# IMAGE LIBRARY & GLOSSARY

SEA ICE Observations & ASPeCt

This library contains a selection of images and definitions of sea ice, as well as a few glaciological terms pertinent to the study of sea ice. The sea ice definitions are based on the World Meteorological Sea Ice Nomenclature. Click to view any of the topics below or browse through them all using the arrow buttons.

**Sea ice overview**
**Brash ice**
**Brown ice**
**Fast ice**
**First-year ice**
**Floe**
**Flooding**
**Fracture**
**Frazil ice**
**Grease ice**
**Grey-white ice**
**Hummock**
**Iceberg**
**Lead**
**Marginal Ice zone**
**Multi-year ice**
**New ice**
**Nilas**
**Pack ice**
**Pancake ice**
**Polynya**
**Rafting**
**Ridging**
**Second-year ice**
**Shuga**
**Slush**
**Snow-ice**
**Tide crack**
**Young ice**

MENU
HOME
BACK

# OVERVIEW

## Sea ice

Sea ice is any form of ice found at sea which has originated from the freezing of sea water.

Sea ice comprises many different types, but may be broadly categorised as new ice, young ice, first-year ice and old ice. These categories reflect the age of the ice and include different forms and thicknesses of ice at various stages of development:

MENU
TOP
BACK

**New ice <10 cm thick**

Frazil ice, Grease ice, Slush, Shuga
Nilas
Pancake ice (may be >10 cm thick)

**Young ice 10–30 cm**

Grey ice 10–15 cm
Grey-white ice 15–30 cm

**First-year ice >30 cm**

Thin first-year or white ice 30–70 cm
Medium first-year ice 70–120 cm
Thick first-year ice >120 cm

**Old ice**

Second-year ice
Multi-year ice

# Brash ice

Accumulations of floating ice made up of fragments not more than 2 m across; the wreckage of other forms of ice.

Brash is common between colliding floes or in regions where pressure ridges have collapsed.

view

Brash ice

view

Brash ice refreezing

view

Brash ice

MENU
TOP
BACK

# Brown ice

Brown sea ice occurs when algal material within the ice becomes highly concentrated. This may occur in any layer of the ice.

view

Brown ice floes in summer pack ice

view

Brown ice visible in a floe turning sideways near the side of the ship

# Fast ice

Sea ice which forms and remains fast along the coast, where it is attached to the shore, to an ice wall, to an ice front, between shoals or grounded icebergs. Vertical fluctuations may be observed during changes in sea level. Fast ice may be formed *in situ* from sea water or by freezing of pack ice of any age to the shore, and it may extend up to several hundred kilometres from the coast. Fast ice may be more than one year old and may then be prefixed with the appropriate age category (old, second-year, or multi-year).

view

Fast ice

view

Fast ice pinned by grounded icebergs

view

Unloading ship on to fast ice

MENU
TOP
BACK

# First-year ice

Sea ice of not more than one winter's growth, developing from young ice; thickness (typically) 30 cm – 2 m. May be subdivided into thin first-year ice/white ice, medium first-year ice and thick first-year ice.

Thin first-year ice is 30–70 cm thick, medium first-year ice is 70–120 cm thick, and thick first-year ice is greater than 120 cm thick. First-year ice may be thicker than 200 cm when it is in the form of ridges. It is unlikely that ice > 200 cm could form by thermodynamic processes alone, due to the oceanic heat flux at the bottom of the Antarctic sea ice cover.

MENU
TOP
BACK

# First-year ice (cont)

view

First-year ice floes with icebergs in background

view

Extensive first-year ice with snow dunes

view

Summer pack ice conditions in the Eastern Weddell Sea

view

Highly deformed first-year ice

# Floe

A floe is any contiguous piece of sea ice. Floes may be described in terms of several size categories:

| | |
|---|---|
| Vast: | >2 km across |
| Large: | 500–2000 m across |
| Medium: | 100–500 m across |
| Small: | 20–100 m across |

Floes less than 20 m across are called “cake ice”.

view

Small first-year floes

view

Aerial photograph of ship moving through pack ice broken into quite uniform recti-linear floes

MENU
TOP
BACK

# Flooding

Flooding of the ice surface may occur in summer due to intense incoming radiation, particularly if the ice is snow free.

view

# Fracture

Any break or rupture through very close pack ice, compact pack ice, consolidated pack ice, fast ice, or a single floe resulting from deformation processes. Fractures may contain brash ice and/or be covered with nilas and/or young ice. Length may vary from metres to kilometres.

Fractures are narrower than leads and do not aid the navigation of surface vessels.

view

Fractures and leads facilitate high heat transport between the ocean and atmosphere. Water vapour (sea smoke) can often be seen rising from the open water.

# Fracture (cont)

view

Deep within the pack leads provide vital access to the ocean for seals and penguins and breathing holes for whales. Minke whales take turns to breath through this lead.

view

Fracture

# Frazil ice

Fine spicules or plates of ice, suspended in water.

Frazil ice formation represents the first stage of sea ice growth. The frazil crystals are usually suspended in the top few centimetres of the surface layer of the ocean and give the water a soupy appearance. In the open ocean the crystals may form or be stirred to a depth of several metres by wave-induced turbulence.

# Grease ice

A later stage of freezing than frazil ice when the crystals have coagulated to form a soupy layer on the surface. Grease ice reflects little light, giving the surface a matt appearance.

Grease ice behaves in a viscous fluid-like manner, and does not form distinct ice floes.

view

Grease ice forming near the ice edge

view

Grease ice forming under turbulent conditions

view

Grease ice

MENU
TOP
BACK

# Grey-white ice

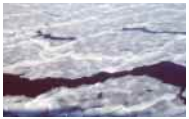
**Grey Ice**

Young ice 10–15 cm thick. Less elastic than nilas and breaks on swell. Usually rafts under pressure.

**Grey-white Ice**

Young ice 15–30 cm thick. Under pressure more likely to ridge than to raft.

view



view

Thin grey-white ice showing the effects of ridging and rafting

# Hummock

Point scale roughness features caused by the convergence of ice floes. Similar to ridges but not linear.

view

Hummocked first-year ice

view

MENU
TOP
BACK

# Iceberg

A massive piece of ice of greatly varying shape, more than 5 m above sea-level, which has broken away from a glacier (or an ice shelf), and which may be afloat or aground. Icebergs may be described as tabular, dome-shaped, sloping, pinnacled, weathered or glacier bergs (an irregularly shaped iceberg).

Icebergs are not sea ice. They originate from the ice mass of the Antarctic continent that has accumulated over many thousands of years. When they melt they add fresh water to the ocean.

view

Iceberg

MENU
TOP
BACK

# Lead

Any fracture or passage-way through sea ice which is navigable by surface vessels.

A more general description of a lead is an area of open water or new ice between ice floes, although the term is generally applied to linear features. If the open area is very large it may be called a polynya.

A lead between the shore and the pack ice is called a coastal lead or shore lead, and a lead between the fast ice and the pack ice is called a flaw lead.

MENU
TOP
BACK

# Lead (cont)

view

Leads may aid the navigation of vessels moving through the pack ice

view

Flaw lead with cover of new ice

view

Aerial photograph of a refreezing lead

# Marginal ice zone

The marginal ice zone (MIZ) is not a very well defined term and it is useful for an author to be specific about its meaning when using it. Probably the most accepted definition is that of Wadhams (1986) who describes it as "that part of the ice cover which is close enough to the open ocean boundary to be affected by its presence". This definition is open to interpretation, but is generally applied to that region of the pack which is significantly affected by ocean swell. In the Antarctic this region may extend hundreds of kilometres from the ice edge, and in some regions right to the coast. The marginal ice zone may be an area of enhanced ice drift, deformation and divergence.

MENU
TOP
BACK

# Multi-year ice

Old ice up to 3 m or more thick which has survived at least two summers' melt. Hummocks (hillocks of broken ice that have been forced up by pressure) are typically smoother than in second-year ice, and the ice is almost salt-free. Colour, where bare, is usually blue.

Multi-year ice is less common in the Antarctic than the Arctic, and is usually confined to the western Weddell Sea and isolated embayments around the coast.

The Weddell Sea accounts for about 80% of the multi-year ice in the Antarctic. The clockwise circulating current known as the Weddell Gyre is responsible for trapping sea ice along the eastern side of the Antarctic Peninsula, allowing it to survive

MENU
TOP
BACK

# Multi-year ice (cont)

for more than one year. Eventually ocean currents transport the ice northward where it dissipates into the ocean and melts.

Melt patterns on multi-year ice are a feature most commonly observed in the Arctic. The ablation season of Antarctic sea ice is rarely associated with the presence of melt water on the surface of the ice.

view

Thick multi-year ice in the Antarctic pack ice

view

# New ice

A general term for recently formed ice which includes frazil ice, grease ice and shuga.

# Nilas

A thin elastic crust of ice, easily bending on waves and swell and under pressure, thrusting in a pattern of interlocking "fingers" (finger rafting). Has a matt surface and is up to 10 cm thick. May be subdivided into dark nilas and light nilas.

Dark nilas is < 5 cm thick and very dark in colour. Light nilas is 5–10 cm thick and reflects proportionately more light than dark nilas, depending on its thickness.

view

view

view

Sampling light nilas can be difficult

view

MENU
TOP
BACK

# Pack ice

Term used in a wide sense to include any area of sea ice, other than fast ice, no matter what form it takes or how it is disposed.

The pack can be described as:

- very open - with an ice concentration of 1/10 to 3/10
- open - 4/10 to 6/10, with many leads and polynyas and the floes generally not in contact with one another
- close - 7/10 to 8/10, composed of floes mostly in contact
- very close - 9/10 to less than 10/10
- compact - 10/10, with no water visible, called consolidated pack ice if the floes are frozen together

MENU
TOP
BACK

# Pancake ice

Predominantly circular pieces of ice from 30 cm – 3 m in diameter, and up to 10 cm in thickness (unrafted). Pancakes often have raised rims due to the pieces striking against one another. Pancake ice may be formed on a slight swell from grease ice, shuga or slush or as the result of the breaking of ice rind, nilas or, under severe conditions of swell or waves, of grey ice.

A common process of sea ice development in the Antarctic is the "pancake cycle". The pancakes start with a diameter of tens of centimetres, but through wind and wave action they aggregate with loose frazil crystals to increase in diameter, and raft with other pancakes to increase in thickness.

MENU
TOP
BACK

# Pancake ice (cont)

In this manner the pancakes can grow rapidly to a few metres in diameter and stack up to 1 m thick. Eventually the pancakes can freeze together into larger floes or a consolidated ice cover.

view

Pancakes forming from grease ice. These are 30 - 50 cm diameter.

view

Swell moving through field of pancake ice

view

Large, loose pancakes up to 1.5 m diameter

view

Cemented pancakes with raised rims

# Polynya

Any non-linear shaped opening enclosed by ice. Polynyas may be covered with new ice, nilas or young ice; submariners refer to these as skylights. If a polynya is bounded on one side by the coast it is called a shore polynya, or if it is bounded by fast ice it is called a flaw polynya. If it recurs in the same position every year, it is called a recurring polynya.

Polynyas range in size from relatively small to enormous. The largest polynya observed in the Antarctic was the Weddell Polynya of 1975-77, covering an area of $2x10^5$ $km^2$. The two main categories of polynya are sensible heat and latent heat, depending on the mechanism responsible for their formation.

MENU
TOP
BACK

# Polynya (cont)

Latent heat polynyas are maintained by persistent katabatic winds that drain off the continent. Newly formed ice is advected away by the wind, leaving the surface ice-free and open to more ice formation. In this manner latent heat polynyas can be major sources of new ice production. Coastal polynyas are primarily of this type. Sensible heat polynyas are maintained by upwelling warm water that supplies a sufficiently large oceanic heat flux to the base of the ice to reduce its thickness, or melt it completely. These polynyas are not responsible for large quantities of new ice production. A polynya may also form by a combination of sensible and latent heat processes.

view

This is a good example of a flaw polynya (or flaw lead). The pack ice has been blown away from the fast ice edge.

MENU
TOP
BACK

# Rafting

Pressure process whereby one piece of ice over-rides another. Most common in new and young ice.

Finger rafting is a type of rafting whereby interlocking thrusts are formed, each floe thrusting "fingers" alternately over and under each other. Finger rafting is common in nilas and grey ice.

Rafting plays an important role in increasing ice thickness within the Antarctic pack. It is the dominant dynamic mechanism by which floes reach about 0.4 – 0.6 m thick. Beyond this thickness converging floes are more likely to form ridges or hummocks than to raft.

# Rafting (cont)

view

Finger rafting in grey ice

view

Surface features caused by rafting sea ice

view

Finger rafting in nilas

# Ridging

The pressure process by which sea ice is forced into ridges.

A ridge is a line or wall of broken ice forced upward by pressure. May be fresh or weathered. The submerged volume of broken ice under a ridge, forced downwards by pressure, is termed an ice keel.

In the Antarctic, ridges are commonly point features rather than the long linear features observed in the Arctic. These may be referred to as hummocks.

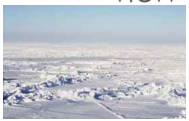
A considerable percentage of ice mass is contained within the ridged component of the Antarctic pack.

MENU
TOP
BACK

# Ridging (cont)

Data from eight voyages into the East Antarctic pack show that by incorporating the ridged ice, the mean thickness increases, on average, by 1.7 times the observed mean undeformed ice thickness.

view



Ridged sea ice

view

Ice being forced upward to form ridges as a result of compression of the pack. Flooding of the surface snow cover can be seen near the centre of the image

view

The RSV *Aurora Australis* stopped in heavily ridged ice

view

Ridged ice typical of the central Weddell Sea

MENU
TOP
BACK

# Second-year ice

Second year ice is the most common form of old ice in Antarctica. It is old ice that has survived only one summer. Because the snow cover does not completely melt during summer, second year ice typically has much thicker snow than first year ice. During the summer melt, water does not usually accumulate on the surface of Antarctic sea ice as it does in the Arctic.

# Shuga

An accumulation of spongy white lumps of ice, a few centimetres across; they are formed from grease ice or slush and sometimes from anchor ice rising to the surface.

view

With the interaction of surface winds and waves, shuga forms in bands oriented along the direction of the wind

MENU
TOP
BACK

# Slush

Snow which is saturated and mixed with water on land or ice surfaces, or as a viscous floating mass in water after heavy snowfall.

# Snow-ice

Snow-ice forms by refreezing flooded snow, and may account for a significant fraction of the total mass of Antarctic sea ice. The snow cover on sea ice can become flooded by sea water by a number of mechanisms; in particular when the mass of snow becomes great enough to depress the ice/snow interface below sea level. The snow cover is porous and sea water can easily infiltrate from the sides of floes to form a slush layer at the ice/snow boundary. The snow may also become flooded by water rising up brine channels within the sea ice, or may accumulate in sea water during precipitation events and form a slushy layer. With sufficiently cold temperatures these slushy layers will freeze to form snow-ice.

MENU
TOP
BACK

# Tide crack

Tide cracks may form in fast ice as a result of fluctuating sea level and may provide penguins and seals living near the coast access to the ocean even in the middle of winter.

view

Tide crack

# Young ice

Ice in the transition stage between nilas and first-year ice, 10–30 cm in thickness. May be subdivided into grey ice and grey-white ice.