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Homeland Security

**United States
Coast Guard**

Domestic Icebreaking
Tactics, Techniques, and Procedures (TTP)

**Force Readiness Command
(FORCECOM)**

**CGTTP 3-91.9
August 2015**

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U.S. Department of Homeland Security
United States Coast Guard

Commander
United States Coast Guard
Force Readiness Command

300 E. Main Street, Suite 1100
Norfolk, VA 23510
Staff Symbol: FC-P
Phone: (757) 628-4881

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COAST GUARD TACTICS, TECHNIQUES, AND PROCEDURES 3-91.9

Subj: DOMESTIC ICEBREAKING

Ref:
(a) Cutter Organization Manual, COMDTINST M5400.16 (series)
(b) Domestic Icebreaking Operations Policy, COMDTINST 16151.1 (series)
(c) Operational Risk Management, COMDTINST 3500.3 (series)
(d) Mackinaw (WLBB 30) Operational Guide for Icebreaking, ELC-023-08-003
(e) Juniper Class (WLB-225) Operational Guide for Icebreaking, ELC-023-04-007
(f) Keeper Class (WLM-175) Operational Guide for Icebreaking, SFLC-NASEC-011-001
(g) Ice Rescue Operations (IROPS) Tactics, Techniques, and Procedures (TTP), CGTTP 3-50.1 (series)

1. PURPOSE. To provide USCG cutter crewmembers with Coast Guard tactics, techniques, and procedures (CGTTP) for domestic icebreaking operations.

2. ACTION. This CGTTP publication applies to all USCG crewmembers engaged in domestic icebreaking operations. Internet release is authorized.

3. DIRECTIVES/TTP AFFECTED. None.

4. DISCUSSION. Domestic icebreaking is a critical Coast Guard mission most often associated with the rivers and bays of northeast United States and the Great Lakes. These operations require precise, calculated cutter maneuvers while also considering prevailing weather, sea room and ice conditions. When combined with careful judgment, this CGTTP provides proven techniques for successful icebreaking operations.

5. DISCLAIMER. This guidance is not a substitute for applicable legal requirements, nor is itself a rule. It provides guidance for Coast Guard personnel and does not impose legally-binding requirements on any party outside the Coast Guard.

6. ENVIRONMENTAL ASPECT AND IMPACT CONSIDERATIONS. While developing this publication, Integrated Process Team (IPT) members examined environmental considerations under the National Environmental Policy Act (NEPA) and determined they are not applicable.

7. DISTRIBUTION. FORCECOM TTP Division posts an electronic version of this TTP publication to the CGTTP Library on CGPortal. In CGPortal, navigate to the CGTTP Library by selecting **References > Tactics, Techniques, and Procedures (TTP)**. FORCECOM TTP Division does not provide paper distribution of this publication.

8. RECORDS MANAGEMENT CONSIDERATIONS. Integrated Process Team (IPT) members thoroughly reviewed this publication during the TTP coordinated approval process and determined there are no further records scheduling requirements per Federal Records Act, 44 U.S.C. Chapter 31 § 3101 et seq., NARA requirements, and Information and Life Cycle Management Manual, COMDTINST M5212.12 (series). This publication does not have any significant or substantial change to existing records management requirements.

9. FORMS/REPORTS. None.

10. REQUEST FOR CHANGES. Submit recommendations for TTP improvements or corrections via email to FORCECOM-PI@uscg.mil or through the TTP Request form on CGPortal. In CGPortal, navigate to the TTP Request form by selecting **References > Tactics, Techniques, and Procedures (TTP) > TTP Request**.

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Date: 2015.08.14 15:01:12 -04'00'

PATRICK J. SHAW
Commander, U.S. Coast Guard
Acting Chief, FORCECOM TTP Division (FC-P)
By Direction of Commander,
Force Readiness Command

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Chapter 1: Introduction

Introduction

This chapter gives an overview of icebreaking tactics, techniques, and procedures (TTP). It also defines the use of notes, cautions, and warnings in TTP publications.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Introduction	1-2
B	Notes, Cautions, and Warnings	1-3

Section A: Introduction

A.1. Introduction

Domestic icebreaking is a critical Coast Guard mission, most often associated with the rivers and bays of the northeast United States and the Great Lakes. Cutter crews assigned to these geographic regions can expect icebreaking missions in these restricted areas to facilitate movement of commercial vessels.

Icebreaking and its associated activities are most often precise, calculated operations. Vessel maneuvers in ice require careful analysis of the prevailing weather, sea room, and ice conditions. Whenever possible, use the elements and sea state to augment ice operations.

This publication contains proven, successful, generations-old methods and techniques used by Coast Guard Ice Operators. This publication cannot address every situation encountered. Always use careful judgment and thoughtful innovation.

NOTE: **Figures in this document illustrate tactics, techniques or procedures. Note however, distances and vessel sizes are NOT to scale.**

NOTE: **CGD NINE (DPW) maintains an excellent library of regional resources. See website at D9 Icebreaking Center of Excellence.**

Section B: Notes, Cautions, and Warnings

B.1. Overview The following definitions apply to notes, cautions, and warnings found in TTP publications.

NOTE: **An emphasized statement, procedure, or technique.**

CAUTION: **A procedure, technique, or action that, if not followed, carries the risk of equipment damage.**

WARNING: ***A procedure, technique, or action that, if not followed, carries the risk of personnel injury or death.***

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Chapter 2: General Icebreaking

Introduction

This chapter discusses tactics, techniques, and procedures (TTP) common to all cutter classes discussed in this publication. Though ship-specific variations might be necessary, these evolutions are generally accomplished in a consistent manner across the fleet.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Fundamentals of Icebreaking	2-2
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Section A: Fundamentals of Icebreaking

A.1. Terms and Definitions

See Appendix A: Definitions and Acronyms for terms and definitions specifically related to icebreaking operations.

A.2. Best Practices

Best practices and lessons learned are invaluable to any cutter crew. The Coast Guard has gained significant knowledge from years of first hand experiences. Cutter crews should use this TTP, which contains the wisdom of previous experiences. While polar and domestic ice operations are distinct, specialized disciplines, there are universal practices that apply to and serve all icebreaking. Figure 2-1 (below) canonizes these practices.

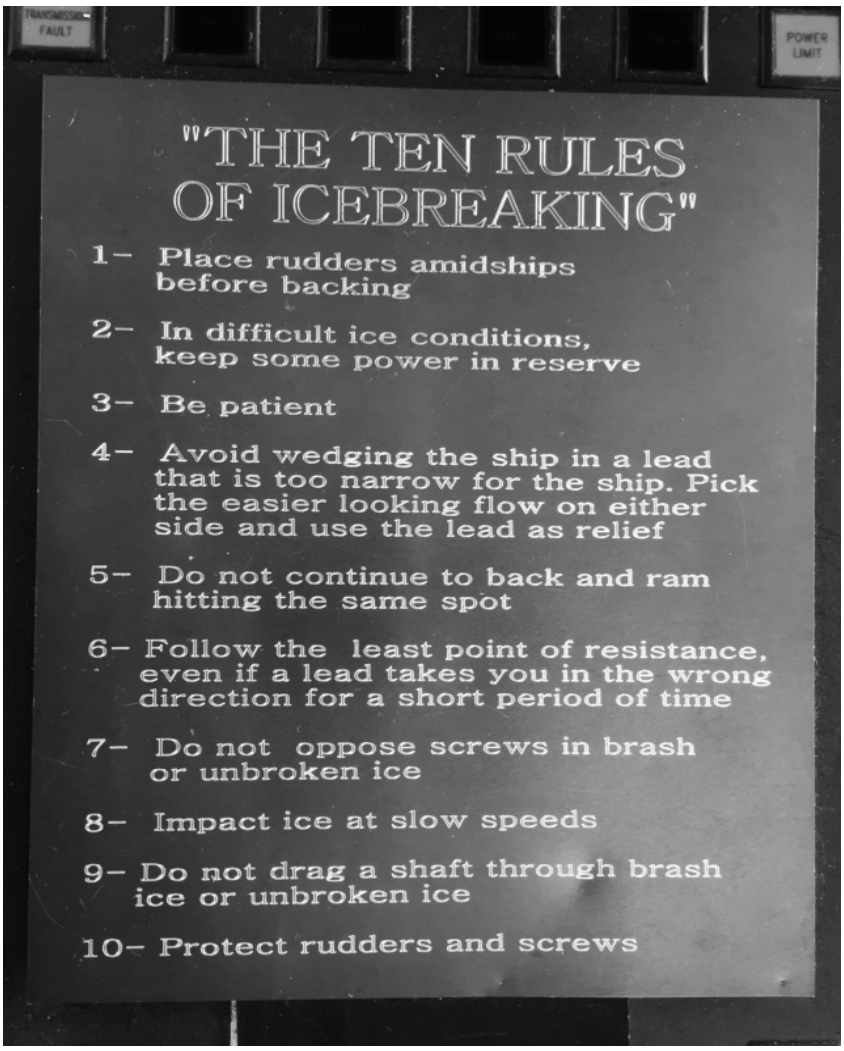

Figure 2-1 Best practices originally developed aboard USCGC POLAR SEA

See this publication's Letter of Promulgation for instructions on adding other valuable experiences to future TTP revisions.

A.3. Ice Management

Icebreakers often use brute force to break ice. However, it is imperative that icebreaking operators understand the larger conditions. For example, breaking ice bank to bank in a river could degrade the overall situation. Broken ice collects in tight turns, increasing brash accumulation in areas already difficult to traverse. Broken ice does not just melt, and planning should account for where it will go. It is also important to remember that, during cold temperatures, breaking ice opens more water to freezing, therefore making more ice. ***"When you break ice, you make ice."***

Icebreaking crews must look ahead and plan operations considering:

- Weather.
- Currents and/or tides.
- Anticipated traffic.
- Where broken ice will travel.
- Historic behavior of ice throughout the season.

Advance planning can also identify how to use otherwise adverse conditions to advantage.

NOTE:

Ice management best practices vary greatly by geographic area. Commanding Officers (COs) should refer to local guidance.

A.4. Fundamentals

Hull friction is an important characteristic that governs icebreaking performance. A reasonable overall estimate of snow's effect is its tendency to reduce the cutter's speed by 1 knot for every 12 inches of snow cover on the ice. Wet snow has a higher coefficient of friction and causes a 1 knot reduction in speed for every 8 inches of snow cover.

WARNING:

Avoid attempts to break large floes of brash, hummocked, or excessively snow covered ice. Becoming beset in a quick moving floe is dangerous. Make every attempt to pick away at these types of floes when breaking them up is necessary. Never attempt to navigate through a floe that has the potential to beset the cutter.

Section B: Winter Open Water Transits

B.1. Cutter Stability Hazards

Per reference (a), Cutter Organization Manual, COMDTINST M5400.16 (series), COs must ensure cutters are ready for cold weather operations.

B.1.a. Ice Accretion

Ice accretion, icing of the superstructure and decks, is a concern during transits of open water when the air temperature is near or below freezing, and particularly when the wind and seas are running. Severe icing causes the cutter's center of gravity to rise. Left unchecked, cutters are in danger of broken masts, booms, and davits and even capsizing. A thorough knowledge of the cutter's stability characteristics and the ability to recognize dangerous levels of ice accretion is paramount. When operating in cold ambient air temperatures, ice accretion increases as sea state worsens. Vessels can reduce ice accretion effects by:

- Entering sheltered waters.
- Entering an ice field.
- Proceeding downwind and down swell or reducing speed.

WARNING: ***Closely monitor the vessel's roll period as an indicator of reduced stability caused by icing.***

WARNING: ***Extreme icing in heavy seas can cause capsizing. Use your vessel's stability program to compute icing limitations for your cutter. You can also use this program to determine optimal courses and speeds to sail to reduce icing given existing wind, temperature, and sea state.***

WARNING: ***Vessels operating in fresh water are more prone to icing than salt water, as fresh water freezes at a higher temperature. The Great Lakes pose particular problems because of their shorter wave periods. Severe icing can occur in relatively small seas as the bow breaks each succeeding wave and throws spray into cold air.***

WARNING: ***Ice accretion adds additional risks to personnel on decks and ladderwells.***

B.1.a.(1). Contingency Considerations

All vessels underway during cold weather conditions can expect some icing to occur. Because icing can quickly imperil a vessel, COs must closely monitor weather conditions and consider:

- Departing early or delaying sailing to take advantage of weather windows.
- Transiting sheltered routes.
- Transiting at slower speeds.
- Tacking off the wind and seas.
- Refer to the cutter's heavy weather bill for other actions and responsibilities.

WARNING: ***If not responding to an emergency, it might be prudent to seek shelter in a safe harbor and delay sailing until conditions improve.***

B.1.b. Mitigating Topside Icing

If icing occurs and a safe refuge is not available, it might be necessary for the cutter to come about periodically and run with the seas so the crew can remove accumulated ice.

Don Personal Protective Equipment (PPE), then use the following tools to remove ice:

- Wooden baseball bats.
- Axe handles.
- Plastic or wooden sledgehammers (specifically designed for ice removal).

Icing of ground tackle, the anchor in particular, is also of concern:

- Employ topside de-icing tactics to remove ice.
- After removing visible ice, exercise ground tackle in protected waters to ensure it moves freely.

CAUTION: **Energizing a frozen tackle can cause damage. Ice can lock components in place, causing mechanical overload and rendering the windlass unusable.**

CAUTION: **Never use metal mauls or hammers. These tools will damage the deck, superstructure and other critical structural components.**

Section C: Transiting in Ice

C.1. Transiting - General

Cutters should always transit around areas covered by ice. If this is not possible, determine the easiest and safest route through.

In some cases, it might be best to establish a track on a predetermined route, such as those recommended by the Great Lakes' Lake Carriers Association or other officially recognized recommended track lines contained in charts or the Coast Pilot. Situations in which a predetermined route transits difficult ice areas might require relief tracks.

WARNING: ***Always ensure routes are sufficiently deep for the cutter's and escorted vessel(s)' navigational draft.***

C.2. Night Transits

See reference (b), Domestic Icebreaking Operations Policy, COMDTINST 16151.1 (series), for guidance on night transits.

Darkness diminishes the ability to judge ice thickness and distinguish pressure ridges. Forcing a route at night can require hours of backing and ramming, while daylight might reveal an easier route. Reduced visibility in darkness can increase a cutter's risk of becoming beset.

If a night transit is required, use the following to identify ice features:

- Bow mounted lights and searchlights.
- Radar to identify windrows and pressure ridges.

Even with the aid of lights, night transits present significant challenges.

C.3. Obstacles

In domestic icebreaking, it is usually not necessary to follow leads in ice. The greatest obstacles are windrows and pressure ridges. Skirting obstacles and transiting through unbroken plate might allow for safer and quicker passage for most large vessels.

Remain vigilant for other obstacles, such as:

- Aids to Navigation (ATON), particularly those beneath or moved off station by ice.
- Ice anglers and shanties.
- Snowmobiles.
- Skiers and trekkers.

- Wild and domestic animals.
- Pilings.
- Trees.
- Shifting ice.

C.4. Sallying the Rudder

Sallying the rudder is an effective method of forcing passage through ice.

To sally the rudder while maintaining a general heading:

- Order the rudder to desired angle, port or starboard.
- As the cutter begins to answer the command, shift the rudder to opposite angle.
- Continue this mode of operation to achieve a rolling effect.

Sallying the rudder when the cutter comes to a stop in ice:

- Helps to reduce friction along the hull prior to backing down.
- Creates relief behind the cutter to aid in backing down, as well as creating areas that might be good targets for the next ramming operation.

WARNING: ***Use extreme caution when sallying in restricted waterways or near shoals and other vessels.***

C.5. Area Familiarization

Area familiarization transits before ice season are essential for identifying safe water. This is especially important in rivers, near bends or eddies, where charts might be inaccurate due to shoaling.

CAUTION: **Due to transducer blockage by ice, fathometers may not function properly during ice operations.**

Section D: Escort Operations in Ice

D.1. Discussion

Domestic icebreakers often assist other vessels through ice. Some of the same shiphandling rules that apply to normal open water operations are useful when escorting or assisting beset vessels. Prevailing conditions and risks associated with escort operations often dictate tactics and the most efficient means of moving escorted vessels.

D.2. General Rules

One primary rule for any operation in ice is to use environmental conditions to your advantage. It is also important to know the capabilities of the escorted vessels and to structure convoys by vessel capability. Calculating a horsepower to length ratio for each vessel in a convoy, considering bow shape and beam, works well to determine the best lead vessel (see D.8.a.(1) Ability, for a more detailed explanation of horsepower to length ratio). In addition to communicating with masters, you can find information on horsepower and length overall in publications such as local ship watching guides.

NOTE: **The approach to domestic ice operations varies among platforms. See Chapter 3 for platform specific guidance.**

D.3. Safe Distance Keeping

The lead icebreaker must proceed at a safe distance ahead of a convoy to give escorted vessels sufficient sea room to stop if the cutter becomes beset (See Figure 2-2 on page 2-9).

Generally, the cutter should operate ***as close as it has to, and as far away as it can***. At a minimum, following distance of the first vessel should be at least her soft water stopping distance, unless ice conditions or operating area dictates otherwise. When ice becomes thicker and the conning officer needs to bring an escorted vessel closer, reduce the escort speed.

When evaluating distance between vessels, use all available means:

- Radar.
- Automatic Identification System (AIS).
- Lookout observation.
- Radio communication.

Select speed to maximize progress through ice while maintaining sufficient reserve power to reduce the possibility of becoming beset.

WARNING: ***Radar and AIS have an inherent lag time and might not be completely accurate as independent range sources. Both instruments indicate the distance between antennas, NOT the distance between the two vessels.***

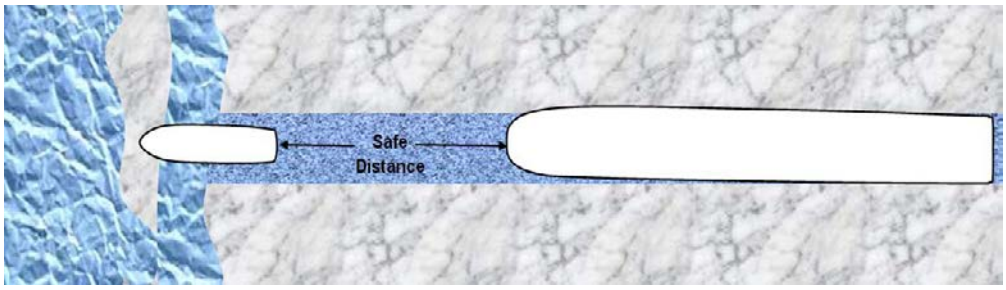

Figure 2-2 Safe escort distance

D.4. Assisted Vessel Ice Relief

Assisted vessels, particularly those with flatter bows, might require low pressure areas in which to shed ice from the bow at periodic intervals, especially in refrozen brash. Parallel and herringbone tracks can meet this need. (See Figure 2-3 below and 2-4 on page 2-10).

Figure 2-3 Ice accumulation around the bow

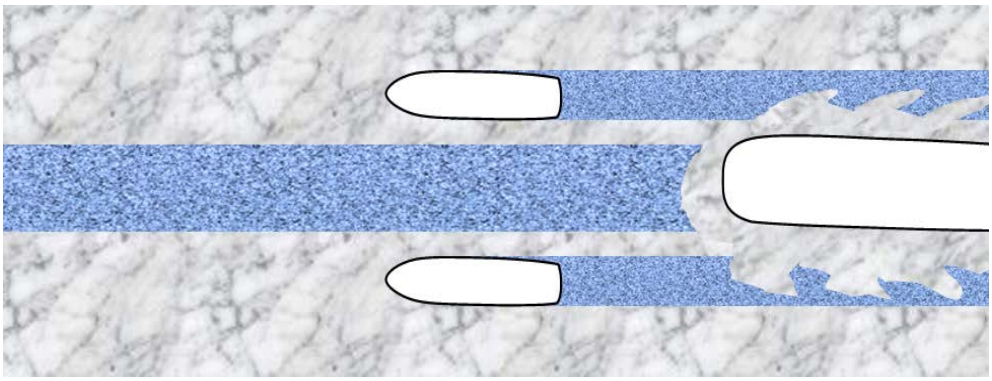

Figure 2-4 Parallel tracks for relieving ice accumulation from the bow

WARNING: ***Low pressure created by the main track increases chances of a cutter being pulled from the relief/parallel track into the path of an escorted vessel. Maintain a safe distance between cutters and escorted vessel(s).***

D.5. Vessels with a Large Sail Area

Considerations for vessels with large sail areas:

- Disadvantages:
  - Greater difficulty maneuvering in high winds.
  - Vessels in ballast often experience partial exposure of the screw and rudder, further reducing usable horsepower and limiting maneuverability.
- Solutions:
  - Escorted vessels should ballast down to near normal trim to improve efficiency and momentum in ice.
  - If ice is wind-driven, create several parallel tracks leeward of the main track. Doing so gives faster-moving broken ice from the windward track, which moves faster than the main ice sheet, somewhere to go. This relieves pressure for escorted vessels.

D.6. Light Vessels

Light vessels, those in ballast and un-laden with cargo, have reduced efficiency and momentum. To get an otherwise unimpeded light vessel moving, you might have to back down to the beset vessel's bow and come ahead with full power. This pushes ice away from the bow and lubricates the beset vessel's hull. Light vessels, once moving, can usually make progress in a prepared track.

D.7. Draft

When escorting, know the escorted vessels' drafts. Maintain a constant plot to avoid leading escorted vessels into shoal water for their respective drafts.

Loaded vessels may experience increased squat when applying heavy power in shallow water, which can damage screws and rudder posts.

WARNING: ***Remind each escorted vessel master that while your selected route ensures safe water for escorted vessels, each master assumes responsibility for his or her vessel's safe navigation.***

D.8. Convoy Techniques

Often, the only efficient way to move vessels through wind driven ice or brash-filled rivers is in a convoy.

Planning for safe convoy escorts requires knowledge of the following:

- Material condition and machinery plant casualties, if any.
- Horsepower.
- Bow shape.
- Length.
- Beam.
- Deepest draft.

Also establish and review:

- Emergency action procedures.
- Minimum safe following distance.
- Desired escort speeds.
- Radio working frequencies.
- General communication procedures.

NOTE: **Your cutter is typically more powerful and maneuverable than the vessels you are escorting. Plan your turns and escort distances for escorted vessels.**

D.8.a.(1). Ability

Generally, you calculate ice performance by horsepower to length ratio (hp/L). Considering bow shape and beam works well as the initial criteria to determine the best lead vessel in a convoy. A 6 to 1 hp/L ratio, at minimum, generally indicates a vessel that can effectively transit areas where ice thickness exceeds 12 inches.

Hp/L ratio is not the sole factor to consider, but is weighed with the following factors when determining vessels' relative positions in a convoy:

- Vessel characteristics and dimensions: length, beam, and draft.
- Available and rated horsepower.
- Condition of loading.
  - A more heavily laden vessel's propeller and rudder are submerged, which improves efficiency. A heavy vessel also benefits from improved momentum.
- Bow and stern shape: blunt, round, flat, flared, raked, spoon, or bulbous.
- Hull configuration: integrated tug and barge, articulated tug and barge, American Bureau of Shipping (ABS) ice class rating.
- Lead ship's structural ice capabilities.
- Vessel's historic performance in ice.
- Master's experience and confidence in ice (generally, by reputation).
- Crew experience and fatigue.
- Ice type: plate, brash, windrowed, fast.
- Weather: wind speed and direction, temperature, visibility, forecast.
- Availability of commercial asset assistance.

D.8.a.(2). Method

There are several methods for providing ice relief to a convoy:

- Break track ahead of the lead vessel and allow the rest of the convoy to follow without further assistance (Figure 2-5).
- Break track ahead of the convoy, then break a parallel track back to the convoy. This works well if the cutter can maintain enough speed to keep a track broken for a safe distance ahead of the lead ship (Figure 2-6).

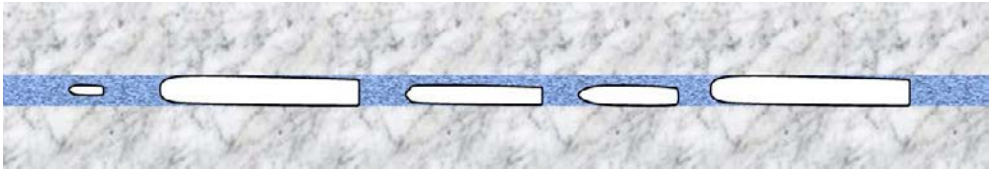

Figure 2-5 Breaking track ahead of lead vessel in a convoy

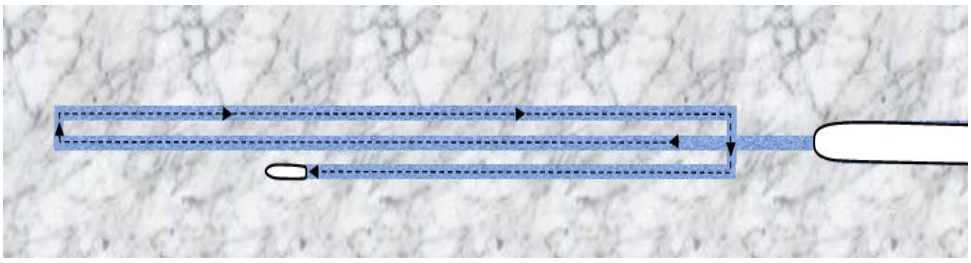

Figure 2-6 Breaking track ahead and breaking parallel track back (break and wake)

D.8.b. Single Escort Disadvantages

A disadvantage of single cutter operations is when the cutter must fall back to assist a struggling vessel. This could prevent the cutter from moving the convoy efficiently. In these cases, leave struggling vessels hove to in a safe condition, then assist them after escorting the remaining convoy.

D.8.c. Multiple Escorts

Often, several cutters will be assigned convoy escort tasking. This expedites the operation. Typically, one cutter breaks the main track, while the other breaks a parallel relief track or assists vessels in the convoy, as necessary. (Figure 2-7).

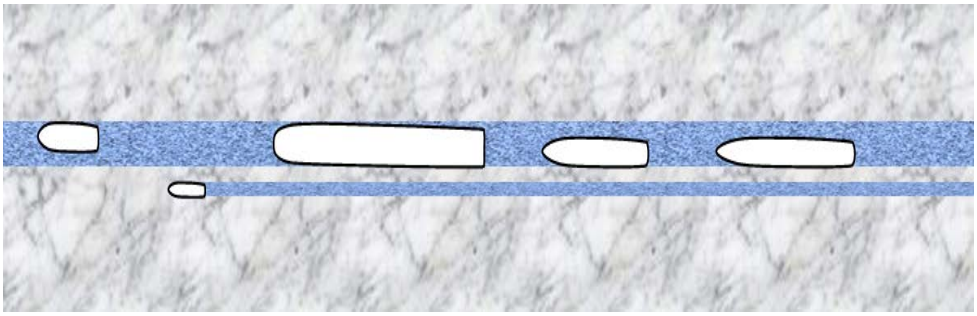

Figure 2-7 Second icebreaker cutting a relief track

WARNING:

Low pressure created by the main track increases the chances of a cutter being pulled from the relief/parallel track into the path of an escorted vessel. Maintain a safe distance between cutters and escorted vessel(s) and main and relief tracks.

D.9. Track Maintenance Prior to Escorts

If possible, perform track maintenance and reconnaissance before conducting escort operations. When faced with deteriorating ice conditions, or those that will benefit from advance preparation, direct a convoy to heave to while preparing the track.

D.9.a. Track Widening

Break or freshen a frozen track in advance of a convoy escort to improve efficiency and safety.

NOTE: **To the extent possible, ensure track width is at least 120 percent of the beam of the broadest vessel escorted.**

Widening a track in advance also allows the crew to assess conditions, including the status of windrows. There are two general methods of widening a track: wake breaking and on the line track widening.

D.9.a.(1). Wake Breaking

You can use the cutter's wake to break ice (Figure 2-8 below and 2-9 on page 2-15).

Wake break as follows:

- Attain sufficient speed to create the desired wake (this speed will vary by cutter type and ice conditions).
- Ice will break on the bow, creating (or refreshing) an initial track.
- As the wake widens, it will break ice out to a significant range.

This can be a very efficient tactic as the wake can break a track significantly wider than the ship's beam. Use caution to avoid unintentionally damaging tracks or fracturing fast ice. Cutter crews must monitor the wake and adjust speed according to mission objectives, ship's characteristics, and prevailing conditions.

Figure 2-8 Wake breaking (actual)

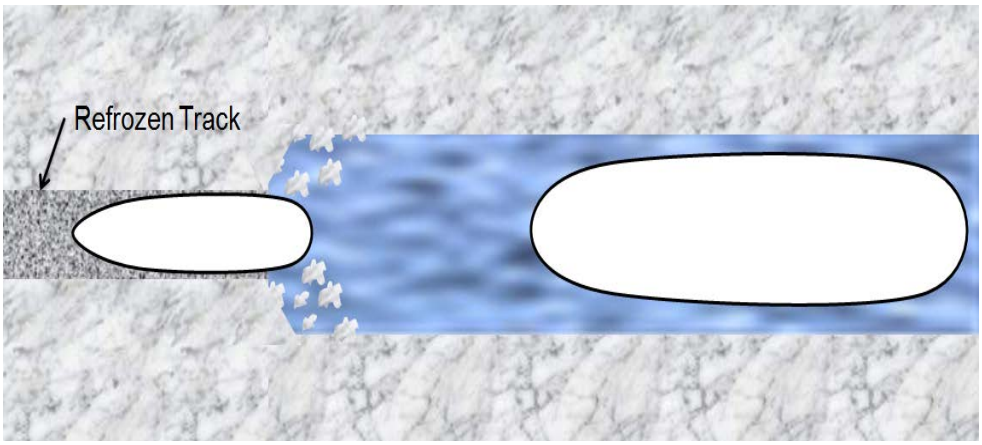

Figure 2-9 Wake breaking technique

D.9.a.(2). On the Line Track Widening

In this method, the cutter transits the edge of a track, widening the track by fractions of the cutter's beam (i.e., half of a ship's width, three quarters of a ship's width, etc.). Conduct on the line track widening as follows:

- The conning officer specifies the cut width (i.e., a ship's width to the left or right of track), and the helmsman steers to transit the edge of the track, cutting into unbroken ice and widening the track.

NOTE: **This technique requires time and patience. The higher pressure of the unbroken plate will push the cutter toward the track. The helmsman must steer into the plate at varying angles to maintain a course parallel to the track. Feedback from an aft-looking crewmember will assist the helmsman in calibrating reference points.**

- Adjust the cutter's speed to counteract the pressure of unbroken plate, while avoiding undesired wake breaking.
- Ice is broken in two ways:
  - Crushed by the hull along the track's edge.
  - By the wake (a cutter can transit faster when breaking only partially out of the track).

This method is especially effective when the cutter runs ahead of a convoy or escort since it allows the cutter to widen both sides of the track on an out and back run (Figure 2-10 and 2-11).

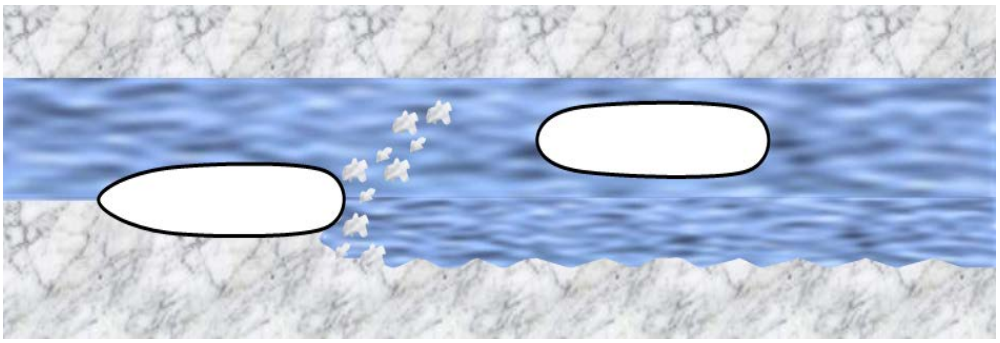

Figure 2-10 On the line track widening

Figure 2-11 WTGB using on the line method

Section E: Flood Relief Operations

E.1. Discussion

Per reference (b), Domestic Icebreaking Operations Policy, COMDTINST 16151.1 (series), the USCG consults with the United States Army Corps of Engineers (USACE) to determine the extent of required flood relief operations. This type of icebreaking occurs in rivers where ice and debris can lodge and form jams. These jams can restrict or stop water flow, causing flooding.

E.2. Procedure for Clearing Jams

Flood relief operations entail breaking ice jams to allow water and debris passage downstream. Also, see General Icebreaking, Section F: Flushing Operations for related methodology and procedures.

CAUTION: **When providing flood relief, be aware of debris (trees, buoys, large appliances, and even cars) floating on or just beneath the surface to avoid damage to the rudder and screw(s).**

Icebreaking in a river removes constrictions and improves water flow. Observe the following when relieving jams:

- Attack an ice jam from downstream, if possible. Working from upstream only adds ice to the jam.
- If forced to approach from upstream, break a passage to the downstream side, then attack from downstream.
- Know where the current is strongest and concentrate operations in that area to more quickly clear broken ice.
- In tidal areas, commence operations at slack tide prior to the ebb, if possible.
- Break the restricting plate first, and then attack the plug directly.
- When loosening ice, break from the river's edge to the center, as outside edges are typically aground on shoals. This releases pressure and allows center ice to move.
- Once ice begins to move, groom edges to prevent a new jam from forming.
- If approaching an ice jam from an area of low-pressure (i.e. open water, lake, or wide portion of a river) transit slowly. Once at or near the jam, come about and transit away from the jam at maximum safe speed.

- If possible, carry a wake all the way to wider bodies of water before coming about.

NOTE:

Without grooming, ice will ground and form a jam from the shore to the center of the channel. Attack the moving ice edge at a shallow angle from upstream. Otherwise, the cutter might cause a stoppage as it turns by forcing ice toward the edge of the channel.

E.3. Using Old Tracks

In some channels with heavy current, large pieces of plate ice can pile up downstream. After breaking a track, make all subsequent transits upriver in a broken track and break new ice during downstream transits (Figure 2-12). This method significantly reduces the amount of backing and ramming required.

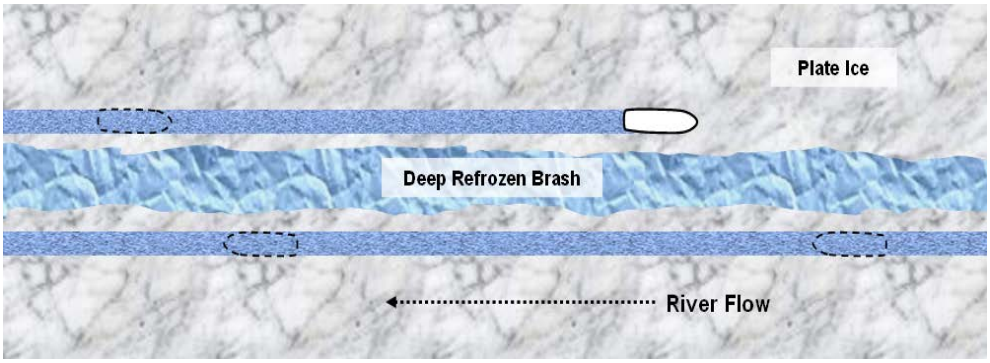

Figure 2-12 Old and new track procedure

E.4. Maneuvering

When an ice jam breaks, it might become impossible for a cutter to maintain station against a moving ice mass or strong current. The best practice is to stem the current from center of the channel. This is the most effective way to prevent damage until you can extract the cutter from this precarious situation.

NOTE:

When transiting restricted waterways, try not to disturb fast ice that can drift downstream and cause a jam. Mind your wake!

Section F: Flushing Operations

F.1. Spring Breakout and Flushing

Flushing operations assist the natural process of the spring thaw. Ice will rot in place, and flushing expedites what warm temperatures do naturally. Therefore, spring breakout should begin when weather conditions are favorable to flush ice to open water and/or establish tracks without causing additional ice formation. Strike a careful balance between reestablishing tracks and flushing operations.

NOTE: **Springtime flushing operations could fill established tracks with refrozen brash overnight.**

F.1.a. Flushing Considerations

The flushing process:

- Begin operations at the mouth of a waterway.
  - Allow ice to flow into an open ocean, lake, or bay.
  - Once ice flows into the larger bodies of water, wind driven seas will aid in breaking it up.
- If flushing begins upstream of the mouth, broken ice created in the river has a greater propensity to create jams.
  - Begin each waterway flushing operation ensuring there are sufficient open water catch basins to receive the flushed ice.
- Breaking ice on an ebbing tide allows it to begin moving downstream.

NOTE: **Before beginning a flushing operation, carefully examine the current and forecasted ice and weather conditions (including wind, tides, currents, and temperatures). Ensure conditions where the ice will travel are favorable for breakup and/or melting.**

F.1.b. Wedge Method

The wedge method opens a large area downstream of a waterway to be flushed, tapering with progress upstream. This enables flushing the ice by current, while minimizing the potential for jam formation. (Figure 2-13).

Figure 2-13 Funnel shaped delta at mouth of waterway built with the wedge method

This approach, combined with the right wind, current, and moderate weather conditions, allows ice to move downstream and flush out of a constricted waterway.

Wedge considerations:

- Keep edges along the wedge as smooth as possible to prevent moving ice from snagging.
- Scalloping is an effective wedging operation. To scallop:
  - Carve progressively larger cuts from the mouth of a waterway.
  - Widen the wedge with each successive cut.
  - Each cut proceeds farther up river (Figure 2-14).

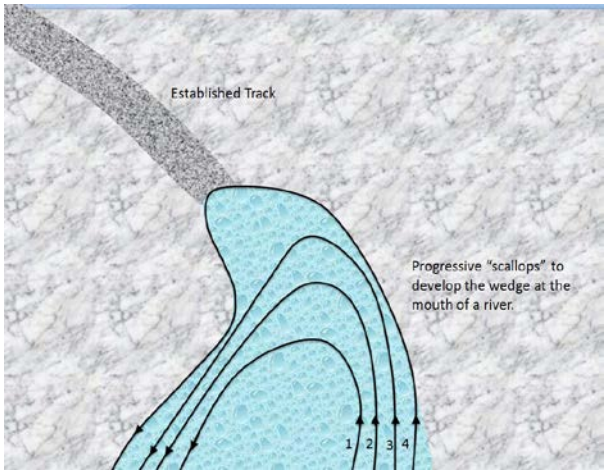

Figure 2-14 Scalloping

F.1.c. Breakout and Flushing Maintenance	When the mouth of a waterway is clear, use appropriate methods to break new plate and project a wake toward shore or shoal water. This creates as much open water on the inside of turns as possible. The prevailing current will then move ice through these areas.

Section G: Mooring, Unmooring, and Heaving to in Ice

G.1. Discussion

Mooring or getting underway from a pier in ice presents additional challenges that demand extra attention and careful planning. This section assists conning officers and commands in evaluating conditions, preparing the deck, and making a safe approach and/or departure.

G.2. Unmooring

Even thin plate ice can prevent a vessel from springing. Use the following tactics for getting underway:

- In an ice jammed mooring:
  - Alternating turns ahead and astern while shifting the rudder might weaken ice sufficiently to allow the vessel to get underway.
  - Vessels equipped with Z-Drives, Azipods, and thrusters can apply direct force to clear ice away from the pier face and create open water outboard of the cutter. Take care to ensure that thrusters do not become jammed with ice.
  - If the cutter is equipped with a bubbler system, activate it 30 minutes before getting underway to destabilize surrounding ice.
- Single-screw tactic:
  - Use Line 1 as a spring line, apply turns ahead, and shift the rudder to swing the stern away from and toward the pier successively until achieving a sufficient angle to safely back away (Figure 2-15).

WARNING: ***Line strength should not exceed limitations of deck fittings and/or bollards.***

CAUTION: **Only attempt these maneuvers while still moored, and use minimal power to achieve desired results. Be aware of propeller wash under ice, which can damage non-strengthened piers or docks in the immediate area.**

NOTE: **There are many different options for mooring lines. Cutters operating in ice should use the largest size mooring line personnel can handle for lines 2 and 3. Doubling spring lines might be a better option than a 10” hawser, as they are easier for personnel to handle.**

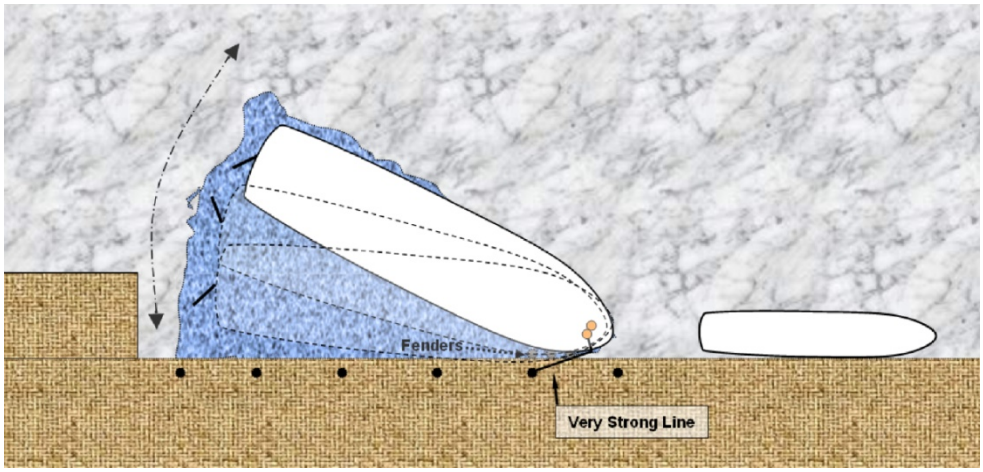

Figure 2-15 Single screw unmooring in ice

G.2.a. Bubbler System Aid at the Mooring

Using bubbler ports with no lines attached to the pier might be advantageous to safely maneuver away from, or press in to, a pier. Control the volume of air to achieve the desired result.

The bubbler can also help keep the cutter pressed in to the pier while lines are made fast, or when deploying or recovering a dock jumper. It can also assist in propelling the cutter away from a pier by combining bubbler force and the cutter's propulsion system.

G.3. Mooring

When mooring in ice, plan your departure accordingly. Methods to prepare for mooring include:

- Leave a piece of fast ice between the cutter and pier to act as a wedge to hold the stern out and to assist in departing. This technique, called angled mooring, is discussed in more detail in G.3.d on page 2-25 (Figure 2-16).
- Clear the slip of enough ice to allow room to maneuver upon departure.
- When mooring to a pier clogged with ice, ensure sufficient speed and angle of approach to complete the maneuver.
- Use Z-Drives and Azipods to flush ice and create a pool for maneuvering.

NOTE: **Before mooring, establish an appropriate relief track or departure plan, which might include using bubblers at the dock, or assistance from another platform.**

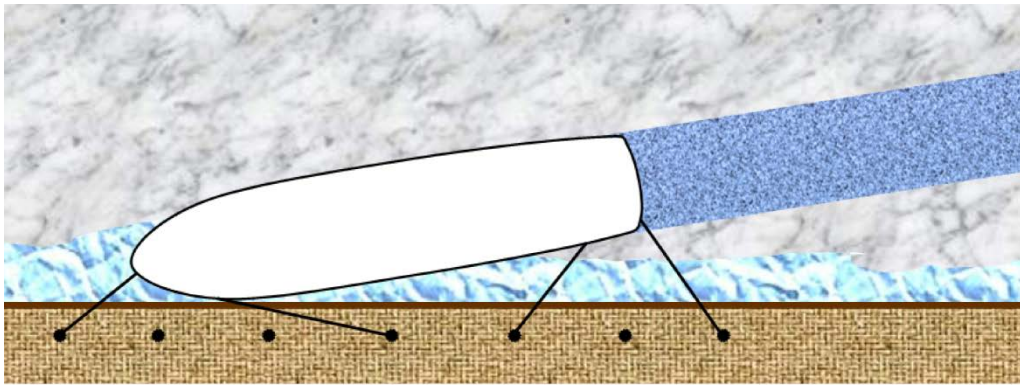

Figure 2-16 Angled mooring

G.3.a. Ice Fender Method

This technique works well in heavy ice. Leave an area of intact ice, called an ice fender, between the cutter and pier.

- During standard approach, steer for a point on the pier short of the stern's desired final position.
- Leave roughly three feet of ice between the cutter and pier face.
- Maneuver the cutter parallel to the pier, keeping the bow angled toward the pier.
  - Required rudder for maneuvering depends upon ice conditions.
  - If the bow is allowed to fall off, the size of the ice fender will increase and force the vessel away from the pier.
- Balance power and control to counteract low pressure pulling the cutter away from the pier while leaving the ice fender intact.
- Beware of, and prepare for, low pressure next to the pier. Depending on speed and tonnage, taking turns off generally allows ice to stop the cutter.

NOTE: **Vessels always seek the path of least resistance in ice. Approaches using the ice fender method allow a cutter to get underway by backing down the same track used for approach.**

G.3.b. Angle Method

When the mooring is sheltered from high winds, the angle method is an effective mooring technique.

- Moor at an angle to the pier.
- Ensure the bow is close to the pier, the stern angled out.
- This leaves a wedge of ice between the cutter and the pier.
- When getting underway, back down the approach track (see Figure 2-17).

CAUTION: **If expecting substantial winds or strong currents, or ice cover is weak, consider using another method. This mooring technique can damage the cutter and/or pier if these conditions exist or develop.**

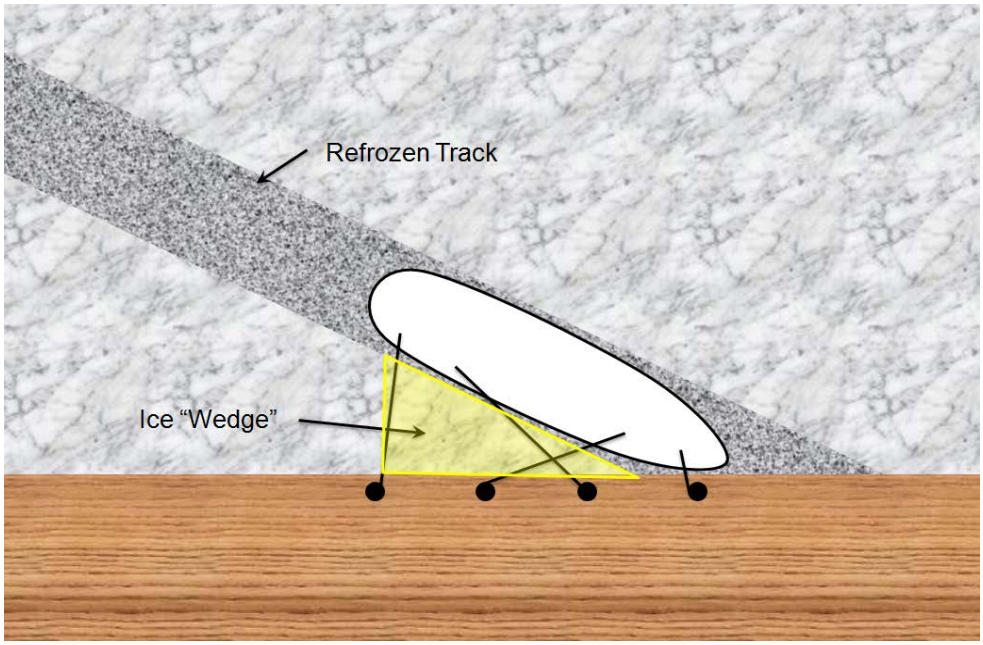

Figure 2-17 Angled mooring (2)

G.3.c. Mooring in Shifting Ice

When mooring in shifting ice, always moor with the bow upstream and canted toward the pier to keep ice from jamming between the pier and the vessel.

G.3.d. Short Term Mooring

When mooring for a short duration, conduct relief track maintenance around the pier before mooring. This makes it easier to get underway, as any new ice formed will be considerably weaker.

G.3.e. Heaving-To

Heaving to in the ice for extended periods (e.g., overnight) requires planning for eventual extraction. Consider the following:

- Use a moderate amount of prop wash to clear the stern after the cutter comes to a stop. This allows a light ice pocket to form astern, which will be useful when getting underway.
- Activate the bubbler (if equipped) periodically to loosen ice adhering to the hull. This might not be feasible if the cutter is in an area of pressurized ice, or suitable in windy conditions that might cause the cutter to drift.
- Use Z-Drives and Azipods as required.
- Monitor rate and direction of ice movement to avoid drifting aground while hove to. Radar range rings are a useful reference tool and frequent, quality fixes are necessary on the hove to watch.

CAUTION: **Plan ahead when heaving to for extended periods. Check the weather forecast (especially for strong wind shifts), currents, and evaluate ice conditions (fast ice, pack ice, etc.). Changes in conditions could cause the cutter to drift outside of an established swing circle.**

CAUTION: **Use radar range rings and quality fixes to monitor drift. Positively identify landmarks used; ice can easily be mistaken for land on radar.**

G.4. Scarfing the Pier Face

Scarfing uses the bow to clear ice from a pier face. Though similar to the ice fender method, scarfing uses an even steeper angle to the pier to clear more ice when mooring flush to the pier. The technique is applied by:

- Determining thickness and density of ice accumulation along and underneath the pier.
- Gauging the appropriate approach angle and power required to clear a track close aboard and parallel to the pier face.
- Reorient and repeat as necessary (Figure 2-18).

NOTE: **When the technique is properly applied, the cutter's bow will not touch the pier face.**

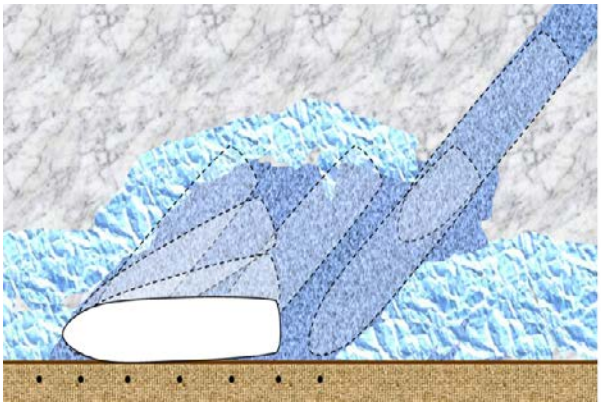

Image of MACKINAW Scarfing

Figure 2-18 Scarfing

G.5. Anchoring in Current Driven Ice

Anchoring in current driven ice presents the risk of dragging anchor. The force of the moving ice might overcome the anchor's holding power and scope of chain. Vigilantly monitor the cutter's position and strain on gear in ice conditions.

Section H: Regional Ice Operations

H.1. Discussion

Ice operations vary in season length and techniques used. Techniques in this document are centric to the Great Lakes, New England, Chesapeake Bay, and Alaska.

See Appendix C: St Mary's River Icebreaking Guide for time tested icebreaking approaches and techniques for this area.

This CGTTP will receive updates as other regional materials become available.

Section I: Track Maintenance

I.1. Considerations

The need for advance track maintenance and track reconnaissance might also dictate decisions about mooring or heaving to. For example, if a westbound convoy is to begin at a certain point, the cutter should consider a hove to position near the western ice edge so that, once underway in the direction of the convoy, the cutter can complete track maintenance en route. If a western hove to position is not possible, consider advance track maintenance before allowing the convoy to proceed.

Other considerations include:

- Customer (characteristics of assisted vessels and abilities of their crews).
- Ice conditions.
- Weather.
- Established routes (LCA tracklines, preferred pilot routes, traffic patterns).
- Convoy timing.
- Hazards to navigation.
- Current and tides.
- Choke points.
- Historic problems.
- Recreational users.
- Facilities.
- Restricted navigation areas.
- Reconnaissance opportunities.
- Resource availability.

I.2. Establishing a Track

When practical, break a track or refresh a frozen track before commencing an escort or convoy. Use these techniques:

- Break a track that is, at minimum, 120% of the width of the broadest escorted ship's beam. This will maximize efficiency by breaking a track wide enough to allow passage plus relief room for displaced ice.
- Widening offers the additional advantages of allowing the bridge team to thoroughly assess:
  - Track conditions.

- Depth and height of windrows.
- Other hazards not previously known.

Other considerations include the characteristics of each vessel being escorted, specifically in relation to:

- Turn radius of the vessel and the geometry of turns.
- Track width.
- Track depth.

I.3. Grooming

As escorted vessels transit through established tracks, they push ice into berms along the track edges, particularly in turns, as their sterns swing through. These areas require attention and grooming before growing berms inhibit a vessel's turn or forward progression.

I.4. Track Widening

When practical, break, freshen, or widen a track before commencing an escort or convoy. See General Icebreaking, Section D.9: Track Maintenance Prior to Escorts.

I.5. Working a Track

Transiting steadily ahead in level ice is common in domestic icebreaking. Strategies change as winter progresses:

- During fall and early winter, most track establishment and maintenance is in level ice:
  - Maintain tracks just wide enough to permit transit of assisted vessels.
  - Manage wakes carefully to avoid unnecessarily breaking ice.
  - Be mindful of cold temperatures and ice making conditions.
- In late winter and spring, as temperatures rise, judicious use of the cutter's wake is the norm to facilitate flushing and floe breakup.

Section J: Harbor and Facility Ice Clearance

J.1. Discussion

Heavy ice conditions or lack of commercial icebreaking capability might make harbor clearing necessary. Generally, harbor and facility ice clearing involves a combination of the techniques previously covered, situational awareness, and finely balanced power and control. These operations present special challenges and hazards. COs should exercise judgment and identify those circumstances or service requests that exceed the unit's ability to operate safely.

Section K: Breaking Out a Beset Vessel

K.1. Discussion

Before commencing a vessel assist, you must establish and agree upon a plan with the master of the beset vessel. Throughout the evolution, ensure the master is cooperating and understands the plan. See Appendix B: Direct Assist and Beset During Assist Checklists.

K.2. Beset Vessels

Occasionally, cutters might have to assist a beset vessel that cannot proceed due to one or more causes:

- Ice clogged channels.
- Vessel is underpowered for existing conditions.
- Ice field is under pressure.
- Established track is too narrow for the beam of the vessel.

To assist, the cutter must relieve pressure by reducing friction and providing a less restricted path for the beset vessel.

K.2.a. First Pass

If possible, make an initial pass, parallel to and for the length of the beset vessel. A slow approach is best. Determine the appropriate speed for the ice conditions present. Often, a first pass is sufficient to relieve pressure around the beset vessel.

When approaching a beset vessel from astern and inside the beset vessel's track, use sufficient rudder early enough to break out of the track and avoid a collision. A deep-draft vessel usually leaves a dense berm of ice along the track, often causing the cutter to skip along the wall (Figure 2-19).

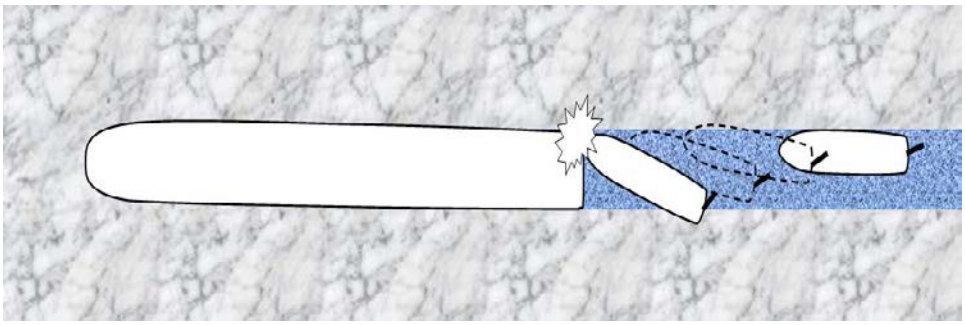

Figure 2-19 Skipping along the track wall

WARNING:

In ice, vessels always seek the path of least resistance (see Figure 2-19). While this law of physics is used to the maximum extent possible, the same principle contributes to the risk of collision between two vessels in close proximity.

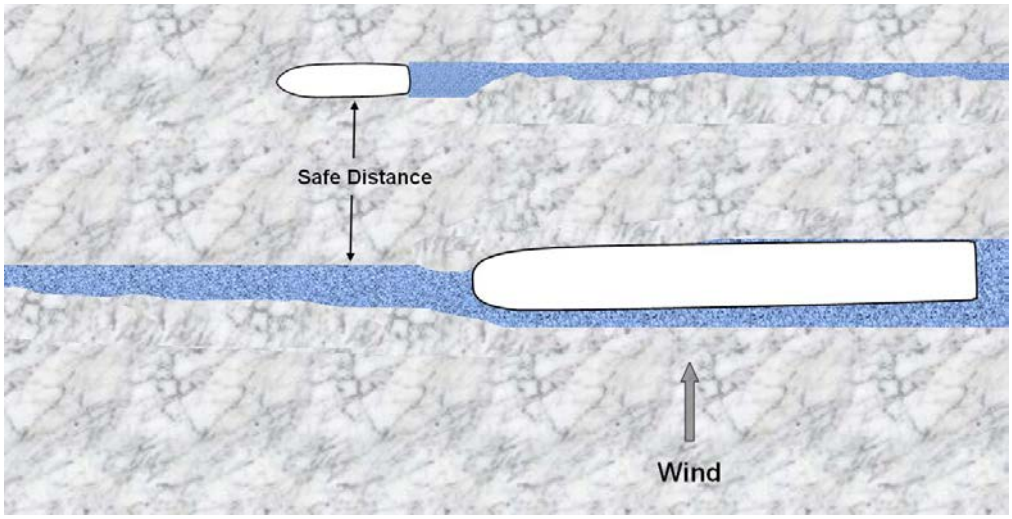

Figure 2-20 Breaking a relief track at a safe distance

K.2.b. Freeing the Beset Vessel

Assess sea room around a beset vessel, then employ the breakout technique to release pressure around the beset vessel:

- Steer the cutter out of the established track several hundred feet forward or astern of the beset vessel, as appropriate.
- Proceed on a parallel track down the length of the vessel (Figure 2-20 and 2-21).
- After clearing the vessel, come about and return along the opposite side, again for the length of the vessel.
- After the second pass, fair up into the established track ahead of vessel.

NOTE:

A beset vessel's master may have a tendency/desire to start applying power as soon as the vessel seems to be free, which could be contrary to CO instruction. Be aware of this, and control the maneuver for the safety of both vessels.

WARNING: ***Instruct the beset vessel's master to keep engines at all stop until cleared to engage. This allows the cutter to re-enter the established track and gain distance from the beset vessel prior to commencing escort. Close communications and coordination between the two vessels are essential.***

Figure 2-21 Track parallel to the beset vessel

K.2.c. Expanding Margin of Safety

Never restrict yourself to a close maneuver if ample sea room exists to provide a safer margin for error. A cutter can occasionally deviate from accepted approaches while controlling risk by taking advantage of the elements and maneuvering room.

Consider the following when sea room exists:

- Use the extra sea room to provide a greater margin of safety while completing a vessel extraction.
- Apply ample power and be aware that, when working in close quarters, failing ice and concurrent low pressure between the cutter and assisted vessel could cause the cutter to drift into the assisted vessel.
- The wake is effective in breaking ice when wake speed is possible.

WARNING: ***Use extreme caution when maneuvering at high speeds near other vessels.***

CAUTION:

Downwind relief track maneuvers work well in plate ice, where ample sea room typically exists. However, they are not recommended in narrow, brash-filled channels. Vessels operating in brash ice react more closely to their open water handling characteristics.

K.3. Effects of Wind on Approaches

Generally, cutters avoid breaking ice on the leeward side of an assisted vessel. This action could result in:

- The cutter becoming beset.
- The assisted vessel blowing down on the cutter.

If circumstances dictate leeward maneuvers:

- When sea room is limited, use extreme caution; employ Operational Risk Management (ORM) per reference (c), Operational Risk Management, COMDTINST 3500.3 (series).

In heavy wind, ice could pile up on the beset vessel's windward side. It might also have ice packed against the leeward side as the wind pushes the vessel.

As an exception to the above rule, a leeward track might be acceptable if there is ample sea room to work on the leeward side. The beset vessel might be set into the open relief tracks on the leeward side faster than the moving ice can fill them in, allowing it to fall in behind the cutter.

Efforts on the windward side might only free more ice to pile against the vessel as the wind pushes plate ice into the track.

K.4. Shear

Shear is the effect of low pressure that causes a cutter to move laterally. It tends to occur near the beset vessel's stern where prop wash and backing cause low pressure, weakening the ice, and creating a pool of open water as the beset vessel attempts to free itself.

As the cutter approaches, the danger of shear exists (Figure 2-22). Observe the following:

- Prudent speed and a safe distance from the beset vessel can prevent a collision caused by shear.
- As the cutter approaches either end of the beset vessel, open the distance between the vessels. Be prepared to maneuver to avoid a collision.

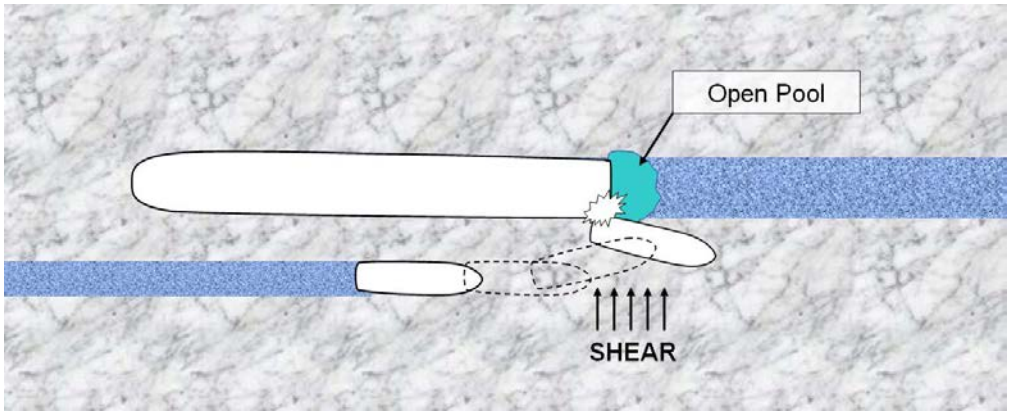

Figure 2-22 The shear effect

K.5. Relief Tracks

Use relief tracks to reduce pressure on a beset vessel, allowing it to resume progress under its own power. Use the following to establish relief tracks:

- Establish parallel tracks at a safe distance per K.2.b. above.
- Observe all safety precautions discussed throughout Section K.
- Provide a herringbone relief track to allow an assisted vessel to shed accumulated brash ice from its bow.

K.5.a. Herringbone Relief Track

Herringbones are accomplished by cutting perpendicular or forward angled notches outside of the track. The amount of brash in the track and its rate of accumulation around the escorted vessel's bow determine the spacing of these notches.

Section L: Backing and Ramming

L.1. Discussion

When solid ice or obstacles prevent forward progress, the backing and ramming technique can be used for:

- Navigating windrows.
- Cutting a straight track.

L.2. Procedure

When backing and ramming, consider the following:

- Judge backing distance in relation to the need for sufficient momentum.
- Too much momentum can result in the cutter carrying so far into unbroken, high-pressure ice that it cannot back down.
- The bow shape allows the cutter to ride up on ice and the cutter's weight then breaks the ice (Figure 2-23). Cutter speed does not break ice by bludgeoning action, as suggested by the term 'ramming.'
- Cycle the rudder, Z-Drives, or Azipods before backing down. This action clears ice from the stern.
- Be mindful of conditions ahead. Even if progress is slow or sizable ridges lie ahead, avoid large course changes and ensure a straight path for following vessels.
- If breaking through a windrow or pressure ridge, attempt to break through as perpendicular to the structure as possible.
- If the cutter comes to a stop and throttle(s) are ahead full, attempt to flush the ice aft by sallying the rudder. This aids breaking ice on the sides of the track just aft of the stern.
- Avoid backing and ramming the same spot continuously. In particularly difficult areas, attempt a modified herringbone.

NOTE: **Backing and ramming operations require a great deal of patience to avoid cutter damage or becoming beset.**

Figure 2-23 USCGC Bridle using weight to break ice

CAUTION: **Forcing a cutter too far up on ice can damage the cutter due to insufficient protective plating in the hull amidships. This risks substantial damage to the cutter's longitudinals and frames.**

CAUTION: **Ensure the rudder, Z-Drives, and/or Azipods are amidships during backing and ramming operations.**

NOTE: **See platform-specific procedures for additional information pertaining to backing and ramming operations.**

Section M: Communications

M.1. Discussion

Communications between the cutter and assisted vessel are critical before and throughout the assist. See Appendix B: Direct Assist and Beset During Assist Checklists, and use as a guide to ensure you address all emergency actions and communication requirements.

M.2. Direct Communications

Establish and maintain direct communication as follows:

- Ensure the assisted vessel's master understands your proposed approach.
- Direct the master when (and when not) to use engines, as appropriate.
- Establish, monitor, and ensure the maintenance of a safe following distance.
- Immediately inform the escorted vessel of any condition that could slow your progress (i.e., ridge or jam) to prevent a collision.

WARNING:

Anticipate that an assisted vessel's master might take independent action, which could endanger both vessels and crews. Clear, concise, frequent communication with assisted vessels is the best recommendation. YOU are responsible for the overall safe and effective execution of the icebreaking operation.

M.3. Contingencies

Consider using the following, in addition to voice communications, when assisting vessels:

- Establish a visual and/or sound signal backup system. Use this signal in addition to voice communication to alert the master of the need for immediate action to avoid collision.
- Some cutters have amber or red warning lights, while others have blue law enforcement lights. Incorporate these into your communication contingency plan.
- If lights are not available or practical, use a system of whistle signals or signal flags.

NOTE:

Use the established signal every time there is a problem, even if using voice communication. This familiarizes the assisted vessel's personnel with the signal if radio communications fail.

Section N: Tandem Operations

N.1. Discussion

Ice conditions or escorted vessel size occasionally requires using two cutters working together to accomplish the mission.

The dynamics of tandem operations depend upon the types of vessels used. Combinations might include any class of ice capable cutters and other vessels such as ice capable commercial tugs. Power and icebreaking capabilities are critical aspects when considering requirements and assets.

N.2. Tandem Operations in a Turn

In established tracks, refrozen brash could fill turns, slowing and stopping vessels. Providing icebreaking assistance, particularly in narrow areas, is challenging and requires icebreakers to work close aboard the beset vessel. Given sufficient sea room, work to:

- Clear open water near the vessel's quarter, allowing stern movement.
- Clear an area off the bow, on the opposite side from the quarter, allowing the bow to move (Figure 2-24). This clearance maneuver will enable the assisted vessel to pivot as it moves through the turn.
- Pass along the outboard side (outboard in the turn) to loosen ice (Figure 2-25).
- Maintain the required close coordination between the cutter and beset vessel, with only one CO issuing direction to the beset vessel at a time.
- When possible, the most maneuverable cutter is the preferred vessel to work near the assisted or beset vessel's stern.

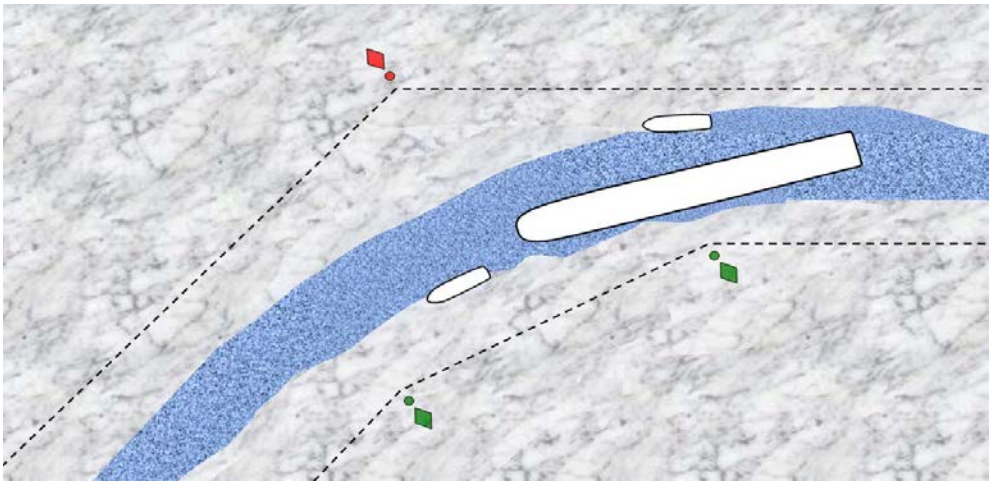

Figure 2-24 Tandem operations in a turn

Figure 2-25 Turn dilemma while assisting large vessels

N.3. Specific Cutter Combinations

Tandem operations are best for track breaking or leading an escort, rather than assisting beset vessels (see figure 2-26). For illustrative purposes, the figure shows tandem ops between a WLBB and WTGB. The WLB is very effective when paired with a WTGB and significantly increases escort efficiency for the following reasons:

- The WLB has better performance ahead in level ice than the WTGB. When working astern of the WLB, the WTGB requires less power to break ice. This scenario allows a WTGB to exceed its single operation capabilities.
- The WLB is larger and longer, which provides more directional control and allows for a straighter track.
- When operating in tandem, the cutters are capable of breaking a track more than 120 feet wide.
- The WTGB is more capable than the WLB in direct assist operations due to greater maneuverability and quicker plant and rudder response.

Figure 2-26 Tandem icebreaking

Section O: Night Icebreaking

O.1. Discussion

Night icebreaking is one of the most difficult seamanship challenges. This section discusses those challenges and associated risks. Unless there is a danger to life or property, such as a beset vessel drifting onto shoals, night operations are not recommended. Per reference (b), Domestic Icebreaking Operations Policy, COMDTINST 16151.1 (series), night ice operations are not normally scheduled.

O.2. Hazards

Below are some of the unique challenges cutter crews face when navigating and conducting ice operations at night:

- Loss of depth perception combined with the inability to distinguish changing ice conditions and features such as windrows, leads, pressure ridges and ice thickness.
- Vessels entering heavy ice and becoming beset.
- Crew fatigue from:
  - Extra strain required to locate and track hazards.
  - Noise and vibration during normal crew rest periods.

Most vessels that routinely operate in ice are equipped with ice lights and use searchlights when forced to transit ice at night. Even with artificial lighting, distinguishing and avoiding all obstacles is difficult.

NOTE: **For specific guidance, refer to your District policy on night icebreaking operations.**

O.3. Risk Assessment

Per reference (c), Operational Risk Management, COMDTINST 3500.3 (series), conduct a risk assessment when considering night operations. Additional tools available to aid in night transits are:

- Artificial lighting.
- Radar and AIS.
- Extra lookouts.

Section P: Towing in Ice (SAR Only)

P.1. Discussion

In general, towing in ice is not used to facilitate commercial navigation. The hull design, horsepower, and fiber hawsers used by icebreaking cutters are not conducive to towing vessels in ice. Towing in ice should only be a last resort to prevent loss of life or property.

P.2. Towing Considerations

Towing astern in ice has been conducted on the Great Lakes. Towing operations with a short hawser were successful due primarily to brash and plate ice that existed in those areas. The significant equipment strain during an ice tow can be mitigated somewhat if a second cutter is available to make a track ahead. Do not attempt a tow in areas of windrows or pressure ridges.

Significant inhibitors to ice towing:

- No USCG ice capable cutters are equipped with towing machines or wire hawsers.
- Towing uses high strength hawsers. In this application, inconsistent strain and shock loading can cause hawsers to damage cutter deck fittings.
- Cutters are not equipped with towing notches.

WARNING: ***Towing in ice is dangerous. Only conduct ice towing when absolutely necessary.***

WARNING: ***Synthetic lines are used for most towing hawsers. Use extreme caution, as these hawsers do not stretch adequately for ice towing. Shock loads and cold temperatures are primary causes of parting.***

WARNING: ***Hawsers sizing is for strength, not diameter, and must be the weak link in any towing system. Ensure the line does not exceed the working load limits of bitts, chocks, and other hardware. In some applications, shock pendants can provide shock absorption properties.***

CAUTION: **When determining if a tow is appropriate, ensure the tow will not exceed deck fitting capacities.**

Chapter 3: Domestic Icebreaking Platforms

Introduction

This chapter contains an overview of icebreaking capable platforms used by the Coast Guard, along with employment tactics for each. Before beginning an icebreaking mission, it is important to understand the cutter and its unique capabilities.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	WLBB 240’ Great Lakes Icebreaker	3-2
B	WLB 225’ - Buoy Tender (Seagoing)	3-14
C	WLM 175’- Coastal Buoy Tenders	3-23
D	WTGB 140’ - Icebreaking Tugs	3-33
E	WYTL 65’ - Harbor Tugs (Small)	3-41

Section A: WLBB 240' - Great Lakes Icebreaker

A.1. Introduction

This section describes the design characteristics and performance of the WLBB 240, Great Lakes Icebreaker. For complete design and performance guidance, see reference (d), MACKINAW (WLBB 30) Operational Guide for Icebreaking, ELC-023-08-003.

A.2. General

The 240-ft Great Lakes Icebreaker, USCGC MACKINAW (WLBB 30), is designed for multi-mission capability, including heavy icebreaking.

The cutter's design uses an azimuthing diesel-electric propulsion system. This system provides the operator with a number of features in both ice and open water not available on other USCG icebreakers. The propulsion system can use the principal of "vectored thrust," delivered by Azipods through 360 degrees. Vectored thrust significantly improves cutter maneuverability compared to a conventional steering gear and rudder system, especially at low speeds.

Azipod system features include:

- Vectored thrust in any direction.
- Exceptional maneuverability and dynamic positioning in open water.
- Full directional control ahead and astern in ice.
- Ability to perform ice flushing by directing Azipod wash toward a ship or the channel edge.
- Efficient, continuous heavy ice transit astern versus backing and ramming ahead.

The WLBB is also equipped with a 550hp bow thruster for improved maneuverability at slow speed and station keeping (primarily in open water). Do not use bow thrusters in ice operations though, in certain conditions, the thruster provides limited effectiveness during mooring, unmooring, and scarfing evolutions.

The WLBB has an icebreaking bow characterized by low stem angle and parallel buttock lines that generate greater flair in the fore body and lesser flair in the mid body. As the cutter moves forward in the ice, it rides up slightly on the ice cover and generates a downward bending force that causes ice to break. The amount of bow rise increases with ice thickness.

The waterline and bow have a pointed wedge shape that provides a balance between maneuverability in level ice and the ability to grab an ice

edge when turning out of an existing track. This bow shape also facilitates backing from a ridge that fails to break.

A.3. Conning Methods

With the exception of transiting open ice fields while in auto pilot mode, the WLBB uses Azimuthing Translation Lever (TC-21) controls for breaking and maneuvering while in the Manual Mode. (Figure 3-1)

Figure 3-1 TC-21 Manual Mode Control (Tractor Controls)

A.3.a. Power Mode and Speed Mode

Power plant in manual mode operation:

- Push forward – RPMs increase.
- Rotate control lever – rotates pods.
- Direct control levers forward – cutter advances straight ahead.
- Rotate control lever to port – pods turn to port, driving the cutter's heading to starboard and stern to port.
- Rotate control lever to starboard – pods turn to starboard, driving the cutter's heading to port, and stern to starboard.
- Directing control levers inward – pods directed inboard with prop wash outboard.

The diesel electric power plant provides two modes of power to the Asea Brown Boveri (ABB) Azipod propulsion system:

- Power Mode: Allows the plant to maintain a consistent amount of power while encountering varying degrees of ice thickness and consistency. Thus, speed varies while encountering varying ice

thicknesses. Most icebreaking operations occur in this mode.

- Speed Mode: Behaves much as cruise control on an automobile, maintaining speed, regardless of power consumption.

Power mode results in more uniform power consumption, and is typically the most economical mode.

NOTE: **Ensure the power plant is in speed mode when using full dynamic positioning (DP) function.**

A.3.b. Conning Station

The cutter has an aft conning station, located amidships, which provides several advantages:

- Visibility of stern relationship to ice structure.
- Improved stern visibility.

Controls can switch station (port and starboard side of bridge, aft conning station) and match the conning officer's orientation.

NOTE: **Despite the advantages of operating from the aft conning station, the cutter's superstructure significantly reduces the conning office's port side visibility.**

A.3.c. Establishing a Track

In level ice, breaking a straight track:

- Typical operation is in manual mode with pods facing forward (the propeller is the attack surface, and pod body follows).
- Consider benefits and drawbacks of the wake effect in the prevailing conditions.

CAUTION: **If prop revolutions continue in situations where Azipods are subject to high ice loads, blades may experience damaging bending forces.**

NOTE: **The WLBB can operate at a continuous speed of three knots in solid level ice up to a thickness of 32 inches.**

NOTE: **A reasonable overall estimate of snow effect on this cutter is to add one inch of ice thickness to the level ice thickness for each 2-3 inches of snow cover.**

To establish a track, make the initial cut using the methods above, then work off each edge and use judicious wake to widen the track.

An effective method is to:

- Cut the channel edges (outlined) first.
- Break ice between the two outlined cuts.

With this method, the cutter is easier to control and the track edge is typically straighter. Cutting the edges first defines the channel width and gives the conning officer a good visual reference for breaking and clearing the remaining ice within the track.

If operating in heavy ice conditions, forward progress can be facilitated by turning the Azipods a few degrees from one side to the other, repeatedly (sallying the pods) (Figure 3-2), while still maintaining a reasonably straight track. Autopilot can also be used to facilitate this maneuver by:

- Disengaging the auto-yaw.
- The conning officer assumes heading control at the joystick, and sally the pods.

The action produces an alternating yawing effect that helps loosen the ice.

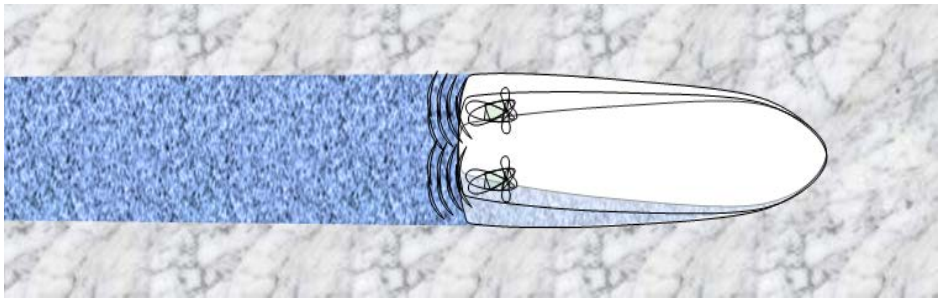

Figure 3-2 Sallying the pods

A.3.d. Smooth Track Edge

To develop a clean, straight track edge:

- Position the Azipods slightly inboard (thrust outboard) to enhance steering control and clear more ice from the track.
- Maintain course by making small, incremental changes to Azipod

orientation.

- Once the conning officer develops a feel for the ice conditions, leave one Azipod (generally the outboard unit along the ice edge) stationary and make heading changes with small adjustments to the other unit. This pushes newly broken ice out of the cut channel and under the fast ice.
- Careful speed adjustment is essential to avoid wake-breaking effects.
- Maintain sufficient power and allow response to environmental changes.
- Straighten the track by grooming the edges of the channel.

A.3.e. Channel Icebreaking

The WLBB has azimuthing propulsion pods, which allow direction of thrust outward to widen a track, as shown in Figure 3-3.

The cutter has the following attributes when using Azipods in this manner:

- Less thrust is available to move the cutter through ice than when the pods are oriented parallel to each other while breaking a straight track.
- As the pod increases angle from 0° to 180°, use more thrust to break ice outboard of the cutter. However, there will be less thrust available to propel the cutter forward.

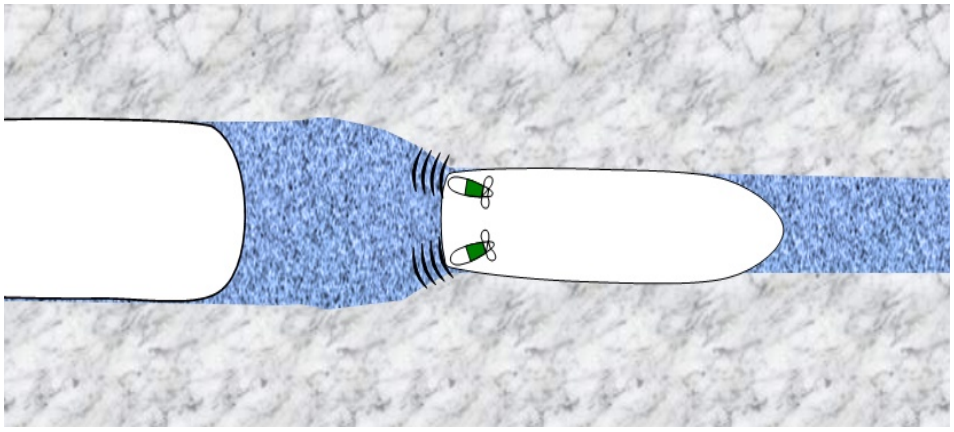

Figure 3-3 Using Azipods to direct thrust to widen a track

A.3.f. Exiting an Existing Track

The breakout maneuver to depart the track starts in a broken or old track, and is useful for coming about in an area with limited space. Conventional icebreakers use additional power in the channel and a sharp turn to “grab” the channel edge. Speed is not necessary for a podded cutter, which can perform the maneuver from a stopped position by turning the pods. Turn the inboard pod outboard to effect the turn and use limited forward speed.

A.4. Turning

To turn the cutter, rotate the Azipod units away from the desired direction of the turn:

- Abruptly rotate both Azipods, creating turns so ice will encounter the blades as shown in Figure 3-4.
- For gradual turns in normal conditions, operate only one pod. Direct the outside or leading pod into the ice.
- For more aggressive turning, utilize both pods grouped in either manual or autopilot. Autopilot uses a maximum of 40° Azipod angle, which is sufficient to complete even the sharpest of turns.
- Heavy ice conditions may require force bias to clear the turning location for stern swing.

As an example, a turn using 30° of pod angle can complete a 360° turn in 2.35 times the cutter's length (approximately a 565ft turning diameter) in 24 inches of ice.

Figure 3-4 Turning

To come about:

- Maneuver the cutter's stern with Azipods (synchronized together) encountering the ice, propeller first.
- Tractor drive into the ice as shown in Figure 3-5.
- Allow the Azipods to pull the cutter through the ice.

Alternate propulsion forward, then astern, using synchronized pod turns to achieve the desired rotation.

Use the same procedure for transiting forward and astern.

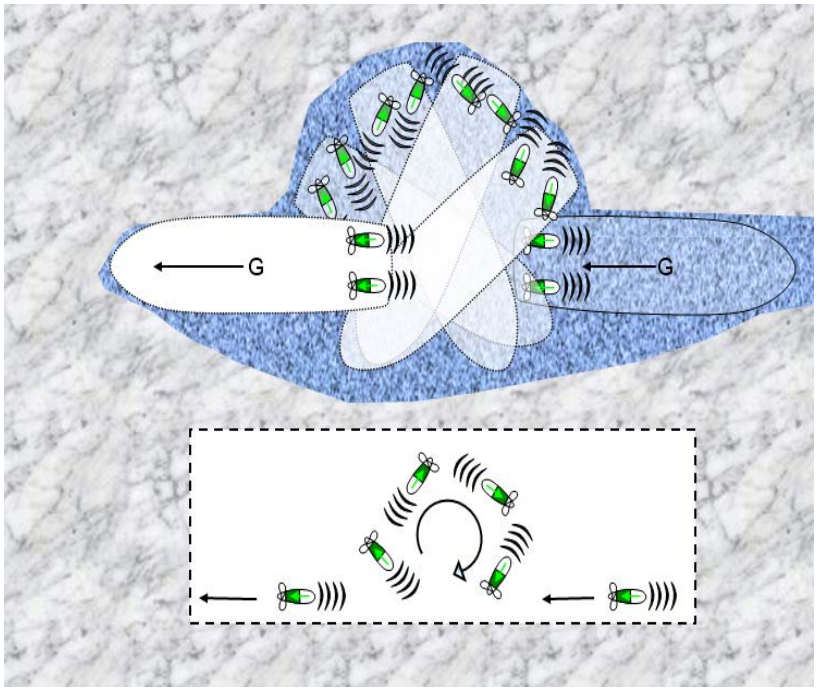

Figure 3-5 Pod manipulation for coming about

NOTE: **At slow speeds, maneuvering the pods to high azimuth angles, can turn the cutter in its own length in up to 24 inches of ice. (Figure 3-5)**

A.5. Stopping and Backing

The WLBB design provides equal performance ahead and backing in ice. Its stern shape has low buttock angles, forming the flat surface of the stern (Figure 3-6). The flat transom transitions into the arch amidships, stretched behind Azipods through the waterline. The arch creates additional breaking points for ice cusps moving down the hull before they reach the vertical edges of the Azipod struts. This design prevents cusps from crushing the struts, which generate high resistance forces.

The stern shape and propulsion system provides excellent backing performance and active directional control in all types of ice conditions. Backing thrust of Azipods is about 86 percent of their thrust ahead when both are in the bollard or zero-speed condition.

Figure 3-6 WLBB stern view

NOTE: **Stern configuration is not designed for ramming ridges, but rather to move continuously through a ridge or rubble field at low speed astern. Azipod drive also restores movement without ramming in the event a ridge stops the cutter.**

A.5.a. Backing During Ice Operations

The WLBB's design effectively breaks ice while transiting astern. The Azipods' ice-milling capabilities use propeller rotations to cut ice rather than relying on weight to crush.

Since the cutter can be accurately steered while going astern, this method of icebreaking is efficient and recommended when encountering heavy ice and large windrows.

A.5.b. Backing in Level Ice and Broken Channels

The WLBB is capable of moving steadily astern in level ice greater than 32 inches. Backing in broken ice is also safe and effective, and backing performance in broken ice, fresh track, and old track may be equal to or somewhat better than performance ahead. In lighter ice conditions, the backing mode is less efficient and not recommended for use.

A.5.c. Stopping in Ice

To stop the WLBB in ice, reduce thrust to 10-15 percent or reverse thrust. Often, resistance caused by heavy plate ice will stop the cutter quickly; simply reduce power.

Reducing power to a low level maintains propeller RPMs and keeps turns on the propeller, reducing the likelihood of damage. Damage is most likely to occur while backing and ramming and the cutter backs into solid ice with the propeller turning slowly or stopped.

NOTE: **If using aggressive reverse thrust to stop, excessive vibration will occur at greater than 55 percent thrust.**

CAUTION: **Rotating the Azipods 180 degrees while making headway exposes them laterally to ice loads and can cause damage.**

A.5.d. Operating Astern in Level Ice

When backing, the preferred method is manual mode, with propellers oriented aft (see Figure 3-7). There are a number of situations, such as maneuvering around a beset vessel, wherein it is desirable to back the cutter in level ice. In most situations, more ice will be milled, producing heavier impacts on the Azipods. Therefore, take greater care when operating astern.

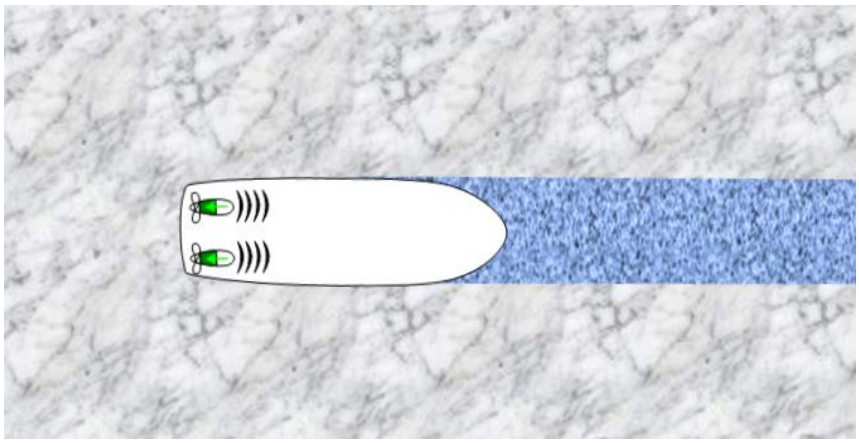

Figure 3-7 Operating astern in ice

CAUTION: **Maintain slow speed when moving astern through ice to avoid impact damage to the propulsion gear. If vibration is detected when operating astern, reduce thrust.**

A.6. Mooring and Unmooring

See General Icebreaking, Section G: Mooring, Unmooring in Ice, Heaving to in Ice.

A.7. Pier Clearing (Scarfing)

When scarfing (Figure 3-8) a pier, the cutter's propulsion system offers the following advantages:

- Variable pod angle and thrust to enable lateral traverse of the pier face.
- Use of bow thruster to manage distance between the bow and pier.
- Use of bow thruster to maintain optimal angle to the pier.

See also Page 2-26, Scarfing the Pier Face.

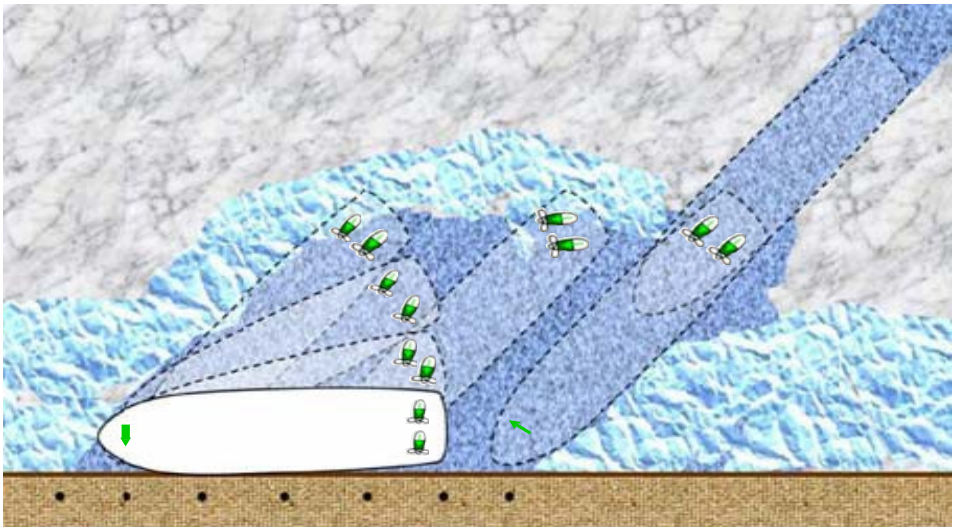

Figure 3-8 Scarfing a pier face

CAUTION: **Some ice conditions permit bow thruster use. Even though grating offers some protection for the bow thruster tunnel, ice can still be drawn into the tunnel, causing damage.**

A.8. Breaking Out a Beset Vessel

The Azipod propulsion system allows favorable station keeping before a beset vessel's bow while using directional thrust to flush ice. Crews can use multiple techniques if the icebreaker has sufficient room to navigate near the beset vessel. See General Icebreaking, Section K: Breaking Out a Beset Vessel, for additional information.

Figure 3-9 and 3-10 are visual representations of using Azipod propulsion to penetrate a plug and flush ice accumulated at the bow of a beset vessel. There are many techniques for accomplishing this operation.

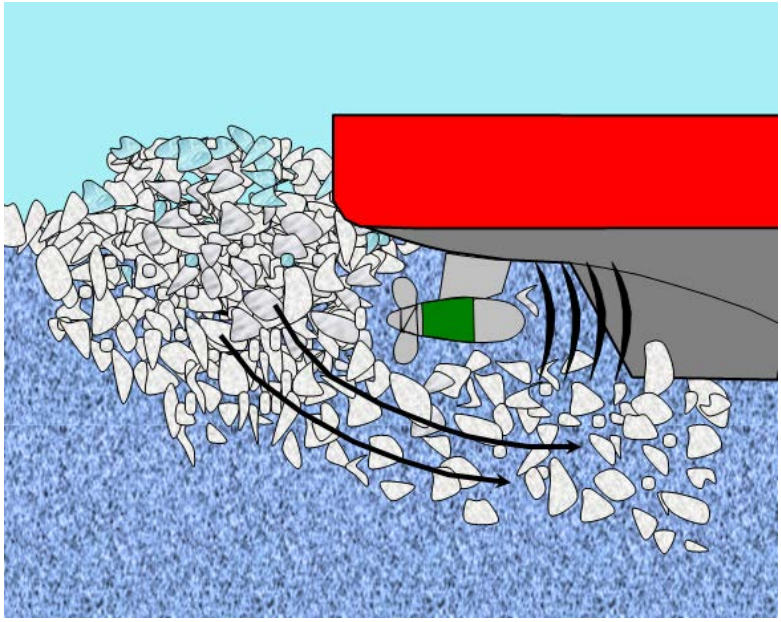

Figure 3-9 Astern propulsion to penetrate ice plug

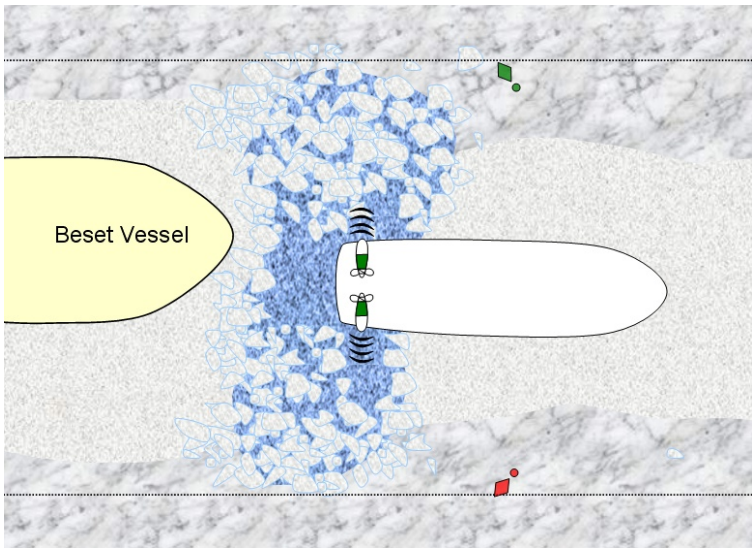

Figure 3-10 Digging a hole (flushing a beset vessel's bow)

A.8.a. Force Bias-Wash Technique

To achieve the force bias wash technique:

- Position Azipods to thrust toward one another.
- Azipods produce prop wash outboard, causing equal force bias motion.
- Action allows milling and washing ice outboard, while slowly making sternway toward the bow of a beset vessel.

When using this method, the pods mill and displace ice from the beset ship's bow, creating an open pool of water (Figure 3-11).

Figure 3-11 Force bias wash technique

A.8.b. Opposing Wash Technique

To achieve the opposing wash technique:

- Position one Azipod facing forward and one aft and apply equal thrust.
  - The technique uses directional wash, creating circular ice and water movement astern.
  - Creates low pressure and breaks up a plug in front of the beset vessel.
  - The technique twists the cutter, similar to splitting the throttles on a twin screw vessel.

Use this technique when bow or stern swing can be minimized by placing the bow or stern of the cutter, respectively, in solid, fast ice.

CAUTION: **Add power slowly and use different angles (vectors) to keep from walking the stern sideways or out of control.**

NOTE: **An icebreaker with the Azipod system performs a breakout maneuver in a completely different manner than a conventional icebreaker.**

Section B: WLB 225' - Buoy Tender (Seagoing)

B.1. Introduction

This section describes design characteristics and performance of the WLB 225 Buoy Tender. For complete design and performance guidance, see reference (e), Juniper Class (WLB-225) Operational Guide for Icebreaking, ELC-023-04-007.

B.2. General

Per reference (e), the WLB was designed as an ice-strengthened vessel, to perform domestic icebreaking missions as one of its operations. As compared to its predecessor, the 225' WLB was designed with enhanced icebreaking and buoy tending characteristics to include:

- Increased horsepower.
- Improved ice-strengthening along its bow and hull.
- Wider, heavier hull designed for increased sea keeping ability and improved buoy tending performance in rough seas.
- Specific bow design elements that aid in icebreaking:
  - The waterline and bow have a pointed wedge shape (Figure 3-12) that provides a balance between maneuverability in level ice and the ability to "grab" into the ice edge when turning out of an existing track.
  - Its shape facilitates backing out of a ridge that withstands the vessel's weight.

NOTE: **The cutter's specific hull design as a buoy tender does not permit its operation in the same manner or as effectively in ice as purpose built icebreakers.**

Figure 3-12 Sloped stern and flared bow shape of the 225 WLB

This cutter class has an A-Class and a B-Class variant. Characteristics for each are listed below:

- A-Class variant:
  - Tip clearance and 5-inch deep flow-accelerating fins.
  - The fairing clearance over the propeller is about 24 inches below the hull.
- B-Class variant (see Figure 3-13):
  - This class has a fairing installed over the propeller, allowing accelerated water flow into the propeller and reduced cavitation. The fairing prevents pulses from impacting the hull, thereby reducing noise.
  - An added benefit of the fairing on the B-Class is highly concentrated prop wash that can be effective for bow flushing during escort operations.
  - The fairing reduces clearance over the top of the propeller to about 15 inches below the hull. This restriction may cause increased frequency of ice milling and resistance in all ice conditions.
  - Stronger reduction gears capable of extended operations in heavy ice conditions.

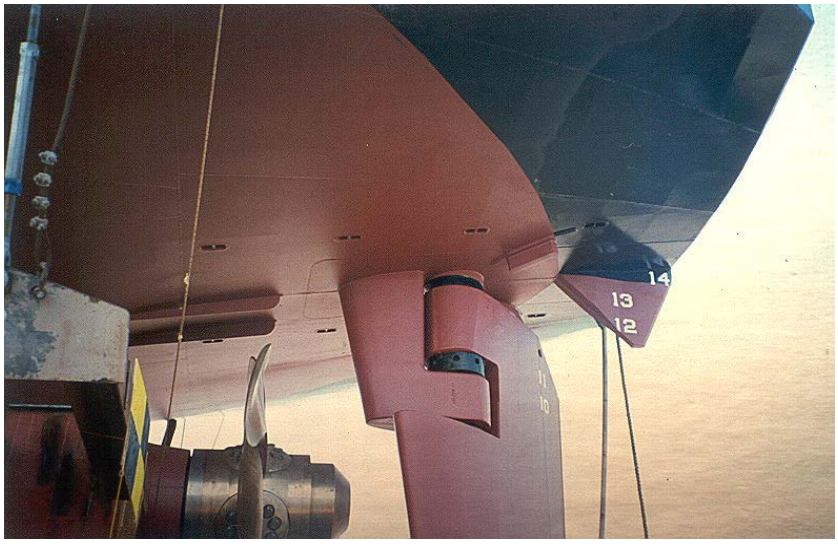

Figure 3-13 Propeller, fairing, rudder, and ice knife

B.3. Conning Methods

The physical breaking of ice by this cutter occurs when the angled portion of the bow rides up on the ice, increasing downward force on the ice. Once the cutter's weight exceeds what the ice can support, it breaks and the cutter moves forward. In thin, level plate ice less than 12 to 14 inches thick, the cutter's speed slows slightly and a small amount of pitch occurs. This change is virtually unnoticeable. The cutter is capable of breaking 24 to 30 inches of plate ice, but added friction encountered in refrozen brash or windrows can significantly slow or stop the cutter.

B.3.a. Machinery Plant Operation in Ice

This cutter is equipped with two modes of operation for propulsion control: transit mode and maneuvering mode.

- Transit Mode:
  - Varies both the pitch and RPM of the controllable pitch propeller in combination as the throttle lever is adjusted.
  - Ensures the most efficient conditions for the propeller throughout the range of cutter speeds in open water.
- Maneuvering Mode:
  - Used during ice operations.
  - Hold shaft speed at a constant 203 RPMs and engine speed at 720 RPMs, and pitch is varied with changing throttle position. By keeping shaft speed high and only varying pitch, the propeller is better protected and thrust response ahead or astern is rapid.

CAUTION: **Use Maneuvering Mode during ice operations to keep the shaft rotating at a high rate of speed. Icebreaking in Transit Mode puts the cutter at a higher risk of damage. Most propellers on icebreakers are broken when stopped or barely rotating.**

NOTE: **To remain in maneuvering mode, the shaft speed must be between 196 and 204 RPMs.**

B.3.b. Machinery Control System

For operations in heavy ice with a controllable pitch propeller system, maintain high propeller RPMs to prevent damage. Propeller blade damage is most likely to occur during backing and ramming if the cutter backs into unbroken ice. During these maneuvers, the propeller can operate in a contrary direction to the flow of water when pitch is reversed while the cutter is still moving ahead. The propeller is more vulnerable to loads on the back, or face, where its bending strength is weaker. Ice strikes on the blade edge are less damaging.

Inflow direction to the propeller is a function of cutter and propeller speeds. The use of maneuvering mode:

- Increases shaft speed, which directs the inflow angle closer to the plane of the propeller disk. Therefore, ice is more likely to strike the edge of the blade where it is stronger and milling will occur.
- Protects the shaft line from over-torque.
- There is a nonlinear relationship between pitch at the propeller and throttle level position. Figure 3-14 graphically shows the pitch/throttle level relationship currently in use on USCGC HOLLYHOCK. Two curves are shown for one or two engine operation. These curves relate throttle position to icebreaking performance.

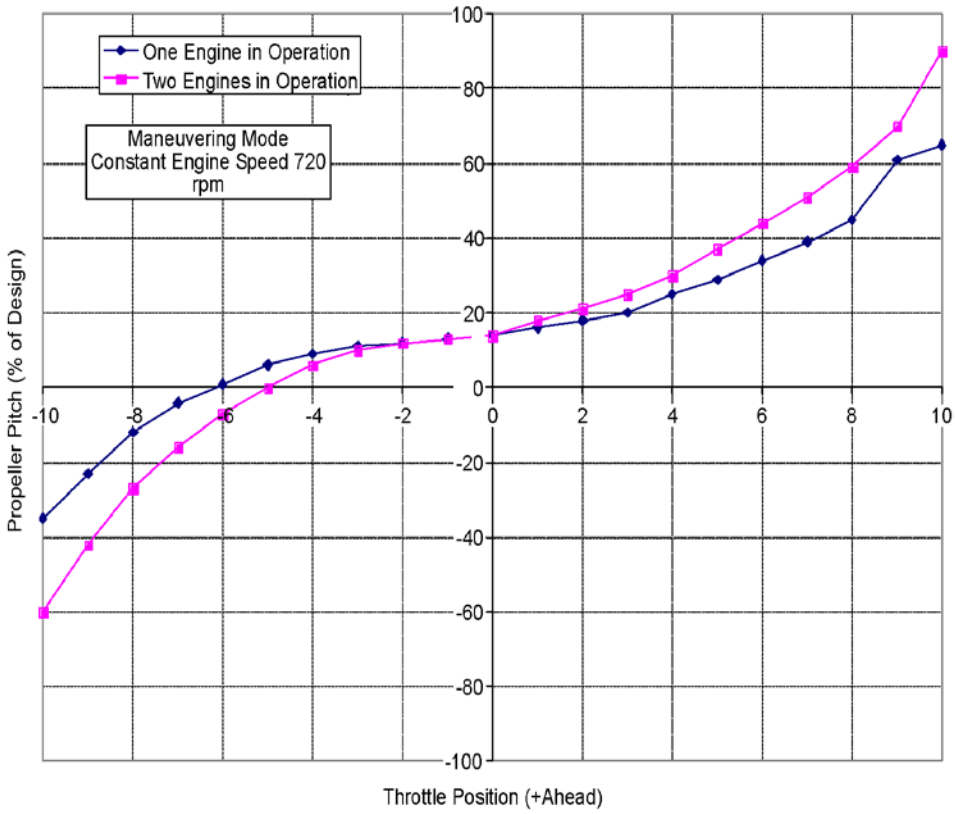

Figure 3-14 Throttle position and pitch for maneuvering mode, based on USCGC HOLLYHOCK

B.3.c. Reduction Gear

During the WLB trials in 24.5-inch level ice, ice milling events were recorded. Ice-induced torque was at or slightly above design load for the shaft system. Some higher torque events are expected with prolonged operation in these conditions. Re-evaluation of the cutter for operation in thicker ice prompted reduction gear strengthening for the 225ft WLB B-Class. The A Class is not recommended for extended operations in heavy ice conditions, but B Class modifications tolerate extended ice breaking.

B.3.d. Steering Gear

The cutter's steering gear system has installed burst discs that fail if pressure in the steering system grows too high due to ice loads (i.e. rudder in heavy brash). If these discs burst, the bridge crew will note steering response slowed by about 50 percent.

CAUTION: **When backing this cutter in ice, align the steering gear to zero degrees (positioned amidships).**

NOTE: **Enable the rudder alarm when maneuvering in ice. The alarm will sound when astern pitch is ordered and the rudder is not amidships.**

B.3.e. Bow and Stern Thrusters

The WLB is equipped with bow and stern thrusters for improved maneuverability at slow speed and station-keeping. They are intended for use in open water, but are effective in light ice and can twist the cutter in light broken ice. Thrusters do not provide enough thrust, nor does the cutter have sufficient flare in the stern area, to break solid ice while attempting to twist. The thruster tunnels have grates over their openings, but ice pieces can be trapped on the grates, blocking flow and starving the propellers of water.

CAUTION: **Thruster damage can occur if starved for water, or milling significant amounts of ice. Secure thrusters when not in use. Securing will prevent propeller jamming or overheating the motor windings due to inability of the propeller to spin freely.**

NOTE: **In heavier ice conditions where ice pieces are forced down the hull, the use of thrusters will not be effective and is not recommended.**

B.4. Working a Track

Figure 3-15 shows WLB performance in a freshly broken track by differing throttle positions. Figure 3-16 is WLB performance in a thoroughly established and transited track, also by differing throttle positions.

Snow and dense brash in the track may create conditions for ice adhesion to the hull. This condition, sometimes called an ice moustache, will significantly increase resistance, slow progress, and make maneuvering more difficult. This phenomenon occurs more frequently at very low speed and is affected by the WLB's straight hull profile. Reduce the probability of this phenomenon by sustaining reasonably high speed whenever possible.

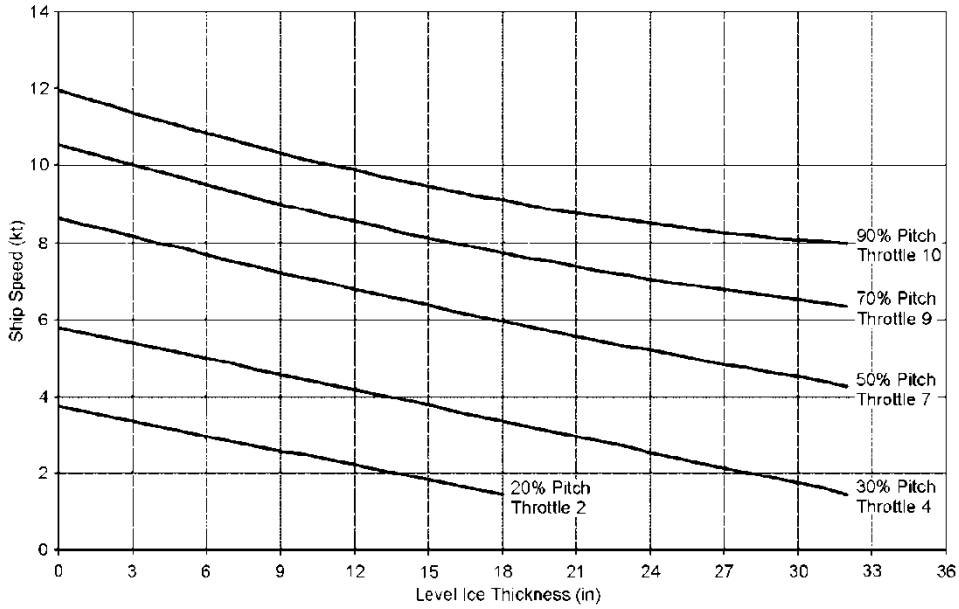

Figure 3-15 WLB performance in a fresh track (maneuvering mode)

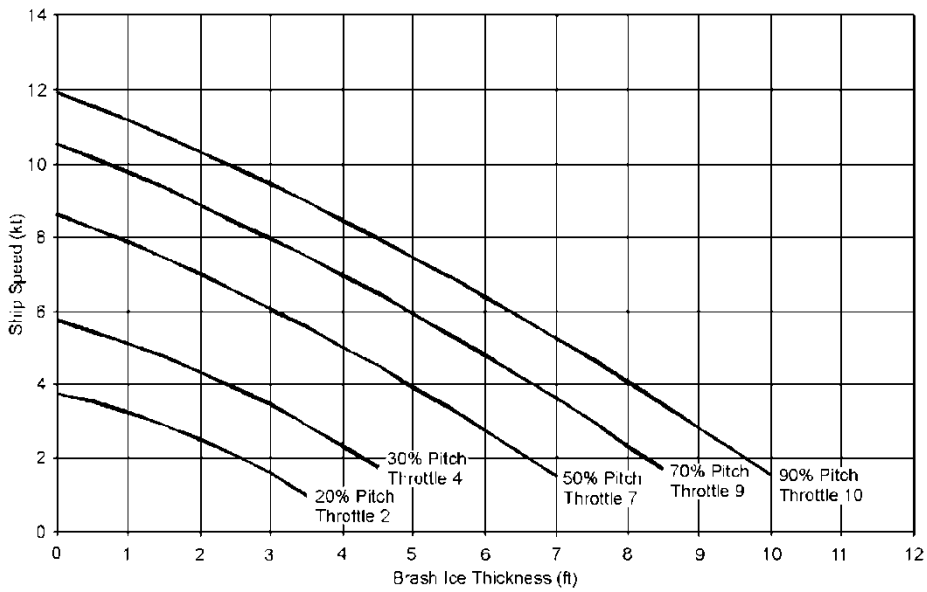

Figure 3-16 WLB performance in an old channel (maneuvering mode)

NOTE: **Brash ice thickness in Figure 3-16 is significant. Expect this in frequently transited tracks in areas such as the St. Mary's River. Performance in broken ice was estimated based on measurements taken during USCGC JUNIPER (WLB-201) ice trials.**

NOTE: **It is important to maintain hull surfaces in good condition and painted with an ice-resistant coating.**

B.4.a. Establishing and Maintaining a Track

This cutter's performance in unbroken plate ice makes it an excellent platform for establishing tracks. It is also excellent for conducting track maintenance in areas with low to moderate brash conditions that have regular traffic to keep ice from becoming heavily refrozen.

For choke points in waterways, or when ice is under pressure, the WLB can encounter more difficulty than a purpose built icebreaker.

B.5. Turning

Considering WLB turning performance is particularly important in the following conditions:

- In level, unbroken ice, the cutter turns effectively. Plan and execute turns so the track will be of sufficient width and radius to accommodate larger vessel traffic (Great Lakes vessels are up to 1000' in length and 105' on the beam).
- In packed ice, the WLB turns more slowly and erratically than in level ice. Consider turns in pools of open water or light ice if these conditions are available.
- The cutter's hull shape makes turning in ice under pressure is very difficult. Turning ice under pressure in limited sea room is limited, might required a star turn, described in reference (e), Juniper Class (WLB-225) Operational Guide for Icebreaking, ELC-023-04-007 for coming about. This is a time-consuming maneuver: consider that the cutter will not be able to turn while going astern.

NOTE: **Turning out of an existing track requires applying significant rudder. The cutter might bounce along the track wall several times before it cuts into fast ice and turns out of the track.**

B.6. Stopping and Backing

Requirements for high speed in a relatively short cutter length meant maximizing the WLB waterline. Meeting the primary ATON mission meant compromising backing capability in ice. The design placed the rudder at the transom, along with an ice knife that passes through the waterline (Figure 3-13). When backing in this configuration, the ice knife impacts ice cover first and protects the rudder. Lack of rudder shielding behind the ice knife, puts the rudder in danger of being pushed to the limits of travel and potentially damaged. This cutter is not able to back in ice thicker than 8 to 10 inches; the ice knife does not break solid ice cover easily, and resistance becomes sufficient to stop progress.

The 225ft WLB Class cutters have controllable pitch propellers, producing a disadvantage during ice operations.

- The backing thrust of a controllable pitch propeller is about 50 percent of its thrust ahead when in the bollard or zero-speed condition.
- For icebreaking, there is excellent thrust ahead to access a tough ice area, but only half the thrust to back out if the cutter is stopped.
- When breaking out a beset vessel, significant power is required due to reduced reverse thrust.

NOTE: **Allow sufficient time and distance to stop the cutter. During backing, controllable pitch propellers provide approximately 50 percent of their forward thrust.**

B.7. Mooring and Unmooring

Mooring to and unmooring from an iced-in pier is difficult for this cutter. Springing on lines is more difficult due to the cutter's long, straight sides and the thrusters' minimal effect against the tremendous force of ice against the flat hull.

CAUTION: **Crews must be careful using a ground tackle to pull the cutter to the pier. This technique increases resistance offered by ice and can damage deck equipment.**

NOTE: **A carefully developed plan considers variable ice thickness, ice movement at various points in the evolution, and how pressure from ice and other elements affects mooring or unmooring.**

B.8. Pier Clearing

If the wind, tide, and current conditions are conducive, using the propeller and thruster wash might help clear a pier.

Section C: WLM 175'- Coastal Buoy Tenders

C.1. Introduction

This section describes design characteristics and performance of the WLM 175, Coastal Buoy Tender. For complete design and performance guidance, see reference (f), Keeper Class (WLM-175) Operational Guide for Icebreaking, SFLC-NASEC-011-001.

C.2. General

The 175ft WLM Keeper Class tenders are ice strengthened buoy tenders stationed along the Atlantic, Gulf, and Pacific coasts. They are designed to retrieve buoys surrounded by light ice. That is a fundamentally different mission than ice escort operations. However, the WLM often operates or assists in ice-choked waters, especially along the rivers and bays of northeast United States. WLM crews must understand the limitations of their cutters when applying this TTP.

The following characteristics provide the WLM with ice operations capability:

- Icebreaking-type bow, characterized by a low stem angle and parallel buttock lines that generate flair in the forebody.
- The waterline and bow have a pointed wedge shape, providing balance between maneuverability in level ice and the ability to grab ice edges when turning out of an existing track. This design also facilitates backing out of a windrow that withstands the cutter's weight.
- Fixed-pitch propellers in nozzles mounted in azimuthing struts (Z Drives) that produce high thrust at slow speeds are particularly useful in icebreaking (See Figure 3-17). This system can also provide direct thrust or propeller wash in any direction; a design useful in clearing ice from a beset vessel or from piers.
- With forward movement, the cutter rides up slightly on ice and generates a downward bending force, causing the ice to break. The amount of pitch is almost imperceptible in level ice, but increases with ice thickness. The pitch becomes more noticeable when ramming thicker ice or ridges, but may not break obstructing ice features.

Figure 3-17 Fixed pitch propellers in azimuthing struts

The following characteristics limit WLM ice operation capabilities:

- Higher top end speed in a relatively short cutter length (beneficial for transiting and servicing buoys in shoal and ice-free waterways).
- Buoyancy requirement for trim and stability result in a wide waterline aft, continuing toward the transom.

C.3. Conning Methods

For icebreaking operations, the most effective operating mode is the Machinery Plant Control and Monitoring System (MPCMS Mode), often referred to as tiller mode. In tiller mode, the throttle controls at the center console control the Z Drives while in-sync or individually, and the thruster is operated by the thruster dial control.

The cutter is very maneuverable in this mode. A helmsman normally operates the cutter during open water transits. During ice breaking operations, the tiller can be rapidly placed in astern propulsion, opposing the Z Drives to clear ice from the nozzles. Forward and astern thrust is equal in the WLM. However, the transom design (wide and flat) produces more resistance while operating astern in ice.

NOTE: **Ice operations are much slower than those in open water. The conning officer must not apply too much power to hasten evolutions.**

C.3.a. Machinery Plant Operation in Ice

The WLM cutter has two shafts with fixed-pitch propellers in nozzles, mounted in azimuthing struts. A direct linked, mechanical Z Drive system powers the propellers. During normal operation, the nozzles point their thrust outboard at throttle position 0 since the system is direct drive and has no clutch. As throttle is increased, the nozzles rotate toward the stern, aligning with the centerline at throttle position 4. Shaft rotation increases from throttle position 4 to 10 to provide more thrust. This type of propulsion is efficient and responsive for operations in ice. Performance observations in ice:

- Nozzles provide protection for propeller blades and prevent high torque excursions in the propulsion drive system due to ice milling.
- Nozzles are prone to ice clogging, which manifests itself in loss of thrust and occasional significant vibration.
- The WLM does not allow reverse shaft rotation.

For clogged nozzles:

- Work the helm back and forth. This is an effective clearing method.
- Difficult pieces stuck to the nozzle inlet can be back-flushed by turning the nozzle around while the cutter is moving forward.
- If the clog remains, stop the cutter to change mode. Temporarily switch from tiller mode to Z-control mode by decoupling the nozzles, then rotate one pod to flush out the other with propeller wash.

C.3.b. Steering Gear

The 175ft WLM class cutters have no particular operating requirements for the azimuthing nozzles in ice. When operating astern in ice, the nozzles are much closer to ice: take care to not back into heavy ice features.

Even though the cutter has limited capability when backing in ice, nozzles and propulsion are ice strengthened. The risk of exerting excessive loads on the propeller pod and nozzle are minimal. Exceptions occur when a nozzle clogs with ice, and very high loads occur when a piece of ice is lodged in the nozzle and the throttle is moved ahead rapidly.

C.3.c. Bow Thruster

The WLM is equipped with a bow thruster for improved maneuverability at slow speed, and station keeping and is intended for use in open water.

CAUTION: **Avoid using the bow thruster during ice operations due to potential damage to the propeller from ice ingestion.**

C.4. Working a Track

The WLM performance in ice:

- Level, fast ice 4 inches thick: 4 knots at throttle position 7.
- Level, fast ice 4 inches thick: 6.7 knots at throttle position 9.

Other performance standards:

- Level, fast ice 6 inches thick: 4 knots at throttle position 8.
- Level, fast ice 8 inches thick: 4 knots at throttle position 9.
- The WLM is capable of making almost 4 knots in 10 inches of ice at throttle position 10. However, this condition would leave no reserve power if more difficult level ice conditions are encountered.

NOTE: **Generally, two knots is the lowest advisable speed for continuous level icebreaking.**

CAUTION: **Use caution when operating in level ice thicker than 8 inches to avoid becoming beset. The WLM has limited backing ability.**

C.4.a. Level Ice

Figure 3-18 illustrates throttle position ranges for effective operation in level ice based on analytical models and full-scale trials of the WLM.

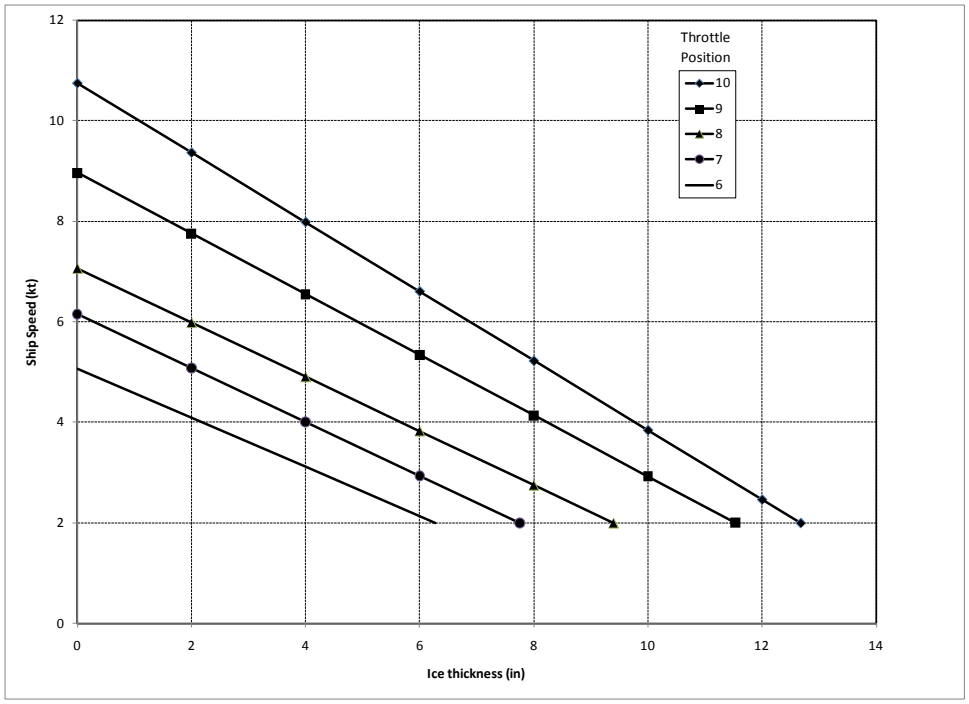

Figure 3-18 WLM performance in level fast ice as a function of throttle position

Hull ice friction is a significant consideration. The WLM has a low-friction hull coating, but surface conditions on ice such as snow can affect performance. Depending on the zone of operations, there can be areas of high snowfall and areas where high winds sweep the ice clean. For a reasonable approximation of the effect of snow cover, treat ice as being bare and thicker by the addition of one-third of the snow depth. In cases when the snow is very sticky, the effect can be greater.

Trim is important for good ice performance and safe operation. Trim by the stern reduces the bow's effectiveness in breaking ice, but the influence is small. Operation at even keel is recommended.

C.4.b. Broken Ice

A WLM transiting a freshly broken track does not encounter the same resistance as in level ice. For a constant speed of 2 knots, the range of throttle positions 6 through 10 tolerates maximum ice thicknesses of roughly 7 to 15 inches in a fresh broken track, but only 6 to 13 inches in level ice.

C.4.c. Brash Ice

A 175ft WLM will typically encounter brash from passing vessels that have repeatedly broken a track through level ice. Figure 3-19 shows performance in an old track for varying throttle positions. Brash ice thicknesses in this table are large relative to those for level and broken ice.

Expect this ice in older tracks formed where there is high vessel traffic, such as at the entrances to ports and in rivers.

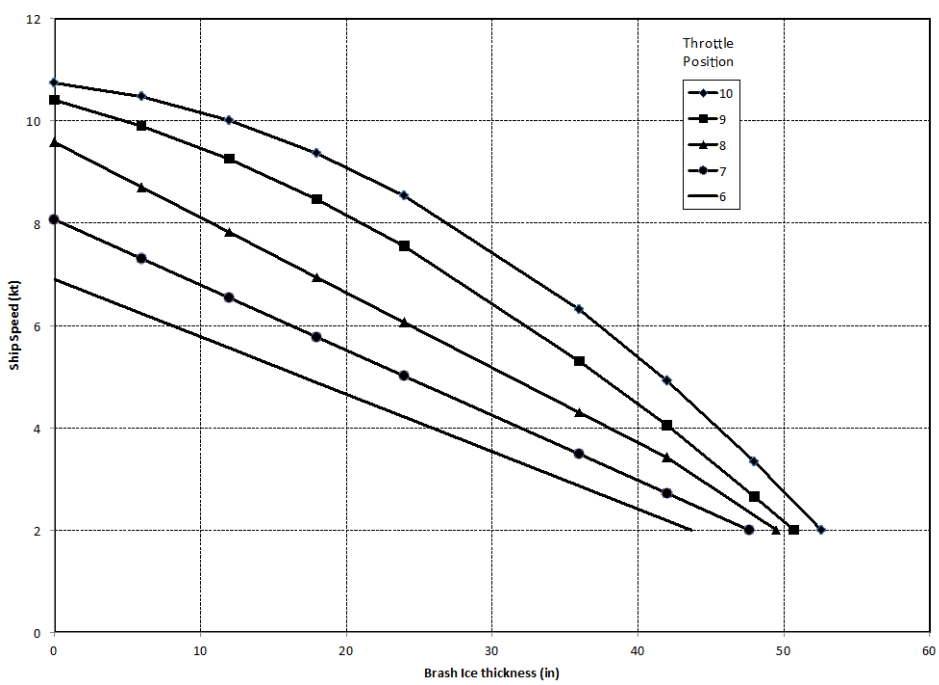

Figure 3-19 WLM performance in old track (brash ice) as a function of throttle position

NOTE: **Snow and dense brash in the channel can create conditions for ice adhesion to the hull. This will significantly increase resistance, slow progress, and make maneuvering more difficult. Minimize this condition by sustained, reasonably high speed when possible. Use sallying to loosen ice build-up.**

C.5. Turning

During WLM ice trials, tactical maneuvering data was limited due to geographical constraints that made complete circles impossible. Partial turns were extrapolated to obtain values presented in Table 3-1 and 3-2 for different speeds and rudder (thrust) angles. Note the rudder (thruster) angles referenced with zero ahead thrust. There is variability in duration and diameter due to applied nozzle angles, initial speed, and ice conditions.

Comparing the tables indicates that turning in an old track is easier than turning in unbroken, level ice. Additionally, the square stern presents a largely perpendicular attack surface to surrounding ice, making turning difficult due to increased ice pressure against the hull.

Ice Thickness (inches)	Port Rudder Angle (degree)	STBD Rudder Angle (degree)	Cutter Speed (knots)	Duration (minutes)	Diameter (feet)	Diameter (Cutter Length)
7 to 8.5	18	16	4.4	14.8	2,114	12.1
7 to 8.5	267	289	3.4	12.5	1360	7.8

Table 3-1Turning circles in unbroken level ice

Ice Thickness (inches)	Port Rudder Angle (degree)	STBD Rudder Angle (degree)	Cutter Speed (knots)	Duration (minutes)	Diameter (feet)	Diameter (Cutter Length)
4 to 8	323	347	6.8	6.3	1360	7.8

Table 3-2 Turning circles in an old track (loose brash or rubble ice)

CAUTION: **Using the bow thruster in ice can cause damage from ice ingestion. In light ice conditions, it might be possible to maintain directional control while backing by using the azimuthing nozzles.**

C.5.a. Star Turning Maneuver in Level Ice

The star maneuver is an effective means for coming about in ice. The maneuver is a commonly used piloting technique to twist a ship in the ice when a turning circle is not feasible. This maneuver is usually performed when ice thickness exceeds the cutter's capability to move continuously while turning, or when sufficient space for such a turning circle maneuver is not available.

Employ the maneuver by:

- Breaking the cutter out of the channel and turning until ice, fairway limit, or other limitations stop progress.
- Back into unbroken ice as far as possible or desirable.
- Use several backing and ramming cycles, each of which provides a relatively small angle turn.
- The maneuver is complete when the vessel has changed heading 180 degrees and re-entered its own track.

The pattern of this maneuver often looks like a star. However, there are a number of different terms applied to the same or very similar technique. Some of the most common terms include cast about, modified captain's maneuver, herringbone, and Christmas tree.

Figure 3-20 shows a sample trackline from a WLM star maneuver. The cutter backed approximately 1.0 to 2.3 cutter lengths during each step until ice resistance stopped its movement.

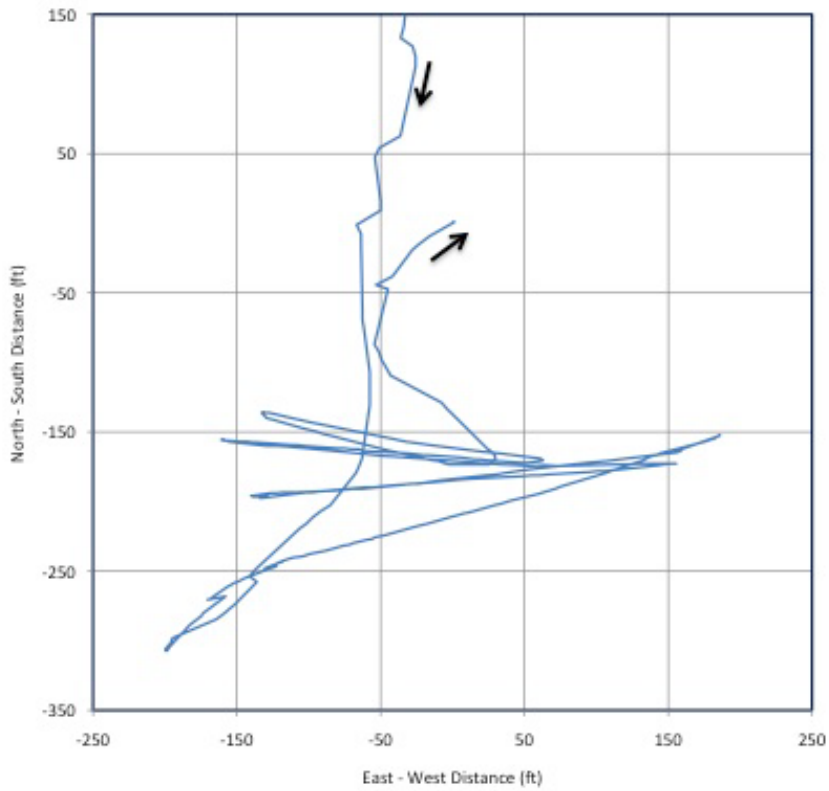

Figure 3-20 Star maneuver in an old track

NOTE:

Limited turn advances result from limited backing and twisting ability caused by the wide, flat stern and transom. Ensuring sufficient time to complete these maneuvers is critically important if there is commercial traffic using the broken track.

C.5.b. Breakout Maneuver

The breakout maneuver starts in an established track and is a method to depart the track in level ice without frozen brash ridges on the sides of a track. The maneuver is useful for coming about in a track in limited space. Figure 3-21 shows the 175ft WLM trackline during one 180-degree turn using breakouts. Segments 1, 2, and 3 in the figure together make one complete breakout maneuver. Note: this is a multi-point turn during which the cutter is backing on segments 2 and 4.

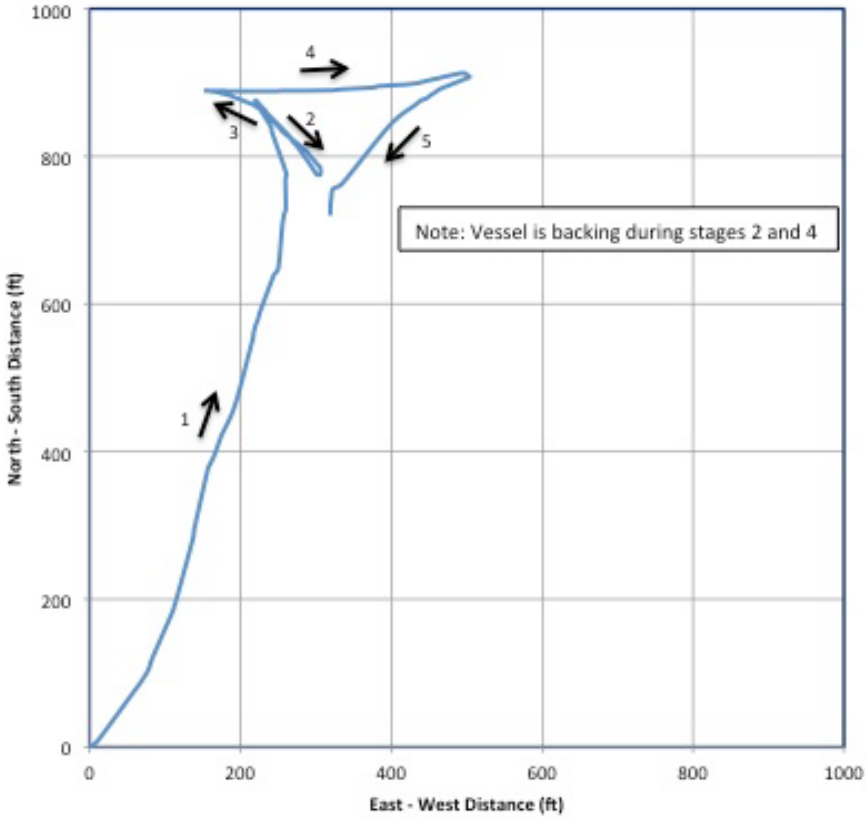

Figure 3-21 Example trackline during the Breakout maneuver

C.6. Stopping and Backing

The wide, submerged transom arrangement impacts ice cover first when backing. A theoretical calculation demonstrates that the WLM is not able to back in unbroken level ice of greater than 1 to 2 inches in thickness.

Transom design buckles ice instead of bending it, and the WLM's thrust is insufficient to overcome the large load. The same characteristic also limits the WLM's ability to back and ram if beset in ice.

The WLM performs better when backing in a preexisting track, either broken or brash ice. Table 3-3 shows data on its capability when backing in preexisting tracks during trials.

WLM Backing Performance						
	Measured Thickness (inches)			# of Cutter Lengths		
Ice Type	Minimum	Maximum	Average	Minimum	Maximum	Average
Fresh Broken Track	7	8	7.6	0.8	2	1.4
Old Track of Loose Brash & Rubble	5.7	6.9	6.3	1.0	2.3	1.6

Table 3-3 WLM backing performance in preexisting tracks

On average, the 175-ft WLM can back 1.4 cutter lengths in a fresh track with 7 to 8.5 inches of brash before being stopped. When backing in a freshly broken track, ice piles up on the transom, filling the broken channel and causing a significant increase in ice resistance. Greater ice thickness magnifies this effect.

C.7. Ice Conditions to Avoid

If possible, avoid these conditions:

- Ice floes in rapidly moving currents.
- Ice jams.
- Breaking into frozen brash ridges formed on the sides of frequently used tracks.
- Brash and broken ice conditions producing high vibration when ice milling occurs.

Section D: WTGB 140’ - Icebreaking Tugs

D.1. Introduction

This section describes design characteristics and performance of the WTGB Icebreaking Tug.

D.2. Conning Methods

While working through an ice field, the conning officer can establish one of two relationships with the helmsman:

- Permit the helmsman discretion by issuing general guidance (i.e., "Widen the track by half a ship's width"; "Break up the larger pieces in the middle of the track"). This is suitable for a helmsman who is proficient in ice operations. When searching for weak ice through which to transit, the conning officer's experience, the helmsman's feel for the cutter, and the ability of both to read environmental conditions will be useful in identifying prospective tracks.
- Retain full control of the helmsman. The conning officer issues helm commands and course changes. This method is best for new helmsmen or those inexperienced in ice. A disadvantage is that the conning officer might not be able to feel the cutter’s movements or react quickly enough.

Using either method usually depends on existing ice conditions, and difficulty of the tasking. Ice operations require close teamwork, which varies greatly from open water operations.

During tight maneuvering situations around piers and beset vessels, the conning officer normally takes station at one of the three bridge consoles. If positioned on either bridge wing, the conning officer has the option of operating the throttle alone, or throttle and non-followup rudder control.

D.2.a. Communications

Constant communication among all vessels during transits through ice is one of the keys to a successful and safe operation:

- Brief masters of vessels assisted thoroughly regarding:
  - Methods and tactics used.
  - Actions required on the part of the master.

Conducting icebreaking operations with masters of commercial ships and tug captains is usually collegial and cooperative. However, they sometimes have their own ideas about working in ice and can make scenarios more difficult and dangerous (e.g., turning their screw ahead while an icebreaker works around their stem). In other situations, their input has been very helpful. See also General Icebreaking, Section M: Communications.

D.2.b. Working in Heavy Ice

The design maximum for continuous icebreaking is 22 inches. While cutters can occasionally exceed their maximum icebreaking capability, normally pressure or a heavy snow cover will quickly reduce any progress through such extreme conditions.

The WTGB has two noticeable motions in heavy ice:

- A cyclic rise and fall of the bow as the cutter makes slow progress through thick floes.
  - Just before the cutter comes to a stop (on a ridge), the bow normally rises more abruptly.
- A slow rolling action not induced by sallying the rudder. Typically, this natural, continuous roll only occurs in the heaviest conditions where ice is under moderate pressure. The unusual motion, coupled with action of the bubbler flow, might be a reason for the cutter's superior performance in snow-covered ice.

The WTGB usually operates in brash up to four feet thick with little difficulty. Heavier brash or slush fill might require using the bubbler system and continuous rudder sallying. The same redundancy precaution used in restricted waters necessitates the use of both steering pumps in heavy ice, which also improves the speed of rudder response.

NOTE: **Thick, slushy conditions increases the possibility of a clogged sea chest. In addition to the installed heaters, using the fire main is an effective alternative method for keeping sea chest clear.**

D.3. Ballast and Trim

A fully loaded fuel condition (90 to 95%) is optimal for WTGB icebreaking effectiveness. There is a loss in icebreaking capability (particularly when icebreaking in areas that are windrowed) as the WTGB's fuel load decreases from full load to 75%. Below 75%, reduced displacement and increased freeboard contribute to reduction in all-around maneuvering effectiveness in the ice.

The design drafts of the WTGB class are 11.5 feet forward and 12.5 feet aft. One foot of trim by the stern is optimal for icebreaking. Any extra draft aft may further reduce vibration and may possibly increase the effectiveness of the stern wake in breaking out a wide track. However, any extra stern draft may have a negative effect on the stepped bow's effectiveness in heavier conditions.

D.4. Hull Air Lubrication System - Bubbler

There are numerous unconventional methods for using the hull air lubrication (bubbler) system. Recognize its limitations (e.g., primarily a slow reaction time), but be careful not to underestimate its potential in a variety of icebreaking situations.

WTGB icebreaking tests with and without activating the bubbler system indicate this independent system is highly effective when icebreaking in most level ice conditions. Other uses for specific evolutions appear to be limited only by the resourcefulness of the WTGB operator. Several example uses include:

- Clearing piers, dolphins, and slips of ice.
- When thicknesses are less than 32 inches, water flow from the bubbler is most effective. An ice-bound slip has been totally cleared of ice by the flooding action of the bubbler flow.
- Clearing ice plugs from the vessel bow.
- Clearing ice that is clogging lock gates.
- Creating a pool of water to allow divers access under an ice field.
- Breaking up light ice while assisting a thin-plated vessel through an ice field.

Small wooden fishing vessels and similar types are particularly vulnerable to ice damage. Using the bubbler flow while slowly breaking a track ahead normally leaves a pool astern when operating in light ice conditions. It is in this pool that a small vessel can make a safe passage if it follows the WTGB closely astern.

D.5. Assisting a Beset Vessel

There are four basic techniques that have been successfully used to pare ice from the sides of beset vessels (see also Figure 3-22):

- Run parallel relief tracks along both sides of the beset vessel. Run all tracks outboard to inboard; do not run the first pass close aboard. Safety margin increases by working through the ice at some distance with moderate speed, and then during a subsequent pass breaking close aboard. With this technique, the WTGB's wake can be most effective in loosening the ice around the beset vessel.
- Flushing stern-to works well in areas of thick slush and heavy brash. The conning officer backs the stern perpendicular to the beset vessel's side. Since it is normally necessary to close to within 15 to 20 yards, an observer stationed on the cutter's fantail to call out distances is recommended. Once in position:

- Apply full power (handle position 9 -10), washing a sizeable section of the hull.
- Flush down the beset vessel at several positions. Although this technique might require considerably more time than running parallel tracks, it can effectively free the vessel.

- Use of the bubbler system can be effective along the sides of barges. The technique is employed by:
  - Angling the cutter with its starboard bow toward the beset vessel.
  - Activate the starboard bubblers, both forward and amidships manifolds.
  - Turn the screw slowly ahead to counteract the forward bubbler's astern thrust. The water flow generated can remove slush, snow, and ice from the beset vessel's hull.
  - Reposition the cutter at several intervals along the hull. By employing this tactic, an entire side is swept clean of ice.
- Using oblique tracks can also be effective in areas of heavy ridging or windrowing where parallel tracking would be most difficult.
  - The conning officer breaks ice in circular tracks adjacent to each side of the beset vessel.
  - Exercise caution as cracks leading from the WTGB's stem to the vessel's side can develop rapidly and produce low pressure.
  - Carefully control use of available power during each turning maneuver close aboard the beset ship. The cutter's stern must swing through an arc that safely clears the vessel's side.

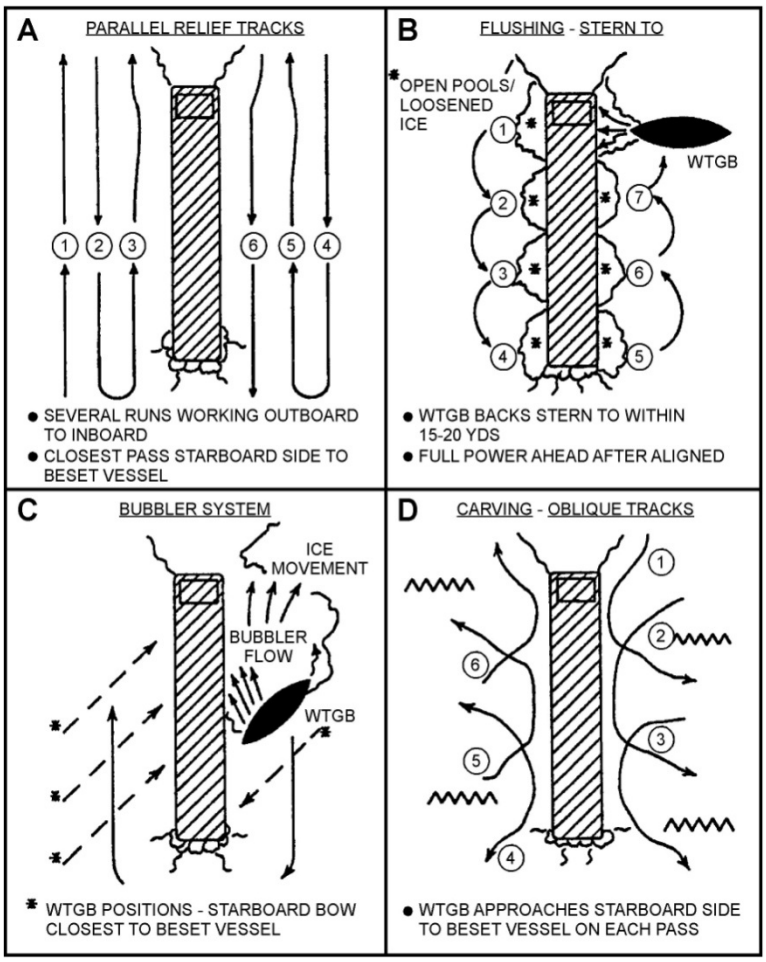

Figure 3-22 WTGB techniques for assisting beset vessels

D.5.a. Maintaining a Track

The cutter's football-shaped hull might require track grooming by slight scarfing along the track edge, with the contact surface along the cutter's bow rather than the midships hull. Transiting the track at an angle while carrying rudder to keep the bow in contact with the edge enables this technique.

See also General Icebreaking, Section D: Escort Operations in Ice.

See also General Icebreaking, Section I: Track Maintenance.

D.6. Stopping and Backing

Occasionally, ice will stop the cutter's progress. As an option before backing down, allow the bubbler to destabilize the ice and provide water to lubricate the hull.

Before backing, keep the propeller turning ahead while the rudder moves to its amidships position. Stern wash will prevent ice from migrating into the rudder.

WARNING: ***Always maintain positive control of the helm during astern operations in ice. Keep the rudder amidships.***

D.7. Casting

The WTGB backs to port, enabling more effective casting to starboard (casts in a tighter radius to starboard) in most ice conditions. When casting, consider the following:

- In heavy plate ice conditions, the ice horn may hinder casting.
- Use the bubbler system to induce a twisting motion, if needed.
- When conducting direct assist, if possible, keep the assisted vessels to the cutter's starboard side. In the event backing down is necessary, the cutter's tendency to back to port will aid in creating distance.

D.8. Mooring and Unmooring

The WTGB's bubbler system is an effective tool during mooring and unmooring. Employ the bubbler:

- To maintain a pool outboard of a WTGB's moorings by periodically activating the outboard manifolds. This tactic will keep medium to heavy ice from building up during in port periods.
- When backing away from a pier, several situations have necessitated departure without disturbing the surrounding ice. Activating the forward bubbler manifolds will generate an astern thrust that can sufficiently move a WTGB without the use of propulsive power.
- Activating the forward bubbler manifolds can generate enough astern thrust to free a WTGB from its mooring after being frozen in place. Once the cutter is loose, the bubbler ports can be secured and moderate astern propulsion can be applied to back the cutter from a pier, minimizing ice disturbance.
- Use the system to counteract the tendency of this cutter to back to port in light ice. The bubbler can "thrust" a WTGB sideways toward a pier and can be used to cushion a rapid closing rate when mooring with an on the dock wind.

When anticipating the need to back from your mooring, tie up starboard side to, if possible; this takes advantage of the cutter's port backing tendency when getting underway.

CAUTION: **If using the bubbler as a thruster, be aware of the significant delay in reaction time to orders.**

D.9. Pier Clearing

For pier clearing guidance, see General Icebreaking, Section G: Mooring, Unmooring in Ice, Heaving to in Ice.

D.10. Wake Breaking

The WTGB's design and power plant allow this cutter to create large wakes, which are useful where significant breaking or wide tracks are needed. Flushing operations are exemplary of this requirement. See also General Icebreaking, Section D: Escort Operations in Ice.

D.11. Emergency Towing in Ice

Towing in ice by any vessel is an extremely dangerous operation. However, towing by the WTGB is further complicated by three, significant limitations:

- Low fantail.
- Lack of a towing notch.
- Lack of a towing machine or a wire hawser.

Towing astern in ice has been conducted on the Great Lakes. Towing operations with a short hawser were successful due primarily to the characteristics of brash and plate ice that existed in those areas. Never attempt this method in areas of windrows or pressure ridges. There are stringent criteria constraining towing in ice by WTGBs. Only attempt it during extreme emergencies.

WARNING: ***Use extreme caution if using synthetic lines aboard the WTGB. These hawsers do not stretch adequately for towing evolutions. Shock loads and cold temperatures are primary causes of parting.***

NOTE: **For additional guidance, see General Icebreaking, Section P: Towing in Ice (SAR Only).**

Table 3-4 Characteristics of WTGB Emergency Towing in Ice, includes a summary of WTGB operator opinions concerning towing in ice. Each of the listed methods has been attempted with varying degrees of success:

- Towing alongside in the ice, either by a single WTGB or in tandem, has consistently proven ineffective.
- Ice clogging between the vessels has prevented successful tows.
- The loss of icebreaking capability as power is diverted to the tow is an inherent problem.

One WTGB successfully pushed (in the notch) a 350-foot barge to safety through heavy brash and plate ice. In another emergent situation, two WTGBs towed a barge through 6 to 9 foot brash. This was a particularly dangerous and unusual operation as the icebreakers were abreast, each having a hawser to the barge. Problems with uneven strain on the towlines, surging between the WTGBs, and reduced maneuverability were major causes of concern.

WTGB Emergency Towing in Ice		
Method of Tow	**Major Problems**	**Consensus Opinion: WTGB Operator Survey**
Towing on the Hip (Pushing vessel made up alongside)	• Ice clogging between WTGB and assisted vessel. • Ice plug buildup ahead. • Icebreaking and maneuvering capabilities of WTGB severely restricted. • Surge causes potential for damage.	Not recommended.
Towing Astern	• WTGB towing equipment inadequate. • Low freeboard on fantail. • Danger of overrun/slingshot effect in brash ice. • Abnormal strain on towline at start. • Icebreaking capability reduced as power transferred to tow.	Last resort; only employ in an emergency if the WTGB cannot push vessel from astern.
Tandem Tow on the Hip (2 WTGBs pushing, each alongside)	• Ice clogging between WTGBs and assisted vessels. • Icebreaking capabilities limited.	Not recommended.
Tandem Tow Astern (2 WTGBs beam to beam with 2 hawsers to the assisted vessel)	• Difficult to maintain even strain on 2 towlines. • Potential damage from surge between the WTGBs. • Danger of vessel overrun. • Limited maneuverability.	Not recommended.
Pushing Ahead (WTGB in stern notch of a barge)	• Ice plug buildup ahead. • No icebreaking capabilities. • Loss of maneuverability.	Use only in an emergency.

Table 3-4 Characteristics of WTGB Emergency Towing in Ice

Section E: WYTL 65' - Harbor Tugs (Small)

E.1. Introduction

This chapter discusses design characteristics and performance of the WYTL Harbor Tugs.

E.2. Conning Methods

The WYTL Harbor Tug has a strengthened hull and large displacement for a relatively small vessel. It is highly maneuverable, and with an experienced crew and a good plan, is a very capable icebreaking asset. Once the cutter nears full speed, its wake can often break ice from bank to bank. Using an ebb current in rivers, narrow bays, and estuaries, a WYTL can clear ice from large areas in a brief period.

Some common recommended practices include:

- Conduct pre-briefs between the conning officer and crew before any ice operation begins.
- When operating in ice, the conning officer assumes the helm and throttle control as more immediate actions might be necessary to safely conn the cutter.
- If the cutter manages no forward movement for three seconds, come to neutral, allow the cutter to settle back in its track, and then back into the existing track. This reduces the likelihood of the cutter becoming beset.
- Backing and ramming is an effective tactic for breaking ice ridges or plugs that form in front of the cutter.
- In thick or snow-covered ice, sally the rudder while maintaining power ahead. This will loosen ice along the hull and create radial cracks ahead of the stem.

CAUTION: **Keep the rudder amidships and use only the minimal necessary speed when backing in ice to prevent rudder damage.**

CAUTION: **To avoid becoming beset or damaging the cutter's hull fittings or power plant, never apply full power farther than two to three ship lengths from the ice you intend to ram.**

E.3. Establishing and Maintaining a Track

Following are general procedures for establishing a track with the WYTL:

- Generally, the straighter the track, the more easily an assisted vessel can follow. Turns should be incremental, if possible. However, the primary consideration is any existing waterway restrictions, such as narrow channels or aids to navigation (ATON).
- Building a new track requires exiting from an existing track as near to a right angle as possible. Long-term maintenance of a track is a prime consideration when fast ice has formed.
- In many situations, break a track at lower power so as to not substantially weaken the entire ice field. This will also ensure the track remains clear of additional floes.
- Large-scale ice field shifting and accompanying area pressure relief might result in an abnormally wide track.
- The common technique for a single WYTL is to establish a base track, then widen it by doubling back along either side.
- Additional passes through a track can increase transit speed once an escort commences.
- Monitor cutter speed to minimize unwanted ice breakage caused by wake.
- If buoys are frozen in place, take care to avoid breaking ice around them to reduce ATON discrepancies.
- For this cutter, the most effective tandem operations are abeam, a ship length apart, proceeding against the current.
- While this cutter is capable as a single resource, tandem operations provide optimal results.

CAUTION: **The low-pressure areas created by icebreaking operations tend to draw cutters operating in tandem together. To counteract this effect, both cutters turn outboard as needed to regain proper range, or use the leapfrog method.**

CAUTION: **Communication via a selected VHF frequency is a best practice to allow for clear, concise delivery of cutter movement intentions. Seconds are often critical in tandem operations; dispense with radio etiquette on non-USCG frequencies.**

E.4. Turning

The WYTL has good maneuverability while using full power ahead and full rudder.

E.5. Stopping and Backing

Before backing, keep the propeller turning ahead while the rudder moves to amidships. Prop wash will prevent ice from migrating into the strut and rudder.

WARNING:

During astern operations in ice, keep the rudder amidships. Always maintain positive control of the helm. Failure to maintain positive control could allow the helm to spin and injure the conning officer, and damage the rudder and prop.

E.6. Mooring and Unmooring

When mooring in ice, consider plans carefully and remain mindful of exposure to ice floes, pier access, shore ties, and supplies.

Mooring considerations include:

- If in shifting ice, moor with the bow upstream and canted toward the pier.
- Because the cutter tracks easily, wind is a diminished factor.
- Ice serves as an excellent cushion between the cutter and pier and will usually stop the cutter quickly when power is reduced.
- If conditions allow, make necessary passes to clear ice from the pier face prior to mooring.
- Maneuvering straight into a slip poses few problems in ice. Moderate ice thicknesses (8-12 inches) requires a steep approach to allow for crew access to the dock.
- Secure all lines ashore. As long as ice is not flowing, the cutter will remain frozen in place. If the pier approach is slow and methodical, a well-defined track will remain astern, making it relatively easy for the cutter to back away from its mooring.

E.6.a. Mooring Lines

Mooring lines become more difficult to handle in freezing temperatures. Three-strand line is preferable in winter. Double braid can be especially difficult to use as the core can freeze and virtually immobilize a line. Use the heaviest line available as an “ice hawser” for line two.

The handler must be acutely aware that unusually high loads are applied to mooring lines (particularly number two) when working alongside an icebound pier.

NOTE: **Always maintain orientation in relation to the pier while using mooring lines throughout the tidal range (see Figure 3-23).**

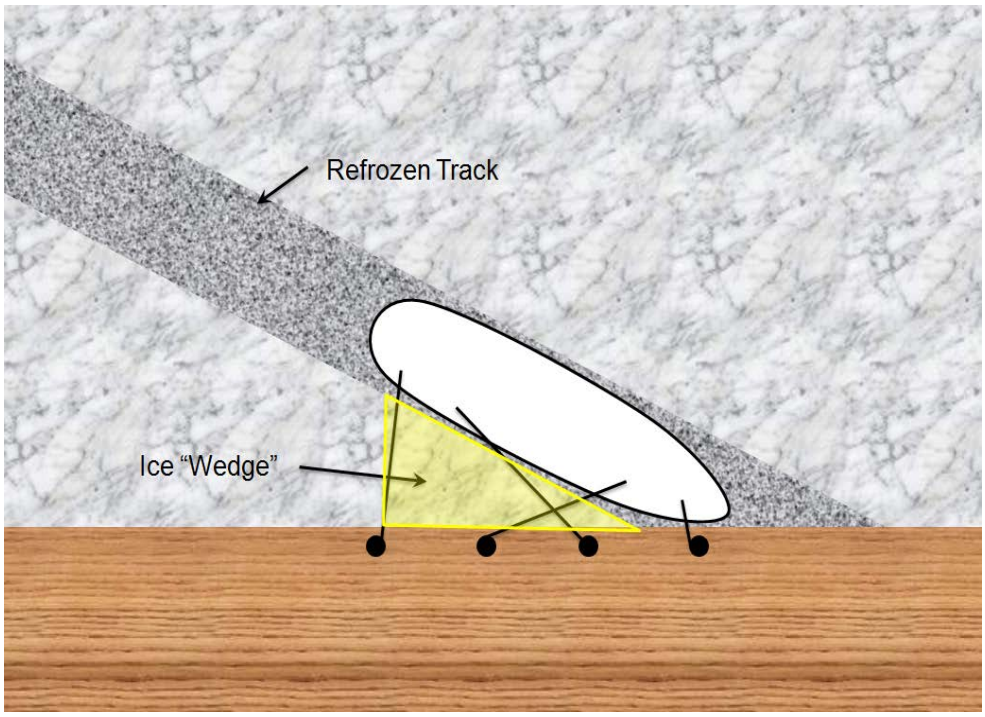

Figure 3-23 Mooring line array with ice wedge

E.7. Pier Clearing

The cutter can accomplish pier clearing by laying the cutter's bow against a sturdy section of the pier and slowly increasing power ahead, using prop wash to clear ice.

E.8. Wake Breaking

The WYTL creates a significant wake which is useful to break large areas of ice, where needed.

CAUTION: **Use care to adjust the cutter's speed in vicinity of shoreline structures such as docks to minimize wake damage.**

Chapter 4: Contingencies

Introduction

This chapter discusses contingencies while engaged in domestic icebreaking.

In This Chapter

This chapter contains the following sections:

Section	Title	Page
A	Topside Icing	4-2
B	Man Overboard	4-4

Section A: Topside Icing

A.1. Discussion

Icing is one of the most hazardous conditions that can occur at sea. A loss of stability due to accretion of ice high on a vessel's superstructure places the cutter and crew in peril. See also General Icebreaking Section B: Winter Open Water Transits.

A.2. Ice Prevention and Removal

If icing occurs and safe refuge is not available, it might be necessary for the vessel to come about periodically and run with the seas so the crew can remove ice. Transits under these conditions fatigue the crew; avoid them if possible.

After donning appropriate PPE, use the following tools to assist with ice removal.

- Wooden baseball bats.
- Axe handles.
- Plastic or wooden sledge hammers (specifically designed for ice removal).

CAUTION: **Never use metal mauls and hammers. These tools will damage the deck, superstructure, and other critical structural components.**

Limit speed to reduce spray. Spray can produce 2 to 5 inches of ice accretion per hour. Monitoring the extent and rate of ice buildup during night transits is difficult. Night transits on open bodies of water (notably the Great Lakes) during winter are discouraged except in emergencies or when the weather is favorable.

The following are general procedures when icing occurs:

- Secure all weather decks.
- When beating to windward, change course to place the seas 30 to 40 degrees off either bow.
- Reduce speed.
- Tack the cutter upwind to reduce spray and moderate roll and pitch while making progress.
- Transit along a lee shore.
- Take the seas off the quarter or ride downwind if possible.

- Where possible, slow the cutter, come down wind, and have crew remove topside icing.
- Determine a course to a harbor of refuge that will limit icing and allow a comfortable ride.
- Transit during daylight hours when possible to allow the sun to aid in de-icing. Nighttime transits decrease the visibility of ice accumulation.
- When clearing ice, be careful to not strike electrical wiring and fixtures with de-icing equipment.
- Ensure vents, damage control fixtures, and escape scuttles remain clear and functional.
- When icing conditions exist, be aware that anchors could freeze in their pockets.

Section B: Man Overboard

B.1. Discussion

A person overboard in ice conditions is extremely serious, and is potentially fatal. Immediately implementing the Man Overboard (MOB) contingency plan provides the greatest chance of safe recovery.

B.2. Self-Rescue

All crewmembers should be familiar with and practice self-rescue techniques to increase probability of survival. For the self-rescue TTP, see reference (g), Ice Rescue Operations (IROPS) Tactics, Techniques, and Procedures (TTP), CGTTP 3-50.1 (series).

B.3. MOB Recovery in Ice

All cutters operating in ice should practice MOB recovery in varied ice conditions using both direct recovery and an ice rescue team, as the situation dictates.

If a person falls overboard while operating in ice, follow the normal MOB procedures with the following considerations:

WARNING: ***Maneuver the cutter with extreme caution, as ice shifted by the vessel can easily crush a person.***

- Determine the correct recovery method.
- The conning officer selects a suitable area to heave to for direct recovery of the MOB or for deploying the ice rescue team from the buoy deck or another designated safe departure point.
- Applying appropriate bow thrust (if so equipped) toward the ice floe has worked well to hold the cutter in place while keeping the floe intact.
- Approach the MOB to deploy the ice rescue team. As shifting ice can crush an individual, the cutter must disturb as little ice as possible when approaching the MOB.
- In unrestricted waters:
  - If the cutter needs to come about, the conning officer makes a determination that the maneuver will not shift ice toward the MOB.
  - Once the cutter comes about and is back in the original track, heave to a safe distance from the MOB and deploy the ice rescue team (Figure 4-1).

- In restricted waters where confined channels do not allow the cutter to come about:
  - Stop in the track.
  - Consider lodging the bow in ice, while leaving enough turns on to hold position and avoid drifting into the MOB.

NOTE: **Remember that forward propulsion can flush the MOB away.**

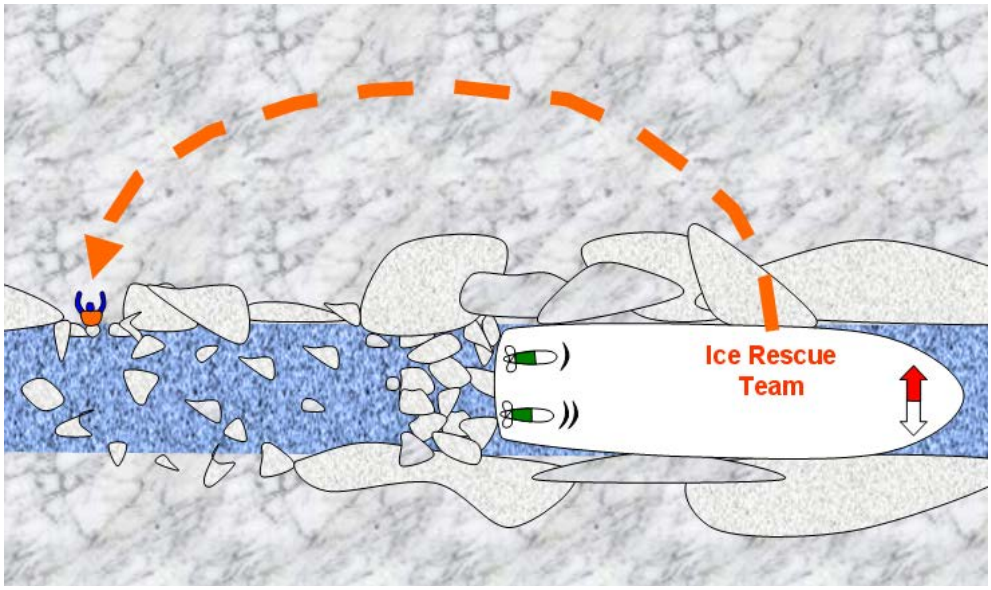

Figure 4-1: Ice rescue team deployment

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Appendix A: Definitions and Acronyms

ABB	Asea Brown Boveri
ABS	American Bureau of Shipping.
AIS	Automatic Identification System.
ATON	Aids to Navigation.
Azipods	Azipod is the registered brand name for Asea Brown Boveri (ABB) range of electric podded azimuthing thrusters. Azipod is a podded electric main propulsion and steering system driving a fixed-pitch propeller at variable speed both in ahead and astern rotation.
Brash Ice	Conglomerations of small ice cakes and chunks that have been broken off from other ice formations. These conglomerations coalesce and refreeze into irregularly shaped masses, one to six feet in diameter, usually with sharp projections. Brash ice can extend all the way to the bottom of an ice-congested waterway.
Candle Ice	Ice in the final stages of deterioration. When impacted by an ice breaker, candling ice falls apart into small thin chards of ice resembling candles.
Cakes	Detached segments of ice sheets. A cake is less than 20 meters (22 yards) across.
CO	Commanding officer.
Coverage	The ratio of water surface covered by ice to the total surface area at a specific location or over a defined area. Ice coverage is always reported in tenths (percentages).
Crack	An opening in the ice sheet or floe that is not navigable by a ship. As a general rule of thumb, “if you can jump across, it’s a crack; if you can’t, it’s a lead.” See Leads.

Drift Ice	Any unattached ice formation or area of ice other than fast ice.
Fast Ice	Immobilized ice formations. Ice frozen into place along a shoreline or islands such that winds and water currents do not dislodge the formation.
Fast Sheet Ice	An ice field.
Floes	Detached segments of floating ice sheets. Following are the recognized categories of floe measurements: 1. Small Floe: 20 to 100 meters (22 to 109 yards) in diameter. 2. Medium Floe: 100 to 500 meters (109 to 545 yards) in diameter. 3. Big Floe: 500 to 2000 meters (545 yards to 1.1 NM) in diameter. 4. Vast Floe: 2 to 10 kilometers (1.1 -5.5 NM) in diameter. 5. Giant Floe: More than 10 kilometers (5.5 NM) in diameter.
Frazil	Fine ice crystals floating freely and individually in water. The initial stage of ice formation.
Grease Ice	The water surface is completely covered by frazil but the crystals have not yet begun to freeze together. The surface has a greasy, matte appearance and may look like an oil slick.
Hummock	A smooth hill of ice that forms on the ice surface from eroding ridges. The formation of hummocks is similar erosion of mountains into smooth, rolling hills.
Ice Accretion	Icing of the superstructure and decks. Occurs during open water transits when air temperature is near or below freezing.
Ice Edge	The boundary, at any given time, between the open sea or lake and ice of any kind, whether drifting or fast.
Ice Jam	Formed when drifting masses of floes and cakes are forced to converge by the configuration of shorelines and/or fast ice formations.

Lake Ice	Ice formed on a lake, regardless of observed location. Nearly all ice on lakes can be classified as either “blue” or “white.” Blue ice consists of closely packed water crystals with relatively few impurities. White ice incorporates large quantities of air. Blue ice is stronger.
Leads and Variations	Any opening or passageway through sea ice that is navigable by a ship. Listed below are differing variations: 1. Blind Lead: A lead blocked at one end (dead end). 2. Shore Lead: A lead between pack ice and the shore. 3. Flaw Lead: A lead between pack ice and fast ice.
MOB	Man Overboard.
MPCMS	Machinery Plant Control and Monitoring System.
Nipped (Pinched)	Ice pushes against both sides of the hull, increasing the friction against the hull. This pressure against the hull is typically caused by wind driven ice floes. Severe nipping can cause crushing of the hull.
ORM	Operational Risk Management.
Pan	Term used by commercial mariners to describe an ice sheet that may be composed of several bonded plates or just one large plate.
Pancake Ice	Predominantly circular pieces of ice. Pieces are one to eight feet across with raised rims caused by striking against one another.
Plate Ice	Flat ice with approximately uniform thickness and without ridges or windrows.
Polynya	(Pronounced, “Pul en ya”). An open, non-linear area of water fully surrounded by ice. This water area remains constant in size and usually has an oblong shape. Some of these are recurring, due to the natural upwelling of warmer water currents.
Pool	A small body of water (usually fresh melt water) in a depression or hollow in ice. Also known as a “Melt Pond”.

PPE	Personal protective equipment.
Pressure Ridge	A line or wall of broken ice forced upward and/or downward by pressure. Usually formed when two floes collide. See Windrow.
Rafted Ice	A type of ice formed when one floe overrides another. Some parts of the overlap trap water, which may freeze and cement the floes together. Other parts may trap air and take on a characteristic white appearance.
Rind Ice	A brittle, shiny crust of ice, usually less than three inches thick. It forms on a quiet surface by direct freezing or from grease ice. Rind ice is easily broken by wind or swells and usually breaks into rectangular pieces.
River Ice	Ice formed in or carried by a river, regardless of observed location.
Rotten Ice	Ice that has become honeycombed because of melting and is in an advanced state of disintegration. Rotten ice may appear transparent or dark when saturated with water. See Candle Ice.
Rubble	Coarse broken plate and brash ice that has accumulated over a large area due to strong winds.
Sea Ice	Any form of ice found at sea that has originated from the freezing of sea water.
Sea Smoke	Fog formed when warmer water vapor contacts cold air. This most commonly occurs when very cold air drifts across relatively warm water.
Shore Ice	A basic form of fast ice that is attached to the shore or grounded in shallow water.
Skim Ice	Frazil crystals have frozen together, but do not yet exhibit tensile strength. Ripples may move through skim ice.
Slush	Snow that is saturated and mixed with water on land or ice surfaces, or as a viscous floating mass in water after a heavy snowfall.
Snow Ice	Wet snow that has refrozen.
TTP	Tactics, techniques, and procedures.

Whiteout	An atmospheric optical phenomenon that appears to engulf the observer appears in a uniformly white glow. Shadows, horizon, and clouds are not discernible; sense of depth and orientation are lost. Only very dark, close quarters objects can be seen. On the Great Lakes a uniformly overcast sky, blowing snow, and an unbroken ice cover can contribute to a whiteout.
Windrow	Rows of ice piles formed by drifting masses of floes and cakes being pushed against the shore or against fast ice by the wind. Windrows continue to grow as long as the wind persists. See Pressure Ridge.

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Appendix B:
Direct Assist and Besetment During Assist Checklists

VESSEL DIRECT ASSISTANCE CHECKLIST

1) VESSEL INFORMATION:

Date/Time: _____ AOR/OP: _____

Drafts. Fore: _____ Aft: _____ Displacement: _____

Vessel Name: _____ Vessel Type: _____

Cargo and Tonnage: _____ Destination: _____

Fix vessels location: _____ Vessel HP: _____

Soft water stopping distance: _____ Limitations/Restrictions: _____

Distance of AIS antenna
from bow: _____

Ensure the charted depth along the intended course is adequate for the vessel.

2) EVOLUTION:

☐ Brief Evolution Plan (discuss approach, speeds, risks, ice conditions, etc).
☐ Evaluate the latest conditions
☐ Conduct Risk Assessment Score: ____
☐ Test Machinery: Engine/SSDG: ☐ Steering: ☐ Bubbler: ☐
☐ Set Restricted Maneuvering Doctrine.
☐ Establish communications: Primary: ☐ Secondary: ☐
☐ Log the evolution.
☐ Brief approach plan to vessel (i.e. circle vessel, stop in front, etc).
☐ Brief vessel: "Keep all turns off and your rudder amidships while we are maneuvering close aboard and until contacted by us over radio."
☐ Brief vessel on escort procedures that will apply upon a successful direct assist:

☐ Brief distances: (optional) Min distance: _____ Max distance: _____

☐ Emergency Light Brief: "Should our cutter become beset, we will turn on our flashing emergency light. When you see this emergency light, immediately stop your vessel. We will also attempt to contact you via radio and sound 5 short blasts on the ship's whistle."

☐ Emergency Light Check: "I will now energize the flashing emergency light, please confirm that you can see it."

☐ Radio Communications: "We will contact you every ____ minutes on channel ____ to check the status of the escort. If communications fail on channel ____ attempt to make contact using channel ____. If you cannot contact us via radio, sound the danger signal."

☐ Confirm maneuvering plan on the bridge.
☐ Notify vessel(s) that we are commencing the direct assist.
☐ Conduct direct assist.
☐ Complete direct assist, notify vessel(s) to come ahead in our track, and commence escort procedures.
☐ Log the evolution.

3) EMERGENCY BESETMENT PROCEDURES:

☐ Activate flashing emergency light.

☐ Sound danger signal (five short blasts).

☐ Contact ships in convoy via radio and ensure they stop their vessel(s).

☐ Initiate action to extricate cutter from besetment.

WARNING: ***Be aware that these procedures only cover beset assistance and do not address the many other significant emergencies that may occur during underway operations such as fire, loss of steering, MOB, etc. Address these other emergencies per established procedures.***

Navigator: _____

CO: _____

Besetment During Ice Assist **CG-ICE-01**

USCG: _____ DATE: _____

References:
(1) Coast Guard Navigation Standards COMDTINST M3530.2 (series)
(2) Navigation Rules, COMDTINST M16672.2 (series)
(3) Watch Officer's Guide

Purpose:
(1) To train the ship's bridge and navigation teams in conducting preparations for ice assists.
(2) To train the ship's bridge and navigation teams in responding to emergencies during ice breaking evolutions.

Procedures:
(1) Conduct a Navigation Brief and Direct Assist/Convoy Brief.
(2) Test the crew's response to a besetment in ice while escorting one or more vessels.

Requirements:
(1) Bridge Watch team.
(2) Navigation Detail for Ice Ops.

1. *Conduct Navigation brief*:

(a) Was navigation brief conducted prior to ice operations?	Yes ☐	No ☐	NA ☐
(b) Were all members of ship control stations in attendance?	Yes ☐	No ☐	NA ☐
(c) Were present and forecasted weather conditions briefed?	Yes ☐	No ☐	NA ☐
(d) Were tides and currents briefed?	Yes ☐	No ☐	NA ☐
(e) Were ice conditions briefed, including current track status?	Yes ☐	No ☐	NA ☐
(f) Were the status of nearby AtoN briefed?	Yes ☐	No ☐	NA ☐
(g) Was a method of determining distance briefed, including AIS antenna positions?	Yes ☐	No ☐	NA ☐
(h) Did cutter notify VTS of evolution?	Yes ☐	No ☐	NA ☐
(i) Was type of IALA buoyage system identified?	Yes ☐	No ☐	NA ☐
(j) Were charts required for transit identified?	Yes ☐	No ☐	NA ☐
(k) Were latest editions and corrections verified?	Yes ☐	No ☐	NA ☐
(l) Were corrections and changes since last brief identified?	Yes ☐	No ☐	NA ☐
(m) Was proposed track information briefed?	Yes ☐	No ☐	NA ☐

(n) Were anchorage or mooring buoy procedures briefed? Yes ☐ No ☐ NA ☐

(o) Was significant anticipated traffic briefed? Yes ☐ No ☐ NA ☐

(p) Was the status and capability (length/HP ratio) of convoy vessels briefed? Yes ☐ No ☐ NA ☐

(q) Was navigation equipment status briefed? Yes ☐ No ☐ NA ☐

(r) Was engineering plant status briefed? Yes ☐ No ☐ NA ☐

(s) Were special considerations/events briefed? Yes ☐ No ☐ NA ☐

(t) Were emergency procedures and contingency plans briefed? Yes ☐ No ☐ NA ☐

(u) ****Was ORM discussed?** Yes ☐ No ☐ NA ☐

(v) **** Was the Navigation Brief signed by the Commanding Officer and Navigator?** Yes ☐ No ☐ NA ☐

2. *Bridge and watchstander performance:*

(a) Was the emergency checklist completed? Yes ☐ No ☐ NA ☐

(b) **** Did the conning officer take appropriate action?** Yes ☐ No ☐ NA ☐

(c) ****Was the emergency light energized immediately?** Yes ☐ No ☐ NA ☐

(d) **** Was the danger signal sounded?** Yes ☐ No ☐ NA ☐

(e) Were radio comms clear and concise? Yes ☐ No ☐ NA ☐

(f) Was noise and confusion kept to a minimum throughout the evolution? Yes ☐ No ☐ NA ☐

(g) Did watchstanders continuously evaluate risk? Yes ☐ No ☐ NA ☐

3. *Overall Drill Performance Evaluation:*

Successful: ☐ Unsuccessful: ☐

Successful= No Critical Drill factors () were incomplete.
Unsuccessful= A minimum of one critical safety factor was incomplete.

Besetment during Ice Assist **CG-ICE-01**

Ref. No.	Task Remarks	Follow-up Actions

Evaluator: _____ Date: _____

Command: _____ Date: _____

*** Keep on file for two years***

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Appendix C:
St Mary's River Icebreaking Guide

ST MARY'S RIVER ICEBREAKING GUIDE

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INTRODUCTION

The St Mary's River is one of the most critical waterways within Operation Taconite, the largest domestic icebreaking operation in the United States. Under international agreement, Operation Taconite assures icebreaking assistance in U.S. and Canadian waters where commercial icebreaking resources are either unavailable or incapable of handling the difficult ice conditions. Extreme weather conditions, narrow channels, relatively shallow waters, locks, and large numbers of vessel transits make the St. Mary's River a particularly challenging icebreaking environment.

This guide is simply a tool to help ensure specific, time-tested icebreaking approaches and techniques are passed on to icebreaking crews in following years. The data included in this guide came from numerous winters of data and experience on the St Mary's River. This by no means makes this gospel, but valuable insight was gained because each winter is distinctly different, tactics that were unsuccessful in a light ice year proved effective in a heavy year or vice versa. Local residents and users provided incredible insight to certain approaches. The insight these maritime users provided KATMAI BAY was critical and they should be consulted regularly.

ICE MANAGEMENT THEORY

Ice management within the St Mary's River can best be defined as maximizing the efficiency ice can be controlled while minimizing the effect on vessel movements, damage to vessel machinery, and to shore side property. There are three aspects to consider while conducting ice management: Control of ice growth, Control of ice movement, and Productive ice breaking techniques.

1. The St Mary's River will freeze each winter, the time and severity with which it freezes is dependent on a number of factors. These factors include; the water temperature, the ambient air temperature, the flow rate of the river, and the amount of "lake effect" snow that falls in the area. Once ice begins to form (usually in December), the primary mission should be to keep the growth to a minimum, because in the area of Sault Ste. Marie from December to early April, the temperature only gets colder. Once freezing degree-days begin accumulating in late November or early December the water temperature will only drop. Thus we say in the Fall "the more ice you break, the more you make". The more open water is exposed during this period, the more ice will re-form, if that ice is broken again, it will freeze again, and so on.

    a) Water temperatures near 35 degrees prims the river for ice formation. While no significant ice growth will take place with temperatures above 32 degrees, nothing more than a mild snowfall will quickly lower the water temperature enough for ice to form. With water temperature in the low 30s, snow will not melt in the open water, it will appear as a white slurry which will quickly turn into snow ice.

    b) Freezing Degree Days (FDDs) are computed by subtracting the average daily air temperature below freezing (32 degrees F). For example, the average daily temperature was 20, that day 12 FDDs were accumulated. A count of FDDs gives a good indication of potential ice growth. A steady accumulation of consecutive FDDs is more conducive to ice formation than a staggered accumulation of FDDs. Generally, non-restrictive ice will form with 150 FDDs. The river will become difficult for navigation after an accumulation of 250 FDDs.

    c) The river has a steady water flow from the Soo Locks to Detour. The rate that the water flows down-river is dependent on Lake Superior drainage, the number & degree the compensating works are opened above the Soo Rapids, the amount of water Edison Sault Electric, the Soo Locks power plant, and the Canadian power plants are running to keep up with demand. All of these factors combine to form the water flow rate, measured in cubic feet per second (cfs). When ice forms, it primarily remains on or near the surface of the water. As it melts or is put under pressure, it will sink. However ice forming over a steady current will not tend to freeze as thick as ice in slack water, with shifting of minimal currents. As the ice gets thicker in the river the water flow is restricted to the deeper channels. This restriction will have a dual effect on the river dynamics by both increasing the current flow within the channel and increasing the pressure of the unbroken track edges.

    d) That predominate winds during the winter months are from Northwest to Northeast. Only on occasion do the winds shift out of the south. West and Northwest winds will cause "lake effect"

snow to fall in the St Mary's River system. This is significant due to the fact that heavy snowfalls will "seed" the river rapidly cooling the water to freezing temperatures.

2. The control of ice movement is a vital aspect of this theory. The navigational channel is only 300 feet wide through the most difficult turns in the lower St Mary's River. With an average water flow rate (approximately 70,000 cfs) and winds out of the West or Northwest, broken ice on or near the surface will move down river with tremendous force. It is the management of this movement that this guide is based. Proper management will ease the burden ice places on shipping. When not properly managed, ice will jam into narrow choke points and turns within the river and distort tracks increasing the difficulty of vessel transits. This theory is based on keeping excessive ice from entering the navigational channel and dealing with the ice that is in the channel.

   a) The most effective tool to prevent excessive ice movement is positive control of the ship's wake. This includes the wake of users as well as the wake of the icebreakers. Any ice broken by the wake of passing ships will be drawn into the channel. The higher pressure of the fast ice on the channel edge will force the broken plate toward the lower pressure of the broken ice track. Further damage to the fast ice edge could cause plate to shift into the channel effectively closing any established ice track.

   b) Brash accumulation within the ice track is a reality of winter navigation. However brash can be moved out of the more difficult turns into straight courses where it is more manageable. There are a couple of techniques that may aid in the process of brash movement. The first and most effective is the use of relief tracks. There are two prime areas within the St Mary's area that greatly benefit using this technique (see relief tracks for Johnson Point and Stribling). The second method is a little slower, but still yields good results. By maintaining smooth track edges in the turns the river current will slowly

3. The approach taken to break ice within the river will vary depending on many factors: type/thickness of ice, weather, and characteristics of the vessel being assisted.

   a) There are various forms of ice. Because ice forms in the winter and melts in the summer there is no ancient ice (that incredibly hard ice that exists on the Poles). Because the river is mostly protected from high-sustained winds (unlike Whitefish Bay or the Straits of Mackinac), the ice will be less likely to form difficult windrows. The most prevalent forms of ice are: new plate ice, brash ice, snow ice, and small flow ice. The thickness of ice varies considerably within the river. The thickness of this ice depends upon:

      - air temperatures
      - water temperatures
      - water flow rate
      - amount of exposed water during Freezing Degree Days

      1) <u>Plate ice</u> is the hard, clear ice that forms when water freezes. This ice will snap with the wake of the ship and has a tendency to leave rough uneven edges. Use slow speed and the beam of the ship to get the desired smooth edges while breaking Plate ice in the turns. During hard winters Plate ice has been recorded in excess of 30".

2) Brash ice. Every year regardless of the severity there will be certain amounts of brash accumulation. Brash is ice that has been broken/frozen/and broken several times until it takes on the look of crushed rock. Brash is very difficult to maneuver in and causes the screw to loose much of its force. Brash has been recorded in excess of 12-15' in certain parts of the river. These deep accumulations are usually confine themselves to turns and choke points, but can by themselves pose a great threat to a vessel's transit.

3) Snow ice is the ice that forms from snowfalls it is flat and milky in color. Because it is frozen snow it is aerated making it lighter and not nearly as hard as Plate ice. Snow ice also has flexibility so it does not break as sharp as Plate ice from the ship's wake.

4) Flow ice is the small broken plates of ice that travel on the current. These present the biggest problem to navigation. The flows will quickly stack up in choke points often turning on their side due to the current pressure. Even small flows less than 1" in thickness when stacked on their side (like a deck of cards) will pose a serious threat to vessel transits.

b) Weather is one of the most important factors to consider when undertaking an ice-breaking mission. Wind, air temperature, and precipitation (snow or rain) are factors that may negate or benefit your effort.

1) Wind is most important during flushing operations. North or Northwestern winds create ideal conditions for moving large quantities of ice out of the river. If these conditions do not exist, do not conduct flushing operations. If ice doesn't move out from the channel the broken plate will simply distort the track and push AToN underwater, out of mariner's view. A very important part of each turn is the associated AToN marking it, especially the light of a buoy. If, for example the buoy is under the ice or not visible, the tendency of the ship master is to ease off of the throttles (rightly so) thus slowing their turn rate. You can really tell a difference with the aggressiveness of the masters when the associated aids are lit and watching properly. Therefore, be careful not to wake these buoys under the ice when grooming turns. A little extra effort to keep them watching properly will make a big difference.

2) Air temperature can create a couple of conditions that will severely hamper ice breaking efforts. Extremely cold temperatures (below 5 deg F) will cause the formation of Sea Smoke in any open water area. Sea Smoke is very low lying fog that forms as the open water quickly freezes in the cold air. It is very dense and can create low of visibility for low profile vessels. If these conditions exists limit ice breaking efforts. Cold temperatures will also effect track conditions, brash ice will quickly refreeze negating track grooming efforts done to far in advance of vessel transits.

3) Snow will greatly diminish ice-breaking efforts. While it does have an insulating effect on ice fields, it creates tremendous drag on the cutter. Heavy snow accumulations will also restrict the effect of the ship's wake. Rain has both positive and negative effects on ice fields. Rain benefits by quickly dissolving any snow accumulation on the surface; it will also begin to melt plate ice. The negative effect is the weakening of stable ice plates. These plates will usually weaken near shore, with

the right current or wind vector they will move into the channel and have to be dealt with to maintain safe navigation.

c) Every vessel moving in the St Mary's River has different characteristics. In general there are three that may be categorized; 1000 footers and smaller Ore carriers, Saltys, and Tug-n-tows.

1) Thousand foot vessels are the biggest challenge when it comes to breaking proper tracks in the river. Their wide beam, plumb bow/beam, large turning radius and deep draft are the extremely limiting factors in their maneuverability. A constructional difference between the 1000ft vessels and smaller ore carriers is in the construction of their sides, particularly near the stern. The smaller ore carriers' sides are angled allowing their sterns to ride over the ice while turning. Not so for the 1000ft vessels, their sides are plumb extending straight down through the ice level. This is important to keep in mind when assisting one of the large ships through a turn. The specifics outlined for turn grooming and track maintenance in this guide are designed for their transits. Vessels of smaller dimensions should easily navigate within these guidelines.

2) Salties are ocean-going vessels transiting the Great Lakes. They typically have high horsepower propulsion plants. Their sides near the stern also allow for easier turning much like the smaller ore carriers. Usually if there is an established and groomed ice track they have little difficulty making the transit. Salties have the toughest time when they are transiting in ballast. Typically when in ballast their bulbous bow rides above or near the ice level. The added drag of the bulbous bow can create great difficulty during ice transits.

3) Tug-n-tows can present the second greatest challenge during winter transits. The greatest problem comes when the tug is pushing an empty barge. Typically a light barge doesn't have the displacement to move ice out of its way so the light barge rides up on the brash, and the tug lacks the horsepower to keep it moving. The most ideal tactic is to place the tug-barge behind a large ore carrier for the transit. The lead ship will move brash and flow ice to the sides of the channel ahead of the tug and barge.

PHASES OF ST MARY'S RIVER ICEBREAKING

PRIOR TO THE LOCK CLOSURE
DURING LOCK CLOSURE
REESTABLISHING TRACKS
SPRING BREAKOUT & FLUSHING

PRIOR TO THE LOCK CLOSURE

Significant ice can form as early as the beginning of December or as late as mid-January. Typically the first ice formation begins in the Mud Lake area, particularly in the Winter Point area. The slow river current and the relative protection of Neebish Island create ideal conditions for ice formation.

Initial icebreaking in the St Mary's River should be limited to periodic ice reconnaissance to locate any areas of significant build up. A critical step in establishing tracks at the beginning of ice season is to let the Lakers show the way. The large ships can easily transit through the first formation of thin ice (less that 1"). These first few transits establish the basic outlines for track and turns. It is easy to see the vital Stern Relief Areas that must be maintained throughout the rest of the navigation season. Most of the commercial traffic can manage ice up to several inches thick, therefore it is recommended to keep recon efforts to a minimum and allow the traffic to initially break on it's own. Every effort must be made to maintain these very fragile new ice tracks. Breaking ice outside the newly established tracks simply creates opportunity for more ice to form particularly in the late fall and early winter as daily temperatures fall. Periodic ice recon trips coupled with a close eye on the forecasted weather and an updated ship transit list should provide an adequate sign when daily track maintenance should be conducted.

Early, significant ice formation within the river, as was the case in 1996, means almost certain escorts and direct assists. There will most certainly be underpowered tugs, tug/barge combinations, or salt water sea going vessels "caught" in the river making their final winter transits. If this occurs, then transiting outside the established tracks will be necessary to free these vessels. Frequent direct assists can cause severe damage to the established tracks and cause freshly broken plate to drift into brash filled tracks, creating brash accumulation and ice jams. An increase in track maintenance ahead of vessel transits along with accurate vessel arrival schedules may help prevent these damaging measures.

If an early freeze is not the case, then the most important factor to consider is "Ice Management" throughout the entire river system. Ice Management is particularly important around the Nebbish Island area, the winter of 1997 taught us that minimal ice breaking above Nebbish Island substantially reduced the broken plates that drift to choke points in Middle (Stribling) and West Nebbish Channels (Rock Cut). Tracks should be broken only to the width to accommodate a 1000ft ore-carrier with a beam of 105ft. A good track width is approximately 140ft. This allows some room of the 1000 footer to push brash from its plumb bow.

DURING LOCK CLOSURE

Upon lock closure the focus of attention is shifted to the Sugar Island ferry crossing and Oil Tanker escorts. Providing assistance to ferries is explained in the "Ferry Crossings" section of this guide.

With closure of the locks comes the closure of West Neebish Channel. The residents of Neebish Island establish two ice bridges above and directly below the Rock Cut. These ice bridges are extremely important because the

ferry will eventually be unable to run and these become the resident's only avenue between the mainland and island. It is extremely important that the ice in these two areas remains undisturbed until the scheduled lock opening on 25 March.

Oil Tanker escorts are vitally important to the residents of Sault Ste Marie, Ont. Heating oil is transported by Tank ship to meet the heating demands of the city. The tanker usually maintains weekly runs, but they may increase in frequency if weather is severe.

An important aspect of Oil Tanker escort is the fact that they have a narrow beam. A single track approximately 80 feet wide should be all that is required for their transit.

NOTE: Maintaining wider tracks simply exposes more open water, which will freeze and add to the ice accumulation within the channel.

Two methods have been successfully employed to provide escort:
a. Thin to moderate ice thickness, leave Sault Ste Marie sometime in the afternoon the day prior to the tanker's arrival and moor at Lime Island. Set sailing orders for the next AM in time to meet the tanker for the up-bound transit at the lower ice edge. Escort the tanker all the way to SSM Ont and pull into Group for an overnight stay. Set sailing orders for the next AM by coordinating with the tanker's scheduled sailing time. The down bound escort should only take him to the lower ice edge and then return to SSM.
b. The second method is ideal for moderate to heavy ice. Set sailing orders for early AM the day of arrival of the tanker (approx 0500), meet the tanker at the lower ice edge and pick up the escort back to SSM. Schedule the next day's down bound transit to coincide with the tanker's sailing time. The second method is preferred with heavy ice because it gives two passes (down bound then up bound) to loosen the established ice track for the tanker. For light to moderate ice it should only take the lead escort to sufficiently loosen the ice track.

REESTABLISHING TRACKS

The time to begin reestablishing tracks in the lower St Mary's River depends upon the weather and availability of the other icebreaking assets. Past weather dictates just how much ice is actually in the river. A severe fall/winter usually means thicker ice in the spring. If the weather is less severe during these periods then there will be less ice. This is important because you want to start the Spring Breakout process at the right time. Too early means your making ice, to late means the tracks don't get established before the locks open on March 25. Note: Quite often up-bound traffic will begin arriving in the river as early as March 23rd to position them at the lower lock entrance. The winter of 94/95 was mild and we laid the lower river tracks in three days beginning 16 March. However, the winter of 95/96 was so severe that we started on 9 March and barely had the tracks in by 25 March. If the weather conditions are good…moderate temps, prevailing NW winds, then I strongly suggest commencing the flushing of the lower river by the end of the first week of March. The overnight temperatures will most likely be

cold enough to still make ice, but nothing that can't be quickly flushed out by an hour or two of productive flushing the next morning (given the right conditions, as previously discussed). Three inches of newly formed plate ice (from the overnight freeze) is a lot easier to move through than 20 inches of refrozen brash.

NOTE: When planning reestablishment of tracks be ready to accommodate Oil Tank escorts that may take as much as 3 days of the schedule.

When reestablishing tracks begin with the dead center of the channel. Most courses are marked with range markers. Follow the deepwater ranges for the initial cut. It is extremely important that a skilled helmsman be utilized to make the initial cut as straight as possible. All further cuts will be based on the initial and the final pass will amplify any small alterations in course. After the initial cut begin by taking another full ship width to the right or left of the initial and repeat the full ship width cut to the opposite side of the initial. The last two cuts should be half-ship widths to each edge of the track. The final cuts should be executed at slow speed keeping the track edges as smooth as possible. A 140 has a beam of 37 feet, but only breaks an ice track of 35 feet. With three full width and two half-width passes you will establish the required 140-foot track width required for the largest freighters.

SPRING BREAKOUT

Spring Breakout should begin in the lower St Mary's River and at a time when establishing tracks won't create too much extra ice. A careful balance should be established between the reestablishment of tracks and flushing operations. Do not get carried away with flushing to early. Spring overnight freezes may erase any established tracks with refrozen small flows of broken plate.

FLUSHING

NOTE: Flushing operations below Moon Island and Johnson's Point are only beneficial with Northerly wind directions. Normal river current is not strong enough to move broken plate all the way out of the system. The river current above these two points is strong enough that flushing operations is not dependent on wind directions.

The flushing process must begin at the mouth of the St Mary's River so that ice can flow into Upper Lake Huron and hopefully be broken up even more by the wind driven seas. Ice must be totally broken out past Frying Pan Shoal. If not, broken ice in the river above those areas will jam up onto the Drummond Island Ferry crossing. Thus, it is imperative to begin each lower river flushing operation with a quick look out past Frying Pan to ensure a sufficient open water catch basin exists to receive the ice you will be flushing.

The "wedge" method simply means opening a large area at the bottom of an intended space and breaking ice toward a point at the top of this same area creating a funnel look—this approach combined with the right conditions of wind, current, and moderate weather will force the ice to move down river. It is important to keep the edges along the sides of the wedge as smooth as possible because broken pieces of ice trying to move down river with the current might possibly hang on jagged corners, thus slowing the ice flow.

Once clearing the mouth area, begin breaking a wedge past Watson's reef Light toward Sweets Point Light in the South Channel. Use whatever methods necessary to break new plate then "project" the WTGB wake as far as possible in towards the shoal water. It is critical to create as much open water as possible behind Watson Reef Light and Sweets Point Light toward shore. This is the inside of the turns and the prevailing current will flow the ice through these areas. Flowing ice will need all the room you can open up to make the bend from above Sweets Point Light.

Resume wedge operations toward Lime Island and this time try and break the ice along the southern shore of Lime Island. A critical jam point is between buoy #14A and the Southern end of the dock at Lime Island. The ice along this area (close to the island) should be thinner because it is in the lee of the island and protected form the current (and winds somewhat). This area, like Watson's reef and Sweets Point is critical because it is the inside of the turn and ice broken up river from here will tend to move into this bend between buoy 14 and the Lime Island Coal Dock. There is ample water outside the buoy line to push the wake toward shore (use caution shoal water is present). It may be advantageous to create a fairly large wedge area here just inside the Lime Island Traffic Buoy. This is fairly sharp turn and is more exposed to the winds, combined with the tighter the space, the more likely the ice will jam here while trying to make the turn.

Continue running the "wedge" up river towards Point Aux Frenes. Concentrate efforts on the Eastern edge from Lime Island to abeam of Round Island. Then shift efforts to the Western edge from Round Island to the turn at Point Aux Frenes. Beware of shifting plates that may come from Raber Bay area on a NW or W wind. Again the inside of the turn at Point Aux Frenes is vital for breaching Mud Lake. Use the ship's wake to break ice towards land as far as possible on the "green" side of the channel. As the turn flushes out continue "wedge" operations all the way through Mud Lake.

An area of concern lies at the Mud Lake Junction Buoy. The fast ice between the down bound and up bound channels is extremely unstable and may break loose at any time. Be cautious of shifting plates in this area and ensure all the buoys in the area are broke free of ice prior to the plates shifting. If the buoys are encased in ice they will be dragged off station and may become hazards to navigation.

The key to flushing out the Rock Cut starts in Mud Lake. Once the Western edge of Mud Lake begins to move, concentrate flushing efforts south of Winter Point near Moon Island turn. Next work the stretch between Moon Island turn and Sawmill turn.

CAUTION: there are many residences on both the mainland and Neebish Island. Wake damage is under close scrutiny in these areas.

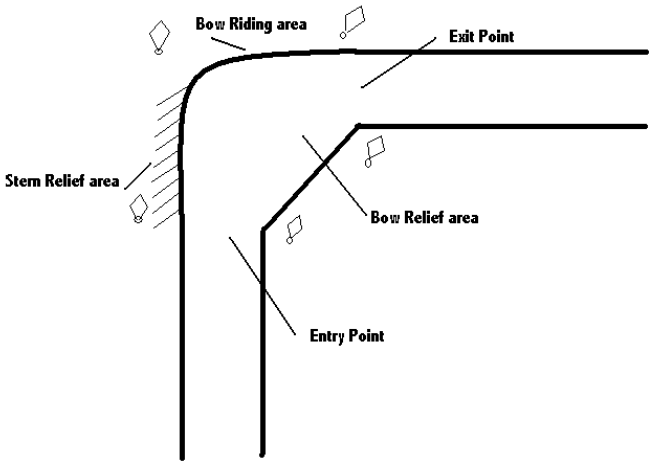
To continue flushing operations in the more restricted turns of the river simply use the ship's power to project the wake beyond the channel edges. Perform frequent down river runs to ensure the broken plate is not stacking up in a turn or choke point.

GROOMING SPECIFIC AREAS

TURNS

The turns on the St Mary's River are where KATMAI BAY and other WTGBs earn their keep. Turns are the most critical part of the waterway because of the difficulty most large, squared stern ore-carriers have trying to execute a turn. Most of these vessels have sufficient power to move forwards along a straight-line course, and can usually backup into their broken track, but turning is difficult. Why emphasize something that seems logical? The important fact to remember is that vessels most likely will do OK on the straightaway within the river, so don't labor on them. Groom them as mentioned below, but put the majority of effort into the turns. Even if a vessel gets beset in a straight away, getting them free and underway again in the river is much easier then getting one started in a turn.

Anatomy of a turn. Every turn has distinct areas that icebreakers should be aware of: Entry Point, Stern Relief, Bow Riding Area, Bow Relief Area, and Exit Point. Below is a graph of a generic right hand turn with these vital areas labeled.



Entry Point – This is the point in the turn where the ship's bow first crests the beginning of the turn. It is at this point that most Captains will begin to make their turn. This is also a crucial junction for the ship captain. If their ship's head does not begin to change within the first few feet of the Entry Point many captains will take off their power diminishing their turning ability. This causes the bow of the ship to reach further into the turn than usual. This reaching of the bow is called "head reaching" and will cause great concern for the captains.

Stern Relief Area – This is where the vessel's stern will swing as the ship's head comes around. It is opposite the direction the ship is turning and subject to great pressure as the ship's square stern moves through the ice. The vital thing about the Stern Relief Area is that it should be loose with plenty of room. At times the to provide enough Stern Relief Area the ice may have to be broken outside of the buoy line.

It is best to use the ship's wake or prop wash while casting for this purpose. Ship Masters say this part of the turn is the most critical.

Note: When waking the bottom outside edge of the turn and casting within this area be careful not to do too much damage to the inside of the down current point of the turn. If two much ice is broken here, it will settle in the approaches, accumulate, and possibly slow the approaching vessel down at a time when they should be beginning to increase their power.

Bow Riding Area – This is the area of hard ice on the outside edge of the turn. Normally the ship captains do not test this area, unless it has been a very hard freeze and there is a significant amount of ice. Providing there is thick ice (normally >2 feet) the ship Captains will use the higher pressure of the Bow Riding Area to assist in getting the bow of a ship to come around.
Note: While working turns is important to leave this area untouched as much as possible. GUARANTEED…if the master feels the Bow Riding Area is not hard enough to deflect his/her bow or slow the progress toward the channel edge, then they will not use power, which will inhibit their turn rate.

Bow Relief Area – This area of a turn is the broken ice, encompassing much of the middle ground, on the inside of the turn. The ice in this area should be broken and loose so as not to obstruct the swing of the bow as the ship comes through the turn.
Exit Point – This is the end of the turn. Ships should be steadied up on their exit heading prior to reaching this point in the turn. Even if they are a few degrees shy of their heading, ice pressures on either bow could send them off and prevent them from gaining their track for the next course heading.

Grooming a turn

The following is a description of how to groom a generic turn. It is just the basics for getting a turn started; ice thickness, snow cover, brash accumulation and air temp will dictate alternate approaches to preparing turns. Thick, refrozen brash or heavy snow may require multiple passes through your own track to generate a wake. Every turn in the St Mary's River is unique and more precise instructions with specific tips follow in the "specific turn" sections below. The definitions above serve as reference points for this section. We do not always have a choice from what direction we approach a turn. An important time saving approach is to make every pass through a turn count, so this is written for any approach scenario. A right or left hand turn designation is based on the direction of the traffic, not the approach of the Icebreaker.

Right hand turn

Approach from Entry Point – First pass on left track edge, carry wake through Stern Relief Area (if possible), cut back wake through Bow Riding Area, cast at Exit Point. Second pass through Bow Relief Area, carry wake to track edge (no further than intact plate), cast at Entry Point. Successive passes should work towards the middle of the turn.

Approach from Exit Point – First pass through Bow Relief Area, carry wake to track edge (no further than intact plate), cast at Entry Point. Second pass on left track edge, carry wake through Stern Relief Area (if possible), cut back wake through Bow Riding Area, cast at Exit Point. Successive passes should work towards the middle of the turn.

Left hand turn

Approach from Entry Point – First pass through Bow Relief Area, carry wake to track edge (no further than intact plate), cast at Exit Point. Second pass on left track edge, keep wake in check through Bow Riding Area, increase power and carry wake through Stern Relief Area, cast at Entry Point. Successive passes should work towards the middle of the turn.

Approach from Exit Point – First pass on left track edge, keep wake in check through Bow Riding Area, increase power and carry wake through Stern Relief Area, cast at Entry Point. Second pass through Bow Relief Area, carry wake to track edge (no further than intact plate). Successive passes should work towards the middle of the turn.

SPECIFIC TURNS

a. Frechette Pt Range (6 mile turn) – Both right and left hand turn. This turn can be characterized by large amounts of broken plate from Sault Harbor that have broken and floated past Little Rapids Cut. The Ice boom placed above the Sugar Island ferry catches a majority of the flows, but a significant amount of ice will bypass the area. This ice will venture down to the ice edge. If the ice has not formed past 6-mile point it will begin to jam up at this choke point. It is possible to break the fast plate below this area and get the heavier plate to shift down into Nicolet Lake. Extreme caution should exercised in use of the Ship's power as many Ice-fishing shanties are placed near the ice track near this point. **(No picture available at this time)**

b. Lt "49" Nicolet Lake – Right hand turn. 21 degree head change, 1300 yards long. This turn takes you out of lower Hay Lake onto Oak Ridge Range. Due to the increased current, ice thickness in this area is usually less than other turns in the river. It is protected from brash accumulation from the fast ice present in Hay Lake as well. During spring breakout this turn will be subjected to shifting plates. The key to this turn is to maintain smooth track edges all the way around. The relative small head change and the longer distance of the turn typically make it an easier turn for the users. **(No picture available at this time)**

c. Oak Ridge (top of Rock Cut) – Left hand turn. 38 degree head change, 800 yards long. This is one of the most unique turns in the entire river. This turn will flow clear after grooming. This is due to the heavy current that is funneled into the Rock Cut. AT ALL times use lower power to groom this turn; any wake generated will devastate the track edge and quickly block the Rock Cut and may reach the ferry crossing. To groom this turn first ensure the plate is broken in a straight line from Buoy "36" to crib light "32" on the "red side" of the channel. Next establish the outside of the turn. Using slow speed, form a smooth edge along the "green" side. This edge should start opposite to Buoy "36" and proceed all the way down to Buoy "35" as near the channel as practical. This will give plenty of room for large ships to swing their stern and line up for the transit through the Rock Cut. **(Slides 1, 2, 3, 4, & 5)**

d. Sawmill – Right hand turn. 25 degree head change, 1300 yards long. This is a very long turn extending from the lower end of the Rock Cut down to Sawmill Point. The turn is usually characterized by heavy brash and broken plate from the Rock Cut jammed at the upper end, to lighter brash and refrozen plate at the lower end. The critical area for this turn is the "red" side of the channel just past the lower dam, this is the beginning of the Stern Relief Area. Here heavy brash and refrozen plate jams as

the large ships push the ice onto the dam. It is extremely important to break the area just past the dam on the "red" side into the 22 foot area outside the channel (no further that 10 yards outside channel). Large ships need lots of relief for sterns to swing through the turn. All attempts should made to maintain a

smooth edge along the “green” channel edge which will help with brash flow out of the Rock Cut. **(No picture available at this time)**

e. Moon Island – Left hand turn. 40 degree head change, 900 yards long. This is a relatively short turn with a large head change. The turn is characterized with light brash accumulation in the Bow Relief Area. Due to the stability of the surrounding area very rarely is there a problem with shifting plates. The key to this turn is the Stern Relief Area. Begin on the “green” side of the channel approximately 60 yards above the Entry Point. The Stern Relief Area should extend all the way over to the channel limits on the green buoy line, use the wake of the ship to just crack the plate outside the channel if possible. **(Slides 6, 7, 8, 9, 10 & 11)**

f. Winter Point – Right hand turn. 54 degree head change, 1400 yards long. This is the longest one-way turn on the river. The slow river current and exposure to the weather provides for large ice accumulation in this area. Typically this is the first area in the river to develop ice at the start of the season. The Stern Relief Area should begin abeam buoy “5” and reach well outside the buoy line on the “green” channel edge. The deeper water outside the marked channel provides extra maneuvering room if the Stern Relief Area cannot be broken with the ship’s wake. This is one of the turns where a Bow Riding Area is likely to develop. The thicker ice provides a good cushion to help guide the bow of the larger ships. Due to the large size of this turn and the heavy ice, typically this turn will take several passes to prepare. Allow additional time to work this turn during escort operations. This turn is very susceptible to shifting plates from the Northern and Eastern shores during spring breakout. Very important to ensure the buoys are free of ice plates before these plates start shifting. **(Slides 12, 13, 14, & 15)**

g. Johnson Point – Left hand turn. 61 degree head change, 500 yards long. Absolutely the most difficult turn on the entire river. Not only is there a large head change, but also it must be accomplished in roughly 1.5 ship lengths of a 1000ft vessel. This requires a very large Stern Relief Area that must begin at approx buoy #18 and extend East all the way over to the Red buoy line then travel up to the Northern limit of the turn. Tip: Approach this turn from the Exit Point, follow the left edge along the Bow Riding Area then pick up speed as the shallow ranges begin to line up. Make your turn with plenty of time (advance & transfer) to be right on the shallow water range and creating a wake that reaches to the East (toward the red buoy line). Check back your speed and set up for a starboard cast just up current from buoy #18. CAUTION: The starboard cast will take you through the main track below the Entry Point, this ice may be loose and the ship’s momentum will be difficult to stop. **(Slides 16, 17, 18 & 19)**

h. Dark hole – Right hand turn. 45 degree head change, 800 yards long. The high current in this section of the river creates brash build up at both Entry Point and Stern Relief Areas of this turn. Although this is a short turn it has a long Stern Relief Area. Begin establishing the Stern Relief Area at buoy “23” on the “green” channel edge carry it all the way past buoy “25”. This turn usually does not develop a Bow Riding Area, but try to maintain the ice edge between the end of the Stern Relief Area up to buoy “29”. The next most important area in this turn is the Bow Relief Area. All the ice between buoys “26” and “28” should be loose to provide relief of the bow as the ship makes the turn. Take precaution not to wake any of the fast plate in this area, shifting plates will quickly push ATON under the ice. **(Slides 20, 21 & 22)**

i. Stribling – Left hand turn. 68 degree head change, 1000 yards long. The large head change and the short distance of this turn make it essential to create a significant Stern Relief Area. Begin on the “red” side of the channel adjacent to the crib light “39”. The shallow water ranges on Hardwood Point are excellent reference points for the extreme eastern channel. Carry the Stern Relief Area deep into the turn just until it crosses the Stribling Point Ranges. This turn is subject to fast current, by maintaining smooth edges on both sides of the turn, brash ice will move through fairly easy. **(Slides 23, 24, 25, 26, 27 & 28)**

j. Lt “62” – Right hand turn. 39 degree head change, 1400 yards long.

Ice formation in this turn is limited due to swift current. In fact it is not uncommon to see open water pools where the current eddies over rocks. This turn can usually be groomed simply by making a single pass through the center and adjusting the ship’s power for the wake to reach each track edge. There is a large amount of ice that will flow through this area, mostly broken plate (small flows) moving down current from Hay Lake. Low power techniques should be used while grooming this turn to prevent breaking the ice bridge that forms between Lt “62” and Stribling dike Lt “58”. If this ice bridge is in place it will prevent loose broken plates/brash from entering the Stribling choke point. **(No picture available at this time)**

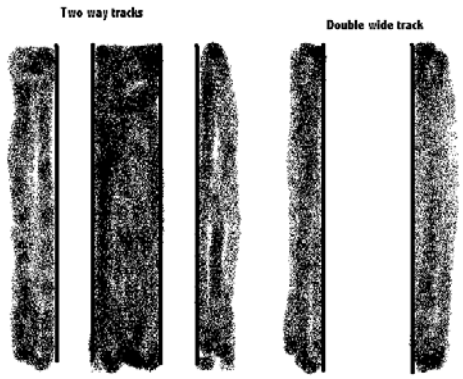
k. Point Aux Frenes – Both right and left hand turn. Like all two-way turns this turn will not have a Bow Riding Area. It is important that the Stern Relief Area extend the entire distance through the turn. This turn is subject to large brash accumulation, and shifting plates. **(No picture available at this time)**

l. Lime Island – Both right and left hand turn. There is an option to the way this turn is established and maintained. A traffic buoy marks an up and down bound routes through the turn. Establishing the down bound track to the west and south of the buoy is optional, keep in mind that the users generally prefer to cut to the inside (east) of the traffic buoy. Generally it makes less area to maintain by using only one side of the traffic buoy. The trick to using only side of the traffic buoy is that you must create a “crossover” ice track so down-bound ships can slide into the down-bound track between Lime Island and Sweets Point. **(Slides 29 & 30)**

RANGES (Straight track courses)

Our general rule is that once the river has frozen and it is apparent that it will remain that way until spring, establish and maintain the tracks only as wide as necessary to move traffic.. no wider. To emphasize the point; do not allow the wake of the icebreaker to travel outside the limits of the established track. That is usually the width of the largest vessel (105ft) plus approximately 35 feet (105+35=140) to allow room for ice to flow around the column bows of the 1000ft vessels. This number is only a starting point as the conditions may dictate wider tracks.

Vessel meetings are always something that should be in the back of the mind of the assisting vessel. Keeping close track of vessel call-in points will be your best method of predicting where vessels will have to meet. Ice tracks are cut in two fashions to accommodate meeting situations; two-way tracks and Doublewide tracks. Two-way tracks are separate, 140' wide tracks, separated by stable plate ice **(Slides 30, 31, 32 & 33)**. Doublewide tracks are a massive single track, >300' wide, in which two ships could pass **(Slide 34)**.



a. Upper Nicolet (Hay Lake) – Two-way tracks. Hay Lake typically last area to freeze. This lake has both up and down bound ranges. Establish two-way tracks using ranges as center point for main tracks. Tracks intersect with Frechette Range in vicinity of 6-mile point. **(No picture available at this time)**
b. West Neebish Channel Upper – Single track. Continuation of down-bound track through Hay Lake. **(No picture available at this time)**
c. Oak Ridge (d/b course 5) – Single track. Ice very unstable due to current and shallow water outside channel limits. All vessels use minimal power to prevent incidental ice breaking. All free ice broken in this area will move into Rock Cut. **(No picture available at this time)**
d. Moon Island to MLJB – Single track. Ice fairly stable, will begin to shift during spring breakout, mostly on westerly wind. **(No picture available at this time)**
e. MLJB to Point Aux Frenes – Two-way tracks. Establishment of two-way tracks through Mud Lake is essential. This is a primary meeting area. The down-bound track is a continuation of the Moon Island to MLJB course. Use the range as the center point of the down-bound track. Establish the up-bound track roughly 300 feet north of and parallel to the down-bound track. The two tracks converge at Point Aux Frenes turn. **(Slides 31, 32 & 33)**

f. Point Aux Frenes to Lime Island – Doublewide track. Establishing a single doublewide track between these two points can save a lot of time. The extra wide channel has a very slight course change just about abeam of Round Island. **(No picture available at this time)**
g. Lime Island to Sweets Point – Two-way tracks. **(Slide 30)**
h. MLJB to Winter Point turn – Single track. Center track on range.
i. Winter Point turn to Johnson Point (course 9) – Single track. Center main track on deep-water range **(Slide 35)**. Relief Track – There is a great potential for brash to move into this course as it bends around Johnson Point. The best way to create a relief for this track is to make a single pass starting at Winter Point turn all the way up to buoy "18" following the Johnson Point shallow-water range. Make the pass ahead of an up-bound 1000ft vessel. The displacement of the 1000ft vessel will move the heavy brash over into the relief area that is created. CAUTION: Be sure the main track on the deep-water range is fully groomed and ready for transit. If it is not the low pressure from the relief track will pull the 1000ft vessel off the range. Center of main ice track cut right on deep-water ranges.
j. Hardwood/Dark Hole(course 7) – Single track. Medium brash accumulation in this course. Main ice track cut right on deep-water ranges. Center of main ice track cut right on deep-water ranges. **(Slide 36)**
k. Stribling (course 6) – Single track. Heavy brash accumulation in this area. Free ice from Hay Lake moves into course. An intact "ice dam" between Lt "62" and Lt "58" helps decrease ice flow. Make every effort to maintain this area intact for as long as possible. Center of main ice track cut right on deep-water ranges. **(Slides 37 & 38)** Relief Track – Much like Johnson Point, start at Lt "58" and follow the shallow-water range into Stribling Turn. Do this ahead of an up-bound 1000ft vessel; the vessel's displacement will move the brash out of the channel. There are a couple of other factors to consider for this area in particular. If there is ice moving into the area from Hay Lake you may be just making a bad situation worse. Also if there will be another up-bound transit following the 1000ft vessel the next vessel in line will simply disturb the track and pull the brash back into the channel. This move is best timed with one single transit with weather conditions that may freeze the brash out of the channel.
l. Lt 62 to 9mile Point – Single track. Very delicate area, subject to wake, wind and vessel displacement damage. All broken plate in this course will float down into Stribling dike choke point. Center of main ice track cut right on deep-water ranges. **(No picture available at this time)**

FERRY CROSSINGS

SUGAR ISLAND FERRY This ferry services the nearly 300 winter Sugar Island residents, every 15 minutes, seven days a week. The key to this crossing is to ensure the ferry has an adequate crossing lane free from ice. Normally an ice bridge will form naturally just above Mission Point with the right combination of cold air temperatures and light winds, this ice bridge combined with the high current will provide an open pool of water. If the Ice Bridge doesn't form, ice flowing over the SOO rapids will quickly stack up below the ferry and backup to obstruct the ferry's crossing. If this occurs, be prepared to render assistance to the ferry. Assistance may be provided in two stages. First use the ship to perform "race track" maneuvers below the ferry crossing. By using this pattern and ensuring the Cutter's wake reaches the shore the broken plate will flow down with the current and away from the crossing. To "drop" the ice below him run close to each shoreline to past Lights 95/96, then soften the middle plates so that the entire ice field will set down Little Rapids Cut with the current. As little as 200 yards of open water below the ferry will allow for a safe transit. The next stage would be to use the ship (low power) to cut a large intact ice plate from SOO harbor, above the ferry crossing. Locate a sizable intact plate above the ferry crossing in Sault Harbor. Using slow speed carefully carve off a large plate that will float down and wedge across the main channel from the Little Rapids ice-boom to the Western shore of

Mission Point. The man-made ice bridge should prevent further ice build-up endangering the ferry crossing.

If plate thickness is less than 4 inches this may not work due to the weakness of the plate. In the event the plate must be traveled through create a dogleg track pattern with the cutter. This will prevent brash from flowing through a straight-line track and again building up on the Sugar Island Ferry crossing.

The best way to manage this ferry is to ensure that
(a) an ice bridge is formed
(b) take a preventative posture and work the ice below the ferry at every opportunity. You never know when the weather will turn bitter cold and back up the cut.

NEEBISH ISLAND FERRY The biggest danger for this ferry is the back up of broken plate that floats through the Rock Cut. The best approach is prevention; keep vessel wakes in check above the crossing. The more plate that is broken on the Oak Ridge Range, the more ice that will float into the Rock Cut. Regardless of the care taken to prevent breakage there will always be certain amounts of ice that will move on the current. The ice will begin to stack up at the lower dams and if not kept moving will quickly reach the ferry crossing. Take every opportunity to break the larger plates within the Rock Cut. The thought here is to make smaller pieces that may move past the lower dam and into Sawmill turn where they are more easily managed. Beware of wake damage to the sides of the Rock Cut, water thrown into the rock crevasses will freeze and cause significant damage to the structure.

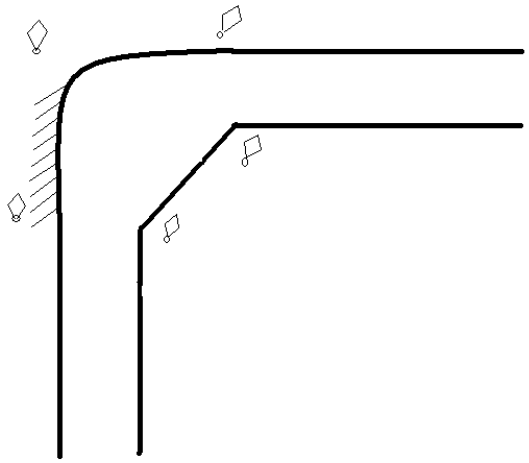
DRUMMOND ISLAND FERRY The Drummond Island ferries are very “ice worthy” and can move through significant amounts on their own. Biggest concern with the Drummond Island Ferry is the movement of large amounts of ice into their crossing while conducting flushing operations. Strong Westerly winds will move broken plate directly onto their island side landings.

ESCORTS (SINGLE & TANDEM)

Escorts are the most efficient, time saving, ice wise means of performing the mission. Conducting escorts breaks ice for a purpose. The distance from the escorted vessel is dependent on the severity of the ice conditions and the weather. Generally, when performing escort service try to work about one hour ahead of the escorted vessel. By working ahead the breaker is provided ample time to groom a turn and exit toward the next turn prior to the vessel's arrival. This also keeps you within easy turn-a-round distance to render assistance if the vessel gets into trouble. A primary benefit of this method is that it keeps the mariner moving, rather having them stop and wait for you to finish working a turn. The strongest factor that affects the lead-time for escorts is the weather. Cold temperatures may quickly freeze the work just completed creating the need for shorter distance in front of the escorted vessel in order to keep the track fresh. Mild temperatures may provide for a longer lead, even to the point of working a section of the river, and then leaving it before the vessel arrives.

Extremely cold temperatures may dictate close aboard escort. In these conditions the icebreaker may have to perform direct assistance to the freighter while moving through a turn. Close aboard escort is essentially station keeping on the vessel during the turn and using the icebreaker to create low-pressure areas in the ice field. The most critical thing to understand in performing this type of assistance is recognizing the pivot point on the freighter. The idea is to create these low-pressure areas just aft and just forward of the pivot point on opposite sides of the ship. These areas essentially create a moving Stern Relief Area and Bow Relief Area as the vessel makes the turn. Whether relieving pressure build up near the stern, or guiding around the bow, it is important that the icebreaker keep station just forward of the desired low-pressure area. Keep in mind that this assistance is performed at very slow speeds by the freighter, and good communications with the shipmaster is vital to safe operations.

This close in assistance is ideal for two vessel escorts (illustrated below), but may be performed alone. If performing alone loosen the Bow Relief Area then take station on the vessels quarter.



UPPER RIVER OPERATIONS

Because of the stability of the ice fields and the open navigation, generally the upper St Mary's River presents little problem prior to lock closure. It is a major area of concern for Spring Breakout. The ice has grown undisturbed for the majority of the winter and has been recorded in excess of 48inches in some locations.
The upper river breaks down into two distinct sections; from the Locks to Gros Cap and Gros Cap to the upper ice edge.

Locks to Gros Cap – This is the primary meeting area for both up and down bound vessels transiting above the locks. The most efficient means of maintaining traffic flow between these points is to establish a single doublewide track. Much like Lime Island turn described earlier, the Lt "26" turn has a traffic buoy marking the separation area. The majority of vessel transits will cut to the inside of this turn staying close on the "red" side of the channel. The plate ice attached to shore between the locks and Point Louise is relatively stable.

Gros Cap to upper ice edge – Just abeam of Gros Cap light the LCA track lines separate into up and down bound courses. The exposure to wind and the distant land masses make this area very unstable and subject to shifting plates. Three methods have been employed to establish ice tracks in this area all depending on the ice thickness. During mild winters, establish and maintain a single track following these separate LCA lines. With stable ice plates and mild temperatures the tracks will be easy for the freighters to find and follow. During heavy winters an alternate approach must be taken. If ice conditions exceed our ability to maintain separate tracks that follow the LCA, two-way tracks can still be established. Two-way tracks may be easier to maintain if they lie in close proximity. Using the down-bound LCA as a base line, establish a second ice track to the west with approximately 400 feet of separation. The second track should run parallel the down-bound LCA. The added benefit of having the tracks close together is it makes it easy for the ship captains to find them at the upper ice edge. During extreme conditions a single one-way track may be the only alternative if two-way tracks are impossible to maintain. If this is the case careful planning of vessel transits will have to be employed. Extra wide sections of the single track can be created in the event vessels will have to meet in the single track.

The greatest danger to navigation in the upper river during ice operations comes from shifting plates. The openness of the area creates great potential for large plates to break free and drift into the navigational channel. The area of greatest concern lies between Point Louise and the turn at Lt "26". Northerly winds often move the plate east of Gros Cap into this area. The best method to mitigate this hazard is to run back and forth along on the Brush Point Range. Use the ship's wake to reach as far as possible past the buoy lines.

PHOTO NOTE & EPILOGUE

The pictures seen in this guide were taken during over a series of winter operations. Some of the pictures reflect more severe conditions than others. The most severe winter was 95/96 when ice breaking hours exceeded 1400. That year ice thickness ranged from 18 inches at Watsons Reef Light to 48 inches at Moon Island, Sawmill Point, and Winter Point. Ice accumulation reached all the way to the bottom at the lower end of the Rock Cut (anchor ice). Many of the tactics explained in this guide are a product of that extreme season. I'm convinced that the flushing and ice management methods used for the first time that year helped the ice season end one or two weeks earlier. Our hope on KATMAI BAY is that these methods serve as a foundation for continual improvement by all users of the St Mary's River.

This guide is not the tell all and certainly new methods should be attempted. It is my hope that this will be a living document that captures lessons learned for future icebreaking students of the craft.

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