaces.ec.gc.ca.

Country	*Address*	*Contact/Telephone*	*Web Site Address*
Climatic Research Unit, University of East Anglia	School of Environmental Sciences University of East Anglia Norwich NR4 7TJ, United Kingdom	Tel: (44-1603) 592722 Fax: (44-1603) 507784 Email: cru@uea.ac.uk	http://www.cru.uea.ac.uk/
Cold Regions Research and Engineering Laboratory- US Army	72 Lyme Road, Hanover New Hampshire, 03755-1290 USA	Tel: (1-603) 646-4582 Email: contactcrrel@crrel.usace.army.mil	http:// www.crrel.usace.army.mil/
Danish Meteorological Institute	DMI Lyngbyvej 100, 2100 København Ø Denmark	Tel: (45-39) 15 75 00 Fax: (45-39) 27 10 80 Email: vmarked@dmi.dk	http://www.dmi.dk/dmi/index/
Environment Canada	Meteorological Service of Canada Atmospheric and Climate Science Directorate (ACSD) 4905 Dufferin Street Toronto, Ontario, M3H 5T4 Canada	Tel: (1-416) 739-4239 Email: firstname.lastname@ec.gc.ca	http:// www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html
European Climate Support Network	KNMI PO Box 201 3730 AE De Bilt The Netherlands	Tel: 31 302 206-522 Fax: ECSN Programme Manager	http://www.eumetnet.eu/ECSN_home.htm
Icelandic Meteorological Office	Bustadavegur 9 150 Reykjavík Iceland	Tel: (354) 522 6000 Fax: (354) 522 6001 Email: climate@vedur.is	http://www.vedur.is/english/
International Oceanographic Data and Information Exchange (IODE)	IOC Project Office for IODE Wandelaarkaai 7 B-8400 Oostende Belgium	Tel: (32-59) 34 01 58 Fax: (32-59) 34 01 52 IODE Programme Coordinator	http://www.iode.org/
International Polarview Organization		Tel: (1-709) 737 3735 Email: info@polarview.org	http://polarview.org/project/index.htm
National Snow and Ice Data Center, University of Colorado	449 UCB, University of Colorado Boulder, CO 80309-0449 USA	Tel: (1-303) 492 6199 Fax: (1-303) 492 2468 Email: nsidc@nsidc.org	http://nsidc.org/data/ewg/index.html
Network of European Meteorological Services	*Refer to European Climate Support Network*		http://www.eumetnet.eu.org/
Norwegian Meteorological Institute (DNMI)	PO Box 43 Blindern 0313 Oslo Norway	Phone: (47-22) 96 30 00 Fax: (47-22) 96 30 50 Email: met.inst@met.no	http://www.met.no/english/index.html
Norwegian Polar Institute	Norwegian Polar Institute, Polar Environmental Centre N-9296 Tromsø, Norway (Norsk Polarinstitutt, Polarmiljøsenteret, 9296 Tromsø).	Tel.: (47-77) 75 05 00 Fax. (47-77) 75 05 01 Email: postmottak@npolar.no	http://npiweb.npolar.no/

Country	*Address*	*Contact/Telephone*	*Web Site Address*
Russian Federal Service for Hydrometeorology & Environment Monitoring	Novovagankovsky Per., 12 Moscow, 123995 Russian Federation	Tel: (7-495) 252-5504	http://www.mecom.ru/
Swedish Meteorological and Hydrological Institute	Folkborgsvägen 1 SE-601 76 Norrköping Sweden	Tel: (46-11) 495 8200 Fax: (46-11) 495 8350 Email: kundtjanst@smhi.se	http://www.smhi.se/en/index.htm
United States Government. Department of Commerce. National Oceanic and Atmospheric Administration,National Climatic Data Center	National Climatic Data Center Federal Building 151 Patton Avenue Asheville NC 28801-5001 USA	Tel: (1-828) 271-4800 Fax: (1-828) 271-4876 Email: ncdc.info@noaa.gov	http://www.ncdc.noaa.gov/oa/ncdc.html
United Status Government. National Oceanic and Atmospheric Administration and the Cooperative Institute for Research in Environmental Sciences NOAA-CIRES - Climate Diagnostic Center Physical Sciences Division	325 Broadway R/PSD1 Boulder, CO 80305-3328 OR CIRES/Climate Diagnostics Center University of Colorado 216 UCB Boulder, CO 80309-0216 USA	Tel: (1-303) 497-6188 Fax: (1-303) 497-6449 and (1-303) 497-7013 Email: cdc.webmaster@noaa.gov	http://www.cdc.noaa.gov/
United States Government. United States Navy, the National Oceanic and Atmospheric Administration (NOAA), and the United States Coast Guard, National Ice Center	National Ice Center Federal Building #4 4251 Suitland Road Washington D.C. 20395 USA	Tel: (1-301) 394-3100 Email: liaison@natice.noaa.gov	http://www.natice.noaa.gov/

APPENDIX **14**

Notes on Polar Code *(2024)*

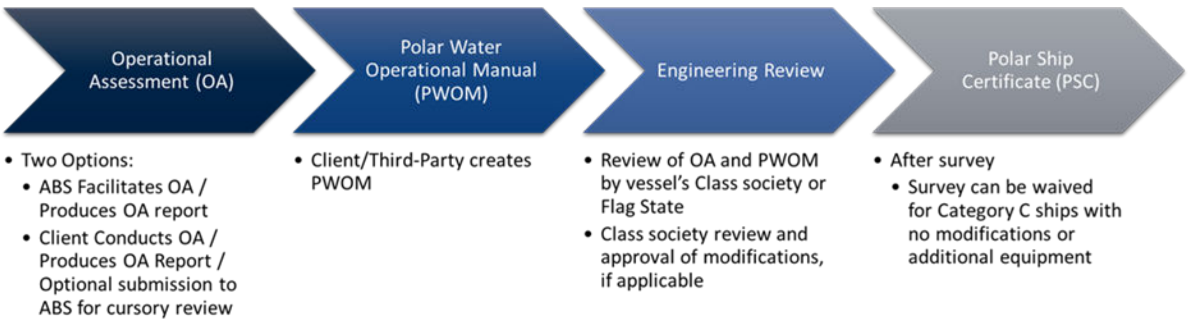
1 Polar Ship Certificate

1.1 Path to a Polar Ship Certificate

A vessel operating in polar waters is required to have a Polar Ship Certificate (PSC). With reference to the figure below, there are four primary phases to Polar Code implementation. During Phase 1, the mandatory Operational Assessment (OA) is to be undertaken. The "depth" of the assessment is directly related to the applicability of the operational hazards, as identified in the Polar Code, and its relevance to the planned operational area and time of year. Hazards to be considered include (but are not limited to) the presence of sea ice, low air temperatures, ice accretion, high latitude, and limited daylight. Means to mitigate identified unacceptable risks, through modification to the ship or its equipment or the addition of operational procedures, are considered during the OA and are documented in a report. Phase 2 is the creation of the Polar Water Operational Manual (PWOM) by the owner/operator or a third party on the owner/operators behalf. The contents of the PWOM reflect the outcomes of the OA. ABS Engineering reviews the OA report, the PWOM, and any necessary ship modifications in Phase 3. In Phase 4, any necessary ABS Survey requirements are addressed and a Polar Ship Certificate (PSC) is issued.

Appendix 14, Figure 1 outlines the general process for an existing vessel to obtain a PSC, and thus the **POLAR(Category, PST)** optional notation if requested. The equipment required by the Polar Code, and any equipment that was deemed necessary during the OA, would be required to be onboard during the survey in Phase 4. If the **POLAR Ready (Category, PST)** optional notation is requested only the minimum mandatory equipment is required to be onboard. Phase 1 through 3 are omitted until the owner/operator conducts the OA and drafts the PWOM and submits the documents to ABS for review.

FIGURE 1
Path to a Polar Ship Certificate



1.2 Polar Ship Certificate Sea Ice Limitation Guidance

The Polar Ship Certificate (PSC) will have one of three ice condition limitations listed:

- Ice Free Waters = No ice of any kind
- Open Waters = Total ice concentration up to 1/10*th* with no ice of land origin (glacial ice).
- Other ice conditions = Anything other than Ice Free Waters or Open Waters.

The selection of the ice conditions is up to the owner / operator. However, increasing the ice conditions requires supplemental procedures for managing the risk of ice. Additionally, Chapter 12 of the Polar Code has various training (STCW) requirements for the crew. The level of training required depends on the vessel type and ice conditions / limitations.

When Other Ice conditions is selected it is expected that the PWOM will contain details of the sea ice risk mitigation measures to be employed by the operator. PWOMs that have "Open Waters" or "Ice Free Waters" restrictions should make very limited reference to a sea ice risk control measure except in case of a contingency measure, when the vessel in in a situation that exceeds its limitations, details of the sea ice mitigation measures must be fully documented.

2 Guidance

The Polar Code process can be time consuming, so it is highly encouraged that the process be started as soon as possible.

2.1 Polar Code Basic Steps

The basic steps to a Polar Ship Certificate are as follows:

i) Owners/operators should fully characterize and understand the environment, conditions, and hazards associated with operating in polar waters. Owners/operators need to understand the hazards the ship will face in order to assess the risks of the vessel operating in those conditions, in order to justify the intended operation for the vessel in polar waters is not subjected to the hazards specified in paragraph 3 of the Polar Code Introduction.

ii) Owners/operators must conduct and document an Operational Assessment to evaluate the operational risks and to determine where risk control measures are required.

iii) Owners/operators are to draft a Polar Water Operational Manual (PWOM) to detail how the identified risk control measures will be implemented on board the ship, give guidance on how to safely operate the vessel in polar waters, identify the vessel's limitations, and give guidance to the crew on what to do if the limitations are reached. or exceeded.

a) If the vessel will have icebreaker escort(s), this should be included when drafting the PWOM procedures.

b) The procedures/guidance when the vessel's limitations have been reached or exceeded must include operational guidance to safely sail the vessel out of the hazards, and include all potential abandonment scenarios (abandonment to ice, abandonment to lifeboat, etc.).

iv) Owners/operators shall submit the OA report and PWOM to ABS for review.

v) After ABS engineering has completed the review of the OA report and PWOM, an ABS Surveyor will survey the vessel to verify that the vessel has the means (systems, equipment, and outfitting) to follow the procedures in the PWOM and close any technical comments arising from the engineering review.

vi) The Polar Ship Certificate will be issued by the ABS Surveyor upon satisfactory survey.

2.2 Polar Code Common Issues

There are several areas where additional equipment/training is common for compliance with the Polar Code. A brief list of normal modifications/additions for ships seeking a Polar Ship Certificate is provided below:

i) Two non-magnetic means of determining heading [Part I-A/9.3.2.2.1]

ii) Airband radio [Part I-A/10.3.1.3.2]

iii) Two remotely rotatable search lights suitable for searching for ice [Part I-A/9.3.3.1]

iv) A4 Radio Installation (if going to an area where A4 is needed) [Part I-A/10.3.1.1]

v) Means of obtaining ice and weather information, functional up to a maximum latitude of intended operation [Part I-A/9.3.1]

vi) Manually activated flashing red stern light (if planned operations with an icebreaker) [Part I-A/9.3.3.2]

vii) Personal and group survival equipment as necessary to enable survival for the maximum expected time of rescue [IMO MSC.1/Circ. 1614 Rev.1][Part I-A/8.3.3]

viii) Heating for emergency fire pump [Part I-A/7.3.2.1]

ix) Additional EPIRB (or procedures to extend battery life for the maximum expected time of rescue) [Part I-A/10.3.2.3]

x) Additional water, rations, seasickness medication [IMO MSC.1/Circ. 1614 Rev.1]

xi) Insulated immersion suits [Part I-A/8.3.3.1.2]

xii) Tools for de-icing (e.g., mallets, shovels, scrapers, etc.) if planned operation is in area and season where ice accretion is expected to occur [Part I-A/4.3.1.2.2]

xiii) Crew training (basic, advanced) depending on the expected ice conditions and vessel type [Part I-A/12.3]

xiv) Radio schedules and procedures in survival craft [Part I-A/10.3.1.4]