U.S. Department of Homeland Security

United States Coast Guard

Spring 2005

The Coast Guard Journal of Safety at Sea

# PROCEEDINGS

*of the* Marine Safety & Security Council

INTERNATIONAL ICE PATROL

## Eliminating the Risk of Iceberg Collision

# PROCEEDINGS

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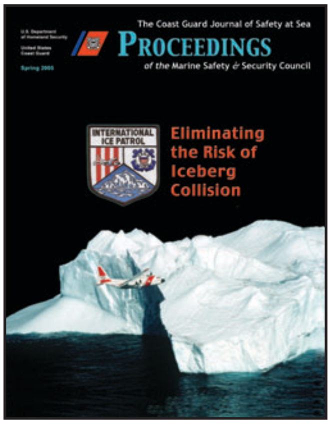



## On the Cover

A Coast Guard C-130 fixed-wing aircraft overflies an iceberg during patrol. An International Ice Patrol (IIP) reconnaissance flight is roughly 1,700 nautical miles long and can last seven hours. As defined by U.S. law and by international treaty, Ice Patrol's responsibilities involve patrolling the Limits of All Known Ice south of 52° N. IIP conducts reconnaissance flights at 6,000–8,000 feet. Typically, it takes about four flight days to cover the Limits of All Known Ice.

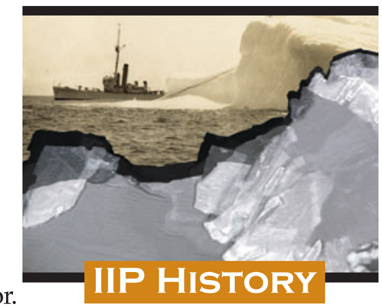

## Intro




## IIP Operations: Reconnaissance, LAKI Creation & Dissemination


## IIP History






## IIP Vision




## On Deck





***Clarification to Winter 2004-2005 Issue***

*Two statements from the Winter 2004-2005* Proceedings *article, Illegal Sewage Discharges, require some clarification in order not to be taken out of context: "Recently, the U.S. Court of Appeals for the Eighth Circuit ruled that it is not a criminal violation of the "Federal Water Pollution" Control Act (FWPCA) for a vessel to discharge raw sewage into the waters of the United States." The case referenced was the subject of an appeal before the Eighth Circuit Court because of a question of whether a towboat bolted to stud pilings met the definition of 'vessel' under FWPCA. While ruling the towboat was a vessel, the court reiterated that the discharge of sewage from a vessel is not a criminal violation of FWPCA. Violations of marine sanitation device requirements of section 312 of FWPCA are civil violations under FWPCA, and making false statements is a criminal violation of Section 1319(c)(4) of FWPCA, as well as 18 U.S.C. 1001.*

*"The FWPCA specifically exempts sewage from a vessel from the definition of a pollutant." While sewage is not included under the definition of pollutant, FWPCA requires the EPA to set standards for sewage discharges, and the Coast Guard is charged with issuing regulations governing the performance of Marine Sanitation Devices (MSDs) to discharge in accordance with the set standards. A vessel which does not have a properly operating MSD is subject to a civil penalty. In addition, discharge of treated or untreated sewage is prohibited in designated no discharge zones.*

# Assistant Commandant's Perspective

by Rear Adm. R. Dennis Sirois
*Assistant Commandant for Operations, U.S. Coast Guard*

The sinking of the *RMS Titanic* in 1912 is one of the core events that shaped our modern-day Coast Guard. Since 1913, the International Ice Patrol has maintained a watch on the Northwest Atlantic to ensure safe passage of transatlantic shipping in and out of U.S. and Canadian waters. Although it has been nearly a century since its formation, the mission of International Ice Patrol—to monitor iceberg danger near the Grand Banks of Newfoundland—has not changed.

Our economy relies heavily on the ability to safely transport goods in and out of our ports in an efficient manner. The cost of a 24-hour delay in a ship's arrival at a port can run upwards of $100,000, once the impact on the railroads, trucking industry, distributors, mills, and retailers is factored in. As the size of bulk carriers and container ships continues to increase at a phenomenal rate, the impact of one iceberg collision could result in millions of dollars in property damage and unacceptable loss of life. Fortunately, the safety record of International Ice Patrol is impeccable. In the 92-year history of the mission, no ships have struck an iceberg outside of the ice limits published by International Ice Patrol. That statistic is more impressive, considering the dramatic increase in the amount of transatlantic traffic since 1912. The cost of this service to the 17 member nations under the second International Convention for the Safety Of Life At Sea of 1929 has remained at less than $0.10 per gross ton.

The Coast Guard has built strong relationships with the international community to aid in the execution of this mission. International Ice Patrol's participation in agencies such as the International Ice Charting Working Group and the North American Ice Service (along with the Canadian Ice Service and the National Ice Center) serves as a model for international cooperation. With the possible opening of Arctic shipping routes in the future, the spirit of cooperation and the method of operations that have been so successful for the Coast Guard will provide the framework for ensuring safe transit, safe borders, and the ability to enforce maritime law through this new shipping regime.

Through its history, International Ice Patrol has endeavored to remain on the forefront of technology—particularly in the study of oceanography in the Grand Banks region. Ice information that used to be gathered with nothing more than ship observations is now being done with the use of aircraft, radar, and satellites. International Ice Patrol remains focused on the oceanographic arena, collecting data on the ocean for use in other Coast Guard mission areas, U.S. Navy operations, and the scientific community. However, the ability to collect and analyze these data for operational use and the implementation of new technology does not override the fundamental truth of this, or any, Coast Guard mission: People—highly skilled, thoroughly trained, dedicated people—are necessary to keep our waters as safe as possible. The "Ice Picks" of the International Ice Patrol are devoted to their unique mission, and they are doing their part within the Coast Guard to keep our homeland secure.

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# Champion's Point of View

by Cmdr. MICHAEL R. HICKS
*Commander, U.S. Coast Guard International Ice Patrol*

In early 1912, a Commission on Economy and Efficiency, appointed by President Taft, had concluded that "after a careful study of the work now being performed by the Revenue-Cutter Service (RCS), the commission is convinced that the service has not a single duty or function that can not be performed by some other existing service, and be performed by the latter at much smaller expense."[1] While making a convincing argument, RCS Captain Commandant Ellsworth Bertholf could not convince President Taft that the service should remain intact. The president favorably endorsed and forwarded the commission's report to Congress on April 4, 1912.[2]

Just 10 days later, on her maiden voyage from Southampton, England, to New York, *RMS Titanic* collided with an iceberg and sank in about two hours, taking the lives of 1,517 passengers and crew. In response to this tragedy, U.S. Navy Scout Cruisers *Birmingham* and *Chester* were ordered to patrol the southern Grand Banks of Newfoundland to warn transatlantic shipping of iceberg danger for the remainder of the 1912 ice season. By 1913, these vessels were needed for patrols in Mexican and West Indian waters and could not continue ice patrol duties.[3] Bertholf seized this opportunity by directing Revenue Cutters *Seneca* and *Miami* to assume the ice patrol for the 1913 ice season. In November of that year, Bertholf represented the United States as a member of the 12-person delegation to the first International Convention for the Safety of Life at Sea (SOLAS). Among other groundbreaking changes, the convention concluded that:

The Government of the United States of America agrees to continue the overall management of the ice patrol service and the study and observation of ice conditions including the dissemination of information therefrom.[4]

Meanwhile, the bill to abolish the Revenue Cutter Service had languished in Congress through the transition from the Taft to the Wilson administration. When the bill surfaced again in 1914, the crews aboard *Seneca* and *Miami*, in just one full year of operation, had proven the tremendous value of an ice patrol to transatlantic shipping. With *Titanic* headlines still fresh in the minds of maritime nations and the public alike, this important new mission became a key selling point in defeating the bill to abolish the service and paving the way for the merger of the RCS with the Life Saving Service to create the modern-day U.S. Coast Guard.

With just 16 members, today's International Ice Patrol in many ways is a microcosm of the Coast Guard itself: a small (even by Coast Guard standards) unit of men and women committed to excellence in the performance of their duties. In the articles that follow, you will read descriptions of nearly every aspect of the International Ice Patrol mission, most of which were written by the men and women who serve or have served in the Ice Patrol. Today's "Ice Picks" are just as committed to promoting safe navigation in the face of iceberg danger as the crews aboard *Seneca* and *Miami* were more than 90 years ago. I hope you enjoy learning about how this small crew has remained so successful in executing a vital Coast Guard and international mission.

[1] Johnson, Robert Erwin. Guardians of the Sea: History of the United States Coast Guard, 1915 to Present. (Annapolis: Naval Institute Press, 1987), 19.
[2] Ibid, 21.
[3] Ibid, 24.
[4] SOLAS convention, Chapter V, Regulation 6 – Ice Patrol Service.

# The U.S. Coast Guard International Ice Patrol

*The Coast Guard's first defense against one of the most dangerous maritime threats—the iceberg.*

by U.S. Coast Guard International Ice Patrol Staff
Edited by Cmdr. Michael Hicks
*Commander, U.S. Coast Guard International Ice Patrol*

Of all the peacetime threats of the sea, none are more fearsome, unyielding, and treacherous than icebergs. Despite ingenuity, resourcefulness, and almost a century of experience and technical advances, this natural wonder has resisted our efforts to control, regulate, and avoid it.

Breaking off from hundreds of West Greenland glaciers, frequently as long as a city block and towering up to 100 feet above the sea surface, icebergs are steered by ocean currents. Their enormous mass and the tremendous environmental forces acting on them render ineffective efforts to restrain or destroy them, or significantly alter their course.

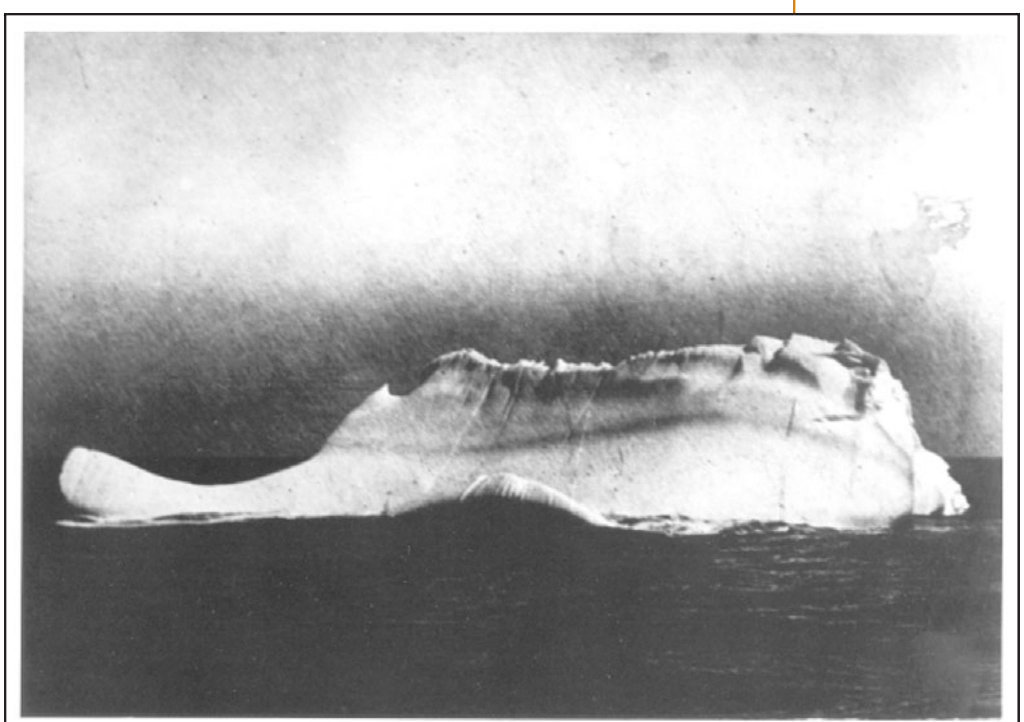


**Figure 1: Photograph of the iceberg that many believe sank the *RMS Titanic*. This was the only berg sighted in the immediate vicinity of the area of the fatal collision.**

**Danger Zone**

Though everywhere within the Arctic, the frigid Labrador Current, running southeastward along the northeast coast of Canada, carries icebergs south to the vicinity of the Grand Banks and into the great circle shipping lanes between Europe and the major ports of the northeast United States and Canada. In this area, the cold Labrador Current clashes with the warm and northward-flowing Gulf Stream. The temperature difference between the two currents can amount to 20 degrees Celsius, the same approximate thermal difference between New England and Florida, within an area only slightly bigger than the state of Maine.

The mixing of these two differing water masses causes the dense fog for which this area is known. This thick shroud of fog and the high concentration of transatlantic shipping vessels, oil platforms, and fishing vessels in the area compound the danger represented by icebergs. The combination of all these factors makes the waters of the Grand Banks one of the most dangerous marine areas in the world.

**This thick shroud of fog, for which this area is known, and the high concentration of transatlantic shipping vessels, oil platforms, and fishing vessels compound the danger represented by icebergs.**

The U.S. Coast Guard commences the seasonal service of ice observation and ice patrol whenever the presence of icebergs threatens primary shipping routes between Europe and North America. The threat of icebergs south and east of Newfoundland is typically present during the months of February through July, but the patrol commences operations when iceberg conditions dictate. The 1992 season, the longest on record, ran from March 7th through September 26th—203 days. Except during unusually heavy ice years, the Grand Banks are normally iceberg-free from August through January.

International or multinational and U.S. laws delineate the activities of the International Ice Patrol to encompass only those ice regions of the North Atlantic Ocean through which the major transatlantic shipping tracks pass. There remain other areas of ice danger where local shipping must exercise extreme caution.

**Ice Reconnaissance**

Fixed-wing Coast Guard aircraft conduct the primary reconnaissance work for the Ice Patrol. Ice reconnaissance flights are made on an average of five days every other week during the ice season. The mainstay of the Ice Patrol flights for the past 40 years has been the Hercules HC-130 aircraft. The usual patrol time for these long-range, multi-engine planes is between five to seven hours, with each flight covering 27,000 square miles of water or more. Information concerning ice conditions is collected primarily from air surveillance flights and ships operating in or passing through the ice area. Ships are requested to report the position and time of all ice sighted and make sea surface temperature and weather reports to the International Ice Patrol Operations Center in Groton, Conn., every six hours when in the vicinity of the Grand Banks.

All the iceberg data are fed into a computer at the operations center, along with ocean current and environmental data. Using this information, the computer is programmed to predict the drift of the icebergs. Every 12 hours, the predicted iceberg locations are used to estimate the Limits of All Known Ice. This limit is broadcast as an Ice Bulletin from radio stations in the United States, Canada, and Europe for the benefit of all vessels transiting the North Atlantic. In addition to a twice-daily broadcast of the Ice Bulletin, a radio facsimile chart of the area, graphically depicting the Limits of All Known Ice, is broadcast twice each day.

Except for the years of the two World Wars, the patrol has been active each ice season since 1913. During this period, the Ice Patrol has amassed an enviable safety record, with not a single reported loss of life or property due to collision with an iceberg outside the advertised Limits of All Known Ice in the vicinity of the Grand Banks. However, the potential for a catastrophe still exists.

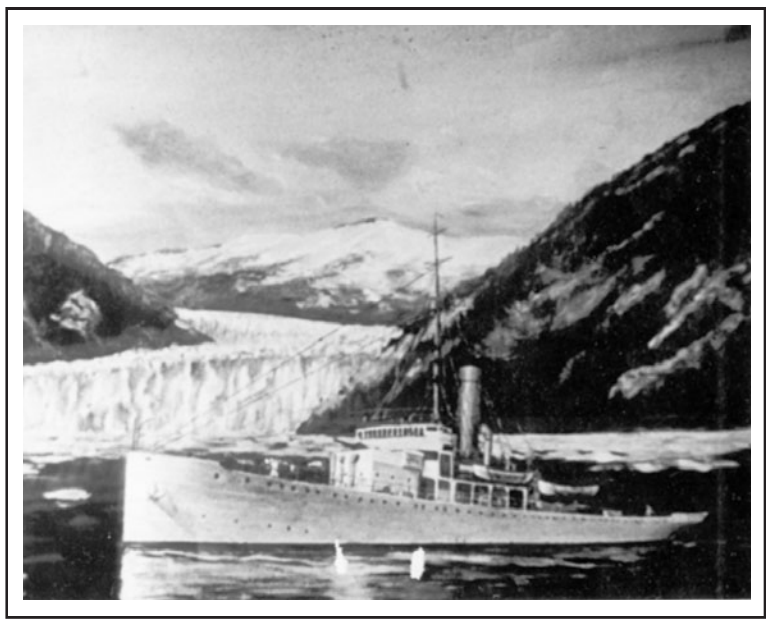


**Figure 2: Coast Guard Cutter *Modoc* in front of a glacier. The *Modoc* was used for ice patrol from 1922 to 1930 and in 1946.**

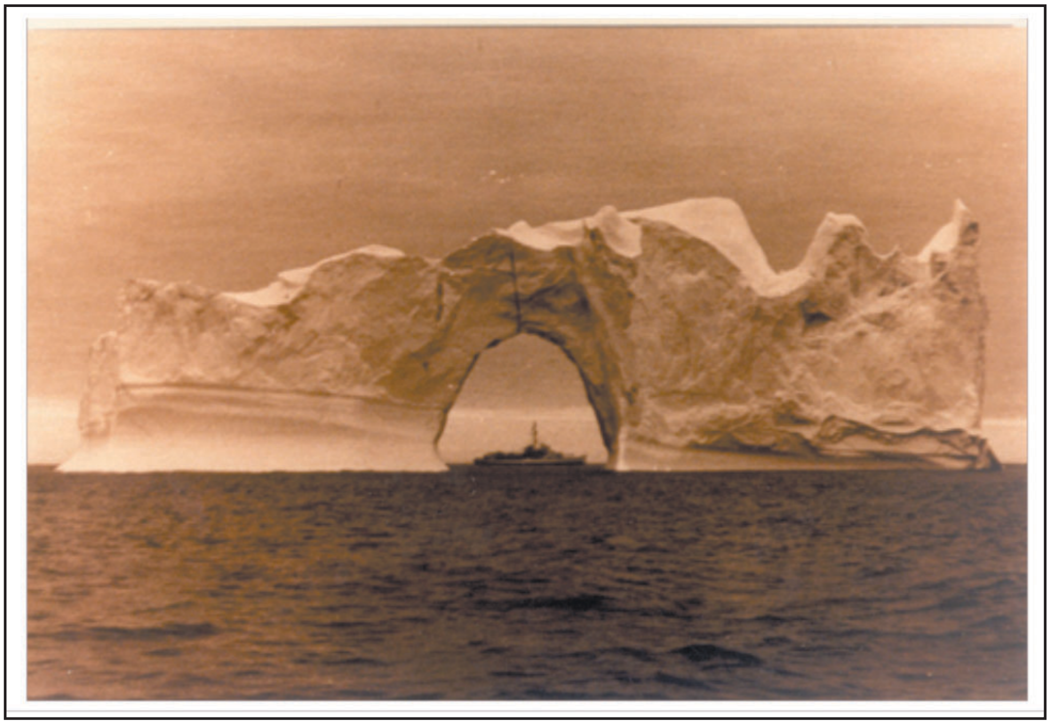


**Figure 3: A U.S. Coast Guard cutter seen through the hole of a large, arched iceberg.**

**History**
From the earliest journeys into the North Atlantic, icebergs have posed a threat to vessels. A review of the history of navigation prior to 1900 shows an impressive number of casualties occurred in the vicinity of the Grand Banks. For example, the *Lady of the Lake* sank in 1833 with a loss of 70 people. Between 1882 and 1890, 14 vessels were lost and 40 seriously damaged due to ice. This does not include the large number of whaling and fishing vessels lost or damaged by ice (refer to "Mariner's Seabag: Ship Collisions with Icebergs" on page 75 for further detail). It took one of the greatest marine disasters of all time to arouse public demand for international cooperative action to deal with this marine threat. This disaster, the sinking of the *RMS Titanic* on April 15, 1912, was the prime impetus for the establishment of the International Ice Patrol.

On its maiden voyage from Southampton, England, bound for New York, the *Titanic* collided with an iceberg just south of the Tail of the Grand Banks and sank within two and a half hours. Figure 1 illustrates the likely culprit. Although the night was clear and seas were calm, the loss of life was enormous, with more than 1,500 of the 2,224 passengers and crew perishing. The *RMS Titanic*, the flagship of the White Star Line, was the largest passenger liner of its time, displacing 66,000 tons and capable of sustained speeds in excess of 22 knots. The vessel had been built with the latest safety design, featuring compartmentation and such innovations as automatically closing watertight doors. It is ironic that publicity regarding these features had given it the reputation of being unsinkable.

**Safety of Life at Sea**
Loss of the *Titanic* gripped the world with a chilling awareness of an iceberg's potential for tragedy. The sheer dimensions of the *Titanic* disaster created sufficient public reaction on both sides of the Atlantic to prod reluctant governments into action, producing the first Safety of Life at Sea (SOLAS) convention, signed in 1914. The degree of international cooperation to produce such an unprecedented document was truly remarkable and probably could not have been achieved during this period without the catalyst provided by this incident.

After the *Titanic* disaster, the U.S. Navy assigned the Scout Cruisers *Chester* and *Birmingham* to patrol the Grand Banks for the remainder of 1912. In 1913, the Navy could not spare ships for this purpose, so

**From the earliest journeys into the North Atlantic, icebergs have posed a threat to vessels.**

the Revenue Cutter Service (the forerunner of the Coast Guard) assumed responsibility, assigning the Cutters *Seneca* and *Miami* to conduct the patrol. Figures 2 and 3 show early ice patrol vessels.

At the first International Conference on the Safety of Life at Sea, which was convened in London on November 12, 1913, the subject of patrolling the ice regions was thoroughly discussed. The convention, signed on January 30, 1914, by the representatives of the world's various maritime powers, provided for the inauguration of an international derelict-destruction, ice observation, and ice patrol service. This service would consist of vessels that should patrol the ice regions during the season of iceberg danger and attempt to keep the transatlantic lanes clear of derelicts during the remainder of the year. Due primarily to the experience gained in 1912 and 1913, the U.S. government was invited to undertake the management of this triple service, with the expense to be defrayed by the 13 nations interested in transatlantic navigation.

**The Ice Patrol has amassed an enviable safety record, with not a single reported loss of life or property due to collision with an iceberg outside the advertised Limits of All Known Ice in the vicinity of the Grand Banks.**

As the convention would not go into effect until July 1, 1915, the government of Great Britain, on behalf of the several nations interested, made inquiry on January 31, 1914, as to whether the United States would undertake the patrol at once under the same mutual obligations as provided in the convention. President Wilson favorably considered the proposition, and, on February 17, 1914, he directed that the (then) Revenue Cutter Service begin the International Ice Observation and Ice Patrol Service. Each year since then, with exception of the wartime years, the U.S. Coast Guard has maintained a patrol.

The second International Conference on Safety of Life at Sea was convened in London on April 16, 1929. Eighteen nations participated, and all signed the final act on May 31, 1929. Because of the fear in the U.S. Senate as a result of ambiguities in Article 54 dealing with control, the 1929 convention was not ratified by the United States until August 7, 1936, and even then the ratification was accompanied by three reservations. At the same time, Congress enacted legislation on June 25, 1936, formally requiring the Commandant of the Coast Guard to administer the International Ice Observation and Ice Patrol Service (chapter 807, paragraph 2, 49 Stature 1922) and prescribing the manner in which this service was to be performed. With only minor changes, this remains today as the basic Coast Guard authority to operate the International Ice Patrol. Since 1929, there have been two SOLAS conventions. Neither of these has recommended any basic change affecting the Ice Patrol. Most recently, a 2002 amendment made use of Ice Patrol products mandatory for ships transiting the iceberg danger area during the ice season (February through July).

The 13 nations signatory to the 1915 SOLAS Convention agreed to share costs in accordance with a formula approximating their degree of individual benefit. This sharing arrangement has been updated over the years as shipping patterns changed and as additional nations acceded to the treaty. Financial relations are handled by the U.S. Department of State, which does the actual billing of each nation for its share of the cost. In the early days, this share was a fixed percentage changed infrequently by treaty revision. In recent years, the cost share has been based on each participating nation's percentage of the total cargo tonnage transiting the patrol area during the ice season averaged over the last three years.

The Ice Patrol has maintained broad-based international support for over eight decades despite changing operational and technological factors. This is a tribute to the soundness of the basic concept. As of 2005 the 17 governments contributing to the Ice Patrol include Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Greece, Italy, Japan, Netherlands, Norway, Panama, Poland, Spain, Sweden, and the United States.

**U.S. Coast Guard**
**Ice Operations Program**

# Coast Guard Ice Operations

*The ability to provide highly effective icebreaking services poses the greatest challenge when it is needed the most.*

by Lt. Jeff Rasnake
*U.S. Coast Guard Ice Operations Program*

**Coast Guard icebreakers have a direct effect on the lives of millions of people throughout the United States, though only a fraction will ever know of them, let alone see one.**

The Coast Guard Ice Operations Program in Washington, D.C., has program management responsibilities for the International Ice Patrol. It provides the United States with the capability and resources necessary to carry out and support national interests in the polar regions, to facilitate the movement of maritime transportation through ice-laden domestic waters, and to assist other governmental and scientific organizations in the pursuit of marine science activities. Additionally, the Ice Operations Program assets are often called upon to support other Coast Guard missions, such as search and rescue, law enforcement, and homeland security, when waters are constrained by ice.

**Figure 1: *Polar Star* and *Polar Sea* escort a supply ship in the ice channel near McMurdo, Antarctica.**

Coast Guard icebreakers have a direct effect on the lives of millions of people throughout the United States, though only a fraction will ever know of them, let alone see one. The Coast Guard's small fleet of cutters capable of operating in ice is responsible for the immense workload of keeping ice-infested waterways open to ensure delivery

**Figure 2: *Morro Bay* (left), a 140-foot ice breaking tug from New London, Conn., cuts a relief track for the passenger ferry *Nantucket* (right) in Nantucket Sound.**

of home heating oil, bulk raw materials, and many other products that require maritime transportation during winter periods. Additionally, the Coast Guard's three polar icebreakers, capable of breaking through up to 21 feet of solid ice, deploy annually to the Arctic and Antarctic regions to maintain navigational channels and support scientific missions.

The U. S. Coast Guard's Ice Operations Program, with a supporting staff of two, plans, analyzes, and develops policy, including supporting and reporting program performance measures to service and departmental management. In addition to managing polar and domestic ice operations, the staff maintains a close liaison with the National Ice Center and the International Ice Patrol.

**Polar Regions**

The United States has significant economic, environmental, and security interests in the polar regions. Responsibility for promoting these interests has been assigned to various agencies in the course of their normal activities. The Coast Guard has been tasked with maintaining a fleet of icebreaking vessels capable of operating effectively in the heavy ice regions of the Arctic and Antarctic. Since 1965, when the U.S. Navy transferred the last of its icebreakers, the Coast Guard has been the sole operator of heavy icebreakers for the nation. Today, we operate a fleet of three polar icebreakers to meet this national requirement.

Each year, a channel must be carved out of the immense accumulation of ice in McMurdo Sound to facilitate the supplying of the scientists that operate out of McMurdo Station (Figure 1). This annual event, Operation Deep Freeze, requires Coast Guard icebreakers to operate in what is undoubtedly the harshest marine environment in the world. The mission requires a vessel capable of breaking through miles of multi-foot-thick, concrete-hard ice. In the last five years, it has called for two of these vessels. Without this capability, the United States would be unable to support its Antarctic science mission.

**The Coast Guard does not charge users for domestic icebreaking services, yet offers a considerable return on each dollar spent to fund it.**

Coast Guard polar icebreakers also regularly conduct scientific missions in the Arctic and Antarctic regions. To investigate global climate change questions, the National Science Foundation sponsors these annual science missions, conducted by scientific bodies throughout the country. While in the process of conducting these unique missions, Coast Guard polar icebreakers are also called upon to conduct other Coast Guard missions. They are often diverted for search and rescue and law enforcement cases and must be ready to support national defense and environmental protection missions. In their daily operations, these highly specialized vessels provide the nation with a wide range of capabilities for operating in these extremely challenging environments.

**Domestic Icebreaking: Benefits and Challenges**

The Coast Guard maintains a fleet of 21 icebreakers of varying sizes, as well as 30 ice-strengthened buoy tenders. From mid-December through the end of April, these vessels, with guidance from regional operation centers, provide domestic icebreaking services on the East Coast and the Great Lakes to keep these waterways open for commerce. Additionally, icebreakers provide winter search and rescue and preventative flood-control capabilities (Figure 2).

As most mariners operating in cold winter regions will attest, domestic icebreakers provide an invaluable service to the maritime community and to the taxpayer. The Coast Guard does not charge users for domestic icebreaking services, yet offers a considerable return on each dollar spent to fund it. Waterborne shipping in the Great Lakes and Northeast during winter months provides the most cost-effective method of transporting raw materials, bulk cargoes, and home heating oil. Approximately 17 million tons of materials, such as coal, ore, and steel, are shipped during the winter on the Great Lakes alone. The East Coast is not far behind, with approximately 15 million tons shipped, approximately 80 percent of which is home heating oil and other petroleum products. Winter waterway closures, which increase transportation costs substantially, would be much more prevalent without icebreaking services.

The direct benefit of Coast Guard icebreaking services to industry is estimated at over $50 million annually. Beyond that, the impact that icebreaking services have on the entire economy is considerable. The jobs of a half-million people employed by Great Lakes iron ore, steel, and freight transporta-


**Figure 3: Coast Guard Cutter *Mackinaw* clears a shipping track through the ice of the St. Mary's River.**

tion industries are, in part, dependant upon the ability of the nation to keep winter waterways open for shipping (Figure 3).

The ability of Coast Guard icebreakers to keep waterways open is largely dependant upon ice coverage and thickness, which increases significantly with increasingly severe winter weather conditions. As winter severity increases, so, too, does the need for highly effective icebreaking. Therein lies our biggest challenge: The ability to provide highly effective icebreaking services poses the greatest challenge when it is needed the most. Also affecting mission effectiveness are industry changes in stockpiling and reliance on just-in-time delivery of products. This practice places additional pressure on our icebreaking assets to deliver services in a timely fashion, regardless of ice or weather conditions. With the reality of the market in place, we must work to establish and maintain best practices for meeting the various demands of commerce.

**Since 1965, when the U.S. Navy transferred the last of its icebreakers, the U.S. Coast Guard has been the sole operator of heavy icebreakers for the nation. Today, we operate a fleet of three polar icebreakers to meet this national requirement.**

**International Organization and Cooperation**

Internal organizational and operation practices are continually reviewed to provide greater services to meet the many challenges of a severe winter season. Often the secret to better performance lies outside of the organization. On the Great Lakes, we have established a partnership with the Canadians to better coordinate the utilization of icebreakers, thereby increasing the overall capability to facilitate maritime commerce to the mutual advantage of both countries. The United States/Canada Icebreaking Agreement for the Great Lakes provides for the coordination of icebreaking activities of the United States and Canada in the Great Lakes. This arrangement includes cooperative decision-making principles and designation of geographical areas within the Great Lakes and connecting waterways, where each organization has principal responsibility for icebreaking.

At the end of most days, we look behind our icebreakers and see a channel cleanly groomed for the next day's traffic. Setbacks often present themselves, but, through hard work, open communication, and enthusiastic cooperation in this challenging endeavour, government and industry team together to get the job done and keep traffic moving.

**Marine Science**

The goal of this program is to provide marine science support to Coast Guard units and missions, in cooperation with other agencies. All icebreaking resources perform various activities to support this objective, including conducting marine science to support Coast Guard operating programs, providing logistical benefit support for marine science-related research and development projects, and providing support for national security. In many cases, this area of ice operations is performed in concert with the National Ice Center, National Science Foundation, and National Weather Service projects.

Marine science work is performed in support of other Coast Guard programs as well. Search and rescue, object drift models, and oil spill trajectory models are excellent examples of events supported by marine science. From time to time, special projects in direct support of Coast Guard objectives are undertaken, such as operational testing of remote sensing systems and satellite imagery. Cooperative marine science projects are conducted on a resource-available basis and are mainly focused on providing routine weather and oceanographic data, including sounding, bathythermograph, and ice observations to other agencies.

**Service**

The Coast Guard is the only federal agency that operates icebreakers. We conduct both polar and domestic ice operations that provide assistance and support to all maritime activities operating in cold weather regions. You will find Coast Guard icebreakers in the Arctic and Antarctic, up and down the East Coast, and throughout the Great Lakes, providing essential support to our nation's interests in these sometimes remote locations and harsh climates.

IIP OPERATIONS

# Sea Ice

*The slow start to ice growth resulted in a 2003–2004 ice season with ice coverage that was much less extensive than normal.*

by U.S. COAST GUARD INTERNATIONAL ICE PATROL STAFF
Edited by Petty Officer TIM DEVALL
*Yeoman, U.S. Coast Guard International Ice Patrol*

**Figure 1: A large iceberg within a field of floe and pancake sea ice.**

Ice floating in the ocean is of two types. Glacial ice forms over landmasses, such as Greenland; sea ice forms and develops entirely on the sea itself or in the waters along a coast. Sea ice comes in a variety of types and forms, depending on the stage of development and the meteorological, atmospheric, and other physical conditions present.

Pancake ice is circular, with pieces of ice 30 cm to three meters in diameter, up to 10 cm in thickness. Brash ice is formed from the wreckage of other forms of ice and is usually no more than two meters across. Ice cake sea ice is relatively flat and less than 20 meters across. Floe sea ice is also relatively flat and consists of any piece of ice 20 meters or more across. Fast ice forms right along the coast. Fast ice higher than two meters above sea level is called an ice shelf. Figure 1 shows a large iceberg within a field of sea ice floes and pancakes.

**Arctic Sea Ice**

The two chief sources of arctic sea ice for the western Atlantic are the Davis Strait and Hudson Strait. In late October or early November, these straits are joined at Cape Chidley by heavy ice floes from Foxe Channel. The combined streams move down the Labrador coast and grow as new ice forms along the way. Off the Strait of Belle Isle, Newfoundland, the first ice masses appear in December or January as open strings of young ice. These are soon supplemented with heavy floes of true arctic character. Some of this ice enters the strait along the northern side, rapidly filling the entire strait and closing the Belle Isle route to navigation until late May or June.

By late January or early February, this ice has reached the northern edge of the Grand Banks, and by March the pack has spread over the northern part of the Banks, often as far south as latitude 47° N. Again, the first ice to appear is deceptively soft and open but is rapidly followed by heavier, more compact fields, extending for 100 or more miles from the coast. The ice field is heavy and compact enough to stop a vessel and may seriously damage ships attempting to force a passage.

There are two possible extensions of this ice. Large quantities drift south along the eastern edge of the Banks, breaking up into ice patches and belts as the ice moves south. If the ice survives to latitude 45°N, it quickly melts in the warmer water south and east of the Banks. This ice, in the last stage of disintegration, is seldom a threat to navigation. There are always icebergs present and often can be found in great numbers when the ice fields arrive off the Banks.

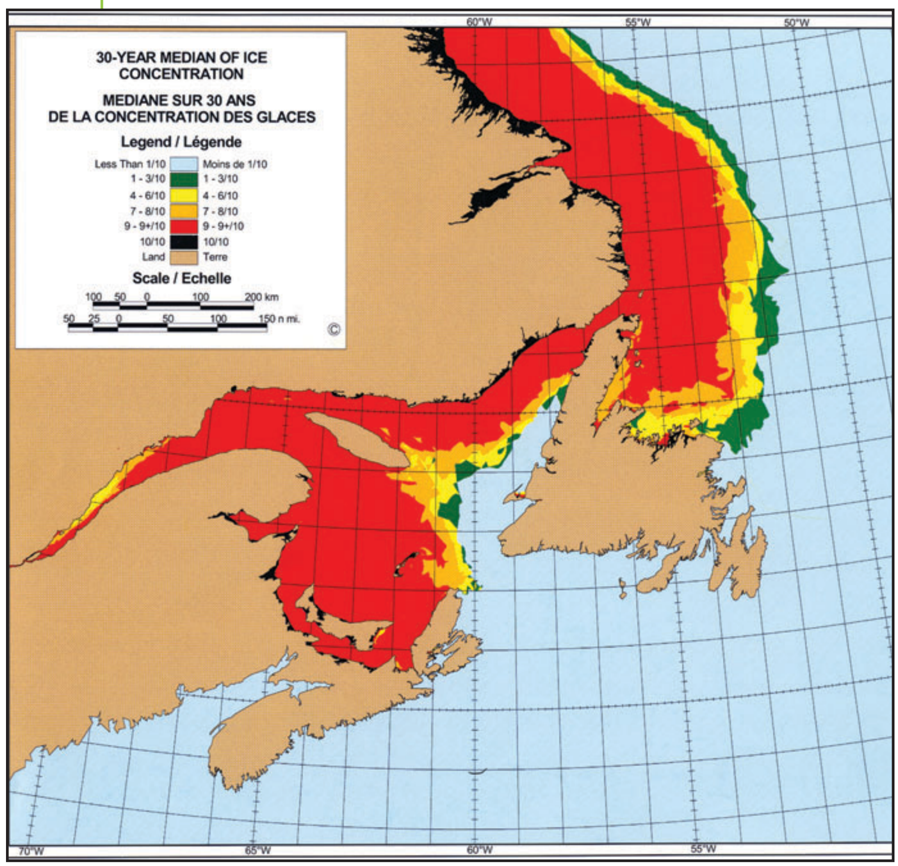



**Figure 2: Thirty year median for sea ice concentration for 29 January 2004. Courtesy of the Canadian Ice Service.**

The other extension of the ice is along the east coast of Newfoundland and around Cape Race. From this point, it spreads south and southwestward over the neighboring banks. There is no appreciable amount of ice experienced southwest of the shelf, and a clear passage can regularly be found in the mouth of the deep Laurentian Channel leading toward Cabot Strait. In some years, the ice spreads westward from Cape Race, completely blocking the harbors on the south coast of Newfoundland as far west as the Miquelon Islands. In April and May, as the winds tend to become westerly, the ice is driven eastward into warmer water and melts, starting a northward retreat of the pack ice. It clears the Strait of Belle Isle about the end of May in most years and the northern Labrador coast about the third or fourth week in July.

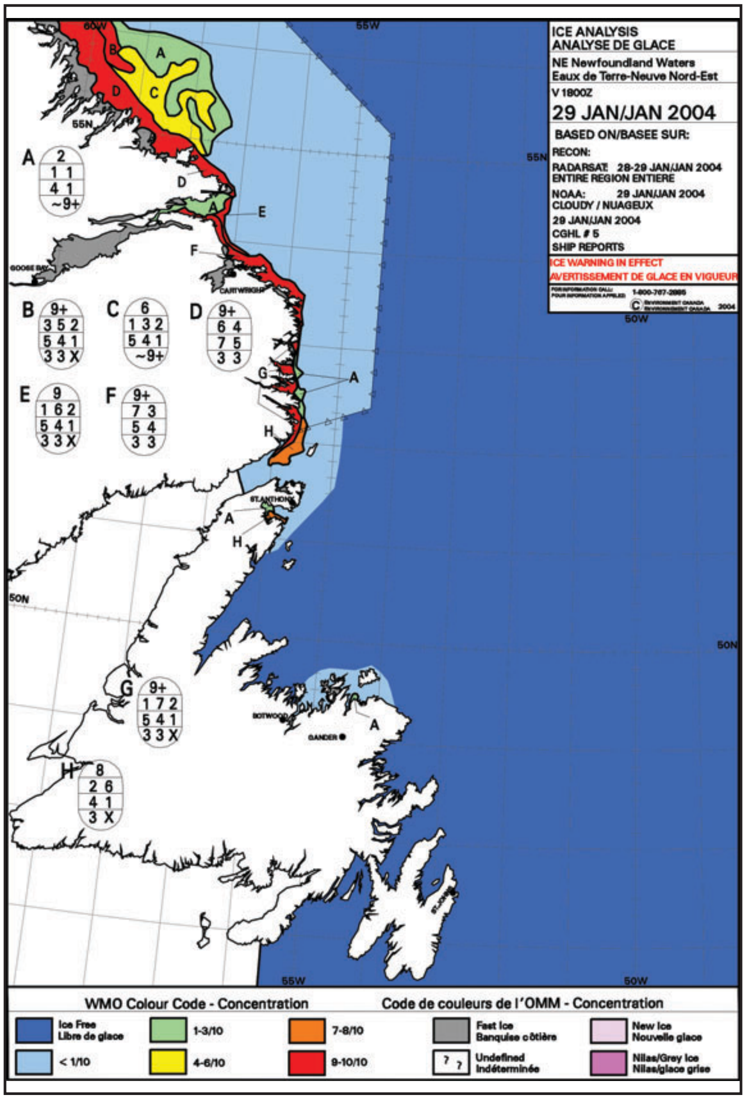



**Figure 3: Actual sea ice concentration for 29 January 2004. Courtesy of the Canadian Ice Service.**

### Signs of Sea Ice

There are two reliable signs of sea ice: one is *iceblink*, or *ice sky*. The presence of any appreciable area of sea ice produces characteristic light effects in the sky above it, which is rarely mistaken for anything else. This phenomenon is caused by the great amount of light reflected from the surface as compared with the surrounding sea and is observed long before the ice appears on the horizon. On clear days, iceblink appears on the horizon as a luminous yellow haze, contrasting sharply with the sky above, its height depending on the proximity of the ice field. The horizontal extent of the effect is strictly limited to the area of ice. On days with an overcast sky or with low clouds, iceblink appears as a whitish glare on the lower surface of the clouds above it. Both effects may occur at once under certain conditions and are a sure indication of field ice just over the horizon. The term *water sky* represents the reverse condition. If the observer is completely surrounded by ice, or nearly so, the bank of iceblink is sharply broken where leads of open water occur in the ice field. By contrast, this water sky appears almost black.

The second reliable sign of sea ice is the abrupt smoothing of the sea and the gradual lessening of the ordinary ocean swell. These are good indications of sea ice to windward. The leeward edge of the ice field is apt to be stringy and loose, while the windward edge will usually be sharply defined and closely packed. Pieces of ice to leeward give warning of its proximity, but absence of pieces should never be assumed to mean that no ice is near.

### Sea Ice and Icebergs

Sea ice plays an important role in the life of an iceberg. The 2004 ice season provides an excellent example. Sea ice will generally follow the same growth patterns every year. While the progress of the sea ice of a normal season is a useful guideline, some years, such as 2004, deviate dramatically from these conditions. During January 2004, the Labrador coast experienced persistent north and northeast winds, which brought relatively warm maritime air to the region. In addition, several strong low-pressure systems passed through the area, bringing storm-force winds that caused widespread ice destruction and compressed the remaining ice along the Labrador coast. The combination of much warmer-than-normal air and strong onshore winds led to sea ice conditions at the end of January that were far less than normal. In a normal year, the southern sea ice edge reaches Cape Freels by the end of January (Figure 2). In 2004 (Figure 3) the southern ice edge was barely into the Strait of Belle Isle.

Without the trace of sea ice, icebergs were more dramatically impacted by onshore winds and thus did not make it out to the offshore branch of the Labrador Current, which made for a relatively light iceberg season—only 262 icebergs drifted south of 48°N latitude.

Warmer-than-normal conditions continued throughout most of February, slowing the advance of the ice edge. Although normal air temperatures returned to the region in March, the slow start to ice growth resulted in a 2003–2004 ice season with ice coverage that was much less extensive than normal.



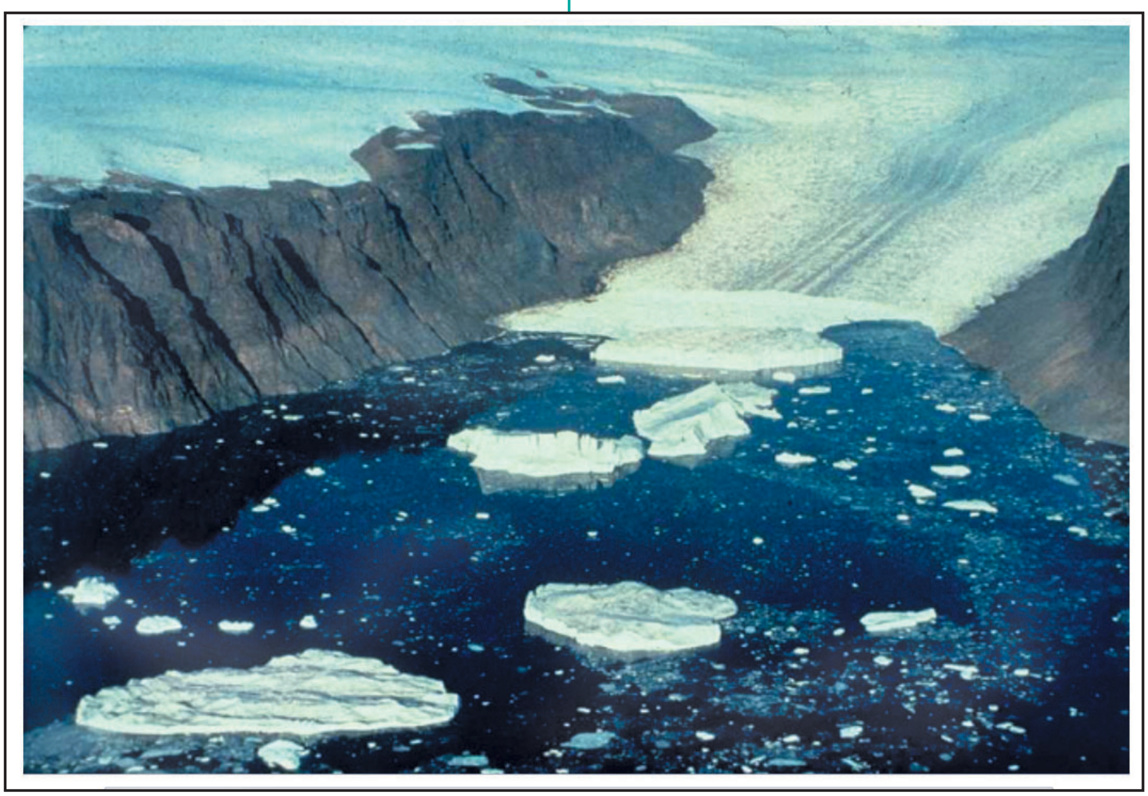
# Icebergs

*Northern Greenland's primary glaciers are some of the fastest-moving and most productive in the world.*

by U.S. Coast Guard International Ice Patrol Staff
Edited by Senior Chief John Stengel
*Marine Science Technician Senior Chief, U.S. Coast Guard International Ice Patrol*

Glacial ice is formed from the accumulation of snow that has gradually changed form as it is compressed into a solid mass of large, granular ice. This process produces a structure quite different from sea ice. Air entrapped within the ice forms a high concentration of tiny high-pressure air pockets, giving the ice a milky appearance and causing it to effervesce as it melts. Since it is formed over land, glacial ice is essentially salt-free. With the exception of a coastal fringe of exposed rock, Greenland is covered with an ice cap of glacial ice nearly two miles thick in some locations. This broad mass of ice feeds northern Greenland's primary glaciers, which are some of the fastest-moving and most productive in the world. Icebergs are produced when the buoyant force of water acts to break off sizable pieces of ice from the seaward point of these glaciers.

**Figure 1. Icebergs that have calved off of Hayes Glacier along the Greenland coast.**



**_Green_land?**

The principal origins of the icebergs that reach the North Atlantic Ocean are the 100 tidewater glaciers of west Greenland. Between 10,000 to 15,000 icebergs are calved each year, primarily from 20 major glaciers between the Jacobshaven and Humboldt Glaciers. It is estimated that these glaciers account for 85 percent of the icebergs that reach the Grand Banks of Newfoundland. Other sources of icebergs are the east Greenland glaciers, which produce about half the amount of icebergs as the west Greenland glaciers (Figure 1) but account for only 10 percent of the icebergs reaching the Grand Banks. The remaining five percent are thought to come from glaciers and ice shelves of northern Ellesmere Island.

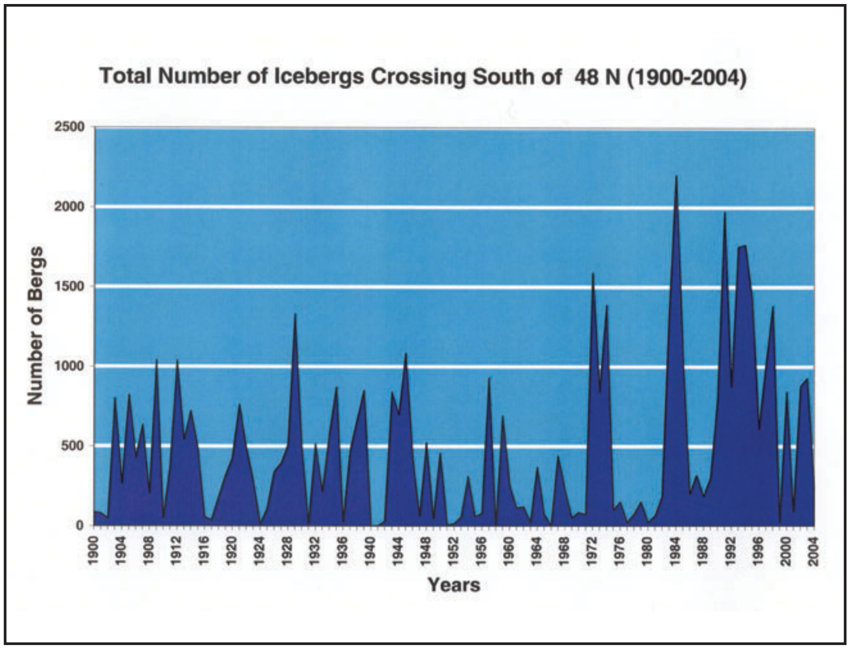



**Figure 2. The Ice Patrol maintains a count of the number of icebergs crossing the 48th parallel.**

The topography of the land along the coast of Greenland governs the general form, size, and rate of production of icebergs. In some areas where the glaciers meet the water away from the coast, the calved icebergs must worm their way down through narrow fjords or over a shallow sill, restricting the size of the icebergs that finally reach open water. In other areas, the glaciers reach the coast and calve icebergs directly into the sea.

**The presence of several growlers and smaller pieces of detached ice often indicates that an iceberg is in the vicinity and is probably to windward. Icebergs have been located in thick fog by this means.**

## Drift

Icebergs of west Greenland origin are initially carried north along the Greenland coast, around the western side of Baffin Bay and then south along the east coasts of Baffin Island, Labrador, and Newfoundland to the Grand Banks. Due to deep drafts of 300 to 600 feet, grounding often slows the larger icebergs. Some may get sidetracked, banging along the fringes of an arctic island or becoming caught in a Labrador cove. Their total drift is about 1,800 nautical miles (over 3,000 nautical miles for east Greenland icebergs), and many take from 11 months to as long as three years to reach the North Atlantic shipping lanes.

Some east Greenland icebergs drift southward along the coast to Cape Farewell, then northward, under the influence of the West Greenland Current. Occasionally, under the effect of wind or in the absence of a well-developed Irminger Current (a relatively warm, northward flowing extension of the North Atlantic Current), icebergs may continue south past Cape Farewell, reaching as far as 100 to 200 miles to the south or southwest. The majority, under the effect of the relatively warm West Greenland Current, disintegrate rapidly, seldom drifting north of latitude 65°N along the West Greenland coast. A few drift westward across the southern Davis Strait to the Labrador and Baffin Island coasts, where they join the main stream drifting southward.

The Ice Patrol maintains a count of the number of icebergs crossing the 48th parallel (figure 2). On average, 482 survive to this latitude each year. There have been some years, such as 1966, when no icebergs were detected this far south but there have also been some years with very heavy iceberg concentration in the vicinity of the Grand Banks. The count was 1,329 in 1929 and 1,588 in 1972. In 1984, the iceberg count was 2,202, nearly five times the normal crossing of 48°N latitude. Most recently in

2004, 262 icebergs drifted south of the 48th parallel.

Occasionally, icebergs may be reported off Newfoundland during November, December, and January, but the icebergs normally appear in this area during April, May, and June. Along the eastern edge of the Grand Banks, the first icebergs of the season are usually sighted in February or early March. In heavy ice years and with a well-developed Labrador Current, icebergs frequently reach as far south as latitude 42°N before rapidly disintegrating in the warm waters of the North Atlantic Current. Few icebergs ever drift south of the 40th parallel.

| Water Temperature | Iceberg Melting Time (approx.) |
|---|---|
| -1 ° C | 180 days |
| 3 ° C | 20 days |
| 6 ° C | 12 days |
| 10 ° C | 8 days |
| 15 ° C | 5 days |

**Table 1: Iceberg deterioration time for a medium-sized iceberg in six-foot seas.**

**Iceberg Deterioration**

The Grand Banks is the ultimate destination of the relatively few icebergs surviving the long journey from Greenland. Although deterioration of icebergs commences as soon as they are waterborne, in arctic seas with near-freezing temperature and when protected by sea ice, an iceberg may last almost indefinitely. Once it reaches the North Atlantic Current, with sea temperatures higher than 15 degrees Celsius, a large iceberg will disintegrate rapidly, usually within one to two weeks. Observations (Table 1) indicate the deterioration time for a medium-sized iceberg (165 feet high by 330 feet long) in six-foot seas.

Iceberg deterioration proceeds in three ways: melting, erosion, and calving. Melting is the normal action that warmer water has on the iceberg. Erosion is the additional disintegration that comes from the constant action of the waves slapping against the iceberg. The higher the sea state, the greater the rate of erosion will be. Calving is the process whereby a large iceberg breaks apart into smaller icebergs or "growlers." In doing this, the amount of surface area of an iceberg that can be acted upon by the surrounding water is greatly increased and allows for more melting and erosion.

The Coast Guard has conducted numerous experiments in attempts to determine means to accelerate the melting of icebergs. These have included gunfire, mines, torpedoes, depth charges, and bombing. However, the use of conventional explosives or combustibles proves difficult. In addition to the operational hazards of approaching and boarding an iceberg in a seaway, the theory of explosive demolition shows that 1,900 tons of TNT are required for the breakup of an average-sized iceberg (70,000 cubic feet). Further, to melt such an iceberg would require the complete theoretical heat of combustion

| Size | Height (feet) | Height (meters) | Length (feet) | Length (meters) |
|---|---|---|---|---|
| Growler | Less than 17 | Less than 5 | Less than 50 | Less than 15 |
| Small Iceberg | 17–30 | 5–15 | 50–200 | 15–60 |
| Medium Iceberg | 51–150 | 16–45 | 201–400 | 61–122 |
| Large Iceberg | 151–240 | 46–75 | 401–670 | 123–213 |
| Very Large Iceberg | Over 240 | Over 75 | Over 670 | Over 213 |

| Shape | Description |
|---|---|
| Tabular | Steep sides with a flat top. Very solid. Length-height ratio less than 5:1. |
| Non-Tabular | This category covers all icebergs that are not tabular-shaped as described above. This includes bergs that are dome-shaped, sloping, blocky, and pinnacles. |

**Table 2: Iceberg classification.**

of 2.4 million gallons of gasoline. Such practices are both economically and scientifically unsound (refer to “Seek and Destroy?” on page 50 for further detail).

**Iceberg Detection**

The density of glacial ice usually varies between 0.82 and 0.87, which means that about seven-eighths of the iceberg's mass is below the surface of seawater. Thus, a growler only three feet high may have an underwater depth of 12 feet and a total mass of over 100 tons. Greenland icebergs frequently reach a height of 200 to 300 feet above the water line and 1,500 feet in length and breadth. Such icebergs may represent 1.5 million tons of ice. Icebergs larger than this, though common in the Antarctic, are rare in the North Atlantic. Table 2 is used by Ice Patrol as a means of classifying icebergs, based on their above-water size and shape.

Icebergs in the warm waters of the North Atlantic Current give off cracking sounds as they melt. When a growler is calved, or a quantity of ice sloughs off from the side of an iceberg, a thunderous roar may be heard as it falls into the water. The presence of several growlers and smaller pieces of detached ice often indicates that an iceberg is in the vicinity and is probably to windward. Icebergs have been located in thick fog by this means. If one must transit ice-infested waters, it is probably best to pass to windward of an iceberg during a period of low visibility or at night to avoid any undetected growlers. The presence of an iceberg has no appreciable effect on the temperature (or salinity) of the water surrounding it. Sudden changes in the temperatures of the surface water, therefore, do not necessarily signify that there is ice near.

**Icebergs are sighted at various distances, depending upon the state of visibility and height of the iceberg and observer. Large icebergs can usually be seen on a very clear day by an observer with a height-of-eye of 70 feet at a distance of 18 miles.**

Icebergs are sighted at various distances, depending upon the state of visibility and height of the iceberg and observer. Large icebergs can usually be seen on a very clear day by an observer with a height-of-eye of 70 feet at a distance of 18 miles. In clear weather, but with low-lying haze around the horizon, the tops of icebergs have been seen at nine to 11 miles. In light fog or drizzling rain, an iceberg is visible at one to three miles.

In 1945–46, and again in 1959, the International Ice Patrol conducted comprehensive evaluations of radar reliability and anti-clutter device effectiveness in detecting icebergs. A summary of the results of these experiments indicated the following for prudent radar use in navigation.

- Glacial ice found on the Grand Banks has a reflection coefficient of approximately 0.33 and reflects radar waves 60 times less than a ship of equivalent cross-sectional area.

- The maximum range of radar contact is proportional to the fourth root of the cross-sectional area of icebergs. A statistical relation derived from 152 observations shows that growlers and medium size floes of sea ice normally cannot be detected at ranges greater than four miles.

- An iceberg is normally detected by radar at a range between four and 15 miles, but in the vicinity of the Grand Banks, subnormal radar propagation is usually experienced during the spring months when fog and ice hazards are most prevalent.

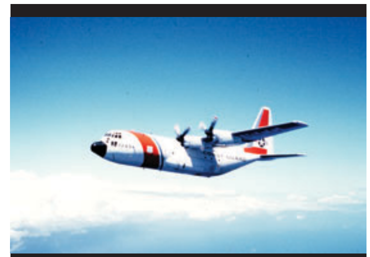
- Waves over four feet might obscure a dangerous growler, even with the expert use of anti-clutter devices. If an ice target is not picked up beyond the sea return, it will probably not be detected at all.

- Ice is not very frequency-sensitive. The response of ice to various radar bands is virtually the same.

- The use of sector scan, trained radar operators, and constant surveillance of the radar scope increases the probability of detecting ice by radar.

The average ship's radar cannot be totally relied upon for the detection of all ice drifting in the North Atlantic Ocean. It is definitely an aid, but it does not provide an assurance against the presence of all floating ice, which might damage or sink a ship upon collision.

# Oceanography



IIP Operations

*The International Ice Patrol has been closely associated with the development of oceanography over the past eight decades.*

by U.S. Coast Guard International Ice Patrol Staff
Edited by Senior Chief John Stengel
*Marine Science Technician Senior Chief, U.S. Coast Guard International Ice Patrol*

The international conventions and laws that created the International Ice Patrol wisely gave the patrol the added advancement of studying the oceanographic character of the waters affecting the drift of icebergs in the North Atlantic Ocean. Oceanography can be described as the application of science to the phenomena of the oceans. Since icebergs and their drift are one of the most striking of these phenomena, it is no small wonder that the International Ice Patrol has been closely associated with the development of oceanography over the past eight decades.

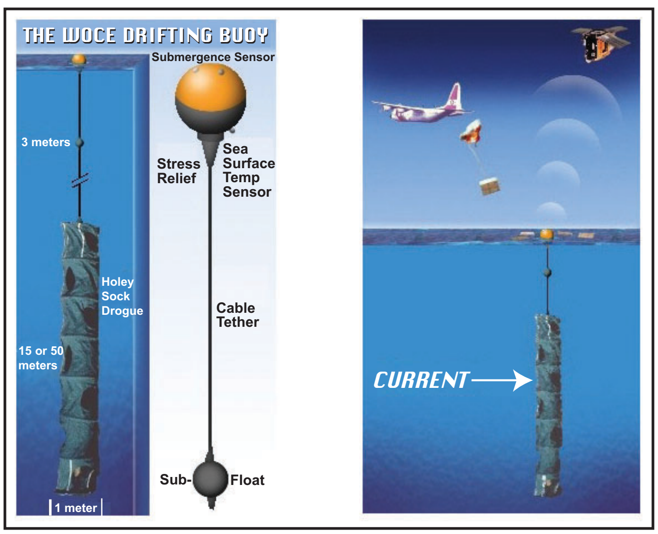



**Figure 1: The World Ocean Circulation Experiment (WOCE) drifting buoy currently utilized by the Ice Patrol. The air-deployed WOCE buoy transmits valuable current and sea surface temperatures for use in the Ice Patrol's models.**

## History

The early history of the Ice Patrol chronicles a pioneering service whose purpose was not only to maintain an effective patrol worthy of the high life-saving and protection standards and traditions of the U.S. Coast Guard, but also to accumulate scientific data regarding the natural forces controlling icebergs. The first patrol in 1914 began a program of oceanographic research, which has materially contributed to the safety of ships at sea and to our knowledge of the seas in general. The Ice Patrol has taken every opportunity and directed a great deal of effort each ice season toward assembling data and making studies of oceanographic conditions in the Grand Banks region. The information gathered during the ice seasons has been supplemented by observations made during special cruises at other periods of the year, to study seasonal changes in ocean currents and water temperatures. Each succeeding season has brought to light new and important information to further our understanding of this oceanographically dynamic area and to strengthen and corroborate opinions derived from previous scientific investigations.

On March 28, 1919, the Cutter *Androscoggin* made the first Ice Patrol oceanographic cast, which is a vertical sampling of the water column. Since then, over 12,000 casts have been completed in support of Ice Patrol operations. The Ice Patrol has pioneered many aspects of oceanography, including the first shipboard use of the inductive salinometer in 1926, the use of the geomagnetic electrokinetograph current meter in 1948, the development of the airborne radiometer in 1954, and some of the first and most extensive studies of the formation, drift, and deterioration of both sea ice and glacial ice. The Cutters *Marion* and *General Green* expeditions in the late 1920s and early 1930s mark some of the original efforts to gain a comprehensive understanding of the oceanographic characteristics of the Grand Banks and Labrador Sea areas.

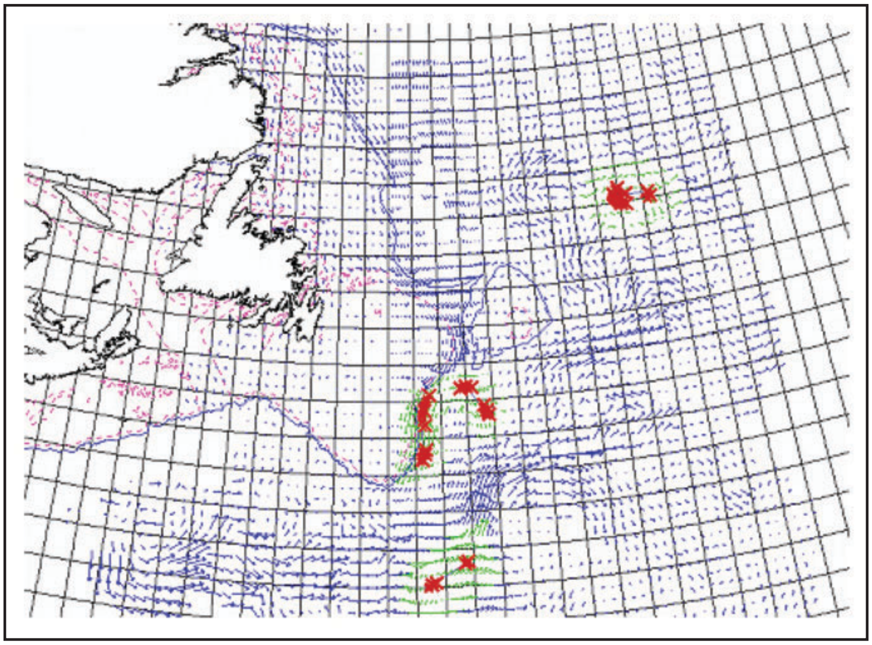


**Figure 2: Ice Patrol collects drift data and sea surface temperatures from the WOCE buoy. Green vectors indicate currents updated by WOCE buoys, whose positions over a one-week period are shown in red.**

### Research and Data Collection

The International Ice Patrol has concentrated on the physics of the ocean to chart ocean currents and predict the drift of icebergs. Using the principle that the ocean, like the atmosphere, is a fluid in motion and by measuring the density structure, or more simply, the "weight" of the ocean at various points in a certain area, there can be certain conclusions drawn about the direction and strength of the water movement. This is analogous to the meteorologist who, by noting the barometer readings at many places, can predict the movement of weather patterns. While the oceanographer has the advantage of a slower situation and more perfect fluid, he does not have the convenient barometer to measure the pressure (or weight) of his atmosphere (or ocean).

The Ice Patrol oceanographer must spend many weeks or months at sea painstakingly measuring the temperatures and salinities of the ocean depths to compute the density structure of the sea. While the density differences are minute, they serve as the driving forces of the great ocean currents. Here we must deal with accuracies of thousandths of a degree in temperature and millionths of parts of salt.

These research and data-collection efforts continued for almost 75 years. The Ice Patrol remains one of the few organizations to use real-time oceanographic data for its operations. During the 1982 Ice Patrol season, TIROS Oceanographic Drifters (TODs) were used for the first time to successfully modify the historic current database used by the International Ice Patrol drift prediction model (see “Tracking Icebergs” on page 25 for further detail). The Ice Patrol is presently using the smaller, less expensive World Ocean Circulation Experiment (WOCE) drifters (Figure 1). These satellite-tracked drifters use the latest oceanographic expertise and measure current speed and direction. The Service ARGOS in Toulouse, France, collects all sensor information and positions and relays them to the International Ice Patrol via computer link. The total drift vector, determined from the WOCE buoys, is used to modify the historic base. The modified currents are then relaxed to return to their original values over a two-week period unless modified again by a more recent buoy drift (Figure 2).

While Ice Patrol aircraft can tell where an iceberg is today, the current data assist in predicting where it will be tonight or in tomorrow's fog. Using such techniques, Ice Patrol oceanographic ships have mapped thousands of miles of ocean currents and traced iceberg drifts back to their Arctic origin. Far from being limited to the Ice Patrol alone, the results of Ice Patrol oceanographic cruises and drifter observations have proven of immense value to scientists studying the great fisheries resources of the northwest Atlantic Ocean and to other oceanographers the world over. This phase of the International Ice Patrol goes unobserved by the mariner who receives, nevertheless, an added measure of safety.

### Ocean Currents

Ocean currents are the main factor affecting the movement of icebergs. Icebergs and sea ice of Arctic origin follow a course from the Arctic to the Tail of the Grand Banks, and are ultimately affected by the complex and variable current patterns that exist

**Opposite page: Ocean currents are the main factor affecting the movement of icebergs.**

along the boundary between the Labrador and North Atlantic Currents. Refer to Figure 3 for a graphical depiction.

The East Greenland Current is a true polar current, having its origin in the Arctic Ocean and flowing southward along the east coast of Greenland as far as Kap Farvel (Cape Farewell). Here it combines with a recurring branch of the warmer North Atlantic Current, called the Irminger Current, to form the West Greenland Current. The tempering effect of the Irminger Current makes the West Greenland Current relatively warm and salty. From here, the current flows north along the west coast of Greenland, with speeds sometimes in excess of 1 knot, yet steadily losing volume as water is fed into the cyclonic (or counter-clockwise) circulatory system in the Labrador Sea. Just south of Davis Strait Ridge, a major westward branching occurs; the remainder of the West Greenland Current continues across Davis Strait Ridge into Baffin Bay, where it feeds the eastern edge of another cyclonic circulatory system.

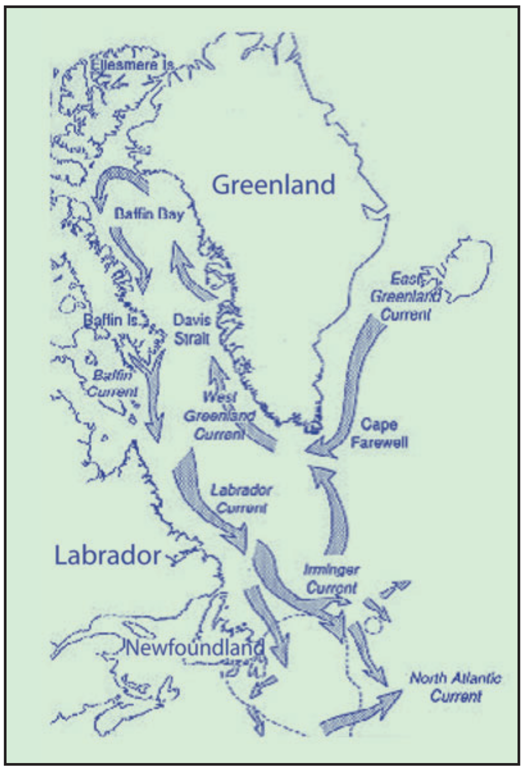


**Figure 3: Drift of icebergs from West Greenland glaciers to the Grand Banks of Newfoundland.**

The Labrador Current is formed by the junction of that portion of the Baffin Island Current, which flows southward across Davis Strait Ridge along the Baffin Island side, with the branch of the West Greenland Current curving westward just south of this ridge. The resulting stream, the Labrador Current, flows southward along the Labrador coast with its axis over, and parallel to, the continental slope. The frigid Baffin Island component, by which the Labrador Current is best known, is on the coastal side of the axis and the warmer (West Greenland) component is on the offshore side of the axis. The Labrador Current retains these characteristics with remarkably little change all the way to the Tail of the Grand Banks. The Baffin Island Current enters Hudson Strait along its northern side and leaves by the southern side. From here the Labrador Current continues southward to the northeast coast of Newfoundland and northern part of the Grand Banks. At this point it divides; one branch sets southwestward along the Avalon Peninsula; another, and usually major, branch continues southward down the east edge of the Grand Banks. This is the portion of the Labrador Current that bears the ice farthest south and constitutes the greatest threat to the shipping tracks between the United States and Europe.

Crossing the area south of Nova Scotia and Newfoundland, the Gulf Stream encounters the Tail of the Grand Banks around which it bends. On passing the Tail of the Grand Banks moving northeastward, the Gulf Stream becomes known as the North Atlantic Current. This current branches, forming many complex tongues and eddies as it continues to the northeast and east past the Tail of the Grand Banks. The surface temperature of the northern edge of the stream near the Grand Banks is approximately 12 degrees C in winter and 18 degrees C in summer.

The region around the Tail of the Grand Banks, where the Arctic and Gulf Stream waters meet, is one of the greatest hydrographical contrasts found anywhere in the world. The Labrador Current curves to the east, parallel to the northern border of the North Atlantic Current and gradually loses its identity through mixing. During the latter part of March and the first part of April, the flowing Labrador Current holds closely to the eastern slope of the Banks and sometimes curls around the southwestern slope. As the volume of discharge from the north increases, the mixing zone between the two currents moves farther offshore to the southwest, south, and southeast of the Tail. This results in the icebergs usually remaining nearer the Banks or being carried southwestward by the currents before reaching the Tail of the Grand Banks. During this cycle, the flow volume of the North Atlantic Current is also changing, and the resulting changes in relative strength of the two currents produce complicated variations in the location of their common boundary and in the courses, drift rates, and life expectancy of the icebergs reaching this area.

# Tracking Icebergs

IIP Operations

*A brief history of iceberg modeling at the International Ice Patrol.*

by Lt. Scott A. Stoermer
*Operations Officer, U.S. Coast Guard International Ice Patrol*

**This massive iceberg is small compared with International Ice Patrol's area of operations.**

The sinking of the *RMS Titanic* initiated a global response to the threat posed to life and shipping interests by icebergs on the waters of the Northwest Atlantic. The International Ice Patrol (IIP) responded to the threat with tenacity and professionalism within the bounds of the available resources. As time and operations have progressed, the method by which the Ice Patrol has monitored the iceberg danger near the Grand Banks and provided the Limits of All Known Ice to the maritime community has changed. To increase efficiency and more greatly ensure safety, the Ice Patrol shifted from drifting radio broadcasts to aircraft-based reconnaissance and computer-based modeling to track and report iceberg limits.

### Early Efforts

Once formally established, IIP quickly realized the importance of environmental and oceanographic factors with regard to the effective tracking of icebergs. While initially concerned with the identification of the southern-most iceberg and reporting its position to shipping, IIP became aware of the wealth of scientific data available in the sub-arctic region as well as the data's benefit to the Ice Patrol mission. In fact, from the onset of the International Ice Patrol, researchers began using Ice Patrol ships to collect oceanographic data. This early data collection began with the goal of recording the details of the environment in the vicinity of the Grand Banks of Newfoundland, to study the factors that influence iceberg motion and deterioration. Indeed, oceanographer A.L. Thuras (1916)[1] collected sea surface temperature, salinity, and in situ density with the purpose of locating water masses and studying their motion and mixing. Thuras had the specific goal of helping Ice Patrol officers better understand iceberg movement.

The ship-based resources of Ice Patrol provided ideal oceanographic data collection platforms for Ice Patrol crews and researchers alike. In fact, each Ice Patrol Officer was given very specific orders to "afford the scientists every facility for, and assistance in, making such observations and collecting such data as they may desire."[2] One of the key points regarding Ice Patrol's interest in the environment in which they operated can also be found in the orders to Ice Patrol commanders to conduct the "ice patrol," or identifying and reporting iceberg positions, in addition to "ice observation," or collecting scientific data for later analysis.

As the processes by which Ice Patrol conducted its mission changed, so did the focus of the oceanographic data collection facet of IIP operations. In the early years of Ice Patrol, the oceanographic data collection had a direct operational link and was used to better understand icebergs, their characteristics, and their behavior in the Ice Patrol area of operations. Today, the link between oceanographic data and operations is still direct, but the focus has shifted to computer-based iceberg modeling. The transition from ship-based drifting to model-produced Ice Patrol navigation warnings is a key part of Ice Patrol history as it maps cultural as well as technological change.

**Tracking icebergs and determining their rate of deterioration are two challenges Ice Patrol faces.**

### Shift to Forecasting

The lack of powerful computers and refined algorithms did not stop early ice observers from attempting to hypothesize the future drift of tracked icebergs. A great deal of effort during early Ice Patrol seasons was placed into the collection of data on water masses and current movement to better judge iceberg motion. Additionally, a great deal of traditional seafaring knowledge was applied to these early "model" estimates. The importance of understanding the average and anomalous ocean currents is evident in that even the first official report of International Ice Patrol operations includes a chart of ocean currents in the vicinity of the Grand Banks.

**Opposite page: Iceberg drift is directly impacted by size both above and below the waterline.**

**Above and below: As reconnaissance means shifted to aircraft-based resources, Ice Patrol identified the need to maintain a record of iceberg sightings and predict iceberg drift.**

As reconnaissance means shifted to aircraft-based resources, Ice Patrol identified the need to maintain a record of iceberg sightings and predict iceberg drift. The fact that airborne reconnaissance was, and is, not necessarily consecutive (day to day) and the same spatial regions are not flown in order, to observe the entire IIP area of operations requires an organized and accurate means of maintaining iceberg-sighting data and predicting iceberg positions. This was necessary both for accurate iceberg warnings as well as for flight planning. The system that was developed involved paper catalogues of iceberg-sighting data as well as manually maintained plots of the iceberg situation. Iceberg drift was estimated using a simple vector addition scheme, taking into consideration the wind and current field. As mentioned in the Ocean Data Application Section, early current maps gave way to dynamic topographic maps for use in this process. The paper system required extensive time and care to ensure transposition errors did not occur. Charles W. Morgan (1971)[3] notes that it could take 1.5 hours for duty personnel to drift and obtain positions for about 50 icebergs.

**Drift Models**

As early as 1966, "computerized" ice patrol proposals were being considered. Ice Patrol made the decision to move forward with a computer model called ICE PLOT in 1968. ICE PLOT was completed during the late summer of 1969 and tested in parallel with manual plotting for the first two weeks of the 1971 Ice Season. On 24 March 1971, IIP used ICE PLOT to create its first computer-generated ice bulletin.[3] ICE PLOT was a card-based program with a simple vector iceberg drift routine that was also able to sort the icebergs by latitude, output the information necessary for the bulletin, as well as print a map of icebergs within the area of operations. ICE PLOT shortened the amount of time necessary to plot and catalog 50 icebergs from about 1.5 hours to less than a minute.[3]

Despite the leap forward that ICE PLOT represented for Ice Patrol operations, it still had shortcomings and required improvement. The next implementation of computerized drift was via the IBERG program developed in 1978. IBERG was first used operationally during the 1979 ice season (Murray, 1979).[4] In terms of drift accuracy, IBERG embodied a tremendous advance over previous drift estimators as it included a highly complex, four-factor scheme to determine iceberg motion. Specifically, IBERG employed a Runga-Kutta technique to the drift estimations and applied additional forcing not previously included. Runga-Kutta formulas apply an iterative, numerical method to solve complex differential equations. IBERG estimated drift by evaluating the effects of the Coriolis acceleration, air drag, water drag, and a vertically dependant current scheme that included density-driven as well as wind-driven motions. The Runga-Kutta technique used, in the case of IBERG, fourth-order differential equations to express and solve the forcing functions.

Between the years of 1979 and 1992, Ice Patrol adapted the IBERG system for use within the larger ICE PLOT system. The ICE PLOT system included modifications to the original ICE PLOT and could therefore be used to sort icebergs, output bulletin information, and plot iceberg maps. In 1993, Ice Patrol shifted from the ICE PLOT system to the Iceberg Data Management and Prediction System (IDMPS), which included drift and deterioration modules as well as administrative (bulletin- and map-printing) functionality. In 1998, Ice Patrol transitioned from IDMPS to the Iceberg Analysis and Prediction System (BAPS) for estimating iceberg drift, deterioration, as well as product generation.

**Melt Models**

As iceberg drift is directly impacted by size both above and below the waterline, the need to accurately predict iceberg size was quickly realized. Early efforts to predict melt used a table that estimated size based on elapsed time and sea-surface temperature. The values within the table were based on historic observations and some preliminary work about iceberg deterioration processes.

The first use of a computer-based deterioration scheme occurred in 1983. Lt. Ian Anderson (1983)[5] described the performance of a melt model based largely on the work of F. M. White, M. L. Spaulding, and L. Gominho, authors of "Theoretical Estimates of the Various Mechanisms Involved in Iceberg Deterioration in the Open Ocean Environment" (1980).[6] Anderson's implementation applied the effects of insulation, buoyant convection, wind-forced convection, and wave-based effects to modeled icebergs to predict changes in iceberg size. Anderson's melt model was included in the ICE PLOT system and used operationally until the implementation of IDMPS and the subsequent BAPS models.

**Before computer modeling, iceberg drift was estimated using a simple vector addition scheme, taking into consideration the wind and current field.**

**Drift/Melt Implementations**

It did not take long for Ice Patrol to realize that separate drift and melt routines were cumbersome and potentially induced errors to the already complex process of iceberg modeling and product creation. As model sophistication increased and computer use became easier, the ICE PLOT system was the initial combined drift/melt system after Anderson's drift routines were introduced in 1983. IDMPS represented the next generation of IIP drift/melt modeling and was implemented in 1993. The IDMPS system was very similar to BAPS, which had been implemented for use by the Canadian Ice Service (then Ice Centre, Environment Canada) as early as 1986. The IDMPS used a Computer Assisted Drawing (CAD) interface for graphics generation and included the Runga-Kutta and Anderson melt routines for iceberg position and size estimates.

The incorporation of BAPS into Ice Patrol operations occurred in 1998 (International Ice Patrol, 1998)[7] and its use has continued until the present. BAPS incorporated a great deal of administrative functionality in addition to the drift and melt schemes of previous models. The administrative functions include product generation, flight planning, and experimental modeling routines. Additionally, BAPS shifted the

**Early efforts to predict melt used a table that estimated size based on elapsed time and sea-surface temperature.**

model to a Microsoft Windows-based operating system, thus improving user interfaces. BAPS also applied a geographic information system (GIS) for graphics production and user viewing of iceberg data. Only after one season of operational use, B E. Viekman (1993)[8] noted significant improvement in the correlation of modeled targets with observed sightings from ships and Ice Patrol reconnaissance.

BAPS has undergone a number of modifications and improvements since its initial implementation and now exists as version 1.7. In fact, at the time this article was written, IIP was in the process of conducting comparisons of version 1.7 with its operational version (1.4).

### Oceanographic Data Application

As noted above, one of the primary applications of collected oceanographic data was to develop an understanding of the environment in which the Ice Patrol operated. However, the data was also critical to IIP operations as it contributed directly to the accuracy of modeling efforts. Early modeling efforts (paper and early ICE PLOT) used ocean currents estimated from dynamic topography maps of the North Atlantic. Consequently, the data (salinity, temperature, density) collected by ice observers operating on Ice Patrol surface resources were key to accurate drift estimates. As IIP shifted to increasingly complex modeling schemes, the necessary data also became more complex.

A discussion of the transition of IIP's data assimilation processes and resources is beyond the scope of this article; but it is interesting to note that IIP shifted from the use of in situ data including sea surface temperature, winds, and derived currents to modeled environmental data (sea surface temperature, winds, and wave parameters) and mean current files modified by near real-time drifting buoy data. The evolution of data assimilation at Ice Patrol has served to increase the accuracy of its iceberg modeling efforts.

### The Future

As noted above, a validation of BAPS 1.7 was conducted during 2004. While version 1.7 did not modify any of the drift or melt algorithms, Ice Patrol desired to ensure that it was the same, or very similar, to its operational model (BAPS 1.4). The Canadian Ice Service has continued its efforts toward model improvements and is working an even more advanced version of BAPS. The new model will include more complex algorithms for drift and melt as well as a dynamic current field as compared to the static current field presently used by versions 1.4 and 1.7.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IIP OPERATIONS

# Ice Patrol Duty

*IIP personnel and the Aviation Mission Specialist insignia.*

by LT. CMDR. BYRON WILLEFORD
*Deputy Commander, U.S. Coast Guard International Ice Patrol*

International Ice Patrol is a 16-member unit comprised of four active-duty Coast Guard officers, two civilians, and 10 active-duty enlisted members, who are nine marine science technicians (MSTs) and one yeoman for administrative duties.

**Officers**

The wardroom is made up of an O5 Commander, International Ice Patrol (CIIP), an O4 Deputy (DCIIP), and two O3s serving as Chiefs of the Operations (OPS) and Ice Information (INFO) branches. IIP is the only oceanographic command in the Coast Guard. As such, all of the officers are required to hold a masters of science in physical oceanography, meteorology, or a related geophysical science. This is necessary, since the planning and decision-making for patrols conducted by IIP and the products sent to the maritime community are based on an understanding of the oceanographic and atmospheric environment. Additionally, the science background provides a basis for interpreting and analyzing the output of the numerical computer models for iceberg drift and deterioration and making sound judgments for when the model results differ from reality.

**Civilians**

A PhD staff oceanographer provides updates and briefings on recent studies of the northwest Atlantic with respect to both research on the environment and technological pursuits, oversight of IIP's buoy and currents program, and consultation on how the operations area (OPAREA) environment, in its current state, impacts Ice Patrol operations. Almost every decision on operations, patrol planning, updates to environmental factors in the computer model, and products sent to the customer are made with the advice of the staff oceanographer. In the rare instance that both CIIP and DCIIP are unavailable, the staff oceanographer serves as acting CIIP.

Since the ability to process all of this information requires a variety of non-standard software, Ice Patrol employs a civilian information technology (IT) specialist. The IT specialist maintains the systems required for the receipt and quality control of oceanographic and atmospheric model data, flight planning software, and the Berg Analysis and Prediction System (BAPS), which is IIP's iceberg drift and deterioration model.

**Enlisted Corps**

With nine of the 10 enlisted billets being MSTs, International Ice Patrol has a higher concentration of MSTs than any other Coast Guard unit. An E8 serves as the Command Senior Chief and two E6s fill the roles of Leading Petty Officer (LPO) for the OPS and INFO branches. Three E5s and three E4s are divided among OPS and INFO.

Every MST stands watch in the Operation Center (OPCEN) and deploys as a member of the Ice Reconnaissance Detachments (IRDs). Being an oceanographic command, the MST billets at Ice Patrol have a very strong science component. This includes completion of an eighth-month Air Force meteorology training program (for E6 and E8) prior to reporting; an understanding of the regional oceanography and meteorology for the OPAREA, including its impact on iceberg behavior; and a working knowledge of oceanographic research equipment such as Air-Deployed Expendable Bathy-Thermographs (AXBTs) and World Oceanic and Circulation Experiment (WOCE) buoys. Additionally, members become adept in the use of non-standard software, assisting the Coast Guard Search and Rescue program with quality control of Gulf Stream current forecasts, and verifying model data output from the Navy's Fleet Numerical Meteorological and Oceanographic Center (FNMOC). And, since all IIP operations occur near the U.S. border with Canada, members coordinate model results and environmental data with our partners at the Canadian Ice Service (CIS).

There is one independent duty Yeoman (YN) billet at IIP to handle all Ice Patrol administrative issues—working directly for DCIIP. However, the YN is still expected to qualify as an OPCEN watch stander and deploy as an IRD member.

One of the most unusual in-rate MST billets in the Coast Guard is located at the National Ice Center (NIC). Although not formally attached to International Ice Patrol, the NIC MST assists IIP through the use of the latest national technical means to identify and track icebergs. It is the only Coast Guard billet at NIC.

**All Members**

Everyone assigned to International Ice Patrol must hold a security clearance. In addition, all active-duty members are required to participate in the Coast Guard Hearing Conservation Program and must be eligible to deploy on IRDs. This eligibility is dependent on the security clearance, the ability to pass a swim test, and successful completion of the Air Force Low Pressure Chamber training. To ensure members are able to complete and maintain the physical requirements for deployment, Ice Patrol has instituted a unit Physical Fitness Program that requires all active-duty members to exercise as a unit twice a week and tracks each individual's performance on a standard fitness battery.

**Watches and Duty**

Every active-duty member at International Ice Patrol stands watch in the OPCEN and deploys as an IRD member. There are two qualification levels in the OPCEN: Watch Stander (WS) for E4 and E5, and Duty Watch Officer (DWO) for E6, E8 and officers. The two-member WS and DWO watch team assimilates all iceberg data from NIC, CIS, IRDs, and reports from the maritime community into BAPS. Environmental conditions, observed and forecasted, are added to the iceberg data and all this is used to make a best prediction on the Limits of All Known Ice (LAKI), the positions of individual icebergs, and the extent of sea ice. Once completed, this information is distributed to the transatlantic shipping community. The OPCEN is staffed during the workday and while products are being generated and distributed. The WS and DWO are on-call after the workday and during weekends, after the day's products have been successfully disseminated.

**Figure 1: The Aviation Mission Specialist (AMS) insignia.**

IRDs are composed of four members from Ice Patrol—Tactical Commander, Radar Ice Observer, and two Ice Observers—and 10 members from Air Station Elizabeth City (ECAS). The Tactical Commander (TC) is in charge of the tactical aspect of the deployment and works hand-in-hand with the Aircraft Commander from ECAS on flight planning and mission execution. The Radar Ice Observer (RIO) serves as the center point for all iceberg information being collected by the two IIP Ice Observers (IOs) and the ECAS radar operators during an IRD patrol. IOs are visual observers and literally look out the C-130 windows to spot icebergs and record their positions, sizes, and shapes—all of which impact the results of the output from BAPS.

**AMS Insignia**

Every Coast Guard specialty has its own specific recognition. IIP's "Ice Picks" are eligible to wear the Aviation Mission Specialist (AMS) insignia (Figure 1). The Aviation Mission Specialists are non-aircrew


**Figure 2: Cmdr. Michael Hicks pins on Petty Officer Tristan Krein's permanent Aviation Mission Specialist Wings.**

personnel who perform specialized mission functions aboard Coast Guard aircraft. In the case of Ice Patrol, that specialized function is the Aerial Ice Observer.

The criteria for AMS qualification, which have been incorporated into IIPs' IO training and qualification program, include the previously mentioned swim test and low pressure chamber training, along with training in crew resource management, land survival, aircraft egress, SAR equipment, pyrotechnics, first aid and CPR, OPSEC/COMSEC, and operational hazard awareness. Lastly, the IO (and therefore AMS) qualification requires that the member maintain an aircrew class II physical.

Once qualified as IO and AMS, Ice Picks wear the insignia for Navy Aviation Observers and Flight Meteorologists. The insignia can be worn temporarily as soon as a member is IO qualified. The insignia cannot be worn permanently until members accumulate 800 flight hours, which is nearly impossible to accomplish in one tour at IIP. Additionally, Ice Picks qualify for non-crewmember aviation hazardous duty incentive pay. Petty Officer Tristan Krein (Figure 2) is one of only two Ice Picks who have accumulated the requisite number of flight hours to earn the AMS permanent designation.

IIP OPERATIONS

# The Foggy, Stormy Grand Banks

## *Weather challenges at International Ice Patrol.*

by Petty Officer TRISTAN KREIN
*Marine Science Technician, Ice Operations Division,*
*U.S. Coast Guard International Ice Patrol*

The International Ice Patrol's area of responsibility, encompassing the region of the Grand Banks of Newfoundland, is notorious for stormy seas and thick fog that have plagued the transatlantic mariner throughout history. Dangerous weather conditions, mixed with the added threat of icebergs traveling south with the Labrador Current, often make the North Atlantic an inhospitable region to travel. Nevertheless, international industry has relied heavily on its shipping routes and abundance of offshore resources for commerce. Although Ice Patrol reconnaissance is no longer conducted from cutters, effective aerial reconnaissance still depends greatly on the environmental conditions of the operational area and the St. John's, Newfoundland, airport, where reconnaissance operations are based.

**Climatology of the Ice Patrol's Operational Area**
From late fall to early summer, Newfoundland and the Grand Banks lie underneath the path of the Polar Front Jet (PFJ) stream that serves as a storm track for the low pressure storm systems traveling from the northeast coast of the United States. These storms carry the weather typically associated with frontal systems: high winds and seas, snow, thunderstorms, rain and freezing rain, low cloud levels, and the infamous fog that persists fore and aft of the warm fronts. By the time they have reached the North Atlantic, these systems have usually matured (occluded), with the worst weather often centered somewhere over the IIP's operational area at the point where the cold, warm, and occluded fronts connect—known as the "triple point."

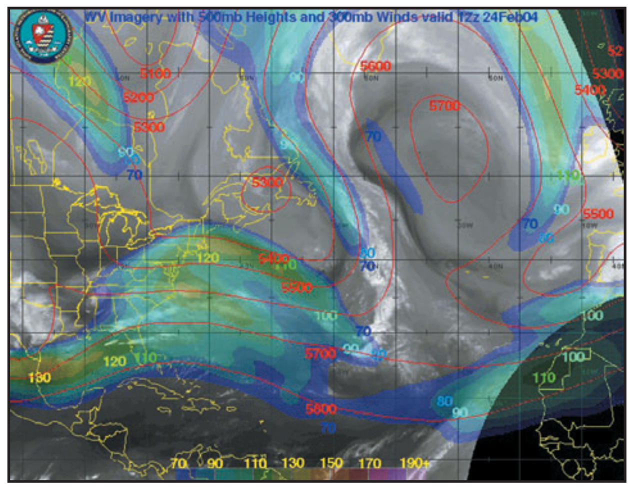


**Figure 1: View of a typical Omega High Pressure System.**

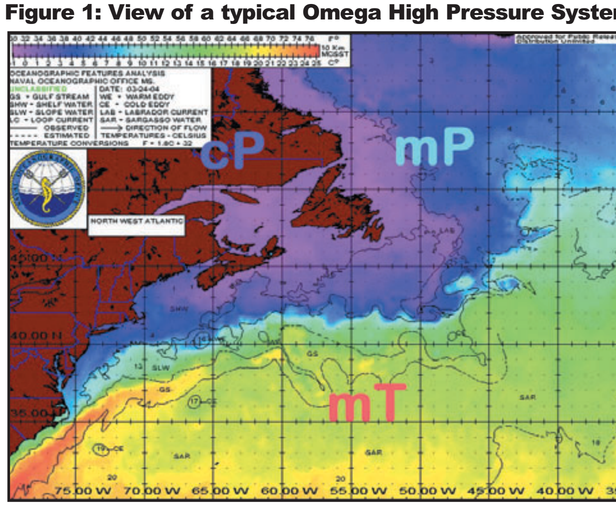



**Figure 2: The boundaries between the cP, mP and mT air masses form the fronts associated with storm systems. Images courtesy of U.S. Naval Atlantic Meteorology and Oceanography Center.**

Generally, North Atlantic storm systems continue to travel northwest toward the semi-permanent Icelandic Low between Greenland and Iceland; however, a storm may stall or even retrograde back over the operational area when a strong ridge of high pressure builds to the east. Known as a blocking ridge or omega high, due to the shape of the path the PFJ takes around the high pressure and its resemblance to the Greek letter omega, these ridges may persist for a week and cause a storm to plague an area, even intensify, until the ridge weakens enough to allow the low pressure to move out (Figure 1). The late spring and summer months may see some relief from the intense storms of the winter months as the PFJ migrates to the north over North America due to the effects of summertime heating. While the moderating effects of the ocean do not see as much north/south seasonal migration, the frontal systems passing through the operational area are often less intense and faster moving along a storm track that is more horizontal or zonal.

In addition to the storm systems, IIP's operational area is constantly affected by the modification of air masses as they move from one source region to another. The weather in the operational area is influenced by the interaction of three air masses: cold, dry, continental polar (cP) air from eastern Canada; cool, moist, maritime polar (mP) air from the Labrador Sea and Labrador Current; and warm, moist, maritime tropic (mT) air from the eastern U.S. coast and the warm Gulf Stream waters (Figure 2). It is the boundaries between these air masses that form the fronts associated with the storm systems passing through the area. Winds with any southern aspect, such as those behind a warm front, are typically bad news for the mariner navigating the cold waters of the Labrador Current. As these winds push the warm, moist, mT air from the Gulf Stream northward over the cold surface waters of the Labrador Current, the water in the lowest layers of moist air cools, condenses, and forms a thick, persistent, sea fog that may cover the entire region.

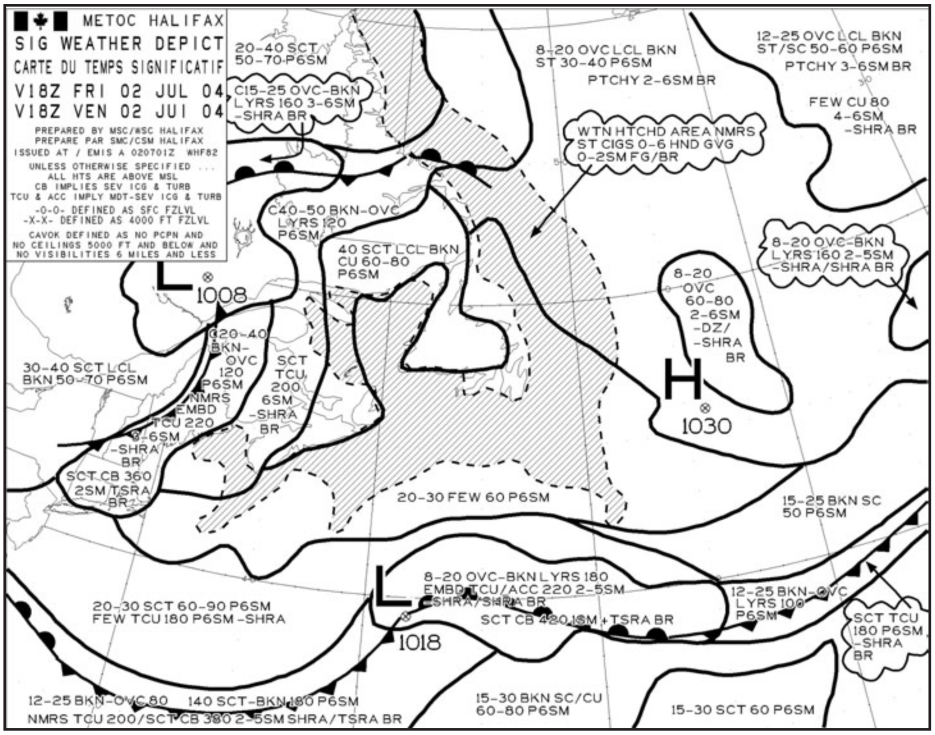


**Figure 3: Clockwise winds around a high pressure center to the east produce an extensive area of sea fog on the Grand Banks region (shown by cross-hatching on figure). Image courtesy of Environment Canada, Meteorological Service of Canada.**

Even high pressure systems, usually associated with clear skies and favorable conditions, can be a disadvantage in this region. With winds traveling clockwise around the high pressure center, a high pressure system sitting over the operational area generates the southerly winds to the west of the center that bring the air from the Gulf Stream region over to the Labrador Current (Figure 3). Conversely, winds from the west, northwest, and north, such as those behind a cold front, generally bring good visibility to the surface, particularly during the late spring and summer months when temperature and humidity contrasts between the continental and maritime air masses are minimized. During the winter months, when temperature and humidity contrasts between the continental and maritime air masses are at their peak, modifications to the cold, dry air of the cP air mass are intensified and result in the rapid formation of stratocumulus clouds off the coastline due to low-level instability (Figures 4 and 5). While these low-level cloud conditions may not pose a problem to the mariner, they can hinder iceberg reconnaissance from the air.

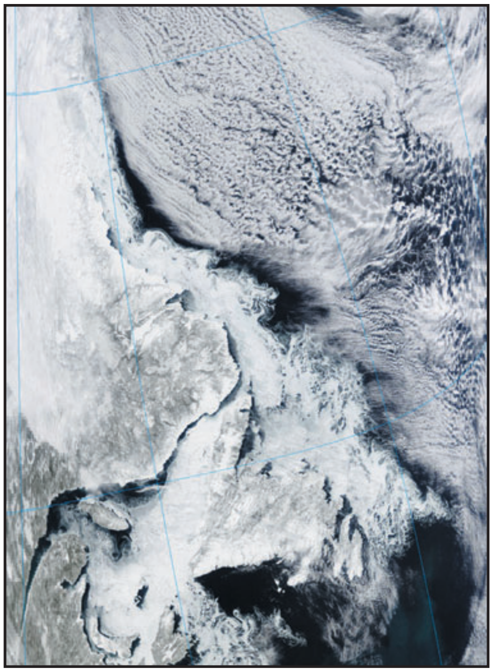
**Figure 4: While these low-level cloud conditions may not pose a problem to the mariner, they can hinder iceberg reconnaissance from the air.**

**Effects of Weather on IIP Reconnaissance**

Safety is of primary concern during any flight, and established criteria must be met and forecasted for iceberg reconnaissance to take place. Crosswinds over 25 knots or low-level wind shear can blow a taxiing aircraft off course. Ice on the runway only serves to compound this hazard. Icing of the aircraft due to snow or freezing rain necessitates expensive de-icing procedures or valuable time in the hangar to thaw (Figure 6). Cloud ceilings below 200 feet or fog that restricts visibility to less than a half-mile will prevent takeoff and landing due to a reduction in situational awareness and the added potential for collision (Figure 7). This poses a particular challenge in St. John's, aptly nicknamed Fog City. In-flight weather hazards include the turbulence associated with high cross winds and wind shear; icing during prolonged periods in clouds during the cold weather months; and thunderstorms associated with frontal systems. Even low cloud ceilings or fog can pose an in-flight safety hazard during low-level operations to deploy oceanographic buoys or visually confirm ambiguous radar targets.

Besides the operational safety concerns, the operational effectiveness of a flight to accurately detect and identify icebergs must be considered before embarking on a day-long mission. Again, low clouds and fog prevent the detection or confirmation of icebergs at the surface. Historically, visibility averages less than 30 percent during aerial reconnaissance. In addition to the visual search conducted by Ice Observers in the windows, Ice Patrol uses two types of radar that rely on certain conditions for optimal performance. Heavy flight level cross winds often result in turbulence and may force the

Figure 5: Low-level cloud conditions can hinder iceberg reconnaissance from the air. Image courtesy of MODIS Rapid Response Project at NASA/GSFC.



airplane to turn into the wind or "crab" (fly sideways) to stay on course. Turbulence, or a crab angle of more than 15 degrees, produces an uneven distribution of the energy of one radar and may adversely affects its image. This radar also depends on relatively calm surface winds and low seas to maximize the detection of targets. The other radar relies on wave motion to identify targets based on their movement and the characteristics of their Doppler signature. If high winds produce sea heights greater than a couple of meters, the ability of either radar to detect objects at the surface is increasingly diminished, as targets hide in the troughs between wave crests. High seas also diminish the ability to detect and distinguish small icebergs from the camouflaging effects of the breaking wave crests.

In a scenario where calm winds and flat seas are present with thick fog at the surface, both radars will detect an abundance of targets, including trash and biological debris, but will be unable to identify them, due to the lack of motion required to produce


Figure 6: Icing of the aircraft due to snow or freezing rain often necessitates expensive de-icing procedures.

**Figure 7: Low cloud ceilings or fog that restricts visibility to less than a half-mile will prevent takeoff and landing.**

the necessary Doppler signature. Without the ability to descend for visual confirmation, the result is an abundance of ambiguous targets that add confusion and little useful information. While these conditions do not pose a threat to the safety of the aircraft, they may not warrant the cost of a flight if confidence in the data does not exist.

**IIP's Weather Program**

The variety of weather conditions encountered in the Ice Patrol area of operations necessitates an understanding of basic weather principles for effective flight planning. Until the spring of 2003, flight services at St. John's airport provided face-to-face weather briefs and forecasting by experienced meteorologists with good knowledge of the region. Due to financial cutbacks, this vital asset was discontinued and weather support services were moved to Halifax, Nova Scotia. To alleviate this loss, the International Ice Patrol has increased efforts to train personnel on the climatology of the North Atlantic, weather product interpretation, and some basic forecasting techniques.

Prior to reporting to Ice Patrol, senior (and some junior) enlisted personnel attend an eight-month course at Keesler Air Force Base in Biloxi, Miss. Working directly with Air Force, Navy, and Marine instructors, they are schooled in weather principals, chart analysis, satellite interpretation, weather briefing, and forecasting. Most of the commissioned officers stationed at Ice Patrol have backgrounds in oceanography, and many have training in meteorology through Naval post-graduate school. Some individuals have taken correspondence courses in basic meteorology. In addition to the formal training listed above, all personnel attend the annual Ice Patrol University that provides in-house refresher training prior to the opening of the iceberg season. This two-week training program encompasses all fundamentals of Ice Patrol, including basic weather and forecasting principals, climatology, and weather product interpretation.

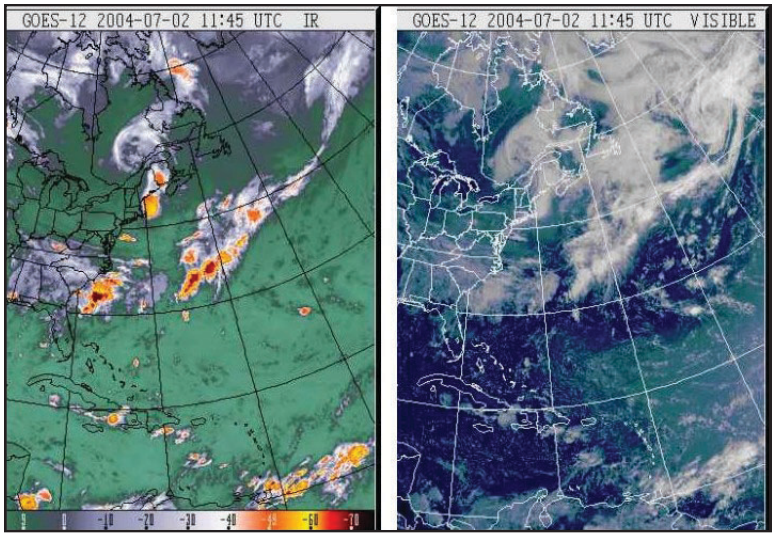



**Figure 8: Ice Patrol relies on comparisons of infrared (left) and visible (right) satellite loops to determine cloud cover, levels, and movement. Image courtesy of Environment Canada, Meteorological Service of Canada.**

Through the ice season, all Ice Patrol personnel are provided on-the-job training and are given a chance to prepare and present an environmental brief. One day prior to a reconnaissance detachment from the Groton, Conn., office, either the newest or junior-most member of the departing team prepares and presents a slideshow to all hands with the guidance of the more experienced personnel. These briefs closely resemble those presented from the Newfoundland office before and after each flight. Ice Patrol members are allowed several hours to prepare and rehearse their Groton presentations, to gain knowledge and build confidence in interpreting and presenting the products used operationally. At the office in St. John's, experienced members typically prepare and review briefs within 15 minutes. These briefs are presented to the pilots and senior Ice Patrol members so that each can make decisions on where, or if, to fly based on aircraft safety and mission effectiveness.

The products used in the Groton and St. John's briefs are almost exclusively obtained over the Internet from a variety of sources. A list of links to preferred sites are saved for rapid access via broadband connection, along with a folder of backup products to ensure availability. Ice Patrol relies heavily on side-by-side comparisons of infrared and visible satellite loops to determine cloud cover, levels, and movement ( Figure 8). Other primary products include significant weather charts to avoid icing or turbulence hazards and to determine cloud ceilings; wave height analysis to determine radar effectiveness; surface prognosis charts to anticipate the movement of pressure systems and associated fronts; and airport Terminal Air Forecasts (TAFs) to ensure a safe return. Many other available products will be used as time allows, and all products are available for printing. While phone briefs and faxed products can still be obtained from the flight services office in Halifax, Ice Patrol has become self-sufficient in obtaining the information needed to effectively plan its reconnaissance missions.

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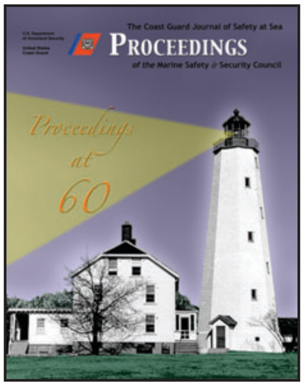



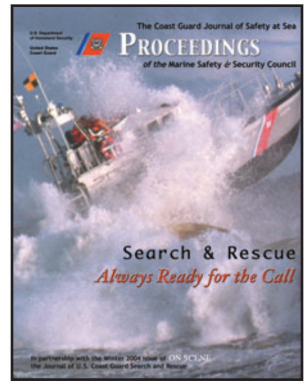


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We look forward to hearing from you soon, and we hope you have enjoyed this issue of **PROCEEDINGS**!

# The Spirit of International Cooperation


IIP OPERATIONS

*International Ice Patrol, in collaboration with other U.S. agencies and various international partners, works to keep mariners informed of ice danger.*

by CMDR. MICHAEL HICKS
*Commander, U.S. Coast Guard International Ice Patrol*

In 1914, some two years after *Titanic*'s tragic collision with an iceberg, 13 nations from both sides of the Atlantic met in a show of unprecedented international partnership with a common goal: to promote safety of life at sea (SOLAS). The spirit of cooperation exhibited by these disparate national entities, and the ultimate adoption of the SOLAS Convention, provided a near-immediate response to Mr. Lawrence Beesley's plea, in his survivor's account of *Titanic*'s sinking:

> "Whoever reads the account of the cries that came to us afloat on the sea from those sinking in the ice cold water must remember that they were addressed to him just as much as those who heard them, and that the duty of seeing that reforms are carried out devolves on every one who knows that such cries were heard in utter helplessness the night the *Titanic* sank."[1]

The International Ice Patrol recognizes that the spirit of international cooperation serves as an engine that drives continuous reforms and is absolutely central to its highly successful operation. IIP's guiding principles document this concept as an Ice Patrol Core Value—"Partnerships built on the spirit of international cooperation." Collaboration occurs at many different levels—within the U.S. Coast Guard, with other U.S. agencies, with our Canadian neighbors, and with other Northern Hemisphere nations. All deal with monitoring icebergs and sea ice and rely, along with hundreds of ships, on the accuracy of IIP's Limits of All Known Ice (LAKI) product. This article provides a short synopsis of the value of each partnership and underscores the fact that the 16 people assigned to the IIP could never accomplish this mission alone.

**U.S. Coast Guard**

***Air Station Elizabeth City***

From an iceberg-reconnaissance perspective, the U.S. Coast Guard's Air Station in Elizabeth City, N.C., clearly provides IIP's most important partnership (Figure 1). Simply put, without the Air Station's HC-130H Hercules long-range surveillance aircraft and the skilled and dedicated aircrews, Ice Patrol could not accomplish its mission. The Side Looking Airborne Radar (SLAR) used to detect icebergs, coupled with the Forward Looking Airborne Radar (FLAR), used to distinguish icebergs from ships or other ambiguous contacts, provides one of the best iceberg reconnaissance platforms in the world.

As described in greater detail in "Airborne Reconnaissance at International Ice Patrol" on page 55, personnel from IIP and from the air station work together as a single unit while patrolling for nine-day detachments out of St. John's, Newfoundland. A unique relationship exists between the Aircraft Commander (the pilot in charge) and the Tactical Commander (the senior "Ice Pick" in charge of the reconnaissance operations). This relationship continues to improve, through a mutual understanding of each other's mission area. With time, the aircrew learns what drives an iceberg and the significance of flying seven hours without seeing a single berg, and Ice Picks grow to understand weather and mechanical variables that impact flight safety and planning.

*CAMSLANT*

The Ice Patrol mission is to monitor iceberg danger in the vicinity of the Grand Banks of Newfoundland and provide the Limits of All Known Ice to the maritime community. Since IIP has no broadcast communication equipment, the Communications Area Master Station, Atlantic (CAMSLANT) in Chesapeake, Va., ensures that the rubber meets the road, so to speak. Product delivery represents the critical link between dozens of daily iceberg reports, the iceberg drift/melt model, and the end-user: the transatlantic mariner. Ice Patrol uses nine different methods to distribute LAKI information. CAM-


**Figure 1: The Ice Reconnaissance Detachment team, comprising USCG International Ice Patrol and USCG Air Station Elizabeth City personnel. Courtesy Ed Huntington, USCG.**

SLANT personnel are responsible for delivering several of the most widely used products: the graphical HF Facsimile chart (twice daily), the NAVTEX bulletin, and safety broadcasts. Figure 2 shows a sample Fax Chart depicting the Limits of All Known Ice for 01 July 2004.

*U.S. Coast Guard Chain of Command*

The IIP Program Manager—the U.S. Coast Guard Headquarters Ice Operations branch—ensures that IIP budgetary needs are met and looks toward the future in a rapidly changing Coast Guard.

The International Ice Patrol is under the operational command of the U.S. Coast Guard Atlantic Area, specifically, the Aids to Navigation branch. As the operational commander, Atlantic Area ensures that sufficient HC-130H flight hours are budgeted to adequately fulfill IIP mission requirements. The Atlantic Area Command Center also serves as a critical link to receive iceberg reports after-hours. This is particularly important for icebergs reported outside of the Ice Patrol's published LAKI. When this occurs, around six times each ice season, Ice Patrol personnel report to the Operations Center within 30 minutes to broadcast an immediate safety message and adjust the LAKI. In addition to the IIP, the U.S. Coast Guard Atlantic Area is responsible for conducting all U.S. Coast Guard missions throughout the Atlantic Area theater of operations to include search and rescue, homeland security, law enforcement, and marine environmental response.

*Groton-New London Partners*

The International Ice Patrol is a tenant command of the Coast Guard's Research and Development Center. Aside from the daily support activities such as processing procurement documents, receiving and distributing funding, government vehicles, computer and other administrative support, the IIP has a longstanding scientific relationship with the R&D Center. Specifically, R&D personnel have collaborated on numerous projects that take advantage of each organization's expertise. For instance, during the mid 1990s, the R&D Center developed satellite-tracked, Self Locating Datum Marker Buoys (SLDMBs) for Coast Guard's Search and Rescue (SAR) program, based on technology that IIP had been employing for measuring ocean currents since the late 1970s. International Ice Patrol watch officers tested this technology in actual SAR cases, by providing near real-time information to SAR controllers. SLDMBs are now used throughout the Coast Guard for SAR planning. In 1995, the R&D Center also played a central role in conducting a comprehensive IIP mission analysis. The R&D Center plays a crucial role for the Ice Patrol by providing a central hub for applying science to operational USCG problems.

**No ships that have heeded our warnings have collided with an iceberg since the inception of the Ice Patrol in 1914.**

Across the Thames River in New London, Conn., resides another important partner—the U.S. Coast Guard Academy (USCGA). Cadets studying in the Marine and Environmental Sciences major have taken the opportunity to conduct directed studies in operational oceanography, providing a connection to the operational Coast Guard for the cadet and valuable research work for the Ice Patrol. At present, a cadet is validating IIP's iceberg deterioration model prior to its operational acceptance. Other projects have included the development of an iceberg season severity index and upgrading the software used to interface with IIP's Airborne Expendable Bathythermograph receiver. Working together with Coast Guard Academy Science Department staff, IIP is nearing completion of a mirror site to produce and disseminate its LAKI products as a back-up for the Groton Operations Center.

**U.S. AGENCIES**

*U.S. Navy Fleet Numerical Meteorological & Oceanographic Center*

The U.S. Navy's Fleet Numerical Meteorological and Oceanographic Center (FNMOC) provides the critical environmental data to run Ice Patrol's iceberg drift and deterioration model. Twice daily, IIP receives data for winds, waves, and sea surface temperature, which are processed, quality-checked, and ingested into the Ice Patrol database to drive the iceberg model. The accuracy and timeliness of this information is absolutely essential for successful production and dissemination of ice bulletins.

*National Ice Center*

"The National Ice Center (NIC) is a multi-agency operational center representing the Department of Defense (Navy), the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the USCG under the Department of Homeland Security. The NIC includes personnel from the National Environmental Satellite Data

Information Service (NESDIS) within NOAA. The Navy component within NIC is called the Naval Ice Center (NAVICECEN) and is a fourth echelon command reporting directly to the Naval Oceanographic Office (NAVOCEANO) at the Stennis Space Center, Mississippi. Both NAVICECEN and NAVOCEANO are part of the Naval Meteorology and Oceanography Command, headquartered at the Stennis Space Center. The Commanding Officer of NAVICECEN also serves as the Director of the National Ice Center."[2] A USCG petty officer assigned to the NIC supports both IIP iceberg reconnaissance during the ice season along with other NIC operations when possible. The National Ice Center is a direct participant in the North American Ice Service (NAIS). NIC's role within this organization is further described in the "North American Ice Service" article on page 46.

*NOAA/NWS*

The National Weather Services plays a key role in converting IIP graphics to a radio facsimile format and then transferring this intermediate product to CAMSLANT for broadcast. The Weather Service also hosts an e-mail on demand server for those Ice Patrol end users who desire to receive LAKI information through this means.

*National Snow and Ice Data Center*

The National Snow and Ice Data Center in Boulder, Colo., maintains an extensive archive of IIP iceberg sighting reports that date back to 1960. This service is important as a long-term repository for unique iceberg data collected only by the International Ice Patrol. This data is available to anyone and will likely be of particular importance to researchers studying climate change.

**International Partners**

*Canadian Ice Service (CIS)*

CIS is a domestic ice service of the Canadian government that provides sea ice and iceberg products for their territorial waters. As a partner in the North American Ice Service, IIP maintains daily contact with the CIS, exchanging critical iceberg information for reconnaissance planning and for exchanging ice information reports. CIS provides a daily data exchange for icebergs that have drifted south of 52° North latitude—the demarcation line between IIP's and CIS' areas of responsibility. In

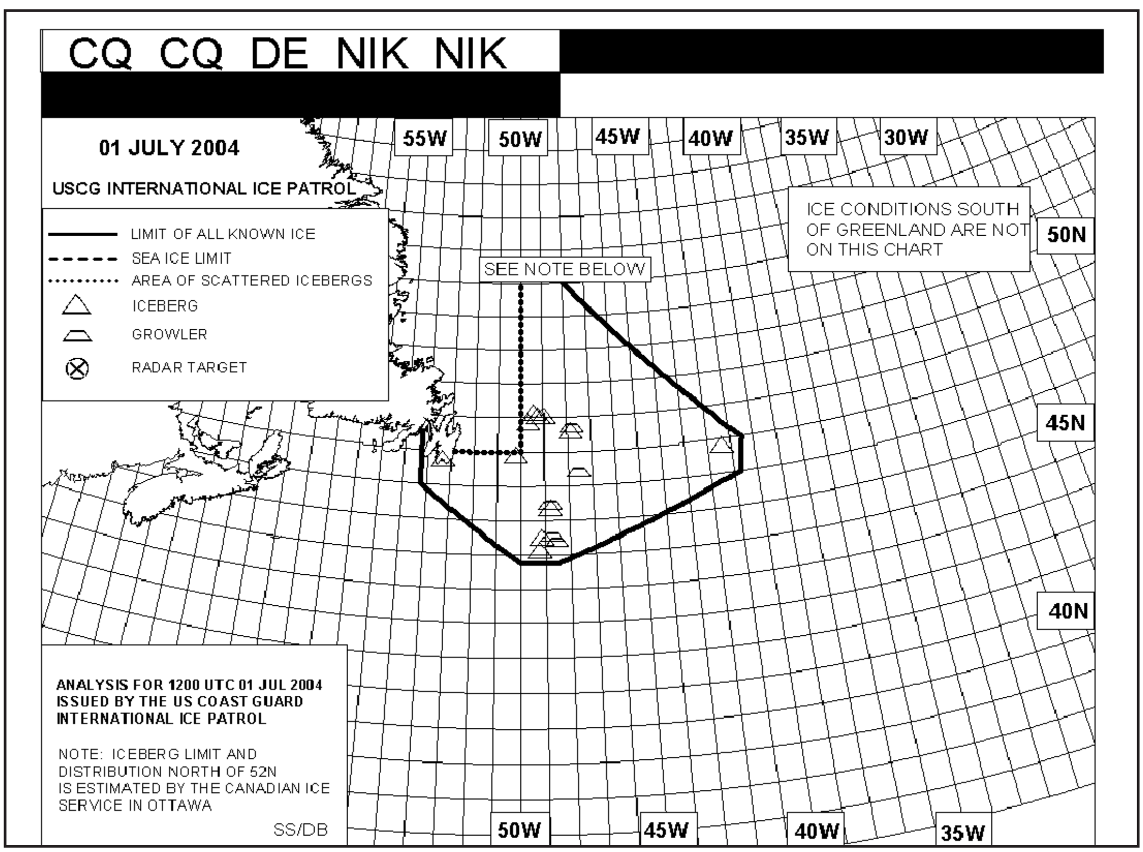



**Figure 2: An example of the Limits of All Known Ice fax chart remotely transmitted from CAMSLANT.**

addition, CIS provides invaluable information technology support for the Ice Patrol's drift model user interface—the Berg Analysis and Prediction System (BAPS). The Canadian Ice Service is Ice Patrol's most important international partner.

***Canadian Coast Guard***

The Canadian Coast Guard provides important support to the IIP operation through two services. First, the Canadian Coast Guard transmits the IIP LAKI product via NAVTEX and voice broadcasts. In addition, the Canadian Coast Guard has been instrumental in deploying satellite-tracked drifting buoys in critical ocean areas. The current data obtained from these buoy provide timely updates to the extremely complex and variable ocean current systems near the Grand Banks.

***International Ice Charting Work Group***

Since the inception of the group in 1999, Ice Patrol has been a standing member of the International Ice Charting Work Group. This group comprises the operational ice centers of nations throughout the Northern Hemisphere, including Germany, Russia, Norway, Finland, Sweden, and the United Kingdom. The International Ice Charting Work Group meets every 18 months to share information and cooperate on endeavors to improve processes at all operational ice services. The primary purpose of this organization is the same as IIP—to promote safe navigation through waters affected by both sea ice and icebergs.

***Signatory Nations***

The "International" in International Ice Patrol results from the 17 nations that fund IIP operations. Each year, the governments of Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Poland, Panama, Spain, Sweden, and the United Kingdom reimburse the U. S. government based on a ratio of the tonnage from each flag, averaged over the last three years, to the total tonnage, averaged over the last three years. Shipping from these nations derives tremendous benefit from IIP's product. Without it, transatlantic ships would either travel needlessly out of the way or run the risk of an iceberg collision. Most of these countries were party to the first SOLAS convention in 1914 and recognize the need to work together to accomplish necessary reforms.

***Thousand Eyes of the Ice Patrol***

Finally, the International Ice Patrol relies heavily upon the mariner to report ice sightings and, nearly as important, to relay information even when no ice has been seen. This is an unusual but highly effective relationship, whereby the mariner is both a customer and data supplier. It is in the customer's best interest to provide accurate, timely information while transiting the iceberg danger area.

**Conclusion**

The International Ice Patrol is a very small unit, even by Coast Guard standards, with a huge mission. While the production of the LAKI may seem like a simple mission, the path from iceberg report to accurate and timely product delivery involves multiple levels of operational and environmental complexities. With just 16 people assigned, the cooperative relationships with the partners mentioned here and many others not mentioned are absolutely essential to continue the Patrol's enviable record: No ships that have heeded our warnings have collided with an iceberg since the inception of the Patrol in 1914.


**Endnotes**

1 Beesley, Lawrence. *The Loss of the S.S. Titanic, By One of the Survivors.* (Mariner Books, 1912), vii.

2 Excerpt from National Ice Center web site, www.natice.noaa.gov.


IIP OPERATIONS

# North American Ice Service

## *An international partnership with the Canadian Ice Service, the National Ice Center, and the International Ice Patrol.*

by CMDR. MICHAEL HICKS
*Commander, U.S. Coast Guard International Ice Patrol*

One of the best examples of a successful international partnership outcome is the recently established North American Ice Service (NAIS). NAIS consists of the North American operational ice services: namely, the Canadian Ice Service (CIS), the National Ice Center (NIC), and the International Ice Patrol (IIP). For many years, Canada and the United States have shared common maritime interests with respect to ice management and have worked together to exchange necessary information. This common interest provided the core around which the predecessor to the North American Ice Service, the Joint Ice Working Group (JIWG), developed.

The first formal meeting of JIWG occurred in October 1986 in Ottawa, Canada. In opening remarks of the inaugural meeting, the group chairman explained that the group would be purely exploratory and that the only commitments expected would be to study the issues raised. The JIWG evolved as an effective, binational organization designed primarily to coordinate ice information data exchange, coordinate research and development, improve communications systems for the collection and exchange of ice-related data, provide back-up capabilities to each center in the event of unforeseen operational problems, and support Canadian and U.S. national climate and global change programs.[1]

Through 16 years of JIWG interactions, it became clear that the next logical step for this group would be to turn the page from a cooperative to a collaborative partnership, with the goal of providing end users with a single point of access for critical ice information products. In June 2003, the Director of the U.S. National Oceanographic and Atmospheric Administration's (NOAA) Office of Satellite, Data Processing and Distribution Division and the Director General for the Meteorological Service of Canada/Environment Canada signed an agreement that formally established the North American Ice Service. NAIS meets annually to address how best to improve products and services for ice information for North American waters to serve the needs of users for safety of navigation and informed decision-making.[2]

### NAIS PARTICIPANTS

#### Canadian Ice Service

The Canadian Ice Service (CIS) is an operational unit of the Meteorological Service of Canada, with the mandate to monitor and provide information services about ice in Canada's oceans and waterways, in support of marine safety and weather and climate prediction. In response to its own mandate and in meeting the needs of the Canadian Coast Guard, CIS produces sea ice, lake and river ice, and iceberg analyses and forecasts for the ice-encum-

**Figure 1: Luc Desjardin (right) of the Canadian Ice Service reviews watch procedures with Lt. j.g. Nic Jarboe of the International Ice Patrol.**

bered waters of Canada's economic zone, the north slope of Alaska east of Point Barrow, the Great Lakes, and the Saint Lawrence River. The focus of the Canadian Ice Service is to enable government and commercial entities to make effective operational and policy decisions to enhance safety, economic prosperity, and environmental security. Decision support information provided by CIS is at regional and local scales and is generally restricted to Canadian navigable waters, but also includes climate studies of the Arctic Ocean.[3]

**National Ice Center**

The U. S. Navy, NOAA, and the U.S. Coast Guard all sponsor the National Ice Center (NIC). NIC is responsible for producing sea ice analyses and forecasts for all sea-ice covered seas of both the Northern and Southern Hemispheres. NIC also provides analyses and forecasts for the Great Lakes, Chesapeake Bay and tributaries, Delaware Bay, the Lower Potomac River, and the Chesapeake and Delaware Canal. NIC products support federal and state governments, the Department of Defense, and the scientific community. While not servicing the commercial sector directly, products from the National Ice Center are used to support U.S. commerce through programs of the Department of Commerce and Department of Transportation. Decision support information provided by NIC is at global, regional, and local scales.[4]

**NAIS Organization**

To efficiently prioritize and execute action items, the North American Ice Service organizes its business through three committees—the Operations Committee, the Science Committee, and the Information Technology and Systems Committee. To ensure appropriate assignment and completion of tasks, the Operations Committee initiates the process by establishing and prioritizing its ice monitoring, analysis, and forecasting requirements to include icebergs. The Operations Committee provides guidance to the other two committees through coordinated joint meetings. The Science and IT and Systems Committees assess these requirements and agree to dedicate personnel from any or all of the three centers. The critical underlying assumption here is that each individual organization (CIS, NIC, and IIP) accepts the concept and guiding principles of the NAIS and incorporates work items into their respective strategic and business plans. Ice Patrol assigns a representative to each committee to ensure that iceberg management needs are considered and prioritized accordingly. During the fall of each year, the committees meet to advance collaborative NAIS efforts.

The Canadian Ice Service and National Ice Center Directors, together with the IIP Commander—collectively referred to as the Directors—serve as an executive steering team to provide broad, strategic guidance toward the development and execution of each committee's project implementation plan (PIP). The PIPs formalize the joint planning process and provide a mechanism for performance management and reporting. The Directors oversee the development and evolution of technical PIPs and ensure their viability, consistency, and alignment with North American Ice Service objectives. The Directors are also responsible for the promotion and acceptance of the NAIS concept within their respective organizations, with service and data suppliers, and users. The Director of the U.S. NOAA's Satellite, Data Processing and Distribution Division and the Director General of Environment Canada's Meteorological Service chair the annual NAIS meeting and provide added strategic guidance to the organization as a whole.

IIP interacts daily with the Canadian Ice Service to coordinate reconnaissance efforts, to exchange information on icebergs crossing 52° N (the line of latitude that separates each service's area of responsibility) and for developing the Limits of All Known Ice (LAKI) product (Figure 1). In addition, Ice Service created the Berg Analysis and Prediction System (BAPS) that executes Ice Patrol's iceberg drift and deterioration model. Both organizations exercise great care to provide contingency support in the event of a disaster at either center. For exam-

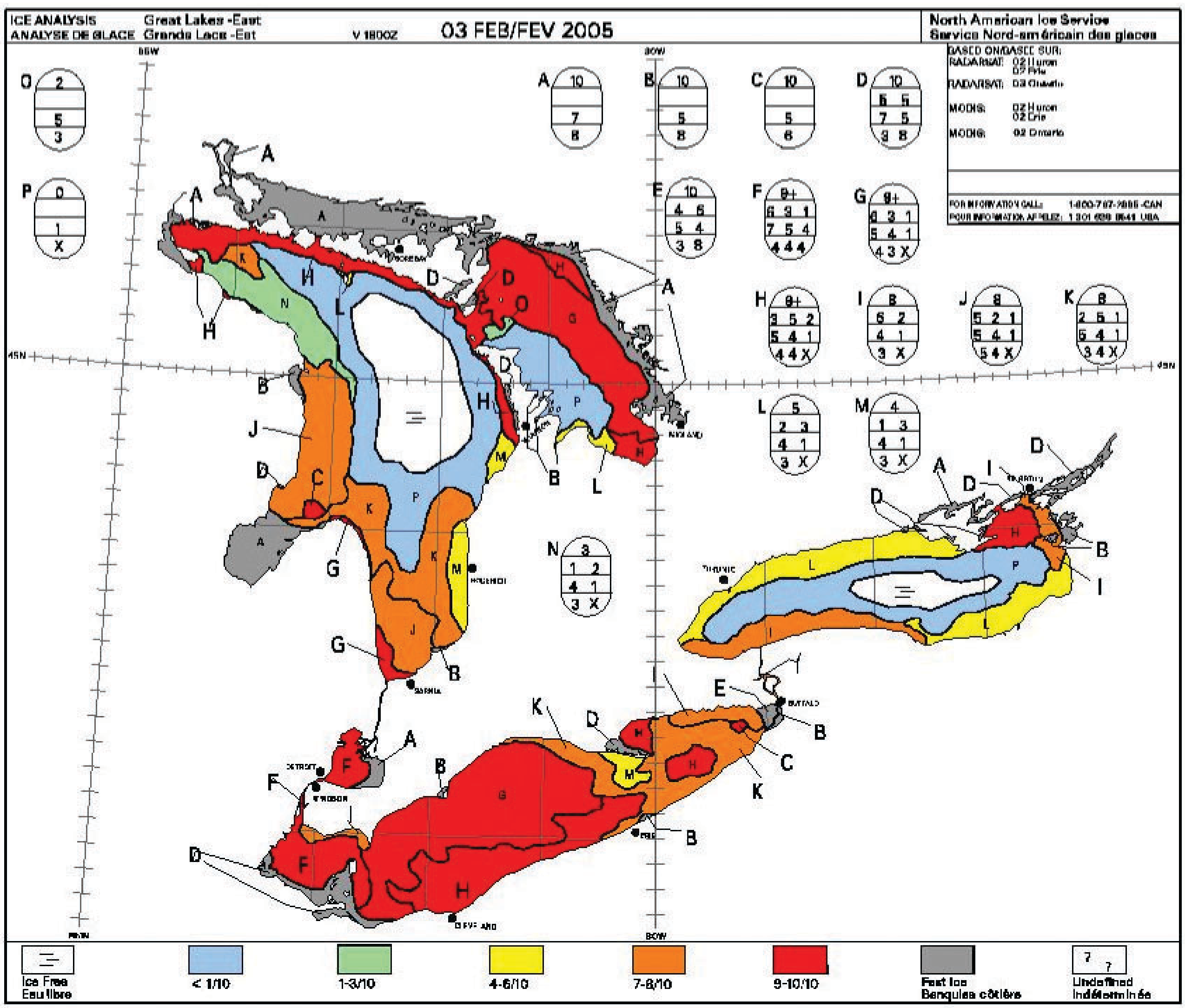



**Figure 2: The years 2004-2005 mark the first ice season with a NAIS jointly issued sea ice concentration chart. Courtesy of the North American Ice Service.**

ple, during BAPS procurement, Ice Patrol consulted with CIS to ensure that new computer hardware and geographic information system software would be compatible with the CIS system. IIP and CIS are presently working toward creating a synchronized iceberg database so that, by the end of each day, both centers will share identical databases, allowing the LAKI product to be created on either side of the border with equal quality.

As a sponsor of the NIC, the U.S. Coast Guard provides and receives mutual support through the Coast Guard Ice Operations division of Coast Guard Headquarters. The Ice Operations division assigns a marine safety technician to the National Ice Center for iceberg information support through national technical means. This division also provides a representative to the NIC steering for executive leadership. The Coast Guard petty officer also contributes to U.S. Department of Defense ice-related missions, and National Ice Center as a whole provides critical data to support the activities of the U.S. Coast Guard polar icebreakers. Specifically, the U.S. Coast Guard requires regional and tactical scale sea ice analyses and forecasts for the Arctic, Antarctic, Great Lakes, Chesapeake Bay, and Delaware Bay.[5]

**Conclusion**

Recognizing the value of a strong partnership with North American ice centers, IIP became a member of the Joint Ice Working Group (JIWG) in 1987. The North American Ice Service superseded the JIWG in 2004 in a push to move from a merely cooperative organization to a collaborative service. This integrated service combines the strengths of the existing centers and intends to create seamless products of high quality and consistency. The NAIS vision is to offer a single point of entry for ice information and will provide a suite of common North American ice products that may be produced at either center equally effectively and indistinguishably to the user. Figure 2 illustrates one of the very first jointly issued operational products bearing the NAIS logo: the Great Lakes Ice Concentration chart. Due to international treaty obligation, IIP will continue to produce and disseminate its LAKI bulletin and fax chart by all traditional means as the International Ice Patrol; however these products will also be made available as part of the harmonized product suite.

Participation in NAIS should promote continuous organizational improvement for all three services. Perhaps the greatest potential to be realized by IIP lies in accessing and sharing remotely sensed data through the international Group on Earth Observations (GEO). Membership should also facilitate support from the Canadian Ice Service in improving the iceberg drift and deterioration model. The NAIS relationship will also strengthen the strong partnership enjoyed between the NIC and IIP. The Coast Guard petty officer assigned there continues to provide iceberg information on the most critical bergs. Finally, being a part of the North American Ice Service will facilitate the business resumption of all three centers, particularly CIS and IIP for iceberg products, in the event that any are incapacitated by disaster. The spirit of international cooperation that brought together 13 nations 92 years ago is still alive within the agencies of the North American Ice Service.

**Endnotes**

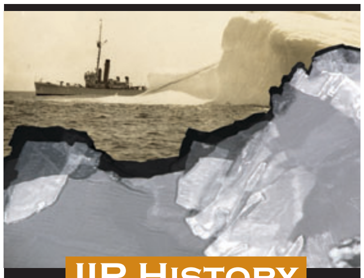
[1] U.S./Canada Ice Working Group Terms of Reference, March, 1988.

[2] Excerpt from the North American Ice Service: Annex 2 to the Memorandum of Understanding between the United States National Oceanic and Atmospheric Administration and the Meteorological Service of Canada, Environment Canada. Signed June 2003. Article 1: Background – The North American Ice Service Concept.

[3] Excerpt from the North American Ice Service: Annex 2 to the Memorandum of Understanding between the United States National Oceanic and Atmospheric Administration and the Meteorological Service of Canada, Environment Canada. Signed June 2003. Article 1: Background - The Canadian Ice Service.

[4] Excerpt from the North American Ice Service: Annex 2 to the Memorandum of Understanding between the United States National Oceanic and Atmospheric Administration and the Meteorological Service of Canada, Environment Canada. Signed June 2003. Article 1: Background – The National Ice Center.

[5] Excerpt from the Memorandum of Agreement among the Department of the Navy, the National Oceanic and Atmospheric Administration and the United States Coast Guard: Annex II National Ice Center. Signed February 1997.



IIP History

# Seek and Destroy?

## *The history of iceberg demolition experiments.*

by Dr. Donald L. Murphy
*Oceanographer, U.S. Coast Guard International Ice Patrol*

by Duyane Alexander
*Marine Science Technician First Class (ret.), U.S. Coast Guard International Ice Patrol*

*"All ice is brittle, especially that in bergs, and it is wonderful how little it takes to accomplish their destruction. A blow of an ax will at times split them, and the report of a gun, by concussion, will accomplish the same end."* [1]
—Ensign H. Rodman

The shocking sinking of the *Titanic* made the menace icebergs pose to shipping horribly evident. Icebergs are a clear and present danger to mariners traversing the North Atlantic Ocean. They are the enemy. Why not just destroy them? In the early 20th century it was unlikely that very many people shared Ensign Rodman's optimism on how easy this would be, especially in the light of *Titanic*'s fateful collision, but destroying threatening icebergs seemed to be a reasonable thing to try. For nearly half a century the Coast Guard International Ice Patrol did just that. The following sections describe the attempts, sometimes spur-of-the-moment and sometimes with extensive planning.

**Figure 1: *Seneca*'s crew conducts target practice with the type of gun used in iceberg demolition attempts in the early 1900s.**

### Gunfire

In April 1913, U.S. Revenue Cutters *Seneca* and *Miami*

**Figure 2: Photo taken minutes after a strike by a 1,000-pound bomb during the 1960 tests.**

began taking turns conducting iceberg-scouting patrols in the vicinity of the Grand Banks. On April 26, less than three weeks after beginning these regular patrols, *Miami* fired a shot from its 6-pounder gun against the vertical wall of an iceberg. The result was far less dramatic than Ensign Rodman would have predicted since the shot "… had no other effect than to shake down a barrelful of snow-like dust." While this was hardly a concerted or even mildly promising effort at iceberg demolition, it marks the beginning of the International Ice Patrol's experimentation with iceberg destruction.[2]

In the years that followed, *Miami* and *Seneca* fired their 6-pounder guns at icebergs sporadically, partly for diversion and partly for experimentation (Figure 1). *Miami*'s efforts on May 26, 1914, involved firing 12 6-pounder shots at an iceberg southeast of the Tail of the Grand Banks. The results were "…just as effective as if we had stormed the Rock of Gibraltar." It had become evident that the small guns on the early patrol vessels were no match for the icebergs they were charged with tracking.[3]

**Mines**

One of the little-known responsibilities of the Revenue Cutter Service in the early part of the 1900s was the destruction of derelict vessels drifting in the ocean. Abandoned wooden vessels could drift for many years, circumnavigating the North Atlantic Ocean several times and creating a great hazard to navigation.[4] Their destruction was usually accomplished using standard Navy-type wrecking mines, which had guncotton as the explosive agent and were detonated using an electrical charge from a battery. The Ice Patrol vessels conducted this important Coast Guard mission and carried the wrecking mines, so it was natural to see if they would fare any better than the gunshots against the icebergs.

In May 1923 USCG Cutter *Tampa* tracked a particularly fast-moving iceberg in the warm (>15° C) Gulf Stream waters south of the Tail of the Grand Banks. Since this iceberg was well into the busy steamer lanes and considered particularly menacing, they decided to use wrecking mines to hasten its demise. The effort was done mostly in the name of experimentation, but the iceberg's location imparted an operational urgency to the destruction of this iceberg.[5]

From May 20–24, *Tampa* exploded four charges alongside the underwater portion of the iceberg at depths ranging from six to 30 feet. Several of the attempts involved attaching the mines to the iceberg using lines with grapnels. This allowed the mines to explode right alongside the iceberg at various depths. Overall, the experiment was considered a success, with the belief that the life of the iceberg was shortened by one to two days, an important achievement, considering the dangerous location of the iceberg. It was clear that the effective use of wrecking mines, while successful in this case, could only be undertaken in calm conditions that permitted small boat operations and in warm water, so natural deterioration processes and the explosives could work in concert to destroy the iceberg.

The final effort at destroying icebergs using wrecking mines was undertaken by *Tampa* on May 28, 1926. It came upon a small to medium iceberg in the steamer lanes, again in the warm Gulf Stream waters. Although natural deterioration processes were taking their toll on this dangerous iceberg, *Tampa* used its 6-pounder gun and 238-pound wrecking mines to speed the decay. The conclusion: "Considerable ice was shaken down, but it is questionable whether the expenditure would be justifiable in continuing the practice on a greater scale." That evening, *Tampa* remained close to the iceberg, warning all approaching ships of its location.[6]

**Heat**

Professor H.T. Barnes, a professor of physics at McGill University and one of the earliest proponents of using thermite, a mixture of aluminum and iron oxide, to destroy ice, was a self-described "ice fighter" who regarded ice as an enemy to mankind.[7] During *Modoc*'s patrol in June of 1924, he had seen Ice Patrol's use of wrecking mines and realized that it would be better to create an intense thermal shock by igniting thermite inside an iceberg. When ignited, thermite creates a violent reaction that burns at very high temperatures, as hot as 3,500° C, which is hot enough to melt steel.

**Figure 3: Drilling a hole in the iceberg with a power auger was a 45-minute procedure during the 1960 tests.**

In the summer of 1926 in Notre Dame Bay, Newfoundland, Barnes conducted several iceberg-destruction experiments using thermite and Bermite, a high explosive. In one of the tests, 500 pounds of thermite were placed about four feet into the iceberg and:

"…fired at sundown in order to allow the people of Twillingate an opportunity to see the spectacle of the burning and disrupting ice. The whole thing was a most wonderful sight when the mighty charge fired and roared, lighting up the iceberg and surrounding hills like Vesuvius in eruption. Flames and molten thermite and ice were shot upwards 100 feet or more by the explosion which followed. Much of this berg was disrupted but the full effect of the big charge was lost to into the air."[8]

He concluded that the charge would be much more effective if it could be placed 50 to 100 feet into the iceberg using a rock drill, a process, he declared, that could be accomplished from a boat without boarding the iceberg.

After the results of Barnes' 1926 experiments became widely known, the following optimistic assessment appeared in the March 1927 issue of *Nautical Magazine:*

"…it would appear that as soon as an iceberg is reported approaching the trans-Atlantic steamer routes all that is necessary is for a handful of men to approach the berg and with the judicious use of thermite completely destroy it in a few hours."[9]

**Bombs, Thermite, and Carbon Black**

While Ice Patrol recognized the promise of Barnes' thermite experiments, the prospect of taking explosive charges and boarding or even approaching an iceberg tossing in the sea conditions that are typical of the North Atlantic seemed foolhardy. Ice Patrol sought a better way to deliver the required thermal shock: bombing.

During and after World War II there were tremendous advances in the manufacture of "shaped" charges and special bomb and rocket designs. In 1959 Ice Patrol obtained 20 aircraft incendiary bomb clusters and conducted a series of bombing experiments against several icebergs near Newfoundland. Two types of incendiary bombs were tested, each consisting of many bomblets containing material, including thermite, that burned at very high temperatures. The airplane delivering the bombs was the USCG UF2G Albatross, a twin-engine amphibious airplane. While there was some modest evidence of success against one of the icebergs that had been struck eight times, the bomb clusters were not able to deliver the concentrated heat source required by Barnes' thermal stress theory of ice demolition.[10]

"...A MAGNIFICENT DISPLAY TOOK PLACE AS SMOKE AND MOLTEN IRON WAS HURLED HUNDREDS OF FEET INTO THE AIR, BUT THE BERG REMAINED VIRTUALLY UNCHANGED. THIS CONCLUDED THE THERMITE TESTS."

The following year, 1960, brought three separate demolition tests: bombing with explosive charges, igniting thermite inside an iceberg, and coating an iceberg with carbon black to accelerate natural, solar deterioration (Figures 2–5).

The bombing tests were a direct follow-on to those conducted in 1959, except that high-explosive bombs were used. Ice Patrol obtained 20 1,000-pound bombs from the U.S. Navy, 10 general-purpose bombs and 10 semi-armor-piercing bombs. Over an eight-day period (May 23–30), an Albatross dropped all 20 bombs on a single large iceberg using the same bombsight design from the previous year and with the same outstanding success. Of the 20 bombs dropped, 18 struck the iceberg, of which three were underwater bursts and three failed to detonate. Some of the bomb strikes resulted in a spray of ice fragments that rose to over 500 ft. Others caused minor changes to the iceberg's waterline orientation due to a loss of ice mass. At the conclusion of the bombing, Ice Patrol estimated that the iceberg's size had been reduced by a quarter to a third but could not say for certain how much of the disintegration was due to bombing and how much was due to natural deterioration processes.[11]

The second phase of the 1960 tests was essentially a repeat of Barnes' thermal shock experiments using thermite. Led by project officer Lt. Cmdr. Bob Dinsmore, an Ice Patrol field party conducted three thermite detonations on June 8 on two icebergs in the protected waters of Bonavista Bay. Because the test was conducted in Canadian territorial waters, Ice Patrol obtained the full support of Canadian authorities, including personal approval from Newfoundland's Premier.

For each detonation, a team boarded the iceberg from a rubber raft, drilled holes in the iceberg with a power auger, and planted the charges. Drilling each hole took about 45 minutes, during which time loud cracking noises could be heard from within the ice. After planting the charges, the party ran a detonation cable to USCG Cutter *Evergreen*, which ignited the thermite. The first detonation, consisting of 196 pounds of thermite, scattered a shower of molten iron over a radius of 100 yards but, other than producing a few growlers, had no significant impact on the size of the iceberg. The second detonation, on a different iceberg, used 364 pounds of thermite, with the same results as the first. A third detonation, a 560-pound thermite charge planted near the base of the iceberg's pinnacle, had the following result:

**Figure 4: Shortly after the detonation of 560 pounds of thermite during the 1960 tests, a large plume of smoke and steam rose hundreds of feet into the air.**

**Figure 5: During the 1960 tests, it took three men using fiber brooms about 30 minutes to cover half the iceberg's surface with carbon black.**

"…a magnificent display took place as smoke and molten iron was hurled hundreds of feet into the air, but the berg remained virtually unchanged. This concluded the thermite tests."[12]

These tests showed that thermite detonations would not necessarily cause the disintegration seen in Barnes' experiments in 1926.

The intent of the final phase of the 1960 tests was to cover an iceberg with carbon black and other dark substances to speed its solar-induced deterioration. Three persons boarded the iceberg and in 30 minutes spread 25 pounds of carbon black with fiber brooms. They covered 6,500 square feet, which was approximately half the iceberg's surface. Five hours after the carbon black was placed on the iceberg, it broke apart, and by the next day it was reduced to less than a third its previous size. As with the bombing and wrecking mine tests, it is not possible to say how much of the observed breakup was due to natural causes and how much to Ice Patrol's intervention.

The tests in 1959 and 1960 can be best be summarized as follows:

"Although some damage to the bergs resulted, it must be admitted that all of the means tried were unsuccessful in destroying the icebergs."[13]

**Conclusion**

The 1960 tests ended Ice Patrol's attempts at iceberg demolition. Rather than destroying icebergs, Ice Patrol adopted *Tampa*'s May 1926 approach, monitoring the dangerous icebergs and warning mariners of their location. There are several reasons why this practice makes good sense. The demolition process is expensive and dangerous. Even if an iceberg could be broken into smaller pieces, the result would be an increase in the number of icebergs. They would be smaller than the parent iceberg and, thus, harder for mariners to detect with their surface radars.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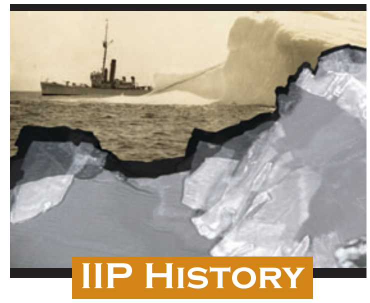
[13] Bullard, R. P., R. P. Dinsmore, A. P. Franceschetti, P. A. Morrill, F. M. Soule, International Ice Observation and Ice Patrol Service in the North Atlantic Ocean, Season of 1960, Bulletin No. 46. 114 p.1960.

# Airborne Reconnaissance at International Ice Patrol




*Achieving effective ice reconnaissance while maintaining crew and aircraft safety.*

by Lt. Scott A. Stoermer
*Ice Operations Officer, U.S. Coast Guard International Ice Patrol*

Even in its earliest years, the Coast Guard's International Ice Patrol (IIP) was tasked with the connected missions of ice observation and ice patrol.[1] Ice observation relates directly to the gathering and analysis of oceanographic and iceberg-related data for use by IIP in carrying out the patrol facet of its mission. The patrol mission employed ships equipped with surface-search radar; aircraft equipped with visual and radar observation tools; and even satellite-based reconnaissance to detect, identify, and track the illusive North Atlantic iceberg. Today, IIP uses a combination of all of the above methods to maintain the most accurate iceberg picture possible. In the case of reconnaissance, IIP uses strictly airborne resources.

**Aircraft Used by Ice Patrol[2]**

The Ice Patrol began its shift from ship-based to aircraft-based reconnaissance following World War II. In fact, in 1946, Ice Patrol employed two different types of aircraft to supplement ice patrol surface vessels. Specifically, Ice Patrol engaged the PBY-5A Catalina (Figure 1) and the PB4Y-1 Liberator (Figure 2). The PB1G, or Flying Fortress (B-17), replaced the Liberator during the following ice season (1947) and became the workhorse of the organization. The PB1G and the Catalina jointly conducted Ice Patrol reconnaissance until 1949, when the Flying Fortress (Figure 3) took over in earnest. From 1949 through 1958, up to three dedicated, winterized PB1Gs were detailed to Ice Patrol and conducted operations under the direction of International Ice Patrol operational commanders. Only rarely during these years were additional aircraft necessary to supplement the PB1G. On those occasions, IIP employed a winterized Catalina.

**Figure 1: Consolidated PBY-5A Catalina.**

The age and maintenance required to sustain the PB1G for ice reconnaissance became too much and it was retired in 1958 after flying 985,612 nautical miles over the course of 761 ice patrol missions. Following the PB1G, the R5D Skymaster (DC4) was used for Ice Patrol operations from 1959 through 1963. The Skymaster (Figure 4) was the sole Ice Patrol aircraft during these years with the exception of a HU-16E Albatross used during the iceberg bombing experiments of 1959–60 and one SC-130B Hercules in 1962.

The age of the Hercules began in 1963, and its era has yet to come to an end. In fact, the C-130 has been used, almost exclusively, as the Ice Patrol's reconnaissance platform since the 1963 season (Figure 5). Ice Patrol initially used the B model and shifted to the Hercules H model in 1984. The use of the HC-130H continues to this day. A few years (1983–1994) also saw the use of the HU-25A and HU-25B Falcon (Figure 6) for logistics flights as well as limited reconnaissance operations.

**Figure 2: Consolidated PB4Y-1 Liberator (B-24).**

For nearly the entire history of Ice Patrol's relationship with aviation, the primary home base for reconnaissance aircraft has been the Coast Guard Air Station in Elizabeth City, N.C. On a few occasions, normally based on availability issues, aircraft were drawn from CG Air Station Clearwater, Fla. During the period when Ice Patrol used HU-25s, the Falcons were deployed from Air Station Cape Cod, Mass.

It should be noted that the PB1G and the C-130 have been the most successful, arguably the only fully successful, aircraft used by Ice Patrol. The endurance of both aircraft, coupled with payload capability, far exceeds that of any other aircraft used to date, permitting effective reconnaissance flights over large and distant search areas.

**Operating Bases**

Since the establishment of a reconnaissance strategy that included aircraft-based reconnaissance, IIP concerned itself with the logistics and infrastructure necessary for effective operations. At the completion of World War II, and with the formal establishment of aircraft reconnaissance, the Ice Patrol operated from the U.S. Naval Facility and Air Station located in Argentia, Newfoundland. From 1946 through 1971, IIP maintained its base of aircraft operations in Argentia, even though IIP moved its Operations Center from Argentia to Governor's Island, N.Y. in 1963.

As Argentia was an ideal base for air operations, with support and infrastructure located near the area of operations, IIP had difficulty identifying subsequent bases. Upon departure from Argentia, the Ice Patrol shifted to the Canadian Forces base at Summerside, Prince Edward Island. The Ice Patrol benefited from excellent logistical support in PEI, but the base's distance from the reconnaissance area limited the overall benefit. In fact, Ice Patrol reconnaissance aircraft had to regularly stop in St. John's, Newfoundland, to refuel on their way to reconnaissance patrols. After only two years on PEI, the Ice Patrol shifted air operations to St. John's to take advantage of its proximity to the search area and operated there from 1973 until 1981. In 1982, IIP relocated its air operations to Gander, Newfoundland, but lacked support infrastructure, particularly hangar space for maintenance. Ice Patrol shifted to its air operations base in 1989, when it returned to St. John's, Newfoundland.

**Reconnaissance Strategy**

While many minor modifications have been made to Ice Patrol's airborne reconnaissance strategy over the years, it has really undergone only one major shift since 1946. The operational adoption of Side Looking Airborne Radar (SLAR) in 1983 altered the primary sensor for iceberg reconnaissance from

**Figure 3: Boeing PB1G Flying Fortress (B-17).**

visual to radar. Basically, during the period from 1946 through 1982, the airborne aspect of ice patrol used radar as a back-up method of detecting icebergs in the North Atlantic.

During the pre-SLAR years, reconnaissance was conducted at 500 to 1,500 feet with track spacing of 20 to 30 nautical miles, depending on the visibility. Fly/no-fly decisions were based on conditions at the airbase, forecasted conditions throughout the intended search area, as well as forecasted conditions at the airbase for return. If visual conditions could be expected for a majority of the patrol, the reconnaissance patrol was launched and track spacing was modified in flight as visibility conditions changed. Modification to the track spacing permitted 100 percent visual coverage of the search area; if visibility permitted observation to 10 miles, the track spacing would be set at 20 miles, so that the next search leg permitted observation that abutted the previous. The observers recorded iceberg characteristics and positions, based on LORAN-A, for later plotting and use in Ice Patrol warning broadcasts. In general, patrols were 7.5 to 8 hours long and covered about 1,000 track miles; however, it was not unheard-of to fly 11- or 12-hour patrols.

**Figure 4: Douglas R5D Skymaster (DC4).**

Aircraft surface search radar was used during the pre-SLAR years as a last resort. When poor visibility conditions existed for a few days, the decision would be made to fly a patrol using radar as the primary sensor. A radar patrol entailed similar parameters as visual patrols (altitude and track spacing), but the aircraft was forced to divert from search track to visually identify all radar-detected targets as early radar provided very limited, if any, information about target identity. Once a divert was completed, the aircraft would return to search altitude and continue the patrol. Radar patrols were often incomplete, as even a small number of diverts could dramatically impact the aircraft's fuel status.

Despite the limitations of early radar systems, Ice Patrol maintained an extensive research and development program, testing and evaluating many radar systems. In 1982, Ice Patrol evaluated the AN/APS-135 SLAR and operationally implemented it the following year, shepherding a dramatic change in the Ice Patrol reconnaissance mindset. As the 135 SLAR became a part of the Ice Patrol toolbox, primary reconnaissance shifted from visual to radar observation. In other words, the ability of 135 SLAR to provide details about target identity was so vastly improved that visual confirmation was desired but not necessarily required. In the event that the radar return was ambiguous and visual confirmation was not available from patrol altitude, diverts from track were used to gain confirmation. Moreover, this shift in strategy also permitted more consistent reconnaissance, as it was not quite as weather-dependent. Additionally, in an effort to further improve confidence about target detection and identification, IIP shifted to 25 mile track spacing, providing "200 percent" coverage of the desired search area.

The implementation of an additional radar, the AN/APS-137 Forward Looking Airborne Radar (FLAR), to Ice Patrol's arsenal in 1993 further solidified radar as the primary sensor for reconnaissance. The FLAR, while not explicitly modifying the strategy, provided additional surface search capability and, in its inverse synthetic aperture mode, provided information on target motion relative to the antenna. In the case of ships, relatively more motion is expected, as they tend to be rolled or pitched by the sea state. The target identification data provided by FLAR dramatically reduced the need for diverts/descents for ambiguous target identification. Finally, the fact that the FLAR search area included the SLAR dead zone, the area beneath the plane, allowed the Ice Patrol to shift track spacing to 30 miles in 1995. This shift maintained 200 percent coverage of the search area but increased the area searched by 20 percent.

**A Day in the Life of a Present IRD**

Current Ice Reconnaissance Detachments (IRDs) travel to St. John's for a period of 10 days every other week during the ice season. The personnel deployed include the aircrew from Air Station Elizabeth City, usually 10, and a group from Ice Patrol, usually four. The structure of the deployed team is such that an IIP member, the Tactical Commander, is overall in charge of the IRD and mission effectiveness. The Aircraft Commander is responsible for the aircraft and is tasked to ensure aircraft and aircrew safety. In practical terms, the responsibility for IRD effectiveness and safety is a team effort. The other members of the IRD team include flight deck personnel, radar operators, aircraft mechanics, a radar ice observer, and visual ice observers.

Over the years, the complex process of conducting ice reconnaissance has been refined into a process that works to ensure that effective ice reconnaissance is conducted while maintaining crew and aircraft safety. A typical reconnaissance patrol actually begins many hours prior to take-off as the Tactical Commander considers the forecasted weather for the airport and the desired search area. Balancing many factors including airport and on-scene weather, search area priority, oceanographic conditions, and anticipated operations, the Tactical Commander develops a flight plan to cover the intended search area. In general, flights are planned for 7.5 hours, allowing coverage of approximately 1,700 track (nautical) miles or approximately 30,000 square nautical miles at 30 mile track spacing.

Once airborne, the mission is directed from the cargo hold

**Figure 5: Lockheed C-130 Hercules.**


**Figure 6: FalconJet HU-25.**

of the aircraft by the Tactical Commander, based on changing environmental conditions and the iceberg situation. As with pre-SLAR flights, present IRDs are still required to conduct diverts from track to identify ambiguous radar contacts, especially in the vicinity of the Limits of All Known Ice, as Ice Patrol wants to ensure that the LAKI is accurate. Team function on the aircraft is impressive as the radar operators and radar ice observer correlate data between both radars with information from the visual ice observers as they spot icebergs and note iceberg characteristics. Iceberg position, from global positioning system (GPS), size and shape are logged for later use by the Operations Center.

The task of iceberg reconnaissance does not end upon landing but continues in the small Ice Patrol office located at the airport in St. John's. The data gathered on the aircraft must be fully correlated, checked for accuracy, and coded into a message format for transmittal to the IIP Operations Center in Groton, Conn. Most often, the post-flight process is fairly simple and straightforward, requiring no more than an hour. In some cases, however, a flight's complexity or the sheer number of targets will require a much longer process.

Once the post-process is completed or on days where flights cannot be conducted, IRD members are free to enjoy the history, scenery, and nightlife of St. John's and the surrounding country. St. John's has a rich and interesting past, including Scottish, Irish, Portuguese, Spanish, and French ancestries, and touts many historic buildings and sites. The city of St. John's is the provincial capital, home to the Memorial University of Newfoundland, and supports vigorous industry including commercial fisheries and oil and natural gas exploration/production. As a vacation stop for other Canadian and European visitors, St. John's supports a bustling nightlife and tourism industry, including many music events, iceberg and whale-watching cruises, and a plethora of restaurants featuring dishes with local and international flair. IRD crews have long enjoyed the hospitality and culture of Newfoundlanders, and a day off from patrolling is usually welcome and enjoyed.

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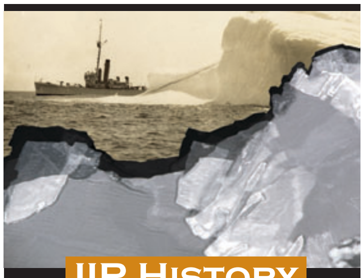



# Walking in the Footsteps of a Hero

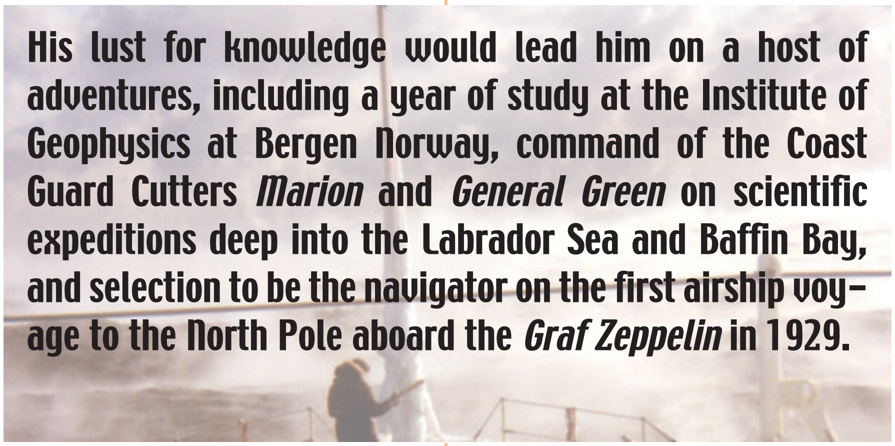
## *The leadership lessons of "Iceberg" Smith— scholar, scientist, lifesaver, guardian, warrior.*

by CAPT. ROBERT L. DESH
*Director, Leadership Development Center, U.S. Coast Guard Academy*

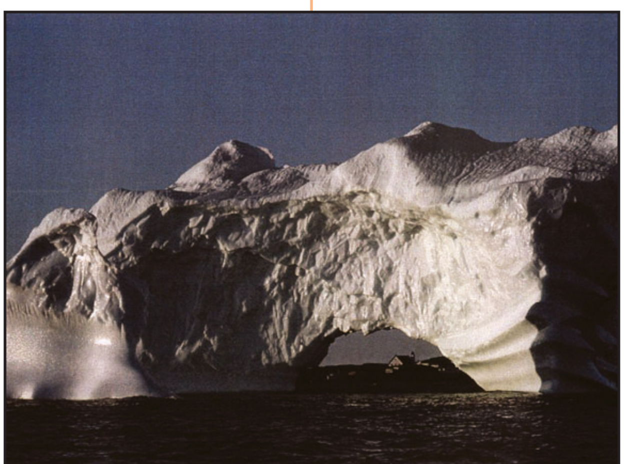
The shelves of bookstores are overflowing with a wide variety of how-to guides on leadership. Many look back on the lives of historical figures we have come to recognize as great leaders—*Lincoln on Leadership*, *The Founding Fathers on Leadership*, and *Leading from the Edge* (about Shackleton's 1914–1917 Antarctic Expedition), just to name a few. Each of these intriguing books contains a wealth of valuable leadership lessons from men and women who truly "walked the talk." For me, this hero worship style of leadership development began long before this latest round of books went into print and required a little more detective work.

I have long admired and studied the life and accomplishments of Rear Adm. Edward "Iceberg" Smith, attempting to ingrain and emulate the many leadership insights that he left behind. Unfortunately, unlike the aforementioned leadership guides, no comprehensive biography exists for Rear Adm. Smith. By assembling bits and pieces from a variety of historical sources, including the annual reports of the International Ice Patrol, I have been able to piece together his fascinating story and learn much about leadership from this remarkable Coast Guard officer. The following is a very brief look at some of those lessons.

Edward Hanson Smith was born in Vineyard Haven, Mass., on October 29, 1889. He was the son of a ship's captain and descended from a long and sturdy line of Martha's Vineyard whalers. He was drawn to the sea—a good and natural outgrowth of both birthplace and heritage. After graduating from Tisbury High School and attending Massachusetts Institute of Technology (MIT), he entered the Revenue Cutter Service School of Instruction (forerunner to the U.S. Coast Guard Academy) in May 1910. His graduation in the spring of 1913 would be the beginning of what would become a legendary Coast Guard career. Before retiring in 1950 to become the Director of the Woods Hole Oceanographic Institution, Iceberg Smith would sail the oceans of the world, command numerous ships at sea, endure combat in two World Wars, and become a world-renowned oceanographer, accomplished diplomat, war hero, and inspirational leader.[1]



**His lust for knowledge would lead him on a host of adventures, including a year of study at the Institute of Geophysics at Bergen Norway, command of the Coast Guard Cutters *Marion* and *General Green* on scientific expeditions deep into the Labrador Sea and Baffin Bay, and selection to be the navigator on the first airship voyage to the North Pole aboard the *Graf Zeppelin* in 1929.**



I could continue on about the exploits of my personal hero, but this article is not intended to be a biography; besides, overt public acclaim would be wholly out of character for the good Admiral. Instead, I will explore just a few of the leadership traits I have gleaned as I have followed the footsteps of Iceberg Smith.


**Suffer from a terrible need to know!**

Rear Adm. Smith's lifelong pursuit of knowledge was extraordinary. As he embarked on his Coast Guard career, the service was simultaneously taking on a new and dramatic mission, the North Atlantic Ice Patrol Service. The disastrous loss of the *RMS Titanic* prompted the maritime powers of the world to take action to prevent further loss of life from iceberg collision in the ever-more-congested North Atlantic shipping lanes. The responsibility for this task would eventually fall to the U.S. Coast Guard, leading to the birth of a Coast Guard mission and unit to be forever known as the International Ice Patrol.[2]

This new mission would become the nexus of scientific study that would make Edward Hanson Smith one of the founding fathers of physical oceanography and lead to the moniker "Iceberg." This distinctive nickname would follow him for the rest of his life.[3]

It was obvious to young Lt. Smith that success for this new mission to prevent iceberg collisions would hinge on knowing much more about icebergs and the forces that propelled them on their sojourn from Greenland to the Grand Banks off Newfoundland. Fortunately, the founders of the North Atlantic Ice Patrol Service had wisely included a treaty requirement for scientific studies of ice and its drift in the ocean.[4]

Shortly after graduating from the School of Instruction, Smith was charged with implementing this scientific research program with the cooperation and guidance of Professor Henry Bigelow at Harvard University. Iceberg Smith immediately began a series of studies from the Coast Guard cutters assigned to Ice Patrol duty in the

North Atlantic. Because of an unquenchable thirst for knowledge and his terrible need to know, Smith would transfer from ship to ship, remaining at sea for the entire ice season—typically February through August—to personally oversee scientific work and gather first-hand knowledge of the beautiful but deadly castles of ice that haunted the transatlantic shipping lanes. At the close of the ice season, he would retreat to the seclusion of Harvard to digest and analyze the information he had gathered.

This lust for knowledge would lead him on a host of adventures, including a year of study at the Institute of Geophysics at Bergen Norway, command of the Coast Guard Cutters *Marion* and *General Green* on scientific expeditions deep into the Labrador Sea and Baffin Bay, and selection to be the navigator on the first airship voyage to the North Pole aboard the *Graf Zeppelin* in 1929. He was recognized for his scholarly achievements with a doctorate degree in physical oceanography from Harvard—the first Ph.D. in this field awarded in the United States.[5]

While my personal academic accomplishments pale in comparison to those of Adm. Smith, I try to cultivate the same terrible need to know that drove and inspired his lust for learning. As we are promoted, move to new jobs, or face expanded responsibilities, we must suffer from a terrible need to know all we can about the details and history of this new mission, job, or responsibility. All good leaders must continually read, study, and absorb if they are to avoid gradual obsolescence. To innovate and improve, you must continually learn.

**Before retiring in 1950 to become the Director of the Woods Hole Oceanographic Institution, Rear Adm. Edward “Iceberg” Smith would sail the oceans of the world, command numerous ships at sea, endure combat in two World Wars, and become a world-renowned oceanographer, accomplished diplomat, war hero, and inspirational leader.**

**Focus on what you control rather than what you do not.**

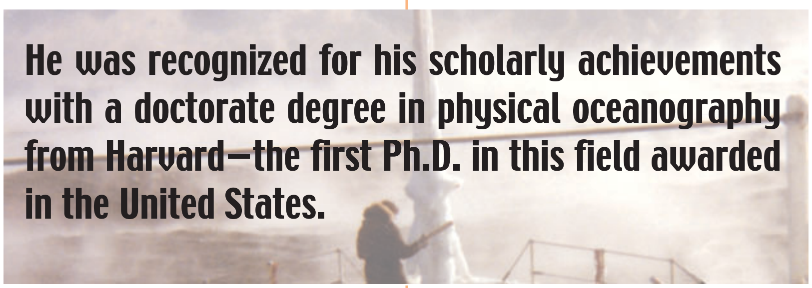
In the early days of World War II, newly promoted Capt. E. H. Smith was given command of a small task force of three mature ships—the cutters *Northland, North Star*, and the venerable *Bear*—and assigned the mission of protecting the largest island in the world, Greenland, from Nazi infiltration. This taskforce would grow to become The Greenland Patrol.[6]

The Axis powers had overrun Europe, and Greenland was now vulnerable. The free Danish government in exile in Iceland requested U.S. help to keep this environmentally sensitive and strategically important ice-covered island out of the hands of the enemy. Facing the unenviable task of protecting 10,000 miles of the most rugged coast in the world,

Iceberg Smith set about the job with initiative and innovation—focusing on the things he controlled rather than what he did not. He organized resident Danes and the native population into effective dogsled patrols. He commandeered a fleet of sturdy North Atlantic fishing trawlers to expand his patrol forces, and he leveraged the rapidly expanding capabilities of long-range patrol aircraft.[7] Through careful coordination of his very limited resources, he was able to stop several German attempts to establish bases on the island and kept Greenland secure throughout the war.[8] (Please see “Greenland Patrol” on page 65 for more details about this

fascinating period in Coast Guard history.)

Again, none of my accomplishments or career successes can hold a candle to keeping an entire country free from foreign invaders, but I try to never forget to focus on that which I control rather than what I do not—it is truly a cornerstone to successful leadership. It is easy to "get wrapped around the axle," expending time, effort, and worry on the many things that one has no power to control. Like Iceberg Smith, the truly accomplished and successful leader recognizes the things they do not control—for instance, the harsh Greenland weather. They acknowledge the impact these obstacles might have on progress or success and then move on—focusing energy, intellect, and effort on the things they do control.




**Concentrate on possibilities, rather than limits.** His success in command of the Greenland Patrol soon garnered Capt. Smith a selection for promotion to Rear Admiral and designation as Commander Task Force Twenty-Four—top naval commander in the North Atlantic and Greenland waters. From his headquarters in Argentia, Newfoundland, he was now responsible for North Atlantic convoy escort and anti-submarine warfare operations as well as the Greenland Patrol.[9] In addition to the job of securing a mammoth ice-covered island, Iceberg Smith now faced a determined and aggressive enemy in a combat theater, challenged by some of the harshest weather to be found anywhere on the planet. If this were not enough, he still needed to worry about his old nemesis, icebergs. These naturally camouflaged mountains of ice lurked in the dense fog of the Grand Banks, waiting silently to sink all ships that survived the gauntlet of German submarines.

The sheer magnitude and difficulty of the task would have overwhelmed lesser men. Not Iceberg Smith; he concentrated on possibilities, leveraging the knowledge and expertise he had acquired during his countless days at sea on Ice Patrol duty, getting every man under his command to be focused and upbeat, to communicate, and to cooperate. He instilled in his men optimism, attention to detail, and a will to win. His successes are succinctly captured in the following excerpt from the citation that accompanied the award of the Distinguished Service Medal for his WWII service:

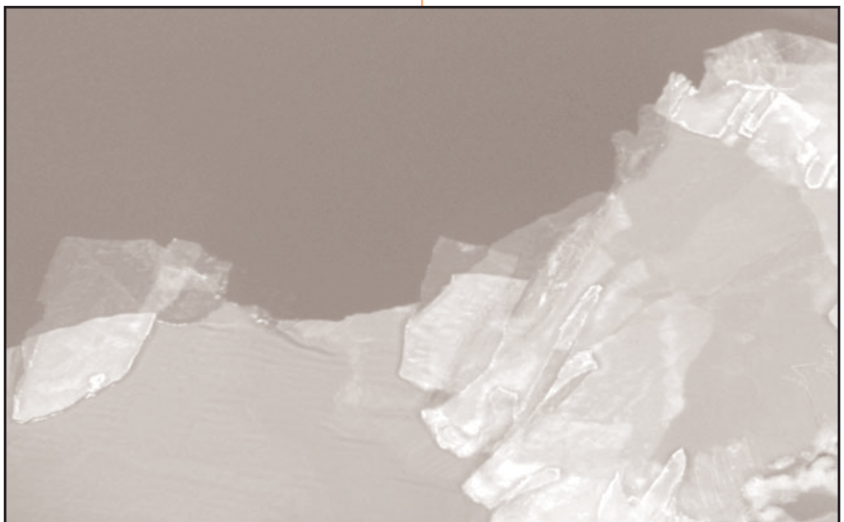
> "In all his negotiations and contacts, Rear Adm. Smith distinguished himself by his splendid diplomacy, sound judgment and intelligent planning and consistently maintained excellent relationships with other United States forces and those of the Allied Nations."[10]

It would literally take volumes to capture a fraction of the accomplishments of the Greenland Patrol and Task Group Twenty-Four under Adm. Smith's leadership; however, the consistent theme one takes away from studying the chronicles of these dramatic days is Iceberg Smith's steadfast focus on the art of the possible. While few leaders will ever face anything as daunting as enemy submarines and the weather and ice of the North Atlantic simultaneously, this steely-eyed focus on possibilities, rather than limits, will serve equally well in less demanding leadership challenges—I like to think of it as "The Greenland Stare."

I have used The Greenland Stare many times to force myself to look to the possible rather than be overwhelmed by much more obvious limitations and obstructions. The truly accomplished leader instills a pervasive positive attitude that accomplishes great things even when resources, talent, or training may be initially lacking.

I close with a quotation from Iceberg Smith's hometown newspaper, *The Vineyard Gazette*. Iceberg Smith never forgot his Martha's Vineyard roots, taking any opportunity to make a port call on his hometown in the cutters he commanded. In 1928, then Lt. Cmdr. Smith was returning to New London, Conn., with the Cutter *Marion*, having completed an historic six-month expedition along the coast of Greenland and into the northern reaches of Baffin Bay. He took the time to make a port-call in Vineyard Haven and invited the entire town aboard to visit the ship and view the polar bear cub that had been captured (a story in itself!) during the cruise.[11] In 1930 he sailed the Cutter *Downs*, a WWI vintage "four stacker" destroyer, proudly into Vineyard Haven harbor. This excerpt chronicling his visit provides wonderful insight into the personality of this great Coast Guardsman:

"Eddie enjoys a position that is distinctly unique in small town life. He has distinguished himself in oceanography research, attained high rating in the Coast Guard, and to top it all, has recently received a Ph.D. from Harvard. In the course of his work he has visited all the principal seaports of the globe and many spots where seaports are not to be found. All this is well known to the home folks, who take the keenest pride in the Vineyard Haven boy who bears his honors so lightly. Unchanged and totally devoid of self importance, Eddie comes home and enters into the spirit of things at just the point where he last left it, and it is because of this fact that his rare visits with his ship are the signal for general letting-down of business while the town's population gravitates toward the dock."[12]



Iceberg Smith died on his 72nd birthday, October 29, 1961. I would begin my own Coast Guard saga 10 years later on a sunny early October morning at the recruiting office in Omaha, Neb. Nine additional years would pass before I discovered Iceberg Smith and started my quest to know more about this dedicated American hero. This article only scratches the surface of the countless lessons I have learned from looking back over his many exploits and accomplishments. I have no doubt that I am a better leader having known Rear Adm. Edward "Iceberg" Smith through the window of the written word. I guess that might be the most important leadership lesson he left me: To be a good leader, you must read.

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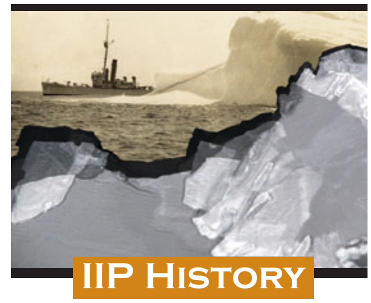
# Greenland Patrol

## *The war years.*




by Petty Officer William Tootle
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Early in 1941, the Commandant of the U.S. Coast Guard, Adm. Waesche, recommended to President Franklin D. Roosevelt that the International Ice Patrol be cancelled that year. President Roosevelt rejected that recommendation, claiming that the International Ice Patrol—sanctioned by the International Convention for the Safety of Life at Sea (SOLAS) of 1914—would provide a legal pretext for current U.S. operations in Greenland, "for which there was as yet no legal sanction."[1] By the time Adm. Waesche made this recommendation, Germany had already invaded Poland, Norway, Denmark, the Netherlands, Belgium, Luxembourg, and France; Italy had declared war on Britain and France; and Britain had survived the German blitzkrieg.[2] The United States would not be officially at war for another 10 months, but Hitler's invasion and occupation of Germany's tiny northern neighbor, Denmark, on April 9, 1940, begins the story of the U.S. Coast Guard's and International Ice Patrol's involvement in WWII.

Denmark itself was of little strategic importance to the Allied effort; the same was not true, however, for its possession, the world's largest island, Greenland. Of Greenland's 836,000 square miles,[3] about 80 percent is covered by ice, and, in 1940, most of its approximately 20,000 inhabitants lived along the southwestern coast.[4] Though largely desolate and uninhabitable, Greenland is perched atop the North Atlantic, like a lookout and way station between two hemispheres, overlooking the vital shipping lanes between North America and Europe. With Hitler in Denmark, Greenland lay defenseless and open to


**Figure 1: Greenland Patrol Memorial at the U.S. Coast Guard Academy, New London, Conn.**

German occupation, thus jeopardizing the supply lines between the U.S. and Europe and making the Western Hemisphere vulnerable to German attack.[5]

Against this backdrop of vulnerabilities, U.S. government and military officials had already begun to make plans for the defense and Allied use of Greenland by the time Adm. Waesche recommended that the International Ice Patrol be cancelled for 1941. It was for those plans and the current U.S. activity in Greenland that President Roosevelt wanted the peacetime cover of the Ice Patrol and therefore denied Adm. Waesche's recommendation for the suspension of that Coast Guard service.

**Strategic Value of Greenland**

Greenland's major significance lay in its cryolite mines and potential to accommodate air bases and weather stations. Cryolite, a mineral necessary for the production of aluminum, was essential to aircraft manufacturing. And the cryolite mine on the southwestern tip of Greenland at Ivigtut was the only mine of its kind in the world large enough to supply cryolite to the American aircraft manufacturers, assiduously filling orders placed by the Western Allies.[6] To ensure that the mine remained under Allied control, U.S. Coast Guard personnel were temporarily discharged in the summer of 1940 to provide armed civilian protection of the mine.[7]

Most of the aircraft produced in the U.S. in the early 1940s were bound for Great Britain, and the quickest way to get them there was to fly the planes along the great circle track that crosses the southern tip of Greenland, where the aircraft were, quite literally, born.[8] To make the long flight from the United States to Britain, the planes would need to refuel along the way. Air bases in Greenland could function as such refueling stations, and weather stations on the island could aid the ferrying of aircraft to Europe and also enhance the weather forecasting that was so critical to naval operations in the North Atlantic and Allied maneuvers in northern Europe. Establishing air bases and weather stations in Greenland, therefore, became a priority of the Roosevelt Administration, especially after April 9, 1941, when the U.S. signed an agreement with the Danish Minister in Washington to defend Greenland and to provide its people with food and supplies, under the Act of Havana of July 30, 1940. Toward this end, the South Greenland Survey Expedition set sail from Boston onboard the Coast Guard Cutter *Cayuga* on March 17, 1941, just three weeks before the U.S. formally accepted responsibility for Greenland's defense.[9]

In the wake of the South Greenland Survey Expedition, numerous Coast Guard cutters were deployed to the coast of Greenland. These cutters, which formed the nucleus of the Greenland Patrol, included the *Northland, Modoc, Comanche, Bowdoin* and two cutters, *North Star* and *Bear*, recently acquired from the Navy. By October 1941, they would be the Greenland Patrol, Task Force 24.8, under jurisdiction of the U.S. Atlantic Fleet and commanded by one of the Coast Guard's and International Ice Patrol's luminaries, Cmdr. Edward H. Smith.[10]

The cutters operating in Greenland were under the command of Commandant Adm. Waesche until May 1941. At that point Chief of Naval Operations Adm. Harold Stark assumed their command by a memorandum in which he stated that the two purposes of naval operations in Greenland were: 1) "to support the Army in accomplishing its task . . . of establishing in Greenland airdrome facilities for use in ferrying aircraft to the British Isles" and 2) "to defend Greenland and specifically to prevent German operations in Northeast Greenland."[11]

November 1, 1941, marked the complete transfer of the Coast Guard from the Department of Treasury to the Department of Navy, where it was to remain for the duration of the war.[12] Though under the Navy's command, the Greenland Patrol mostly comprised Coast Guard assets and personnel, among them vessels and Coast Guardsmen who had served in the International Ice Patrol.

**The Treacherous North Atlantic**

Of the Greenland Patrol's various tasks—which included, among others, establishing and maintaining aids to navigation, reporting weather, charting the Greenland coast, engaging enemy vessels, and destroying German radio stations on land—none was more common and routine, nor closer to danger, than escorting convoys. For their survival, the U.S. military bases in Greenland and the country's natives depended on food and supplies shipped from the U.S. and Canada via merchant vessels and cutters of the Greenland Patrol.

Seafaring, by nature, endangers life and property, even under the most hospitable conditions at sea, and those of the North Atlantic during WWII were all but hospitable. The pack ice and glaciers off the coast of Greenland damaged even the hardiest ships built for Arctic conditions. This fact, combined with the unpredictable, turbulent weather of the region, made sailing from the continent to Greenland a dangerous occupation, even during peacetime.[13] But during the years of the Greenland Patrol, (1940–45), the hemispheres were at war, and German U-boats transformed an already treacherous ocean into a deadly theater of war through which Allied supply convoys had to pass.

Unfortunately, escorts were often unable to prevent U-boat attacks on the vessels in their charge. But that reality was the result of ships that were ill-equipped for antisubmarine warfare, rather than a lack of courage or competence of the sailors who manned them.[14] On February 2, 1943, the *Tampa, Comanche,* and *Escanaba* left St. John's, Newfoundland, in charge of three vessels bound for Greenland, among them the transport *Dorchester*. Near midnight, the *Dorchester* was torpedoed and quickly sank. The *Tampa* continued to escort the two remaining vessels to Greenland, while the *Comanche* and *Escanaba* began rescue work, after having searched unsuccessfully for the attacking U-boat. Over the course of eight hours, the two Greenland Patrol escorts rescued more than 200 of the 904 men on board. This is a formidable number, given that the ship made no distress signal and therefore its escorts did not immediately learn of its plight. Moreover, the *Comanche* and *Escanaba* conducted rescue efforts in the dark without the aid of lights, which would have made them easier U-boat prey. The frigid water itself was an even greater handicap, because it prevented survivors from helping themselves.[15]

Water temperature at this latitude is so cold, especially in February, that, once in it, one loses the use of limbs in seconds, preventing a survivor from climbing up cargo nets or sea ladders, even taking hold of a line or life preserver within reach. Therefore, with the *Dorchester*'s crew overboard and helpless, Coast Guardsmen themselves took to the water on this Arctic night. They implemented for the first time the retriever method, by which Coast Guardsmen in rubber suits were lowered into the water to secure lines to those paralyzed by the cold so that personnel onboard could pull them up to safety. Here, in the perilous midst of war and nature, was a lifesaving service true to its mission. By the war's end, this same courage and innovation had saved countless lives that otherwise would have been lost.[16]

**Greenland Patrol's Contribution to the War Effort**

The rescue of the *Dorchester*'s crew represents the dogged courage and faithfulness that characterized the Greenland Patrol throughout all its service, whether rescuing survivors in the water or on the Greenland ice cap, breaking ice, destroying German radio stations, escorting ships, or establishing aids to navigation in one of the most inclement environments on earth. The fortitude of its members helped to secure the Western Hemisphere from German invasion and contributed not only to the Allied success in the Atlantic, but also to Allied victory in the war.

The U.S. entered the war on December 8, 1941, and Adm. Waesche again recommended suspension of the International Ice Patrol. In a memorandum to the President, Secretary of Navy Frank Knox, on the Commandant's behalf, recommended suspension based "upon existing war conditions and disruption to normal maritime commerce and practices in the North Atlantic." President Roosevelt signed the memorandum on December 22, 1941, and the suspension held through 1945.[17]

**Figure 2: Petty Officer Jay Buehner (left) and Petty Officer Allie Rogers prepare to drop the Greenland Patrol Memorial wreath into the North Atlantic.**

Despite the International Ice Patrol's official suspension, however, there was no dearth of ice data collected during this interval, to which Ice Patrol's 1946 annual report is a testament. The forward to that document states that, in spite of Ice Patrol's suspension during the war years, ice conditions were observed and reported, though by means and over an area "altered to fit the naval needs and facilities of nations at war."[18]

Part of that means was the Greenland Patrol. Four of its cutters—the *Tampa*, *Mojave*, *Northland*, and *Modoc*—had served in the International Ice Patrol, and a detachment of experienced Ice Patrol personnel was detailed to Argentia, Newfoundland, to serve under Commander, Greenland Patrol, Task Force 24.8. These personnel helped coordinate and disseminate ice reports from convoys, cutters, and reconnaissance flights,[19] which, unofficially, inaugurated Ice Patrol's use of aircraft. One may argue then, that in the International Ice Patrol's suspension, the Greenland Patrol was the de facto Ice Patrol; that the peacetime Ice Patrol was not necessarily suspended but rather re-centered and mobilized to help win the war. In 1946, after Germany and Japan had surrendered, the *Modoc*, *Tampa*, and *Mojave*, again, were officially monitoring ice conditions in the North Atlantic as part of the International Ice Patrol, which also officially inaugurated aerial reconnaissance that same year.[20]

**Remembering the Greenland Patrol**

World War II and the Greenland Patrol are as much a part of the International Ice Patrol's history as the *Titanic*. On the northwestern edge of the U.S. Coast Guard Academy in New London, Conn., stands a modest memorial to the Greenland Patrol (Figure 1). It is among other memorials located at Bertholf Plaza, named for the Commandant largely responsible for making, at its inception in 1914, the International Ice Patrol a U.S. Coast Guard service. The memorial and Bertholf Plaza are situated, fittingly, near Waesche and Smith Halls, named for the WWII Commandant and the aforementioned Cmdr. Edward H. Smith.

Recently, the Ice Patrol has begun an annual custom of dedicating a wreath to the Greenland Patrol at the memorial. During a reconnaissance flight following the dedication ceremony, a member of Ice Patrol drops the wreath into the North Atlantic, beneath which so many sailors lie; among them are those who bravely served in the Greenland Patrol (Figure 2). With pride and humility, the Coast Guard and International Ice Patrol remember them and the entire corps that was the Greenland Patrol.


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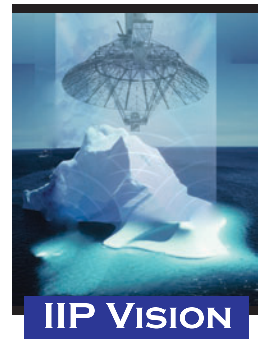



# From Shipboard Sighting to Airborne Reconnaissance and Beyond

## *IIP seeks continuous improvement for methods of iceberg detection.*

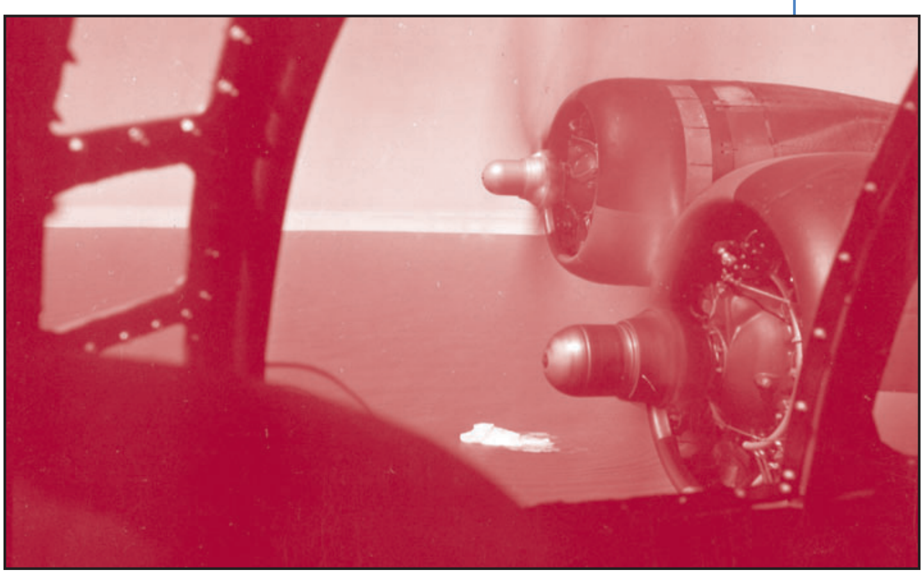
by Lt. j.g. Nicolas A. Jarboe
*Ice Information Officer, U.S. Coast Guard International Ice Patrol*

Ever since the Coast Guard was officially tasked with monitoring the iceberg conditions in the North Atlantic in 1914, the individuals responsible for carrying out this mission have been focused on continuous improvement through the use of technology. Iceberg scouting began with ships patrolling the foggy waters of the North Atlantic in search of the southernmost iceberg. The focus shifted from shipboard reconnaissance to aerial reconnaissance in 1946; however, visibility was still the limiting factor in the detection of icebergs. With the advent and operational implementation of airborne radars, the primary sensor for iceberg detection changed from the human eye to radars.

**Figure 1: Revenue Cutter *Seneca*: One of the original two cutters assigned to ice patrol duty.**

The International Ice Patrol (IIP) began to test the use of satellites for iceberg hunting in 1997 and continued satellite validation efforts during the 2004 ice season. Despite the numerous technological advances in iceberg scouting, the task today is the same as it was in 1914, and finding a relatively small chunk of ice in the 500,000 square nautical miles of ocean for which the IIP is responsible remains extremely challenging. The IIP culture has been, and will continue to be, to push the technological envelope to come up with innovative ways to detect and classify icebergs in the North Atlantic.

**Figure 2, Above and below: Aerial Ice Observer looking out over the foggy waters of the Grand Banks from the nose of the B-17 Flying Fortress PB1G in search of icebergs.**



Ships were assigned to ice patrol duty in pairs so that a continuous presence could be maintained on the Grand Banks of Newfoundland. A small contingent of ice observers, who managed iceberg data collection and radio broadcasts, were transferred from ship to ship by small boat or boatswain's chair. This group would spend months at sea, ensuring continuity of the operation, collecting environmental observations, and compiling reports.

**Shipboard Reconnaissance**

In 1913, the Revenue Cutter Service (forerunner to the Coast Guard) allocated the Coast Guard Cutters *Seneca* and *Miami* to the Grand Banks in search of icebergs. These first patrolling cutters assigned to International Ice Patrol duty made immediate use of an emerging technology: wireless radio communications. These revolutionary shipboard radio systems made real-time collection and distribution of ice and iceberg reports a practical means of improving safety.

Detection of icebergs was limited to visual observations in an area of notoriously poor weather conditions. Foggy, cold, and uncomfortable seas were prevalent. Ships were compelled to anchor in low visibility, and systematic searches or surveys for icebergs were generally ineffective. Patrolling cutters usually covered an area from Flemish Pass to the Tail of the Grand Banks, "Iceberg Alley," where cold water preserved and carried icebergs into shipping lanes (Figure 1). Much of a cutter's time was spent laying alongside and drifting with the southernmost iceberg or ice floe. Patrolling cutters followed individual icebergs south in the Labrador Current for weeks until they deteriorated. The assignment of patrolling cutters began in 1913 and continued on a regular basis, as dictated by the prevailing ice conditions, until the end of the 1950 ice season. Since then, cutters have been utilized sporadically during severe ice conditions, for oceanographic cruises or applied research programs.

**Airborne Visual Reconnaissance**

During World War II, regular ice patrol service was suspended as the Coast Guard supported Allied shipping and convoy operations and performed the Greenland Patrol. Maritime patrol aircraft, used for antisubmarine warfare, frequently reported icebergs on the Grand Banks and demonstrated the effectiveness of aerial reconnaissance for iceberg detection.

Upon cessation of hostilities, a permanent Coast Guard presence was established in Argentia, Newfoundland. This base was equipped with aviation facilities, a radio station, and an International Ice Patrol office to coordinate surface and aerial patrols, collect ice reports, and disseminate warnings.

Regular aerial patrols commenced in 1946 with long-range maritime patrol variants of bomber and transport aircraft, such as the B-17 Flying Fortress PB1G, patrolling several thousand miles during 12-hour flights (Figure 2). In 1963, the mainstay of the Ice Patrol became the HC-130 Hercules. Forward deployment of modern reconnaissance aircraft to Newfoundland has eliminated the need for permanent aviation facilities in Newfoundland. Today, in a manner very similar to the early cutters, aircraft and ice observers rotate every two weeks during the ice season to maintain regular ice patrols in the vicinity of the Grand Banks.

**Airborne Radar Reconnaissance**

The advent of reliable airborne radars revolutionized iceberg reconnaissance. Extensive tests and operational experience demonstrated that both 3-centimeter (X-band) and 10-centimeter (S-band) radars effectively detected ice. From the air, large icebergs could be detected at ranges exceeding 30 nautical miles. Cutters were no longer cost-effective when compared to aerial radar reconnaissance covering large swaths of fog-covered ocean. However, the need to identify whether small radar targets were vessels or ice required the radar-equipped aircraft to visually identify many targets. With prevailing visibility under two miles and ceilings below 1,000 feet, a safe descent to identify icebergs (which may exceed 350 feet in height) was often difficult and sometimes impossible.

As early as 1957, Ice Patrol began experimenting with a Side Looking Airborne Radar (SLAR), because this system possessed the potential for high-resolution detection in nearly all weather conditions. Validation efforts continued through the 1960s and 1970s, and in 1983 the International Ice Patrol began using SLAR operationally for iceberg detection. The current model of SLAR, an X-band, real aperture surveillance and mapping radar system, is capable of detecting most icebergs in the sea conditions prevalent on the Grand Banks. A typical patrol, conducted at an altitude of 8,000 feet, covers 30,000 square nautical miles.

Forward Looking Airborne Radar (FLAR) was added to the HC-130 sensor suite in 1993. In addition to long-range detection, this Inverse Synthetic Aperture Radar (ISAR) uses Doppler shift, created by target motion, to form images of the targets. Distinct features of hard targets (hull form, king posts, stacks, and rigging) and movement (Doppler shifts created by pitch, roll, and yaw) enable classification of radar targets as ships, buoys, sea ice, or icebergs. Combining these two powerful radar systems, SLAR for detection and FLAR for identification, gives the International Ice Patrol an all-weather capability to detect and classify icebergs (Figure 3). The inclement weather of the Grand Banks, while always a factor in aircraft operations, no longer impedes effective surveillance of icebergs in the North Atlantic.

**Satellite Reconnaissance**

In 1972, IIP began receiving ERTS-A satellite imagery. This visual sensor had the capability to detect sea ice as well as medium and large icebergs but could not

**Figure 3: Radar Ice Observers use SLAR and FLAR to detect and classify targets on the ocean surface.**

see through the fog and clouds. This system was not used operationally for iceberg reconnaissance. In 1975, an internal assessment was conducted on remote sensing as it applied to the International Ice Patrol. That report displayed IIP's interest in using satellites to perform the mission, as IIP eagerly awaited the projected 1978 launch of the ocean monitoring satellite SEASAT-A. They rather ambitiously stated, "satellites could prove invaluable to Ice Patrol, possibly eliminating the need for routine aircraft reconnaissance by the late 1980s."

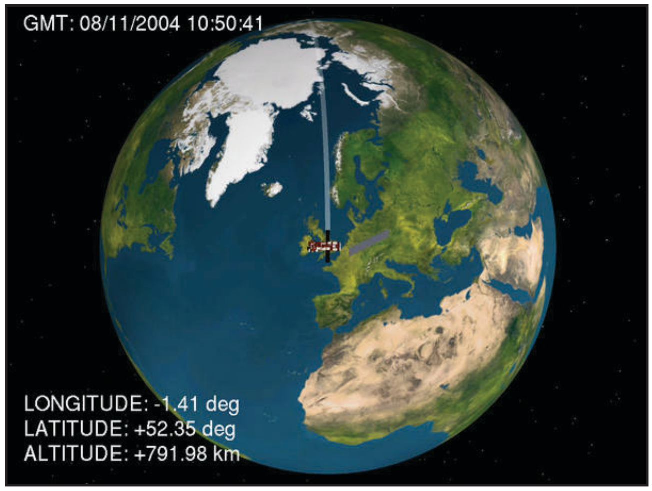



**Figure 4: ENVISAT in orbit over the North Atlantic. Image courtesy of the European Space Agency.**

In early 1996 the IIP began considering satellites for operational iceberg reconnaissance by testing the target-detection capability of the Canadian satellite, RADARSAT. RADARSAT has a synthetic aperture radar (SAR) with a C-band horizontal (HH) polarization microwave radar instrument that is capable of gathering ocean surface data, day or night, and is virtually unaffected by fog or weather. In July 1997 IIP conducted a validation flight of RADARSAT data to determine the satellite's ability to detect icebergs. This study concluded that RADARSAT could detect targets 15 meters wide or greater. The limiting factors associated with RADARSAT were the cost and the satellite's inability to classify targets to distinguish between an iceberg and a ship.

During the 2003 and 2004 ice seasons, the IIP participated with the Newfoundland-based organization C-CORE, to evaluate the ability of the European Space Agency satellite operation (ENVISAT) to detect and classify targets on the ocean surface. ENVISAT possesses an advanced synthetic aperture radar (ASAR) sensor similar to RADARSAT SAR (Figure 4). ENVISAT ASAR differs from RADARSAT SAR in that it possesses dual alternating polarization in HH and vertical (HV). The dual polarization helps the image analyst distinguish between icebergs and ships. In addition to comparing HH and HV imagery, C-CORE also developed an automated algorithm to classify both icebergs and ships from the ASAR imagery. The data was sent to the IIP in a form to be ingested into the iceberg analysis and prediction system for further tracking. The data was not used operationally, due to the necessity of further validation, but was used for flight planning and decision-making purposes.

During the 2004 ice season, a targeted experiment involving IIP, C-CORE, Provincial Air Lines, and the Canadian Ice Service was conducted to validate the algorithm's ability to distinguish between icebergs and ships. Five under-flights were conducted in April and May of 2004, which ground-truthed 101 icebergs and 41 ships. Probability of detection (POD) results did not meet IIP's thresholds for operational use, however, and IIP plans to continue validation efforts during the 2005 ice season, focusing primarily on a more narrow swath width than that used in 2004. With present technology, IIP does not intend to use ENVISAT imagery to determine the Limits of All Known Ice; however IIP could potentially use this data to assess the feeder population of icebergs in an area less critical to shipping traffic, if POD numbers increase and improvements are made to the algorithm's ability to accurately classify targets.

**Conclusion**

At present, it is unlikely that satellites will replace the HC-130 aircraft as IIP's primary means for iceberg scouting. The flexibility in directing the aircraft and the ability to visually identify ambiguous radar targets give the airplane a huge advantage over satellite means for reconnaissance. Satellites do, however, have the realistic potential to augment aircraft reconnaissance in the near future, potentially allowing some HC-130 hours to be reallocated to other Coast Guard missions.

The IIP will continue to seek technological advances to improve its ability to find the icebergs that pose a threat to transatlantic mariners. IIP is beginning to examine the possibility of using unmanned aerial vehicles (UAV) for iceberg reconnaissance. The use of UAVs, combined with satellite coverage over the IIP operations area, could eventually eliminate the need to send aerial ice observers over the North Atlantic. The IIP of the future could be two people sitting in a command center directing a UAV and receiving satellite iceberg data to issue iceberg warnings. Much work still needs to be accomplished to validate the ability to incorporate these technologies operationally.

# Lessons Learned: The International Ice Patrol

by Diana McLaughlin[1] and Bill Abernathy
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What does "lessons learned" mean? Most often, this means learning by that most memorable and painful of teachers: experience. When the *RMS Titanic* sank, the world was shocked to hear that such a large, strong vessel, built with the latest safety design, could sink due to a few scrapes of an iceberg. As a result, the International Ice Patrol (IIP) was created to eliminate the risk of iceberg collision in the transatlantic shipping lanes of the Grand Banks of Newfoundland. It has great success to share: Since the inception of the IIP, not one vessel has reported a single loss of life or property due to collision with an iceberg when heeding the Patrol's published Limits of All Known Ice.[2]

**International Ice Patrol: Reaction to a Tragedy**

Marketed as the grandest vessel of its time, the *Titanic* was built with the latest technology. Thomas Andrews, who supervised the ship's design and construction, declared it "as nearly perfect as human brains can make her."[3] Those very words would prove to be ironic, as the "human brains" of its builders never imagined it would sink. Even the busy, fog-shrouded shipping lanes of the Grand Banks seemed no match for this new, powerful vessel. Built with a double-bottomed hull divided into presumably watertight compartments, the ship was declared "practically unsinkable" because it could retain its buoyancy even if four of its sixteen compartments became flooded. It was unthinkable that a single iceberg could cause the ship to, in fact, take on 31,000 tons of water in *five* compartments, driving the bow down and greatly straining the midsection.[4]

Though the same waters had already claimed multiple ships and hundreds of people by 1912, the *Titanic*'s loss of over 1,500 passengers finally jolted the world into action. The public's shocked outcry resulted in the first International Convention for Safety of Life at Sea (SOLAS) in 1913. The convention drew up rules requiring that every ship have lifeboat space for each person onboard, lifeboat drills be held during each voyage, and ships maintain a 24-hour radio watch. The convention also provided for the inauguration of what was to become the International Ice Patrol.

These provisions required a substantial amount of international cooperation to create and provide for, which may help to explain why these seemingly common-sense guidelines were not in place from the start. Unfortunately, that is usually the way it is in any industry—most laws are a reaction to, and a direct result of, incidents in the public spotlight. When the public was understandably incensed by the *Exxon-Valdez* oil spill, Congress responded by passing the Oil Pollution Act of 1990. Likewise, the Maritime Transportation Security Act of 2002 (MTSA), designed to protect the nation's ports and waterways from terrorist attack, stemmed from the World Trade Center attacks on September 11, 2001.

**Prevention Through People:**
**More *Prevention* = Less *Reaction***

While rulings such as these attempt to address specific issues at fault, Prevention Through People (PTP)'s efforts extend one step forward and one step back from a range of potential scenarios to cover all aspects of a situation, further questioning *"What if …?"* Back in 1912, PTP may have explored a number of other human and organizational factors and lessons learned: *"What if the ship had been traveling more slowly? What if the iceberg had been sighted from further away? What if the ship had enough lifeboats for all passengers? What if the crew had been more familiar with the ship and its procedures?"*

One of the biggest challenges to the PTP program is that "prevention" is not nearly as melodramatic as "reaction." Film director Steven Spielberg is not banging down our door for the rights to produce "Crew Endurance Management: A Guide for Maritime Operations." Preventive efforts do not always have such impressive numbers or the devastating impact of a *Titanic* tragedy. Instead, as evidenced by regular cycles of oil spills, men overboard, fatalities, groundings, bridge allisions, and other maritime accidents, some might be tempted to turn a deaf ear to PTP's non-regulatory recommendations by mistakenly categorizing them with sensationalistic warnings on late-night news broadcasts. One can become numb to a seemingly constant flow of warnings; it becomes easy to disregard important information.

**Lessons Learned: International Ice Patrol Core Values**

What lessons can be taken from the creation of the International Ice Patrol? There are several core values shared between the IIP and PTP that can help to promote awareness of human element issues and a resulting preventive, rather than reactive, safety culture. The IIP's success can be contributed to three core values:

**Individual Commitment to the International Ice Patrol Mission**

The strongest chain is only as reliable as its weakest link. Perhaps if the *Californian's* operator had not turned in for the night and therefore missed the *Titanic's* distress call, the *Californian* could have traveled the 20-mile distance quickly enough to save more people. Individual commitment is expressed through PTP's encouragement of managing, motivating, and leading by example a "safety culture" in which every member of a vessel, from its master to its newest apprentice, is aggressively educated on the reasons why every single member must execute procedures correctly and consistently.

> **Steven Spielberg is not banging down our door for the rights to produce "Crew Endurance Management: A Guide for Maritime Operations."**

**Continued Improvement Through the Use of Technology**

Technological advancements in the areas of iceberg reconnaissance and modeling have improved both the quality of iceberg limit reliability and the cost-efficiency of IIP over the 83 years of its history. Yet, even with its rate of success, the IIP still cautions mariners not to rely on technology too heavily. In particular, they are warned not to rely upon radars entirely, since icebergs are often not detected by radar alone. The IIP continues, "There is no substitute for vigilance and prudent seamanship, especially when navigating near sea ice and icebergs."[5] PTP, too, suggests that technological improvements be introduced through proper training in an appropriate work environment with competent, well-functioning workers. New technology applications are advised to be created and evaluated with human capabilities and limitations in mind.

**Partnerships Built on the Spirit of International Cooperation**

This core value is best demonstrated by the fact that the Ice Patrol has maintained broad-based international support for over eight decades despite changing operational and technological factors. The IIP also acknowledges and rewards the input of ships passing within its patrolled areas, which is in line with PTP's guiding principle, "Seek Non-Regulatory Solutions," where incentives and innovation are emphasized. Each ship is requested to report its position, any sighting of ice and its characteristics (or even "no ice sighted"), the sea surface temperature, and a weather report every six hours. This information is plugged into an IIP computer model to help predict the drift and deterioration of ice, and to plan aerial patrols accordingly. PTP has also developed formal relationships with organizations at home and abroad to further its use in the maritime industry. Both partnerships and advisory committees work with the Coast Guard in providing support—and fulfilling the need—to identify root causes and cost-effective preventive measures for casualties and near-miss events.

**Changing the Culture from "Reactive" to "Preventive"**

Efforts such as the International Ice Patrol have turned a catastrophe into a learning experience for the world, changing aspects of the maritime industry for the better and helping mariners to avoid treacherous waters.

Whether preventive or reactive, PTP has many stories to share regarding pollution and casualties in the maritime industry. The effort will continue to recognize that safe and profitable operations require constant and balanced interaction among management, the work environment, the behavior of people, and appropriate technology.

We hope to never again hear a story like the *Titanic's*. To further that effort, and to exemplify its goals to "Know More" and "Cooperate More," PTP promotes the sharing of all maritime experiences, best practices, and lessons learned—both positive and negative—through its Website. You are encouraged to submit your own stories by e-mailing fldr-g-mse@comdt.uscg.mil.

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[1]Diana McLaughlin is a SAGE Systems Technologies, LLC, technical writer for the Human Element and Ship Design Division (G-MSE-1) in Washington, DC.
[2]International Ice Patrol, "Mission," <http://www.uscg.mil/lantarea/iip/General/mission.shtml>.
[3]Encyclopaedia Brittanica, "Titanic," <http://search.eb.com/titanic/03_SINK/pict_14.html>.
[4]Encyclopaedia Brittanica, "Titanic," <http://search.eb.com/titanic/05_UNDERWATER/pict_31.html>.
[5]International Ice Patrol, "Products," Announcement of 2004 International Ice Patrol Services, <http://www.uscg.mil/lantarea/iip/pdf/AOS2004.pdf >.

The PTP website can be found at http://www.uscg.mil/hq/g%2Dm/nmc/ptp/index.htm.

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# Ship Collisions with Icebergs

*A brief review, past to present.*

by Brian T. Hill
*Institute for Ocean Technology, National Research Council Canada*

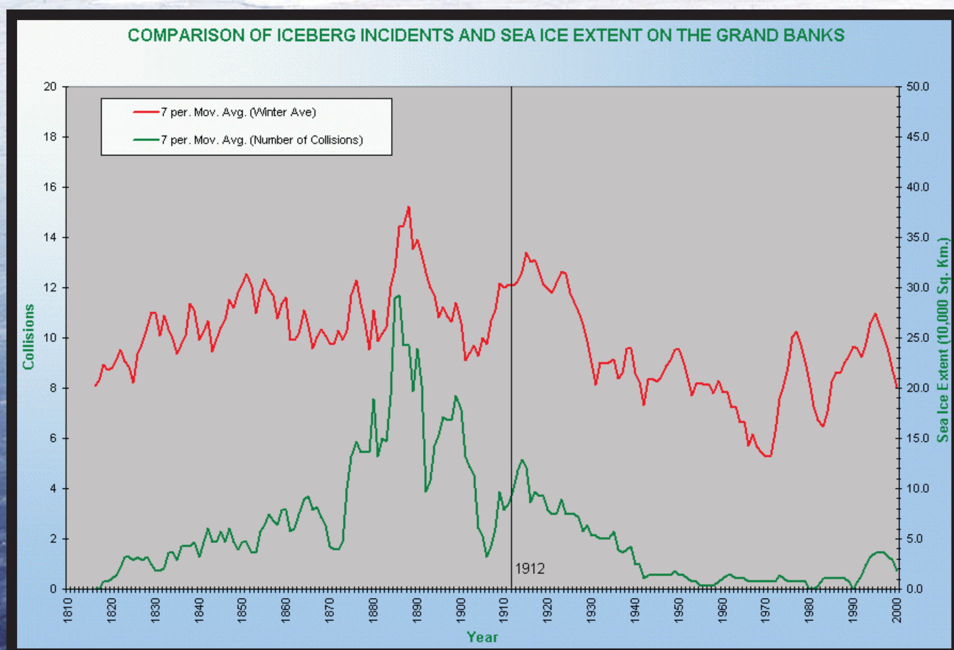


**Figure 1. A comparison of iceberg incidents and sea ice extent on the Grand Banks, from the early 1800s.**

Ice in the North Atlantic has been a known hazard to navigation for as long as we have written records. What could be the earliest description of an iceberg comes from the account of St. Brendan's voyage from Ireland to North America in about 570 A.D, in which there is a description of a column of pure crystal. Over the following centuries, ice must have been a threat to the Norse settlers and the Basque whalers and fishers who persistently expanded their frontiers into cold regions. Casualties must have been common, but it is not until 1619 that we have note of perhaps the first recorded incident. An iceberg in the making fell from an ice cliff in Spitzbergen (Arctic Ocean, north of Norway) onto a whaling vessel, breaking masts and killing three people.

## The Perils of Ice at Sea

Ice in the North Atlantic has two different origins: sea and land. Sea ice is formed by the freezing of seawater, while icebergs originate from the calving of glaciers, predominantly in western Greenland. Ice type was no doubt of little consequence to early seafarers, as any kind of ice was a threat. Our first recorded collision with ice occurred in 1686, when the inaptly named *Happy Return* of the adventurous North West Fur Company sank in Hudson Strait while attempting to get into Hudson Bay. Accounts of the transatlantic trade in the 18th and early 19th century are sparse. Many vessels set sail and were never seen again. How many fell victim to ice, we will never know. The accounts of the survivors from the ships such as the *Anne* in 1704 and the *Lady Hobart* in 1803 leave one chilled to the bone. In the aftermath of the collision, when the passengers have taken to the open boats in haste and with little or no rations or clothing, they are then faced with hunger, hypothermia, and the horrors of frostbite.

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At this time, voyages across the Atlantic were slow—taking weeks and sometimes months. Means of communication were slow, too, so if ice was met on a voyage, any warnings passed along would have had little meaning at a later date because the ice was always on the move. The shipping newspaper, *Lloyd's List*, in London had been printing a single page shipping report since 1741, but the increase of local printing presses in the early 19th century, along with efficient packet ships, permitted wider dissemination of shipping intelligence, which occasionally mentioned sightings of ice.

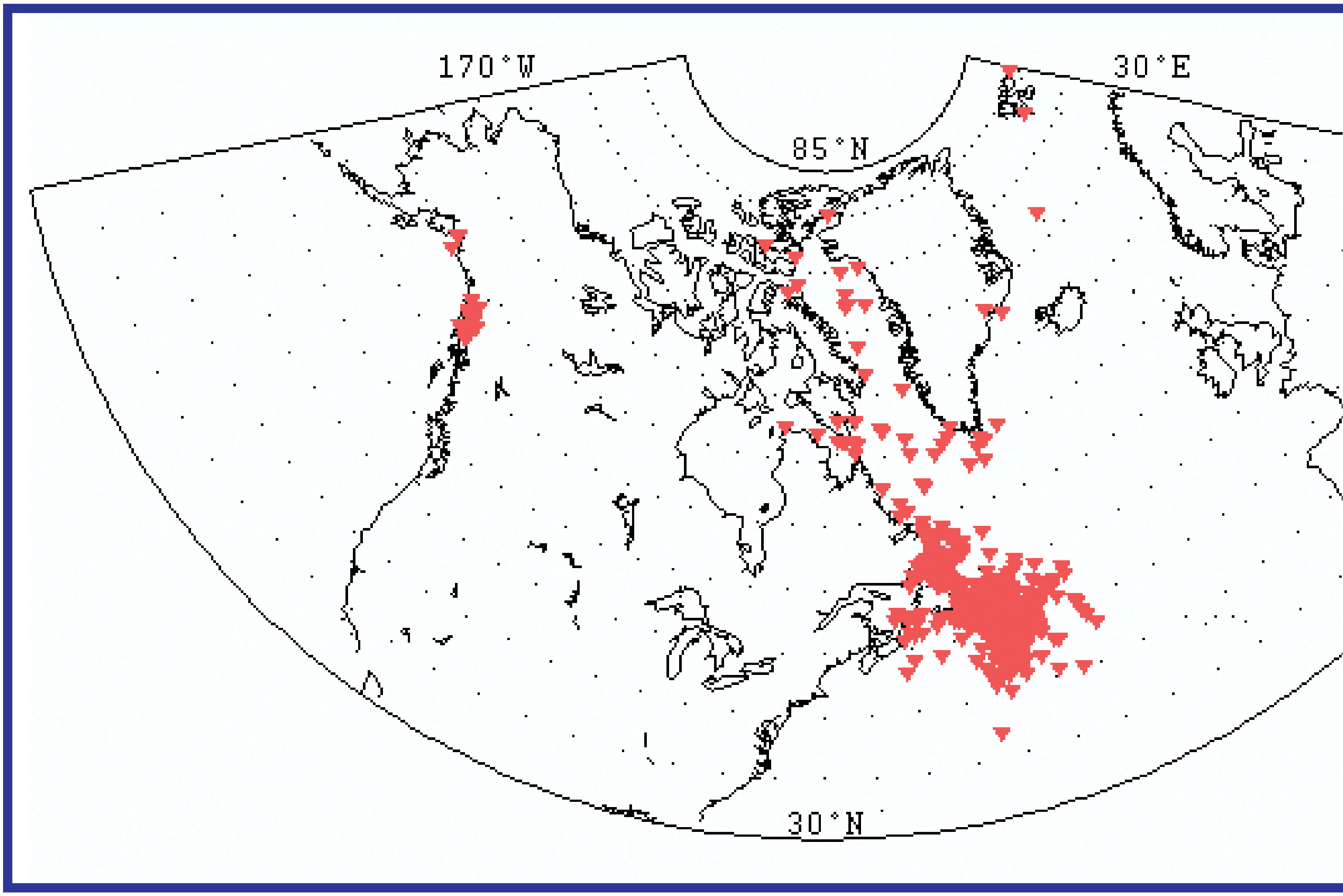



**Figure 2. It is Ice Patrol's mission to determine the Limits of All Known Ice in the Grand Banks area.**

**Every Man for Himself?**

Emigration to North America was now also on the increase, and in April 1841 the first iceberg collision to shake the world occurred. The *William Brown*, with 17 crew and 64 passengers, mainly Irish emigrants, collided first with a pan of ice and, then, within a few minutes, an iceberg, while at the speed of around 10 knots. The ship went down in 20 minutes, taking with it 33 passengers, because there were insufficient lifeboats for all.

All the crew and the 31 remaining passengers got away in two small boats, but, when one of the boats was in danger of being swamped, the crew threw 14 passengers overboard to lighten the boat, with the reasoning that a few should die so that the rest might live. The crew was not part of the equation, of course, since their seamanship was required to save the rest. A murder trial followed. The contemporary press had a field day, and politicians assuaged public fears that they had a right to safety at sea, while at the same time trying to protect the interests of a profitable emigration trade. The case of the *William Brown* and the morals of lifeboats ethics are still cited today.

**Speed Kills**

In 1819, the *Savannah* was the first steam-powered ship to cross the Atlantic, although it made most of the voyage by sail. By the middle of the century, powerful paddle wheelers were churning across the ocean, reducing the length of voyages to a matter of days. However, 1856 was a bad year for them (Figure 1). On its maiden voyage from Liverpool to New York, and with approximately 200 passengers aboard, the *SS Persia* arrived in February badly damaged after a collision with an iceberg. The *SS Pacific*, which had set sail a few days earlier, did not turn up at all and is presumed to have met her fate in the same ice field, echoing the current theory of the loss of the *City of Glasgow* with its 480 passengers two years previously.

Editorial comments criticized the shipping owners' obsession with speed, which endangered the lives of passengers in the hazards of ice and fog. The invention of the screw propeller, however, made the ships all the faster. By the 1890s, ice conditions were well reported in newspapers and official bulletins and, because of expanding telegraph service, were also more speedily broadcast, but the ice conditions were getting worse. Whatever the cause, with more ice around and ships becoming faster, there were more collisions, and the editorials continued to cry out against this foolishness. Collisions with derelicts were also a problem. Iron steamships were replacing wooden sailing vessels, but there were still lots of these around, which, when abandoned because of ice, storm, or fire, often left half-floating hulls and spars to menace faster ships. There were calls for patrols to monitor these floating hazards in the North Atlantic shipping lanes.

**Birth of the International Ice Patrol**

It was at about this time that Morgan Robertson wrote his short novel, *Futility*, otherwise known as *The Wreck of the Titan*. The similarities with the events of its near-namesake 14 years later are many. Inevitable as the *Titanic* disaster might have appeared to some, the tragedy was enormous and was to have far-reaching effects for safety at life at sea including, at last, lifeboats for all. Also in the wake of the *Titanic* disaster, patrols for hazards in the North Atlantic were established, resulting in the formation of the International Ice Patrol (IIP). The purpose of the Ice Patrol was to advertise the Limits of All Known Ice in the Grand Banks area, which would pose a threat to ship traffic (Figure 2). The patrol could not prevent collisions any more than a speed limit sign can prevent vehicle accidents on a highway, but it would help.

It took another disaster for the Danes to form the Greenland Ice Patrol. The *Hans Hedoft* sank in blizzard conditions after striking an iceberg off Cape Farewell on its maiden voyage in January 1959. About eight ships appear to have collided with icebergs on their maiden voyages. Alaska is another source of icebergs, which caused a major disaster of another sort. The *Exxon Valdez* went aground in 1989 trying to avoid small bergs in her path, spilling 11 million gallons of crude oil and causing the worst pollution disaster in our time. This type of pollution is a threat for any vessel carrying fuels or chemicals in ice-strewn waterways.

The patrol could not prevent collisions any more than a speed limit sign can prevent vehicle accidents on a highway, but it would help.

In April 1993, despite good ice warnings, the

*Omikronventure L*, carrying 21 million gallons of oil struck a growler, which cracked open its hull but, fortunately, left the cargo tanks intact. In Alaska, real gold was lost as well as black. Eleven years before the *Titanic*, the *Islander*, another ship declared unsinkable because of its watertight compartments, struck an iceberg and sank. It had perhaps as much as $6 million of Klondike gold onboard, of which only a fraction has been so far recovered.

**Figure 3. The *Solborg* sustained damage from a sizeable berg at least 50-65 feet high, off St. John's, in June 2004. Courtesy Keith Gosse, The Telegram, a division of Transcontinental Media Inc.**

Wheat was also a valuable commodity. In 1932, a brand-new $50 million terminal was built at Churchill, Manitoba, on Hudson Bay, to ship grain from western Canada. East/west rivalries were irked by this apparent intrusion into the traditional market of eastern ports. When the *Bright Fan*, loaded with 250,000 bushels of wheat, hit a berg in Hudson Strait and sank, accusations abounded, including the theory that the east had deliberately sabotaged the voyage and, with it, the future of Churchill as a port.

Some other events border on the tragic-comical. Approaching Newfoundland in 1909, the schooner *Geisha* struck a berg but managed to carry on until near St. John's, where she bumped into an unlit schooner. Bearing off, she struck another huge iceberg, 150 feet tall, which turned her over. The crew escaped by rowing the 50 miles through ice floes to the shore.

In May 1945, a convoy of approximately 70 ships was heading westward with *HMS Chelmer* in the van. When the order came to turn together, 90° to port to avoid icebergs, *Samaustral* and three other ships struck the ice and some 18 other ships struck each other.

Modern-day technology in iceberg observation and detection and more efficient rescue services make another

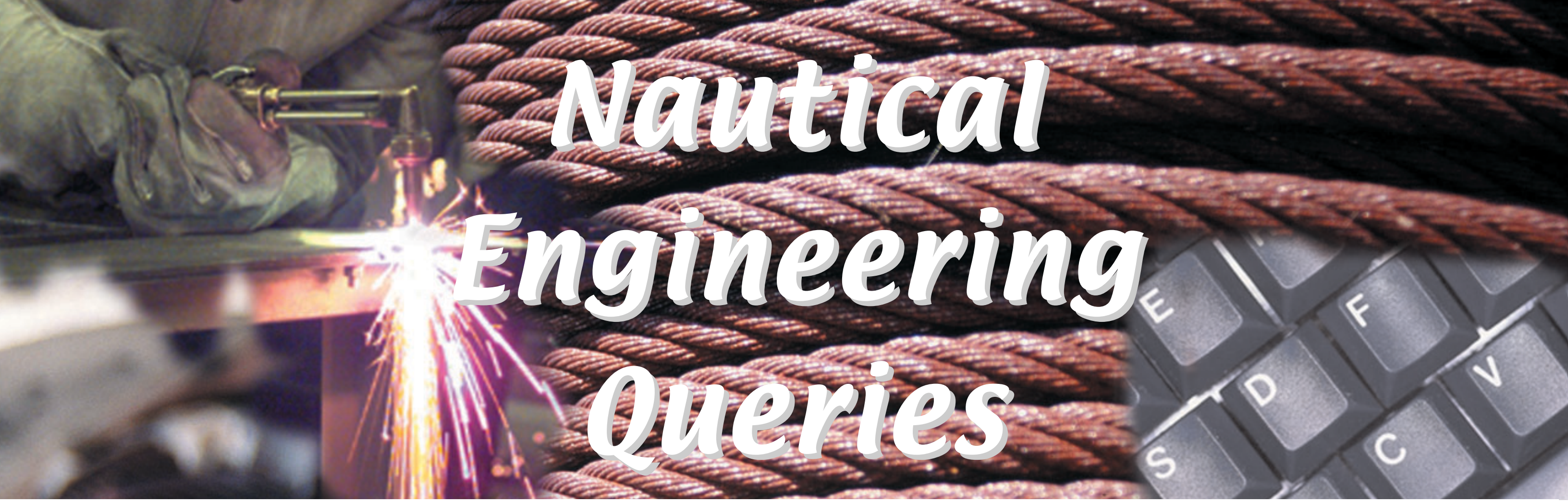
**Eleven years before the *Titanic*, the *Islander*, another ship declared unsinkable because of its watertight compartments, struck an iceberg and sank. It had perhaps as much as $6 million of Klondike gold onboard, of which only a fraction has been so far recovered.**

*Titanic* scenario very unlikely, but collisions still happen. "Bergy" waters are increasingly visited by fishing vessels and tourist ships, and the detection of the smaller iceberg masses, growlers, and "bergy bits," especially in heavy seas, are still a problem. The crew of the *BCM Atlantic* had a narrow escape when their trawler struck a growler and went down in rough conditions off Labrador in March 2000. As recently as June 2004, the *Solborg* (Figure 3) hit a sizeable iceberg some 50–65 feet high, off St. John's.

The IIP cannot entirely prevent such accidents, but there have been only approximately 100 collisions on the Grand Banks during the 90 years since its inception, compared with 350 in the 90 years before. Prior to 1914 there were 3,100 fatalities, compared to 13 since, and only four of these were related to transatlantic shipping, as opposed to local fishing vessels. The last was in 1928 when the *Montrose* collided with a berg; ice from the impact fell and killed two men on deck. No collision has ever occurred outside the IIP's Limits of All Known Ice.

Icebergs are a threat now as in the past, as this quote from an old newspaper column published just six months before the *Titanic* disaster reminds us: "A lady passenger on a steamer, who was very nervous and the cause of great irritation to the captain, said to him one day: 'Captain, I'm so terribly afraid of icebergs! What would happen if there should be a collision between us and an iceberg? Please tell me frankly. I can bear the truth.' 'Why, madam,' said the captain without a moment's hesitation, 'the iceberg would move along just as if nothing had happened.'"

This article is based on a ship collision with iceberg database of over 650 incidents compiled by the author and available at www.icedata.ca.



# Nautical Engineering Queries

1. Refrigerant leaving the metering device in a refrigeration system is a _______.

*NOTE: As the liquid passes through the thermal expansion valve (metering device), the high pressure liquid experiences an adiabatic process in which the total heat (sensible heat plus latent heat) at the inlet and the total heat at the outlet on the low pressure side are virtually the same. The specific heat of the liquid at the inlet is much higher than the specific heat at the outlet. Since heat can neither be created nor destroyed, but only transformed, the remaining heat at the low pressure outlet will be transformed as latent heat. As the former high pressure liquid passes into the low pressure, the excess specific heat flashes the low pressure liquid and through the flash process reduces the sensible heat of the liquid until it stabilizes at the corresponding saturation temperature to that of the existing low pressure in the evaporator coil.*

A. Sub-cooled liquid

Incorrect: The liquid cannot attain a temperature lower than its saturation condition without having been physically removed from the immediate point of entry.

B. Sub-cooled vapor

Incorrect: A saturated vapor cannot be sub-cooled.

C. Saturated liquid/vapor mixture

Correct Answer: The fluid form leaving the metering device after entering the area of lower pressure and affected by the adiabatic process noted above, now exists as both a saturated vapor and saturated liquid.

The mixture continues to pass through the evaporator coils where the remaining liquid continues to absorb additional heat from the space being cooled, completely and ideally vaporizing at a point about 2/3 of the distance into the evaporator coil.

D. Saturated liquid

Incorrect: The only means by which "all" of the liquid could continue to exist as a saturated liquid would be for it to exist at the same temperature/pressure conditions as it did upon entering the metering device.

---

2. At what temperature would the reading on the Fahrenheit scale and the Centigrade scale be identical?

A. 16 degrees above zero.

Incorrect

B. 32 degrees below zero.

Incorrect

C. 40 degrees below zero.

Correct Answer: See solution below.

D. 64 degrees below zero

Incorrect

Solution: The question is asking for the temperature at which the numerical value is identical on both the Centigrade and Fahrenheit scales.

Temperature $_{(Centigrade)}$ = Temperature $_{(Fahrenheit)}$ = Temperature $_{(Answer)}$

Our standard temperature conversion formula is:

$1.8\,T_{(C)} + 32 = T_{(F)}$ if $T_{(C)} = T_{(F)} = T_{(Ans)}$ then: $1.8\,T_{(Ans)} + 32 = T_{(Ans)}$

Subtract 32 from both sides of the equation:

$1.8\,T_{(Ans)} + 32 - 32 = T_{(Ans)} - 32$ $1.8\,T_{(Ans)} = T_{(Ans)} - 32$

Subtract $T_{(Ans)}$ from both sides of the equation:

$1.8\,T_{(Ans)} - T_{(Ans)} = T_{(Ans)} - T_{(Ans)} - 32$ $0.8\,T_{(Ans)} = -32$

Divide each side of the equation by 0.8 $\frac{0.8\,T_{(Ans)}}{0.8} = \frac{-32}{0.8}$ $T_{(Ans)} = \frac{-32}{0.8} = -40$

Answer = 40 degrees below zero


3. The amount of voltage induced in the windings of an AC generator depends mainly on __________.

A. the number of field poles energized
Incorrect: The number of field poles and the speed of rotation of the rotor determines the value of bus frequency, not voltage.

B. the speed at which the stator windings rotate through the magnetic field
Incorrect: The stator windings are attached to the generator stationary housing and do not rotate.

C. the strength of the magnetic field
Correct Answer: DC excitation voltage when applied to the rotating field windings induce an electro-magnetic force in the stator windings, which produces generator output voltage.

D. all of the above
Incorrect: Since choices A and B are incorrect, all of the above cannot be a valid answer.

---

4. In the operation of a flash type evaporator equipped with air ejectors, the air and non-condensable gases are evacuated directly from the ________.

A. first stage flash chamber
Incorrect: Evacuating air and non condensable gas directly from the first stage flash chamber would result in maximum vacuum to be developed in the first stage. The two-stage process would be reduced to that of a single stage, as there would no longer be a sufficient pressure differential to force the fluids into a lower pressure area, as normally occurs from the first to the second stage.

B. second stage flash chamber
Incorrect: If the suction line were physically located in the second stage flash chamber, the air ejector would draw large quantities of flashed vapor into the air ejector suction line instead of non condensable gases, impairing its ability to continue to produce the vacuum as required.

C. first stage after condenser
Incorrect: There is no component in a two-stage evaporator identified as an "after condenser" as is usually associated with the standard design for the main and auxiliary air ejectors.

D. second stage distilling condenser
Correct Answer: The air ejector normally draws from the lower section of the second stage distilling condenser, which performs, as one of its functions, the separation of air and non condensable gases from the flashed vapor of the second stage. The enhanced method of vapor and non condensable gas separation is similar to the process performed by the air cooler sections of the main and auxiliary condensers.

# Nautical Deck Queries

1. Your vessel is required to have an impulse-projected line-throwing appliance. The auxiliary line must __________.

*Note: Three lines in succession are involved with in the process and firing a line-throwing gun. The "service line" is connected directly to the projectile, such as a quarter-inch (diameter) braided nylon or dacron line. The service line pulls the "auxiliary line," which, in turn is used to pull the wire cable that is being used as the towline. Logically, the "service line" weight must be kept to a minimum, so it will not hinder the flight of the projectile, but it must be of sufficient strength to pull a considerable length of "auxiliary line." Historically, the auxiliary line would have been a three-inch (circumference) manila line, where today, the "auxiliary line" is typically a synthetic material, with a circumference on the order of two inches.*

A. be of a light color
Incorrect: The auxiliary line may be either of manila or synthetic material. If the line is synthetic, it must be of a color to resist deterioration from ultraviolet light. The colors red, orange, and yellow are more susceptible to deterioration from exposure to ultraviolet light; whereas dark colors, such as those toward the violet end of the color spectrum, are less susceptible to deterioration by ultraviolet light. Therefore, where synthetic materials are used in the line throwing system, the line will be formed of a material that is dark in color.

B. be 250 meters in length
Incorrect: The auxiliary line is required to be 450 meters (1,500 feet) in length.

C. have a breaking strength of 9,000 lbs
Correct Answer: The auxiliary line is required to have a breaking strength of 40,000 Newtons (9,000 pounds).

D. be made of synthetic material
Incorrect: It does not have to be made of a synthetic material, as there is no prohibition in using manila.

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2. Your vessel is being towed and back-up wires have been installed. Back-up wires carry the towing load in the event that the __________.

*Note: Back-up wires are installed in the event of pad eye failure to maintain hold on the towing bridle legs. Each back-up wire connects the shackle and/or last link of chain in each bridle leg (at the towing bitt or padeye) to a bitt or cleat farther aft on the towed vessel. The slack is removed with a turnbuckle or a "steamboat ratchet." This wire must not be confused with a forward-leading spring line when a barge is being towed "alongside."*

A. bridle legs part
Incorrect: The back-up wires take the load only if the pad eye fails or the bitt parts from the deck. If both bridle legs part, the connection to the tow will be lost.

B. towing bitt or pad eye fails
Correct Answer: If the towing bitts or pad eyes fail, the back-up wires are to take the load. The back-up wires, having been passed fore and aft several times to a bitt farther aft, are of sufficient strength to take the strain of the tow.

C. bight ring fails
Incorrect: The back-up wires take the load only when the pad eye fails. If the bight ring or fish plate fails (device used to connect the bridle to the main tow line), the back-up wires will not be capable in preventing the loss of the tow.

D. main towing hawser parts
Incorrect: If the main towing hawser parts between the towing vessel and the fish plate, the back-up wires which are not actively involved in this segment of the tow will not prevent this separation.


3. When may a seaman on a vessel engaged in foreign trade be paid before earning the wages?

A. The seaman may only draw an advance on earned wages.
Correct Answer: A seaman may only draw an advance on wages already earned. The law states that "a person may not pay a seaman wages in advance of the time when the seaman has earned the wages," but a cash advance on the earned wages may be issued.

B. Wages up to fifty percent of the seaman's base wage may be advanced upon proof of serious family illness.
Incorrect: It is unlawful to pay a seaman for wages that he or she has not yet earned and only a maximum of 50% of the earned wages may be advanced, regardless of the personal circumstances, as per Title 46 to the U.S. Code. The seaman may be discharged by mutual agreement with the master. If it is agreed that the seaman must be discharged from the vessel, such as for a serious personal matter, the seaman would be "paid off" in full for the wages earned.

C. Wages equivalent to three days base wage may be advanced upon arrival in a foreign port.
Incorrect: There is no provision in the law for the advancement of wages to be based upon a specific period of time such as three days. However, the seaman may be advanced a "draw" of up to 50% of his or her base wage, whether the period is for three days or three months. This law was passed to prevent ship owners from being burdened with indebted seamen and to protect seamen from squandering their wages.

D. The advance of wages is at the discretion of the Master; however, seaman cannot be in an overpaid status at signoff.
Incorrect: The law does not allow the Master discretion to extend an advance beyond the wages earned.

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4. A latitude line will be obtained by observing a body __________.

*Note: As a celestial body crosses an observer's meridian, the line of position (LOP) resulting from a sextant observation is a latitude line. The observer's meridian is also known as the principal vertical circle, which is determined to pass through (1) the north and south celestial poles, (2) north and south points of the horizon, and (3) the zenith and nadir. The principal vertical circle intersects the prime vertical circle (at right angles) at the zenith and nadir.*

A. on the prime vertical
Incorrect: The prime vertical circle passes through the east and west points of the horizon and the zenith and nadir. If a body is observed on the prime vertical circle, the resulting LOP is a longitude line.

B. on the celestial horizon
Incorrect: When a body is on the celestial horizon it has a sextant altitude of a fraction of a degree. Therefore, accurate measurement with a sextant would be impossible. If such an observation were to be made, the result would be an (inaccurate) ordinary LOP.

C. at lower transit
Correct Answer: Latitude can be determined from a sextant observation when a celestial body transits the lower (or upper) branch of an observer's celestial meridian. The navigational triangle at this time has become a straight line with the elevated pole, the zenith, and body on the same meridian. Latitude can now be determined with simple addition and subtraction. At lower transit, the observed altitude of the body is subtracted from 90° to obtain the zenith distance, which is then subtracted from (180° - the declination of the body), giving the latitude at time of transit.

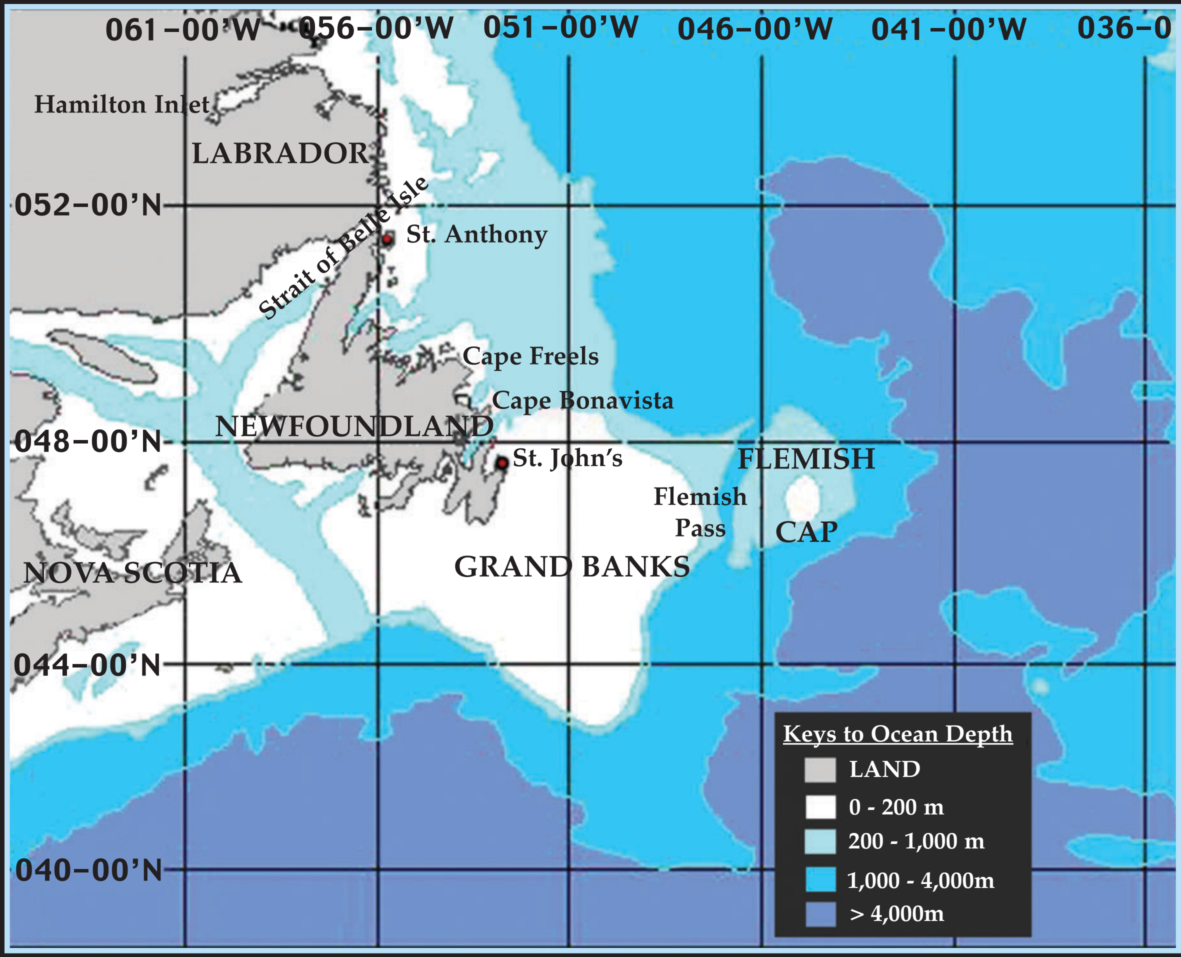
D. on the Greenwich meridian
Incorrect: If a navigator observes a body that happens to be on the Greenwich meridian at the moment of observation (Greenwich hour angle equal to 0°), the result would be an ordinary LOP. If the observer were on the Greenwich meridian, only then would the result be a latitude line. The condition as stated in the question is general, and this specific instance does not adequately answer the question as stated.

U.S. Department
of Homeland Security

United States
Coast Guard

# THE INTERNATIONAL ICE PATROL

## Area of Operations




### AREA OF OPERATIONS

The International Ice Patrol's Area of Operations extends from 40 degrees North latitude to 52 degrees North latitude and 39 degrees West longitude to 57 degrees West longitude—encompassing nearly one-half million square miles.

### CORE PURPOSE

To promote safe navigation of the Northwest Atlantic Ocean when the danger of iceberg collision exists.

### CORE VALUES

1. Individual commitment to the International Ice Patrol mission.
2. Continuous improvement through the use of technology.
3. Partnerships built on the spirit of international cooperation.

### MISSION STATEMENT

The International Ice Patrol will monitor iceberg danger near the Grand Banks of Newfoundland and provide the Limits of All Known Ice to the maritime community.

### VISION STATEMENT

Eliminate the risk of iceberg collision.

### OPERATIONS

The U.S. Coast Guard formally begins its seasonal ice observation and Ice Patrol service whenever icebergs threaten primary shipping routes between Europe and the U.S. and Canada. The activities of the International Ice Patrol are delineated by treaty and U.S. law to encompass only those ice regions of the North Atlantic Ocean through which the major transatlantic tracks pass.