JCOMM EXPERT TEAM ON SEA ICE (ETSI)
First Session
STEERING GROUP FOR THE GLOBAL DIGITAL SEA ICE DATA BANK (GDSIDB)
Ninth Session

Buenos Aires, Argentina, 21-25 October 2002

FINAL REPORT

JCOMM Meeting Report No. 16

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

JCOMM EXPERT TEAM ON SEA ICE (ETSI) FIRST SESSION STEERING GROUP FOR THE GLOBAL DIGITAL SEA ICE DATA BANK (GDSIDB) NINTH SESSION

Buenos Aires, Argentina, 21-25 October 2002

FINAL REPORT

JCOMM Meeting Report No. 16

C O N T E N T S

GENERAL SUMMARY OF THE WORK OF THE MEETING

1. Opening of the session

1.1 Opening

1.1.1 The first session of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) Expert Team on Sea Ice (ETSI) and the ninth session of the Steering Group for the Global Digital Sea Ice Data Bank (GDSIDB) were opened at 0930 hours on Monday, 21 October 2002, in the Regente Palace Hotel conference room by Mr Vasiliy Smolianitsky, chairman of the ETSI. Mr Smolianitsky welcomed participants and called on the Permanent Representative of Argentina with WMO, Comodoro Miguel Rabiolo, and Argentine IOC Alternate Representative, Capitan de Navio Javier A. Valladares, to address the meeting.

1.1.2 Comodoro Rabiolo welcomed participants to the meeting and expressed that it is an honour for him to welcome the prestigious experts that visit Argentina today, and he wished a pleasant stay in Buenos Aires along with a most fruitful working week. Comodoro Rabiolo then reviewed briefly a number of priority issues to be addressed during the meeting and outlined that objectives of the meeting will be achieved through new developments in collecting and processing data; the compilation and relay to end-users of sea ice information; the development of ice models; the exchange and training of ice experts; the review and update of the WMO Sea Ice Documents, the normalization of colour coding for electronic ice charts; research on ice decay and melting, and the study of new formats for operational and historical sea ice data exchange, among other goals. Comodoro Rabiolo concluded that this task would not be easy to achieve without the efforts and knowledge of the expert members of these groups, as well as the firm support of the Organizations involved. Their conclusions will surely enhance the development of the meteorological and oceanographic sciences, for the continuous benefit, welfare and safety of the human life at sea.

1.1.3 Capitan Valladares welcomed participants to the meeting and to Buenos Aires, and expressed his pleasure at being able to host the first session of ETSI and ninth session of GDSIDB on behalf of the Argentine Naval Hydrographic Service. He stressed that WMO and IOC entered into a close inter-organisational collaboration and joint programme activities within the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology. Considering that mutual understanding not only between WMO and IOC, but also between meteorologists and oceanographers in his country, had greatly facilitated the successful development and implementation of joint activities in the Polar areas of our Planet. Captain Valladares also noted the importance of meeting to develop international coopperation on appropriate matters relating to polar seas and other areas affected by sea ice, in particular the Antarctic area, where Argentina is involved directly in the development of sea ice observations for operational purposes and scientific projects and programmes. In concluding he wished participants a constructive fruitful meeting and an enjoyable stay in Buenos Aires.

1.1.4 On behalf of the Secretary-General of WMO, Professor G.O.P. Obasi, and the Executive Secretary IOC, Dr P. Bernal, the Secretariat representative also welcomed participants to the meeting. He expressed the very sincere appreciation of WMO and IOC to the Argentine Navy Hydrographic Service, and especially to the local organizer of the meeting, Captain Manuel Picasso, for hosting this meeting and for providing friendly and stimulating working conditions for the participants. The Secretariat representative then outlined the objectives and importance of the meeting. He assured participants of the full support of the Secretariat, both during the meeting and in the future, and he concluded by wishing all participants very fruitful deliberations in this important meeting.

1.1.5 The list of participants in the meeting is given in *Annex I*.

1.2 Adoption of the agenda

1.2.1 After discussion of the provisional agenda, it was decided to include additional agenda items on the status of sea ice products for the Southern Hemisphere under 2.2 and on requirements to observational, nowcasting and numerical weather prediction sea ice parameters under item 2.5. The meeting adopted the agenda for the sessions on the basis of the corrected provisional agenda prepared by the Secretariat. This agenda is given in *Annex II.*

1.3 Working arrangements

1.3.1 The meeting agreed its hours of work and other practical session arrangements. The documentation for the meeting was introduced by the Secretariat.

2. FIRST SESSION OF THE JCOMM ETSI

2.1 Report by the Chairman of the ETSI

2.1.1 The meeting noted with interest and appreciation a report by the chairman of the Expert Team on Sea Ice (ETSI), regarding the present status and effectiveness of its activities during the intersessional period since the last meeting (Ottawa, May 2000), and plans for the future. This report, which is reproduced in *Annex III***,** outlined the main activities so far within the overall Team as well as the main results of the first session of the Services Programme Area Coordination Group (SCG) (Geneva, 3-6 April 2002) relating to the ETSI. The SCG reviewed and revised its detailed work strategy, including the ETSI component and outlined additional ad-hoc ongoing action items with moderate priority, including revision by ETSI of JCOMM requirements for sea ice observations to support operations, nowcasting and numerical weather prediction.

2.1.2 The meeting noted that substantial progress had been made in the implementation of the previous work plan. This included: a revision of the WMO Sea Ice Nomenclature, development of new standards for colour coding of sea ice charts, new formats for historical sea ice data exchange, ice decay and incorporation of sea ice information in electronic charting systems in collaboration with the International Ice Charting Working Group (IICWG), the Baltic Sea Ice Meeting (BSIM).

2.1.3 The meeting was informed that the chairman of ETSI prepared information documents on the status of ETSI activities for the first session of the JCOMM Data Management Coordination Group (Paris, May 2002) and the first session of the JCOMM Observations Coordination Group (La Jolla, USA, April 2002).

2.1.4 Participants discussed the report, especially the part dedicated to an overview of information related to sea ice as developed by JCOMM-I in June 2001, as well as an introduction to the overall strategy and vision for ETSI in the future, as a guidance to subsequent discussions on this important topic. These activities are addressed in detail under the appropriate agenda items. In addition to the subjects, dealt with above, the meeting considered that there were a number of topics, which require attention during the intersessional period, in particular:

- visit the UN Atlas of the Oceans (http://www.oceansatlas.org/) once it was formally opened to the public on 6 June 2002, and offer comments and suggestions as appropriate regarding its enhancement within the context of JCOMM and its work;

- visit the new JCOMM web portal being hosted by IOC (http://www.jcomm.net/), provide comments and suggestions as appropriate, and also make use of the portal as a means for information exchange in support of JCOMM;

- provide the Secretariat with suggestions regarding a JCOMM logo;

- visit the JCOMM Electronic Products Bulletin (JEB), provide support and technical proposals for JEB Editorial Board chaired by Dr I.Tourre. In particular, during SPA-I meeting it was tentatively agreed that ice products, now absent in JEB, for the Arctic and Antarctic, developed within the GDSIDB will be implemented in JEB.

2.1.5 After some discussion regarding sea ice data management K.Strübing proposed to address to WMO Secretariat the ETSI concerns about the decreased availability of data necessary to support safety of navigation in ice covered waters that has resulted from the space agencies` data policies (**Action: Chairman, Secretariat)**

2.1.6 Ms Miriam Andrioli, Member JCOMM Management Committee, proposed and meeting agreed to prepare a document on training in the field of sea ice activities to be submitted for information to the JCOMM Capacity Building PA Coordinator (**Action: ETSI Chairman, Members**)

2.2 Reports by the members of ETSI

2.2.1 The session reviewed ETSI members reports from USA, Canada, Japan, Argentina, Sweden, Germany, Iceland, China, Russia and Denmark.

Report from the USA ice service

2.2.2 Mrs C. Bertoia provided information on sea ice activities in the USA carried out by the National Ice Center (NIC) (*Annex IV, p. 51*). In that context, the session was informed that the NIC has routinely produced maps of sea ice conditions since 1972. Using visible and infrared (NOAA AVHRR and DMSP OLS), SAR (Radarsat), scatterometer (QuikScat) and passive microwave (DMSP SSM/I) imagery, bi-weekly charts are produced of all ice covered regions of the Arctic and Antarctic, and twice weekly charts of the Alaskan and Great Lakes regions. These charts are made freely available on the web (http://www.natice.noaa.gov). Tailored support is also available to qualified users, to include annotated imagery support, upon request.

2.2.3 The session noted with appreciation that in the intersessional period, NIC provided tailored support to a number of national and international users. Much progress was made on the development of a computer based training system for ice analysis, working with the Canadian Ice Service and Noetix Corp. Ice recognition, Radarsat, Ice Physics, and Remote Sensing (AVHRR and OLS) modules were completed. Modules currently in production include Remote Sensing (SSM/I), Geography and Climatology. Proposed future modules include WMO Ice Code, Interactive Ice Analysis and Ice Forecasting.

2.2.4 The meeting was informed that NIC put effort into developing a more robust plan for continuity of operations to specifically address homeland security threats. Provisions were made for creation of ice products and delivery of services from an off-site location, and Radarsat emergency ordering procedures were solidified.

2.2.5 During the intersessional period, NIC operationally tested several new SSM/I algorithms and selected the NASA Team 2 algorithm for operational implementation. NIC also transitioned from research to operation QuikScat scatterometer ice and iceberg products. In preparation for the improved visible/infrared sensors aboard NPOESS, NIC is working towards operational use of MODIS imagery.

2.2.6 The meeting noted that much progress was related to development of a new Sea Ice Mapping System (SIMS). The National Ice Center, working with various contract support, transitioned to operations a new hardware/software Sea Ice Mapping System (SIMS). The system is based on a Commercial Off-the-Shelf (COTS) software package from Lockheed Martin known as CARTERRA and allows for end-to-end digital ice chart creation. This system is a highly integrated imagery analysis and geographic information system (GIS). Current work involves the development of a web-based dissemination system, working in conjunction with the Canadian Ice Services under the auspices of the North American Ice Service (NAIS).

2.2.7 The meeting noted with interest and appreciation the information on the Polar Ice Prediction System (PIPS 3.0), which was developed by the Office of Naval Research (ONR). PIPS 3.0 will be based on a global ocean model and a sea ice model (C-ICE) developed at Los Alamos National Laboratory. PIPS 3.0 will use data assimilation routines developed at the Naval Postgraduate School. As an initial step, validation of PIPS 2.0 was documented in several case studies (VanWoert et al, 2001). Future work will include final selection of a global ocean model (or an Arctic ocean model), determination of the feasibility of coupling the sea ice model to the global ocean model, adding International Arctic Buoy Programme (IABP) to the data assimilation scheme and further validation studies.

Report of the Canadian Ice Service

2.2.8 Mr J.Falkingham presented information on the Canadian Ice Service (CIS) activities (*Annex IV, p. 32*). The meeting noted with interest that the Canadian Ice Service (CIS) provides information about floating ice in the major navigable waters of the Canadian economic zone for the present, the future and the past. This information in intended to meet two main objectives; to ensure the safety of Canadians, their property and their environment by warning them of hazardous ice conditions; and to provide present and future generations of Canadians with a knowledge of their ice environment sufficient to support environmental science and the development of informed policies. The CIS works with the international community to foster a global awareness of floating ice for operational and scientific purposes.

2.2.9 Throughout the intersessional period, the CIS provided operational ice information on a 7-day-a-week basis throughout the year for areas covered by sea ice. The Canadian Coast Guard (CCG), which operates the fleet of icebreakers and is responsible for marine safety, is a major partner of the CIS. Ice Service Specialists from the CIS work aboard CCG icebreakers to directly advise the captain on ice navigation and also in regional Coast Guard ice offices to support vessel traffic routing through ice-covered waters.

2.2.10 The CIS also monitors the ice cover on 135 inland lakes using satellite data for numerical weather prediction. The Canadian Meteorological Center reports that this information has made a noticeable improvement in weather forecasts over Canada.

2.2.11 The meeting noted that the CIS relies on a mix of satellite, aircraft and surface observations. The most important single data source is the Radarsat satellite complemented by AVHRR, OLS optical, SSM/I and QuikSCAT. The CIS ice reconnaissance aircraft provides tactical data in direct support of navigation as well as “ground truth” for satellite data; it carries Side-Looking Airborne Radar (real aperture) and is specially fitted for visual observations. Surface observations are provided by ships and helicopters.

2.2.12 Mr Falkingham then reviewed briefly a number of specific issues on the main achievements of CIS in the field of information technology, producing long range ice forecasts, the future availability of sea ice data from SAR satellites and development of a sea ice data assimilation system, which can incorporate observational input from remote sensing (and other) sources.

2.2.13 The meeting noted that substantial progress had been made in training in the science of ice analysis and forecasting. In cooperation with the U.S. National Ice Center (NIC) and the Canadian company Noetix Corp., considerable progress was made in the development of a Computer Based Training system. Modules for ice recognition, Radarsat analysis, ice physics and optical remote sensing have been completed and are now part of the mandatory added in to training for ice analysts and forecasters. In addition, CIS has been working on an “Ice University” concept in which senior ice forecasters develop ½ day modules on various science topics for delivery to all analysis and forecasting staff. In cooperation with the Royal Military College, the CIS has developed a one-week introductory course in oceanography specifically aimed at ice forecasters who typically have a meteorology background but little oceanography. Two sessions of the course were delivered in 2002 to include most of the CIS forecasters as well as two NIC staff.

2.2.14 The meeting noted with considerable interest CIS international activities in the field of sea ice development, including the close long-standing collaboration between the CIS and the U.S. NIC. The ice information programme for the Great Lakes is now operated jointly by the two services and they are in the final stages of developing a completely seamless suite of products. The intention is to not only reduce the overall cost of production by eliminating duplication of effort but to also avoid any possible confusion in the Great Lakes shipping community that different information sources could cause. Discussions have been initiated to extend this integration to the Alaskan Coast for the summer of 2003. All of this activity is progressing toward the creation of a North American Ice Service that will eventually encompass integrated databases, joint product preparation and a single window of access to North American ice information products.

Report of the Japan Meteorological Agency

2.2.15 The meeting considered with interest a report presented by Mr Matsumoto on sea ice activities provided by the Japan Meteorological Agency (JMA) (*Annex.IV, p*. 46). Sea ice monitoring in the Sea of Okhotsk is carried out usually from November to July by JMA, and the results of monitoring are published for public use. Sea ice monitoring by satellite began 10 December 1970 and now makes use of SSM/I data. JMA operationally analyses sea ice extent and its concentration, makes Ice Condition Chart in the Sea of Okhotsk, every day from December to May. It is planned to feed the result to JMA's Numerical Weather Prediction Model and Climate Prediction Model. **(Action: JMA)**

2.2.16 The meeting noted that JMA acquires the observation data and observation charts via facsimile from Japan Coast Guard and Japan Self-Defense Forces and that JMA acquires the Coastal RADAR data of Hokkaido University via Internet and facsimile.

2.2.17 It was also informed that a numerical model to predict sea ice distributions was first utilized by JMA during the sea ice season in 1991. JMA provides 7-day forecasts of sea ice distributions in the southern part of the sea of Okhotsk and the neighbouring sea.

Report from the Argentinean Naval Hydrographic Service

2.2.18 The representative of Argentina with the ETSI Mr M.Picasso from the Naval Hydrographic Service introduced a report on sea ice activities in Antarctic areas (*Annex.IV, p. 30)*. It was considered that the Glaciological Division of the Argentine Navy Meteorological Service (SMARA), at the Naval Hydrographic Service (SHN), is the head office responsible for operational sea ice support in the Weddell and Bellingshausen Seas, mainly from 25° W to 70° W, and beyond those limits under special requirements. All the activities are devoted to fulfil the Argentine Navy demands and needs, but also service is provided to any navigator requesting sea ice conditions in those areas. The Naval Río Grande Meteorological Central, Province of Tierra del Fuego works jointly with the SMARA's Glaciological Division, giving sea ice overviews to mariners. Finally, the Meteorological Office on board the Icebreaker A.R.A. "ALMIRANTE IRIZAR" (AI) provides full sea ice support to its Command and to any ship that requests service, but only when AI is at sea.

2.2.19 The session considered with appreciation that Naval Hydrographic Service developed programme of sea ice observations for Antarctic area which is a permanent cooperative effort between civilian and military institutions, mainly sustained by the Argentine Navy, the SHN, the Argentine National Meteorological Service (SMN) and the Antarctic Army Command. Code messages IISS (for ship observations) and IILL (for coastal observations) are used after annual training of personnel, renewed each year, in a fifteen course held at SMARA. Up to now almost five hundred persons have been formed. IISS and IILL messages are transmitted in real time to the NIC and sent to the USA National Snow and Ice Data Center (NSIDC) and AARI after being validated through quality control.

2.2.20 M.Picasso informed the session that the SMARA continues the Antarctic Navigation Course for professional sailors. Its syllabus encompasses Antarctic issues to be dealt with under six main modules such as environment, politics and legislation, ecology, prevention of seawater contamination, nautical safety and maritime operations, and survival. Four hundred and thirty five civilian and military mariners from Australia, Belgium, Bolivia, Brazil, Chile, Germany, Guatemala, India, Italy, Mexico, Norway, Paraguay, Peru, South Africa, South Korea, Spain, United Kingdom, United States of America, Uruguay and Argentina attended the course.

2.2.21 Participants were informed about the inconsistency between the present Spanish version of the official WMO Sea Ice Nomenclature and national practice in Argentina. The meeting agreed that, after this discussion, M.Picasso will submit a draft of the revised Spanish version to the WMO Secretariat to be edited and published. (**Action: M.Picasso, Secretariat**)

Report from the Swedish Meteorological and Hydrological Institute

2.2.22 The meeting noted with interest the report by Mr Grafström regarding the present and future status of Swedish Meteorological and Hydrological Institute (SMHI) development of sea ice activities in Baltic Sea area (*Annex IV, p. 49)*. He stressed that SMHI is responsible for mapping both sea ice and surface temperature conditions in waters with merchant ship traffic in the Baltic region, including Lakes Vanern and Malaren. Since 1957 daily ice charts have been produced during winter time and approximate period is November 20 – May 20. Sea surface temperature charts are produced twice a week the remaining part of the year. To the main customer, Swedish Maritime Administration/Icebreaking department, following data are transmitted on a daily basis: 24-hour as well as 5-10-day weather and ice forecasts, Baltic ice chart and satellite images to be ingested in a combined presentation and planning system onboard the icebreakers. Other users are scientific researchers (climate etc) and also some institutions. Finally, the ice limit and ice concentration are incorporated on a daily basis in the Scandinavian weather prediction model in order to improve forecast reliability.

2.2.23 The SMHI ice service consists of a team with 5 experienced ice meteorologists and 3 ice assistants, virtually the same persons from year to year. Operational training of new staff is mainly carried out by following an experienced ice meteorologist in the daily work during at least one ice winter combined with literature studies and visits to icebreakers in operational service. Introduction of new techniques has been very sparse during the intersessional period.

2.2.24 The main data source is satellite information, NOAA AVHRR (visible and infrared channels) and RADARSAT (SAR). Furthermore, daily reports from a number of coastal stations are received as well as frequent reports in plain language from Swedish and Finnish icebreakers (including sea ice information collected from helicopter surveillance) provide more details on ice thickness, ridges and cracks. Effort has been focused on transmission of more high-resolution RADARSAT images than previous winter to the Swedish icebreaker fleet.

Report from Bundesamt für Seeschifffahrt und Hydrographie

2.2.25 The session reviewed the report submitted by Mr Klaus Strübing.on sea ice activities in Germany *(Annex VI, p. 41)* and noted with interest that the sea ice service at the Bundesamt für Seeschifffahrt und Hydrographie (BSH) is mainly responsible for ice observations in German waters and regular reporting on and mapping the ice conditions in the area of the Baltic Sea and the coastal areas of the eastern North Sea. Furthermore, on request the service is providing ice information world-wide. Daily ice reports and ice charts have been produced during winter ice season, i.e. approximately from the end of November to the end of May. Weekly sea surface temperature charts for the North and Baltic Seas a provided by another BSH unit during the whole year. The ice observations from the German coast are stored in a special ice data bank, and allow statistical evaluation of the development of ice conditions with time series more than 100 years long. An ice chart data bank covers the ice conditions of the sea area in the region of the western Baltic Sea.

2.2.26 The session also noted that throughout the intersessional period, the GIS provided during the Baltic Sea ice season operational ice information on a Monday to Friday basis. During the last two seasons twice weekly ice charts for the northern region of the Baltic Sea have been produced.

Beside the normal black and white (hatching) version, within the season 2000/01 charts based on the IICWG proposed colour code were provided on a regular basis. In the last season the parallel chart production was continued.

2.2.27 Beside the regular published products, the service can be addressed for world wide ice information. Cruise and research vessels as well as some yachts in the Polar Seas are the normal customers. The radiofax re-distribution of the iceberg charts of the Canadian Ice Service (CIS) and the International Ice Patrol (IIP) of the U.S. Coast Guard via the radio station Offenbach/Pinneberg is another routine service.

2.2.28 The participants of the meeting were also informed that during the last summer 2002 the problems with the supply vessel "Magdalena Oldendorff" in the Antarctic sea ice cover was an additional challenge - not only for BSH, but especially for the National Ice Center (NIC) and Argentina's Naval Glaciological Centre, Hydrographic Service (see: www.esa.int/export/esaCP/ESAOC976K3D_Protecting_0.html).

2.2.29 In his report Mr Strübing emphasized that in Germany the main sea ice data source besides coastal observations is satellite information, primerily NOAA AVHRR (visible and infrared channels), which is received on-line via a SeaSpace HRPT station. Scenes from the Baltic Sea are presented as b/w products on the web page. Within the last season a new colour product was added. Weekly SST/ice composites are presented, too. ERS/SAR scenes were available in NRT until the season 2000/01. Daily observations from the coastal stations - and in case of ice at sea - from icebreakers and merchant vessels as well as helicopter and aircraft reconnaissance are used in addition. The daily plain language reports and ice charts from the Nordic countries are available for the presentation of the ice conditions in the northern part of the Baltic Sea.

2.2.30 The BSH routinely uses an in-house developed operational model system to support maritime shipping, and to monitor and study the marine environment. The model system, which has been operated for quite a number of years now, comprises several computer programmes producing data in a daily operational programme routine without any manual intervention.

2.2.31 The session noted with appreciation that the Baltic Sea Ice Services have a long-standing collaboration. Its improvement is a continuous process within the activities of the Baltic Sea ice Meeting (BSIM), which has a more than 75 years tradition. With respect to modern communication links the intention is to more and more harmonize products in order to save manpower and reduce the duplication of effort (details are presented in the BSIM Report). GIS has been active in the International Ice Charting Working Group that has now held three annual meetings, actively contributing to several scientific and operational action items.

Report from the Icelandic Meteorological Office

2.2.32 The expert from the Icelandic Meteorological Office (IMO) Dr Jakobsson presented information on IMO sea ice activities in areas of the Icelandic waters (*Annex IV, p. 44*). The meeting noted with interest that the Sea Ice Research Unit of the Icelandic Meteorological Office (IMO) is responsible for sea ice monitoring and sea ice service all year round in this area. The monitoring is performed in cooperation with the Icelandic Coast Guard, the Marine Research Institute in Iceland as well as ships in and close to ice covered areas in the Iceland Sea and the Denmark Strait (Greenland Sound).

2.2.33 The session was informed that sea ice information is received from Icelandic and foreign ships in Icelandic waters and that the Icelandic Coast Guard performs sea ice reconnaissance flights in the Iceland Sea north of Iceland and the Denmark Strait. In addition to these main sources of sea ice observations data, any other reliable information obtained at IMO is recorded and taken into account by further processing, as, for example, reports from coastal meteorological observation stations or from smaller airplanes.

2.2.34 On a larger scale, though not satisfactory for warnings on sailing routes, satellite imagery received at the IMO forecast division sometimes gives a useful indication of the overall extension of sea ice in the Denmark Strait (Greenland Sound).

2.2.35 The meeting noted further that all the various observation data mentioned above are recorded at IMO and forwarded further to those who need them. All data obtained are then preserved and gathered in an electronic data bank. Preliminary monthly overviews on sea ice at the coasts of Iceland are placed on the IMO web site as soon as possible. Eventually, annual reports containing final monthly overviews as well as the Icelandic Coast Guard ice charts are published in annual reports.

2.2.36 The meeting recognized that it is important to maintain and improve information channels back and forth between those who submit information on sea ice in the field and users who eventually receive it, together with some estimate concerning further sea ice development in the area. It is the duty of the Sea Ice Research Unit at IMO to oversee that this is done as effectively as possible. Useful development work has been done lately by participating in a European Commission project belonging to a programme category called the Information Society Technology (IST): Integrated Weather, Sea Ice and Ocean Service System (IWICOS). The IWICOS project will be terminated at the end of 2002, but the resulting system will hopefully turn out to be very useful for all kinds of ships in Icelandic waters, and elsewhere.

Report from the Danish Meteorological Institute

2.2.37 The representative of Denmark with the ETSI Dr Andersen did not participate at the meeting and Mr Grafström from SMHI was requested to present Denmark's report. In response to this request Mr Grafström informed the meeting that the Danish Meteorological Institute (DMI) is responsible for monitoring and charting of sea ice in the Greenland waters. The purpose of the sea ice service is to aid navigation and provide tactical and strategic support to the shipping community. The service is now predominately based on satellite Earth Observation data sources but for local inshore routing and monitoring operations DMI is using a helicopter which is situated in Narsarsuaq.

2.2.38 It was also mentioned that the ice service has mainly provided ice charts and other sea ice information to the two major Greenland shipping companies responsible for transportation of all inland passengers and goods to and from Greenland and the Danish Navy operating in the Greenland waters. Furthermore the ice service has provided dedicated support to commercial and scientific programmes, e.g. oil exploration activities at Fyllas Banke in David Strait and monitoring of the so-called Odden feature in the Greenland Sea. The meeting recognized the important work that DMI done with the EUMETSAT Ocean and Sea Ice Satellite Application Facility which, from November 2003 will produce operationally a daily 10-km sea ice product.

2.2.39 The meeting noted with appreciation research programmes developed by DMI in cooperation with the following international projects. In the framework of the European Commission 5th Framework Research Programme DMI has been involved in the development of dedicated interactive 'Ocean, Weather and Sea Ice' computer presentation tools. DMI has entered into a new contract with Radarsat International from April 2002. The contract makes possible combined near real time use of images from RADARSAT and the European satellite ENVISAT. Data from ENVISAT is expected to contribute to the operational ice service from the beginning of 2003. A drift forecast model for the Cape Farewell region has been developed by DMI and applied in a pre-operational mode. The goal is reliable 12 to 24 hours forecasts of the sea ice drift. The forecasts are initiated by the latest ice chart and will be used to provide information when no satellite coverage is available. The full report of DMI is attached as *Annex IV, p. 39.*

Report from the National Marine Environment Forecast Centre

2.2.40 The representative of China with the ETSI Prof Huiding Wu informed the meeting on sea ice activities developed by Chinese agencies and services. It was noted with interest that the

National Marine Environment Forecast Center (NMEFC), the Qingdao Marine Forecasting Observatory (QMFO) of State Ocean Administration (SOA), the Group of Sea Ice Management (GSIM) of CNOOC (China National Offshore Oil Corp.) Limited-Tianjin are responsible for monitoring and forecasting in the Bohai Sea, the Northern Yellow Sea and Antarctic sea ice covered areas. The Chinese Antarctic and Arctic Administration (CAA) and the Polar Research Institute of China (PRIC) are responsible for implementing of national polar research policy and affairs.

2.2.41 The meeting also noted that the visible and infrared imagery from NOAA (AVHRR), MODIS (EOS-AM) and GMS (S-VISSR), data from aircraft reconnaissance and Icebreakers, are used for operational sea ice monitoring and forecasting in the Bohai Sea and the northern Yellow Sea. The reports on local ice conditions including sea ice type, thickness, concentration and temperature are daily sent to NMEFC from 11 shore stations along the Bohai Sea and the northern Yellow Sea. Real-time ice data at the oil platforms JZ20-2 (40º27' N, 121º17' E) and JZ9-3 (40º40' N, 121º29' E) in the Liaodong Gulf are provided daily by CNOOC Limited-Tianjin.

2.2.42 In addition to the subjects dealt with above the meeting considered that Ice information from the composite analyses of the above data and the sea ice forecasts in the form of chart, code and plain language are issued by appropriate Chinese agencies to users including oil industry, shipping, coastal and harbour activities. NMEFC is also responsible for sea ice forecasting and monitoring of the Antarctic sea areas near to the two Chinese Antarctic stations, the Great Wall and the Zhongshan, and related to Chinese Antarctic research expeditions. The warning level of severe ice condition for various structures and operators is established. More attention is paid to the monitoring of offshore drilling rig, temporary offshore structures and other structures without any capability against ice.

2.2.43 The meeting noted with appreciation and interest the information provided by Prof Huiding Wu on research and development in the field of sea ice modelling and forecasting for Bohai Sea and the northern Yellow Sea including sea ice researches in the Antarctic and Arctic areas implemented by Chinese National Antarctic and Arctic Research Expeditions. The full report of Chinese activities in sea ice development is reproduced in *Annex IV, p 36.*

Report from the Russian Ice Service

2.2.44 The information on the developments of operational sea ice activities of the Arctic and Antarctic Research Institute (Russia) was presented by V. Smolianitsky. The meeting noted that sea-ice information services in Russia are provided with ice information by the centre at the Arctic and Antarctic Research Institute in St Petersburg (AARI), as well as by the Hydro-Meteorological Centre in Moscow (Hydrometcentre) and local hydro-meteorological offices in the Arctic, Far East and Baltic countries. AARI provides services mainly for shipping and coastal and harbour activities within the Northern Sea Route, for the Central Arctic Basin and Arctic seas – Greenland, Kara, Laptevs, Eastern-Siberian, Chukha as well as for the seas with the seasonal ice cover and for Antarctic areas.

2.2.45 The meeting considered that data sources include GTS data, routine daily observations from coastal weather polar stations and satellite imagery from national METEOR, OKEAN, RESURS, as well as NOAA and MODIS satellites. Ice reconnaissance flights are conducted only occasionally during hydro-meteorological support of certain applied and scientific activities. AARI satellite reception station provides HRPT and APT imagery for Western Arctic and North Atlantic.

2.2.46 The meeting noted that common usage of ice products includes weekly sea-ice condition charts of the Arctic, weekly sets of numerical forecast charts of mean daily drift of sea ice, waves, currents and level. Mentioned products are available via AARI web page (http://www.aari.nw.ru). Other sea ice related products (elevation and they more than 23) include detailed sea-ice conditions and forecast charts of sea ice parameters, prepared by AARI and other local meteorological offices in formatted or in a plain language form both routinely and on request and on different time scales. All sea ice products are disseminated for disaster prevention, shipping companies, news media etc.

2.2.47 Participants of the meeting noted with interest that from 1999 AARI and other federal hydrological and meteorological institutions in Russia collaborate in development of the Unified System of Information on World Ocean Conditions – ECIMO (http://www.oceaninfo.ru). ECIMO will be based on new informational technologies like GIS, Internet, XML, electronic charting. AARI actively cooperates with a number of services to develop a format and SDK extensions for presenting ice and meteorological layers on navigational electronic charts.

2.2.48 The session recognized the progress made by the national ice services on the variety and complexity of ice informational products during the intersessional period and in this connection it was proposed to make a revision for the WMO publications No 574. (**Action: Chairman, Secretariat)**

2.2.49 The meeting noted all information presented by the ETSI members with considerable interest, and agreed that they provided an excellent framework and overall objectives for its own work during the intersessional period. Full reports of the main results of sea ice activities in national agencies and services are given in *Annex IV.*

Sea ice products for the Southern Hemisphere

2.2.50 The meeting noted with appreciation the report on sea ice products and services for the Southern polar region, based on activities of the USA National Ice Center and the Russian Arctic and Antarctic Research Institute. Ms C.Bertoia informed that NIC routinely produces maps of Antarctic sea ice conditions using visible and infrared, SAR, scatterometer and passive microwave (DMSP SSM/I) imagery. These charts are made freely available on the web (http://www.natice.noaa.gov). Tailored support is also available to qualified users, to include annotated imagery support, upon request. In the intercessional period, the US, German, Russian and Argentine ice services collaborated to provide support to the beset Magdalena Oldendorf and the rescue icebreaker Almirante Irizar. This support was concentrated in the period June 2002 through August 2002, with weekly annotated imagery support to the Magdalena Oldendorff continuing today. US NIC also makes available daily SSM/I ice concentration products on its website.

2.2.51 The AARI produces maps of Antarctic sea ice conditions for the navigation period of the Russian research vessels. Maps are usually complied twice a week using visible and infrared NOAA AVHRR, Meteor and Ocean. Additional support outside the period of navigation is also available upon request. During Magdalena Oldendorf's rescue operation AARI close collaborated with ice services from another countries and provided daily estimates of ice conditions with spatial resolution 12.5 km based on DMSP SSM/I. AARI also makes available daily ice concentration productson its website (http://www.aari.nw.ru/south).

2.2.52 The meeting noted with interest and appreciated the technical presentation by Mr M.Picasso on the rescue operation "Assistance of Icebreaker "Almirante Irizar" to MV "Magdalena Oldendorff"". He informed that from the 25th of June up to the 18th of August 2002 an Antarctic Task Force (ATF) of the Argentine Navy sailed to Antarctica to assist MV "Magdalena Oldendorff" anchored in a small bay Muskegbukta, located near the meridian of Greenwich. The ATF included the Argentine Icebreaker A.R.A. "Almirante Irizar", two helicopters of the Second Naval Squadron of Helicopters, commissioned personnel of the Argentine Navy, like the Naval Hospital, the Naval Hydrographic Service (SHN), etc., and an Antarctic Terrestrial Patrol of the Argentine Army. This unique rescue operation in the Southern Polar regions, due to winter constraints, daily darkness and without logistic points of support, relayed additional valuable products of the sea ice community, such as NIC, the AARI and the BSH. Visual sea ice observations on board the icebreaker were performed using NIC codes and IISS messages and sent after QC to NIC and AARI. At the same time, the products received from the ice community were intensively used and analyzed. The ATF, IAC and SHN expressed their gratitude to NIC, AARI and BSH for their help and permanent cooperation.

2.3 Report of the BSIM

2.3.1 The meeting further reviewed the activities of the Baltic Sea Ice Meeting (BSIM) submitted by its chairman Mr. Klaus Strübing *(Annex V)*. It was noted that eleven Baltic countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Netherlands, Norway, Poland, Russia and Sweden) within the BSIM successfully cooperate in compilation and relay to end-users of sea ice information, in maintaining common ice terminology and joint ice model to develop an integrated sea ice information and navigation support system. The main results of the last BSIM-20 session are summarized in *AnnexV, Appendix* 1. The defined action items include among others to create a BSIM logo and the draft and maintenance of a joint web site for the Baltic Sea Ice Services. A WG was formed consisting of J.-E.Lundqvist (SMHI - S), K. Strübing (BSH - D), J. Vainio (FIMR - FI) and K. Wierenga (RIZA - NL). Beside several E-Mail contacts there was WG meeting on January 24-25, 2002, in Helsinki. The results are given in *Annex V*, *Appendix 2*. The website is now under construction at the German ice service unit in Rostock. It will be embedded in the Internet environment of BSH. A test version will be started during the coming ice season 2002/2003. One of the anticipated products will be station lists with the daily ice observations. A supplement to the booklet *The Baltic Sea Ice Code* (published in 1981by SMHI) including changes in fairway sections and areas for ice report and complementary new national ice terms was issued by SMHI on behalf of BSIM.

2.3.2 Ice climatology is of basic interest for the future development of winter navigation in the Baltic Sea. Several thousands of cruises are affected each season in ice covered sea areas and waterways. An accumulation of milder winters during the last 15 years may stress the intention of global warming in the region. The Baltic Sea history offers several long time series on sea ice conditions. The length of direct observations varies between 50 and 150 years and several hundred years for indirect information. Much analysing work has been done in the nine countries around the Baltic Sea. The work was concentrated and harmonized since 1993, when the First Workshop on the Baltic Sea Ice Climate was performed in Tvärminne, Finland. The 4th Workshop was performed in May this year in Norrköping, Sweden. As a major result of the activities so far, a report on *Ice Time* Series *of the Baltic Sea* with special contributions from 6 countries was published early this year.

2.3.3. A special Workshop on Baltic Sea Ice Research was performed 17-21 September 2002 on occasion of the 100 years anniversary of the Helsinki's University Zoological Station in Tvärminne, near Hanko, Finland. About 15 international scientist discussed the various aspects and scales of sea ice in the Baltic Sea between micro-organisms and winter navigation.

2.3.4 The yearly Baltic Icebreaker Meeting took place in Kiel, Germany, on 25 September 2002 *(Annex V, Appendix 3).* Beside the reports of the national delegates on the ice season 2001/02 various aspects of icebreaking activities were discussed. Despite the issue of global warning it was agreed on the fact that in further on possible severe ice winters a lack of assistance is to be expected in the Baltic Proper. Joint efforts have to be discussed.

2.3.5. The Chairman of BSIM informed the session that the 21st Baltic Sea Ice Meeting (BSIM-21) will be performed next year in Helsinki (9-13 June 2003). The intention is to even strengthen the joint efforts for closer cooperation, to more and more harmonize products in order to save manpower and reduce the duplication of effort. Furthermore, an Baltic Sea ice service information network has to be established, for which the joint website is a first step. The requirements for high resolution satellite radar data have to be further harmonized in order to address the distributing agencies/companies with one vote. Future user requirements have to be discussed, etc. A draft agenda will be presented within the next few weeks.

2.3.6 The meeting agreed that joint BSIM and ETSI experience is essential for JCOMM practices and future collaboration should be continued between the ETSI and BSIM **(Action: ETSI, BSIM)**

2.4 Report of the IICWG

2.4.1 The representative of the International Ice Charting Working Group (IICWG) Ms Cheryl Bertoia submitted a report on its activities (*Annex VI*). The session noted that this group includes most of the national sea ice institutions which operate in the Northern Polar Region. Being an open and independent group, IICWG provides effective linkages with a number of commercial bodies like shipping companies, remotely sensed data supplies, etc.

2.4.2 The IICWG developed a new initiative in support of sea ice research and development, data and product exchange, terminology, mapping standards, technology for analysis and forecasting, and training. The session noted that the next IICWG-IV meeting will take place in St.Petersburg (AARI, Russia), 7-11 April 2003. The agenda of this meeting will be prepared after the current meeting. Ms Cheryl Bertoia also informed that the Sixteenth Meeting of US/Canada Joint Ice Working Group inside of IICWG was held April 29-May 1 2002 in Wood's Hole, USA.

2.4.3 The session appreciated the important work being undertaken by regional and international bodies, such as the BSIM, the IICWG and the U.S. - Canada Joint Ice Working Group (JIWG) in the development of the electronic chart display information system. It agreed that future collaboration should be continued between the ETSI and these groups, and requested the chairperson of the ETSI and the Secretariats to arrange for such collaboration, as appropriate**.**
(Action: Chairmen ETSI, BSIM, IICWG; Secretariat)

2.5 WMO sea ice documents and publications

2.5.1 The meeting was informed that in response to the recommendation of the meeting of polar experts, organized by WMO Secretariat in 1999, the IOC/WMO consultant, Mr G.L. Holland (Canada), prepared a report on oceanographic and marine meteorological observations, including sea ice parameters in the polar regions. The report, entitled *Oceanographic and Marine Meteorological Observations in the Polar Regions* was reviewed by participants at JCOMMTRAN-II meeting in Paris, June 2000, and subsequently published by WMO as WMO/TD-No. 1032, JCOMM Technical Report No. 8.

2.5.2 The eighth session of the Steering Group for the GDSIDB took place in Ottawa from 30 April to 1 May 2000. *The Final Report of the Eighth Session of the Steering Group for the Global Digital Sea Ice Data Bank* has been issued by WMO Secretariat, as JCOMM Meeting Report No.5 and a copy of this was passed to Permanent Representatives of Members of WMO and all participants of the session.

2.5.3 The session was informed that the joint WMO/CIWG Workshop on Mapping and Archiving Sea-ice Data Derived from Radar Data Processing had taken place in Ottawa from 2 to 4 May 2000, hosted by Canada. The report compiled Workshop's papers on recent developments in remote sensing instrumentation for sea ice parameters, radar signal interpretation, data management, data assimilation and sea ice modelling was published by WMO as the *JCOMM Technical Report No. 7, WMO/TD-No. 1027.* It is available in English and was distributed among participants in the Workshop for information, and additional copies may be obtained, on request, from the Secretariat.

2.5.4 *The Final Report of the First Session of the JCOMM Services Programme Area Coordination Group (SCG)* was issued by the WMO Secretariat in 2002. This meeting took place in Geneva in April and discussed among others a report by the Chairman of the JCOMM Expert Team on Sea Ice (ETSI), regarding the present status and effectiveness of its activities during the intersessional period since the last meeting (Ottawa, May 2000), and plans for future. The strategy and work plan of the ETSI was formally constituted at JCOMM-I as a part of the JCOMM Services Programme Area (SPA).

2.5.5 The meeting noted that the WMO Secretariat issued in 2002 the fifteenth *Annual Report for the Data Buoy Cooperation Panel, as DBCP Technical Document No. 20, 2002,* which includes development of the International Arctic Buoy Programme (IABP) and the International Programme for Antarctic Buoys (IPAB) and their activities in the polar regions.

2.5.6 *The UN Atlas of the OCEANS* (http://www.oceansatlas.org) was formally opened to the public on 6 June 2002. . FAO was taking the lead role in the preparation of the Atlas and both IOC and WMO had concluded formal agreements with FAO concerning their participation in, and contributions to, the project. The Atlas is an Internet portal providing information, data, products and analyses produced under contributing agency programmes, including programmes on sea ice activities. This publication was also discussed under item 2.1.

2.5.7 The WMO publication *Sea-Ice Information Services in the World (WMO-No. 574)* was revised by sea ice experts from Sweden and the Russian Federation, with support of the WMO Secretariat, and includes contributions from 19 countries involved in some way in sea-ice activities. This revised publication continues to enhance the exchange of information relating to sea ice and sea-ice services to the benefit of many national Meteorological Services. In addition to providing operational information to mariners, marine operations and controllers, it also aids other national Meteorological Services, which are developing their own sea-ice services. This publication is located at the home Web pages of the GDSIDB:

- http://www.aari.nw.ru/gdsidb/gdsidb_2.html;
- http://nsidc.org/noaa/gdsidb

2.5.8 The meeting was informed that special pages describing historical sea ice data were published on the Programme Areas section of the *WMO Marine Programme Web-page*: http://www.wmo.ch/index-en.html. The work on updating of the operational exchange of sea ice data through the WWW was done during the intersessional period and will be done to the future.

2.5.9 After some discussion regarding electronic versions of WMO publications related to sea ice, the meeting requested the WMO Secretariat to publish on Internet electronic versions of all existing mentioned publications as official WMO publications. **(Action: Chairman, Secretariat)**

2.5.10 The meeting noted the information on requirements for sea ice observations to support operations, nowcasting and numerical weather prediction proposed for revision by JCOMM. The meeting therefore agreed that Chairman would organize preparation of these revisions. **(Action: ETSI Chairman, all members and WMO Secretariat, by 15 November 2002)**

Sea ice nomenclature

2.5.11 The meeting was informed that the Canadian Ice Service revived and published a new edition of its ice observing and reporting standards in 2002. During the review process it was noted that some inconsistencies between terminology and symbology used in Canada and that which is documented in WMO Sea Ice Nomenclature, No. 259, Suppl. No. 5. On the basis of this comparison, a few amendments to the WMO Sea Ice Nomenclature were recommended (*Annex.VII*). The meeting reviewed these recommendations and agreed on specific changes to WMO No. 259 to be submitted to the JCOMM co-presidents for formal approval on behalf of JCOMM for publication as a supplement to the WMO Sea Ice Nomenclature. **(Action: Chairman Secretariat)**

2.5.12 The meeting noted with interest and appreciation amendments to the WMO Sea Ice Nomenclature prepared by AARI and agreed that proposed amendments should be revised and discussed during the intersessional period in order to be submitted for formal approval by JCOMM. **(Action: ETSI, BSIM, IICWG, Secretariat)**

2.5.13 The session was informed that a new updated version (in Russian) of the WMO Sea Ice Nomenclature has been prepared by AARI. Proposed version reflects among others a new technology in sea ice variables acquisition and mapping. The meeting proposed to issue an English version of that document to be discussed during intersessional period. **(Action: ETSI, BSIM, IICWG, Secretariat)**

2.5.14 The meeting agreed that ETSI should appoint an expert to prepare, with the help of the Secretariat, a consolidated set of requirements and proposals for a new revision to the WMO Sea Ice Nomenclature, including the information already submitted by participants of the meeting and proposed draft of XML version (Extensible Markup Language). This review should be done and discussed during the intersessional period, and submitted for approval to the JCOMM second session in 2005. (**Action: ETSI Chairman, Members**)

Colour standard for ice charts

2.5.15 The meeting noted the results of actions undertaken by experts from the IICWG, to develop technical specifications on colour tables and codes. Proposals for colour coding of ice charts have been discussed since 1930s but these proposals were used only by a few national sea ice services. However, recent widespread use of electronic navigational information systems demand ice services to change the approach. Standardization of colour coding for ice charts is a part of a strategy to put ice information in electronic navigation charts. In this relation, the IICWG plans to consult with IMO and IHO that revisions of the S57 standard (in 2003) will support ice information also.

2.5.16 The IICWG experts succeeded in preparation of the draft colour standard which includes, according to the decisions of the third IICWG meeting, two mutually exclusive separate colour codes, one based on total concentration and another based on stages of development (*Annex VIII*). Proposed codes are complimentary to the existent WMO black and white ice symbols and flexible in use. The IICWG planed that during 2002 each ice service, participating in IICWG, would produce ice charts according to the proposed standard from January to October 2002. The meeting recognized the work of the IICWG to develop an international colour code for ice charts. The meeting reviewed the initial proposal, agreed on minor revisions, given as *AnnexVIII, p. 99,* and agreed to submit it to the JCOMM co-presidents for formal approval on behalf of JCOMM to be published by WMO Secretariat. **(Action: ETSI with IICWG, and Secretariat)**

Ice decay/stages of melting

2.5.17 The session reviewed the comprehensive report prepared by experts from Canada on the results of research, undertaken by the Canadian Ice Service experts, under the Arctic Sea Ice Shipping System (AIRSS), to identify ice decay with the help of radar backscatter (*Annex IX*). JCOMM-I agreed that as a result of this work, appropriate amendments to the nomenclature for coding sea ice decay should be developed during the next intersessional period. In turn, during the third IICWG meeting, it was agreed for IICWG experts from Canada and Russian Federation to investigate the inter-relationship between traditional stages of melt and new ice strength index with respect to physical process in seasonal cycle and movement of ships in ice, to improve exchange of ice melt / strength science (past, present, future) within IICWG. **(Action: Canada, Russia)**

2.5.18 The meeting noted with appreciation that the following papers were prepared by the experts from Canada in response to the mentioned recommendation:

(a) De Abreu, Roger, John Yackel, David Barber and Matthew Arkett; *Operational Satellite Sensing of Arctic First Year Sea Ice Melt*; draft report by the Canadian Ice Service; 2002.

(b) Timco, G.W., M. Johnston and I. Kubat; *Ice Decay and the Ice Regime System*; Canadian Hydraulics Centre Technical Report HYD-TR-070; National Research Council of Canada; December 2001.

(c) Gauthier, M-F., R. De Abreu, G.W. Timco and M.E. Johnston; *Ice Strength Information in the Canadian Arctic: From Science to Operations*; accepted for presentation at the 16th IAHR International Symposium on Ice; December 2002.

2.5.19 Paper (a) above presents the results of work done at the Canadian Ice Service and its university partners to define stages of melt from satellite remote sensing. It was determined that five stages of melt – Winter, Snow Melt, Ponding, Drainage and Rotten Ice – can be determined.

2.5.20 Paper (b) above presents the results of work sponsored by the Canadian Ice Service (CIS) to relate these stages of melt to ice strength and the effect on vessels operating in ice. In light of the recommendations presented in this paper, the meeting agreed with the CIS that changes to WMO Nomenclature related to ice decay would not be proposed at this time.

2.5.21 The CIS is evaluating methods of presenting ice strength information directly without referring to a proxy ice melt indicator. The status of this initiative is described fully in paper (3) above. Briefly, a prototype "Ice Strength" chart product was developed and distributed to a select group of users for evaluation during the 2002 summer navigating season. Evaluation reports have been received from the participating vessels. The analysis of these reports is expected to be completed by the spring of 2003 and will be presented in a report recommending future directions. **(Action: CIS)**

2.6 Status of formats for operational and historical sea ice data exchange

2.6.1 The meeting considered the joint report prepared by the IICWG experts from Canada, Denmark, Russia and USA and presented by Ms Florence Fetterer on the development of a new format to standardize the international exchange of operational sea ice data for electronic sea ice charts. The JCOMM-I noted with appreciation the important work in that direction being undertaken by regional and international groups, such as IICWG and IHO/IMO (ECDIS). Previous formats SIGRID and SIGRID-2 were established by WMO in 1981 and in 1994, respectively, to store primarily climatological data. Now all historical sea ice data for 1950-2001 are kept in this format by the GDSIDB. In comparison to a number of commercial standards SIGRID format has an advantageous capability of comprehensive depiction of sea ice parameters. However, SIGRID has a number of restrictions and inconveniences as a practical operative format, so most ice services are no longer submitting data to GDSIDB in SIGRID. Based on the current international practices utilizing Geographical Information Systems (GIS) for chart production and SIGRID code tables for quantitative description of sea ice parameters IICWG experts prepared "SIGRID-3" draft format for sea ice data operational and climatological exchange (*Annex X*).

2.6.2 The meeting was informed that the proposed vector format SIGRID-3**,** would join SIGRID and SIGRID-2 as standard WMO formats. SIGRID-3 is based on an "Open Published Data" (ESRI, 2002, http://www.esri.com/software/opengis/openpdf.html) vector file format developed by a commercial entity. Storing ice chart data in vector format rather than raster format has advantages. The vector file preserves all of the information in the original chart, and charts can be re-projected or re-scaled without loss of information. It is also possible to convert a vector product to raster if necessary. These qualities make the vector format attractive to the researchers who are the main users of the GDSIDB. In addition, charts in SIGRID-3 format will be easy for ice centres to produce ice charts using many of the current production systems that employ Geographical Information Systems (GIS).

2.6.3 The meeting noted that for SIGRID-3 to be successful it will rely upon two different established formats. The first portion of SIGRID-3 relies upon Environmental Systems Research Institute's (ESRI) open and published Shapefile format. Shapefiles are a format that is open and in fairly common use by ice centres. They consist of three core files, and may include several optional files. Each file in the set shares the shapefile name with a different extension. The main file (*.shp) stores the geometry and must always have an index file (*.shx). A database file (*.dbf) stores all the attributes of the shapes in the main file. Using commercial software, each centre can easily produce and exchange ice charts. Shapefiles can be produced and utilized without commercial software but this requires the development of custom software.

2.6.4 The second portion of SIGRID-3 uses the widely accepted, public domain eXtensible Markup Language (XML) to store the metadata information of ice chart generation. The advantage of XML is that information is readily stored, it is easily searched via the Internet, and the metadata can be read using a web browser. XML will be used to store the metadata that pertains to each ice chart. The Metadata will include projection, location, keywords, and contact information for additional information. XML provides an easily readable metadata and an excellent way of searching for the ice chart across the web.

2.6.5 All together there will be four files that make up the basic requirements of SIGRID-3: three for the ice chart in Shapefile format and one for the metadata in XML format (all described in the following sections). All together, they provide an archive format that is easily shared and broadly acceptable.

2.6.6 The session recognized that the proposed draft format should be revised by ETSI members and sent to national agencies for comments, and then submitted to Secretariat for approval by appropriate WMO bodies. **(Action: ETSI Chairman, Members, Secretariat)**

2.7 ETSI future activities and working plan for the next intersessional period

2.7.1 The session was introduced to a document containing a detailed work plan and strategy for the Expert Team on Sea Ice. The meeting reviewed, corrected and agreed the ETSI strategy and work plan, which were based on the plan approved by the JCOMM-I. The meeting noted that ETSI will provide in future specific strategic tasks including review and advice on scientific, technical and operational aspects of sea ice observations and forecasting, coordination of service development, training and cooperation with international programmes. The final version of the agreed strategy and work plan are reproduced in *Annex XI.*

3. NINTH SESSION OF THE STEERING GROUP FOR THE GDSIDB

Reports of the GDSIDB centres
Development of sea ice historical data processing

3.1 The meeting noted with interest progress achieved by the Steering Group (SG) for the GDSIDB. It was informed that during the first JCOMM session the Commission expressed its appreciation to the SG for the considerable and very valuable work accomplished during the period after CMM-XII. The Commission in particular noted with satisfaction that cooperation among sea-ice experts from the Russian Federation, Finland, Sweden, Canada, Denmark, Japan and USA had resulted in the inclusion, within the GDSIDB, of newly digitized data sets for Arctic and Antarctic areas, including data sets from the Sea of Okhotsk, Baltic Sea and Canadian Arctic Area. It was noted with appreciation that Argentine Naval Hydrographic Service will continue to submit information on sea ice observations to the GDSIDB`s centres (NSIDC, Boulder, USA and AARI, St Petersburg, Russian Federation), as well as the offer by China to contribute data to the GDSIDB.

3.2 The meeting was presented with reports by experts from two GDSIDB centres at the Arctic and Antarctic Research Institute (AARI, St. Petersburg; Russian Federation, *Annex* XII) and the USA National Snow and Ice Data Centre (NSIDC, Boulder, CO, USA; *Annex XIII*) on the status of these centres activities during the intersessional period, including contributions of sea ice data sets to the bank from Member States, development of formats, archiving processes, and project visibility**.** Experts of the steering group for the GDSIDB, co-chaired by Professor Roger Barry from the WDC for Glaciology, Boulder, and Dr Ivan Frolov from AARI, continue to provide QC and software enhancement for archived data for the support of climate oriented programmes. GDSIDB has a plan to access a number of additional sea ice data sets to be digitized for Arctic and Antarctic areas, as well as for the Baltic Sea, the Sea of Okhotsk, the Bohai Sea and Greenland waters.

3.3 Ms F. Fetterer, representative of USA with the GDSIDB steering group on behalf of GDSIDB co-chairman Prof R.G.Barry informed the session on activities of NSIDC. The session noted that the GDSIDB at NSIDC acquired a more visible identity with the publication of project web pages in 2002. The NSIDC GDSIDB site (http://nsidc.org/noaa/gdsidb) describes GDSIDB origins, structure and meetings with links to JCOMM and WMO, links to GDSIDB reports and other material at the AARI GDSIDB and a link to the IICWG participants, since many of these are also GDSIDB contributors. The format page briefly describes the 1981 proposal for SIGRID, SIGRID (SIGRID-1), SIGRID-2, Contour, and the proposed SIGRID-3, with links to documents that have complete descriptions. The site joins the IICWG website (http://nsidc.org/noaa/iicwg/) at NSIDC in publicizing the contributions of the world's operational ice services to the research community.

3.4 The session noted that NSIDC and NIC have expanded a Memorandum of Understanding on archiving NIC chart products to include digital ice charts as well as historical paper products. There will be an entry for NIC Arctic and Antarctic NIC charts in on-line catalogue (http://nsidc.org/data/catalog) in 2003. Digital chart products are archived permanently in partnership with the NOAA National Geophysical Data Center (NGDC), with which NSIDC is affiliated.

3.5 The session was informed that NSIDC has continued to work on the development of the SIGRID–3 format with the AARI GDSIDB and IICWG members. During the intersessional period, the NSIDC GDSIDB received data from the CIS for 1999-2000, the 2000 and 2001 Weekly Ice Analysis covering Greenland from the DMI and files for 2000 and 2001 from the JMA. In addition, JMA provided replacement files for their data from 1970 through 1999, owing to a change in map data and method of conversion from bmp to SIGRID-2 format. JMA's Takanori Matsumoto visited NSIDC on 3-5 April, 2002, and presented NSIDC with copies of ice charts from around Hokkaido and the Kuril Islands, 1937-1944.

3.6 The session noted the report submitted by the AARI expert V.Smolianitsky. He informed that during intersessional period ETSI continued to provide guidance on the WMO GDSIDB project. GDSIDB pages (http://www.aari.nw.ru/gdsidb) were extended and now incorporate working information on ETSI activities. More than 4500 visits were logged to that web-page from July 1999, which makes about 10 visits per 1 day.

3.7 Presently the GDSIDB at AARI holds 7 or 10-days period mapped ice data for the Arctic starting from March 1950 and for Antarctic from January 1973 and to near the present for both regions. Charts are stored in a number of digital formats including WMO standard SIGRID, EASE-GRID and ESRI GIS ArcInfo compatible. Most of the project data are available on-line from GDSIDB centres or in recently published Joint U.S.- Russian Arctic Atlas for Sea Ice. GDSIDB material can be regarded as the source of the most robust statistics (norms) for the ice conditions in the Arctic during 1950s-1990s. Project content is expanding, more data are awaiting or expecting for Antarctic region from Australia, Argentina, Russia; extended and updated data for the Northern Polar Region and new data for the Baltic Sea, Sea of Okhotsk, Bohai Sea, Greenland waters.

3.8 The session noted that a report on the GDSIDB was presented at the recent "Workshop on Advances in the Use of Historical Marine Climate Data" (29.01-01.02.2002, Boulder, Colorado, NOAA, CDC). Based on above discussions and concerns a set of recommendations related to cooperation with ETSI and GDSIDB were elaborated for the workshop documents, including blended GDSIDB and COADS products, products for Southern Hemisphere, sea ice in summer period. The session was further noted that several reports on GDSIDB activities, including assessment of climatic trends in sea ice and development of new data formats, were presented SG members at the ACSYS/CliC Workshop on "Sea Ice Extent and the Global Climate System", held at Meteo-France in Toulouse from 15 to 17 April 2002.

3.9 The meeting was provided with separate overview reports of SG members on sea ice historical data processing maintained in their services, including preparation of historical archives on the basis of operational sea ice products, QC, climate data applied in operational practice, requests from the users for historical ice products, etc.

Submission of new sea ice data to the GDSIDB

3.10 The meeting noted further that the National Ice Center (*Annex* IV, *p. 51)* is working to provide the GDSIDB a complete and very extensive set of sea ice data for the Arctic 1972-2002 and Antarctic data 1973-2002. The NIC’s sea ice data consists of weekly regional JPEG and/or GIF and Arc Export coverage (e00’s) and Hemispheric e00’s through mid-June 2001. Starting in mid-June 2001 and into 2002 most NIC Arctic and Antarctic areas are analyzed bi-weekly. Great Lakes and Alaskan regional coverage are produced twice per week. Chesapeake Bay and Delaware Bay Sea ice coverage are available when ice conditions warrant. NCI's climatological dates were documented in a Canadian Journal of Remote Sensing paper. A paper analyzing the NIC dataset in relation to climate trends is in progress.

3.11 The meeting welcomed the future activities of NIC, which will include sea ice datasets to be submitted to GDSIDB from polar areas. It was noted further that the NIC received NOAA funds through Environmental Services, Data, and Information Management Programme (ESDIM) for three years (2002-2004) to create an Antarctic historical database 1973-2001. The ESDIM money allows for the funding of a part time contractor who will provide quality control to the data set 1973-2001 (provided funding is sufficient). Work has been started by the NIC and the University of Delaware, a partner in the digitising effort, to complete digitisation of the 1995-2001 charts and to add to the 1973-1994 charts already digitized.

3.11 The meeting considered that from 1995-2000, only a few digital Antarctic hemispheric charts were created and no QC has taken place. The data in this time span comes in a variety of formats and will be jointly worked on by the National Ice Center and the University of Delaware**. (Action: NIC, Approximate Completion October 2005).** The majority of the 2001-2002 charts are already in hemispheric digital format. NIC is currently quality controlling 2001 charts while awaiting delivery of the digitized 1995-2000 charts. (Action: NIC, Approximate completion August 2003). Quality control of the Antarctic digital data set from 1973-1994 has been designated as lower priority. **(Action: NIC, Approximate Completion for the entire data set 1973-2002 end of 2007)**

3.12 NSIDC/GDSIDB will archive NIC data in the future in the following formats:

- NIC will switch to Hemispheric Shapefiles by January 2003.
- NIC will convert to Sigrid-3 format when approved by WMO.
- Regional JPEG's and Regional e00's into the future.
- NIC retains the .e00 hemispheric coverages and also places them in deep archive at the National Climatic Data Center. These files can be archived at GDSIDB as well, if there is interest.

3.13 The session supported the contributions which DMI was making to the GDSIDB. According to the GDSIDB work plan for May 2000 to October 2002 (see annex VII, JCOMM Meeting Report No. 5) the digital weekly charts from 2000 and 2001 have been made available to GDSIDB since the 8th session meeting. It is the plan to continue transfer of the weekly charts to the GDSIDB as they become available during the next intersessional period. **(Action: DMI)**

3.14 The meeting expressed its appreciation that JMA provides the sea ice data in the sea of Okhotsk to GDSIDB every 5 days, from December to May in 1970-2001 and that it issues operationally, sea ice information including forecasts for safety of ship cruising and the two types of sea ice charts named Ice Condition Chart and Ice Forecast Chart (*Annex IV, p. 46*) promulgated through the meteorological radio facsimile.

3.15 The session also noted with interest that in response to the growing interest in Arctic climate change and its potential impacts, the CIS completed its digital database of sea ice charts and used the database to publish a number of reports on sea ice trends in the Canadian Arctic. This digital database contains weekly charts from 1969 to 2001 spanning all Canadian offshore ice-covered waters (Hudson Bay is from 1971 only). The intention is to make this database available freely to the scientific community from the CIS website (http://ice-glaces@ec.gc.ca). (**Action: CIS)** As soon as the SIGRID-3 format for archive chart exchange is approved, these charts will be submitted to the World Data Centres and the GDSIDB **(Action: CIS).** The full text of information on sea ice data from Canada to GDSIDB is in *Annex IV, p. 32*.

3.16 Mr Grafström provided the information that some progress has been made by SMHI during 2002 on outlining the successor to ICEMAP, the current mapping system at SMHI developed in the beginning of the 1990´s. SMHI anticipates providing charts in SIGRID-3 format beginning in 2004.

3.17 The meeting was also informed on the status of the ongoing project to provide sea ice data sets from the Baltic Sea to GDSIDB. It was noted that the procedure of digitising the ice conditions in Baltic region for period of 1980 – 1994 continues but is not yet finalized; period 1989-2002 is digitized, quality control however remains before transmitting the data set to GDSIDB; period 1980-1988 is not yet digitized. The session also noted with interest the future plans of SMHI which include:

- Digitizing continues during the autumn 2002, in total another approximately 6 months effort is needed to complete the period 1980 – 2002;
- Quality control;
- Interaction with GDSIDB concerning formats and transmission.

3.18 The session was informed by Mr M. Picasso that during the intersessional period the Glaciological Division of SMARA continued to send sea ice observations to NSIDC and AARI from five Argentine Bases (Orcadas, Jubany, Esperanza, Marambio and San Martín), from the Icebreaker A.R.A. “Almirante Irizar”, the Oceanographic Ship A.R.A. “Puerto Deseado” and other auxiliary ships of the Argentine Navy. During next months the files of sea ice observations, here in the Southern Hemisphere, will be available as new products of the Argentine Centre of Oceanografic Data (CEADO), Argentine Naval Hydrographic Service, and will be also replicated at the SMN.

Sea ice products based on GDSIDB data

3.17 The meeting noted that the JCOMM-I, recognizing the direct value of the GDSIDB to the WCP and WCRP recommended to WMO and IOC continue to support the valuable work of the steering group for the GDSIDB during the next intersessional period. It agreed with the proposed project objectives for this period, which are included in the overall JCOMM’s work plan. The GDSIDB project now incorporates the most extensive amount of historical sea ice information for the 20th century and is capable of providing vital information for numerical modelling, testing of remotely-sensed data as well as for estimation of global changes or oscillation of sea ice cover. In the light of those consideration the members of the GDSIDB informed the meeting on the status of sea ice climatic products, based on GDSIDB data, and comparison of different sea ice statistics from other sources such as numerical ice cover prediction models. The meeting discussed the reports and investigated the means aimed to facilitate utilization of GDSIDB data within WCP and WCRP.

New contribution to the GDSIDB from the Member States

3.19 The members of the steering group provided proposals on new sea ice data sets to be submitted to the bank during the next intersessional period.

Working plan for the next intersessional period

3.20 The session discussed and adopted a comprehensive work plan for the SG for the GDSIDB for the next intersessional period, based on requests and proposals from international projects and programmes, which are included in the overall JCOMM work. It was noted that this work plan *(Annex XIII)* will be implemented through the steering group, in close cooperation with the ETSI.

3.21 The session noted that the NSIDC GDSIDB, as the only non-operational centre at the GDSIDB SG meeting, expressed sincere gratitude to the operational ice services for their voluntary participation in the GDSIDB. It was also appreciated that notwithstanding limited funds for data management, the contributed data sets are of great value to the scientific research community.

4. RELATIONS TO OTHER WMO/IOC AND OTHER INTERNATIONAL PROGRAMMES

4.1 The meeting recognized the close collaboration of the ETSI with WCRP, GCOS, CliC, IICWG and BSIM. The meeting noted the reports presented by the chairman of the ET on GDSIDB activities at the Workshop on Advances in the Use of Historical Marine Climate Data (Boulder, Colorado, USA, January-February 2002), the 17^{th} Conference "Okhotsk Sea and Sea Ice" (Mombetsu, Japan, February 2002) and the ACSYS/CLiC Workshop on Sea Ice Extent and the Global Climate System (Toulouse, France, 15-17 April 2002). The first workshop recommended to the ETSI and to the steering group for the GDSIDB to develop blended sea ice variables for global climate reanalysis and to prepare historical sea ice data information for the Southern Ocean during 2002-2004. Based on above discussions and concerns following draft recommendations related to cooperation with ETSI and GDSIDB were elaborated for the workshop documents. (**Action: SG GDSIDB, ETSI Chairman, Members)**

- It is critical for the 2002-2003 that a blended product based on GDSIDB data and existing one (Arctic wide total concentration in COADS) be derived, as it is vital for accurate global analyses of SST and sea ice climate. Estimates of errors should be determined in the blended product.
- It is desirable to ask SG GDSIDB to provide recommendations for proper and best-guess blending and averaging procedures.
- Inventory from ETSI on possibly available historical sea ice data for the Southern Ocean is desirable during 2002-2004.
- It will be useful to consider a future (in 2002 or 2003) JCOMM report from ETSI on assessing stages of melting using visible and microwave and its correspondence to visible ice surface features. Techniques provided in the report may be possibly used during 2003-2005 for retrospective calculations of stages of melting.
- It is also important that during 2002-2005 SSM/I algorithms be examined in cooperation with ETSI using ice charts and standard observations as ground truth material so that the most accurate one is selected. Differences between algorithms may help define the errors. For those purposes it would be helpful if the location and type of observations were indicated in the blended product.

4.2 The session further noted with interest and appreciation information of Ms F.Fetterer that NSIDC continues to be active in the World Climate Research Programme's Arctic Climate System Study (ACSYS)/ Climate and Cryosphere (CliC) projects. A poster on Ice Chart Archive Formats: Progress in the International Ice Charting Working Group was presented at the ACSYS/CliC meeting on Sea Ice Extent and the Global Climate System, 15-17 April, Toulouse, France. At the ACSYS/CliC Moored Upward Looking Sonar meeting in Tromso, Norway, 1-3 July, NSIDC contributed to discussions on coordinating processing and archival of data from moored instruments. NSIDC expects to receive about 65 buoy years of data from Australian, Canadian, German, and U.S. research groups.

4.3 An ad hoc meeting to discuss a U.S. CliC programme (analogous to U.S. CLIVAR) was coordinated by R. Barry, held in Washington, DC 10-11 January, 2002, and attended by some 20 scientists, and 14 U.S. funding agency representatives. Two topics were addressed: the need to designate a U.S. focal point for WCRP and any U.S. CliC activities, and the potential role and representation of a U.S. CliC Science and Coordination Committee (SCC). Possible terms of reference for such a committee were presented, and recommendations were submitted to potential agency sponsors of these activities.

4.4 Recognizing the direct value of the GDSIDB to scientific programmes, as well as to services and other sea-ice activities, the meeting stressed the importance of continuing this valuable work of the ETSI during the coming inter-session period**.**

4.5 The Meeting expressed the desire to share conference and workshop information among the ETSI and GDSIDB members as a means of extending our collective knowledge. **(Action: ETSI)**

4.6 The session reviewed the information presented by K.Strübing on the European international activity on the Global Monitoring of Environment and Security (GMES) Programme. A Norwegian proposal on a virtual ice centre was noticed with interest.

5. DATE AND PLACE OF THE NEXT MEETING

5.1 The meeting recognized that it would need to meet again during the present JCOMM-I ntersessional period, to review progress on the many action items and to begin the preparation of appropriate actions and recommendations for JCOMM-II. It suggested that ETSI and GDSIDB might be timed to take place in Germany or in China during the second part of 2004. The chairman and Secretariat were requested to finalize arrangements for the timing and venue for the meeting in due course, and notify group members accordingly.

6. CLOSURE OF THE MEETING

6.1 The meeting reviewed and approved the final report of the meeting, including action items and recommendations.

6.2 In closing the meeting, the chairman thanked all participants for their valuable input to what had been a very productive meeting, and looked forward to working with ETSI and GDSIDB members on the many ongoing action items during the remainder of the intersessional period. He also thanked the Secretariat for its continuing support. Speaking on behalf of all participants, Mr J.Falkingham thanked the chairman for his substantial input and wise guidance for the Group, both during the meeting and outside.

6.3 The first session of the JCOMM Expert Team on Sea Ice and the ninth session of the Steering Group for the Global Digital Sea Ice Data Bank closed at 1300 hours on Friday, 25 October 2002.

Annex I

LIST OF PARTICIPANTS

Cheryl A. Bertoia
Co-chairman of IICWG
National Ice Center
4251 Suitland Road
FOB4 Room 2301
USA
Telephone: +1-301 394 3005
Telefax: +1-301 394 3200
E-mail: Cheryl.Bertoia@noaa.gov

John Falkingham
Chief, Ice Forecasting Services
Canadian Ice Service
373 Sussex Drive
OTTAWA, Ontario
Canada K1A OH3
Telephone: +1-613 996 4552
Telefax: +1-613 996 4218
E-mail: john.falkingham@ec.gc.ca

Florence Fetterer
National Snow and Ice Data Center
Cooperative Institute for Research and Environmental Sciences (CIRES 449 UCB)
1540 30th Street
BOULDER, CO 80309-0449
USA
Telephone: +1-303 492 4421
Telefax: +1-303 492 2468
E-mail: fetterer@kryos.colorado.edu

Ivan Frolov
Director
The Arctic and Antarctic Research Institute (AARI)
38, Bering Street
ST PETERSBURG 199397
Russian Federation
Telephone: +7-812 3521520
Telefax: +7-812 352 27 91
E-mail: frolov@aari.nw.ru

Torbjörn Grafström
Swedish Meteorological and Hydrological Institute (SMHI)
S-601 76 NORRKOPING
Sweden
Telephone: +46-11 495 8533, 495 8535
Telefax: +46-11 495 8403
E-mail: Torbjorn.Grafstrom@smhi.se
(ice@smhi.se)

Takanori Matsumoto
Scientific Officer
Office of Marine Prediction
Marine Division
Climate and Marine Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku
TOKYO 100-8122
Japan
Telephone: +81-3 3212 8341 Ext. 5156
Telefax: +81-3 3211 2300
E-mail: matsumoto@met.kishou.go.jp

Vasily Smolyanitsky
Chairman, JCOMM Expert Team on Sea Ice
Arctic and Antarctic Research Institute (AARI)
38, Bering Street
ST PETERSBURG 199397
Russian Federation
Telephone: +7-812 352 2152
Telefax: +7-812 352 2688
E-mail: vms@aari.nw.ru

Klaus Strübing
Chairman, BSIM
Bundesamt für Seeschiffahrt und Hydrographie (BSH)
Bernhard-Nocht-Strasse 78
20359 HAMBURG
Germany
Telephone: +49-40 3190 3120
Telefax: +49-40 3190 5032
E-mail: klaus.struebing@bsh.de

Wu Huiding
National Marine Environment Forecast Centre
8, Dahuisi Road, Haidian District
BEIJING 100081
China
Telephone: +86-10 6217 3322 ext. 146
Telefax: +86-10 6217 3620
E-mail: hdwu@nmefc.gov.cn

Miriam Andrioli
JCOMM Capacity Building PA Coordinator
Member JCOMM Management Committee
National Weather Service of Argentina
25 de Mayo 658 (I002)
Buenos Aires
Argentina
Telephone/Telefax: (54-11) 5167-6711
E-mail: andrioli@meteofa.mil.ar

Beatriz E. Lorenzo
DTO Meteorologia-Glaciologia
Servicio de Hidrografia Naval
Av. Comodoro Py 2055 Piso 15 OF 23
Argentina
Telefax: 54 11 4317 2309
E-mail: lorenzo@ara.mil.ar

Manuel Hipolito Picasso
Servicio de Hidrografia Naval
Av. Montes de Oca 2124
1271 Buenos Aires
Argentina
Telephone: +54 11 4301-7576
Telefax: +54 11 4303-2298
E-mail: picasso@ara.mil.ar

Thor Edward Jakobsson
Icelandic Meteorological Office
Bustadavegur 9,
150 Reykjavek
Iceland
Telephone: +354 522 6000
Telefax: +354 522 6001
E-mail: thor@vedur.is

Mikhail N. Krasnoperov
Ocean Affairs Division
World Weather Watch-Applications
Department
World Meteorological Organization
7 bis, Avenue de la Paix
Case postale No 2300
CH-1211 GENEVE 2
Switzerland
Telephone: +41-22 730 82 23
Telefax: +41-22 730 80 21
E-mail: krasnop@www.wmo.ch
Telex: 41 41 99 OMM CH

Annex II

AGENDA

21 - 23 October, 2002

1. Opening of the meeting

1.1 Opening
1.2 Adoption of the agenda
1.3 Working arrangements

2. First session of the JCOMM ETSI

2.1 ETSI terms of reference and future activities
2.2 Report by the Chairman of the ETSI
2.3 Reports by the members of ETSI
2.4 BSIM report
2.5 IICWG report
2.6 WMO sea ice documents and publications
2.6.1 Sea ice nomenclature
2.6.2 Colour standard for ice charts
2.6.3 Ice decay/stages of melting
2.7 Formats for operational and historical sea ice data exchange
2.8 Working plan for the next intersessional period

24 - 25 October, 2002

3. Ninth session of the Steering Group for the GDSIDB

3.1 Reports of the GDSIDB centres
3.2 Development of sea ice historical data processing
3.3 Submission of new sea ice data to the GDSIDB
3.4 Sea ice products based on GDSIDB data
3.5 New Contributions to the GDSIDB from Member States
3.6 Working plan for the next intersessional period

4. Relations to other WMO/IOC and international programmes
5. Data and place of the next sessions
6. Closure of the sessions

Annex III

REPORT OF THE CHAIRMAN OF THE EXPERT TEAM ON SEA ICE

Introduction

1. The Expert Team on Sea Ice (ETSI) was formally constituted at JCOMM-I as a part of the JCOMM Services Programme Area (SPA). Initial work plan for the ETSI was developed at JCOMM-I and included in the JCOMM intersessional work programme. Mr Vasily Smolyanitsky was elected the chairman of the ETSI. The members of the ETSI presently comprise the chairman (and ex-officio member of the Team), nine experts representing the national services related to sea ice and the ice-covered regions from Argentina, Canada, China, Denmark, Germany, Iceland, Japan, Sweden and USA, and invited representatives of regional and international sea ice bodies in particular the Global Digital Sea Ice Data Bank (GDSIDB) project, the Baltic Sea Ice Meeting (BSIM) and the International Ice Charting Working Group (IICWG).

Strategy and workplan for the ETSI

2. The period after JCOMM-I has been one of update, since ETSI incorporated most of the working aspects from the former WMO CMM Subgroup on Sea Ice. The strategy and work plan firstly developed at JCOMM-I were revised and updated at the ad-hoc ETSI meeting during the 3rd meeting of the IICWG in November 2001 (Tromso, Norway), during November 2001 – January 2002 by correspondence between ETSI members, in January 2002 were submitted to the SPA chairman for the first session of the JCOMM Management Committee and in April 2002 were reviewed and extended at the first meeting of Services Programme Area Coordination Group (SPA-I). Strategy and work plan items shown beneath closely follow the submitted documents.

3. The SPA-I meeting also discussed a report by the ETSI chairman, regarding the present status and effectiveness of its activities during the intersessional period since the last meeting (Ottawa, May 2000), and plans for the future and noted that substantial progress had been made in the implementation of the previous work plan. The meeting noted and approved the ET strategy and work plan, which are based on the plan developed by the JCOMM-I, revised and updated by ETSI members during November 2001 - January 2002. The meeting noted that ETSI will provide in future specific strategic tasks including review and advice on scientific, technical and operational aspects of sea ice observations and forecasting, coordination of service development, training and linkages with major international programmes as well as close cooperation and supervision of the GDSIDB project, WCRP, GCOS and CliC.

4. The SPA-I meeting noted a provisional agenda and an annotated provisional agenda for ETSI-I meeting and recommended to include additional item on marine safety services. The meeting also recommended and the chairman of ETSI agreed to prepare information documents on the status of ETSI activities for other SPA expert teams meetings.

5. After reviewing various actions taken by the joint JCOMM Secretariat in support of the Commission and other SPA activities the SPA-I meeting outlined several other action items general for SPA expert teams. All these action items are listed below after "<u>Ongoing/Moderate Priority</u>" tasks list.

Strategy

5. Similar to other bodies, ETSI should answer both general and specific strategic tasks:

- Provide advice to the Services CG and other Groups of JCOMM, as required on issues related to sea ice and the ice-covered regions;
- Review and advise on scientific, technical and operational aspects of sea ice observations and forecasting, oversee operations of the GDSIDB, coordinate services development and training and linkages with major international programmes.

Workplan

6. The following significant short and long-term tasks have been identified for the plan (in brackets – nearest corresponding listing numbers from the JCOMM work plan):

Urgent/High Priority

Develop amendments and during the first ET meeting in October 2002 review a draft revision of the WMO Sea Ice Nomenclature, for approval by the co-presidents and publication by WMO (para 6.3.9);

Intersessional/Moderate Priority

- Develop amendments to the Sea Ice Nomenclature for colour standards of ice charts and coding sea ice decay from remotely sensed data (para 6.3.8);
- Develop and revise Sea Ice Nomenclature, terminology, data formats and software codes (para 6.3.15);
- Review and provide guidance on the GDSIDB (Global Digital Sea Ice Data Bank project) including QC, error analysis and archiving and recommend action (Res. 16/2);
- Develop techniques and capabilities to systematically measure ice thickness by means of remote sensing (para 6.3.15);
- Prepare historical sea ice data sets (para 6.3.15);
- Review and catalogue products and services required in sea ice areas (Rec. 16/2);
- Provide support to Southern Hemisphere countries to enhance Antarctic sea ice services (para 6.3.15)

Ongoing/Moderate Priority

- Develop technical guidance, software exchange, specialized training and other capacity building support concerning sea ice observations and services (Res. 16/2);
- Develop cooperation and coordination with climate oriented programmes such as WCRP, WCP and CLIC (para 6.3.15);
- Continue collaboration with BSIM, IICWG and ECDIS (para 6.3.19)

Ad-hoc additional ongoing/Moderate Priority

8. The SPA-I meeting recommended:

- ETSI chairman to prepare information documents on the status of ETSI activities for the first session of the Data Management Coordination Group (Paris, May 2002) and the first session of the Observations Coordination Group (La Jolla, USA, April 2002);
- To include in the ETSI-I agenda a separate item on the dissemination of sea ice information to shipping and other marine users, including through INMARSAT SafetyNET, as part of the GMDSS;

- To prepare a report on this issue for the first session of the Expert Team Maritime Safety Services (Lisbon, Portugal, 11-14 September 2002);
- To prepare a progress report on electronic charts for ETMSS, based on discussion at ETSI-I on graphical products;
- To review during the forthcoming meeting relevant to the ET topic requirements for marine observational data to support the provision of all types of marine services (included as appendices 1, 2 and 3). It is expected that this process should be completed in October 2002.

9. The SPA-I meeting recommended all SPA ET members to:

- Visit the UN Atlas of the Oceans (http://www.oceansatlas.org/) once it was formally opened to the public on 6 June 2002, and offer comments and suggestions as appropriate regarding its enhancement within the context of JCOMM and its work;
- Visit the new JCOMM web portal being hosted by IOC (http://www.jcomm.net/), provide comments and suggestions as appropriate, and also make use of the portal as a means for information exchange in support of JCOMM;
- Provide the Secretariat with suggestions regarding a JCOMM logo;
- Visit the JCOMM Electronic Products Bulletin (JEB), provide support and technical proposals for JEB Editorial Board chaired by Dr I.Tourre. In particular, during SPA-I meeting it was tentatively agreed that ice products, now absent in JEB, for the Arctic and Antarctic, developed within the GDSIDB will be implemented in JEB.

10. It is expected that during ETSI-I participants will review and take into consideration the above terms of references, tasks and action items, provide necessary amendments, as well as include additional agenda items on Southern Region ice products, related to sea ice data requirements, MSS.

Implementation of the work plan

Progress on revision of WMO Sea Ice Nomenclature

11. In July 2001, a draft version of the WMO Sea Ice Nomenclature in XML format was developed and published at http://www.aari.nw.ru/gdsidb/XML/si_xml.asp. It is expected that the given material will be also a part of a broader JCOMM XML Marine Glossary currently under development. The XML version of the nomenclature is also interlinked with a future new SIGRID-3 format for sea ice charts coding also utilizing XML technology. Other amendments to the nomenclature, to be discussed at ETSI-I include extensions for ice decay and ice chart colour coding, additional proposals from Canadian and Russian ice services.

Development of new standards for sea ice charts, including colour coding, ice decay and incorporation of sea ice information in electronic charting systems (in collaboration with IICWG)

12. In collaboration with the IICWG ETSI developed proposals for a) colour standards of ice charts, b) sea ice decay from remotely sensed data and c) for a new format for operational and historical sea ice mapped data exchange. It may be noted that standardization of colour coding for ice charts is a part of a longer term strategy to place ice information in electronic navigation charts and reflects collaboration between the ice community, JCOMM and such international organization as ECDIS, IMO, and IHO. Similar, ice decay from the remotely sensed data and a new format for data exchange are a part of a long-term strategy to extend the scope of information supporting ice navigation and to facilitate its relay to end-users.

Colour coding

13. During the 2000-2002 period, IICWG ice experts succeeded in preparation of the draft colour standard which, according to the decisions of the 3rd IICWG meeting (November, 2001) includes two mutually exclusive separate colour codes: one mainly based on total concentration and another based on stage of development. Proposed codes are complementary to the existent WMO black and white ice symbols and are flexible in use (for ice services). It is planned that ETSI-I will discuss and adopt the draft and recommend steps for its further implementation.

Ice decay

14. Extension of summer season ice description by introducing ice decay parameter measured from radar back scatter is a result of research undertaken by Canadian Ice Service experts, under the Arctic Sea Ice Regime Shipping System (AIRSS). The JCOMM-I agreed that as a result of this work, appropriate amendments to the nomenclature for coding sea ice decay should be developed during the next intersessional period. During the last 3rd IICWG meeting it was agreed for IICWG experts from Canada and Russian Federation to investigate inter-relationship between traditional stages of melt and new ice strength index with respect to physical process in seasonal cycle and movement of ships in ice, to improve exchange of ice melt / strength science (past, present, future) within IICWG. This action item may be recommended for prolongation to the next intersessional period.

New format for operational and historical sea ice mapped data exchange

15. Currently used formats for ice chart coding SIGRID (Sea Ice Grid) and SIGRID-2 were introduced by WMO in 1981 and in 1994 respectively and allow storing primarily climatological data. Presently within the GDSIDB project practically all historical sea ice data for 1950-2001 period are kept in this format. In comparison to a number of commercial standards SIGRID format has an advantageous capability of comprehensive depiction of sea ice parameters. However, it has a number of restrictions and inconveniencies to be kept as a practical operative format. So far most ice services are no longer submitting data to GDSIDB in SIGRID. Based on the current international practices utilizing GIS for chart production and using SIGRID code tables for quantitative description of sea ice parameters, IICWG ice experts succeeded in preparation of the so-called "SIGRID-3" draft format for sea ice data operational and climatological exchange. Harmonization of the draft was made by electronic correspondence and phone conference during summer 2002. It is planned that ETSI-I will discuss the draft and recommend further steps for its implementation.

16. The above three items are complimentary to existent WMO technical guidance material and are presently under active discussion. Comprehensive reports will be prepared by October 2002 for revision at ETSI session and will serve as a basement to provision of amendments to WMO Sea Ice Nomenclature.

Remote sensing of sea ice parameters including training

17. The following new products and initiatives were noted by or related to ETSI members:

- Remote sensing of ice decay is now actively developed by Canadian Ice Service and is discussed above;
- In cooperation with German Ice Service, BSI's Marine Climatology Section has developed a new Video Product on Global (hemispheric) Sea Ice Distributions. The product and background info can be addressed via the following web sites:
- http://www.bsh.de/Oceanography/Ice/Publications.htm
- http://www.bsh.de/Oceanography/Climate/Climate.htm

- IWICOS (Integrated Weather, Sea Ice and Ocean Service System) is now collaboratively developed by the Danish Meteorological Institute, the Finnish Institute of Marine Research, the Icelandic Meteorological Office and other technical groups and is hosted by the Technical University of Denmark, Danish Centre for Remote Sensing at:
- http://www.dcrs.dtu.dk/sea-ice/
- USA National Ice Center developed an “International Ice Chart Working Group Training Cite”; cite comprises guides to analysis of satellite imagery, ice physics and ice covered seas specific info and is now available at:
- http://www.natice.noaa.gov/IICWG%20WEB/page2.html
- Arctic and Antarctic Research Institute started a special web pages for the Russian Antarctic Expedition / Russian Programme Antarctic. Portal contains reference information for Russian Antarctic stations, on-line climatological data and daily estimates of Antarctic ice coverage. Information is available at: http://www.aari.nw.ru/south

It is expected that during ETSI-I given list will be commented, extended and complemented by the participants.

Planning for SI-I, Buenos Aires, Argentina, 21 to 25 October 2002

18. A draft annotated agenda was collaboratively prepared by ETSI members for the first session of the ETSI combined with the ninth session of the GDSIDB project planned to be held in Buenos Aires, Argentina, 21 to 25 October 2002, and hosted by the Argentinean Navy Hydrographic Service. It is planned that the Sessions will provide progressive reports and elaborate updated implementation plan for the full scope of ETSI and GDSIDB tasks.

19. Prime items of 1st session of ETSI are planned to include:

- report by the Chairman of the ETSI;
- reports by the members of ETSI, BSIM and IICWG reports;
- WMO sea ice documents and publications, including sea ice nomenclature, colour standard for ice charts, ice decay/stages of melting, Formats for operational and historical sea ice data exchange;
- ETSI future activities and working plan for the next intersessional period;
- Prime items of 9th session of GDSIDB project are planned to include:
  - reports of the GDSIDB centres;
  - development of sea ice historical data processing;
  - submission of new sea ice data to the GDSIDB;
  - sea ice products based on GDSIDB data;
  - new Contributions to the GDSIDB from Member States;
  - working plan for the next intersessional period;
  - relations to other WMO/IOC and international programmes.

Annex IV

SUMMARY REPORTS OF THE MEMBERS OF ETSI

Report of Argentina

Introduction

1. The Glaciological Division of the Argentine Navy Meteorological Service (SMARA), at the Naval Hydrographic Service (SHN), is the head office responsible for operational sea ice support in the Weddell and Bellingshausen Seas, mainly from 25°W to 70°W, and beyond those limits under special requirements. All the activities are devoted to fulfil the Argentine Navy demands and needs, but also service is provided to any navigator requesting sea ice conditions in those areas.

2. The Naval Río Grande Meteorological Central, Province of Tierra del Fuego works jointly with the SMARA's Glaciological Division, giving sea ice overviews to mariners. Finally, the Meteorological Office on board the Icebreaker A.R.A. "ALMIRANTE IRIZAR" (AI) provides full sea ice support to its Command and to any ship that requests service, but only when AI is at sea. In both cases the areas covered are the same of the above paragraph.

Antarctic Treaty

3. Rules activities of all countries South of latitude 60°S. Its outstanding points are those related to the inhibition of economic activities and national sovereignty claims, preservation of the Antarctic environment, and protection of its living marine resources.

ETSI related activities

4. In order to maintain operational skills the following tasks are carried out: *Sea ice visual observations programme*. Is a permanent cooperative effort between civilian and military institutions, mainly sustained by the Argentine Navy, the SHN, the Argentine National Meteorological Service (SMN) and the Antarctic Army Command. Code messages IISS (for ship observations) and IILL (for coastal observations) are used after annual training of personnel, renewed each year, in a fifteen course held at SMARA. Up to now almost five hundred persons have been formed. IISS and IILL messages are transmitted in real time to the National Ice Center (NIC) and sent to the National Snow and Ice Data Center and Arctic and Antarctic Research Institute (AARI) after being validated through sanity checks. By the end of this year IISS and IILL code messages will be transferred to the South African Meteorological Service to be used in their Antarctic stations, as a consequence of recent cooperative work during the assistance to the Magdalena Oldendorff.

5. *Antarctic Navigation Course (NAVANTAR).* Is specially designed for professional sailors. Its syllabus encompasses Antarctic issues to be dealt with under six main modules such as environment, politics and legislation, ecology, prevention of seawater contamination, nautical safety and maritime operations, and survival. Four hundred and thirty five civilian and military mariners from Australia, Belgium, Bolivia, Brazil, Chile, Germany, Guatemala, India, Italy, Mexico, Norwegia, Paraguay, Peru, South Africa, South Korea, Spain, United Kingdom, United States of America, Uruguay & Argentina attended the course.

6. *Sea ice support* comprises sea ice edge in the NAVAREA VI (area for nautical safety messages to mariners, after the International hydrographic Bureau), a weekly report of sea ice and icebergs conditions for six selected areas of Weddell and Bellingshausen Seas, and outlooks of ice fields for planing and operational purposes.

7. *Sea ice nomenclature.* Revised definitions of English terms, waiting for new terms to be consolidated during this meeting. Then, send the formal proposal to the WMO through the local Permanent Representative.

GDSIDB related activities

8. During the intersessional period the Glaciological Division of SMARA remained sending sea ice observations to NSIDC and AARI. of five Argentine Bases (Orcadas, Jubany, Esperanza, Marambio and San Martín, as shown in red in the map below), of the Icebreaker A.R.A. "ALMIRANTE IRIZAR", the Oceanographic Ship A.R.A. "PUERTO DESEADO" and other auxiliary ships of the Argentine Navy.

9. During next months the files of sea ice observations, here in the Southern Hemisphere, will be available as new products of the Argentine Centre of Oceanographic Data (CEADO), Argentine Navy Hydrographic Service, and will be also replicated at the Argentine National Meteorological Service.

Report of Canada

Introduction

1. The Canadian Ice Service (CIS) provides information about floating ice in the major navigable waters of the Canadian economic zone for the present, the future and the past. This information in intended to meet two main objectives; to ensure the safety of Canadians, their property and their environment by warning them of hazardous ice conditions; and to provide present and future generations of Canadians with a knowledge of their ice environment sufficient to support environmental science and the development of informed policies. The CIS works with the international community to foster a global awareness of floating ice for operational and scientific purposes.

Operational Support

2. Throughout the intersessional period, the CIS provided operational ice information on a 7 day-a-week basis throughout the year. In the December to May period, the main areas of support included the Great Lakes, the Gulf of St Lawrence and the east coast of Canada. From June to November, the support areas shifted to the Canadian Arctic, including Hudson Bay, Baffin Bay, the Canadian Archipelago and the Beaufort Sea. Several level of products are issued including:

- Weekly regional scale charts for planning purposes – these cover the complete Canadian area and double as the basis for Climatology
- Daily tactical scale charts for vessel routing – produced where vessels are operating in the vicinity of ice
- Daily ice hazard warning bulletins – text messages warning of hazardous ice conditions present or developing
- Daily iceberg distribution chart showing the estimated numbers of icebergs in each degree latitude/longitude square as well as the Limit of All Known Ice (copied from the International Ice Patrol when IIP is in operation)
- 30-Day Forecasts – text forecasts issued about the 1st and 15th of every month describing expected changes in ice conditions over the next 30 days
- Seasonal Outlooks – text and graphical products issued about December 1st to provide an outlook for the freeze-up and development of the ice season in southern Canadian waters, and about June 1 to provide an outlook for the break-up and development of the navigation season in northern Canadian waters

The most active ice area is the Gulf of St Lawrence with approximately 1,500 ship transits during the ice season, mostly to the ports of Montreal, Sept Lies and Port Carter. About 20 ships routinely sail throughout the ice season between the Great Lakes Erie, Huron and Michigan. There are about 300 voyages into the Canadian Arctic each summer, including an increasing number of cruise ships, scientific expeditions and adventure cruises (e.g. small sailboats).

3. The Canadian Coast Guard (CCG), which operates the fleet of icebreakers and is responsible for marine safety, is a major partner of the CIS. Ice Service Specialists from the CIS work aboard CCG icebreakers to directly advise the captain on ice navigation and also in regional Coast Guard ice offices to support vessel traffic routing through ice-covered waters.

4. The CIS developed and delivered a prototype service to provide arctic communities with information regarding the position and condition of local “floe edges” (fast ice edges) which are important hunting and social gathering places. Using satellite remote sensing and ancillary data, prototype products were developed and regularly delivered to two

communities to assist them in planning on-ice travel to avoid potentially dangerous situations. In 2001, the service consisted of a simple web page where communities could access floe edge information. This service has been well received by the communities.

5. The CIS also monitors the ice cover on 135 inland lakes using satellite data for numerical weather prediction. The Canadian Meteorological Service reports that this information has made a noticeable improvement in weather forecasts over Canada.

Data Sources

6. The CIS relies on a mix of satellite, aircraft and surface observations. The most important single data source is the Radarsat satellite from which about 4,000 images are acquired annually; AVHRR and OLS optical imagery from U.S. satellites are of almost equal importance despite their vulnerability to cloud cover; SSM/I and QuikScat data provide useful background information but have limited resolution. The CIS ice reconnaissance aircraft provides tactical data in direct support of navigation as well as “ground truth” for satellite data; it carries Side-Looking Airborne Radar (real aperture) and is specially fitted for visual observations. Surface observations are provided by ships and helicopters.

7. Although Radarsat-1 continues to function normally, it is beyond its design life and could fail before Radarsat-2 is launched in late 2004. As a contingency against loss of this important data source, the CIS has concluded an agreement with the European Space Agency and the Canada Centre for Remote Sensing for a continuing supply of Envisat data. Additionally, the replacement of the aircraft SLAR with a modern radar is underway to increase the capabilities of the aircraft. As well, a research aircraft equipped with a Synthetic Aperture Radar has been outfitted with a data downlink and can be called into operational service should the need arise.

Information Technology

8. The main computer system at CIS is known as “ISIS”. Dual screen, multiple-processor client workstations operate under Windows 2000 and servers run HP-UX operating systems. ISIS is built on ERDAS Imagine image processing software and ESRI Arc-Info GIS software. An Oracle relational database underlies the system. The software has been extensively customized to meet the exacting performance requirements of the CIS. All products are produced digitally and made available via the CIS website (http://ice-glaces@ec.gc.ca) and other means. Ice Service Specialists in the field have access to all of the data, including satellite images, via Internet and Inmarsat. Charts and radar data from the ice reconnaissance aircraft are communicated in real time to the ice offices and icebreakers by a direct downlink coupled with a satellite communications network.

Long Range Ice Forecasting

9. Seasonal Outlooks and 30-Day Forecasts are produced using an analogue forecasting procedure that has recently been documented by Gauthier and Falkingham (2002). Recognizing client demands for reliable long range forecasts, the CIS has started to make investments in long range forecasting science. A literature review and assessment of various long range forecasting techniques has been undertaken to develop an action plan to approach the science. This report (Carriers 2002) is available from the CIS upon request. Additionally, a CIS ice forecaster is currently on assignment at the Canadian Centre for Climate Modelling and Analysis and is working on a standardized way of quantifying ice severity. The Total Ice Severity Index (TISI) is the subject of a paper to be written by Bernard Movie. Work in progress may be viewed at the website http://www.cccma.bc.ec.gc.ca/~bmiville/seaice/. Application of the TISI in correlation with atmospheric and oceanic predictors is also described at this website.

Sea Ice Climatology

10. In response to the growing interest in Arctic climate change and its potential impacts, the CIS completed its digital database of sea ice charts and used the database to publish a number of reports on sea ice trends in the Canadian Arctic (Falkingham et al. 2001, 2002). This digital database contains weekly charts from 1969 to 2001 spanning all Canadian offshore ice-covered waters (Hudson Bay is from 1971 only). The intention is to make this database available freely to the scientific community from the CIS website (http://ice-glaces@ec.gc.ca). As soon as the SIGRID-3 format for archive chart exchange is approved, these charts will be submitted to the World Data Centres and the GDSIDB. As a general note, analysis of the database has shown a general decrease in ice extent in the Canadian Arctic that is consistent with the 3% per decade widely quoted for the northern hemisphere – with some significant regional variation.

11. The CIS published two updated sea ice atlases during the intersessional period. The *Sea Ice Climatic Atlas for the East Coast of Canada 1971-2000* and the *Sea Ice Climatic Atlas for Northern Canadian Waters 1971-2000* are available from the CIS in hard copy and CD-ROM formats.

Training

12. After many years of purely technical training necessitated by the implementation of new technology, the CIS has begun to re-emphasize training in the science of ice analysis and forecasting. In cooperation with the U.S. National Ice Center (NIC) and the Canadian company Noetix Corp., considerable progress was made in the development of a Computer Based Training system. Modules for ice recognition, Radarsat analysis, ice physics and optical remote sensing have been completed and are now part of the mandatory added in to training for ice analysts and forecasters. In addition, CIS has been working on an "Ice University" concept in which senior ice forecasters develop ½ day modules on various science topics for delivery to all analysis and forecasting staff. In cooperation with the Royal Military College, the CIS has developed a one-week introductory course in oceanography specifically aimed at ice forecasters who typically have a meteorology background but little oceanography. Two sessions of the course were delivered in 2002 to include most of the CIS forecasters as well as two NIC staff.

Science

13. Over the intersessional period, CIS has been assessing the capabilities and limitations of space-borne SAR (RADARSAT-1 and Envisat ASAR) for detecting icebergs as part of our iceberg monitoring programme. An automated target/iceberg detection algorithm has been developed and is undergoing testing and evaluation in preparation for future operational use.

14. CIS is also investigating the utility of SAR and visible and thermal infrared remote sensing data for providing proxy information relating to the strength of unreformed first year sea ice. Recent efforts have focused on the incorporation of modelled surface temperature data and the integration of these data into an operational, automated ice strength product.

15. In preparation for the future availability of data from advanced SAR satellites (Envisat ASAR and RADARSAT-2), CIS has maintained a careful review of programmes to ensure they meet CIS requirements. In conjunction with the Canadian Space Agency, airborne polarimetric SAR data was acquired in 2001 and 2002 over Canadian ice areas to assess the potential and application of multi-polarization and polarimetric data for operational sea ice monitoring.

16. In1998, the CIS set up a model lab with a small team to develop and run operational ice models. Coupled ice-ocean models currently support most operational areas and the

plan is to extend these. A semi-lagrangian ice model with a novel ice thickness redistribution scheme is being tested and is expected to replace our more traditional ice models. A new iceberg model has also been developed and includes up-to-date iceberg drift and deterioration physics, iceberg geometry modelling and improved environmental forcing. Work will continue on developing tailored model output products. Over the next several years, the modelling team will be focusing efforts towards the development of a sea ice data assimilation system, which can incorporate observational input from remote sensing (and other) sources.

International Activities

17. The CIS and the U.S. NIC have a long-standing collaboration that has been further increased during the intersessional period. The ice information programme for the Great Lakes is now operated jointly by the two services and we are in the final stages of developing a completely seamless suite of products. Our intention is to not only reduce the overall cost of production by eliminating duplication of effort but to also avoid any possible confusion in the Great Lakes shipping community that different information sources could cause. Discussions have been initiated to extend this integration to the Alaskan Coast for the summer of 2003. All of this activity is progressing toward the creation of a North American Ice Service that will eventually encompass integrated databases, joint product preparation and a single window of access to North American ice information products.

18. The CIS has been active in the International Ice Charting Working Group that has now held three annual meetings. In addition to actively contributing to several scientific and operational action items, the CIS has taken the lead to develop an international ice chart colour code and new terminology for ice decay.

References:

Carriers, Tom (scientific authority). *Analysis of Sea Ice Climate Trends in Canadian Waters.* Ballicater Consulting Ltd. under contract to the Canadian Ice Service. April 2001.

Carriers, Tom (scientific authority). *Action Plan for Long Range Ice Forecasting Research.* Balanced Environments Associates under contract to the Canadian Ice Service. August 2002.

CCAF Summer 1998 Project Team. *The State of the Arctic Cryosphere During the Extreme Warm Summer of 1998: Documenting the Cryospheric Variability in the Canadian Arctic.* Canadian Climate Change Action Fund. Available at http://:www.socc.ca.

Falkingham, J.C., Chagnon, R. and McCourt, S. *Sea Ice in the Canadian Arctic in the 21st Century.* 16th International Conference on Port and Ocean Engineering under Arctic Conditions, POAC '01, August 12-17, 2001, Ottawa, Ontario, Canada.

Falkingham, J.C., Chagnon, R. and McCourt, S. *Trends in Sea Ice in the Canadian Arctic*. To be presented at the 16th IAHR International Symposium on Ice, Dunedin New Zealand, December 2-6, 2002.

Gauthier, M-F. and Falkingham, J.C. *Long Range Ice Forecasting Techniques in the Canadian Arctic – Initial Verification.* To be presented at the 16th IAHR International Symposium on Ice, Dunedin New Zealand, December

Report of China

Introduction

1. The National Marine Environment Forecast Centre (NMEFC) is responsible for monitoring and forecasting of sea ice in the Bohai Sea and the northern Yellow Sea. The Qingdao Marine Forecasting Observatory (QMFO) of State Ocean Administration (SOA) provides also information about monitoring and forecasting of ice conditions in the waters during winter. The ice service for the exploration, production and transportation of oil and gas in the Bohai Sea during winter is managed by the Group of Sea Ice Management (GSIM) of CNOOC (China National Offshore Oil Corp.) Limited-Tianjin.

2. The Chinese Antarctic and Arctic Administration (CAA) is the lead agency responsible for implementing national polar research policy and affairs being with responsibilities for national polar research activities. The Polar Research Institute of China (PRIC) and NMEFC are important institutions of polar research expedition.

Operations

3. Data Acquisition and Monitoring

The visible and infrared imagery from NOAA (AVHRR) and the visible imagery from GMS (S-VISSR) have received by NMEFC and National Satellite Meteorological Centre (NSMC) and used for operational sea ice monitoring and forecasting in the Bohai Sea and the northern Yellow Sea. MODIS (EOS-AM) imagery was also used for sea ice monitoring and forecasting in NMEFC during the last winter.

4. The data from aircraft reconnaissance have been used for operational monitoring and forecasting in China. The North Sea Branch (Qingdao) of SOA manages the affairs of ice reconnaissance missions in Liaodong Gulf, Bohai Gulf, Leizhou Bay and the shore region of the northern Yellow Sea.

5. Icebreakers are used by Navy and CNOOC Limited-Tianjin for observation of sea ice edge, thickness and type according to "The Specification for Oceanographic Survey (GB/T 12763-91, SOA)" and special survey. The information of the ice conditions in the Bohai Sea and the northern Yellow Sea is provided by SOA patrol ship and other ships.

6: The reports on local ice conditions including sea ice type, thickness, concentration and temperature according to "The Specification for Offshore Observation (GB/T 14914-94, SOA)" are daily sent to NMEFC from 11 shore stations along the Bohai Sea and the northern Yellow Sea.

7. The sea ice images from shore-based radar have been interpreted and digitized for monitoring inshore ice and ice in harbour. The observation is managed by National Marine Environment Monitoring Centre (NMEMC, Dalian), SOA. And the real-time ice data at the oil platforms JZ20-2 (40º27' N, 121º17' E) and JZ9-3 (40º40' N, 121º29' E) in the Liaodong Gulf are provided daily by CNOOC Limited-Tianjin.

Forecasting

8. The empirical-statistical schemes have been traditionally used for operational ice forecast based on analyses of meteorological and oceanic data and ice conditions. The long-range seasonal outlook is prepared using the statistical method to estimate the severity index of ice conditions of the Bohai Sea and the northern Yellow Sea in the next winter. A

10-day forecast and outlook up to one month are made by the empirical-statistical schemes in NMEFC and QMFO / SOA.

9. A dynamic-thermodynamic ice model with three levels has been coupled with Blumberg-Mellor ocean model. The coupled model with the output of T213L21 from National Meteorological Centre of China (NMCC) is daily used for the 5-day sea ice forecasts of the Bohai Sea and the northern Yellow Sea.

Services and Activities

10. The ice information from the composite analyses of the above data and the sea ice forecasts in the form of chart, code and plain language are issued to users including CNOOC Limited-Tianjin and companies for shipping, coastal and harbour activities. The consulting meeting on annual outlook of sea ice in the Bohai Sea and the northern Yellow Sea is organized by NMEFC in the October of each year, and the long-range ice condition outlook of the next winter is mailed and transmitted by facsimile at the end of October. The 10-day forecast and outlook up to one month are mailed and transmitted by facsimile per 10-day and month. Plain-language ice information and 10-day forecast of ice conditions in the Bohai Sea and the northern Yellow Sea with images are prepared by NMEFC and disseminated from CCTV (China Central Television) and radio at each 10-day during winter. The 1-5 day numerical sea ice forecast charts, covering the Bohai Sea and the northern Yellow Sea, are daily transmitted by facsimile and computer network to GSIM of CNOOC Limited-Tianjin and other users. The forecast output of ice concentration, thickness and velocity at grid points in tenths of degrees of latitude and longitude at 12-hour intervals up to 120 hour and the analyzed fields are transmitted daily by computer network as well. And NMEFC is also responsible for sea ice forecasting and monitoring of the Antarctic sea areas near to the two Chinese Antarctic stations, the Great Wall and the Zhongshan, and related to Chinese Antarctic research expeditions.

11. The warning level of severe ice condition for various structures and operators is established. More attention is paid to the monitoring of offshore drilling rig, temporary offshore structures and other structures without any capability against ice. The annual meeting on sea ice prevention is held at the end of October or the beginning of November by the institution in charge of sea ice management, which assigns task of sea ice prevention and works out an emergent measure as well as defines its goal for major project on ice prevention.

Research and Development

Model and Forecast for the Bohai Sea

12. The long-term variation and seasonal evolution of ice conditions in the Bohai Sea and the northern Yellow Sea and their relation with climatic predictors are investigated by using EOF and other statistic methods. The PIC (particle in cell) model has been applied for sea ice simulation of the Bohai Sea. The meso-scale atmospheric model (MM5) nested in the global atmospheric model (T213) will be connected with the coupled ice-ocean model and a new operational sea ice forecast system will be developed for improving the sea ice modelling and forecasting of the Bohai Sea and the northern Yellow Sea.

Satellite Remote Sensing

13. The test of operational possibility of RADARSAT/SAR for monitoring sea ice in the Bohai Sea was performed according to the project "The Evolution and Demonstration of RADARSAT Data and Their Application to the Bohai Sea Research in China" by NMEFC and CCRS (Canadian Centre of Remote Sensing), sponsored by RADASAT International (RSI), in January-February, 1997.

14. The digital data of MODIS (EOS-AM) will be used for the operational numerical sea ice forecast of the Bohai Sea and the northern Yellow Sea in the next winter. In order to improve sea ice monitoring and forecasting, NMEFC will also try using the images and digital data of the China ocean satellite HY-1 launched in May, 2002 for sea ice monitoring and forecasting.

Polar Sea Ice Research

15 The First Chinese National Antarctic Research Expedition (CHINARE-1) was dispatched in late 1984, and the first Chinese Antarctic research base – the Great Wall Station was constructed in February, 1985 at the King George Island, South Shetland Islands, west Antarctica. And the second year-round base, the Zhongshan Station, was established in February, 1989 at the Larsemann Hills in the Elizaberth Land, East Antarctica. Eighteen CHINARE voyages have been implemented until now. These activities have been successfully operated aimed at comprehensive scientific investigations including Antarctic sea ice. The CHINARE – 19 (2002/03) will be launched in November, 2002.

16. And The First Chinese National Arctic Research Expedition implemented in the Bering Sea, the Chukchi Sea and the Central Arctic during the summer of 1999. Its major research interests include sea ice geophysics and air-ice-ocean interaction. The Second Chinese National Arctic Research Expedition will be carried out in the summer of 2003. One of the scientific goals of this expedition is further research on influence of the Arctic marine processes including sea ice on the Arctic climate and global change. Its investigation areas will include the Bering Sea, the Chukchi Sea and the Canadian Basin.

17. A sea ice model for the polar seas is developed on the basis of Flato's cavitative fluid theology and Hiber's heat-balance zero layer thermodynamic ice model. The ice model is coupled with the global ocean model of LASG / IAP (Institute of Atmospheric Physics, Chinese Academy of Sciences). The coupled ice-ocean model with the monthly climatic atmospheric data is used for modelling the global distribution, drift and seasonal variation of sea ice.

Publications

19. The summary and report on sea ice conditions, disaster and activities are annually prepared and issued in "China Ocean Annual"(in Chinese), "China Marine Environment Annual Report"(in Chinese) and "China Marine Disaster Bulletin"(in Chinese) by SOA. In order to prompt the development of offshore oil and gas industries, and to ensure the safety of operation as well as to improve economic benefit, the specifications for sea ice design and operation conditions in the Bohai Sea including offshore areas in the northern Yellow Sea were drawn up during the intersessional period and "Bohai Sea Ice Design and Operation conditions" (in Chinese and English) was issued (Wu et. al, 2001).

Report of Denmark

Introduction

1. The Danish Meteorological Institute (DMI) is responsible for monitoring and charting of sea ice in the Greenland waters. The purpose of the sea ice service is to aid navigation and provide tactical and strategic support to the shipping community. The present ice service was established in 1959 but information about sea ice conditions has been gathered by DMI since 1872. The ice service is managed by DMI staff both at DMI headquarters in Copenhagen and in Narsarsuaq (southern Greenland).

1. The service is now predominately based on satellite Earth Observation data sources but for local inshore routing and monitoring operations DMI is using a helicopter which is situated in Narsarsuaq.

Operations

3. In March 1999 the operational production of digital ice charts began including the production of weekly charts covering all Greenland waters. The digital charts, both tactical and strategic, are primarily based on satellite Earth Observation sources. In particular, radar images from the Canadian satellite RADARSAT may now be regarded as the backbone of the service. The radar images are delivered in near real time to the DMI by Radarsat International via three ground stations, situated in Scotland, Norway and Canada. Furthermore, DMI makes extensive use of images from the US satellite systems NOAA and DMSP.

4. The ice service has mainly provided ice charts and other sea ice information to the two major Greenland shipping companies responsible for transportation of all inland passengers and goods to and from Greenland and the Danish Navy operating in the Greenland waters. Furthermore the ice service has provided dedicated support to commercial and scientific programmes, e.g. oil exploration activities at Fyllas Banke in David Strait and monitoring of the so-called Odden feature in the Greenland Sea.

5. New ice analysts have been trained using both general training tools, e.g. Ice Tutor by Noetix and material developed by DMI. Consequently, DMI has now a sufficient number of highly skilled ice analysts capable of accurate satellite image interpretation.

Research and Development

6. DMI is part of the EUMETSAT Ocean and Sea Ice Satellite Application Facility which, from November 2003 will produce operationally a daily 10 km. sea ice product. The product is based on a combination of DMSP SSM/I, NOAA AVHRR and Scatterometer and contains three information layers (probability, concentration and type). The present version will cover the Northern hemisphere north of 50º N from 90º East to 90º West. Ongoing developments will extend the product to cover the whole northern hemisphere. The extended product is expected to be available before 2005. DMI is responsible for the quality control of the western part of the product.

7. In the framework of the European Commission 5th Framework Research Programme DMI has been involved in the development of dedicated interactive ‘Ocean, Weather and Sea Ice’ computer presentation tools. DMI has been providing near real time weather and sea ice information and one of the presentation applications has been tested by selected Greenland users with good results.

8. DMI has entered into a new contract with Radarsat International from April 2002. The contract makes possible combined near real time use of images from RADARSAT and the European satellite ENVISAT. Therefore, the DMI is in the process of adapting its production environment to be able to ingest and display image data from ENVISAT when these are operationally available. It is expected that data from ENVISAT will improve coverage and timeliness, especially with regards to ice charts covering the Cape Farewell region. Data from ENVISAT is expected to contribute to the operational ice service from the beginning of 2003.

9. An automatic SAR sea ice classification algorithm has been developed which classify an image into four classes; two of sea ice (low and high concentration) and two of open water (calm and turbulent water). It is based on combining the information in the original SAR data with those in the two 'image' products derived from it, namely Power-to-Mean Ratio (PMR) and the Gamma distribution, respectively. As SAR signal from sea ice covered regions and open water are ambiguous, it was found that for the sea ice infested waters around Greenland four surface classes (2 of sea ice and 2 of open water) in the near range and a similar number in the far range of the image are needed to reliably classify an image. Daily EUMETSAT Ocean and Sea Ice Satellite Application Facility pre-operational ice concentration products together with the DMI's ice concentration product corrected for atmospheric contamination using weather prediction model forecasts (HIRLAM) are used both to locate automatically the representative classes of sea ice and open water and to fine tune the final results.

10. A drift forecast model for the Cape Farewell region has been developed by DMI and applied in a pre-operational mode. The goal is reliable 12 to 24 hours forecasts of the sea ice drift. The forecasts are initiated by the latest ice chart and will be used to provide information when no satellite coverage is available. The model has been run for two seasons and the results are now being evaluated

Intersessional contributions

11. During the intersesssional period DMI has been contributing to definition and creation of two proposals, namely the Colour Code and the Exchange format proposal as a member of the exchange format ad hoc group (see annex X, JCOMM Meeting Report No. 5) formed by AARI, CIS, NIC, NSIDC and DMI.

12. According to the GDSIDB work plan for May 2000 to October 2002 (see annex VII, JCOMM Meeting Report No. 5) the digital weekly charts from 2000 and 2001 have been made available to GDSIDB since the 8^{th} session meeting. It is the plan to continue transfer of the weekly charts to the GDSIDB as they become available during the next intersessional period.

Report of Germany

Introduction

1. The Ice Service of the Federal Maritime and Hydrographic Agency of Germany (BSH) - further on named GIS (German Ice Service) - is responsible for ice observations in German waters and regular reporting on and mapping the ice conditions in the area of the Baltic Sea and the coastal areas of the eastern North Sea. Furthermore, on request the service is providing ice information world-wide.

2. Daily ice reports and ice charts have been produced during winter ice season, i.e. approximately from the end of November to the end of May. Weekly sea surface temperature charts for the North and Baltic Seas a provided by another BSH unit during the whole year.

3. The ice observations from the German coast are stored in a special ice data bank, and allow statistical evaluation of the development of ice conditions with time series more than 100 years long. An ice chart data bank covers the ice conditions of the sea area in the region of the western Baltic Sea.

Staff and Operations

4. GIS has fixed positions of 2 ice scientists, 1 engineer, 2 technicians and 1/2 secretary. Furthermore, 2 remote sensing engineers are members of the section. The service is split between the two BSH head quarters in Hamburg and Rostock.

5. Throughout the intersessional period, the GIS provided during the Baltic Sea ice season operational ice information on a Monday to Friday basis. As the last winters were rather mild, no regular weekend service for the German coast was necessary. In 2001/02 (2000/01) the reporting period for the EISBERICHT, the official gazette of BSH, was started on Dec. 6 (Dec. 20), and it ended on May 14 (May 15). The dates are depending on the 'opening and closing' of the season by the ice services in the northern region of the Baltic Sea (Finland, Russia, Sweden). The average dates for the last 40 years are November 27 and May 27. The season 2000/01 was the shortest on record. Only 99 issues (average 123) of the Ice Report were published. The last season (2001/02), in which the EISBERICHT was presented in a new layout, was not much longer (105 reports).

6. During the last two seasons twice weekly ice charts for the northern region of the Baltic Sea have been produced have been produced. Beside the normal b&w (hatching) version, within the season 2000/01 charts based on the IICWG proposed colour code were provided on a regular basis. In the last season the parallel chart production was continued.

7. The EISBERICHT and the attached ice charts are distributed to the subscribers and other users via mail, telefax, e-mail and from the season 2001/02 also via Internet. All products of the German Ice Service can addressed on-line or as sample product on the GIS website (www.bsh.de/Oceanography/Ice/Publications.htm). On the German coasts - as well as on the coasts of the other countries in the southern region of the Baltic Sea (Denmark, Norway, Poland, Sweden) and the North Sea (The Netherlands) ice formation during the last two winters were restricted during short cold periods to the inner coastal waters. Therefore, only a limited numbers of German Ice Reports were distributed via GTS and E-Mail to the ice services in the Netherlands and the countries surrounding the Baltic Sea: 13 in 2000/01 and 20 in 2001/02.

8. Beside the regular published products, the service can be addressed for world wide ice information. Cruise and research vessels as well as some yachts in the Polar Seas are

the normal customers. The radiofax re-distribution of the iceberg charts of the Canadian Ice Service (CIS) and the International Ice Patrol (IIP) of the U.S. Coast Guard via the radio station Offenbach/Pinneberg is an other routine service.

9. During the last summer 2002 the problems with the supply vessel "Magdalena Oldendorff" in the Antarctic sea ice cover was an additional challenge - not only for BSH, but especially for the National Ice Center (NIC) and Argentina's Naval Glaciological Centre, Hydrographic Service (see: www.esa.int/export/esaCP/ESAOC976K3D_Protecting_0.html).

Data Sources

10. The main data source is satellite information, mainly NOAA AVHRR (visible and infrared channels), which are received on-line via a SeaSpace HRPT station. Scenes from the Baltic Sea are presented as b/w products on the web page. Within the last season a new colour product was added. Weekly SST/ice composites are presented, too. ERS/SAR scenes were available in NRT until the season 2000/01. Daily observations from the coastal stations - and in case of ice at sea - from icebreakers and merchant vessels as well as helicopter and aircraft reconnaissance are used in addition. The daily plain language reports and ice charts from the Nordic countries are available for the presentation of the ice conditions in the northern part of the Baltic Sea.

Information Technology

11. The main computer system at BSH are SUN Mainframes and Workstations under Solaris 2.x (2.6, 2.7, 2.8). PCs are operated under Microsoft NT4, the standard Software is MS Office 97, Professional Edition. For ice chart production the Finnish VTT ICEMAP software is jointly used with Finland and Sweden. An ESRI ArcView GIS software package was recently purchased to meet the future requirements for shape file formats. During the last months the ice data bank was migrated from INGRES into an ORACLE relational database. The NOAA satellite data are processed with the TeraScan software package. All products are produced digitally and made available - at least as sample products - via the BSH website (www.bsh.de/Oceanography/Ice/) and other means. NETSCAPE 6.2 is available for Internet communication.

Modelling

12. The BSH routinely uses an in-house developed operational model system to support maritime shipping, and to monitor and study the marine environment. The model system, which has been operated for quite a number of years now, comprises several computer programmes producing data in a daily operational programme routine without any manual intervention. Its main constituents are a programme package to compute oceanographic parameters in the North Sea and Baltic Sea (circulation model) and programmes to compute the drift and dispersion of substances (dispersion models).

13. The Operational Circulation Model of the BSH is computing in nightly routine runs on interactively coupled grids currents, water levels, water temperatures, salinities, and ice coverage for the North Sea and Baltic Sea. Grid spacing in the German Bight and western Baltic is 1.8 km, and 10 km in the other North and Baltic Sea areas. The model also simulates the flooding and falling dry of tidal flats, allowing the complex processes in the highly structured German coastal waters (tidal flats, sandbanks, tidal channels, barrier islands) to be modelled realistically. A special forecasting algorithm computes for most of the international coastal ice observation stations sea surface temperatures below 2 °C (early warning system before freezing) and ice formation (ice concentration and thickness).

14. In the context of short-term sea ice forecasting, the development of a model is envisaged that should capture as many of the synoptic features and as much of their variability as possible (E. Kleine, 2002). We are interested in the meso-scale properties and processes, i.e. thickness, consolidation, compactness, smoothness, accumulation of ridges, formation of leads and ice edge, drift and displacement, etc. Modelling and forecasting of synoptic ice formation are of interest to shipping as it affects route planning and the operation of icebreakers. With a view to conventional ice charting, the forecast problem might read: *Given today's ice chart, what will tomorrow's ice chart look like?* In addition, the influence of navigation on the ice cover in the Baltic Sea, where intensive shipping traffic occurs also during the winter season, needs to be considered.

Sea Ice Climatology

15. The ice observations from the German coast are stored in a special ice data bank, which was recently migrated from INGRES into an ORACLE relational database. It allows statistical evaluation of the development of ice conditions with time series more than 100 years long. GIS has contributed to an international report on the ice conditions in the Baltic Sea during the last century (cp. BSIM Report). Basic information is presented on the GIS website (see above). An ice chart data bank covers the ice conditions of the sea area in the region of the western Baltic Sea for the period from 1960. Contributions to GDSIDB are planned.

International Activities

16. The Baltic Sea Ice Services have a long-standing collaboration. Its improvement is a continuous process within the activities of the Baltic Sea ice Meeting (BSIM), which has a more than 75 years tradition. With respect to modern communication links the intention is to more and more harmonize products in order to save manpower and reduce the duplication of effort (details are presented in the BSIM Report). GIS has been active in the International Ice Charting Working Group that has now held three annual meetings, actively contributing to several scientific and operational action items.

References

Eckhard Kleine, 2002 (unpublished manuscript): On the problem of sea ice mechanics.

Report of Iceland

Area of responsibility

1. The Sea Ice Research Unit of the Icelandic Meteorological Office (IMO) is responsible for sea ice monitoring and sea ice service all year round in ocean waters around Iceland. The monitoring is performed in cooperation with the Icelandic Coast Guard, the Marine Research Institute in Iceland as well as ships in and close to ice covered areas in the Iceland Sea and the Denmark Strait (Greenland Sound).

Observations received

2. Ship reports are received from Icelandic and foreign ships in Icelandic waters. Any ship, small or large, is obliged to send a report to IMO whenever sea ice is spotted in the area. The reports are received quite frequently every day from many ships in late winter during heavy ice years but during light ice years the frequency of reports tapers naturally down to a few or none for periods of time.

3. The Icelandic Coast Guard performs sea ice reconnaissance flights in the Iceland Sea north of Iceland and the Denmark Strait, resulting in sea ice charts of the sea ice edge area. Flights are made according to needs, depending on the extension of sea ice close to or covering fishing grounds and transport routes along the coasts of Iceland.

4. In addition to these main sources of sea ice observations data, any other reliable information obtained at IMO is recorded and taken into account by further processing, as, for example, reports from coastal meteorological observation stations or from smaller airplanes.

5. On a larger scale, though not satisfactory for warnings on sailing routes, satellite imagery received at the IMO forecast division sometimes gives a useful indication of the overall extension of sea ice in the Denmark Strait. Ice charts obtained from sea ice divisions abroad, in particular the East-Greenland ice charts made at the Danish Meteorological Institute, are very informative in relation to following the large scale sea ice development further north in the East-Greenland Current.

Processing and warnings

6. All the various observation data mentioned above are recorded at IMO and forwarded further to those who need them. First of all, the information is broadcasted in the next radio weather broadcast via the State Radio Broadcasting Service as well as put on the NAVTEX system where all ships in the area are able to receive latest reports on sea ice. Also, the information is immediately put on the IMO web site.

7. Besides the reports, warnings are issued if considered necessary and broadcasted. Judgement has then been made according to weather forecasts at IMO which are prepared on the basis of various large scale forecasts, as medium range weather forecasts received regularly from the European Medium Range Weather Forecast Centre in Reading. In addition, warnings are based on knowledge of normal ocean currents in the vicinity of Iceland.

8. All data obtained are then preserved and gathered in an electronic data bank. Preliminary monthly overviews on sea ice at the coasts of Iceland are placed on the IMO web site as soon as possible. Eventually, annual reports containing final monthly overviews as well as the Icelandic Coast Guard ice charts are published in annual reports.

Development work at present

9. It is important to maintain and improve information channels back and forth between those who submit information on sea ice in the field and users who eventually receive it, together with some estimate concerning further sea ice development in the area. It is the duty of the Sea Ice Research Unit at IMO to oversee that this is done as effectively as possible. Useful development work has been done lately by participating in a European Commission project belonging to a programme category called the Information Society Technology(IST): Integrated Weather, Sea Ice and Ocean Service System (IWICOS).

10. The overall objective of the three year IWICOS project was to develop a marine information system which could provide a single entry access to meteorological, sea ice and oceanographic data and products from weather forecasting centres, ice centres and research centres in electronic form. Recently, IWICOS and results already obtained, mainly by the Icelandic IWICOS group (lead by Halla Björg Baldursdóttir, chief of the Information Technology Department of IMO), were introduced to seafarers and ship owners at a big international marine and fisheries exhibition in Kópavogur, Iceland, on September 4 - 7, 2002 (Icelandic Fisheries Exhibition 2002). The IWICOS project will be terminated at the end of 2002, but the resulting system will hopefully turn out to be very useful for all kinds of ships in Icelandic waters, and elsewhere.

11. Further information is to be found at web sites:

http://www.nersc.no/~iwicos
http://www.vedur.is/iwicos

The Sea Ice Research Unit
Dr. Thor Jakobsson, Meteorologist, Eiríkur Sigurðsson, Technician Sigthrudur Armannsdottir
Department of Research and Processing, Icelandic Meteorological Office
Bustadavegur 9, 150 Reykjavik, Iceland

Report of Japan

Japan Meteorological Agency

2. Sea ice monitoring in Japan Meteorological Agency (JMA)

Sea Ice monitoring in the sea of Okhotsk is carried out from November to July by Japan Meteorological Agency, and the results of monitoring is published for public use. Sea Ice monitoring by satellite began 10^{th} December 1970. The global sea ice data is analyzed by use of SSM/I data automatically. It is planned to feed the result to JMA's Numerical Weather Prediction Model and Climate Prediction Model.

2. Data acquisition

- Satellite data

Data name	Data Processing Center	Delay time
GMS(Visible)	Meteorological Satellite Center	15 minutes
NOAA(AVHRR, AMSU-B)	Meteorological Satellite Center	2 – 3 hours
DMSP SSM/I	NOAA NESDIS / NASA Marshall	About 6 hours
QuikScat	NOAA	About 12hours

- The other data

JMA acquires the observation data and observation charts via facsimile from Japan Coast Guard and Japan Self-Defense Forces. JMA acquires the Coastal RADAR data of Hokkaido University via Internet and facsimile.

3. Data Analysis

By the data referred on section 2, JMA operationally analyzes sea ice extent and its concentration, makes Ice Condition Chart in the Sea of Okhotsk, every day from December to May.

4. Sea Ice Forecast

A numerical model to predict sea ice distributions was first utilized by JMA during the sea ice season in 1991. JMA provides 7-day forecasts of sea ice distributions in the southern part of the sea of Okhotsk and the neighbouring sea.

5. Contributions to GDSIDB

JMA provides the sea ice data in the sea of Okhotsk to GDSIDB every 5 day, from December to May in 1970-2001.

6. Products of JMA

Operationally, JMA issues the sea ice information including forecasts for safety of ship cruising etc. There are two types of information charts named Ice Condition Chart (Figure6.1) and Ice Forecast Chart (Figure6.2) promulgated through the meteorological radio facsimile.

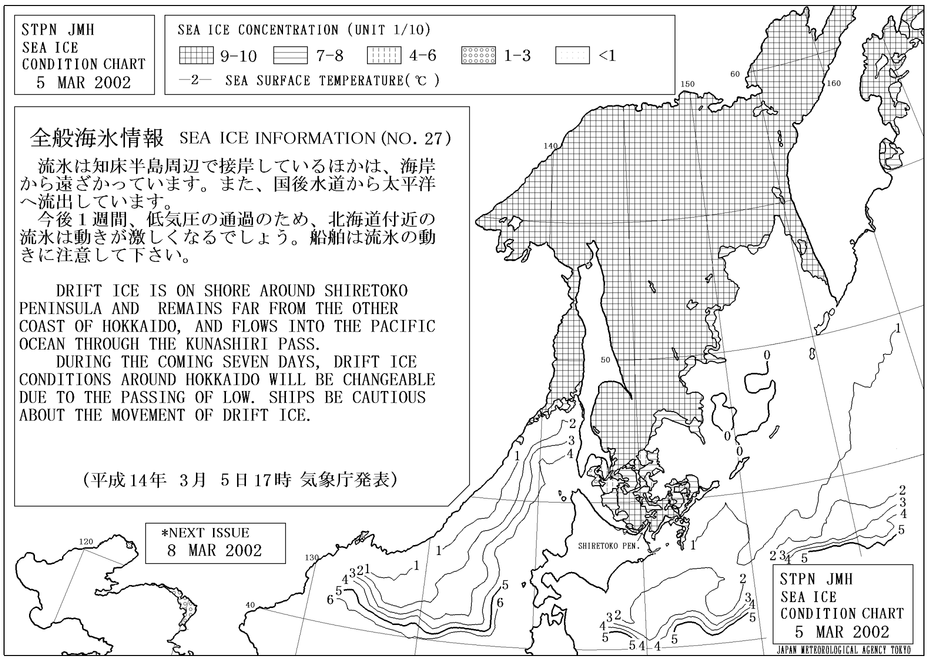


Figure 6.1 Ice Condition Chart issued on 5th March 2002

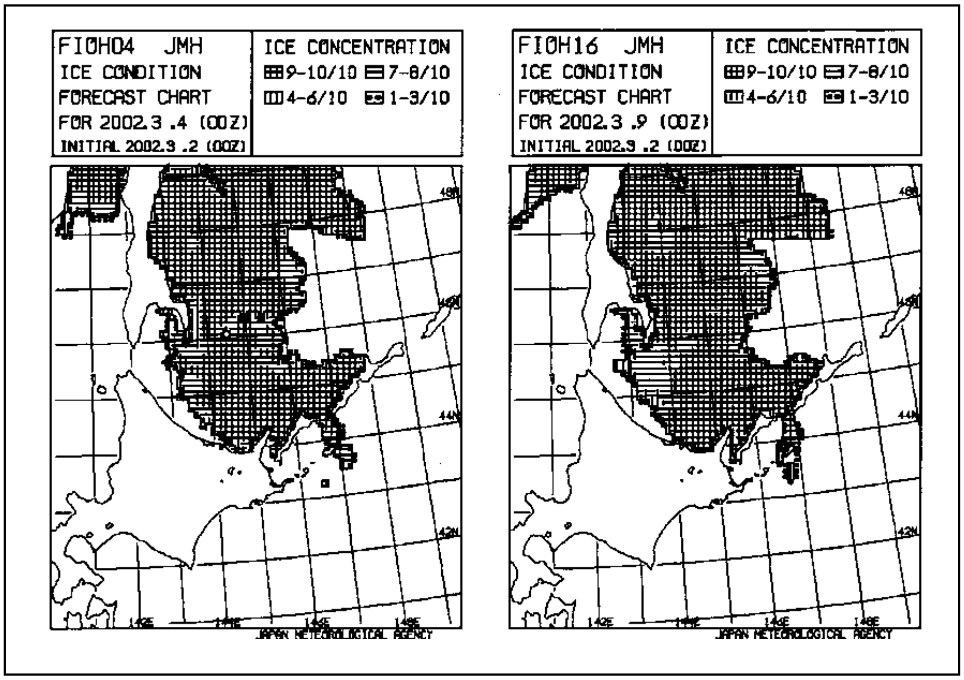


Fig 6.2 Ice Forecast Chart issued on 2-nd March 2002

Report of Sweden

Introduction

1. Swedish Meteorological and Hydrological Institute is responsible for mapping sea ice and sea surface temperature conditions in waters with merchant ship traffic in the Baltic region, including Lakes Vanern and Malaren. Daily ice charts have been produced during winter time, approx period Nov 20 – May 20 since 1957.Sea surface temperature charts are produced twice a week the remaining part of the year.

2. To the main customer, Swedish Maritime Administration/Icebreaking department, following data are transmitted on a daily basis: 24-hour as well as 5-10-day weather and ice forecasts, Baltic ice chart and satellite images to be ingested in a combined presentation and planning system onboard the icebreakers. Other users are scientific researchers (climate etc) and also some institutions.

3. Finally, the ice limit and ice concentration is incorporated on a daily basis in the Scandinavian weather prediction model in order to improve forecast reliability.

Staff and Operational Training

4. The Ice Service consists of a team with approximately 5 ice meteorologists and 3 ice assistants, virtually the same persons from year to year. Operational training of new staff is mainly carried out by following an experienced ice meteorologist in the daily work during combined with literature studies and visits to icebreakers in operational service. Introduction of new techniques have been very sparse during the intersessional period.

Data Sources

11. The main data source is satellite information, NOAA AVHRR (visible and infrared channels) and RADARSAT (SAR). Frequent reports in plain language from Swedish and Finnish icebreakers (including helicopter surveillance) and also from merchant ships are used as a complement and for providing more details on ice thickness, ridges and cracks etc.

12. Effort has been focused on transmission of more high-resolution RADARSAT imagesthan previous winter to the Swedish icebreaker fleet.

Development of a new ICEMAPping system

7. Some progress has been made during 2002 on outlining the successor to ICEMAP, the current mapping system at SMHI developed in the beginning of the 1990´s. The aim is, until next ice winter (2003/2004), to produce the Baltic Sea ice charts with an updated tool and thus conform to SIGRID-3 format for data transmission to GDSIDB and other institutes interested in sea ice conditions.

Ongoing project on providing Baltic Sea ice data to GDSIDB

8. The procedure of digitising the ice conditions in Baltic region for period of 1980 – 1994 continues but is not yet finalized.

<u>Present status:</u>
- Period 1989-2002 is digitized, quality control however remains before transmitting the data set to GDSIDB.
- Period 1980-1988 not yet digitized

Future plans:

- Digitizing continues during the autumn 2002, in total another approximately 6 months effort is needed to complete the period 1980 – 2002.
- Quality control
- Interaction with GDSIDB concerning formats and transmission

Report of the USA

Introduction

1. The US National Ice Center (NIC) has routinely produced maps of sea ice conditions since 1952. Using visible and infrared (NOAA AVHRR and DMSP OLS), SAR (Radarsat), scatterometer (QuikScat) and passive microwave (DMSP SSM/I) imagery, bi-weekly charts are produced of all ice covered regions of the Arctic and Antarctic, and twice weekly charts of the Alaskan and Great Lakes regions. These charts are made freely available on the web (http://www.natice.noaa.gov). Tailored support is also available to qualified users, to include annotated imagery support, upon request.

Operational Support and Training

2. In the intercessional period, NIC provided tailored support to users including the US Navy submarine fleets, Military Sealift Command (Thule Greenland resupply), International Ice Patrol, the National Science Foundation (Antarctic operations), the Argentine Hydrographic Office (Almirante Irizar Antarctic operations), MSO Valdez AK (Prince William Sound), USCGC Healy, USCGC Polar Star, USCGC Polar Sea, the Naval Oceanographic Office (Arctic buoy deployment) and the US Coast Guard (Great Lakes operations). Training of numerous analysts and forecasters was accomplished, a requirement due to the high turnover of military analysts. Much progress was made on the development of a computer based training system for ice analysis, working with the Canadian Ice Service and Noetix Corp. Ice recognition, Radarsat, Ice Physics, and Remote Sensing (AVHRR and OLS) modules were completed. Modules currently in production include Remote Sensing (SSM/I), Geography and Climatology. Proposed future modules include WMO Ice Code, Interactive Ice Analysis and Ice Forecasting.

Continuity of Operations

3. NIC put effort into developing a more robust plan for continuity of operations to specifically address homeland security threats. Provisions were made for creation of ice products and delivery of services from an off-site location, and Radarsat emergency ordering procedures were solidified.

Data Sources

4. During the intercessional period, NIC operationally tested several new SSM/I algorithms and selected the NASA Team 2 algorithm for operational implementation. NIC also transitioned QuikScat scatterometer ice and iceberg products. In preparation for the improved visible/infrared sensors aboard NPOESS, NIC is working towards operational use of MODIS imagery.

Progress on Development of a New Sea Ice Mapping System (SIMS)

5. NIC, working with various contract support, transitioned to operations a new hardware/software Sea Ice Mapping System (SIMS). The system is based on a Commercial Off-the-Shelf (COTS) software package from Lockheed Martin known as CARTERRA and allows for end-to-end digital ice chart creation. This system is a highly integrated imagery analysis and geographic information system (GIS). Current work involves the development of a web-based dissemination system, working in conjunction with the Canadian Ice Services under the auspices of the North American Ice Service (NAIS).

6. The system is based on the following hardware and software:

- Dell Precision 620
    - Dual Pentium III 933MHz Processors
    - 36GB 10,000RPM Hard Drive
    - 1GB RAM
    - Read/Write CD
    - 1.44MB Floppy Drive
    - 8mm Tape Drive
    - Windows 2000 Pro
    - but no DVD

- Sony GDM-W900
    - 24 inch, Colour
    - 1920 x 1280 pixels

- Clinton D21MD2LM
    - 21 Inch, Gray Scale
    - 1600 x 1280 pixels
    - Stereo Capable (Z-Screen

- Imagery Exploitation Software (COTS)
    - RemoteView Pro (Sensor Systems, Inc)

- GIS Applications (COTS)
    - ArcView and ArcInfo GIS (ESRI)
    - Imagine (ERDAS)
    - 3D Analyst
    - Spatial Analyst

Polar Ice Prediction System

7. Working with the Office of Naval Research (ONR) and its funded investigators, NIC is working to develop the next generation of the Polar Ice Prediction System (PIPS). PIPS 3.0 will be based on a global ocean model and a sea ice model (C-ICE) developed at Los Alamos National Laboratory. PIPS 3.0 will use data assimilation routines developed at the Naval Postgraduate School. As an initial step, validation of PIPS 2.0 was documented in several case studies (VanWoert et al, 2001). Future work will include final selection of a global ocean model (or an Arctic ocean model), determination of the feasibility of coupling the sea ice model to the global ocean model, adding International Arctic Buoy Programme (IABP) Arctic buoys to the data assimilation scheme and further validation studies.

Development of Sea Ice Historical Archive

8. The National Ice Center is working to provide the GDSIDB a complete set of sea ice data for the Arctic 1972-2002 and Antarctic data 1973-2002. The NCI's sea ice data consists of weekly regional JPEG and/or GIF and Arc Export coverages (.e00's) and Hemispheric .e00's through mid-June 2001. Starting in mid-June 2001 and into 2002 NIC Arctic and Antarctic areas are analyzed bi-weekly. Great Lakes .e00's, and Alaskan regional coverages are produced twice per week. Chesapeake Bay and Delaware Bay Sea ice coverages are available when ice conditions warrant.

9. NCI's climatological dates was documented in a Canadian Journal of Remote Sensing paper (Dedrick, 2001). A paper analysing the NIC dataset in relation to climate trends is in progress (Partington, personal communication).

NIC Contributions to the GDSIDB

10. The following regions/years were present in the GDSIDB archive before the intercessional period:

Arctic Hemispheric	1972-1994	weekly

Data that was digitized but not quality controlled:

Antarctic Hemispheric	1973-1994	weekly

During the intercessional period, NIC prepared the following data for archive at GDSIDB:

(i) Quality controlled Arctic Hemispheric 1995, 1998, and 1999 charts in digital (.e00) format.
(ii) Quality controlled Regional charts for Great Lakes, Alaska, Yellow Sea, Arctic and Antarctic in the following formats; JPEG and GIF 1995-2002 and Arc export format (.e00) 1995-2002.

13. Future Activities will include the following:

Arctic Data

(i) Hemispheric 1996, and 1997 .e00 charts are in digital format but approximately 58 charts still require QC before archiving at GDSIDB.
(ii) Hemispheric 2000 and 2001 .e00 charts are in Digital format and approximately 60 charts are in need of QC before archiving at GDSIDB.

Antarctic

- The NIC received NOAA funds through Environmental Services, Data, and Information Management Programme (ESDIM) for three years (2002-2004) to create an Antarctic historical database 1973-2001. The ESDIM money allows for the funding of a part time contractor who will provide quality control to the dataset 1973-2001 (provided funding is sufficient). Work has been started by the NIC and the University of Delaware, a partner in the digitising effort, to complete digitization of the 1995-2001 charts and add to the 1973-1994 charts already digitized.
  (i) From 1995-2000, only a few digital hemispheric charts were created and no QC has taken place. The data in this time span comes in a variety of formats and will be jointly worked on by the National Ice Center and the University of Delaware. *Approximate Completion October 2005*.
  (ii) The majority of the 2001-2002 charts are already in hemispheric digital format. NIC is currently quality controlling 2001 charts while awaiting delivery of the digitized1995-2000 charts. *Approximate completion August 2003*.
  (iii) Quality control of the digital data set from 1973-1994 has been designated as lower priority. *Approximate Completion for the entire data set 1973-2002 end of 2007.*

Archive formats

- NSIDC/GDSIDB will archive NIC data in the future in the following formats:
  (i) NIC will switch to Hemispheric Shapefiles by January 2003.
  (ii) NIC can convert its historical data set to Sigrid-3 format (when approved by WMO), if desired by the data centres.
  (iii) Regional JPEG's and Regional .e00's into the future.

(iv) NIC retains the .e00 hemispheric coverages and also places them in deep archive at the National Climatic Data Center. These files can be archived at GDSIDB as well, if there is interest.

References:

Dedrick, K.R., K. Partington, M. Van Woert, C.A. Bertoia, and D. Benner, 2001. U.S. National/Naval Ice Center Digital Sea Ice Data and Climatology. *Canadian Journal of Remote Sensing,* Vol. 27, No. 5, pp. 457-475.

VanWoert, M.L., W.N. Meier, C.-Z. Sou, J.A. Beesley and P.D. Hovey, 2001. Satellite Validation of the May 2000 Sea Ice Concentration Fields from the Polar Ice Prediction System. Canadian Journal of Remote Sensing

Annex V

REPORT OF THE BSIM

Background

1. The Baltic Sea Ice Services have a long-standing collaboration within the Baltic Sea Ice Meeting (BSIM). This Meeting started in July 1925 in Hamburg as an Expert Meeting with the main topics on a Baltic sea ice code and the exchange of ice observations. During the last decades the topics have continuously increased aiming at better and more effective cooperation between the countries of the Baltic Sea and the Netherlands. There was always a strong relation to formal requirements of WMO/CMM activities as international ice codes, nomenclature and symbology considering the special regional aspects of the Baltic Sea. This fact was stressed by the fact that at most Meetings since 1977 an WMO officer was participating.

Activities

2. We are now in the intersessional period between BSIM-20 (Sept. 2000 in Riga) and BSIM-21 (June 2003 in Helsinki). The main results of the Riga Meeting are summarized in Appendix 1 to this report. The defined action items include among others to create a BSIM logo and the draft and maintenance of a joint web site for the Baltic Sea Ice Services. A WG was formed consisting of J.-E.Lundqvist (SMHI - S), K. Strübing (BSH - D), J. Vainio (FIMR - FI) and K. Wierenga (RIZA - NL). Beside several E-Mail contacts there was WG meeting on January 24-25, 2002, in Helsinki. The results are given in Appendix 2. The website is now under construction at the German ice service unit in Rostock. It will be embedded in the Internet environment of BSH. A test version will be started during the coming ice season 2002/2003. One of the anticipated products will be stations lists with the daily ice observations. A supplement to the booklet *The Baltic Sea Ice Code* (published in 1981by SMHI) including changes in fairway sections and areas for ice report and complementary new national ice terms was issued by SMHI on behalf of BSIM.

3. Ice climatology is of basic interest for the future development of winter navigation in the Baltic Sea. Several thousands of cruises are affected each season in ice covered sea areas and waterways. An accumulation of milder winters during the last 15 years may stress the intention of global warming in the region. The Baltic Sea history offers several long time series on sea ice conditions. The length of direct observations varies between 50 and 150 years and several hundred years for indirect information. Much analysing work has been done in the nine countries around the Baltic Sea. The work was concentrated and harmonized since 1993, when the First Workshop on the Baltic Sea Ice Climate was performed in Tvärminne, Finland. The 4th Workshop was performed in May this year in Norrköping, Sweden. As a major result of the activities so far, a report on *Ice Time* Series *of the Baltic Sea* with special contributions from 6 countries was published early this year (see: references).

4. A special Workshop on Baltic Sea Ice Research was performed 17-21 September 2002 on occasion of the 100 years anniversary of the Helsinki's University Zoological Station in Tvärminne, near Hanko, Finland. About 15 international scientist discussed the various aspects and scales of sea ice in the Baltic Sea between micro-organisms and winter navigation. The yearly Baltic Icebreaker Meeting took place in Kiel, Germany, on 25 September 2002 (Appendix 3). Beside the reports of the national delegates on the ice season 2001/02 various aspects of icebreaking activities were discussed. Despite the issue of global warning it was agreed on the fact that in further on possible severe ice winters a lack of assistance is to be expected in the Baltic Proper. Joint efforts have to be discussed.

5. The 21st Baltic Sea Ice Meeting (BSIM-21) will be performed next year in Helsinki (9-13 June 2003). The preparations have been initiated. The intention is to even strengthen the joint efforts for closer cooperation, to more and more harmonize products in order to save manpower and reduce the duplication of effort. Furthermore, an Baltic Sea ice service information network has to be established, for which the joint website is a first step. The requirements for high resolution satellite radar data have to be further harmonized in order to address the distributing agencies/companies with one vote. Future user requirements have to be discussed, etc. A draft agenda will be presented within the next few weeks.

References

Report of the 20th Baltic Sea Ice Meeting, Riga, 25-29 September 2000.

Ice Time Series of the Baltic Sea. Report Series in Geophysics, No 44, University of Helsinki, Division of Geophysics, Helsinki 2002.

The Baltic Sea Ice Code, Supplement. SHMI, Norrköping, 2002

Appendices: 3

APPENDIX 1 to Annex V

BSIM-20 MAIN RESULTS

1. The 20th Baltic Sea Ice Meeting was hosted by the Latvian Hydrometeorological Agency in Riga, Latvia. The meeting opened on Monday, 25 September, at 2 p.m. and closed on Friday, 29 September, at 12 o'clock.

2. The Meeting was visited by 25 representatives of ice services and icebreaker services of The Netherlands and all countries bordering the Baltic Sea beside Lithuania and Norway as well as of other national Latvian agencies. WMO/JCOMM was represented by Mr Mikhail Krasnoperov.

3. Mr. Strübing was elected as chairman of this jubilee meeting.

4. The Meeting decided to transmit ice information products in the winter 2001 in addition to GTS and telefax also routinely via e-mail. In case of positive experience (e.g. timeliness), there is no further need to use telefax from the winter 2002.

5. It is agreed that administrative information and the lists of products, telephone & telefax numbers, e-mail & web-site addresses from various ice and icebreaker services will be listed and added to the report.

6. The Meeting noticed that a review of the brochure *The Baltic Sea Ice Code of 1980* is necessary (especially with respect to changes in the fairway section of various countries). Mr. Jan-Eric Lundqvist agreed to take care of the editing of a revised version of the present booklet by spring 2001. Some missing contributions from Lithuania (e.g. vocabulary of WMO sea ice terms) may cause some delay. The chairman will address the responsible agency.

7. The Meeting recognized the need to *Identify a subset of ice climate product statistics* initiated by the relevant IICWG Standing Committee. The table compiled by Florence Fetterer was distributed to take further action (if it has not already be done by directly addressed ice services).

8. The Meeting appreciated the main achievements and activities in the field of sea ice relevant to JCOMM which have taken place since the twelfth session of the former CMM. In particular activities were reviewed in relation to the Global Digital Sea Ice Data Bank, processing, exchange and quality control of sea-ice data, sea-ice publications and future structure of the former CMM Sub-group on Sea Ice.

9. The Meeting noted that WMO appreciated the important work being undertaken in sea ice activities by regional and international groups, such as the BSIM, IICWG and ECDIS. It was agreed that future collaboration should be continued between the recommended Expert Team on Sea Ice and these groups, and requested the future chairman of the Expert Team and WMO and IOC Secretariat to arrange for such collaboration, as appropriate.

10. The Meeting agreed to continue the activities related to digitising of sea ice charts. The technical assistance provided by Mr. Vasily Smolyanitsky of AARI-GDSIDB, is appreciated very much.

11. The Meeting recognized the considerable advantages of colour coding in ice charts. It was decided to initiate/assist at the 2nd IICWG meeting in Reykjavik, Oct 3-5, 2000, a proposal in order to approach the chairman of the JCOMM Sub-Group on Sea Ice to consider this problem at the JCOMM-I session in June 2001, Iceland. to take further action

for a two years test phase and final official approval for international use within the WMO Sea Ice Symbols.

12. The Meeting claimed that the largest problem in the use of RADARSAT and other SAR data is the high price of the data. Considering the requirements of winter navigation, Finland is more keen to continue the use of RADARSAT SAR data than Sweden. The official ESA data policy to put governmental ice services in the same user category as commercial users with respect to ENVISAT SAR data was sentenced, and any EUMETSAT initiative to improve the situation by special negotiations with ESA would be very much welcomed by the Meeting.

13. The chairman informed the Meeting on the III Workshop of Baltic Sea-ice Climate held in Poland in October 1999.

14. The chairman informed the Meeting on the terms of reference and activities of the *International Ice Charting Working Group* (IICWG) launched for cooperation at the global level. He emphasized the objectives of the WG, and the Meeting recognized IICWG as a considerable improvement for international cooperation beyond the regional limits of the Baltic Sea. – BSIM will be represented at the 2nd IICWG meeting in Reykjavik, Oct 3-5, 2000, by participants from Denmark, Finland, Germany, Russia and Sweden.

15. In order to make actions and activities and relevant responsibilities to take action resulting from the Meetings more clearly, the Meeting agreed with appreciation on Mr. Krasnoperov proposal to create an *action shit*.

16. Considering the political and commercial aspects of future cooperation within the region of the Baltic Sea, and the relevance of new communication techniques for the information of the public, the Meeting agreed to present the Baltic sea ice services and their activities jointly under the umbrella of BSIM on a WebPage in the Internet and to aim for the future on the presentation of joint ice information products. It was decided to take immediately action on the following objectives, which are to be harmonized by an ad Hoc group with following members: Jan-Eric Lundquist (SMHI, Sweden), Klaus Strübing (BSH, Germany), Jouni Vainio (FIMR, Finland) and Klaas Wierenga (RIZA, The Netherlands):

- To link the relevant INTERNET addresses (if not already done)

- To create a web page for *The Baltic Sea Ice Services* in order to present themselves and their activities jointly in the Internet. The Meeting agreed on the draft logo proposed by the chairman. The Finnish ice service will the technical lead for the transfer of the ideas.

- To start with the presentation of joint products on the web page first a simplified ice/SST chart of the Baltic Sea will be available weekly free of charge. In addition a list of the daily coded ice information for harbours and fairway sections will be presented.

- To present shortly after the winter a joint report on the development and character of the ice season in the Baltic Sea. Similar reports for shorter periods (weeks, months) as already prepared by Germany may be added.

17. The 21st Baltic Sea Ice Meeting will be held in Helsinki, Finland, at the last week of September 2003.

APPENDIX 2 to Annex V

BSIM INTERNET Working Group Meeting
FIMR Ice Service, Helsinki, 24-25 Jan. 2002

Participants: Patrick Eriksson, FIMR - Helsinki
Jan-Eric Lundqvist, SMHI - Norrköping
Klaus Strübing, BSH – Hamburg
Jouni Vainio, FIMR – Helsinki (partly)
Klaas Wierenga, RIZA – Lelystad

Background: The Baltic Sea Ice Meeting (BSIM) decided on its 20th Meeting in Riga (25-29 September 2000) to present information and products on a joint web site (item 13 and Annex 03 of the Final Report). The responsibility was given to the above mentioned participants (beside P. Eriksson). The Finnish delegation volunteered to prepare a first draft.

Results of the Meeting

status: The Finnish colleagues did prepare a first draft of a home page and outlined some more pages. However, technical and administrative constraints prevented the expected progress. Because of this it would hardly possible to host the web page, too. As the participants noticed that the web pages of the German Ice Service are in a exemplary presentation, Mr. Strübing was asked by the meeting whether it would be possible to host and maintain the pages on a server of BSH. He promised to address his administration and the President with this request and to check the technical requirements.

web address: The meeting anticipated that it would be necessary to get the name www.bsim.. registered as soon as possible. Mr. Strübing was asked to get information on the procedure.

cover page: The meeting agreed that the cover page shall include

- a column with the names of the Baltic Sea Ice Services and possibly the logos of their institutions (see IICWG web site: http://nsidc.org/noaa/iicwg/services.html), to be linked as closely to the 'ice sites'.
- a column with the linked names of Baltic Sea Icebreaker Services
- the BSIM logo
- a product list
- a headline to background information on BSIM (who, what, when, why, etc)
- a linked list of closely related institutions (WMO, JCOMM, IICWG, BOOS, ...)

products: The meeting discussed in detail a first set of ice information products. Problems related to the available commercial products of national services were considered. Competition shall be avoided. Products are in general regarded as non-commercial, if they are presented to the public by media's like broadcast, radio facsimile transmission or coastal radio stations.

- **ice chart:** the chart shall cover the whole region of the Baltic Sea including the North Sea coasts and adjacent sea areas of Denmark, Germany and the Netherlands. The ice will be presented in white, the ice-free water in blue and the land mask in a greenish tone. The latter shall include the locations of the Ice Services. From these ‘points’ links may be installed to relevant national products or other information. The chart will be up-dated on Monday and Thursday.

- **coded ice observations:** Daily lists of the national coded ice observations shall be presented. The German Ice Service is working on an automatic procedure to transfer the GTS messages into a suitable presentation similar to the form given in their Eisbericht. In order to avoid conflicts with commercial products, it could be considered to delay the presentation in the web to about 2 p.m.- As off-line products lists of all international observation stations and chartlets with their positions (as e.g. in the BSH handbook for radio officers) are anticipated.

- **restrictions to navigation:** This information is provided by the Maritime Administrations (Icebreaker Services). It is essential for the planning of ice navigation in the Baltic Sea. Therefore it is part of the daily (printed) national ice reports and partly (Finland, Sweden) noticed on the ice charts, too. As the information is up-dated only from time to time, it is not a real operational product. Therefore from the Swedish side their are no concerns for the web presentation, while the Finnish colleagues consider a possible competition with respect to their daily ice chart offered for commercial auto-polling via fax. A compromise can be to inform only on the harbours or regions for which restrictions are valid without the details on tonnage and ice-classes, however, the details which are basically nautical information would be better.

Action items:

- Definition of hosting agency (BSH ?)
- Registration of a web address
- Draft layout of the coverpage and product pages. Internal agreement within the WG
- Presentation of the results to the BSIM representatives via an internal web address
- Consideration of response from above within WG
- Pre-Operational phase during ice season 2002/03
- Confirmation by BSIM-21 in Helsinki

APPENDIX 3 to Annex V

Baltic Icebreaking Meeting

Kiel, Germany

25 September 2002

Contents

- Minutes -

The meeting was attended by the representatives of the ice breaking services of Poland (Piotr Zenni), Estonia (Rene Sirol, Tarmo Ots, Rein Einberg), Russia (Nikolay Monko, Oleg Kudriavtsev), Finland (Arne Sandell), Sweden (Anders Backman, Mats Andersson, Ulf Gullne) and Germany (Raven Kurtz, Klaus Strübing, Klaus-Peter Nitsch, Stefan Mau).

Chairmans: Raven Kurtz, Wasser- und Schifffahrtsdirektion Nord
and
Klaus-Peter Nitsch, Wasser- und Schifffahrtsamt Kiel- Holtenau

After a brief visit to the Holtenau locks of the Kiel Canal including the waterway's traffic control centre and the Kiel Canal exhibition, the meeting started on board the inspection vessel "Friedrich Voss".

Following a short welcome, the chairman introduced the following agenda:-

(1) News from HELCOM meeting
(2) Presentation of reports on the last icebreaking season
(3) Wind farms in German coastal waters
(4) Paper presented by BSH Hamburg
(5) Any other business
(6) Next meeting

(1) News from HELCOM meeting

Raven Kurtz reported that at the last HELCOM meeting the German delegation offered to host a workshop on the harmonisation of icebreaking services in the Baltic Sea. This workshop will take place in Warnemünde in 2003.

The central aspect to be dealt with is to develop a clear and straight forward identification of aims of a joint ice service in the Baltic region which can be presented to the federal ministry of transport in Berlin to trigger further support.

In this context it has to be made clear that hydrographic research, as conducted by the federal shipping and hydrographic office (Bundesamt für Seeschifffahrt und Hydrographie, BSH), and thoughts on nautical and other shipping related aspects are to be understood as being two separate fields of action.

During the discussion of this point, the remark was made that there is still a considerable “lack of resources” concerning ice services in the Baltic during strong icewinters. The need for increased ice breaker capacity in the Baltic should be met, due to financial considerations, by introducing multi-purpose vessels rather than specialized ice breakers.

(2) Presentation of reports on the last icebreaking season

For details please refer to the respective reports which can be found in the appendix.

Comments made during the presentations but which are not included in the reports:-

Estonia: The port of Pärnu experiences particularly serious problems during strong south westerly winds which press the ice into the bight surrounding the port’s shallow approach (abt. 6 metres). As Estonia currently operates only one own ice breaker (draught: 7 metres), Russia offered assistance with its ice breakers. Ironically, Estonia sold its last remaining shallow-draught ice breaker to Russia a few years ago.

Sweden: The icebreaking department has moved from Norrköping to Gothenburg.

Germany: The German ice service plan is set up annually by the responsible authority, listing up all available vessels which are able to break ice, giving information on the respective areas of ice breaking service, the expected ice situation etc. (cf. appendix).

The announcement was made that in case of an ice winter in German territorial waters the usual recommendations for ships have now been replaced by obligatory restrictions of which the vessels' owners will be informed in advance.

(3) Wind farms in German coastal waters

About 500 large wind generators are planned to be placed within the German Baltic waters into the next few years. The distance between each generator will be approximately 500 to 600 metres.

Important questions which arise in this context are:

- In general terms, will there be a danger caused by such wind farms?
- Who can provide information based on experience concerning the relationship of windfarms at sea and the formation of ice?
- If such experience already exists, which conclusions can be drawn from it?

A number of sites off the German Baltic coast is already applied permission for. The federal shipping and hydrographic office (BSH) is responsible for carrying out the necessary research work concerning possible problems. These are anticipated to be such as:-

- possible influence of sea-based wind generators on the ice formation process;
- pillars which are placed too close to another might generate solid ice where no ice-related problems have been experienced before.

(4) Paper presented by BSH Hamburg

Klaus Strübing presented an overview of some results of this year's International Workshop on Baltic Sea Ice Research in Tvärminne on 19 September 2002. Under the heading "Sea Ice in the Baltic Sea – Interaction with Navigation and Climate Elements", the following was reported:-

One major reason for concern is the global warming process which is set to stimulate climate changes not only on a global but, more importantly, on a regional basis. Here, regional climate can actually become characterized by lower rather than milder temperatures. Besides that, increased ice dynamics is currently focused on by the researchers. That is, if the sea is covered with level ice and ships plough through this ice in a staggered manner, the resulting high number of ship tracks will help the formation of ice ridges within a short period of time. This has been observed in the Gulf of Bothnia but is expected to be well possible in the western Baltic, too. Particularly, the V-shape of approaches like in the cases of Kiel or Lübeck helps to increase this formation of barriers.

BSH are in an early process of developing a categorisation of ice conditions in order to be able to forecast particular conditions, differentiated by particular region. Examples of trial coloured ice charts were shown. The thoughts also include the consideration of questions as fundamental as: Will the principle of convoys still be needed in the decades to come? The models currently under development are to help forecast the kind of ice services needed in the future.

A short report on the Baltic Sea Ice Meeting (which takes place every two to three years) outlined the efforts of this working group which are currently at the planning stage. The underlying aim is to improve and harmonize services, both hydrographically orientated and shipping-related. A suggestion has been made to produce and publish a joint web page presenting the joint ice services to the public.

This objective also includes a possible joint ice chart. The problem with this particular issue has been identified as a commercial one. Some ice services have to sell their products (e.g. ice reports), some do not. As the suggestion of a joint web page includes the principle of providing information free of charge, a compromise has to be found.

Following Klaus Strübing's report, various options of researching valuable information and the way they might be provided were discussed. In this context, it was agreed that in order to collect reliable information on ice conditions helicopters are still much needed means as radar observation appears to be not yet fully developed.

(5) Any other business

The Estonian delegation mentions a new concept which is in the planning stage and concerns several projects funded by the European Commission, including clarification of questions as, for example, how a new traffic separation scheme in the Gulf of Finland could work under ice conditions. Furthermore he expressed his thanks to Finnish, Swedish, Danish and German authorities, all assisting Estonia in the planning of a completely new port to be constructed.

The Estonian delegation hopes to be able to give further and more in-depth information during the next meeting in Gothenburg in September 2003.

Klaus Strübing of BSH Hamburg announced the date of the next Baltic Sea Ice Meeting which will take place in Helsinki from 9th to 13th June 2003.

(6) Next meeting

Swedish delegate, A. Backman, invites the conference to Gothenburg should no other country insist on hosting the next meeting. This proposal was accepted and agreed unanimously. The next Baltic Icebreaking Meeting will take place in Gothenburg in September 2003 (39th week).

Mailing List:

Swedish Maritime Administration
Icebreaking Department
Att: Mats Andersson, Anders Backman, Ulf Gullne
601 78 Norrkoping, Sweden
Fax: +46 11 10 31 00
Mail: roy.jan@sjofartsverket.se

Finnish Maritime Department
Traffic Department
Att: Matti Aaltonen, Markku Mylly Arne Sandell
Postbox 171 , 00181 Helsinki, Finland
Fax: + 358 204 48 44 31
Mail: matti.aaltonen@fma.fi
markku.mylly@fma.fi

Maritime Office in Gdynia
Harbour Master´s Office
Att.: Zenni Piotr
Fax: + 48 58 661 60 51
Mail: zenni@umgdy.gov.pl

Administration of Northérn Sea Route
Att.: Nikolay Monko, Oleg M. Kudryacvtsev
Fax.: 0 95 926 16 96
Mail: MonkoNA@morflot.ru

Sovaernets Operative Kommando
Att.: Jens Hulgaard
Postboks 483, 8100 Aarhus C, Denmark
Fax: +45 894 33 230
Mail: istjeneste@sok.dk

Freeport of Latvia
Att.: Aigars Pecaks
Meldru 5 a , Riga, Latvia LV- 105
Phone: +371 7 030 807
Fax: +371 7 030 864
Mail: Aigar@MAIL.ROP.lv

Freeport of Riga
Att.: Edgars Ukis
Meldru 5 a , Riga, Latvia LV-105
Phone: +371 7 082 000
Fax: +371 7 322 750
Mail: Lienite@ROK.BKC.lv

Maritime Administration
Rene Sirol
Head of Maritime Safety Division
Lume 9, 104161 Tallinn
Phone: +372 6205 700
Fax: +372 6205 706
Mail: Rene.sirol@vta.ee

Maritime Administration
Tarmo Ots
Head of Foreignrelationsdept

Valge 4, 11413 Tallinn
Phone: +372 6205 529
Fax: +372 6205 506
Mail: Tarmo.ots@vta.ee

Maritime Administration
Rein Einberg
Dead of Coordination Centre
Lume 9, 104161 Tallinn
Phone: +372 6205 668
Fax: +372 6205 706
Mail: Rein.einberg@vta.ee

Freeport of Riga
Att.: Edgars Ukis
Meldru 5 a , Riga, Latvia LV 105
Phone: +371 7 082 001
Fax: +371 7 322 750
Mail: captain@ROK.BKC.lv

Struebing@bsh.de

Poststelle@wsd-nord.de

DSchnell@ki.wsd-nord.de

HSchaefers@ki.wsd-nord.de

MMau@ki.wsd-nord.de

Annex VI

Report of the IICWG

Separate .ppt file pp. 69-90

Annex VII

Proposed WMO Sea-Ice Nomenclature Amendments

Canadian Ice Service
D. Fequet
August 30, 2002

Ice Terms (definitions) Part I and II

Section 10.4.5 page E-8 Growler: *Smaller piece of ice than a bergy bit or floeberg, often transparent but appearing green or almost black in colour, extending less than 1 m above the sea surface and normally occupying an area of about 20 sq. m.*

Our observers find that *growlers* are rarely transparent and usually white in colour. We also think that *floebergs* are not relevant in this definition since it is not ice of land origin. We suggest the definition for *growler* be revised as follows;

Growler: Smaller piece of ice than a bergy bit and floating less than 1 m above the sea surface, a growler generally appears white but sometimes transparent or blue-green in colour. Extending less than 1 m above the sea surface and normally occupying an area of about 20 sq. m., growlers are difficult to distinguish when surrounded by sea ice.

Section 4.4.7 page E-5 Ice jam: *An accumulation of broken river ice or sea ice caught in a narrow channel.*

This definition of an *ice jam* is restrictive. Other features such as bridges and shoals can cause *ice jams*. We suggest the definition for *ice jam* be revised as follows;

Ice jam: An accumulation of ice not moving due to some physical restriction and resisting to pressure.

Section 6.4.1 page E-6 Finger rafting: *Type of rafting whereby interlocking thrusts are formed, each floe thrusting "fingers" alternately over and under the other. Common in nilas and grey ice.*

Our observers find that *finger rafting* is common in nilas but much less common in grey ice. We suggest the definition for *finger rafting* be revised as follows;

Finger rafting: Type of rafting whereby interlocking thrusts are formed, each floe thrusting "fingers" alternately over and under the other. This is commonly found in nilas and sometimes in grey ice.

Section 9.3 page E-7 Dried ice: *Sea ice from the surface of which melt-water has disappeared after the formation of cracks and thaw holes. During the period of drying, the surface whitens.*

Our observers find that as ice dries it does not whiten but takes on a silver tone. We suggest the definition for *dried ice* be revised as follows;

Dried ice: Sea ice from the surface of which melt-water has disappeared after the formation of cracks and thaw holes. After the drying period, the surface previously flooded has a silver tone.

Section 4.2.6 page E-4, Open Water: *A large area of freely navigable water in which sea ice is present in concentrations less than 1/10. There may be ice of land origin present, although the total concentration of all ice shall not exceed 1/10.*

For this definition of *open water* we disagree with the inclusion of ice of land origin. It is Canadian practice to give priority to icebergs since they are a greater threat to mariners. When there are icebergs present and less than 1/10th of sea ice the area should be labeled *Bergy Water*. We suggest the definition for *open water* be revised as follows;

Open Water: A large area of freely navigable water in which ice is present in concentrations less than 1/10. No ice of land origin is present.

Part II Page E-12, Open Water: *A large area of freely navigable water in which sea ice is present in concentrations less than 1/10. When there is no sea ice present, the area should be termed ice free, even though icebergs are present.*

For this definition of *open water* we disagree again with the inclusion of ice of land origin. We give priority to icebergs since they are a greater threat to mariners. When there are icebergs present and less than 1/10th of sea ice the area should be labeled *Bergy Water*. We also disagree with the statement " *the area should be termed ice free, even though icebergs are present*". An *ice free* area should not have any type of ice present. We suggest the definition for *open water* be revised as follows;

Open Water: A large area of freely navigable water in which ice is present in concentrations less than 1/10. No ice of land origin is present.

Section 4.2.7 page E-4, Bergy Water: *An area of freely navigable water with no sea ice present but in which ice of land origin is present.*

It is Canadian practice to give priority to icebergs since they are a greater threat to mariners than a trace of sea ice. When there are icebergs present and less than 1/10th of sea ice the area should be labeled *Bergy Water*. We suggest the definition for *Bergy Water* be revised as follows;

Bergy Water: An area of freely navigable water in which ice of land origin is present. Other ice types may be present, although the total concentration of all other ice is less than 1/10.

Section 4.2.8 page E-4, Ice-free: *No ice present. If ice of any kind is present, this term shall not be used.*

We agree with this definition of *ice free*.

Part II Page E-11 -Ice-free: *No sea ice present. There may be some ice of land origin.*
We disagree with this definition of *ice free*. Ice Free is an area with no ice types present. . We suggest the definition for *Ice Free* be revised as follows (as per Section 4.2.8 page E-4, Ice-free);

Ice Free: No ice present. If ice of any kind is present, this term shall not be used.

Sea-Ice Symbols

Section 6. page E-7: *Ridging/hummocks symbol:*

▲▲

We recommend that the horizontal line under the triangle is not required and should be removed. The new symbol would look like this;

▲▲

Section 10.1 page E-8: *Radar target (suspected berg)*: **X**

This symbol is also a text symbol and could be confused with other annotation on a chart. We suggest the symbol for radar target be changed to include a circle around the **x** as follows;

⊗

Annex I

***Page E-13*, Form of Ice table**:

Element	***Symbol***
Fast Ice, growlers or floebergs	*8*
Icebergs	9

Since fast ice is very common we suggest it should have a unique *form of ice* code. The *form of ice* code 8 should used only for fast ice. If growlers or floebergs are reported, as part of an egg code, the *form of ice* code should be 9, the same as with icebergs. We suggest the *form of ice* table be revised as follows;

Element	Symbol
Fast Ice	8
Icebergs, growlers or floebergs	9

If this change is accepted then Notes: #2 (*page E-13 Form of ice* table be revised as follows;

Element	Symbol
Fast Ice	8
Icebergs, growlers or floebergs	9

If this change is accepted then Notes: #2 (*page E-13 Form of ice table*) can be omitted.

Annex VIII

Ice Chart Colour Standard Proposal-I

- This proposal was drafted based on comments received from Ice Services who tested the original proposal during the first half of 2002.

Proposal

- Two separate colour codes be adopted for use on ice charts
  - one based on total concentration intended for use when the stage of development is relatively uniform but concentration is highly variable
    - arctic summer navigation
  - one based on stage of development intended for use when the concentration is relatively uniform (high) but the stage of development is variable
    - arctic winter navigation

Concentration Colour Standard

Colour is based on Total Ice Concentration with optional colours for Close Pack Multi-Year Ice and Young Ice

Colour (RGB)	Description
o 000-100-255	Ice Free
150-200-255	Open Water or Bergy Water (<1 tenth sea ice)
140-255-160	1-3 tenths ice
255-255-000	4-6 tenths ice
255-125-007	7-8 tenths ice
255-000-000	9-10 tenths ice
150-150-150	Fast Ice
210-210-210	Shelf Ice
? ? o 000-000-000	Undefined Ice

Optional

Colour (RGB)	Description
255-175-255	7-10 tenths New Ice
255-100-255	9+-10 tenths Nilas, Grey Ice (mainly on leads)

Stage of Development Colour Standard

Colour is based on Stage of Development of Predominant Ice

(blank) or 150-200-255 *	Ice Free
000-000-255	New Ice
255-175-255 *	Dark Nilas
255-100-255 *	Light Nilas
220-080-235	Young ice
135-060-215	Grey ice
170-040-240	Grey-white ice
155-210-000	FY thin ice
215-250-130	FY thin ice (30 -50 cm)
175-250-000	FY thin ice (50-70 cm)
000-200-020	FY medium ice
000-120-000	FY thick ice
180-100-050 *	Old ice
255-120-010	Second-year ice
200-000-000	Multi-year ice
150-150-150	Fast ice
210-210-210	Shelf ice
? ? ? ? or (hatched) 000-000-000	Undefined Ice

Areas of No Information are annotated accordingly

Ice Chart Colour Code - Notes

- The two separate colour codes are mutually exclusive - only one or the other should be used on a single chart
- A legend depicting the colour code used should be included on every chart
- The optional colour indicating 9+-10 tenths of nilas or grey ice should only be used to indicate level ice, mainly on leads; it should not be used for ice broken into brash or ice cakes or for concentrations less than 9+ tenths
- Undefined ice is used when it is known that ice is in an area but its characteristics are not known - this is different from No Information which indicates that nothing at all is known about the area
- No specific colour is assigned to areas of "No Information"; such areas should be clearly indicated on ice charts - text annotation may be used where appropriate; an assigned colour within the code should not be used to indicate "No Information"
- Colour codes do not preclude use of black and white hatching patterns or egg codes; egg codes may be used along with colours
- Other symbols may be used in addition to the standard colours to depict special ice conditions under national practice

Ice Chart Colour Standard Proposal-II

Separate .ppt file pp. 99-104

Annex IX

REPORT ON ICE DECAY/STAGES OF MELTING

Introduction

1. JCOMM-I noted the results of research undertaken by Canadian Ice Service experts, under the Arctic Sea Ice Regime Shipping System (AIRSS), to identify ice decay from radar back scatter. The JCOMM-I agreed that as a result of this work, appropriate amendments to the nomenclature for coding sea ice decay should be developed during the next intersessional period. In turn, during the last third IICWG meeting it was agreed that IICWG experts from Canada and Russian Federation investigate the inter-relationship between traditional stages of melt and new ice strength index with respect to the physical process in the seasonal cycle and movement of ships in ice, to improve the exchange of ice melt/strength science (past, present, future) within IICWG and to prepare a progress report by October 2002.

2. Three papers are submitted to ETSI members for information:

(a) De Abreu, Roger, John Yackel, David Barber and Matthew Arkett; *Operational Satellite Sensing of Arctic First Year Sea Ice Melt*; draft report by the Canadian Ice Service; 2002.

(b) Timco, G.W., M. Johnston and I. Kubat; *Ice Decay and the Ice Regime System*; Canadian Hydraulics Centre Technical Report HYD-TR-070; National Research Council of Canada; December 2001.

(c) Gauthier, M-F., R. De Abreu, G.W. Timco and M.E. Johnston; *Ice Strength Information in the Canadian Arctic: From Science to Operations*; accepted for presentation at the 16th IAHR International Symposium on Ice; December 2002.

3. Paper (a) above presents the results of work done at the Canadian Ice Service and its university partners to define stages of melt from satellite remote sensing. It was determined that five stages of melt – Winter, Snow Melt, Ponding, Drainage and Rotten Ice – can be determined.
Paper (b) above presents the results of work sponsored by the Canadian Ice Service (CIS) to relate these stages of melt to ice strength and the effect on vessels operating in ice. In light of the recommendations presented in this paper, the CIS has decided not to propose changes to the WMO Sea Ice Nomenclature with respect to ice decay at this time.

4. The CIS is evaluating methods of presenting ice strength information directly without referring to a proxy ice melt indicator. The status of this initiative is described fully in paper (c) above. Briefly, a prototype “Ice Strength” chart product was developed and distributed to a select group of users for evaluation during the 2002 summer navigating season. Evaluation reports have been received from the participating vessels. The analysis of these reports is expected to be completed by the spring of 2003 and will be presented in a report recommending future directions.

Appendices: 2

APPENDIX A to Annex IX

CHC CANADIAN HYDRAULICS CENTRE

TP 13871 E

Ice Decay and the Ice Regime System

G.W. Timco, M. Johnston and I. Kubat
Canadian Hydraulics Centre
National Research Council of Canada
Ottawa, Ont. K1A 0R6
Canada

Technical Report
HYD-TR-070

December 2001

ABSTRACT

The Canadian Ice Regime System takes into account the decay of sea ice by allowing the addition of +1 to the Ice Multiplier for ice that is deemed to be decayed at the "rotten" stage. This report examines this approach based on an analysis of the strength of both first-year sea ice and multi-year sea ice, and the damage statistics for Arctic vessels. The analysis shows that there is no quantitative scientific basis for the current approach of taking into account the decay of sea ice in the Ice Regime System. The report provides a detailed discussion of the analysis with recommendations that (1) the decay of sea ice should be recast in terms of the strength of ice; (2) the summer bonus for reduced ice strength should be given once the ambient air temperature has been above 0°C for one month; (3) an analysis should be performed to define a similar criterion to be used during the growth (autumn) season; and (4) there should be no bonus for decayed multi-year ice.

TABLE OF CONTENTS
(page numbers have changed - click to go section)

LIST OF FIGURES

(page numbers have changed - click to go section)

LIST OF TABLES

Ice Decay and the Ice Regime System

INTRODUCTION

Navigation in Canadian waters north of 60°N latitude is regulated by the Arctic Shipping Pollution Prevention Regulations (ASPPR). These regulations include the date Table in Schedule VIII and the Shipping Safety Control Zones Order, made under the Arctic Waters Pollution Prevention Act. Both of these are combined to form the "Zone/Date System" matrix that gives entry and exit dates for various ship types and classes. It is a rigid system with little room for exceptions. It is based on the premise that nature consistently follows a regular pattern year after year.

Transport Canada, in consultation with stakeholders, has made extensive revisions to the Arctic Shipping Pollution Prevention Regulations (ASPPR 1989; Canadian Gazette 1996; AIRSS 1996). These changes, introduced only outside the zone-date system, were designed to reduce the risk of structural damage in ships which could lead to the release of pollution into the environment, yet provide the necessary flexibility to shipowners by making use of actual ice conditions, as seen by the Master. In this new system, an "Ice Regime", which is a region of generally consistent ice conditions, is defined at the time the vessel enters that specific geographic region, or it is defined in advance for planning and design purposes. The Arctic Ice Regime Shipping System (AIRSS) is based on a simple arithmetic calculation that produces an "Ice Numeral" that combines the ice regime and the vessel's ability to navigate safely in that region. The Ice Numeral (IN) is based on the quantity of hazardous ice with respect to the ASPPR classification of the vessel (see Table 1). The Ice Numeral is calculated from

$$IN = [C_a \, x \, IM_a] \quad + \quad [C_b \, x \, IM_b] \quad + ... \qquad (1)$$

where
IN = Ice Numeral
C_a = Concentration in tenths of ice type "*a*"
IM_a = Ice Multiplier for ice type "*a*" (from Table 1)

The term on the right hand side of the equation (*a, b, c,* etc.) is repeated for as many ice types as may be present, including open water. The values of the Ice Multipliers are adjusted to take into account the decay or ridging of the ice by respectively adding or subtracting a correction of 1 to the Ice Multiplier (see Table 1).

The Ice Numeral is therefore unique to the particular ice regime and ship operating within its boundaries.

Table 1 Table of Ice Multipliers for AIRSS

Table Of Ice Multipliers By Ship Category

AES / WMO Ice Codes	Ice Types		Ice Multipliers for each Ship Category: Type E	Type D	Type C	Type B	Type A	CAC 4	CAC 3
7• or 9•	Old / Multi-Year Ice.......... (MY)		-4	-4	-4	-4	-4	-3	-1
8•	Second Year Ice .... (SY)		-4	-4	-4	-4	-3	-2	1
6 or 4•	Thick First Year Ice .... (TFY)	> 120 cm	-3	-3	-3	-2	-1	1	2
1•	Medium First Year Ice .... (MFY)	70-120 cm	-2	-2	-2	-1	1	2	2
7 9	Thin First Year Ice .... (FY) Thin First Year Ice - 2nd Stage	30-70 cm 50-70 cm	-1	-1	-1	1	2	2	2
8	Thin First Year Ice - 1st Stage	30-50 cm	-1	-1	1	1	2	2	2
3 or 5	Grey-White Ice.................. (GW)	15-30 cm	-1	1	1	1	2	2	2
4	Grey Ice............................. (G)	10-15 cm	1	2	2	2	2	2	2
2	Nilas, Ice Rind	< 10 cm	2	2	2	2	2	2	2
1	New Ice .... (N)	< 10 cm	"	"	"	"	"	"	"
	Brash (ice fragments < 2 m across)		"	"	"	"	"	"	"
⇨Δ	Bergy Water		"	"	"	"	"	"	"
⊕⊕⊕⊕	Open Water		"	"	"	"	"	"	"

Notes:

Decayed Ice: For the following ice types: MY, SY, TFY, and MFY that are 'decayed', add 1 to the Ice Multiplier.

Ridged Ice: For floes of ice that are over 3/10ths 'Ridged' and in an overall concentration that is greater than 6/10ths, subtract 1 from the Ice Multiplier.

The ASPPR deals with vessels that are designed to operate in severe ice conditions for transit and icebreaking (CAC class) as well as vessels designed to operate in more moderate first-year ice conditions (Type vessels). The System determines whether or not a given vessel should proceed through that particular ice regime. If the Ice Numeral is negative, the ship is *not* allowed to proceed. However, if the Ice Numeral is zero or positive, the ship is allowed to proceed into the ice regime. Responsibility to plan the route, identify the ice, and carry out this numeric calculation rests with the Ice Navigator who could be the Master or Officer of the Watch. Due care and attention of the mariner, including avoidance of hazards, is vital to the successful application of the Ice Regime System. Authority by the Regulator (Pollution Prevention Officer) to direct ships in danger, or during an emergency, remains unchanged.

At the present time, there is only partial application of the ice regime system, exclusively outside of the "zone-date" system.

Credibility of the new system has wide implications, not only for ship safety and pollution prevention, but also in lowering ship insurance rates and predicting ship performance. Therefore, there is a need to establish a scientific basis for the system. To this end, Transport Canada approached the Canadian Hydraulics Centre of the National Research Council of Canada (CHC/NRC) in Ottawa to assist them in developing a methodology for establishing a scientific basis for AIRSS. Considerable progress has been made in addressing the scientific basis (see Timco and Kubat (2001) for a recent update).

One important aspect of the Ice Regime System (IRS) is the decay of the sea ice. As noted in Table 1, an additional integer value is added to the Ice Multiplier if specific types of sea ice are decayed. The IRS allows the addition of one to the Ice Multiplier if the multi-year (MY) ice, second-year (SY) ice, thick first-year (TFY) ice or medium first-year (MFY) ice is decayed. No allowance is made for decay in thinner ice. This modification can significantly increase the Ice Numeral for decayed ice regimes.

This modification for decay was originally done on an "ad hoc" basis with no scientific evidence established for it. Further, there is no accepted definition of ice decay. Because of this, Transport Canada has asked the CHC/NRC to review this question. In this report, the strength of sea ice is reviewed with an eye towards the decay process. This is done for both first-year sea ice and older, multi-year and second-year sea ice. Following that, the ship damage events in the Arctic are reviewed to look for a correlation between sea ice decay and (less) damage. This is followed by some recommendations for the approach that should be taken for considering the decay of sea ice in the Ice Regime System.

FIRST-YEAR SEA ICE

Growth of Sea Ice

Sea ice is a complex material which is composed of solid ice, brine, air and, depending upon the temperature, solid salts. Ice growth mechanisms can produce several different grain structures, depending upon the prevailing conditions. The details of the ice microstructure influence significantly the mechanical and physical properties of the ice. In general, sea ice is a mix of grain structures including S2 columnar, granular, frazil and discontinuous columnar. The classic picture of sea ice structure (see e.g., Weeks and Ackley 1982) shows an upper granular structure overlying a S2 columnar structure. Although this type of composite structure is prevalent in land-fast ice in Arctic regions, it is certainly not universal. In many cases, especially in pack ice, there can be considerable "banding" of alternating layers of columnar and granular ice, often with discontinuous columnar ice. Moreover, in certain areas, considerable frazil ice has been observed on the bottom of an ice sheet. Thus the overall structure of the ice can be quite variable.

When the ice grows, it traps some of the salt that is present in the seawater. The amount of salt that is trapped in the growing ice sheet is affected by several factors. Typically first-year sea ice has salinity in the range of 4 to 6 parts per thousand (‰) salt. This is lower than the salinity of seawater, which is typically 35 ‰. The brine, air and solid salts are usually trapped at sub-grain boundaries between a mostly pure ice lattice. Also, because a temperature gradient exists, the upper surface temperature is close to the ambient air temperature, and the lower surface temperature is at the freezing point (usually -1.8°C for sea ice). Because there are a number of salts in the ice, the phase relationship with temperature is multifarious (see e.g., Weeks and Ackley 1982). All of these factors make understanding and charactering sea ice extremely difficult.

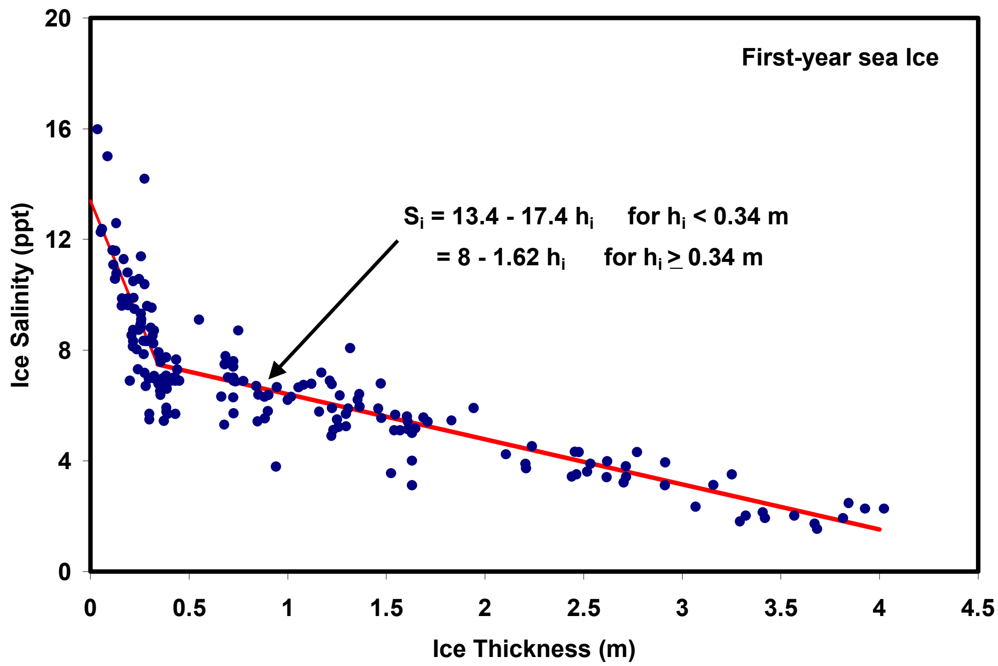
Ice Salinity

For sea ice, the salinity (S_i) is usually expressed as the fraction by weight of the salts contained in a unit mass. It is usually quoted as a ratio of grams per kilogram of seawater, that is, in parts per thousand (‰ or ppt). In sea ice there is usually some salinity variation with depth in the ice sheet. This depth dependence of the salinity changes throughout the winter as the salt within the ice migrates downward through the ice. There can be, however, marked salinity variations even within a small sample. In many cases, therefore, the average value of a salinity profile is used as a first approximation of salinity for an ice sheet.

In collating information on sea ice from a wide number of sources, Cox and Weeks (1974) found that the average salinity of a cold ice sheet could be related to the thickness of the ice (h_i). Figure 1 shows a plot of the average ice salinity versus ice thickness for a large number of measurements on sea ice sampled during the growth season. The graph gives the original data of Cox and Weeks along with some more recent data from Frederking and Timco, Sinha and Nakawo, and Frederking. The data were collected from cores from all parts of the Arctic including the Beaufort Sea, Bering Sea, Labrador, Eclipse Sound and Strathcona Sound. From Figure 1 it appears that a reasonable representation of the ice salinity for a given ice thickness h_i can be expressed as (from Timco and Frederking 1990):

$$S_i = 13.4 - 17.4\, h_i \quad for \quad h_i \le 0.34\, m\,;$$
$$S_i = 8.0 - 1.62\, h_i \quad for \quad h_i \ge 0.34\, m\,; \qquad (2)$$

This approach assumes that there is no salinity variation with depth through the ice sheet, which is a reasonable first approximation for sea ice. Equation (2) gives the average salinity of sea ice as a function of the ice thickness. As evidenced in Figure 1, there is a good fit of the equations to the data. The change in salinity with thickness reflects the drainage of the brine during the year, and the fact that slower growth rates trap less salt in the ice sheet. With thicker ice, the growth rate is substantially lower than that for a thin (usually snowless) ice sheet in the early winter. All of these factors affect the strength of the ice.



- Figure 1: Ice salinity versus ice thickness for cold first-year sea ice

Brine Volume and Total Porosity

Historically sea ice has been analyzed in terms of the "brine volume" in the ice. The brine volume represents the amount of liquid brine in the host ice matrix. The determination of the brine volume integrates the influence of both temperature and salinity. The brine volume of the ice is related to the temperature (T_i) of the ice, the salinity (S_i) of the ice and the types of salts present. For sea ice, the brine volume can be determined from the Frankenstein and Garner (1967) Equation:

$$\upsilon_b = S_i \left[\frac{49.185}{|T_i|} + 0.532 \right] \qquad (3)$$

where -0.5°C ≥ Ti ≥ -22.9°C; or from the Cox and Weeks (1982) equation:

$$\upsilon_b = \rho_i \, S_i \, / \, F_1(T) \qquad (4)$$

where ρ_i is the bulk ice density, and

$$F_1(T_i) = -4.732 - 22.45\,T_i - 0.6397\,T_i^2 - 0.01074\,T_i^3 \quad \text{for } -2 \geq T_i \geq -22.9$$

$$= 9899 + 1309\,T_i + 55.27\,T_i^2 + 0.716\,T_i^3 \quad \text{for } -22.9 \geq T_i \geq -30$$

Although the latter is more accurate, the former provides a reasonable estimate of the brine volume. The brine volume is usually quoted in terms of the volume in parts per thousand, similar to the salinity. Alternatively, it can be expressed as a volume fraction. (For example, a brine volume of 20 ‰ is equivalent to a brine volume fraction of 0.020).

Knowledge of the brine volume for sea ice is useful on its own. However, in addition to the liquid brine in the ice, air is present in the ice. In certain instances (especially where brine drainage occurs) the air volume can be significant. For this reason it is usually better to express the porosity of the ice as the total porosity (i.e. brine plus air). For this, the total porosity (ν_T) of the ice is expressed as

$$\nu_T = \nu_b + \nu_a \tag{5}$$

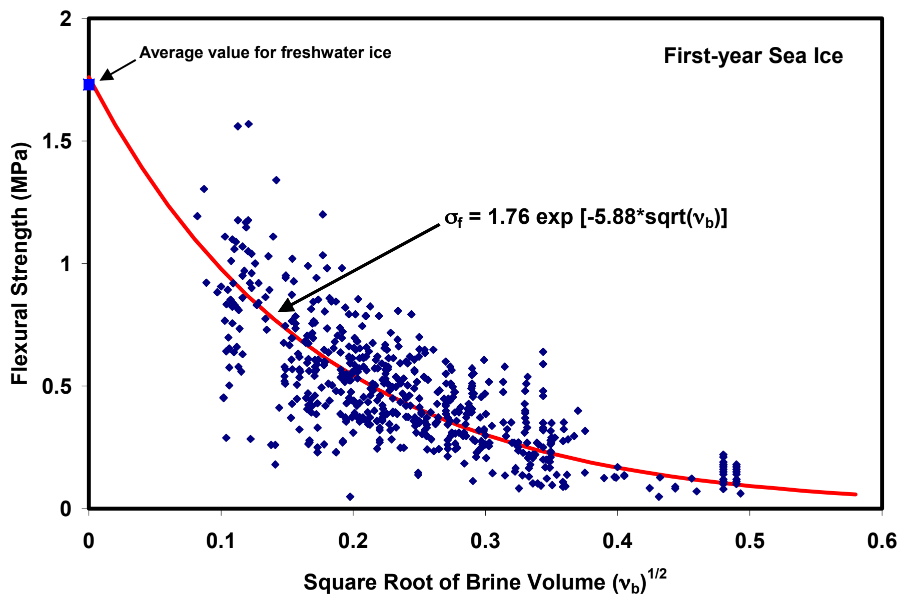
where ν_b is the relative brine volume and ν_a is the relative air volume. Cox and Weeks (1982) developed equations to calculate the total porosity. To do this, the bulk ice density must be known accurately. Since this is a property that is not usually known due to the difficulty of an accurate measurement, the following discussion will be related only to the brine volume.

Flexural Strength

Several researchers have attempted to relate the strength of sea ice to the brine volume or total porosity of the ice. There is a good reason for this. It is generally assumed that as the total porosity in the ice increases, the strength should decrease since there is less "solid ice" that has to be broken. Timco and O'Brien (1994) have done the most comprehensive analysis of the flexural strength of ice. They compiled a database of over 2500 reported measurements on the flexural strength of freshwater ice and sea ice. For this data set, approximately 1000 tests were performed on sea ice. Timco and O'Brien (1994) showed that the data for first-year sea ice could be described by:

$$\sigma_f = 1.76 \exp(-5.88 * \sqrt{\upsilon_b}) \tag{6}$$

where σ_f is the flexural strength of the ice and the brine volume (ν_b) is expressed as a brine volume fraction. This relationship is shown with the data in Figure 2.



- Figure 2: Flexural strength versus the square root of the brine volume for first-year sea ice.

There are several things to note from this figure:

- The value of 1.76 MPa for zero brine volume is in excellent agreement with the average strength (1.73 MPa) measured for freshwater ice.
- The general scatter in the data increases with decreasing brine volume. This is a reflection of the fact that, at low brine volumes, the ice is much more brittle. The range of scatter approaches that measured for freshwater ice. This type of scatter is characteristic of a brittle material. It is natural scatter.
- This equation is the most comprehensive equation for flexural strength to date. There have been a few other equations proposed to relate strength and brine volume but these have been based on substantially fewer data points, and data that extended over a very limited range. In other words, the other equations are valid over only a small brine volume range. The wider range of this equation represents these other equations very well in the ranges where they are valid.
- The data for the equation was compiled from a large number of investigators, and from a variety of geographic locations, in both polar and temperate climates. Therefore it should be quite representative of the flexural strength of sea ice in most regions.
- The brine volume used to represent the ice beam for any test was taken to be the average brine volume, determined from the average temperature and salinity of the beam. Thus, to calculate the flexural strength, it is only necessary to know the average temperature and salinity of the ice.

In summary, the fact that a very large number of data points have been used in this analysis, the excellent agreement with the flexural strength of freshwater ice at zero brine volume and the associated scatter comparable to freshwater ice, indicates this equation is a very good representation of the dependence of flexural strength of sea ice on the brine volume.

Internal Processes within Sea Ice

The information discussed above provides some insight into the internal processes within sea ice. During the mid-winter months, the air temperature is very low and the ice is cold. When the ice is cold, the majority of entrained salt is in the form of precipitated crystals within the brine pockets. As spring approaches, the air temperature progressively warms and the internal temperature of the ice increases. Increasing ice temperatures cause a phase change within the brine pockets whereby precipitated salts dissolve and enter solution. As the salts dissolve, ice melts along the walls of the brine pocket and the overall brine volume increases.

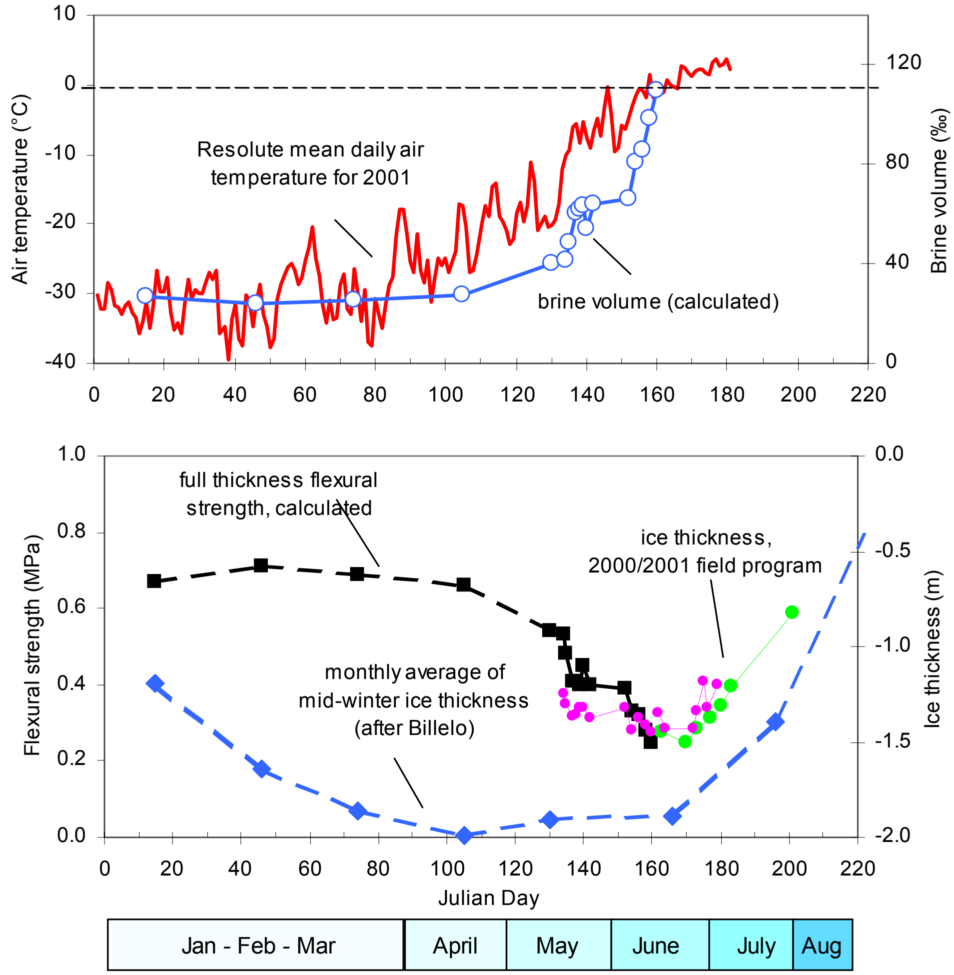
As the ice temperature warms, the ice becomes nearly isothermal. Brine pockets continue to increase in size and eventually interconnect to form large brine drainage channels within the ice. These channels provide a conduit for the liquid brine to "drain" out of the ice. Once the brine drainage channels form the ice salinity decreases rapidly. Ice that is isothermal and from which most of the salinity has drained is considered to be in an advanced state of decay. What does ice decay mean quantitatively in terms of the degradation in ice strength? To answer this, a natural starting point would be to calculate the flexural strength of the ice using the inverse relationship between ice strength and brine volume described in Equation 6. The following discussion focuses upon changes in the flexural strength of the ice during the decay season.

Changes in Flexural Strength: Case Study

Techniques for measuring the properties of cold, winter sea ice are straightforward. Once the air temperatures and solar radiation increase however, the physical properties of the snow and ice quickly begin to change. The properties of an ice core change as soon as it is extracted from the ice sheet. The difficulty of measuring the properties of warming sea ice explain why there is an absence of data on the properties of first-year sea ice during the decay stages.

The decay of landfast first-year sea ice was characterized during two field seasons near Resolute, Cornwallis Island in the Canadian Arctic. The field programmes were conducted for two sequential years, in 2000 and 2001. The programmes began in May, when the ice was cold, and extended until June and July, when the snow cover had melted fully and the ice was beginning to ablate. Property measurements included snow depth, ice thickness, air and ice temperature and ice salinity.

Most of the property measurements were used to calculate the flexural strength of the ice using Equation (6) and the model discussed in Timco and O'Brien (1994). Figure 3 presents a typical case study illustrating a portion of the annual (winter-spring) ice cycle. The relationship between the measured air temperature (for year 2001), ice thickness, calculated brine volume and calculated flexural strength is shown for January to mid-July. Mid-winter ice conditions were approximated using ice thickness measurements made by Billelo (1980) on first-year ice near Resolute from 1959 to 1972. The author reported ice that was, on average, about 0.40 m thicker than ice during the decay season field measurements (for the same time of year). As a result, Figure 3 shows a discontinuity between ice thickness reported by Billelo (1980) and the field measurements from years 2000 and 2001. The air temperatures shown in Figure 3 are the mean daily air temperatures recorded at Resolute in year 2001.



- Figure 3: Flexural strength and ice measurements used in the calculation

The case study in Figure 3 shows that the calculated brine volume and flexural strength of the ice remain relatively constant throughout the winter. In spring, there is a steady increase in air temperature and solar radiation intensifies. At that point the brine volume increases and the internal structure of the sea ice changes, causing a decrease in the flexural strength of the ice. Figure 3 shows that by 11 June (JD162), the ice temperature and brine volume have increased to a point where Equation 6 is invalid for calculating the flexural strength of the ice. The flexural strength equation breaks down when the ice temperature is close to the melting point. At this stage, the increase in the brine volume is in a "runaway" condition and the equations for calculating the brine volume are no longer valid. At the same time, as shown by measurements from the 2000/20001 field programmes (Figure 3), the ice begins to decrease in thickness.

In order to calculate the flexural strength of decaying sea ice, an equation would need to be developed to take into account the total porosity of the ice (Equation 5), rather than only the brine volume. Calculation of the total porosity requires reliable information about the density of the ice. The wide range of scatter in the reported densities of cold, winter sea ice (Timco and Frederking, 1996) illustrates the difficulty of obtaining accurate ice density measurements. It is considerably more difficult to measure accurately the density of warm sea ice. As a result, developing an equation that requires the total porosity as input is a formidable task. Clearly, it becomes necessary to use other means to measure the strength of decaying sea ice. The most feasible means of determining the strength of warm ice would be to avoid performing property measurements on an extracted ice core, i.e. to do the strength tests *in situ*. The borehole jack assembly fulfils that requirement.

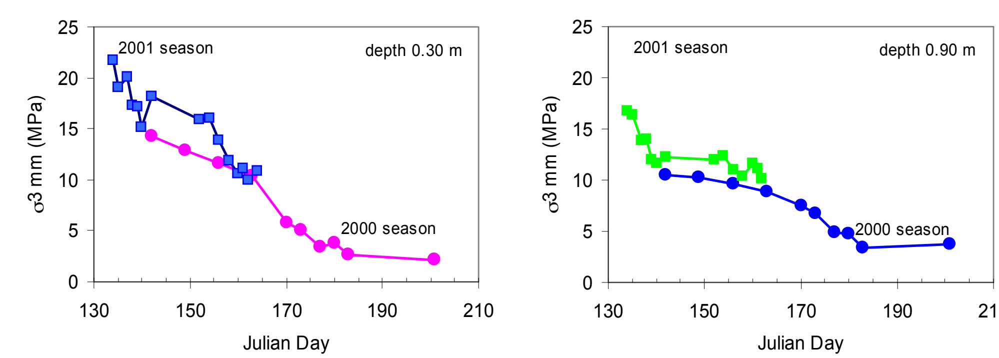
Ice Borehole Strength

Borehole jack tests are convenient in that, after a core has been extracted from the ice, strength tests are conducted in the hole made by the corer. The borehole jack is mounted with its curved, stainless steel indentor plates flush to the wall of the ice core hole. A pump circulates hydraulic fluid into the jack to activate its laterally acting piston. The piston applies hydraulic pressure to the indentor plates, causing them to extend and penetrate the wall of the borehole. Once a test has been run at a specified depth, the jack is rotated and lowered to the next test depth. In first-year sea ice, the borehole jack tests are typically conducted at a 0.30 m depth interval. A total of four tests would be conducted for ice about 1.2 m thick.

An external data acquisition system records the oil pressure and displacement during each test. These measured values are then used to determine the ice pressure. The test length and indentor rate differ for each borehole jack test, so it is not possible to compare tests results based upon the peak pressure recorded during an individual test. Rather, the information from different tests should be compared based upon the ice pressure at a specified indentor displacement.

- Measuring the *in situ*, confined compressive strength of the ice (i.e. ice borehole strength) with a borehole jack was a significant component of the Resolute field programmes conducted in years 2000 and 2001. Strength measurements were obtained at least twice per week in the early season and more frequently as the season progressed. Each test day, depth profiles of the ice borehole strength were obtained throughout the full thickness of the ice for a total of three holes. Results from the different borehole jack tests were compared based upon the pressure at an indentor displacement of 3 mm (σ_{3mm})

Figure 4 shows changes in the ice borehole strength that occurred at two representative ice depths (0.30 and 0.90 m) during the 2000 and 2001 measurement seasons. Air temperatures and ice thickness during the two field seasons were comparable, providing good repeatability of the borehole jack tests. Strength measurements from the two years showed similar trends. The reader is referred to Johnston et al. (2000) and Johnston and Frederking (2001) for a more thorough discussion of results from each season.



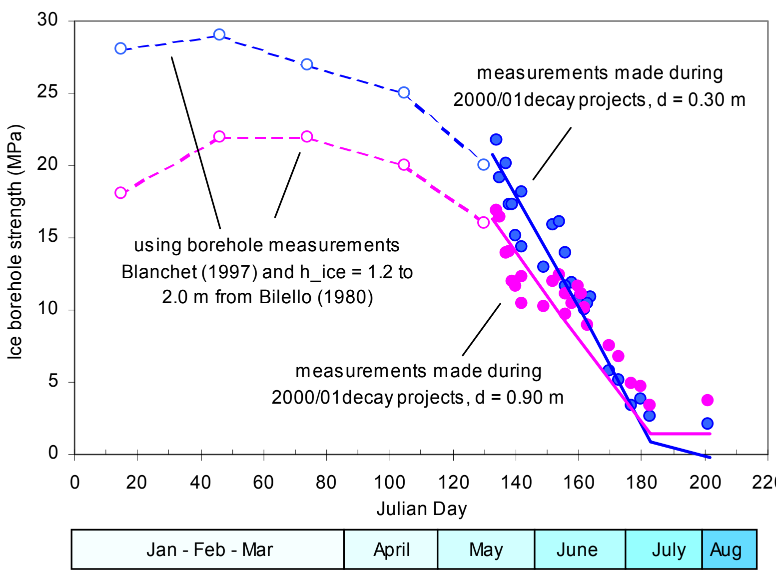
(a) depth 0.30 m (b) depth 0.90 m

- Figure 4: Ice borehole strength for two measurement seasons

When the measurement programme began on 14 May (JD134) in year 2001, the ice strength was 21.7 MPa. The ice strength decreased quite rapidly during the first week, by about 5 to 7 MPa. After that, the ice strength continued to decrease, although at a considerably slower rate. The ice strength at all depths stabilized at 2 to 3 MPa in early July (2 July, JD183). The ice maintained a 2 to 3 MPa strength throughout most of July (the last measurements were taken 20 July - JD201).

Results from the borehole jack tests during the decay season were placed in perspective by consulting the literature for the ice borehole strength of mid-winter, first-year sea ice. Masterson et al. (1997) reported a depth averaged ice borehole strength of 24.4 MPa for 29 tests in natural first-year sea ice. Blanchet et al. (1997) reported results from a series of borehole jack tests that were conducted in cold, first-year sea ice at Tarsiut Island in the Beaufort Sea. The authors reported a maximum ice borehole pressure of 27 to 8 MPa for first-year ice in the (ice) temperature range –17°C to near 0°C.

A curve was fit to the data points reported in Blanchet et al. (1997) and this was used to extrapolate the strength measurements from years 2000 and 2001 to mid-winter conditions. Figure 5 presents results of the mid-winter extrapolation of the ice borehole pressure for ice depths 0.30 and 0.90 m. The comparison shows that the ice borehole strength of cold, mid-winter ice ranges from 20 to 28 MPa for ice at a depth of 0.30 m and 16 to 22 MPa at an ice depth of 0.90 m. Variations in the mid-winter ice borehole strength resulted from changes in the ice thickness and air temperature (hence ice surface temperature). Figure 5 shows that the ice borehole jack strength changes most during the spring, when air and ice temperatures begin to warm.

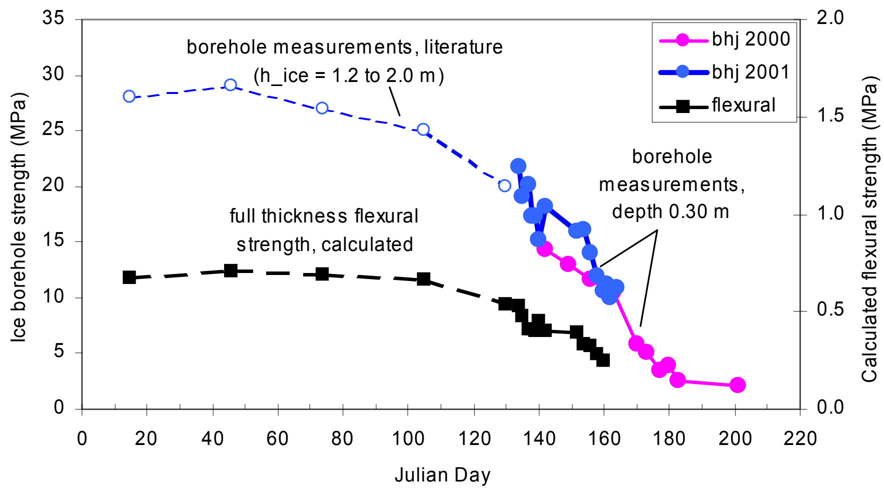


- Figure 5: Typical, mid-winter ice borehole strength and strengths from decay work

Decay Process in First-Year Sea Ice

As previously discussed, the flexural strength equation is not reliable for warm sea ice. In the temperature region where the flexural strength equation is not appropriate, borehole jack tests offer a feasible means of measuring the *in situ* confined compressive strength of the ice. Having demonstrated the feasibility of the borehole jack in measuring the strength of decaying ice, how does the *in situ* confined compressive strength relate to the flexural strength of the ice?

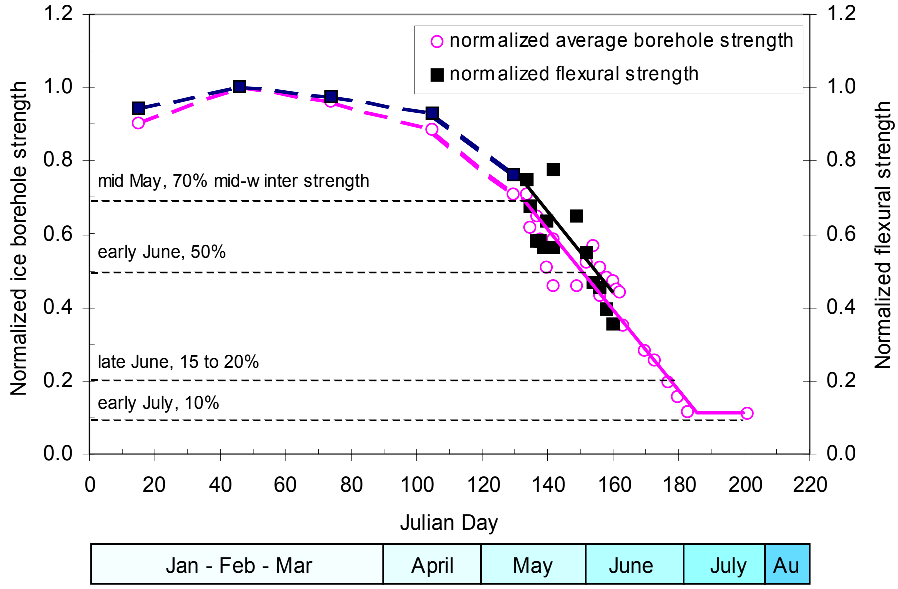
Figure 6 shows a comparison of the extrapolated and measured ice borehole strength (ice depth 0.30 m) and the calculated, full thickness flexural strength of the ice. The region of overlap between the strengths shows that the ice strength is stable during the winter months. During the spring season, the ice strengths begin to decrease and continue to decrease until early July. Results show that the ice borehole strength in the surface layer decreased from its mid-winter maximum of 29 MPa in February to about 2 MPa in July. The calculated flexural strength of the ice had a mid-winter maximum of 0.71 MPa and decreased to 0.25 MPa on 9 June (JD160).



- Figure 6: Comparison of ice borehole strength and calculated flexural strength

The ratio of ice borehole strength to flexural strength was 43 in mid-winter and decreased to 8 in late spring. Since the relation between the two strength measurements cannot be represented by a constant ratio, the two strengths were normalized with respect to their maximum, mid-winter values. The results of the normalization are shown in Figure 7. To provide an indication of the normalized, full thickness ice borehole strength, the borehole strengths at depths 0.30 and 0.90 m (shown in Figure 5) were averaged. That averaged strength was then normalized with respect to the extrapolated, average, mid-winter strength of the two ice depths (25.5 MPa). A similar procedure was used for normalizing the flexural strength (maximum mid-winter strength of 0.71 MPa).

The trends of decreasing normalized strengths in Figure 7 are in excellent agreement with one another. Both strengths show that in mid-May, the ice had about 70% of its mid-winter strength. By early June, the ice had about 50% of its mid-winter strength. After the first week of June, only the borehole jack measurements provided information about the degradation in ice strength. Measurements showed that by the end of June, the ice had only 15 to 20% of its mid-winter strength. The ice strength was stable during the month of July, when only 10% of the mid-winter ice strength remained. [To put this in perspective, this flexural strength value for the sea ice of approximately 70 kPa is only slightly higher than the flexural strength of ice using in physical modelling facilities. In physical model tests, the flexural strength of the model ice is typically on the order of 30 to 60 kPa.]



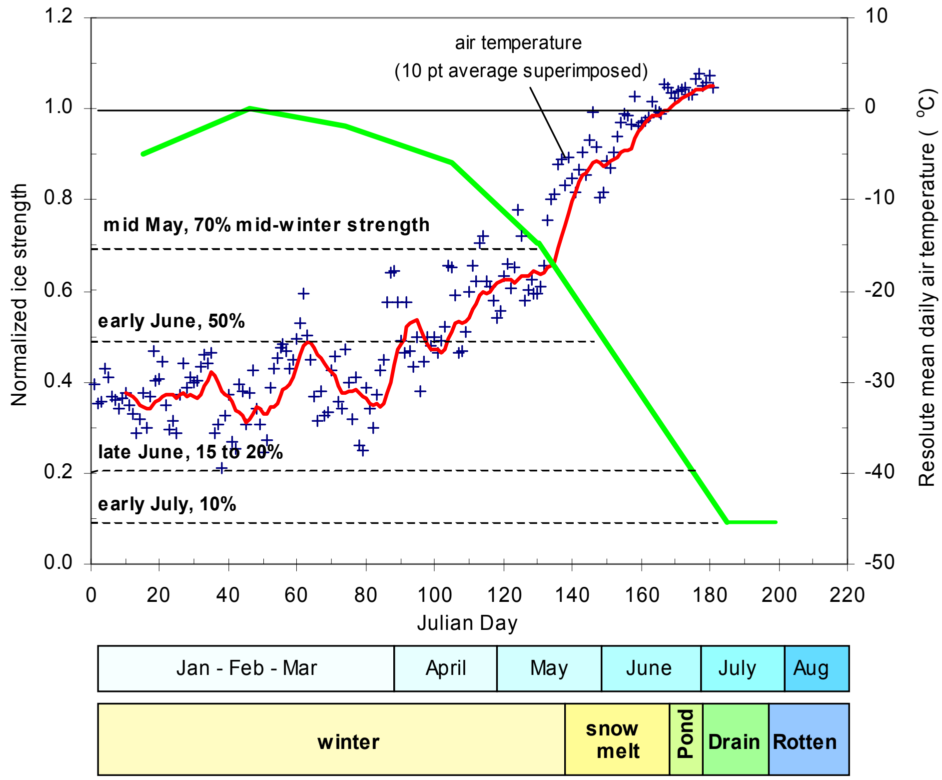
- Figure 7: Comparison of normalized ice borehole strength and calculated flexural strength

The correlation between the ice strength and air temperature is shown in Figure 8. Increasing air temperatures are the primary reason for the decrease in ice strength during the decay season. Once the air temperature warms to about –10°C, the majority of the internal salts within the ice have converted from the solid phase to the liquid phase, and the sea ice is no longer in its mid-winter state. After the ambient air temperatures rise above about –10°C, the brine pockets rapidly begin to increase in size, causing a decrease in ice strength. Figure 8 shows that the decrease in ice strength continues until early July, by which time the ice has about 10% of its mid-winter strength.

Ice Strength and Stages of Decay

A considerable amount of work has been devoted to describing the stages of ice ablation using remotely sensed imagery. Barber et al. (1997) qualitatively described ice decay in terms of various stages of ablation. Similarly, DeAbreu et al. (2001) examined time- sequenced satellite images of landfast first-year sea ice in the Resolute region during the 2000 ice decay season. The authors described at least five stages of ablation, including sea ice in its winter state, snow melt, pond formation, pond drainage and rotten ice. Although remote sensing is an effective means of monitoring processes that occur at the ice surface, it does not provide information about the bulk layer of ice. One of the objectives of the 2000 and 2001 seasons of field measurements was to relate remotely sensed observations to changes within the internal layers of ice.

Since the work of DeAbreu et al. (2001) coincided with the area in which the ice borehole strength measurements were performed, DeAbreu's five stages of ablation were superimposed in general terms on Figure 8. The snow melt stage began in mid-May and extended to late-June. Ice strength during the snow melt stage ranged from 70 to 40% of its mid-winter strength. After the snow melt stage, melt ponds began to form on the ice surface. The ponding stage occurred in late June and lasted for about one to two weeks. During the ponding stage, the ice had about 30 to 20% of its mid-winter strength. Melt pond drainage began in early July and continued throughout the month. Ice strength during the pond drainage stage was from 20 to 10% of the mid-winter ice strength. Once the melt ponds drained from the ice, it was considered rotten ice, the most advanced stage of decay. No information was available about the strength of rotten ice.



• Figure 8: Relation between decay of ice strength and air temperature

MULTI-YEAR AND SECOND-YEAR ICE

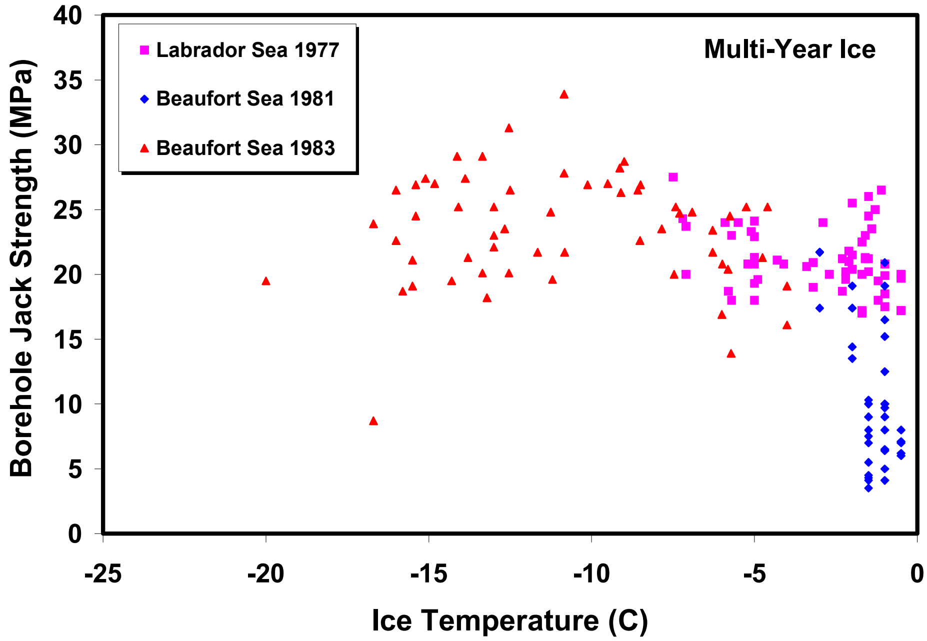
Strength of Multi-year Ice

In contrast to first-year ice, multi-year ice and second-year ice have very low salinities. As such, there is little porosity in the ice and it is considerably stronger than first-year sea ice. Further, since there is little salt, there is not a large change in the brine volume with increasing temperature. There is, however, a general decrease in strength with increasing temperature, but this is mostly as a result of the decreasing strength of the ice matrix itself. In many ways, multi-year ice is similar to freshwater ice and glacial ice.

Although there have been a large number of strength tests performed on freshwater ice, only a handful of tests have been performed on multi-year and second-year ice. There have been no reported measurements of the flexural strength of multi-year ice. However, there have been a number of measurements of the compressive strength of multi-year ice (Timco and Frederking, 1982; Sinha 1984; Cox et al., 1984) and second-year ice (Sinha, 1985). These measurements showed that (1) the strength of the multi-year ice is similar to the strength of first-year ice when the ice is very cold (i.e. -20°C), but (2) multi-year ice is considerably stronger than first-year ice when the ice is warmer. This is a reflection of the lack of brine volume increase with increasing temperature with multi-year ice.

There have been very few reports of the borehole jack strength of multi-year ice published in the open literature (Iyer and Masterson, 1987; Blanchet et al., 1997). However, there were a number of field measurement programmes carried out in the 1970s and 1980s as part of the oil and gas exploration in the Beaufort Sea. The results of these studies are not available publicly, but they are available to the CHC as part of the NRC Centre of Ice-Structure Interaction (Timco, 1998).

Fenco (Dome Petroleum, 1982) carried out a series of borehole jack tests in multi-year ice during August and October 1981 field trials. Geotech carried out borehole jack tests during two field programmes to the Canadian Arctic. During the 1982 test programme reported by Dome (1982), 40 borehole jack tests were performed. For the Geotech (1984a) study, 60 borehole jack tests were done using the conventional borehole jack, and 22 tests were done at a higher rate (fast borehole jack tests). For the latter tests, the time to the peak pressure was less than 0.5 s, which is substantially quicker than the conventional loading times, which averaged about 10 seconds. Detailed information on the Geotech (1983) field programme was not available, although Geotech reported that there were 33 vertical tests performed with an average strength of 30.1 MPa, and 9 horizontal tests performed with a mean strength of 26.5 MPa. In addition to these Beaufort Sea studies, Fenco (1977) measured the borehole jack strength of multi-year ice off the coast of Labrador. The information from these field studies was extracted and plotted as a function of temperature in Figure 9.



- Figure 9: Borehole jack strength as a function of ice temperature for multi-year ice.

Figure 9 shows that the strength of multi-year ice is not a strong function of temperature until very close to the melting point. Strength values for colder ice are in the range of 18 to 35 MPa. In the temperature range above -2°C, there can be a very large range of ice strength. The data indicate that the strength of very warm multi-year ice can range from 4 to 26 MPa.

It should be noted that the strength of first-year sea ice in mid-winter is of the order of 20 to 28 MPa (see Figure 5), which is not dissimilar to the strength of cold multi-year ice as shown in Figure 9. This is a reflection of the fact that most of the salt in first-year sea ice is in its solid state, and as such, there is little brine porosity in the ice. As the melt season progresses, however, the strength of first-year ice decreases considerably more than that of multi-year ice.

Decay Process in Multi-year Ice

Virtually nothing is known about the actual decay process in multi-year ice. As discussed above, there have been only a limited number of measurements on multi-year ice throughout the winter and spring seasons. The information available is not conclusive for making any concrete statements about the decay process. There are a few things to note in this regard for multi-year ice:

1. The limited number of borehole jack tests at higher temperatures do not show a strong temperature dependence, indicating that multi-year ice does not decay in the same manner as first-year ice. This is understandable based on the phase relationships of the salts and the low salinity of multi-year ice.
2. Multi-year ice can decay. Figure 9 shows a decrease in strength very close to the melting point of the ice. Further, large multi-year ice floes have broken apart very easily with the MV Arctic (B. Gorman, personal communication). It is not clear, however, whether this was due to lower ice strength or a relatively thin multi-year ice floe.
3. There is no visual method for judging if multi-year ice has decayed.

4. The large range of strength values for multi-year ice close to the melting point indicates that temperature cannot be used as a method for defining low strength for multi-year ice.
5. Freshwater ice decays through a “candling” process. This comes about from the absorption of solar radiation at the impurities at the grain boundaries of the individual ice crystals. For freshwater ice, the grain structure is often columnar, and when sufficiently decayed, the ice breaks apart in a large number of long slender columns that resemble candlesticks. This process could also play a role with multi-year ice, but it is not clear how deep this candling process would occur within the ice.

Decay of Multi-year Ice and the Ice Regime System

Based on the limited information available on the decay of multi-year ice, there is no scientifically-based reason to increase the Ice Multiplier for decay of multi-year ice. It should be noted that in the original ASPPR document (ASPPR, 1989) there is no adjustment for the decay of multi-year ice. However, in the Arctic Ice Regime Shipping System Standards (AIRSS, 1996) there is a bonus given for the decay of multi-year ice. The authors do not know the reason for this change.

Based on this analysis, the following recommendations are made for **multi-year ice**:

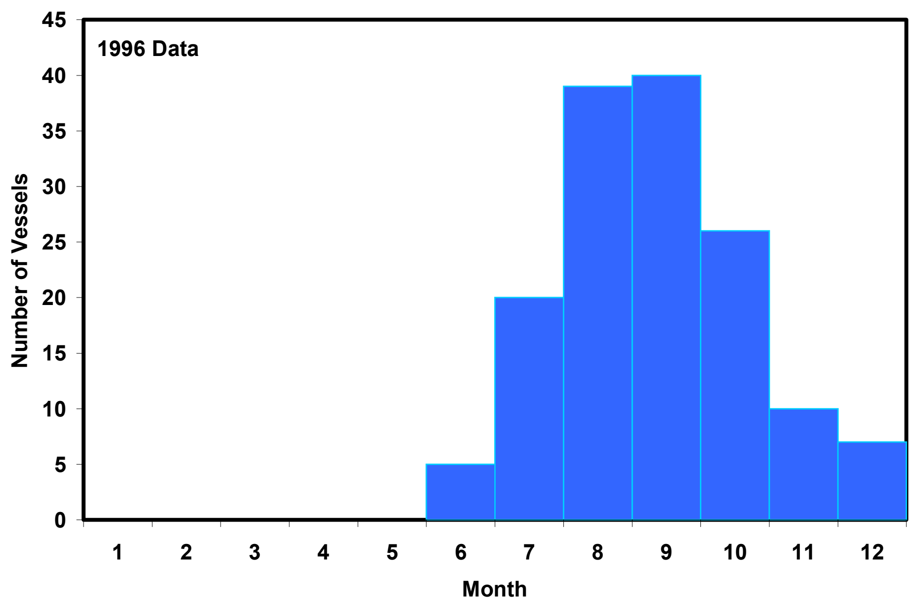
1. The bonus of +1 to the Ice Multiplier should **not** be given for decay of multi-year ice. It is recommended that the approach proposed in the ASPPR be re-adopted;

2. Field measurements of multi-year ice throughout the summer season should be undertaken to provide more insight into the decay and strength of multi-year ice. This work would provide the necessary information for making the final decision on the issue of decayed multi-year ice and the Ice Regime System.

SHIP DAMAGE IN THE CANADIAN ARCTIC

The current Ice Regime System gives a bonus of +1 to the Ice Multipliers if the ice is decayed. In this section, an analysis will be made to investigate whether there is any evidence to support this bonus to the Ice Multiplier.

As a first step, it is necessary to understand the volume and timing of vessel traffic in the Arctic. The majority of vessel traffic occurs during the summer months. This traffic is primarily comprised of commercial shipping for transporting goods to the Arctic, removal of natural resources from mines, fishing vessels, tour boat operations and regulatory vessels. In the 1970's and 1980's there also was some activity in the Beaufort Sea related to offshore oil and gas exploration. At the present time, this Beaufort activity has stopped. To quantify the volume of traffic, use was made of a database developed by Mariport Inc. They have compiled a list of vessel traffic in the Arctic for several years. For the present analysis, the data from 1996 was used. In this year, Mariport reported that there were 59 different vessels in the Canadian Arctic. These data were analysed to count the number of different vessels that were in the Arctic during each month of the 1996 calendar year. Figure 10 shows the results in a histogram with the months indicated numerically from 1 to 12 (January to December). From this figure is clear that there is some limited shipping in June and July, but the majority of traffic takes place during August and September.

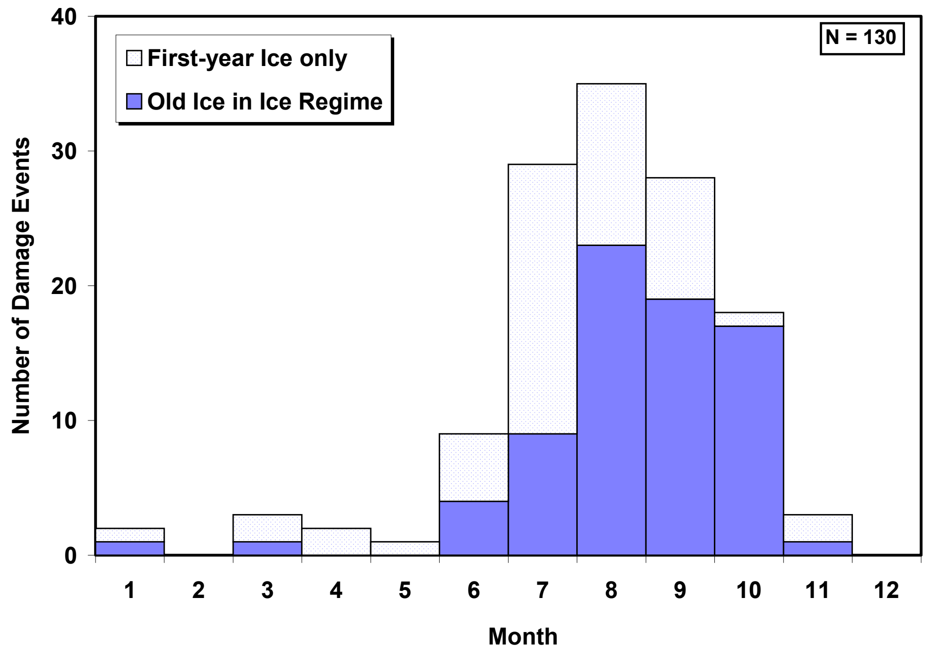


• Figure 10: Vessel traffic in the Canadian Arctic by month for the 1996 calendar year (data from Mariport Inc.)

The Canadian Hydraulics Centre has developed a database related to vessel damage due to ice, as part of their work to put the Ice Regime System on a scientific basis (Timco and Kubat, 2001). This database contains over 1500 Events related to both damage and no-damage Events of ships in ice-covered waters. The database was queried to extract the information related to vessel damage due to ice. The query included all types of damage (not just hull-related damage). The data was filtered to look at regions with latitude north of 57° and includes approximately 20 years of damage statistics. The vast majority of the damage Events relates to the Canadian Arctic, but there are also a few Events in the American Arctic and in the Baltic Sea. Figure 11 shows a histogram of the results.

The data have been further separated based on the presence of multi-year ice at the time of the vessel damage. There are several things to note in this figure:

- The shape of the histogram is very similar to Figure 10; i.e. there are more damage events with more vessel traffic.
- The largest number of damage events occurred in August, with slightly fewer damage Events in both July and September.
- In July, there are a large number of Events in which only first-year ice is present.
- Between August and October, there are a similar number of damage events with multi-year ice present, but a decreasing number with only first-year ice present.



- Figure 11: Histogram showing the number of damage Events in the Arctic for each month

FIRST-YEAR ICE DECAY AND THE ICE REGIME SYSTEM

The current Ice Regime System takes into account the large difference in strength between mid-winter ice and summer ice by introducing the "decay" of the sea ice. This is done by allowing the addition of +1 to the Ice Multiplier when the ice is decayed to the "rotten" stage. This is a very qualitative approach. The definition of the rotten stage is not quantitatively well-defined (and it is not easily detectable). Further, as can be seen from Figure 7 and Figure 8, there is not an abrupt change in strength at any time – rather, there is a continual decrease in the strength of the ice once the air temperature begins to rise. This decrease in strength is directly related to the rise in the air temperature. The data show that the strength of the ice sheet has decreased to approximately 20% of its mid-winter strength when the mean ambient air temperature remains consistently above 0°C. Further, when the air temperature remains above 0°C for several weeks, the strength of the ice drops to approximately 10% of its mid-winter strength. This analysis provides a quantitative method for incorporating the difference in mid-winter and summer strength.

Measurement of air temperature is very easy. The present analysis has shown that this property can be directly related to the strength of first-year sea ice. This can be used as a means of defining the stage at which the summer bonus could be given to the Ice Multiplier for first-year sea ice.

When should the summer bonus be given? There are several aspects that must be considered for this. The data show that the strength of the ice is approximately 20% of the mid-winter strength once the air maintains a temperature of 0°C for a few days. This is a result of a gradual increase in temperature during the spring with a resultant decrease in strength. Does this value seem reasonable to take for the summer bonus? For the Arctic, above zero temperatures occur typically at the end of June. An examination of the ship traffic and damage statistics (see Figure 10 and Figure 11) shows that there are a large number of damage incidents during July when the vessel traffic is still relatively low. Thus, a value of 20% of mid-winter strength is too high. If a value of 10% of mid-winter strength were used, this would typically occur in early August; i.e. one month with ambient air temperatures above 0°C. This strength of the ice at that time should not present any potential hazard for ice-strengthened vessels. Further, the ice at this time has thinned considerably from its mid-winter thickness (see Figure 3).

It should be borne in mind that the Ice Regime System is related to safety, not operational efficiency. Thus, it could be argued that decayed ice allows the vessels to travel at higher speeds where there is more risk of damage with a collision with a multi-year floe. This should be considered in the application of the summer bonus.

The present analysis shows that there is a good reason to take into account the strength of sea ice in the Ice Regime System. Since the Regulations must cover all of the calendar year, they should be structured to take this large strength difference into account. This is necessary not only for the spring season, but also for the autumn season when the ice is forming and increasing in strength.

Based on this analysis, the following recommendations are made with regard to **first-year** sea ice decay:

1. The concept of ***decay*** of sea ice should be re-cast in terms of the ***strength*** of the ice in the Ice Regime System.
2. There should be a bonus given for low strength during the summer months, since the ice is considerably weaker and thinner than in mid-winter.
3. The springtime (i.e. melt) limit for the summer bonus could be based on the present analysis. It is noted that the strength of ice can be directly related to the ambient air temperature. This is a convenient and easily-measured quantity to define the summer bonus. **It is proposed that the summer bonus be given once the ambient air temperature has been above 0°C for one month.**
4. Additional analysis should be performed to define a similar criterion to be used during the autumn/winter growth season.

SUMMARY AND RECOMMENDATIONS

The analysis presented in this report has clearly shown that there is no quantitative scientific basis for the current approach of taking into account the decay of sea ice in the Ice Regime System. The present analysis pointed towards an approach to take into account the large difference in strength between mid-winter and summer ice. To do this, it is recommended that:

1. The concept of decay of sea ice should be re-cast in terms of the strength of the ice in the Ice Regime System.
2. There is justification to provide a bonus given for low strength during the summer months, since the ice is considerably weaker than in mid-winter.
3. The bonus of an increase of +1 to the Ice Multipliers can be based on the ambient air temperature since this is directly related to the strength of first-year ice. It is proposed that the summer bonus be given once the ambient air temperature has been above 0°C for one month.
4. A detailed analysis should be done on the strength of ice during the growth (i.e. autumn) season to define a similar criterion to be used during the growth season.
5. The bonus of +1 to the Ice Multiplier should not be given for decay of multi-year ice. It is recommended that the approach proposed in the ASPPR be re-adopted.
6. Field measurements of multi-year ice throughout the summer season should be undertaken to provide more insight into the decay and strength of multi-year ice. This work would provide the necessary information for making the final decision on the issue of decayed multi-year ice and the Ice Regime System.

This work should be carried out in conjunction with the Canadian Ice Service. Appropriate discussions should be held with the important Stakeholders of the Ice Regime System to ensure that the approach developed is both practical and easily implemented.

REFERENCES

AIRSS 1996. Arctic Ice Regime Shipping System (AIRSS) Standards, Transport Canada, June 1996, TP 12259E, Ottawa. Ont., Canada.

ASPPR, 1989. Proposals for the Revision of the Arctic Shipping Pollution Prevention Regulations. Transport Canada Report TP 9981, Ottawa. Ont., Canada.

Barber, D. 1997. Sea Ice Decay: Phase I. Centre for Earth Observation Science, University of Manitoba, Winnipeg, Canada, March 1997, 108 pp.

Billelo, M. 1980. Maximum Thickness and Subsequent Decay of Lake, River and Fast Sea Ice in Canada and Alaska, United States Corps of Engineers, CRREL report 80-6, February, 1980, 160 pp.

Blanchet, D., Abdelnour, R. and Comfort, G. 1997. Mechanical Properties of First-year Sea Ice at Tarsiut Island. Journal of Cold Regions Engineering, March 1997, Vol. 1, No. 1, pp. 59 – 83

Cox, G., Richter-Menge, J., Weeks, W., Mellor, M. and Boswoth, H. 1984. Mechanical Properties of Multi-year Ice, Phase 1: Test Results. US Army CRREL Report 84-9, Honover, NH, USA.

Cox, G. and Weeks, W.F. 1974. Salinity Variations in Sea Ice. J. Glaciology. Vol 13, No. 67, pp 109-120.

Cox, G. and Weeks, W. 1982. Equations for Determining the Gas and Brine Volumes in Sea Ice Samples. CRREL Report 82-30, Hanover, N.H., USA.

Cox, G. and Weeks, W. 1988. Profile Properties of Undeformed First-year Sea Ice. CRREL Report 88-13, Hanover, N.H., USA.

DeAbreu, R., Yackel, J., Barber, D., and Arkette, M, 2001. Operational Satellite Sensing of Arctic First-Year Sea Ice Melt. Can. J. of Remote Sensing, Vol. 27, No. 5, October 2001, pp. 487 – 501.

Dome Petroleum, 1982. Tarsiut Island Data Analysis 1981-1982. Dome Petroleum Report APOA 213, Calgary, Al., Canada.

Fenco, 1977. 1977 Winter Field Ice Survey Offshore Labrador. Report submitted to Total Eastcan Exploration Ltd., Calgary, AL., Canada.

Frankenstein, G.E. and Garner, R., 1967. Equations for Determining the Brine Volume of Sea Ice from -0.5 to -22.9 C. Journal of Glaciology, Vol. 6, No. 48, pp. 943-944.

Geotech, 1984. Multi-Year Ice Strength Test Programme, Phase II. Report 9100 submitted to Gulf Canada, Calgary, Al. Canada.

Geotech, 1983. Multi-Year Ice Strength Testing Programme for Gulf Canada Resources Inc. Report submitted to Gulf Canada, Calgary, Al. Canada. (APOA 200).

Iyer, S.H. and Masterson, D.M. 1987. Field Strength Tests of Multi-Year Ice using Thin-Walled Flat Jacks. Proceedings POAC'87, Vol. 3, pp 57-73, Fairbanks, AL, USA.

Johnston, M., Frederking, R. and Timco, G. 2000. Seasonal Decay of First-year Sea Ice, Technical Report by Canadian Hydraulics Centre HYD-TR-058, April 2001, 24 pp.

Johnston, M. and Frederking, R. 2001. Decay Induced Changes in the Physical and Mechanical Properties of First-year Sea Ice. Proceedings Port and Ocean Engineering under Artic Conditions, POAC'01, Vol. 3, pp. 1395-1404, Ottawa, Canada.

Masterson, D.M., Graham, W.P., Jones, S.J. and Childs, G.R. 1997. A Comparison of Uniaxial and Borehole Jack Tests at Fort Providence Ice Crossing, 1995. Can. Geotech. J., Vol. 34, pp. 471 – 475.

Sinha, N.K. 1984. Uniaxial Compressive Strength of First-year and Multi-year Sea Ice. Can. J. Civil Eng., 11, pp 82-91.

Sinha, N.K. 1985. Confined Strength and Deformation of Second-Year Columnar-Grained Sea Ice in Mould Bay. Proceedings OMAE'84, Vol. 2, pp 209-291, Dallas, Tx, USA.

Timco, G.W. 1998. NRC Centre for Ice Loads on Offshore Structures. NRC Report HYD-TR-034, Ottawa, Ont., Canada.

Timco, G.W. and O'Brien, S. 1994. Flexural Strength Equation for Sea Ice. Cold Regions Science and Technology, Vol., 22, pp. 285 – 298.

Timco, G.W. and Frederking, R. 1982. Compressive Strength of Multi-year Ridge Ice. Proceedings Workshop on Sea Ice Ridging and Pile-up. NRC/DBR Technical Memo 134, Calgary, Al, Canada.

Timco, G.W. and Frederking, R.M.W. 1996. A Review of Sea Ice Density. Cold Regions Science and Technology, Vol., 24, pp. 1 – 6.

Timco, G.W. and Kubat, I. 2001. Canadian Ice Regime System: Improvements using an Interaction Approach. Proceedings POAC'01, Vol 2, pp 769-778, Ottawa, Ont., Canada.

APPENDIX B to Annex XI

ICE STRENGTH INFORMATION IN THE CANADIAN ARCTIC: FROM SCIENCE TO OPERATIONS

M-F. Gauthier[1], R. De Abreu [1], G. W. Timco[2] and M. E. Johnston[2]

ABSTRACT
The Canadian Ice Service (CIS) promotes safe and efficient maritime operations and helps protect Canada's environment by providing reliable and timely information about sea ice, lake ice and iceberg conditions in Canadian waters. New initiatives at the CIS have highlighted the need for improved information regarding the seasonal decay of sea ice. Specifically, CIS requires reliable, efficient techniques whereby the seasonal decrease in first year ice strength can be monitored and reported regularly.

In the past few years, considerable work has been done to categorize and characterize the decay process of Arctic first year ice and to develop ways of estimating its spring and summer strength. This paper will report on the development of a prototype ice strength product provided by the CIS to the Canadian Arctic marine community in the spring of 2002. The theoretical basis for the product, the implementation at the CIS and its utilization by mariners will be discussed.

INTRODUCTION
Navigation in the Canadian waters north of 60N latitude is regulated by the Arctic Shipping Pollution Prevention Regulations (ASPPR). In 1996, Transport Canada extensively revised the ASPPR giving way to the creation of the Arctic Ice Regime Shipping System (AIRSS). AIRSS is based on a simple calculation that produces an “Ice Numeral”. The Ice Numeral is calculated using information about the ice and the vessel’s ability to navigate safely in that region. The value of the Ice Numeral takes into account the decay of the ice but the current CIS suite of products does not include any strength or melt-related information.

Over the past few years, the Canadian Ice Service and partners have been characterizing the process of first year sea ice decay and developing techniques whereby it can be monitored and reported. DeAbreu and al. (2001) concentrated primarily on remote sensing data to report on the stages of melt of the ice. The theory behind this approach was that the weakening of the sea ice volume is accompanied by concurrent changes in the surface condition of first year sea ice. These changes in the surface layer lend a distinct seasonality to remote sensing signatures. As a result, RADARSAT and NOAA AVHRR image data could be used to identify the stages of ice melt, which could then be used by navigators to estimate the strength of ice. However, there were obstacles identified with this approach: time and resources needed to monitor the change in remote sensing signatures were not available and the image coverage was not systematic. An alternative method to automatically provide ice strength information consistently over large regions thus was needed.

ICE STRENGTH INDEX
In fall 2001, forecasters, analysts and scientists of the CIS met with members of the Canadian Hydraulics Centre, National Research Council of Canada to discuss a new approach for predicting and reporting ice strength information in a more automated manner. The following describes the Ice Strength Index.

In the spring of 2000 and 2001, *in situ* measurements of confined compressive ice strength were conducted in fast, smooth (i.e. undeformed) first year ice within the Canadian Arctic Archipelago using a borehole jack. The results provided the first observations of the spring/summer reduction of the strength of first year sea ice (Johnston and Frederking, 2001; Johnston et al., 2002). Analyses showed that the seasonal reduction in winter ice strength was accompanied by a steady increase in measured air temperatures. This correspondence is expected given the understood established relationship between ice temperature, brine volume, and ice strength. The apparent relationship

[1] Canadian Ice Service, Meteorological Service of Canada, Environment Canada, Ottawa, Ont., Canada
[2] Canadian Hydraulics Centre, National Research Council, Ottawa, Ont., Canada

between ice strength and air temperature was attractive from an operational standpoint. Air temperature can be modelled and observed systematically within CIS regions, thus creating the possibility of estimating ice strength on a regular basis over these areas. The Canadian Meteorological Centre's (CMC) GEM global weather model estimates surface air temperature (10 m height) at a 1 degree spatial resolution. Information from surface observations (e.g. weather station, marine observations) is integrated with model forecasts to produce an analysis field every 12 hours. The 2000 and 2001 GEM air temperature data corresponding to the field sampling area and period were extracted and compared to the measured ice strength data. Good agreement was found between an accumulated measure of air temperature, or *accumulated warming degree day (AWDD)* and the first year ice strength. Specifically, the daily departure of the daily average GEM temperature (i.e. 0 and 12 GMT fields) (T_{mean}) from a baseline of –30 ºC (T_{cutoff}) was accumulated starting on April 1 using

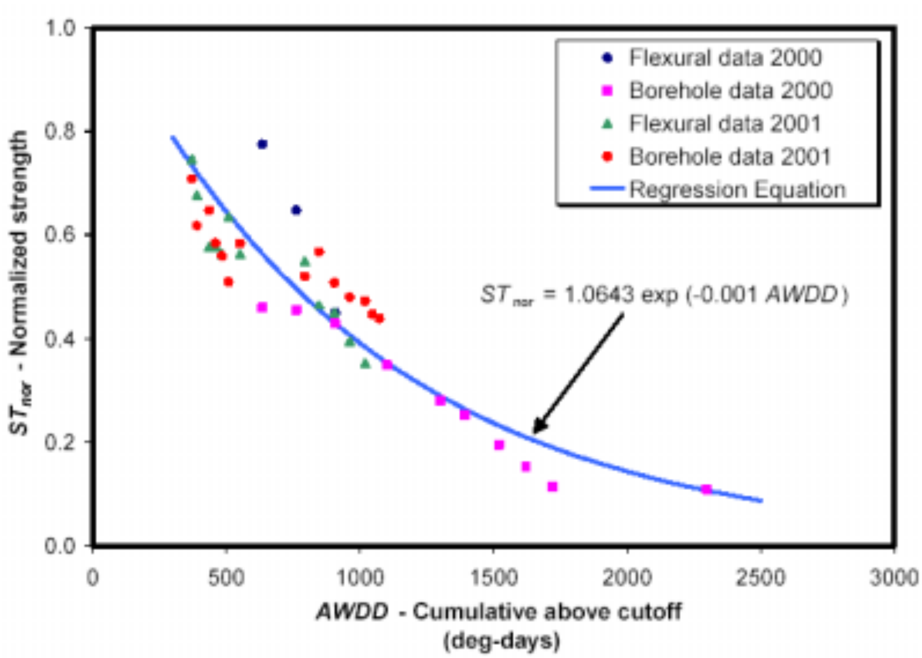
$$AWDD = \sum \left(T_{mean} - T_{cutoff}\right) \tag{1}$$

Accumulated warming degree-days were compared to the observed and calculated ice strengths (Figure 1). The borehole strength measurements represent an average of the sampled strengths at 0.3 and 0.9 m depths. The flexural strength was based on an empirical equation developed by Timco and O'Brien (1994). The borehole and flexural strength values were normalized against estimated mid-winter ice strength using values of 25.5 MPa and 0.71 MPa respectively (see Timco and Johnston, 2002, this volume). The data reflect the seasonal trend of decreasing ice strength. The following exponential model was fit to the 2000 and 2001 data with good agreement (R^2=0.87):

$$ST_N = 1.0643 \exp\left(-0.001 AWDD\right) \tag{2}$$

where ST_N is the normalized mid-winter ice strength (0-100%). Again, the strong relationship with air temperature is logical given the dependence of sea ice strength on ice temperature (in fact brine volume). We consider this parameterization preliminary, in need of further data and validation. For example, the final data point exerts significant influence on the proposed function. Further measurements will be made during this period to clarify the late spring, summer trend. Of specific interest is the validity of this function over other first year ice regimes in the Arctic. The proposed function is dependent on the relationship between air temperature and internal ice temperature and is modulated by snow cover. The sensitivity of the function to varying snow depths and ice thickness will be investigated.

Figure 1. Normalized winter first year ice strength vs. accumulated warming degree-days.



ICE STRENGTH CHART DEFINITION

The CIS has developed a prototype new product describing the seasonal decrease in the strength of first year sea ice using the index described above. Figure 2 shows the first product that was created and disseminated at the beginning of May 2002. The Ice Strength Chart displays ice strength indices (current strength relative to a mid-winter strength in percentage) for level first year ice as isostrength lines: lines of constant ice strength index value. It also reports on ice surface conditions by superimposing the stages of melt to the range of indices. This Ice Strength prototype chart was designed to be used in conjunction with the CIS Arctic Regional Charts and is valid for the Approaches to Resolute area (area within the box on Figure 2). This new product was provided to the Canadian Arctic marine community in the spring and summer of 2002.

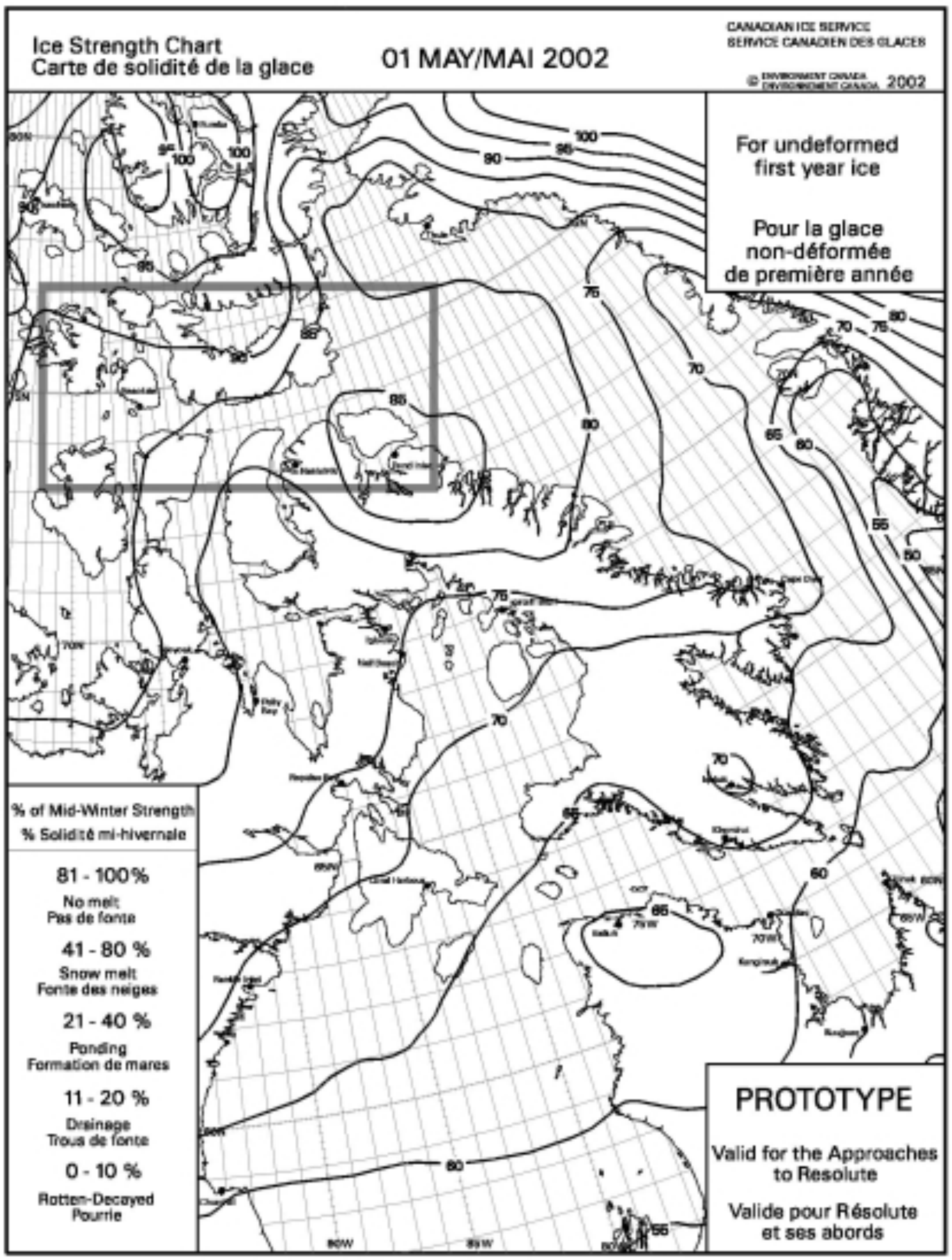


Figure 2. May 01st 2002 Ice Strength Chart

IMPLEMENTATION PLAN

As indicated above, the Ice Strength Chart was developed as a companion product to the CIS Arctic Regional charts and therefore followed the same production schedule: beginning of May, mid-May, beginning of June then weekly until the beginning of August. Establishing an operational production schedule for this new product is only one element of the CIS implementation plan.

Ice forecasters and ice analysts are using ISIS (Ice Service Integration System) workstations equipped with GIS (Geographical Information System) applications such as ERDAS and ARCINFO to generate and disseminate their products. In order to support the production of the Ice Strength Chart, the Ice Forecasting and Informatic Divisions of the CIS have worked together in allocating new identifications for this product and in setting up operational procedures compatible with current CIS work flow for its generation. Figure 3 illustrates some of the steps undertaken by ice forecasters and ice analysts at their workstations to generate the Ice Strength Chart in an operational environment.

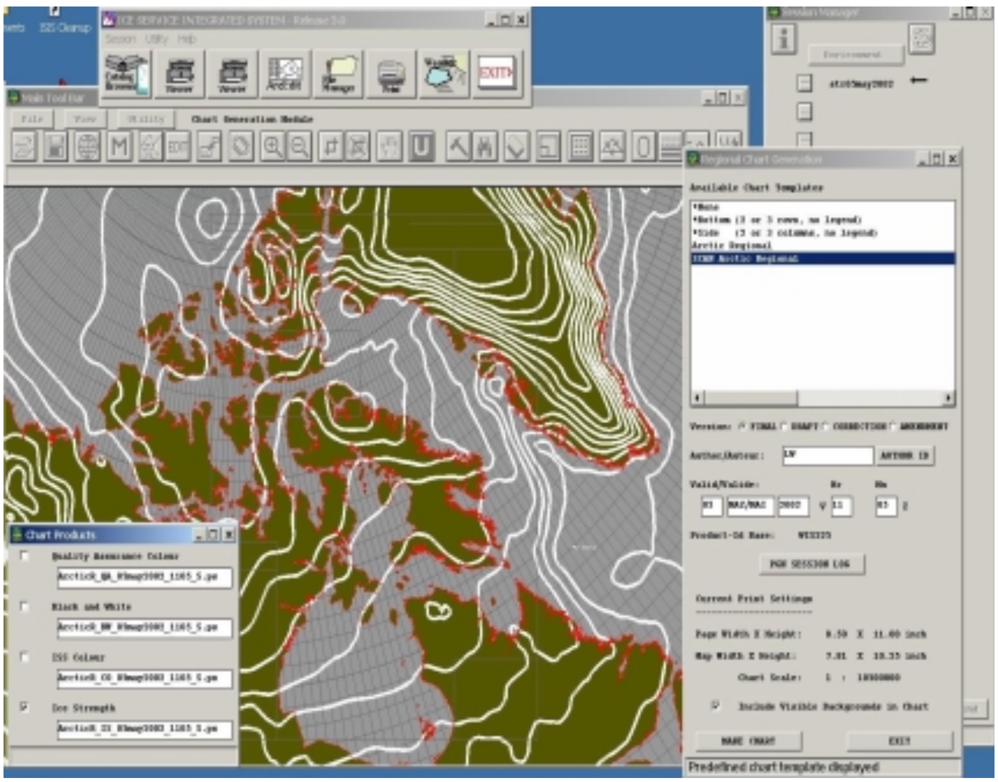


Figure 3. Ice Strength model results display and chart

Another aspect of the CIS implementation plan is training. Ice forecasters and ice analysts have attended a half a day training session on Ice Decay including a one-hour lecture explaining the theory behind the Ice Strength Index. A similar lecture was given to the Ice Service Specialists (ISS), CIS personnel deployed on board icebreakers.

VALIDATION PLAN

Developing and implementing a new product requires a validation plan. The CIS, in partnership with the Canadian Coast Guard, Transport Canada, the National Research Council and various commercial shipping companies have co-developed a validation programme for its new prototype Ice Strength Chart.

Staff from the Canadian Ice Service participated in three validation field exercises. The first took place in Lancaster Sound and Barrow Strait, which is the main validation area (area within the box on Figure 1). This field exercise, part of a larger sea ice experiment C-ICE 2002, was composed of three airborne sampling trips and one ship-based trip timed to coincide with the following seasonal stages of melt: winter/spring – early May, snow melt – early June, ponding – late June and drainage – mid July. At each regional sampling site, ice strength measurements were again taken with a borehole jack. The strength values will be compared to those estimated by the relevant CIS Ice Strength Chart.

During the second field validation exercise, an ice forecaster embarked on board the Fednav ship M.V. Arctic to validate the Ice Strength Chart outside the main validation area. The purpose of this validation was to see if values of the strength of undeformed first year ice relative to peak winter strength (0-100%) developed from data obtained in level first year sea ice over the Approaches to Resolute area, could be extrapolated to other areas of the Arctic, where first year ice is deformed and under pressure. There were no strength measurements taken during this exercise. Ice strength was referenced to observations from the ship and compared with the Ice Strength Chart. To assist in the validation, a form has been developed. A sample of the form is illustrated in figure 4.

Arctic Voyage 2002: Ice Strength Chart Validation Program

Ship Name: __________ **Ship Call Sign:** **Ship Ice Class:**

Date	Time	Ship's				Vis	Temp	Observed Ice Conditions									Melt	AIRSS Numeral		Ice Strength	Comments
dd-mm	Z	Lat	Long	Speed	Head			Total Conc.	MY,Old	SY	TFY	MFY	FY	GW	G	OW	Stage	Visual	Egg	Index	
		N	W	Knots		NM	C	Tenths													ice roughness,
																					floe size, etc.

Stages of Melt	
1	No melt
2	Snow melt
3	Ponding
4	Drainage/Many thaw holes
5	Rotten/decayed

Figure 4. Commercial ship validation form

The third exercise required the participation of the ISS working on board six Canadian Coast Guard icebreakers. As the ships were deployed in July, the ISS reported ice conditions and ice strength (inferred from the Ice Strength Chart) and AIRSS information in a field book for each ice regime encountered while navigating in the Arctic. Figure 5 shows a sample of the Arctic 2002 field book; elements of the field book are similar to the ones displayed on the validation forms. The data collected by the ISS will provide information on both stages of decay and the ice regimes encountered by the vessels. Digital cameras were also supplied to the ISS to photograph the detailed ice conditions. This data collection exercise will provide invaluable ground-truthing of the CIS Ice Strength charts.

General Information	
Observation #	Location:
Date:	Vessel Speed (knots):
Time:	Visibility (n.mi):
Latitude:	Ice Roughness (please circle): Low Medium High
Longitude:	Floe Size (m):
Digital Photo File Name:	

Stage of Melt (please circle)				
No melt	Snow melt	Ponding	Drainage	Rotten/ decayed
CIS Ice Strength Index				

Ice Regime						
☐ Daily Ice Analysis Chart (date)						☐ Visual
Ice Type	Ice Conc.	Ice Multiplier (IM) (please circle)				Ice Type Contribution
	C		Normal	Decay*	Ridged**	C X IM
MY		x	-4	-4	-5	=
SY		x	-3	-3	-4	=
TFY		x	-1	0	-2	=
MFY		x	1	2	0	=
FY		x	2	3	1	=
GW		x	2	3	1	=
G		x	2	3	1	=
N		x	2	3	1	=
OW		x	2	2	2	=
Sum =	10	Ice Numeral =				

*use Decay Ice Multiplier if the Stage of Melt is Drainage or Rotten/Decayed
**use Ridged Ice Multiplier if Ice Type is more than 30% ridged

CO ____________ OOW ____________ ISS ____________

Comments from the Officer of the Watch

How would you rank the severity (damage potential) of this ice regime?
☐ high potential of damage ☐ potential for damage
☐ not likely to damage vessel ☐ highly unlikely to damage vessel

Do you think that the Ice Numeral reflects the degree of severity of the ice conditions? ☐Yes ☐No If no, why not?

Did you alter your mode of operation with this ice regime?
☐Yes ☐No - if so, how?

General Comments and Work Area

Observation # ________

Figure 5. Ice Service Specialist validation book
2

3 CONCLUSION

This paper has provided details on an ambitious programme developed by the Canadian Ice Service and Canadian Hydraulics Centre to develop a product that will provide timely and accurate information on the strength of the ice in Canada's Arctic. A considerable amount of research and background development has taken place in support of this product. The work described in this paper will be used to validate and improve it. At the present time, the Canadian Ice Service supplies timely and accurate information in Canada's Arctic regions that includes ice type, ice concentration and ice thickness. This new product will provide timely and accurate information on the ice strength.

REFERENCES

DeAbreu, R., Yackel, J., Barber, D., and Arkette, M, 2001. Operational Satellite Sensing of Arctic First-Year Sea Ice Melt. Can. J. of Remote Sensing, Vol. 27, No. 5, October 2001, pp. 487 – 501.
Timco, G.W. and O'Brien, S. 1994. Flexural Strength Equation for Sea Ice. Cold Regions Science and Technology, Vol., 22, pp. 285-298.
Timco, G.W. and Johnston, M.E. 2002. Sea Ice Strength During the Melt Season. Proceedings IAHR Symposium on Ice, (this volume), Dunedin, New Zealand.
Johnston, M., Frederking, R. and Timco, G. 2002. Properties of Decaying First Year Sea Ice: Two

Seasons of Field of Field Measurements. Proceedings 17th International on Okhotsk Sea and Sea Ice, pp 303-311, Mombetsu, Hokkaido, Japan.

Johnston, M. and Frederking, R. 2001. Decay Induced Changes in the Physical and Mechanical Properties of First-year Sea Ice. Proc. POAC'01, Vol. 3, pp. 1395-1404, Ottawa, Canada.

Annex X

SIGRID-3: A PROPOSED VECTOR ARCHIVE FORMAT FOR SEA ICE CHARTS

National Ice Center
Washington, D.C.
Applied GIS Technology Document 2
Jonathan Hasse
(page numbers have changed - click to go section)

28 August 2002

Introduction

1. Through the International Ice Charting Working Group (IICWG), the world's ice centres are adopting a new vector format for archiving digital ice charts. We propose the new archive format join the current World Meteorological Organization (WMO) standards for ice charts in the Global Digital Sea Ice Data Bank (GDSIDB). WMO ice chart archive formats are the Sea Ice Grid (SIGRID) format developed in 1981, and its successor SIGRID-II The vector format proposed and defined in this document, SIGRID-3, would join SIGRID and SIGRID-2 as standard WMO formats.

2. SIGRID-3 is based on an "Open Published Data" (ESRI, 2002, http://www.esri.com/software /opengis/openpdf.html) vector file format developed by a commercial entity. Storing ice chart data in vector format rather than raster format has advantages. The vector file preserves all of the information in the original chart, and charts can be re-projected or re-scaled without loss of information. It is also possible to convert a vector product to raster if necessary. These qualities make the vector format attractive to the researchers who are the main users of the GDSIDB. In addition, charts in SIGRID-3 format will be easy for ice centres to produce using many of the current production systems that employ Geographical Information Systems (GIS).

3. This document is intended to introduce the SIGIRD-3 vector format to join SIGIRD-2 as an archive format for data layers storing sea ice information. This document will provide a vector data format for international ice analysis activities that can also be used by research, government, or private activities. For the Sea Ice Grid 3(SIGRID-3) format to be successful it must be understood by a variety of users, be in broadly accepted digital file types, and be produced by an easily repeatable process.

4. The SIGRID-3 archive format evolved from SIGRID formats and incorporates much from what is established in predecessors. All of the sea ice and related variable identifiers from SIGRID are included. The required data in the SIGRID-3 format will be those variable identifiers and subsequent variables that are common to all producers and essential to ice charts. Many sea ice chart producers already use variable identifiers depicting concentration, form of ice and stage of development. The specifics will be addressed later in this document, but users familiar with SIGRID code will already be familiar with SIGRID-3.

5. For SIGRID-3 to be successful it will rely upon two different established formats. The first portion of SIGRID-3 relies upon Environmental Systems Research Institute's (ESRI) open and published Shapefile format. Shapefiles are a commercial file format that is open and in fairly common use by ice centres. They consist of three core files, and may include several optional files. Each file in the set shares the shapefile name with a different extension. The main file (*.shp) stores the geometry and must always have an index file (*.shx). A database file (*.dbf) stores all the attributes of the shapes in the main file. Using commercial software, each centre can easily produce and exchange ice charts. Shapefiles can be produced and utilized without commercial software but this requires the development of custom software.

6. The second portion of SIGIRD 3 uses the widely accepted, public domain eXtensible Markup Language (XML) to store the metadata information of ice chart generation. The advantage of XML is that information is readily stored, it is easily searched via the Internet, and the metadata can be read using a web browser. XML will be used to store the metadata that pertains to each ice chart. The Metadata will include projection, location, keywords, and contact information for additional information. XML provides an easily readable metadata and an excellent way of searching for the ice chart across the web.

7. All together there will be four files that make up the basic requirements of SIGRID-3: three for the ice chart in Shapefile format and one for the metadata in XML format (all described in the following sections). All together they provide an archive format that is easily shared and broadly acceptable.

Shapefile Geometry

8. When in a Geographic Information System (GIS) display, the shapefile will portray the continental shoreline, islands, and all the ice lines of the analyst. This information will be stored in the three files of the Shapefile set: .shp, .shx. and .dbf. The first two files contain positional information about coastlines and ice polygons, which are viewed in a GIS display. The third file contains ice attributes for each ice polygon.

Main and Index Files

9. The Main (.shp) and Index (.shx) files store the polygons and use an index to link them to the attributes in a 1 to 1 relationship. The Main file contains the list of vertices needed to build each polygon. The Index file contains the link between the polygon and the attributes storied in the dBase (.dbf) file. A technical description is available with greater detail in Appendix 1. This description can be used to code a programme capable of using Shapefiles.

dBase Files

10. The dBase file stores the attribute information for each polygon in the Shapefile set. The dBase file must have the same prefix as the Main and Index files, and it must contain only one record of SIGRID-3 attributes for each polygon. These records must be in the same order as the Main file.

11. dBase files are constructed of ASCII and binary portions (Appendix 2, dBase / .DBF File Structure). Using Appendix 2, custom software can be written to create or open a dBase file. In order for SIGRID-3 files produced from different ice services to be commonly used with the least amount of effort, each record needs to be as similar as possible. Consequently, each dBase file will use the same byte order for the first 70 bytes. 2 or 4 characters will be reserved to store any of the 13 potential variable identifiers. Each byte pair or set of 4 bytes will contain the ice code variable or dummy variable. One character will be used for the land or water variable identifier titled 'poly_type'. All records in dBase files begin with a blank space. Please refer to table 1 for the total byte order.

12. A more detailed description of the dBase file type is presented in Appendix 2 (dBase / DBF File Structure). If programmers need to work with dBase files Appendix 2, addresses issued such as file headers and records. In general, for each record to be used, regardless of origin, the SIGRID-3 dBase file needs to be defined and remain the same for every centre. The beginning and ending locations for each variable identifier is provided in Table 1.

Required Columns

13. The dBase file stores all the attribute information for the ice type polygons. It can be directly accessed by reading the header record and the attribute record, or by using an object orientated or relational database control. When viewed in a columnar format, the variables are readily apparent in separate fields for individual polygons. The fields begin with area and perimeter. They are then followed by mandatory ice information, optional ice information and other attributes. Any field which is not used will be filled with a dummy variable of –9.

14. SIGRID 3 is different from previous SIGRID versions in that it requires a specific set of fields to be located in the dBase file. Thirteen of the sixteen mandatory columns are the same variable identifiers in SIGRID. Of the mandatory columns, thirteen are used to store the WMO variable identifiers and their variables (Table 1). The first two columns are the variable identifiers for Total Concentration (CT) and then the thickest ice (CA). Each of the three partial concentrations (CA, CB, and CC) are followed by the variables identifiers depicting form and stage of development and Form (SA,..SC, and FA,..FC). The last three columns are used for the variable identifiers depicting stages of development less than 1/10th but thicker than the first stage

of development (CN), stages of development not reported elsewhere (CD), and predominant Form of ice (CF).

15. The final column identifies the surface type of the polygon. Using a single character, polygons that depict water, land, ice, no data, and ice shelf are identified. Water polygons are those that are sea ice free, polygons containing any other concentration of sea ice are ice polygons. An ice shelf is a floating ice sheet of considerable thickness attached to the coast. The characters for each type are listed in table 4.5. This column aids in cartographic presentation.

Name	Type	Length	Begin/End Byte
Space		1	1
AREA	Double	20	2-21
PERIMETER	Double	20	22-41
CT	Text	2	42-43
CA	Text	2	44-45
SA	Text	2	46-47
FA	Text	2	48-49
CB	Text	2	50-51
SB	Text	2	52-53
FB	Text	2	54-55
CC	Text	2	56-57
SC	Text	2	58-59
FC	Text	2	60-61
CN	Text	2	62-63
CD	Text	2	64-65
CF	Text	4	66-69
Poly_type	Text	1	70

Table 1

16. Table 1 also lists the width and level of precision for several fields. The area and perimeter fields will be fixed in width and precision. The remaining fields are fixed in width and of character type. Most are two characters wide and the land identifier is one character wide. Fields must be included even it they are not used in order to standardize location of data within SIGRID-3. For example a land mask could be created by using Poly_type from the 70th byte location. Fields that are not used by ice attributes will be filled with 2 or 4 blank spaces (ASCII character 32).

Additional or Optional Columns

17. For any of the producers who wish to archive other information, columns unique to each producer can be placed after the section of required columns. Each producer must select what information, if any, will be placed here. Any variables attached to the data set must be of the same feature class. A potential list of variables is listed in table 4.4 (Appendix 4) and is based upon SIGRID (WMO, 1989). The additional columns are not limited to ice data, but may also record other variables such as snow in ice, temperature, observation method or source.

18. Shapefiles can store a number of different variable types (Appendix 1). Additional variables must also be labeled and defined in the Entity and Attribute Information section of the XML metadata. The attribute definition (Table 3) for the additional variable must include the byte order count.

Metadata

19. The Federal Geographic Data Committee (FGDC) coordinates the development of the U.S. National Spatial Data Infrastructure. The NSDI encompasses policies, standards, and procedures for US organizations to cooperatively produce and share geographic data. As a producer of

geographic data, The U.S. National Ice Center is mandated to transition its geographic data into the NSDI/FGDC format.

20. The International Organization for Standardization coordinates the international development of policies, standards and procedures for the production and distribution of geographic data. Under ISO/TC 211, the ISO members, which includes the U.S., are continuing to develop the ISO/TC 211 standardization of geographic data. Project 19115 of TC 211 specifically deals with metadata. Since the U.S. is a member, FGDC metadata will eventually be harmonized with the ISO standard. At this time The NIC is obligated to implement FGDC standards and doing so will minimize the steps needed to make SIGRID 3 ISO compliant.

21. Extensible Markup Language (XML) provides a powerful way of documenting, defining and communicating the metadata about each ice chart. XML, like html, is a descendent of the mark up language, SGML, developed in the early 1980s. These mark up languages are not programming languages but are written in text. XML is not intended to be viewed as plain text, but if need be it can.

```
Identification_Information:
    Citation:
        Citation_Information:
            Originator:
            Publication_Date:
            Title: Organization-Code_Region-Name_YYYYMMDD_feature-
            type_version
    Description:
        Abstract:
        Purpose:
        Supplemental_Information: Supplemental information not required.
    Time_Period_of_Content:
        Time_Period_Information:
            Range_of_Dates/Times:
                Beginning_Date:
                Ending_Date:
        Currentness_Reference:
    Status:
        Progress:
        Maintenance_and_Update_Frequency:
    Spatial_Domain:
        Bounding_Coordinates:
            West_Bounding_Coordinate: Western-most coordinate of the limit
            of coverage expressed in longitude.
            East_Bounding_Coordinate: Eastern-most coordinate of the limit
            of coverage expressed in longitude.
            North_Bounding_Coordinate: Northern-most coordinate of the limit
            of coverage expressed in latitude.
            South_Bounding_Coordinate: Southern-most coordinate of the
            limit of coverage expressed in latitude.
    Keywords:
        Theme:
            Theme_Keyword_Thesaurus: none
            Theme_Keyword: Sea Ice
            Theme_Keyword: Sea Ice Maps
            Theme_Keyword: Pack Ice
            Theme_Keyword: Fast Ice
            Theme_Keyword: Marginal Ice Zone
            Theme_Keyword: Ice Thickness
            Theme_Keyword: Ice Concentrations
            Theme_Keyword: Ice Extent
            Theme_Keyword: Polynya
            Theme_Keyword: additional : theme keywords
        Place:
```

```
            Place_Keyword_Thesaurus: None
            Place_Keyword: Consistent Place Keyword List. First Item
            Place_Keyword: Second Item
    Access_Constraints:
    Use_Constraints:
Metadata_Reference_Information:
    Metadata_Date:
Metadata_Contact:
        Contact_Information:
            Contact_Organization_Primary:
                Contact_Organization:
            Contact_Address:
                Address_Type:
                City:
                State_or_Province:
                Postal_Code:
            Contact_Voice_Telephone:
    Metadata_Standard_Name: FGDC Content Standards for Digital
    Geospatial Metadata
    Metadata_Standard_Version: FGDC-STD-001-1998
```

Table 2

22. XML provides structure and definition to the metadata document, and parts of the XMLdescribe the content of the document. In this archive format, XML provides the structure that controls the location of all the metadata. For example the projection information will always be located within the same set of XML tags. Those tags will always be the same for each chart and unique from every other tag used in the XML document.

23. An additional benefit of XML is that XML allows for the metadata to be easily communicated over the Internet. The XML tags can be searched for over the Internet, and the metadata document is intended to be viewed in a web browser. XML may be a slight challenge to use at first but its benefits are significant.

Mandatory Elements

24. When using the FGDC as a model, several attributes are identified as mandatory when addressing geospatial data (tables 1 and 2). These attributes describe the data and the metadata itself. In the context of XML, mark up tags provide a series of blanks or questions that need to be answered for each data set or map layer.

Identification Information

25. Identification information attributes describe some of the higher order information about the map layer. As shown in the first list in Table 2 shows, Identification Information attributes provide information on the producer, location of the coverage and date of origin. This list also includes the date, restrictions, location and associated keyword attributes. The list included in Appendix X (metadata) is the minimum required list of theme keywords. Each centre needs to assemble a suitable list of place keywords that must be consistent to all charts in a series.

Metadata Reference Information

26. The second list in Table 2 describes metadata about the metadata. They provide the amplifying information about the creator of the map layer. If this contact information is the same for every part of the map layer, this is the only location it needs to be provided.

Mandatory if Applicable Elements

27. Several attributes are identified as mandatory in the FGDC model if they are applicable to the data set. For the SIGRID-3 archive format, several attributes will be mandatory.

Data Quality Information

28. A Data Quality section in the XML is included. This section is intended to describe the resolution of the data source. Source type and data of acquisition can be repeated for the total number of different sources used to include both in-situ observations and remote sensed data.

Spatial Reference Information

29. Table 3 lists the mandatory elements that are associated with the spatial aspect of the data set. This is often referred to as the projection information. Whereas projections are different, they all have similar attributes. This section of the XML document will begin with the projection name followed by descriptions of the relevant parts that define the projection. This will most likely include longitudes, parallels, units, datum name and ellipsoid. If the projection is not a common projection, the equations used to define the projection will be included in this section.

```
Data_Quality_Information:
    Logical_Consistency_Report: (quality-assurence comments)
    Completeness_Report: (comments about unknown or land regions
    Lineage:
        Source_Information:
        Source_Citation:
        Citation_Information:
        Originator:
        Publication_Date:
        Title:
        Type_of_Source_Media: : Type of First Source Media (electronic,
        observation)
        Source_Time_Period_of_Content:
        Time_Period_Information:
        Range_of_Dates/Times:
        Beginning_Date: : Begin Date of Source
        Ending_Date: : End Date of Source
        Source_Currentness_Reference: (ground conditions at time of
        Source)
        Process_Step:
        Process_Description:
        Process_Date:
Spatial_Reference_Information:
    Horizontal_Coordinate_System_Definition:
        Planar:
            Map_Projection:
                Map_Projection_Name: Polar Stereographic
                    Straight_Vertical_Longitude_from_Pole: 180.000000
                    Standard_Parallel: 60.000000
                    False_Easting: 0.000000
                    False_Northing: 0.000000
                Planar_Coordinate_Information:
                    Planar_Coordinate_Encoding_Method:
                    coordinate_pair
                    Coordinate_Representation:
                        Abscissa_Resolution: 0.061565
                        Ordinate_Resolution: 0.061565
                    Planar_Distance_Units: meters
        Geodetic_Model:
            Horizontal_Datum_Name: WGS 1984
            Ellipsoid_Name: WGS 1984
            Semi-major_Axis: 6378137.000000
            Denominator_of_Flattening_Ratio: 298.257224
```

Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label:
Entity Type Definition:
Entity Type Definition Source:
Attribute:
Attribute_Label: FID
Attribute_Definition: ESRI created internal feature number. Sequential unique whole numbers that are automatically generated.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry. Coordinates defining the features.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source
Attribute:
Attribute_Label: AREA
Attribute_Definition: Area of polygon.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source
Attribute:
Attribute_Label: PERIMETER
Attribute_Definition: Perimeter of polygon.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source
Attribute:
Attribute_Label: CT
Attribute_Definition: Total Concentration.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source

Attribute element repeated for CA, SA, FA, CB, SB, FB, CC, SC, FC, CN, CD, and CF

Attribute:
Attribute_Label: POLY_TYPE
Attribute_Definition: Land Column.
Attribute_Definition Source:
Attribute Domain Values:
Codeset Domain:
Codeset Name
Codeset Source

Table 3

Entity and Attribute Information

30. This section is used to describe the Shapefile's dBase file. This section is directly linked to previous agreements and recommendations concerning what type of information will be available in the archive data layer format. All of the data fields are explained here. There is a field for each variable identifier and variable in SIGRID.

General Information

File Naming Conventions

31. All ice centres should follow the same guidelines when naming their files. A dataset's name will be divided into five parts in the archive format for clarity. Filenames will contain information on issuing organization, region covered, date of the chart, feature type and version. Organization Code will be a unique identifier to be adopted by each issuing organization (e.g. CIS, DMI, AARI, NIC etc.). Region Name will be a descriptive name assigned by the issuing organization to identify the geographic region contained in the file (e.g. Baffin, Baltic, Chuckchi, Hudson Bay, Arctic, and Antarctic). Date will be the date for which the information in the file is valid in the form yyyymmdd. If the information in the file is valid for more than one date, the issuing organization should assign a date that is most representative.

32. The next division will describe the one feature type contained in the Shapefile set.
Two characters will be used to identify polygons (pl), lines (ln), or points (pt). The final division will be used to distinguish between charts that would otherwise have the same name or to facilitate versioning. If more than one chart has the same name in the other divisions, a single sequential character can be incremented to distinguish them. The first or only chart will use '_a'. An underscore will separate each division.

(Organization-Code_Region-Name_yyyymmddd_feature-type_version).

Stylesheet

33. A stylesheet makes the XML document easier to read in an XML/Java capable browser. The stylesheet can be referenced over the Internet. If the XML document is viewed without access to the stylesheet it will not be viewable in a browser. The stylesheet (.XSL file) can be included in the archive to ensure that the XML file is always viewable. The SIGRID-3 set of files will not require a stylesheet be included.

34. The XML file can be adjusted so that it is not dependent on the XSL portion. XML can be more difficult to read in a browser without a stylesheet. In the end, this file is not needed but is small enough to include in every archive set or access over the Internet at the GDSIDB. Regardless of the presence of or dependence on a stylesheet, the XML document itself will always be viewable in a text editor. It will also always provide the benefits of being a valuable, searchable, and Internet able document.

APPENDIX 1 to Annex X

Awaiting legal agreement from ESRI to include Shapefile Technical Description.
http://www.esri.com/library/whitepapers/pdfs/shapefile.pdf

APPENDIX 2 to Annex X

dBase / .DBF File Structure

1. The dBase file used in the SIGRID 3 Archive Format is actually an amalgamation of the dBase 3 and 4 file types with a few additional non standard ESRI features. The dBase file can easily be read following the file structure of dBase version III. The dBase III file is accessed as two lines of input. The first line is the header. The second line will contain every polygon record without field separators or record terminators. The header describes how to use the second line.

2. The header line structure consists of a file header structure and a structure for describing each field. The file header portion occurs once while the description is repeated for each field included. Below are the file structures for SIGRID 3 dBase files.

Table 2.1 File Header

Byte	Contents	Description
0	1 byte	'3' indicating valid dBase III Plus file.
1-3	3 bytes	Date of last update in YYYMMDD format. YYY plus 1900 equals current year
4-7	32-bit number	Number of records in the table.
8-9	16-bit number	Number of bytes in the header.
10-11	16-bit number	Number of bytes in the record.
12-31	20 bytes	Reserved bytes
32-n	32 bytes each	Field descriptor array (table X.2).
n+1	1 byte	0Dh stored as the field terminator.

Table 2.2 Field Description

Byte	Contents	Description
0-10	11 bytes	Field name in ASCII (Zero-filled)
11	1 byte	Field type in ASCII (C, D, L, M, or N)
12-15	4 bytes	Field data address (set in memory; not useful on disk).
16	1 byte	Field length in binary.
17	1 byte	Field decimal count in binary
18-19	2 bytes	Reserved
20	1 byte	Work area ID.
21-22	2 bytes	Reserved
23	1 byte	SET FIELDS flag
24-31	1 byte	Reserved bytes

APPENDIX 3 to Annex X

Table 3.1
SIGRID-3 Variable Identifiers

Variable Identifier	Definition
CT	Total Concentration
CA	Partial Concentration of thickest ice
SA	Stage of Development of thickest ice
FA	Form of thickest ice
CB	Partial Concentration of second thickest ice
SB	Stage of Development of second thickest Ice
FB	Form of second thickest ice
CC	Partial Concentration of the third thickest ice
SC	Stage of Development of third thickest ice
FC	Form of third thickest ice
CN then 1/10	Stage of Development of ice thicker than SA but less
CD	Stage of Development of remaining class of ice
CF	Predominant and secondary forms of ice
Poly_type	General description of feature

Table 3.2
SIGRID-3 Variable Identifier Size

Variable Identifier	Characters Per Variable
CT	2
CA	2
SA	2
FA	2
CB	2
SB	2
FB	2
CC	2
SC	2
FC	2
CN	2
CD	2
CF	4
Poly_type	1

Table 3.3
SIGRID 3 Variable Identifiers

Dynamic Processes
DP - Dynamic processes
DD - Direction of dynamic processes
DR - Rate of ice drift in tenths of knots
DO - Source of information, Op
Water Openings
WF - Form of water openings
WN - Number of water openings
WD - Orientation (direction) of water openings
WW - Width of water openings
WO - Source of information
Topography Features
RN - Nature of topography feature
RA - Age of topography feature
RD - Orientation of topography feature
RC - Concentration of topography feature
RF - Frequency of topography feature
RH - Height (mean) of topography feature
RO - Source of information
RX - Maximum height of topography feature
Thickness of Ice
EM - Mean thickness of level ice in cm
EX - Maximum thickness of level ice in cm
EI - Thickness interval
EO - Source of information
Surface features and melting forms
SC - Concentration of snow
SN - Snow depth
SD - Orientation (direction) of sastrugies
SM - Melting forms
SA - Area coverage of water on ice in tenths
SO - Source of information
Icebergs or ice of land origin
BL - type of iceberg
BD - direction of drift of iceberg
BE - rate of drift in tenths of knots
BN - number of icebergs
BY - day of month
BO - source of information
Sea surface temperature
TT - sea surface temperature in tenths of degrees
TO - source of information
Source of information

OP - primary source of information on which the chart is based
OS - secondary source of information on which the chart is based
OT - tertiary source of information on which the chart is based

APPENDIX 4 to Annex X

Code Tables for SIGRID 3 Variables

Table 4.1

Concentration Codes for Variable Identifiers CT, CA, CB, and CC.

Code Table 1 - Concentration	
Definition	Code Figure
Ice Free	00
Less than 1/10 (open water)	01
Bergy Water	02
1/10	10
2/10	20
3/10	30
4/10	40
5/10	50
6/10	60
7/10	70
8/10	80
9/10	90
10/10	92
Concentration Intervals (lowest concentration in interval followed by highest concentration in interval)	
9/10 –10/10	91
8/10 – 9/10	89
8/10 – 10/10	81
7/10 – 9/10	79
7/10 – 8 /10	78
6/10 – 8/10	68
6/10 – 7/10	67
5/10 – 7/10	57
5/10 – 6/10	56
4/10 – 6/10	46
4/10 – 5/10	45
3/10 – 5/10	35
3/10 – 4/10	34
2/10 – 4/10	24
2/10 – 3/10	23
1/10 – 3/10	13
1/10 – 2/10	12
Unknown	99

Table 4.2

Thickness of Ice or Stage of Development Codes for Variable Identifiers SA, SB, SC, CN, and CD.

Code Table 2 -		
Stage of Development	Thickness	Code Figure
Ice Free		00
No Stage of Development		80
New Ice		81
Nilas, Ice Rind	< 10 cm	82
Young Ice	10 - 30 cm	83
Grey Ice	10 - 15 cm	84
Grey - White Ice	15 - 30 cm	85
First Year Ice	30 - 200 cm	86
Thin First Year Ice	30 - 70 cm	87
Thin First Year Stage 1	30 - 50 cm	88
Thin First Year Stage 2	50 - 70 cm	89
For Later Use		90
Medium First Year Ice	70 - 120 cm	91

For Later Use		92
Thick First Year Ice	> 120 cm	93
For Later Use		94
Old Ice		95
Second Year Ice		96
Multi-Year Ice		97
Glacier Ice		98
Undetermined/Unknown		99

Table 4.3
Form of Ice Codes for Variable Identifiers FA, FB, FC, and CF.

Form	Size/Concentration	Code Figure
Pancake Ice	30 cm - 3 m	00
Shuga/Small Ice Cake, Brash Ice	< 2 m across	01
Ice Cake	< 20 m across	02
Small Floe	20 m - 100 m across	03
Medium Floe	100 m - 500 m across	04
Big Floe	500 m - 2 km across	05
Vast Floe	2 km - 10 km across	06
Giant Floe	> 10 km across	07
Fast Ice		08
Growlers, Floebergs or Floebiits		09
Icebergs		10
Strips and Patches	concentrations 1/10	11
Strips and Patches	concentrations 2/10	12
Strips and Patches	concentrations 3/10	13
Strips and Patches	concentrations 4/10	14
Strips and Patches	concentrations 5/10	15
Strips and Patches	concentrations 6/10	16
Strips and Patches	concentrations 7/10	17
Strips and Patches	concentrations 8/10	18
Strips and Patches	concentrations 9/10	19
Strips and Patches	concentrations 10/10	20
Level Ice		21
Undetermined/Unknown		99

Table 4.4
List of Poly_type character variables

Land	L
Water	W
Ice	I
No Data	X
Ice Shelf / Ice of Land Origin	S

Table 4.5
Dynamic processes

Compacting ice, no intensity given	0
Compacting ice, slight	1
Compacting ice, considerable	2
Compacting ice, strong	3
Diverging ice	4
Shearing ice	5
Ice drift, rate 0,1 - 0,9 knots	6
Ice drift, rate 1,0 - 1,9 knots	7
Ice drift, rate 2,0 - 2,9 knots	7
Ice drift, rate 3,0 knots or more	9

Table 4.6
Direction indicator

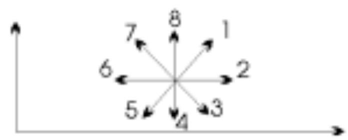


Table 4.7
Form of Water Opening

cracks	1
crack at specific location	2
lead	3
frozen lead	4
polynia	5
ice edge	6

Table 4.8
Number of Water Openings

1	1
2	2
3-5	3
5-10	4
> 10	5

Table 4.9
Nature of topographic feature (deformation)

rafting	1
hummocks	2
ridges	3
jammed brash barrier	4

Table 4.10
Age of topographic feature

new	1
weathered	2
very weathered	3
aged	4
consolidated	5

Table 4.11
Melting Forms

no melt	0
few puddles	1
flooded ice	3
few thaw holes	4
many thaw holes	5
dried ice	6
rotten ice	7
few frozen puddles	8
all frozen puddles	9

Table 4.12
Snow Depth

WMO code

Table 4.13
Ice of Land Origin

growler and or bergy bit	1	unspecified	0
iceberg, unspecified	2	small	1
iceberg, glacier berg	3	medium	2
iceberg, dome	4	large	3
iceberg, pinnacled	5	very large	4
iceberg, tabular	6		
ice island	7		
floeberg	8		
radar target	9		

Table 4.14
Number of Icebergs

WMO code 2877

Table 4.15
Observational method

visual surface observation	1
visual aircraft observation	2
visual and infrared satellite observation	3
passive microwave satellite observation	4
radar satellite surface or airborne observation	5
radar satellite observation (SAR)	6
laser/scatterometer/sonar	7
data buoys	8
estimated (temporal and/or spatial)	9
unknown	0

Annex XI

STRATEGY AND WORK PLAN OF THE EXPERT TEAM ON SEA ICE

ETSI at its first session from 21 to 25 October 2002in Buenos Aires, Argentina reviewed and adopted the following Strategy and Work plan for the next intersessional period.

Strategy

- Provide advice to the Services CG and other Groups of JCOMM, as required on issues related to sea ice and the ice-covered regions;

- Review and advise on scientific, technical and operational aspects of sea ice observations and forecasting, oversee operations of the GDSIDB, coordinate services development and training and linkages with major international programmes.

Work plan

The following significant short and long-term tasks have been identified for the plan (in brackets – nearest corresponding listing numbers from the JCOMM work plan):

Urgent/High Priority

- Develop amendments and during the first ET meeting in October 2002 review a draft revision of the WMO Sea Ice Nomenclature, for approval by the co-presidents and publication by WMO (para 6.3.9);

Intersessional/Moderate Priority

- Develop amendments to the Sea Ice Nomenclature for colour standards of ice charts and coding sea ice decay from remotely sensed data (para 6.3.8);

- Develop and revise Sea Ice Nomenclature and terminology (para 6.3.15);
- Develop data formats and software codes;

- Review and provide guidance on the GDSIDB (Global Digital Sea Ice Data Bank project) including QC, error analysis and archiving and recommend appropriate actions
- Promote development of improved techniques and capabilities to systematically measure ice parameters, especially ice thickness, by means of remote sensing.;

- Prepare historical sea ice data sets and provide ice statistics for reference periods (1971-2000, plus additional reference periods if possible);

- Review and catalogue products and services required in sea ice areas

- Provide support to Southern Hemisphere countries to enhance Antarctic sea ice services

- Ongoing/Moderate Priority

- Develop technical guidance, software exchange, specialized training and other capacity building support concerning sea ice observations and services Develop cooperation and coordination with climate oriented programmes such as WCRP, WCP and CliC (para 6.3.15);

- Offer accurate sea ice data to numerical weather prediction, climate prediction and ocean prediction communities;

- Continue collaboration with BSIM, IICWG and IHO/IMO (on ECDIS);

- Endorse efforts to educate the public and students about sea ice, such as the establishment of sea ice science centres like the one already built in Japan;

- Regularly inform ice services in World on GDSIDB and ETSI activities and invite them to participate in GDSIDB as members of the Bank;

- Address to WMO Secretariat the ETSI concerns about the decreased availability of data necessary to support safety of navigation in ice covered waters that has resulted from the Space Agencies' data policies;

- Monitor quality of communications in Polar Regions and if necessary address ETMSS on appropriate actions.

Ad-hoc additional ongoing/Moderate Priority

- Prepare a status report on sea ice in ECDIS for the World Ocean in respect of Marine Safety Services;

- Review during the forthcoming meeting relevant to the ET topic requirements for marine observational data to support the provision of all types of marine services. It is expected that this process should be completed in November 2002.

- Visit the UN Atlas of the Oceans (http://www.oceansatlas.org/) once it was formally opened to the public on 6 June 2002, and offer comments and suggestions as appropriate regarding its enhancement within the context of JCOMM and its work;

- Visit the new JCOMM web portal being hosted by IOC (http://www.jcomm.net/) provide comments and suggestions as appropriate, and also make use of the portal as a means for information exchange in support of JCOMM;

- Provide the Secretariat with suggestions regarding a JCOMM logo;

- Visit the JCOMM Electronic Products Bulletin (JEB), provide support and technical proposals for JEB Editorial Board chaired by Dr I.Tourre. In particular, during SPA-I meeting it was tentatively agreed that ice products, now absent in JEB, for the Arctic and Antarctic, developed within the GDSIDB will be implemented in JEB.

Annex XII

REPORT OF THE GDSIDB CENTRE IN AARI

Report on activities of the Global Digital Sea Ice Data Bank at AARI, May 2000 – October 2002

Introduction

1. The project was started in 1989 according to recommendations and resolutions of CMM to provide data for WCP, WCRP etc. At its second session in August 1992 NSIDC, NIC and AARI were only contributors. 11 years later, in May, 2000 the last 8th session was held, where representatives from the main ice services and data centres were present, including AARI, Argentina, BSIM, China, CIS, DMI, Iceland, JMA, NIC, NSIDC. During 1980s-2000s project was supervised by the former CMM sub-group on sea ice, and from 2001 - by JCOMM Services PA Expert Team on Sea Ice along with its own Steering Group with two co-chairmen.

2. The Steering Group for the WMO project GDSIDB is open group, however in practice it is closely interlinked with and supervised by ETSI, formally constituted at JCOMM-I. Activities of GDSIDB projects were reviewed and approved by JCOMM-I, which endorsed its future activity and provided recommendations for strategy, tasks and working plan (included and linked with ETSI strategy and tasks). Working plan for the present intersessional period was developed by the previous 8th session of GDSIDB in Ottawa, 30.04-01.05.2000. The members of the GDSIDB Steering Group presently comprise two co-chairmen (from USA centre Prof Roger Barry, NSIDC and from Russia Dr Ivan Frolov, AARI) and experts representing the national services related to sea ice and the ice-covered regions from Argentina, Canada, China, Denmark, Germany, Iceland, Japan, Russian Federation, Sweden (representing also BSIM) and USA. Project has two archiving centres at NSIDC (http://nsidc.org/noaa/gdsidb) and AARI (http://www.aari.nw.ru/gdsidb).

Work plan

3. The period after JCOMM-I has been one of update since both ETSI and GDSIDB incorporated most of the working aspects from the former WMO CMM Sub-Group on Sea Ice. The following significant short and long-term tasks related to GDSIDB Working Plan were identified by JCOMM-I (in brackets – nearest corresponding listing numbers from the JCOMM work plan):

<u>Intersessional/Moderate Priority</u>

- Review and provide guidance on the GDSIDB (Global Digital Sea Ice Data Bank project) including QC, error analysis and archiving and recommend action (Res. 16/2);
- Develop techniques and capabilities to systematically measure ice thickness by means of remote sensing (para 6.3.15);
- Prepare historical sea ice data sets (para 6.3.15);
- Review and catalogue products and services required in sea ice areas (Rec. 16/2);
- Provide support to Southern Hemisphere countries to enhance Antarctic sea ice services (para 6.3.15)

<u>Ongoing/Moderate Priority</u>

- Develop technical guidance, software exchange, specialized training and other capacity building support concerning sea ice observations and services (Res. 16/2);
- Develop cooperation and coordination with climate oriented programmes such as WCRP, WCP and CLIC (para 6.3.15);
- Continue collaboration with BSIM, IICWG and ECDIS (para 6.3.19)

Progress in the Intersessional Period

4. Prime data source for the Project remains digitisation of historical and operational sea ice charts, in this respect main data unit is a sea ice chart, describing linear elements of ice cover and uniform ice zones. That strongly differentiate GDSIDB data from other existing collections based on automatically processed satellite imagery.

5. Presently the GDSIDB holds 7 or 10-days period mapped ice data for the Arctic starting from March 1950 and for Antarctic from January 1973 and to near the present for both regions. The most prominent data collections are from AARI, CIS and NIC and include following information on sea Ice parameters: total concentration, stages of ice development (up to 11 according to WMO Nomenclature, including NY, FY, MY etc.), indicator for drifting/fast ice. It may be noted that estimates of mean-weighted thickness of level ice can be assessed rather easily using stages of ice development. Other regional collections include data for the Sea of Okhotsk (JMA) and for the Baltic Sea (BSIM).

6. Project content is expanding, more data are awaiting or expecting 1) for Antarctic region from Australia, Argentina, Russia; or 2) for the Northern Polar Region – to eliminate artificial lack for ice charts in standard, easily readable by users, format for late 1990s for the Arctic Ocean; and 3) new data for the Baltic Sea, Sea of Okhotsk, Bohai Sea, Greenland waters.

Development of sea ice historical data processing

7. Majority of charts are stored in WMO standard SIGRID and SIGRID-2. In order to facilitate user access, in 1996-1997 NSIDC and AARI converted sea ice charts from basic SIGRID into EASE-GRID projection coinciding with 25 or 12.5 km SSM/I. One grid correspond to sea ice parameter, e.g. CT (total concentration) or MY (partial concentration of multi-year ice). In 1997-2000 while preparing Joint Russian-USA Artic Ocean sea ice Atlas AARI and NIC archives in SIGRID-1 were converted or reproduced in GIS ArcInfo .e00 and other import format. However, SIGRID coding for ice parameters remained. In 2000-2002 in cooperation with IICWG a new draft SIGRID-3 was developed based on vector coding of sea ice spatial distribution. SIGRID-3 is expected to be used by ice services for providing newly issued ice charts to GDSIDB after its adoption by WMO.8. Most of the project data are now available on-line from GDSIDB centres (at AARI or NSIDC), in recently published Joint U.S.- Russian Arctic Atlas for Sea Ice, or on request to User-services (by e-mail at AARI, or by e-mail, fax – at NSIDC). From summer 2000 AARI centre makes it possible for the user to browse all data in SIGRID format using special Java-browser capable to show data in geographical/polar stereographic projections, zooming and colour coding by total concentration or by partial NY/FY/MY concentrations. AARI log book now shows >4500 visits from July, 1999 which makes in average ~10 visits per day.

Sea ice products based on GDSIDB data

9. There are a number of gaps in Project data: temporal (mostly in winter time) and spatial (mostly outside navigable areas like Northern Sea Route or areas of interest), yet GDSIDB material from the 1970s is alternative or complimentary and may be ground-truth to pure SSM/I products (as it is based on comprehensive usage of all available sources of ice information and expert knowledge) or the unique source of ice conditions and climate for the earlier than 1978 period. In that respect, starting from late 1960s blended datasets based on AARI, CIS and NIC charts and containing sea Ice total concentration, ice extent and estimates of mean-weighted thickness in principal can be constructed for the Arctic Ocean with 7-10 days periodicity on a 25x25 km or 12.5x12.5 km grid.

10. To show the GDSIDB data quality, as well as in attempt to provide evidence either for linear trend or oscillations in modern Arctic ice cover variability, statistics based on different sub-sets from data collections were assessed. Gained results show, for example, that statistics for the Arctic shelf seas assessed with incorporation of AARI data (staring in 1950) and Canadian data (starting

in 1968) are more complicated than ones assessed from 1978 and show more evidence for oscillation in ice extent tendencies rather than trends. In that respect, GDSIDB material can be regarded as the source of the most robust statistics (norms) for the ice conditions in the Arctic during 1950s-1990s.

Collaboration with WCRP, GCOS and CliC

11. A report on the GDSIDB was presented at the recent “Workshop on Advances in the Use of Historical Marine Climate Data” (29.01-01.02.2002, Boulder, Colorado, NOAA, CDC). The prime goal of the workshop was to collaboratively build a new “blend of the US Comprehensive Ocean-Atmosphere Data Set (COADS), with the UK Met. Office, Main Marine Data Bank (MDB), plus with newly digitized data in the US and from other international partners. A key focus of the meeting was on the work of the SST (Sea Surface Temperature) and Sea-Ice Working Group (SST/SI WG) of the GCOS/WCRP Atmospheric Observation and Ocean Observations Panels for Climate (AOPC/OOPC), as well as new NOAA initiatives in the SST) area”. During the workshop recommendations related to sea ice were elaborated and included into workshop documents.

12. In respect to sea ice it was noted that there is still insufficient intercalibration of the global sea-ice analysis dependant on passive microwave SSM/I and IR satellite or traditional air reconnaissance and shipborne data where available, and so far underrating of ice charts based on the given sources. Next, it was noted that summer season modelers currently try to model sea ice in AGCMs in a simplified way by increasing the ice concentrations to compensate for melt phenomenon. Also expressed during the workshop were a need and fine perspectives for a blended 7-10 days and monthly products collaboratively compiled by ice services and groups (e.g. Canada, Russia and USA).

13. Based on above discussions and concerns following draft recommendations related to cooperation with ETSI and GDSIDB were elaborated for the workshop documents:

- It is critical for the 2002-2003 that a blended product based on GDSIDB data and existing one in COADS be derived, as it is vital for accurate global analyses of SST and sea ice climate. Estimates of errors should be determined in the blended product.
- It is desirable to ask ETSI to provide recommendations for proper and best-guess blending and averaging procedures.
- Inventory from ETSI on possibly available historical sea ice data for the Southern Ocean is desirable during 2002-2004.
- It will be useful to consider a future (in 2002 or 2003) JCOMM report from ETSI on assessing stages of melting using visible and microwave and its correspondence to visible ice surface features. Techniques provided in the report may be possibly used during 2003-2005 for retrospective calculations of stages of melting.
- It is also important that during 2002-2005 SSM/I algorithms be examined in cooperation with ETSI using ice charts and standard observations as ground truth material so that the most accurate one is selected. Differences between algorithms may help define the errors. For those purposes it would be helpful if the location and type of observations were indicated in the blended product.

14. Several reports on GDSIDB activities, including climatology and formats, were presented at the ACSYS/CliC Workshop on “Sea Ice Extent and the Global Climate System”, held at Meteo-France in Toulouse from 15 to 17 April 2002.

Annex XIII

REPORT OF THE GDSIDB CENTRE AT NSIDC

Report on activities of the Global Digital Sea Ice Data Bank at NSIDC, May 2000 – October 2002

R. Barry, Director, NSIDC
F. Fetterer, Assistant to the Director and NOAA Liaison, NSIDC

Introduction

1. The GDSIDB is important to the National Snow and Ice Data Center/World Data Center for Glaciology, Boulder, because the project provides access to chart data that would otherwise be difficult for our user community of scientists to locate. These chart data are usually the most accurate and often the only record of historical ice conditions. As such, operational chart data have an important role in understanding ice as part of the global climate system. With the support of NOAA, and in partnership with the GDSIDB at AARI and members of the IICWG, the GDSIDB at NSIDC has made progress on formats, archiving processes, and publicizing the project and its data.

Progress in the Intersessional Period

2. The GDSIDB at NSIDC acquired a more visible identity with the publication of project web pages in 2002. The NSIDC GDSIDB site (http://nsidc.org/noaa/gdsidb) home page describes GDSIDB origins, structure and meetings with links to JCOMM and WMO, links to GDSIDB reports and other material at the AARI GDSIDB, links to the DMI mirror site, and a link to the IICWG participants, since many of these are also GDSIDB contributors. The format page briefly describes the 1981 proposal for SIGRID, SIGRID (SIGRID-1), SIGRID-2, Contour, and the proposed SIGRID-3, with links to documents that have complete descriptions. The site joins the IICWG website (http://nsidc.org/noaa/iicwg/) at NSIDC in publicizing the contributions of the world's operational ice services to the research community.

3. NSIDC and NIC have expanded a Memorandum of Understanding on archiving NIC chart products to include digital ice charts as well as historical paper products. NSIDC received the original paper charts from NIC for the following years and areas: Arctic (1988-1994), Antarctic (1987-1995), and Antarctic (1996 and 1997, Ross and Weddell Seas). Currently, NSIDC distributes copies of NIC charts upon request, but we do not have an entry for Arctic and Antarctic NIC charts in our on-line catalogue (http://nsidc.org/data/catalog). We plan to create an NSIDC catalogue entry in 2003. The entire record of Great Lakes charts from NIC is available on line at present, however. Earlier Great Lakes charts are scanned, while later charts are the NIC Great Lakes digital product (http://nsidc.org/data/g00486).

4. NSIDC has permanently archived NCI's digital chart products that NIC has quality controlled and prepared for archival, as of 5 September, 2002. These include regional and hemispheric files in e00, shp, jpg, and gif format ranging from 1995 –2002. NSIDC will continue to work with NIC to archive additional chart data as they are readied for archive by NIC. Some or all of these charts will be archived at NOAA's National Climatic Data Center as well as at NSIDC. A duplicate archive in multiple locations is advantageous, and reduces the risk that archived material will be lost.

5. Digital chart products are archived permanently in partnership with the NOAA National Geophysical Data Center (NGDC), with which NSIDC is affiliated. At NGDC, data receives a unique identifying number and transferred from incoming media to 3480 cartridge. Two copies of each cartridge are created, one is the working copy and is stored at NGDC, the other is stored off site. Both locations are climate controlled and secure. Each year a

random sampling of 10% of the entire archive is conducted, tapes are read and the volume of data recovered is compared to the volume recorded at the time of archive to ensure there has been no loss of data.

6. NSIDC has continued to work on the development of the SIGRID–3 format with the AARI GDISDB and IICWG members. After initiating discussion of the need for a new archive format at the second IICWG meeting, we are pleased that the operational services are now leading the charge to define, gain acceptance for, and implement a new vector format that will be recommended for acceptance by WMO/JCOMM.

7. During the intersessional period, the NSIDC GDSIDB received data from the Canadian Ice Service for 1999-2000 in SIGRID format, and for 1999 in e00 format (see the Canada Report). We also received the 2000 and 2001 Weekly Ice Analysis covering Greenland from the Danish Meteorological Institute in shapefile format, and SIGRID-2 format files from the Japan Meteorological Agency (JMA) for the Sea of Okhotsk. These are every 5 days from July through December, for 2000 and 2001. In addition, JMA provided replacement files for their data from 1970 through 1999, owing to a change in map data and method of conversion from bmp to SIGRID-2 format. JMA's Takanori Matsumoto visited NSIDC on 3-5 April, 2002, and presented NSIDC with copies of ice charts from around Hokkaido and the Kuril Islands , 1937-1944.

Other activities

8. Other activities that may be of interest include the development of a web site with summaries of passive microwave and other data sets. It was created to help the research community choose between the many sea ice data products distributed by NSIDC (http://nsidc.org/data/seaice/), and includes links to other sources of sea ice data.

9. NSIDC continues to be active in the World Climate Research Programme's Arctic Climate System Study (ACSYS)/ Climate and Cryosphere (CliC) projects. A poster on Ice Chart Archive Formats: Progress in the International Ice Charting Working Group was presented at the ACSYS/CliC meeting on Sea Ice Extent and the Global Climate System, 15-17 April, Toulouse, France. At the ACSYS/CliC Moored Upward Looking Sonar meeting in Tromso, Norway, 1-3 July, NSIDC contributed to discussions on coordinating processing and archival of data from moored instruments. NSIDC expects to receive about 65 buoy-years of data from Australian, Canadian, German, and U.S. research groups.

10. An ad hoc meeting to discuss a U.S. CliC programme (analogous to U.S. CLIVAR) was coordinated by R. Barry, held in Washington, DC 10-11 January, 2002, and attended by some 20 scientists, and 14 U.S. funding agency representatives. It was supported by NASA Headquarters and NOAA's Office of Global Programs. Two topics were addressed: the need to designate a U.S. focal point for WCRP and any U.S. CliC activities, and the potential role and representation of a U.S. CliC Science and Coordination Committee (SCC). Possible terms of reference for such a committee were presented, and recommendations were submitted to potential agency sponsors of these activities. A request for consideration of funding support for a US CliC committee has been sent to the NASA Cryosphere programme.

Annex XIV

WORK PLAN FOR COOPERATION BETWEEN THE MEMBERS OF THE STEERING GROUP FOR THE WMO PROJECT GLOBAL DIGITAL SEA ICE DATA BANK FOR OCTOBER 2002 - OCTOBER 2004

1. Technique Development

The experts from the GDSIDB centres will continue make available data browsers, translating and other necessary software for processing data in SIGRID, various GIS, and EASE-grid formats, and will develop tools for working with the new SIGRID-3 format. NSIDC plans to develop software to translate from SIGRID-3 to EASE-Grid files of total, multi-year, first year and thin ice concentration.

2. Data Exchange

2.1 Anticipated data sets to be contributed by GDSIDB members, on a schedule dictated by available resources, during the intersessional period 2002 - 2004

	Institute	Region	Time interval	Exchange date (notes)
1.	AARI	Antarctic Arctic	1971-1990 (10-days period) before 1950	SIGRID, EASE-GRID, 2003 SIGRID, EASE-GRID, After availability of data at WDC
2	Argentinean Navy Hydrographic Service	Weddell and Bellingshausen Seas	App. 1982 to 1990, point observations Current observations	To be checked Point observations in NIC-code in .db format, submitted with weekly interval to NSIDC and AARI ftp-servers
3.	Australia, within the ASPeCT project	Antarctic, en-route and point observations	1980-1997	In special ASPeCT code, during intersessional period
4.	SMHI	Baltic Sea	1980 – up to present, twice a week 2004 ?	Ice Map Format (to be translated into SIGRID) SIGRID-3
5.	CIS	Canadian Arctic	1999- ongoing data forward in time	SIGRID, SIGRID-3
6	China, State Oceanic Administration	Bohai Sea	1995 (???) – up to present Before 1994	0,1° by 0.1° grid, total and partial concentrations and stages of development (submitted) To be specified
7.	DMI	Greenland waters	Weekly composite1999–2002 2003, forward in time	Shapefile (submitted) SIGRID-3 (once a year, for the whole ice season)

8.	Germany, Federal Maritime and Hydrographic Agency (BSH)	Baltic Sea (south of 56°N and to the west of 14° 20'E)	3 times a week, 1960-1996	Ice Map Format, to be submitted during intersessioinal period after QC
9	Icelandic Meteorological Office	Icelandic waters	2001 1993-1996 (ship reports and paper charts)	to be mirrored from IMO web-site next steps TBD
10.	JMA	Sea of Okhotsk	Every 5 days, forward in time	Once a year in SIGRID-2 format
11.	NIC	Arctic Antarctic Arctic Antarctic	1996,1997 1995–2000 1995,1998,1999 2001-till present 2001–till present	In .e00 format, undergo QC before submission Under preparation, need to undergo QC before submission ArcInfo e00-format(submitted) Need QC before submission ArcInfo e00-format All data are available on-line via NIC web-site

2.2 Technical assistance

2.2.1. SG experts from AARI and NSIDC centres of GDSIDB will continue to provide assistance to data contributors and data users who wish to use formats other than SIGRID (EASE-grid, Contour, etc.) provided that resources are available for adequate documentation and development of any needed access software.

2.2.2 NSIDC and AARI will continue to provide guidance on preparation of metadata and other necessary documentation accompanying data submitted or to be submitted to GDSIDB.

3. Modification of formats for data exchange

3.1 The GDSIDB centres will work with the ice services to finalize documentation of SIGRID-3 and to assist with its implementation ***(see ANNEX…).***

3.2 NSIDC and AARI, with the assistance of experts from operational centres, will prepare a report on the given activity for the next IICWG meeting in April 2003, St. Petersburg.

4. Use, validation and intercomparison of GDSIDB data

4.1 Experts from SG will continue joint activity on development of blended sea ice data sets and sea ice climate estimates from the GDSIDB data.

4.2 SG members will endeavour to establish linkages with the other programmes and projects concerning the development of climate estimates, validation and intercomparison of GDSIDB data.

5. Future activity

5.1 The GDSIDB at NSIDC and AARI will publish charts from AARI, DMI, JMA, NIC, and CIS in the format in which they were received and in EASE-Grid format if resources allow. Publishing these data sets includes developing documentation, a citation for their use, on-line access, and tracking users inquires concerning data sets.

5.2 The GDSIDB and the Icelandic Meteorological Office will explore publication of Icelandic ship reports and ice charts for the year 2001, as well as the possibility of publishing additional data from Icelandic waters including scanned versions of paper charts, and historical reports.

5.3 The GDSIDB will acquire and publish the ASPeCT data of ice observations from Antarctica.

5.4 The GDSIDB will explore the possibility of publishing ice observations from the "climatological" Baltic Sea Ice Meeting stations.

5.5 The GDSIDB SG will inform all ice services of GDSIDB activities, and invite them to participate, in a letter signed by the GDSIDB Co-chairs.

Annex XV

ACTION SHEET ON DECISIONS OF ETSI-I
(Buenos Aires, Argentina, 21 - 25 October 2002)

ETSI Chairman

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.1.5	Sea ice data management	To address to WMO Secretariat the ETSI concerns on the decreased availability of data necessary to support safety of navigation in ice covered waters that has resulted from the space agencies` data policies	Secretariat	ASAP	
Para 2.1.6	Sea ice training	To prepare a document on training in the field of sea ice activities to be submitted for information to JCOMM Capacity Building PA Coordinator	Members	Intersessional period	
Para 2.2.48	Sea-Ice Information Services in the World	To revise the WMO publication No. 574, 2000	WMO consultant	JCOMM-II	
Para 2.5.9	Electronic versions of WMO publications	To publish on Internet electronic versions of all existing sea ice publications, as official WMO publications	Secretariat	Intersessional period	
Para 2.5.10	Requirements for sea ice observations	To prepare requirements for sea ice observations to be revised by JCOMM-II	Members, Secretariat	15 November 2002	

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.5.11	WMO Sea Ice Nomenclature	(i) To submit to WMO Secretariat agreed corrections for WMO publication No. 259 for formal approval by JCOMM;	Secretariat	Before JCOMM-II	
Para 2.5.12, 2.5.13, 2.5.14		(ii) To revise prepared by AARI amendments, to WMO. Sea Ice Nomenclature to be submitted for formal approval by JCOMM;	Members, BSIM, IICWG, Secretariat	Before JCOMM-II	
		(iiI) To appoint an expert to prepare a consolidated set of requirements and proposals for a revision of WMO publication No. 259	Members	Intersessional period	
Para 2.6.6	Archive format for sea ice data	To revise and comment the proposed archive format for sea ice data to be submitted for approval by appropriate WMO bodies	Members, Secretariat, National services	Intersessional period	
Para 4.1	Relations to WMO/IOC and other international programmes	To develop blended sea ice variables for global climate analysis and to prepare historical sea ice data information for the Southern Ocean	Members, SG GDSIDB	Intersessional period	
Para 5.1	Date and place of the next meeting	To finalize arrangements for the timing and venue for the next ETSI-II and GDSIDB-X sessions in due course, and notify group members accordingly.	Secretariat, China, Germany	2003	
Team members					
Para 2.1.6	Sea ice training	To prepare a document on training in the field of sea ice activities to be submitted for information to JCOMM Capacity Building PA Coordinator	Chairman	Intersessional period	

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.5.10	Requirements for sea ice observations	To prepare requirements for sea ice observations to be revised by JCOMM-II	Chairman, Secretariat	15 November 2002	
Para 2.5.12, 2.5.13, 2.5.14		To revise prepared by AARI amendments, to WMO. Sea Ice Nomenclature to be submitted for formal approval by JCOMM;	Chairman, BSIM, IICWG, Secretariat	Before JCOMM-II	
		To appoint an expert to prepare a consolidated set of requirements and proposals for a new revision of WMO publication No. 259	Chairman	Intersessional period	
Para 2.5.16	International colour code for sea ice charts	To submit agreed international standard for colour code for sea ice to the JCOMM copresidents for formal approval on behalf of JCOMM to be published by WMO Secretariat	IICWG, Secretariat	Before JCOMM-II	
Para 2.6.6	Archive format for sea ice data	To revise and comment the proposed archive format for sea ice data to be submitted for approval by appropriate WMO bodies	Chairman, Secretariat, National services	Intersessional period	
Para 4.1	Relations to WMO/IOC and other international programmes	To develop blended sea ice variables for global climate analysis and to prepare historical sea ice data information for the Southern Ocean	Chairman, SG GDSIDB	Intersessional period	
Others					
Para 2.2.15	Sea ice monitoring in the Sea of Okhotsk	To feed the result of JMA operational analysis of sea ice in the Sea of Okhotsk to JMA`s Numerical Weather Prediction Model and Climate Prediction Model	JMA	Continuous	
Para 2.2.21	WMO Sea Ice Nomenclature	To submit a draft of the revised Spanish version of WMO Sea Ice Nomenclature to WMO. Secretariat to be edited and published	M.Picasso, Secretariat	ASAP	

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.3.6	ETSI and BSIM collaboration	To continue development of ETSI and BSIM collaboration	ETSI, BSIM	Continuous	
Para 2.5.12, 2.5.13	WMO.Sea Ice Nomenclature	To revise prepared by AARI amendments, to WMO Sea Ice Nomenclature to be submitted for formal approval by JCOMM;	Chairman, BSIM, IICWG, Secretariat	Before JCOMM-II	
Para 2.5.16	International colour code for sea ice charts	To submit agreed international standard for colour code for sea ice to the JCOMM copresidents for formal approval on behalf of JCOMM to be published by WMO Secretariat	IICWG, Secretariat	Before JCOMM-II	
Para 2.5.17	Ice decay/stages of melting	(i) To develop of appropriate amendments to the WMO Sea Ice Nomenclature for coding sea ice decay;	CIS, AARI	ETSI-II	
Para 2.5.21		(ii) To compile the analysis of evaluation reports on presentation of ice strength information received from ships	CIS	Spring 2003	
Para 3.11	Sea ice charts for the Southern hemisphere	To digitize and compile results of QC of sea ice charts for the Antarctic areas:	NIS		
		- from 1995 to 2000;		October 2005	
		- from 2001 to 2002		August 2003	
		- from 1973 to 1994		End 2007	

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 3.13, 3.15	Contributions to GDSIDB	(i) To transfer weekly sea ice charts for the Baltic Sea to the GDSIDB to be digitized during the next intersessional period.	DMI	Continuos	
		(ii) To make digital database of sea ice charts for the Canadian Arctic available to users from CIS website	CIS	ASAP	
Para 4.1	Relations to WMO/IOC and other international programmes	To develop blended sea ice variables for global climate analysis and to prepare historical sea ice data information for the Southern Ocean	SG GDSIDB	Intersessional period	

Secretariat

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.2.21	WMO Sea Ice Nomenclature	To submit a draft of the revised Spanish version of WMO Sea Ice Nomenclature to WMO Secretariat to be edited and published	M.Picasso,	ASAP	
Para 2.2.48	Sea-Ice Information Services in the World	To revise the WMO publication No. 574, 2000	WMO consultant	JCOMM-II	
Para 2.5.9	Electronic versions of WMO publications	To publish on Internet electronic versions of all existing sea ice publications, as official WMO publications	Chairman	Intersessional period	
Para 2.5.10	Requirements for sea ice observations	To prepare requirements for sea ice observations to be revised by JCOMM-II	Members, Chairman	15 November 2002	

Ref.	Subject	Action proposed	With whom	Target	Comments
Para 2.5.12, 2.5.13, 2.5.14	WMO Sea Ice Nomenclature	(i) To revise prepared by AARI amendments, to WMO Sea Ice Nomenclature to be submitted for formal approval by JCOMM;	Members, BSIM, IICWG,	Before JCOMM-II	
		(ii) To appoint an expert to prepare a consolidated set of requirements and proposals for a new revision of WMO publication No. 259		Intersessional period	
Para 2.5.16	International colour code for sea ice charts	To submit agreed international standard for colour code for sea ice to the JCOMM copresidents for formal approval on behalf of JCOMM to be published by WMO Secretariat	IICWG, ETSI	Before JCOMM-II	
Para 2.6.6	Archive format for sea ice data	To revise and comment the proposed archive format for sea ice data to be submitted for approval by appropriate WMO bodies	Chairman, Members, National services	Intersessional period	
Para 5.1	Date and place of the next meeting	To finalize arrangements for the timing and venue for the next ETSI-II and GDSIDB-X sessions in due course, and notify group members accordingly.	Chairman, China, Germany	2003	

LIST OF ACRONYMS AND OTHER ABBREVIATIONS

AARI	Arctic and Antarctic Research Institute
ACSYS	Arctic Climate System Study
AIRSS	Arctic Sea Ice Regime Shipping System
APT	Automatic Picture Transmission
ATF	Antarctic Task Force (Argentina)
AVHRR	Advanced Very High Resolution Radiometer
BSH	Bundesamt für Seeschiffahrt und Hydrographie (Germany)
BSIM	Baltic Sea Ice Meeting
CAA	Chinese Antarctic and Arctic Administration
CEADO	Argentine Centre of Oceanographic Data
CCG	Canadian Coast Guard
CDC	Climate Data Centre
CIS	Canadian Ice Service
CLIC	Climate and Cryosphere project
CLIVAR	Climate Variability and Predictability (WCRP)
COADS	Comprehensive Ocean Atmosphere Data Set
COTS	Commercial Off-the-Shelf
CNOOC	China National Offshore Oil Corp.
DMSP	Defense Meteorological Satellite Program (USA)
DMI	Danish Meteorological Institute
EC	Executive Council
ECDIS	Electronic Chart Display Information System
ECMWF	European Centre for Medium-Range Weather Forecasting
ENVISAT	Environmental Satellite
ERS	European Remote-Sensing Satellite
ESA	European Space Agency
ESDIM	Environmental Services, Data, and Information Management Programme
ETSI	JCOMM Expert Team on Sea Ice
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization of the United Nations
FIMR	Finnish Institute of Marine Research
GCOS	Global Climate Observing System
GDSIDB	Global Digital Sea Ice Data Bank
GIS	Geographic Information System
GMES	Global Monitoring of Environment and Security Programme
HRPT	Higher Resolution Picture Transmission
IABP	International Arctic Buoy Programme
IHO	International Hydrographic Organization
IICWG	International Ice Charting Working Group
IIP	International Ice Patrol
IMO	Icelandic Meteorological Office
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IPAB	International Programme for Antarctic Buoys
IST	Information Society Technology
IWICOS	Weather, Sea ice and Ocean Service SystemIUGG International Union of Geodesy and Geophysics
J-EPB	JCOMM Electronic Products Bulletin
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
JCOMMTRAN	JCOMM Transition Committee
JEB	JCOMM Electronic Products Bulletin
JIWG	Joint USA/Canada Ice Working Group
JMA	Japan Meteorological Agency
MODIS	Moderate Resolution Imaging Spectrometer
NAIS	North American Ice Service
NASA	National Aeronautics and Space Administration (USA)

NGDC	NOAA National Geophysical Data Center
NIC	National Ice Center (USA)
NMEFC	National Marine Environment Forecast Centre (China)
NOAA	National Oceanographic and Atmospheric Administration (USA)
NPOESS	National Polar Orbiting Environmental Satellite (USA)
NSIDC	National Snow and Ice Center (USA)
OLS	Operational Linescale System
ONR	Office of Naval Research
PIPS	Polar Ice Prediction System
PRIC	Polar Research Institute of China
QC	Quality Control
QMFO	Qingdao Marine Forecasting Observatory
RADARSAT	Satellite from Canada
RIZA	Institute for Inland Water Management and Waste Water Treatment (the Netherlands)
SAR	Synthetic Aperture Radar
SCC	CLiC Science and Coordination Committee
SCG	JCOMM Services Programme Area Coordination Group
SG	Steering Group
SIGRID	Format for the archival and exchange of sea-ice data in digital form
SHN	Naval Hydrographic Service (Argentina)
SIMS	Sea Ice Mapping System
SMARA	Argentine Navy Meteorological Service
SMHI	Swedish Meteorological and Hydrological Institute
SMN	Argentine National Meteorological Service
SOA	State Ocean Administration (China)
SPA	JCOMM Services Programme Area
SSMI	Special Sensor microwave Imager
SST	Sea Surface Temperature
TD	Technical Document
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCP	World Climate Programme
WCRP	World Climate Research Programme
WDC	World Data Centre
WMO	World Meteorological Organization
XML	Extensible Markup Language