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Distribution Statement

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Seasonal Outlook
Western Ross Sea and McMurdo Sound
2006-2007

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I. INTRODUCTION

This outlook presents the expected positions of the sea ice "edges" in the Western Ross Sea and the depiction of the mid-October fast ice boundary in McMurdo Sound. Figure 1 is a map of the areas of interest within McMurdo Sound. Ice edge positions at 15-day intervals, beginning 15 December, are forecast through the end of the shipping season in mid-February. The term "edges" is used to indicate and describe the typical "hourglass" melt pattern of the Ross Sea ice cover. This pattern of pinching off the pack ice occurs due to the concurrent ice melt along the northern ice edge and an enlarging polynya adjacent to the Ross Ice Shelf. The concentration and stage of development of ice remaining between these two edges are important factors in this outlook as a measure of predicted severity along the shipping route located between 175E-177W.

Additional factors evaluated for the forecast are sea ice model estimates, atmospheric forecast model estimates, climate teleconnective patterns, and the ice thickness and linear distance from Hut Point to the fast ice edge in McMurdo Sound. The linear distance is measured along a bearing of 330 degrees from Hut Point to the closest access point at the fast ice edge for incoming vessels. Additional estimates of the fast ice edge use optimal distance from Hut Point.

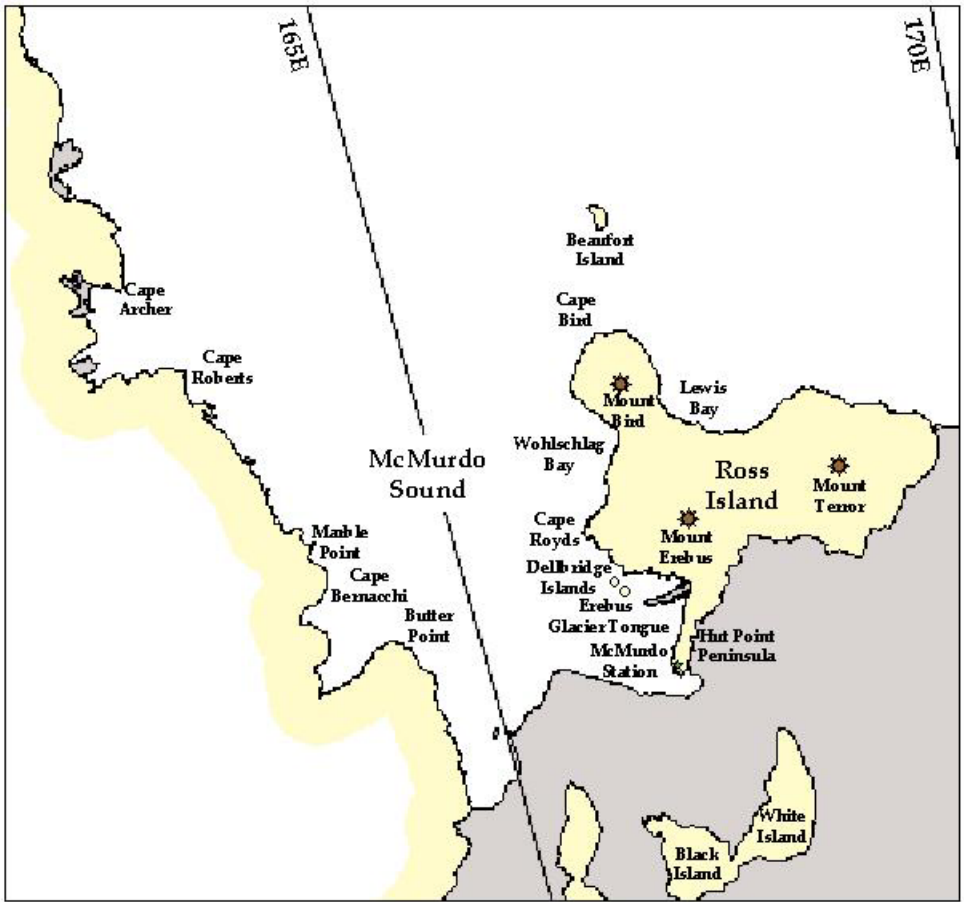


Figure 1 Map of McMurdo Sound

The categories of environmental data used to compile this outlook include:

1) Remotely sensed imagery: visible satellite imagery from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS), the Defense Meteorological Satellite Program (DMSP) Operational Line-Scan System (OLS), NOAA's Advanced Very High Resolution Radiometer (AVHRR), DMSP Special Sensor Microwave Imager (SSMI), QUIKSCAT, EnviSat Global Monitoring Mode (GMM), and Advanced Microwave Scanning Radiometer for EOS (AMSR-E),

2) Drilled ice thickness measurements in McMurdo Sound,

3) Archived meteorological data received from McMurdo Station for 2006,

4) National Centers for Environmental Prediction (NCEP) / National Center for Environmental Research (NCAR) Reanalysis Data through September 2006, and

5) Sea ice climatology for the Ross Sea.

The rates of recession for the Ross Sea ice edge and the McMurdo Sound fast ice edge are derived using an analogue forecasting technique that relates historical observations of pre-season ice extent and thickness to the predicted severity of austral summer ice conditions. This relationship is based upon the premise that ice conditions of similar areal extent and thickness will follow the same historical progression of decay. This "persistence" of antecedent ice conditions and recession rates has been well documented during the many years of Operation DEEP FREEZE.

(Operation DEEP FREEZE is the unclassified code name given the operations previously conducted by the U.S. Navy to provide operational and logistic support to the United States Antarctic Program (USAP).)

The estimated position of the ice edge and the "opening date" are based on the collection of evidence from analogue years, adjusted to reflect alterations of current conditions from past conditions, forecast atmospheric models, oceanic models, and cryospheric models.

II. Initial Ice Conditions and Ice Climatology

The National Ice Center (NIC) ice analysis from 02-06 October 2006 (**Figures 2a-2c**) reveals that the position of the northern ice edge is between a climatological mean and a maximum across the majority of the Ross Sea. Concentrations of multi-year pack ice are found to the west of 176E in the southern Ross Sea, continuing northwestward around Cape Adare and into the western Ross Sea to the south and west of the Bellany Islands. Additionally, much of the fast ice to the south of the Drygalski Ice Tongue is old ice that has survived several years of melt. Total concentration and stage of development of sea ice and icebergs is labeled using World Meteorological Organization (WMO) international system of sea ice symbols, also known as "Egg Code" (see **Figure 5** for an explanation).

Historically, a flaw lead occurs along the Ross Ice Shelf during the first week of November. This flaw lead is already beginning to develop to the east of Ross Island (see **Figure 3**), but still has a few more weeks before it becomes a persistent feature.

Fast ice edge measurements from satellite imagery on 11 October 2006 reveal a minimal navigation distance of approximately 25 NM from Hut Point to the fast ice edge. Historical measurements of the October distance from Hut Point to the fast ice edge are as follows: minimum distance of 5 NM, mean of 26 NM and maximum of 70 NM. Taking this fast ice climatology into account, this year's fast ice extent of 25 NM is fairly close to the mean extent of 26 NM. It is important to note that a residual fast ice boundary from the 2003-04 season remains embedded within this year's fast ice, and extends 13.5 NM northward from Hut Point. It is also of note that this year's distance from Hut Point to the fast ice edge is significantly less than what was seen at this time in 2005, when the distance was close to 60 NM.

As of 11 October 2006, there are three icebergs of significance remaining in the Ross Sea. B-15J is closest to McMurdo Sound, and is centered near 76°3'S/167°10'E. C-25 is a little further to the north, and is centered near 73°54'S/168°8'E. **Figure 3** shows the relative positions of these two icebergs. A third iceberg of interest is C-19A, which is currently centered at 61°37'S/160°54'E. At 88x17 NM, iceberg C-19A is the largest of the three large icebergs in the Ross Sea. C-19A is far enough north that it has become caught in the West Wind Drift (see **Figure 2b**), and is slowly drifting eastward. Numerous smaller bergs are calving off of C-19A. These smaller bergs, along with C-19A itself, could pose a hazard to the shipping route into the Ross Sea between 175E and 177W at some point during Operation DEEP FREEZE 2006.

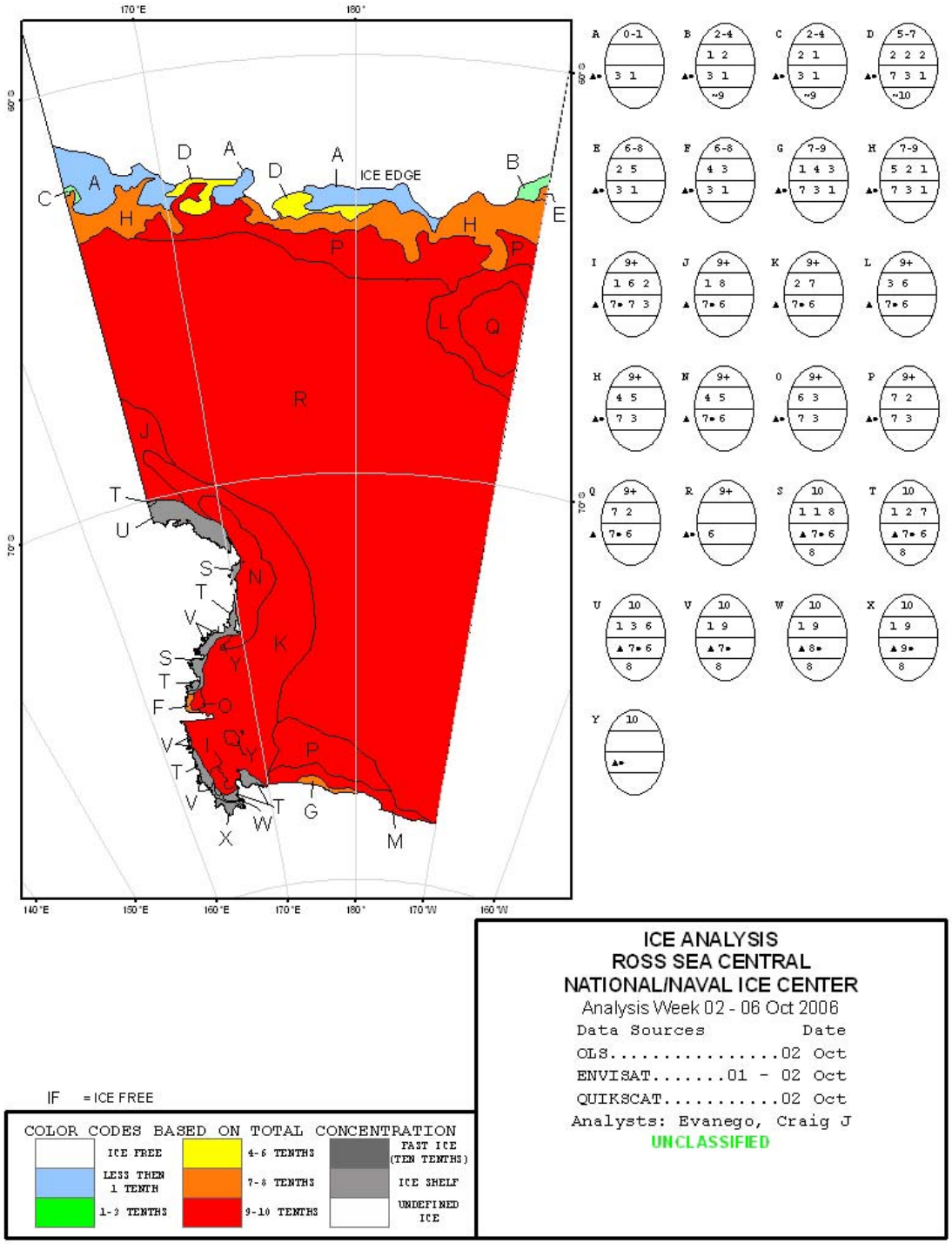


Figure 2a. 02-06 October 2006 Ross Sea Central Ice Conditions

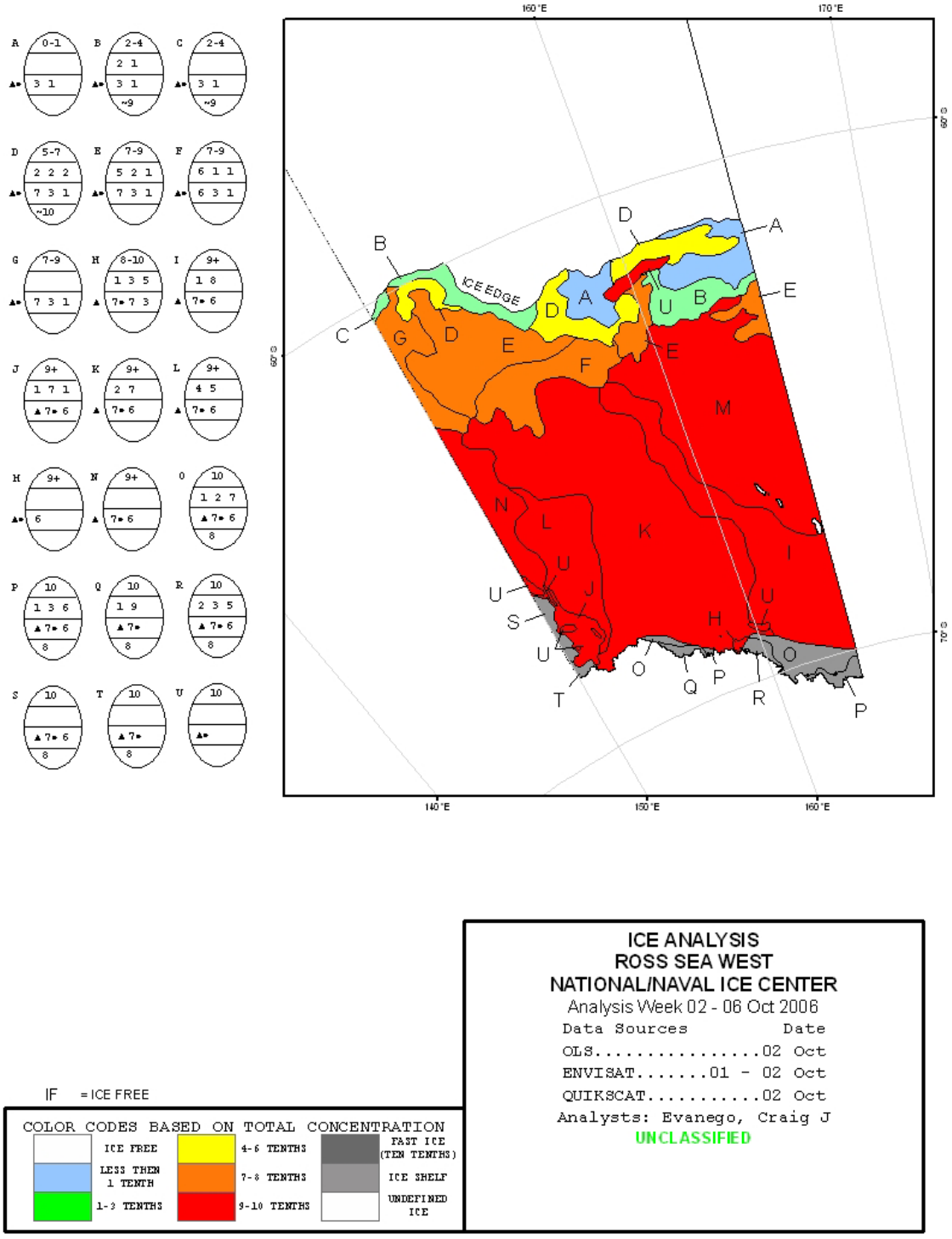


Figure 2b. 02-06 October 2006 Ross Sea West Ice Conditions
(Note the location of iceberg C-19A near the ice edge)

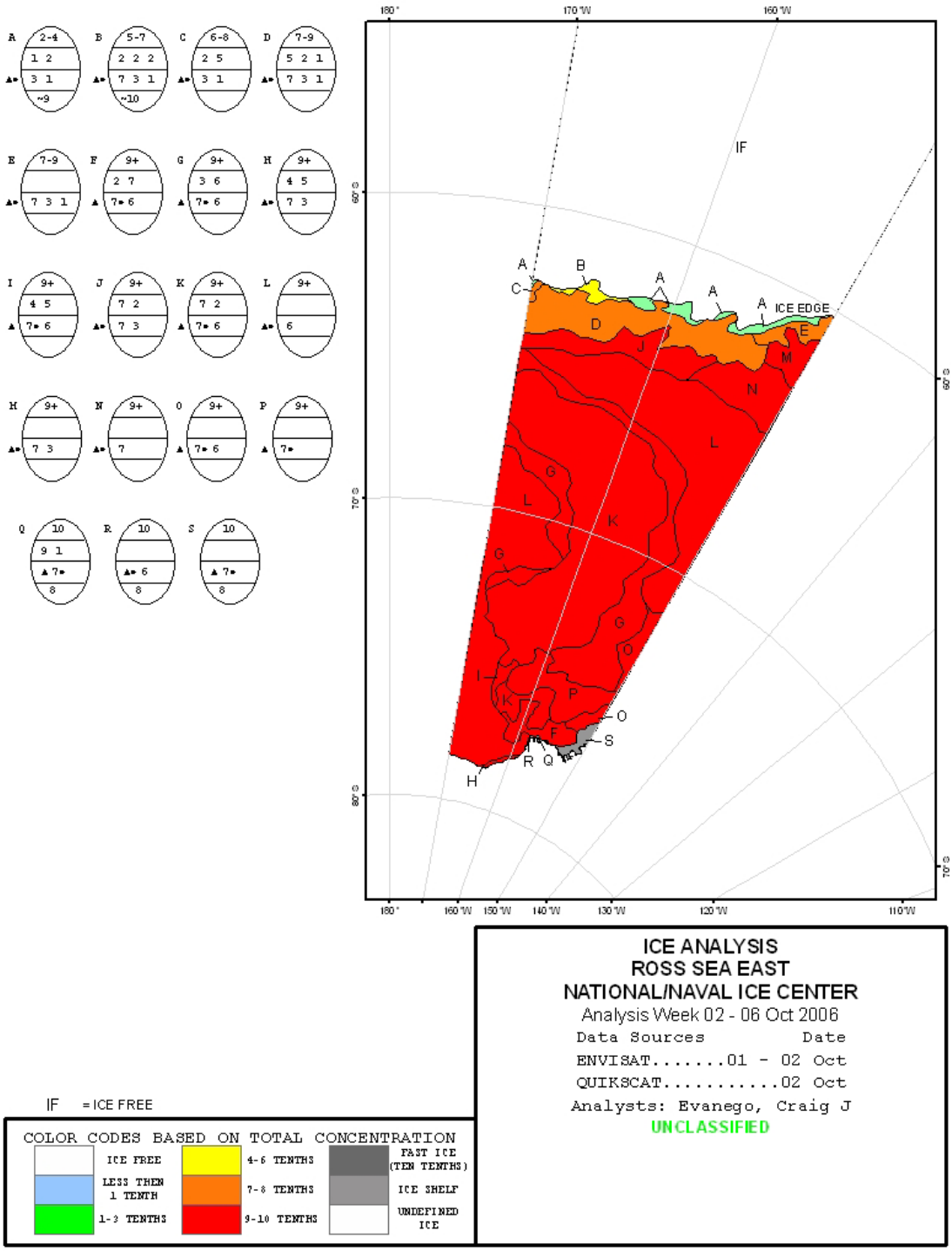


Figure 2c. 02-06 October 2006 Ross Sea East Ice Conditions

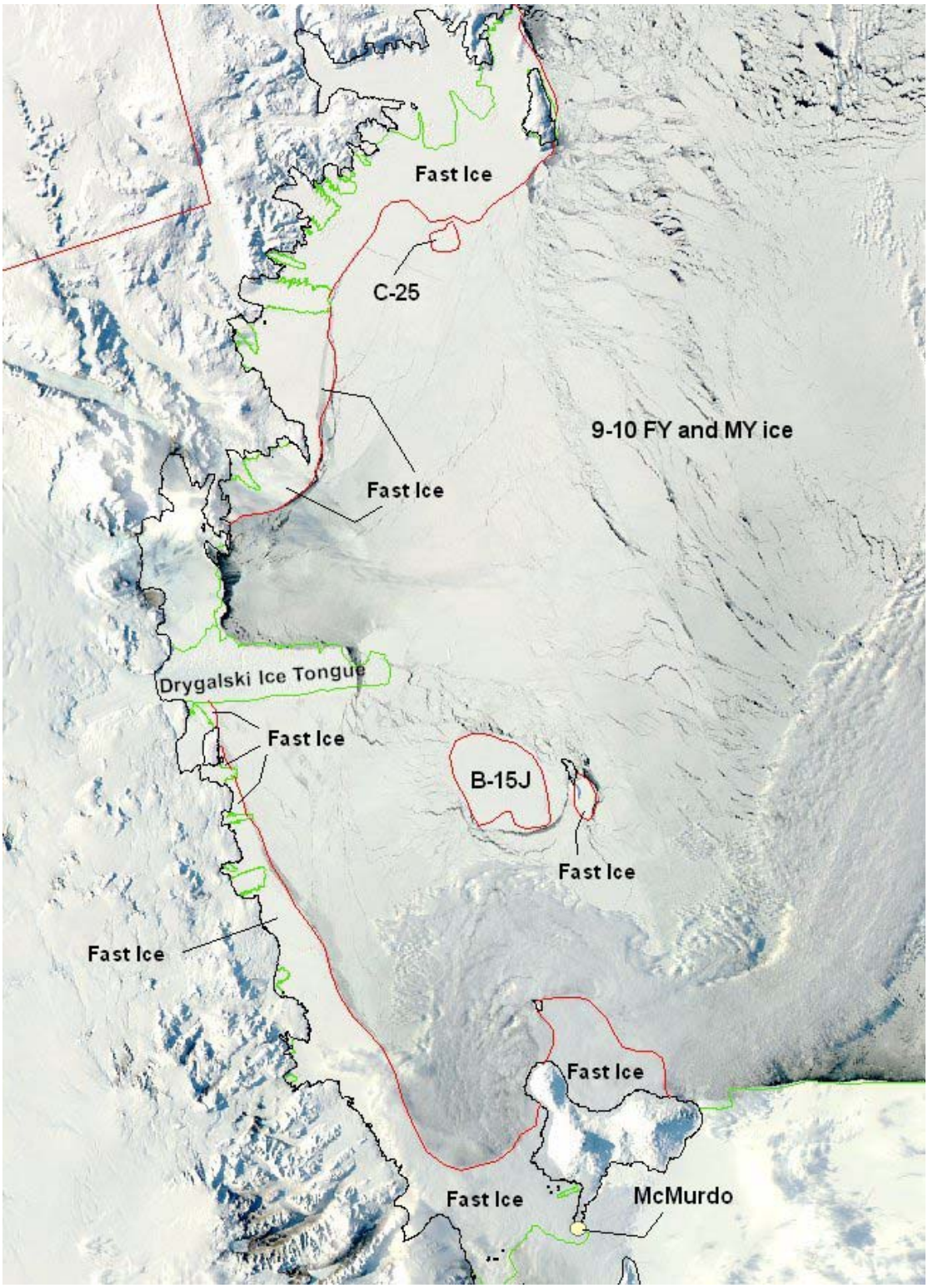


Figure 3. 12 Oct 2006 - MODIS - aqua (bands 143)

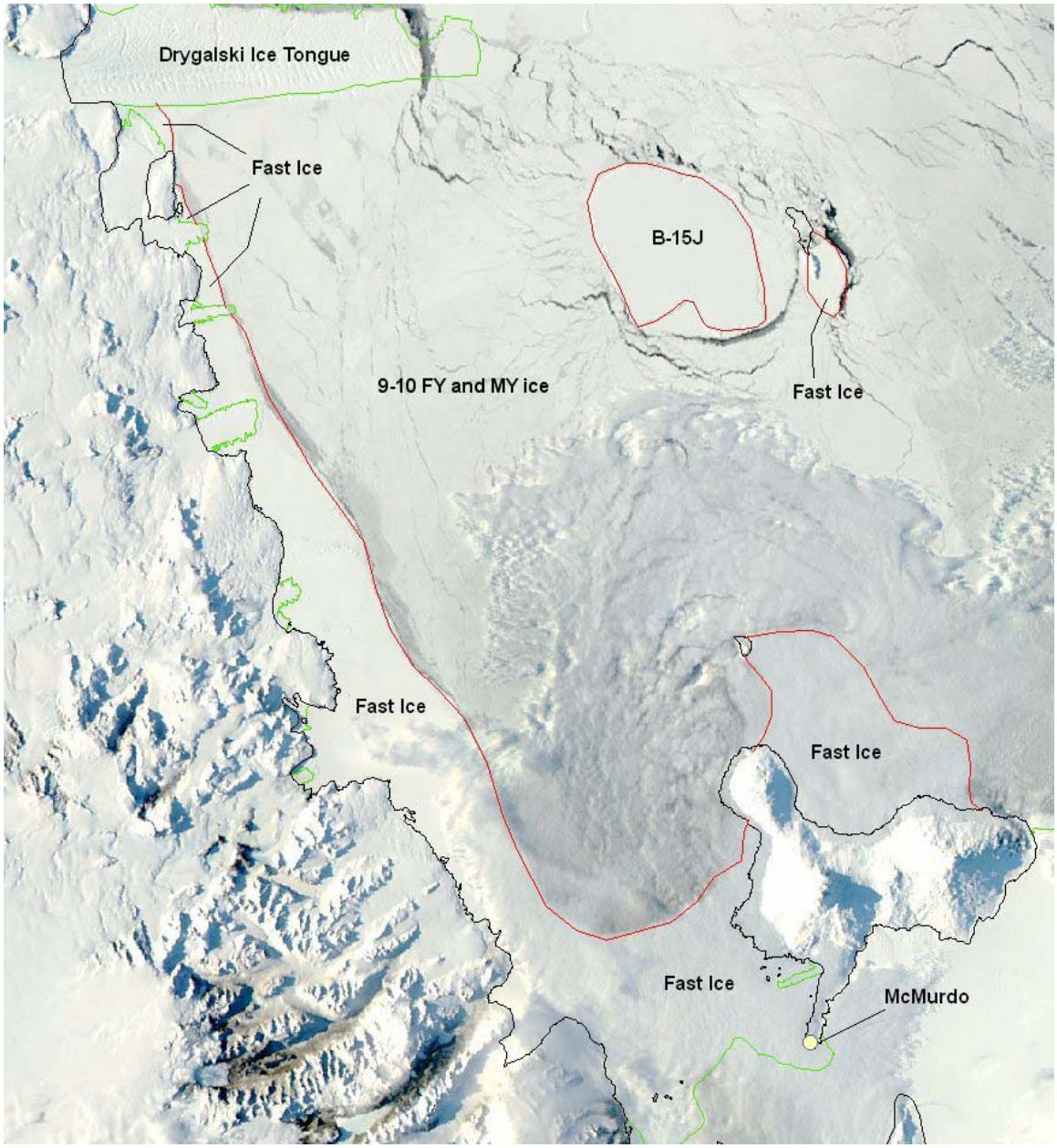
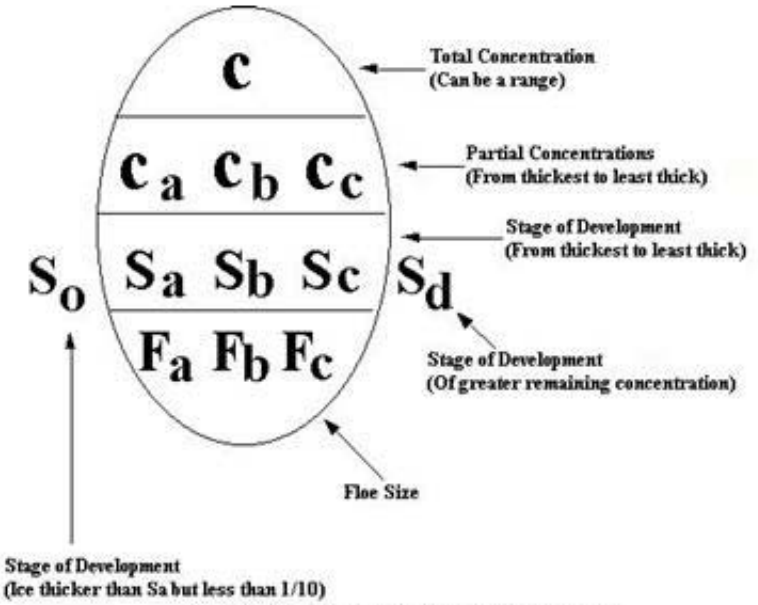


Figure 4. 12 Oct 2006 - MODIS - aqua (bands 143)



STAGE(S) OF DEVELPOMENT

1 = New ice (0-10cm)

3 = Young ice (10_30cm)

6 = First year (30_200cm)

7 = First year thin (30_70cm)

1.= First year medium (70-120cm)

4.= First year thick (120-200cm)

7.= Old ice (survived at least one summers melt)

8.= Second year ice (survived one summer melt)

9.= Multi-year ice (survived at least two summer melts)

Figure 5. WMO Egg Code

III. OUTLOOK

Ross Sea

The average opening date for the icebreaker-led convoys to transit the western Ross Sea shipping lane is historically 7-10 January. Typical conditions on the opening include a 20-50 NM wide "band" of lesser (<4/10 tenths) concentration ice. **A slightly later than normal opening date is forecast this year.** This forecast is based on:

a) *Surface Air Temperatures*. The NCEP reanalysis model suggests that surface air temperatures over the Ross Sea were mild during the austral winter. Air temperatures at McMurdo Station suggest a mild winter as well, although temperatures were significantly below normal in April and May of 2006. The mild winter should act to lessen both the ice thickness and the subsequent time required to melt the first/multi-year sea ice. Additionally, global climate models (GCMs), like the Scripps' Global Spectral Model, indicate slightly warmer than normal conditions are expected for the summer in the Ross Sea. This will aid the melt of sea ice along the Ross Ice Shelf, although it will take substantial warming to recess the thicker ice located along the ice edge.

b) *Near Normal Sea Surface Temperatures along Ice Edge*. Near normal sea surface temperatures have been seen along the western Ross Sea ice edge from March-September 2006. The current outlook from NOAA's Climate Prediction Center suggests near normal conditions will persist until early 2007.

c) *Fast Ice Extent in McMurdo Sound.* The past two seasons (2004-05 and 2005-06) both saw near record maximum extents of fast ice. However, the fast ice extent in McMurdo Sound in October 2006 is closer to a normal extent for this time of year. The majority of this fast ice has survived through 2 years, but is likely to fracture and flush from the sound. Isolated areas of fast ice with large multiyear content located along the shoreline from Drygalski Ice Tongue south to Cape Royds (see **Figure 7**) are likely to remain later into the Antarctic summer melt.

d) *Icebergs*. Icebergs scattered in the western Ross Sea continue to drift along with oceanographic currents typical throughout the region. Recent seasons with heavy iceberg presence in the Ross Sea have been associated with delayed opening dates. However, most of the larger icebergs have advected out of the southern Ross Sea during the past year. Therefore, the impact of icebergs on the flushing of sea ice out of the McMurdo region should be significantly less this season than in the recent past. However, because icebergs typically move at a slower velocity than sea ice, the sea ice could be restricted from advecting around the remaining large icebergs, resulting in greater ice concentrations along their windward side.

e) *Analog Years*. Comparing Ross Sea ice conditions in early October of 2006 reveals similarities to ice conditions found in early October of 1994, 1996 and 2005. During these analog years, the mean unescorted date (<4/10 ice coverage) was 12 January.

Taking into consideration the inputs mentioned above, **it is projected that the Ross Sea ice "band" will be 70-90 NM in width and vessels will require icebreaker escort until about 12 January 2006 (Figure 6**). Navigable ice conditions for unescorted vessels (<4/10 tenths) are expected after 12 January 2006.

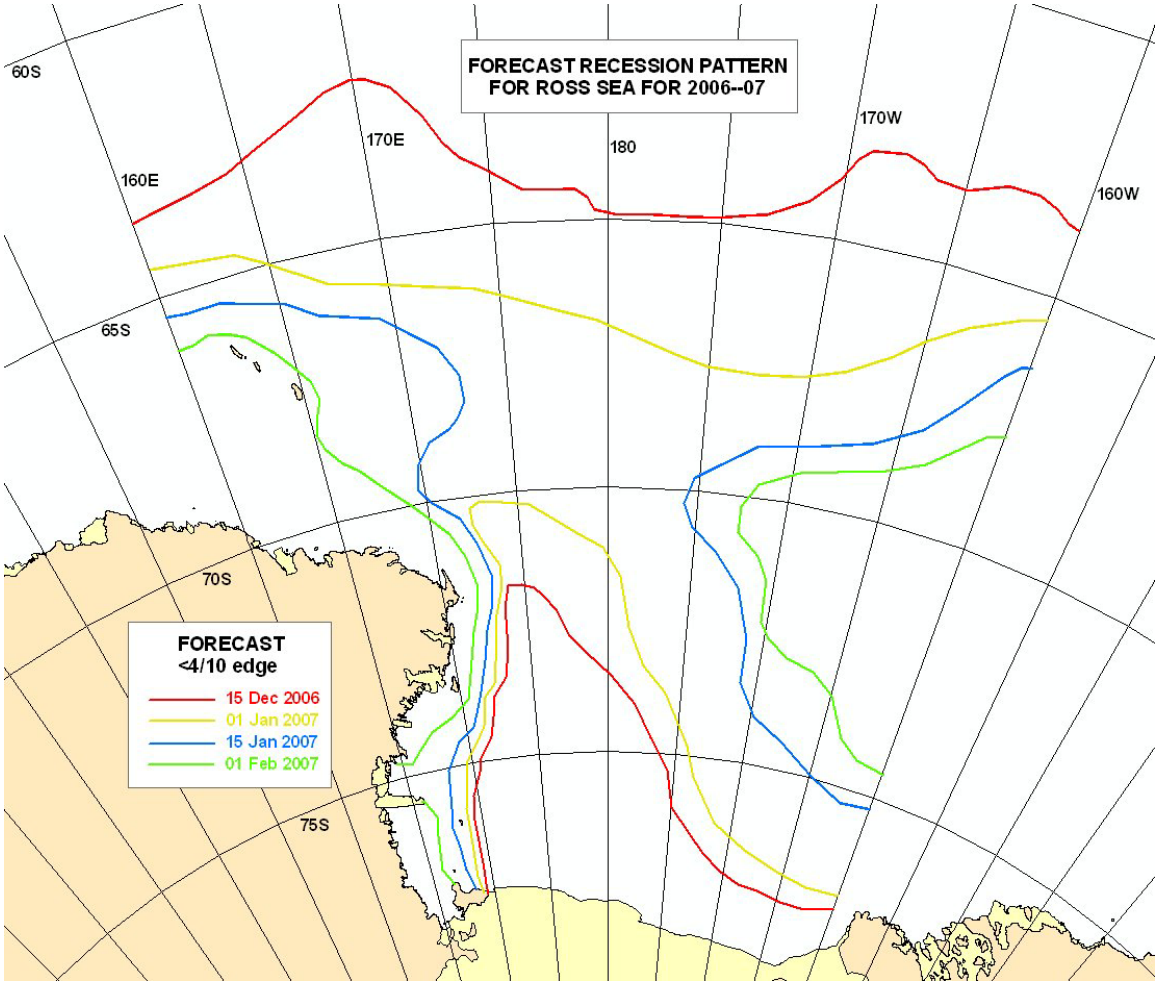


Figure 6. Forecast Recession Pattern for Ross Sea (2006-2007) Season (<4/10 edge)

McMurdo Sound

After a cooler than normal period from March through June, July through September of 2006 was milder than normal for McMurdo Sound. Current observed fast ice thickness around McMurdo is at least 4 ft in first-year thick and multi-year ice within the previous years' ice channels. The historical average breakout date of the land fast ice at Hut Point is 15 February. Fast ice with large multiyear content, located along the shoreline from Drygalski Ice Tongue south to Cape Royds (see **Figure 7**) may remain throughout much of the summer melt. Ice cut during the icebreaker transit should be expected to flush from the channel. This will provide a lane of safer navigation along the channel with reduced ice concentrations and thickness. Existing conditions are demonstrated in **Figure 4** (MODIS) and **Figure 7** (Envisat GMM).

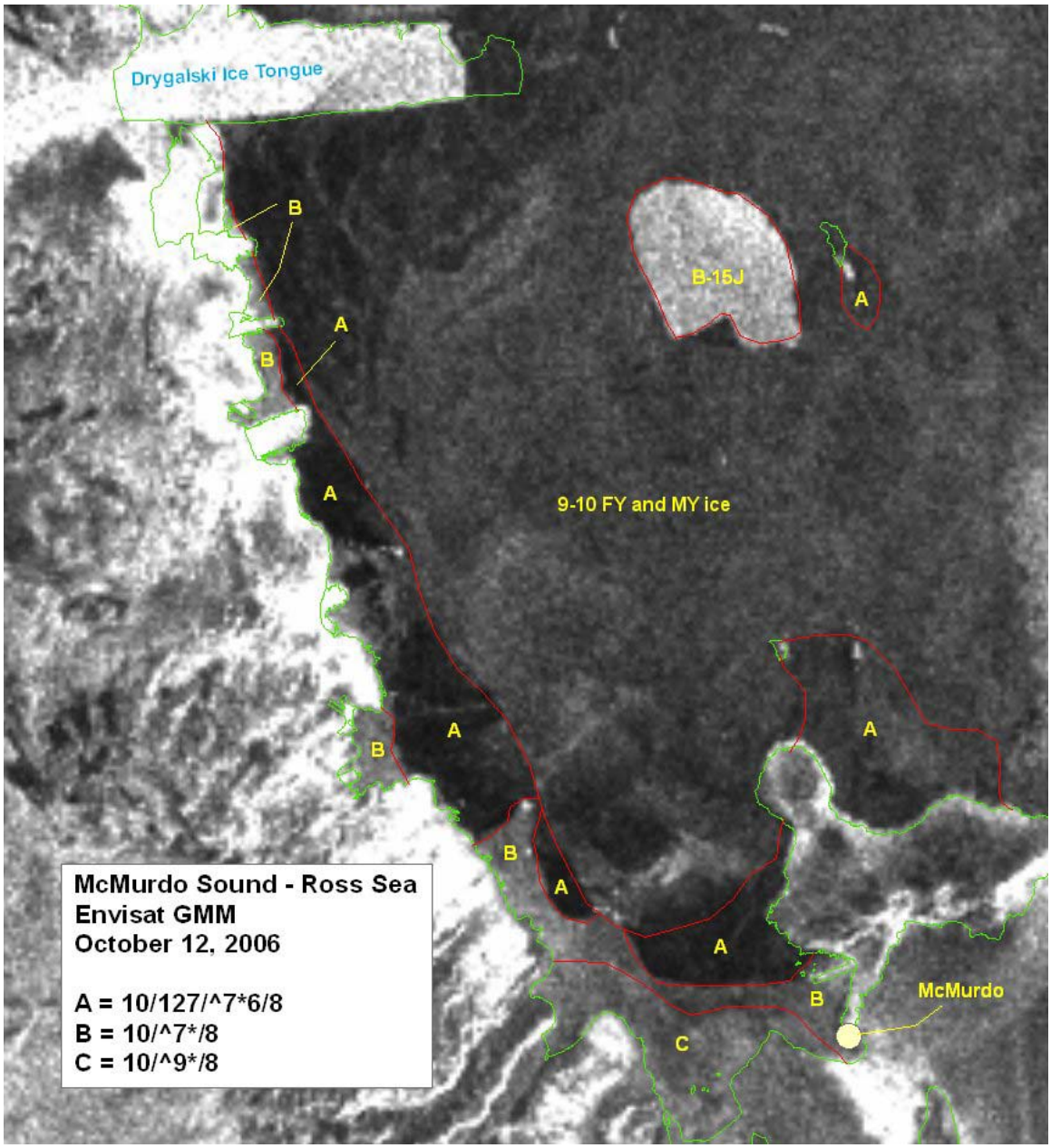


Figure 7. 12 Oct 2006 Annotated EnviSat GMM Image - McMurdo Sound

Icebergs and Shelf Ice

Due to the significant calving of the Ross ice shelf over the past few years, icebergs have posed a greater than normal hazard to navigation in the Ross Sea, and have had a significant influence on the ocean currents, weather, and sea ice conditions in the vicinity of McMurdo Sound. However, the past couple of years have seen the number and magnitude of icebergs in the McMurdo Sound region decrease. The continuing presence of iceberg B-15J is likely to have some impact on ice cover. B-15J is meandering slowly to the north as it passes on the west side of Franklin Island. As long as B-15J remains in the vicinity, it will serve as a hindrance to the prevailing winds and the Antarctic Coastal Current, and pack ice may accumulate on the windward side of the iceberg.

During the past year, iceberg C-16, which had been grounded to the north of Ross Island since 2002, finally advected northward and out of the McMurdo region. However, during its trek northward and out of the Ross Sea, C-16 knocked a portion of the Drygalski Ice Tongue loose, creating iceberg C-25 (**Figure 3**). (Note that the end of the Drygalski Ice Tongue is missing in **Figure 7**). C-25 is a relatively small iceberg (7x6 NM), and is currently floating just southwest of Coulman Island in the western Ross Sea.

Another iceberg feature of interest is C-19A, which is near the ice edge at 61°37'S/160°54'E on 11 October 2006. C-19A is caught in the West Wind Drift, and should continue to slowly drift eastward. This should eventually place C-19A, along with the numerous smaller bergs calving from it, in the path of the shipping route into the Ross Sea between 175E and 177W.

For regular updates on the location of these and other Antarctic icebergs, visit the National/Naval Ice Center's Iceberg Database at:

http://www.natice.noaa.gov/products/iceberg/index.htm