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Report of the Working Group on Oceanic Hydrography (WGOH)

3–5 March 2008

Aberdeen, UK

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CIEM Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

ICES Report on Ocean Climate 2007

- The scientific highlights of the IROC 2007 are:

The upper layers of the North Atlantic and Nordic Seas remained exceptionally warm and saline in 2007 compared with the long-term average. The largest anomalies were observed at high latitudes.

The North Sea, Baltic Sea and Bay of Biscay had an unusually warm winter and spring. This was due to a combination of stored heat from the warm autumn in 2006, and high solar radiation in 2007.

The trend in the past decade (1996–2006) has been of warming and increasing salinity in the upper ocean. Temperature and salinity have been relatively stable since 2004.

- The improvement of the IROC continues: the new publication format is very welcome; *Coriolis* products and a Deep Water section are now included; most IROC data are available electronically; and data sources and archive locations are fully credited.

ICES Data Centre

- The WGOH expresses its support for the ongoing and planned future activities of the ICES Data Centre, and we reiterate our belief that an active oceanographic Data Centre with adequate resources and specialist expertise is essential for the proper functioning of ICES.
- The WGOH recommends that both the ICES Data Centre and WGOH members should approach national data centres with a view to encouraging those national data centres to submit all relevant hydrographic (and other) data to the ICES Data Centre in as complete and timely a manner as possible.
- The WGOH recommends that the ICES Data Centre and the IROC editors begin a dialogue to determine how the Data Centre can contribute to the production of the IROC.

ICES Issues

- *The OSPAR Request*: The WGOH *ad hoc* group formed to respond to the OSPAR request submitted its input, comprising a small number of time-series of 3 decades duration of temperatures and salinities that represented each of the OSPAR subregions, and included seasonal information. Indicators of sea ice extent and atmospheric circulation were also provided.
- *The ICES Science Plan*: The WGOH recommends that the existing ICES Science Plan research theme 1 is relabelled "Climate Change impact processes", and that a separate theme is inserted: "Climate change processes: changes of physical conditions and processes in the ocean and the mechanisms linking them to climate".
- *The ICES Advisory Structure*: The WGOH recommends that when ToRs are being defined by ACOM / CONC for EGs, there should be a dialogue between ACOM / CONC and the relevant EGs to ensure firstly that the

ToR is written comprehensibly, and secondly, that it should in principle be answerable (a “sanity check”).

1 Opening of the meeting

The Working Group on Oceanic Hydrography (WGOH) was welcomed to the Fisheries Research Services Marine Laboratory (Marlab), Aberdeen, by Colin Moffat, Director of Marlab's Aquatic Environment Programme, and by the local host, Sarah Hughes. The list of participants is given in Annex 1. Apologies for absence were received from Keith Brander, Peter Galbraith, Gilles Reverdin, Vladimir Ozhigin, Waldemar Walczowski, Martin Visbeck, Bob Pickart, Jan Piechura, Hjalmar Hatun, Garry Dawson and Harald Loeng. The WGOH was pleased to welcome new members Ilona Goszczko, Fabienne Gaillard, and Hjalte Parner (ICES Data Centre).

2 Adoption of the agenda

The Meeting Agenda (Annex 2) was adopted, based on the 2008 Terms of Reference. Some items were taken out of order on account of availability of relevant individuals. The order of reporting (as below) follows the order of presentation.

3 Introduction

The primary aim of the meeting was to review scientific results from the standard sections and stations, and to compile and to continue the development of the ICES Report on Ocean Climate (IROC). This year's (2008) publication will be the IROC 2007, referring to last year's data as reported during the meeting.

The working group also aimed to consider issues relating to the ICES Data Centre, the work of other ICES expert groups, and advice required by the ICES advisory committees.

4 Standard Sections and Stations

This part of the meeting addressed ToR (a), "update and review results from Standard Sections and Stations". WGOH members presented their national or regional reports, as follows. All members contributed to the IROC, as appropriate; extended national or area reports are provided for a subset, identified by the annex number below.

a) Karin Borenäs, Skagerrak, Kattegat and Baltic (Annex 6)
b) Agnieszka Beszczynska-Möller, Greenland Sea and Fram Strait (Annex 7)
c) Holger Klein, North Sea (Annex 8)
d) Eugene Colbourne, North-west Atlantic (Annex 9)
e) Hedinn Valdimarsson, Icelandic Waters
f) Alicia Lavin and Victor Valencia, Spain (Annex 10)
g) Bert Rudels, the Arctic (Annex 11)
h) Svein Østerhus, Ocean Weather Station Mike
i) Bogi Hansen, Faroese Waters (Annex 12)
j) Ilona Goszczko, Polish report (Annex 13)
k) Fabienne Gaillard, Coriolis products; Roscoff data; Ovide 2008
l) Hendrik van Aken, Atlantic Monitoring 2007 and Area 5b (Annex 14)
m) Stephen Dye, Southern North Sea; Denmark Strait Overflow

n) Kjell Arne Mork, Norwegian Waters (Annex 15)
o) Sarah Hughes, Faroe Shetland Channel
p) Penny Holliday, the Ellett Line
q) Ross Hendry, Labrador Sea 2007
r) Glenn Nolan, Ireland national report

We note that although our Russian colleague Vladimir Ozhigin was unable to attend the meeting, he very kindly provided text and data both for the IROC and for the Russian standard sections, thus:

s) s) Vladimir Ozhigin, Russian national report (Annex 16).

5 ICES Data Centre

This item addresses ToR (f), "provide expert knowledge and guidance to ICES Data Centre … ". A representative of the ICES Data Centre (DC) usually attends the meetings of the WGOH, and in this instance we were pleased to welcome Hjalte Parner (HP), who told us that he has been at the DC since August 2007, and has a 4-year contract dating from 1 January 2008. HP gave us an overview of the DC's activities and plans; a brief summary of his presentation – the paragraphs below beginning with the underlined items – and some of the WG's questions follow.

Data submission: now endorsed in free format, to preserve data quality and to avoid conversion bottlenecks.

Question (Q): ICES data are freely available?
Answer (A): Yes, and with no delay / moratorium. Also, the ICES DC can search in other DCs.

Data types: focus on CTD / bottle data / nutrients (including dissolved oxygen).

Storage: move to "relational database". Presently ICES data are held in fixed ASCII format. In future, there will be a link to metadata (e.g. cruise report).

Data Quality Control: ICES will QC the data it holds, using flags. This may involve some duplication if the originator has included QC information in the data files.

Products: focus on the North Atlantic region, serving ICES working groups and the community. Future products may be derived both from in-house hydrographic data and external data (e.g. buoy or remote-sensed data).

Status: the new database will be ready for the end of 2008; new products by the end of 2009.

Q: Is it now recognised that DC effort is better spent on collecting data than on (e.g.) implementing GIS?
A: Yes.

Q: What is the relationship between national DCs and ICES? "Push" or "pull"?
A: It is voluntary; there are some agreements to exchange data.

Q: Does ICES intend to push for real-time data acquisition?
A: Not currently, although this does happen to some extent through SeaDataNet.

Q: Data centres are listed in the back of the IROC. Does ICES routinely receive data from national data centres?
A: Generally no.

Q: Can the ICES DC report how much data has been received from national data centres?
A: Can try to find out.

Comment (WG): we all need to be sure that our data is submitted to ICES DC.

As a result of this discussion, the WGOH formulated the following recommendation:

- The WGOH **recommends** that both the ICES Data Centre and WGOH members should approach national data centres with a view to encouraging those national data centres to submit all relevant hydrographic (and other) data to the ICES Data Centre in as complete and timely a manner as possible.

The WGOH also **expresses** its support for the ongoing and planned future activities of the ICES Data Centre, as described by HP.

In the context of the discussion about the ICES DC, the issue of IROC production was raised. Given that the production of the IROC to such a high standard imposes a heavy workload on the editors of the document, in order to improve the efficiency of production of the IROC, the WGOH wishes to explore the possibility of employing, for example, internet data submission and collation, or the creation of a plot-generating tool, through collaboration with the DC. Discussion of these possibilities with HP resulted in a further recommendation relevant to the ICES DC:

- The WGOH **recommends** that the ICES Data Centre and the IROC editors begin a dialogue to determine how the Data Centre can contribute to the production of the IROC.

6 The OSPAR Request

This item address ToR (c), the "OSPAR Request", specifically to "provide support to other expert groups requiring information on oceanic hydrography in support of their responses to the OSPAR request on 'An assessment of the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature'". The 1992 OSPAR Convention is the current instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. "OSPAR" seems to be a contraction of the names Oslo and Paris, which conventions it replaced.

The WGOH **noted** that the OSPAR request is imperfectly phrased, since "hydrodynamics", simply defined, is the study of fluids in motion, and thus probably not what was meant; which was probably just "ocean circulation" (and hence observed changes thereof).

P. Holliday provided a brief review of the progress in 2007 regarding the OSPAR request to ICES. The scientific expert groups involved in addressing the request include the WGOH, 9 ecology groups, the WGRED (Working Group on Regional Ecosystem Description) and the WGECO (Working Group on Ecosystem Effects of Fishing Activities). ACE (Advisory Committee for Ecosystems) and WGECO were tasked with integrating the results from the other EGs.

The spring 2007 EG meeting reports contained the initial analysis; with no guidance as to what was expected of them, the WGOH put forward the IROC2006 as their contribution. The WGECO reviewed the evidence in those reports and concluded that the information was too inconsistent in terms of methods and data sets to allow a synthesis to be made. In autumn 2007 ACE and WGECO put forward a new workplan and timetable for the steps necessary to complete the advisory document in 2008. The new work plan identified 4 steps; a) developing a common framework for hydrographic conditions, b) developing a common framework for assessing changes in distribution and abundance, c) developing a common framework for interpreting results, and d) selecting species for more intensive investigations. *Ad hoc* groups of experts were formed in autumn 2007 to address each step; the WGOH *ad hoc* group consisted of P. Holliday, S. Hughes, G. Nolan, H. Klein, A. Lavín, G. Reverdin and F. Gaillard.

At the 2007 Annual Science Conference, Hughes and Holliday met with Jake Rice (WGRED) and Mark Tasker (ACE) to establish precisely the information required for the hydrographic attributes framework. In essence the requirement was for simple environmental parameters, which were consistent across the region. They asked for a small number of time-series that represented each of the OSPAR sub-regions (see map in Annex 5), with actual temperatures and salinities (not anomalies from means), and with seasonal information. The *ad hoc* group selected some suitable time-series that were as long as possible and could be viewed as representative of the sub-regions. Some atmospheric and ice indices were also chosen. The full document was completed in January 2008, sent to ACE and ICES secretariat, and is given in Annex 5. Electronic versions of the data files and figures were provided with the document.

WGECO established a Study Group on Working Hypotheses Regarding Effects of Climate Change to prepare for the spring 2008 scientific expert group meetings. The draft report was made available to WGOH prior to this meeting. It described changes in marine ecosystem components, functions and habitats which may be due to climate change, and provided 10 hypotheses for the major ways that ecosystem components could be altered by the effects of climate change and other major drivers of ecosystem change. At the time of the meeting there had been no substantial progress on the two other steps in the work plan.

7 Relations with International Climate Monitoring Programmes

This item addresses ToR (d), "review and improve relations with international climate monitoring programmes".

We note that probably the most important and welcome development in this regard is the participation of French colleagues Fabienne Gaillard and Gilles Reverdin in the WGOH, and the resulting incorporation of output from the Coriolis project into the IROC.

One new item was raised under this heading during the meeting: it was remarked that WGOH members should attempt to attend the *OceanObs '09* meeting in Venice, Italy, 21–25 September 2009. The meeting title is "Ocean information for Society: sustaining the benefits, realising the potential". The goals of the meeting are (i) to document the importance and benefits of the existing ocean observing system; (ii) to demonstrate its scientific, societal and economic impacts; (iii) to revisit the current status, and update plans for the physical and carbon ocean observing systems, and (iv) to advance capabilities for marine biogeochemistry and ecosystems.

8 ICES Matters

This item is relevant to ToR (e), "take action for strengthening the role of WGOH and physical oceanography within ICES".

WKOOP:

WKOOP is the Workshop on Operational Ocean Products: this is an attempt to rationalise NORSEPP and SGGOOS. The workshop comes first; there may be a new WG later. (News received after the WGOH meeting: Holger Klein confirmed that he will be able to attend the WKOOP meeting, 8–9 April 2008 in Copenhagen, and will find out whether the group can provide products of use to the IROC).

SG Climate Change:

Sarah Hughes was invited to participate. We note that the SG is likely to overlap with the WGOH.

ICES Science Plan:

Having read the ICES Science Plan, the WGOH agreed with the observation that a fundamental prerequisite to its stated aims is to study what climate change is happening, and further, that such study is more than just monitoring, it also requires interpretation (cf. IROC). Accordingly, the WGOH agreed the following recommendation:

- The WGOH **recommends** that the existing ICES Science Plan research theme 1 is relabelled "Climate Change impact processes", and that a separate theme is inserted: "Climate change processes: changes of physical conditions and processes in the ocean and the mechanisms linking them to climate".

ICES Advisory Structure:

A presentation entitled "ICES Advisory Services: Reforming the ICES Advisory Programme", credited to the ICES Management Committee on the Advisory Process (MCAP), was provided to us by Hans Lassen. Being a rather long presentation, a cut-down version was prepared and shown to the WGOH by the Co-Chairs. We summarise the relevant portions thus.

The advisory structure shall have five elements. At the top is the Advisory Committee (ACOM), which works under instruction of the Council. Its role is to define the advisory process and to finalise the advice. Next down is the Advice Drafting Group, which is the major source of the advice texts, and formulates the advice. Third is the Review, which is a technical review of the analytical and science input to the advice formulation, and assures the "best science". Then comes the Expert Groups, which provide the scientific and technical foundation for the advice; and finally Workshops on data compilation.

We note that information flow in this structure is largely bi-directional (this is good); however, there is one element of the flow which is unidirectional: Terms of Reference flow only downwards, from the top (ACOM and CONC) to the EGs. We think that this is not ideal, and that when formulating ToRs, ACOM and CONC should insert a step which is essentially "sanity check" to give the EGs the opportunity to comment on ToRs. This would defend against incorrect formulations such as that noted in section 6 above in the "OSPAR Request". The following recommendation was written as a result.

- The WGOH **recommends** that when ToRs are being defined by ACOM / CONC for EGs, there should be a dialogue between ACOM / CONC and the relevant EGs to ensure firstly that the ToR is written comprehensibly, and secondly, that it should in principle be answerable (a "sanity check").

Presentation to FRS Marlab staff and WGOH by Eugene Colbourne:

As an exercise in "outreach", and also to make use of local (Marlab) expertise to find ways in which we could interact with fisheries assessment biologists better, we were pleased that Eugene Colbourne, from the Northwest Atlantic Fisheries Centre, St. John's Newfoundland and Labrador, was able to give a presentation describing his long experience in eastern Canada of providing oceanographic support to the process of fish stock assessment. Briefly summarised, the presentation first described the practice, over several decades, of data collection on multi-species assessment surveys, and the resulting data products routinely generated. These comprised gridded physical oceanographic data, and were shown as contoured maps of water properties and of their anomalies, temperature and salinity time-series, climate indices, and derived properties such as stratification and mixed layer depth. This was followed by a discussion on how environmental information is currently considered within stock assessments and how it is documented and disseminated to various user groups.

The second part of the presentation illustrated several examples of how physical parameters such as surface or bottom temperatures were known to be (statistically) correlated with certain species abundances; and further, how species abundances had been observed to respond, over decades, to changes in ocean climate. The important point was made that for environmental information to feed into fish stock assessments there needed to be sound working hypotheses of the relationships between environmental observables and consequent stock recruitment: i.e., the development of statistical models, particularly lagged correlations, which if significant, enable some predictive power. In the absence of known functional relationships, all such models are heuristic and thus predictions are tentative.

The future challenges listed by Eugene at the end of his presentation were: (i) the need to identify causal relationships in this context; (ii) that more information is needed on primary and secondary production; (iii) the need to evaluate the relative importance of the environment vis-à-vis fishing and natural mortality; and (iv) the development of the ability to interpret departures from models based on causal understanding.

Subsequent discussion:

The feedback received from ICES users regarding the usefulness of the IROC content covers a wide spectrum of views. At one end are those who are troubled by too much detail and would like a simple index that includes all environmental indices to represent variability in a particular area. Eugene Colbourne showed a useful example of such an index developed for the Newfoundland and Labrador Shelf region that comprised more than two dozen different meteorological, sea ice and oceanographic time-series. At the other end of the spectrum are those who would like detailed environmental information pertaining to a specific place and time in order to understand a particular "event" and the processes that affected marine biota during that event.

The discussion at FRS seemed to fall at the "more information" end of the spectrum, but was further divided into those who found the information broadly useful and interesting, and those who could not find a use for the information at all. The people directly involved in providing fisheries advice and stock prediction seemed to be unable to use the information for a number of reasons. One problem was the inadequacy of empirical relationships between environmental and biological parameters, since as soon as such a relationship is used to make a prediction it subsequently breaks down. Another problem was a concern about the use of additional parameters that may in fact reduce the relevance of advice by increasing errors in predictions. Both of these issues can be ascribed to the third and most pressing problem, and that is the lack of understanding of processes that link the environment to fish stocks via primary production and the trophic levels between. This is an ongoing research question currently being addressed by international science programmes, and is not an issue that the WGOH can resolve alone.

Among the biologists researching those processes however, there was more positive feedback. The information was viewed as interesting and useful, though it was noted that there would always be instances when a biologist would need further information in order to really understand the data they had. There were two aspects to that point. The first was a requirement for information in places away from the locations of the WGOH time-series. It was noted that there are no additional time-series that are excluded from the IROC. Instead the requirement could be addressed by gridded data products from intensively sampled regions (e.g. NORSEPP reports), or else by products generated by models (either data assimilating such as Coriolis, or driven by variable surface forcing). It was also noted that anyone can extract existing data from the ICES data centre for a particular region, though it is unlikely that very recent data would be accessible. The second was for interpretation of the data that would explain why certain physical changes had occurred, and which might be related to observed biological events.

9 IROC

The ICES Report on Ocean Climate is now the WGOH's main output, and ToR (b) reads "consolidate inputs from member countries to, and continue development of, the ICES Report on Ocean Climate (IROC), and align data sources acknowledgements in IROC with ICES policy; archive data used to compile report".

Stephen Dye presented the report on 2007 atmospheric conditions. Winter 2007 showed a strongly positive North Atlantic Oscillation (NAO), with a higher pressure Azores High, and a bigger and deeper Iceland Low; also the Iceland Low was displaced somewhat to the east of its "normal" position. Summer 2007 showed a low pressure anomaly centred on the UK, leading to warm conditions in the north-west Atlantic, the region of France and Spain unusually cool, and high precipitation over western Europe and western Greenland.

Interestingly, in the context of the record Arctic sea ice minimum extent in September 2007 (see e.g. the US National Snow and Ice Data Center website, http://nsidc.org/), circum-Arctic sea level pressure showed a low anomaly over Eurasia and a high anomaly over the region of Greenland and the Beaufort Sea, enhancing the winds over the Transpolar Drift Stream. This indicates the sea ice minimum was at least partly mechanical: i.e. the ice was blown out of the Arctic. This interpretation was supported by the presence of unusually high ice concentrations in and south of Fram Strait.

Some issues were raised over the WGOH's ability to comply with ICES data policy, due to external factors. In particular, the Helgoland Roads and Kola Section data are not available for public release.

Following Tom Rossby's retirement, we need to determine from his US replacement (Bob Pickart) whether the Oleander data will continue to be available for the IROC.

Penny Holliday described a new, long-term time-series to be incorporated into the IROC, possibly from next year: the station E1 of the Western Channel Observatory, Plymouth Marine Laboratory (PML), UK. This time-series begin approximately 100 years ago with breaks due to the first and second world wars, and more recently between the late 1980s to the late 1990s, as a consequence of the scientific-political climate in the UK. The time-series was restarted by PML around 2001. We hope that the responsible scientist at PML, Tim Smyth, will join the WGOH from next year to present the data. E1 is in about 50 m water depth, in the English Channel (aka La Manche) 20 nm south of Plymouth, and should help fill a gap in coverage, being representative both of the western Channel and, to some extent, the wider Celtic Sea region. We note that E1 will provide an interface with the UK Marine Environmental Change Network (MECN): http://www.mba.ac.uk/MECN/.

Following the presentation of the National and Regional reports earlier in the meeting, the WGOH agreed the following draft summary statements of the state of the North Atlantic Ocean in 2007.

i) The upper layers of the North Atlantic and Nordic Seas remained exceptionally warm and saline in 2007 compared with the long-term average. The largest anomalies were observed at high latitudes.

ii) The North Sea, Baltic Sea and Bay of Biscay had an unusually warm winter and spring. This was due to a combination of stored heat from the warm autumn in 2006, and high solar radiation in 2007.

iii) The trend in the past decade (1996–2006) has been of warming and increasing salinity in the upper ocean. Temperature and salinity have been relatively stable since 2004.

Subsequent discussion of ways to improve further the IROC produced some modest technical suggestions: use thicker lines on plots; include more seasonal cycle plots of SSTs; encourage WGOH members to submit photographs to the IROC editors so that they can fill white spaces where they occur. The Deep Water section is to be extended from the Nordic Seas to cover the whole IROC region, and Agnieszka Beszczynska-Möller volunteered to do this. The WGOH was also very sensibly reminded not to get carried away with “improving” the IROC: an excess of material could make the document unwieldy and therefore less appealing to target users.

10 ICES Awards

Tom Rossby was nominated for a merit award last year. ICES delayed the issuing of awards. Tom’s nomination will be resubmitted this year.

11 2011 Decadal Symposium

Alicia Lavín has proposed Spain to host the 2011 Decadal Symposium. The WGOH needs to start thinking about what kind of symposium it should be, what its title should be, whether to hold it in conjunction with another organisation. Volunteers were requested from the WGOH to serve on the Steering Committee, to decide on session, honours, reports etc. An organising committee and a publications committee are needed. Volunteers were: Glenn Nolan, Stephen Dye, Bert Rudels, Agnieszka Beszczynska-Möller, Victor Valencia, Kjell Arne Mork, Sarah Hughes; also Bogi Hansen offered to ask Hjalmar Hatun. Alicia will identify the chair of the scientific steering committee.

12 New Co-Chairs

This was the last of three years' co-chairing by Penny Holliday and Sheldon Bacon. The offer by Glenn Nolan (Ireland) and Hedinn Valdimarsson (Iceland) to be the next Co-Chairs was welcomed unanimously by the WGOH.

In this context, Sheldon Bacon told the group that this would be the last time he attended a WGOH meeting, as he would be resigning from the WG (and hence also from ICES) following the conclusion of this year's chairing responsibilities.

13 ASC 2009 and 2010

A session on biophysical interactions was suggested for the 2009 Annual Science Conference in Berlin by Glenn Nolan.

14 WGOH Website

The WGOH website presently resides under the NOC, Southampton, domain at http://www.noc.soton.ac.uk/ooc/WGOH/. It is likely that it will have to move some time in the future, meaning the next year or two. Stephen Dye offered to host it at CEFAS in Lowestoft, UK, and suggested the purchase of a suitable domain name such as wgoh.org. This possibility will be pursued during the coming year.

15 Next Meeting

Hendrik van Aken invited the WGOH to Royal NIOZ, Texel, the Netherlands for the 2009 meeting. The suggested dates (10–12 March 2009) were confirmed by correspondence after the meeting as suitable (i.e. not clashing with local holidays).

Annex 1: List of participants

Name	Address	Email
Sheldon Bacon (*Co-Chair*)	NOC, Southampton, UK	shb@noc.soton.ac.uk
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Stephen Dye	CEFAS, Lowestoft, UK	stephen.dye@cefas.co.uk
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Annex 2: Agenda

1) Welcome; local arrangements; membership and introductions
2) Update and review results from standard sections and stations (ToR a)
3) IROC (ToR b)
4) OSPAR Request (ToR c)
5) ICES Data Centre: Review of recent activities and future plans (ToR f)
6) Relations with international climate monitoring programmes (ToR d)
7) ICES Matters: Improving interaction between WGOH and other EGs (ToR e)
8) ICES Awards
9) 2011 Decadal Symposium on Hydrobiological Variability in the 2000s
10) ASC theme sessions
11) New chair
12) Website
13) AOB
14) Next Meeting

Annex 3: WGOH terms of reference for the next meeting

The **Working Group on Oceanic Hydrography** [WGOH] (Co-chairs: Glenn Nolan*, Ireland, and Hedinn Valdimarsson*, Iceland) will meet in Texel, The Netherlands from 10–12 March 2009 to:

a) update and review results from Standard Sections and Stations;

b) consolidate inputs from Member Countries to, and continue development of, the ICES Report on Ocean Climate (IROC), and align data source acknowledgements in IROC with ICES policy; archive data used to compile report;

c) provide support to other Expert Groups requiring information on oceanic hydrography in support of their responses to the OSPAR request on 'An assessment of the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature';

d) review and improve relations with international climate monitoring programmes;

e) take action for strengthening the role of WGOH and physical oceanography within ICES;

f) provide expert knowledge and guidance to ICES Data Centre (possibly via sub-group) on a continuous basis;

g) take part in the intersessional work led by WKOOP in developing the mission and draft resolutions for a new Expert Group related to operational oceanographic products and services.

WGOH will report by 30 April 2009 to the attention of the Oceanography Committee and ACOM.

Supporting Information

Priority:	The activities of this Group are fundamental to the fulfilment of the Oceanography Committee's Action Plan.
Scientific Justification and relation to Action Plan	Action Plan Nos. 1.2, 1.3, 1.6, 1.7, 1.10, 5.13.4, 5.14 and 6.3. This is a repeating task established by the Working Group to closely monitor the ocean conditions in the ICES area. The materials presented under this item will be utilised to prepare an overview of the state-of-the-environment in the North Atlantic for 2006. The Working Group recognises the need for disseminating climate information in a timely and appropriate manner. This agenda item will allow WGOH members to prepare the document during the meeting, thus avoiding delays in the dissemination of the information. We will review proposed new developments in IROC content. This is in support of a request from OSPAR. Links have been made with the CLIVAR programme; it would be of benefit both to ICES and the international programmes to enhance internal information exchange. To follow up on the ICES General Secretary's suggestions for increasing the visibility of WGOH within ICES. To improve communications between working groups under the ICES system. This is in compliance with a request from the ICES Data Centre The work of the proposed Expert Group will be relevant for WGOH.
Resource Requirements:	No extraordinary additional resources
Participants:	WGOH members; Chair of Oceanography Committee.
Secretariat Facilities:	N/a
Financial:	Publication and reproduction costs for the IROC.
Linkages to Advisory Committees:	Advisory Committees on Fishery Management, Marine Environment, and Ecosystem
Linkages to Other Committees or Groups	Publications Committee; Consultative Committee; ICES/IOC Steering Group on GOOS
Linkages to Other Organisations:	IOC, JCOMM, CLIVAR

Annex 4: Recommendations

RECOMMENDATION	FOR FOLLOW UP BY:
1. The WGOH **recommends** that both the ICES Data Centre and WGOH members should approach national data centres with a view to encouraging those national data centres to submit all relevant hydrographic (and other) data to the ICES Data Centre in as complete and timely a manner as possible.	ICES Data Centre WGOH Members
2. The WGOH **recommends** that the ICES Data Centre and the IROC editors begin a dialogue to determine how the Data Centre can contribute to the production of the IROC.	ICES Data Centre IROC Editors
3. The WGOH **recommends** that when ToRs are being defined by ACOM / CONC for EGs, there should be a dialogue between ACOM / CONC and the relevant EGs to ensure firstly that the ToR is written comprehensibly, and secondly, that it should in principle be answerable (a "sanity check").	ACOM / CONC EG Chairs
4. The WGOH **recommends** that the existing ICES Science Plan research theme 1 is relabelled "Climate Change impact processes", and that a separate theme is inserted: "Climate change processes: changes of physical conditions and processes in the ocean and the mechanisms linking them to climate".	ACOM / CONC

Annex 5: WGOH Response to the OSPAR request

Hydrographic Attributes of the OSPAR Sub-Regions

By

ICES Working Group on Oceanic Hydrography

January 2008

1. Introduction

In this document and accompanying data files we provide some key hydrographic indices that may be used to investigate interannual to decadal changes in the marine ecosystems of the OSPAR region. It is not a comprehensive review of observed changes, but it provides a consistent framework within which biological parameters may be examined.

Oceanic variability across the OSPAR region covers many spatial and temporal scales. Here we focus on the broad-scale, long-term changes that have occurred over the past 50 to 60 years during which we have high quality measurements. The time-series presented here are annual values that best describe the decadal and year-to-year changes. Decadal patterns tend to be driven by basin-scale changes in ocean circulation as a response to prolonged patterns of atmospheric forcing. Year-to-year patterns tend to be a response to shorter time-scale atmospheric forcing such as winter wind fields, net precipitation and evaporation, and sea-ice cover. Superimposed on those patterns are higher frequency variations due to local processes such as changing positions of fronts, passing of eddies, river run-off and the changing inflow of different water masses.

The OSPAR region is being affected by anthropogenic climate change, most notably increasing temperatures in the upper ocean. Distinguishing the “global warming” element from the observed decadal-scale pattern of natural variability is not straightforward, but all climate models under the IPCC CO_2 scenarios predict increasing marine temperatures over the next 50 years. It should be noted that the Arctic and shelf seas (regions I–IV) are predicted to show warming at a significantly greater rate than the wider North Atlantic (region V).

2. Atmospheric Indices

There are two useful atmospheric indices for the OSPAR region, the North Atlantic Oscillation index and the Arctic Oscillation index (also called the Northern Annual Mode). There are several slightly different versions of the NAO index calculated by climate scientists. The winter (DJFM) Hurrell or station-based NAO index is calculated as the difference of normalized sea level pressure (SLP) between Lisbon, Portugal and Stykkisholmur/Reykjavik, Iceland. This index is most commonly used by climate scientists, has particular relevance to the eastern North Atlantic.

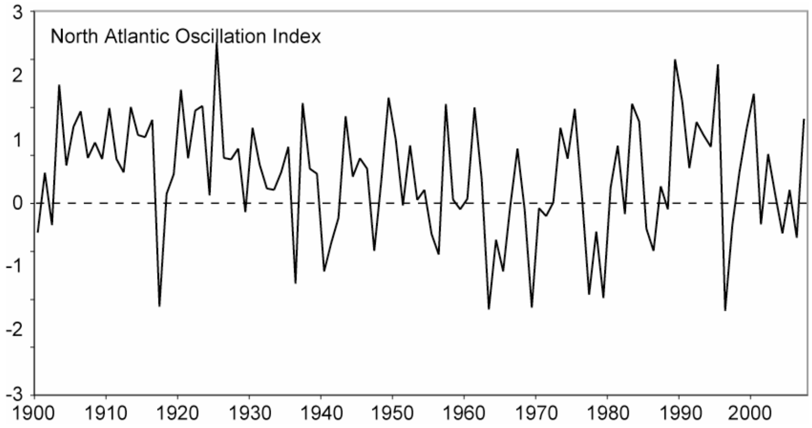


Figure 1. The winter (December-January-February) North Atlantic Oscillation index (data file D1).

The Arctic Oscillation (AO) is a pattern in which atmospheric pressure at polar and middle latitudes fluctuates between negative and positive phases. The index is derived from statistical analysis of the winter sea level pressure over 20–90°N. The negative phase brings higher-than-normal pressure over the polar region and lower-than-normal pressure at about 45 degrees north latitude. Some researchers argue that the NAO is in fact part of the AO.

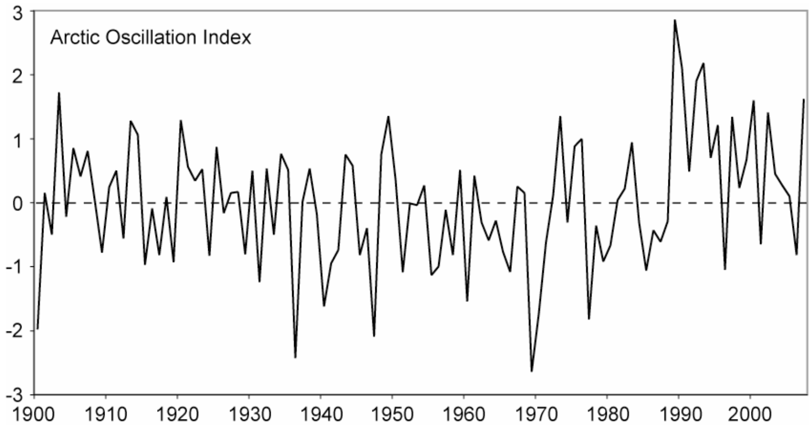


Figure 2. The winter (December-January-February-March) Arctic Oscillation index (data file D2).

Data credits and further reading

NAO index: Climate Research Unit, University of East Anglia, UK, www.cru.uea.ac.uk/~tmo/projpages/nao_update.htm

AO index: Jim Hurrell, National Center for Atmospheric Research, USA, http://www.cgd.ucar.edu/cas/jhurrell/indices.html

3. Sea Ice Indices

The Barents Sea ice extent index represents the ice cover between 25–45°E. It is a sum of a winter index and a summer index. The winter index is defined by the ice covered area south of 76°N while the summer index is defined by the ice free area south of 79°N. Note that a low index value corresponds to high ice cover. The ice coverage is taken from ice maps from the Norwegian Meteorological Institute.

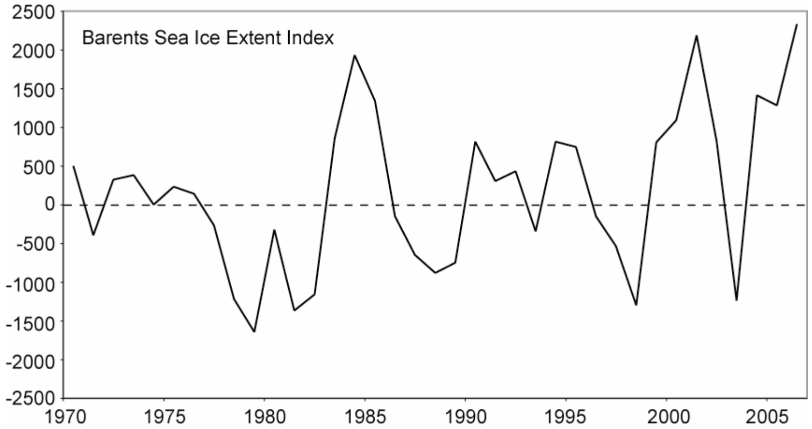


Figure 3. The Barents Sea ice extent index (data file D3).

The Arctic sea ice extent is defined as the total area covered by some amount of ice, including open water between ice floes. The ice extent index, produced from satellite data, is reported monthly. The August values for each year since 1979 provide an indication of changes in the minimum ice conditions.

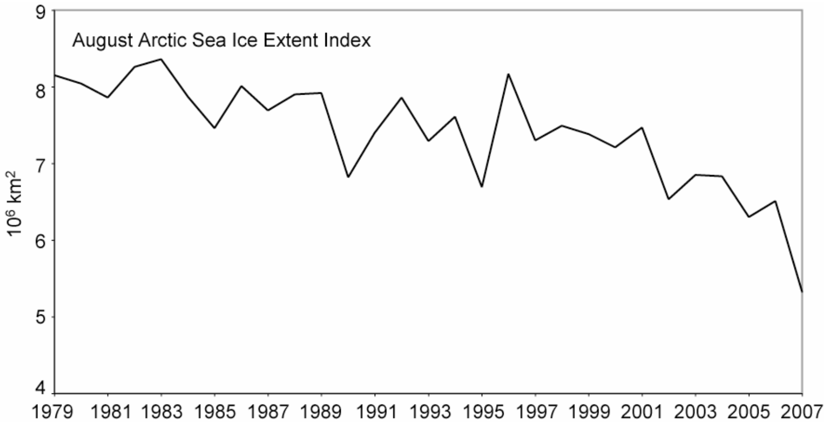


Figure 4. The August Arctic sea ice extent (data file D4).

Data credits and further reading

Barents Sea ice extent index: Harald Loeng, Institute of Marine Research, Norway, harald.loeng@imr.no

Arctic Sea Ice Extent Index: National Snow and Ice Data Center, USA, http://nsidc.org/data/seaice_index/archives/index.html

4. Hydrographic Attributes by OSPAR Sub-Region

We provide representative hydrographic time-series for the 5 OSPAR sub-regions. Each series is from a single location within the region (i.e. they are not regional means) but they have been selected for their suitability to show the integrated effects of large-scale patterns. The annual sub-surface temperature and salinity values that represent the upper ocean conditions are given. A time-series of annual sea surface temperature (SST) data are also provided for each location. The SST data have been obtained from a product derived from in situ and satellite data, the Smith and Reynolds Extended Reconstructed SST (version 3). Data are extracted from the nearest 2x2° grid box from the global data product. Note that data from the Barents

Sea and Fram Strait are affected by seasonal ice cover and so have some months with absent data.

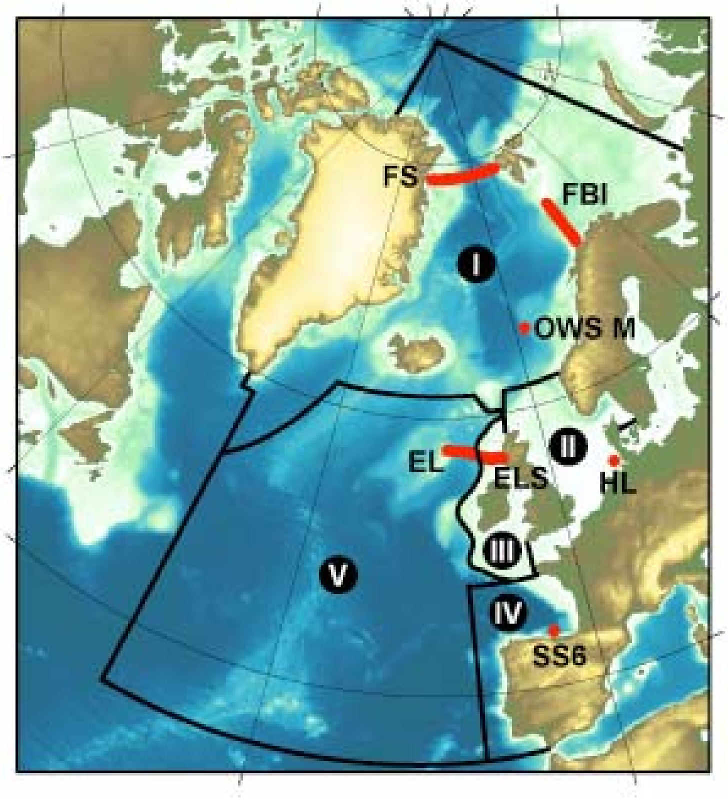


Figure 5. Location of selected hydrographic time-series within the OSPAR sub-regions (stations in red, boundaries of sub-regions in black). In Region I (Arctic Waters) are time-series at Fram Strait (FS), Fugløya-Bear Island (FBI) and Ocean Weather Station Mike (OWS M). Region II (Greater North Sea) is represented by Helgoland Roads (HR). Region III (Celtic Seas) is represented by Ellett Line Shelf stations (ELS). Region IV (Bay of Biscay and Iberian Coast) is represented by station 6 of the Santander Section (SS6). Region V (Wider Atlantic) is represented by the deep Ellett Line stations (EL).

I Arctic Waters

The Arctic Waters sub-region covers all seas north of the Greenland-Iceland-Scotland sill, plus the East Greenland Current as it flows around southern Greenland. It includes therefore several hydrographic "regimes". We have selected 3 time-series that can be used to characterise this large area.

a) Norwegian Sea

The Norwegian Sea can be represented by data from Ocean Weather Station Mike (66°N 2°E, OWS M in Figure 5). The time-series samples the northward moving Atlantic Inflow, with some influence from surface polar waters. The data given here are annual temperature and salinity at a single location, at 50 m below the surface, 1948–2006.

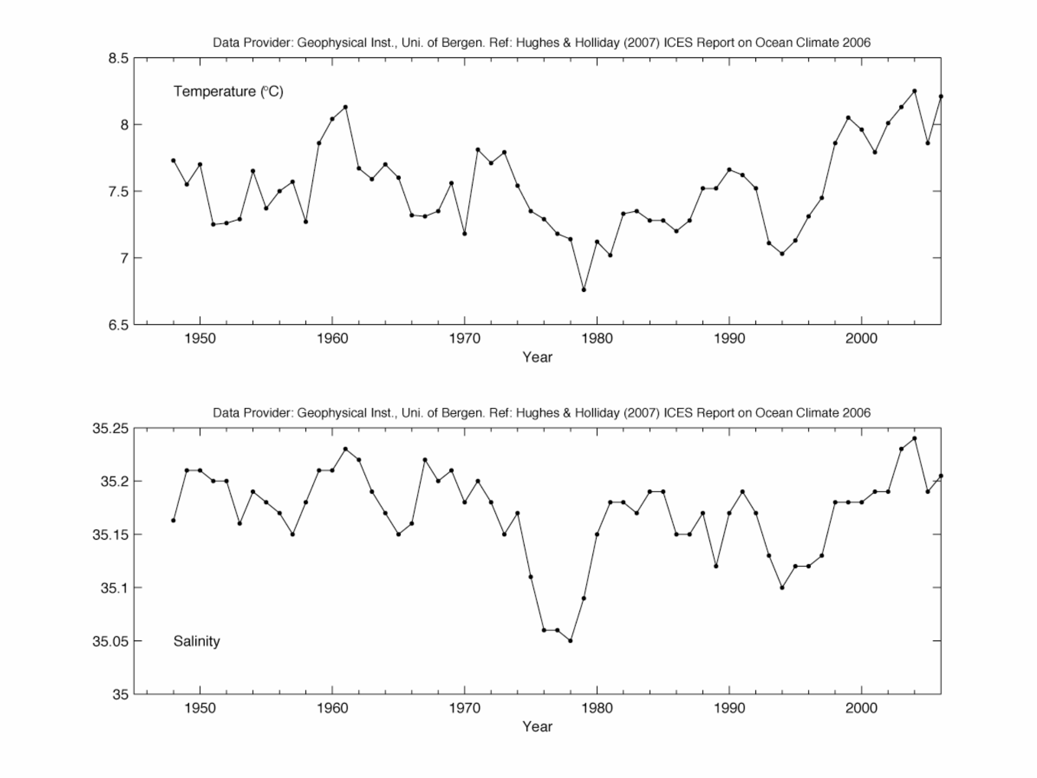


Figure 6. Temperature and Salinity at 50 m depth at Ocean Weather Station "Mike", 66°N 2°E (data file D6).

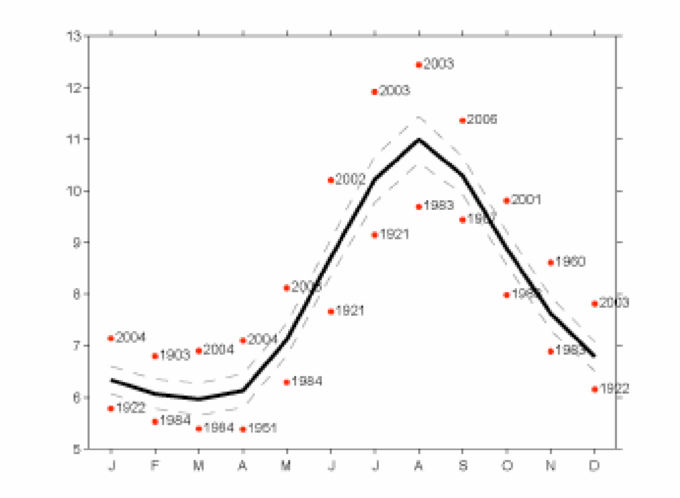


Figure 7. Sea Surface Temperature at 66°N 2°E from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

b) Barents Sea

The Fugløya-Bear Island Section represents the Atlantic inflow to the Barents Sea (FBI in Figure 5). The time-series is of annual temperature and salinity averaged across the section, over the depth range 50–200 m, 1977–2006.

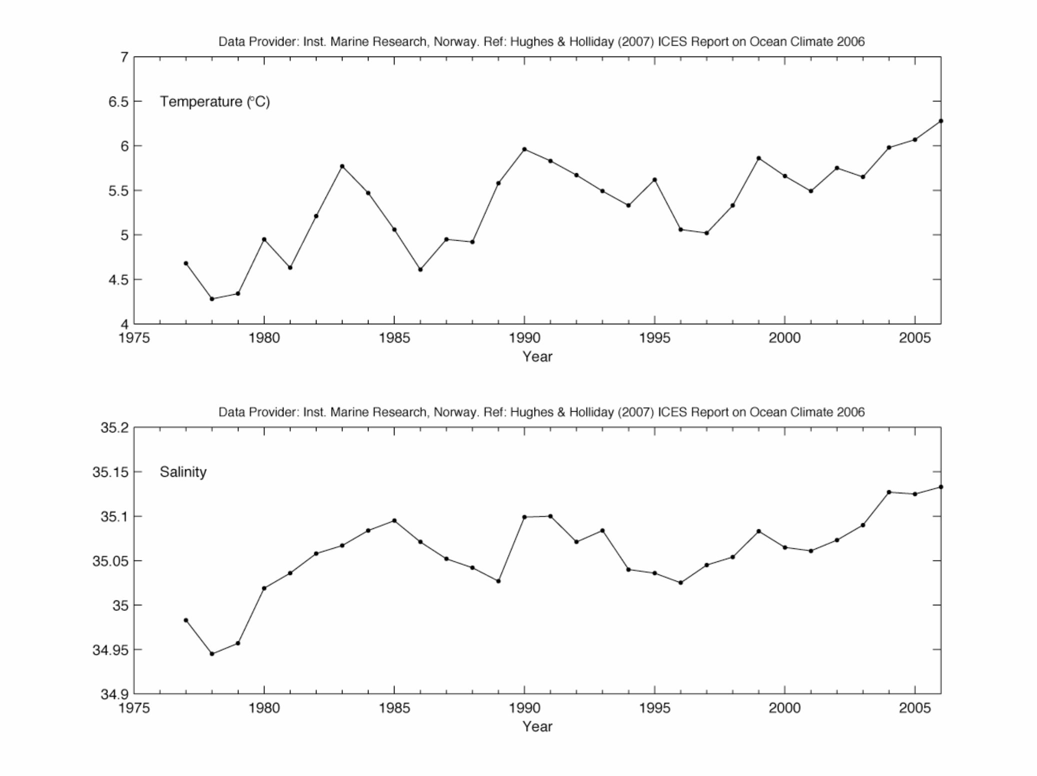


Figure 8. Temperature and Salinity averaged over depth range 50–200 m at Fugløya-Bear Island Section, Barents Sea (data file D7).

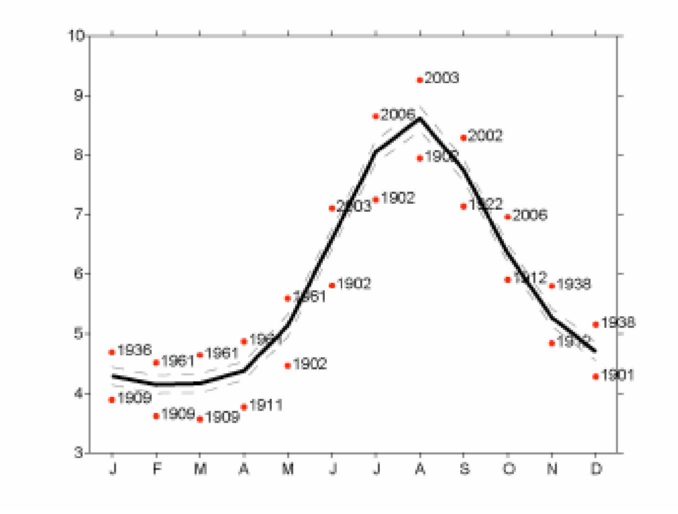


Figure 9. Sea Surface Temperature at 72°N 20°E from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

c) Greenland Sea

The southward flowing polar water of the East Greenland Current is measured in the Fram Strait Section at the northern end of the Greenland Sea (FS in Figure 5). The time-series is of annual temperature and salinity in the East Greenland Current (western part of the section) in the depth range 50–500 m, 1980–2006.

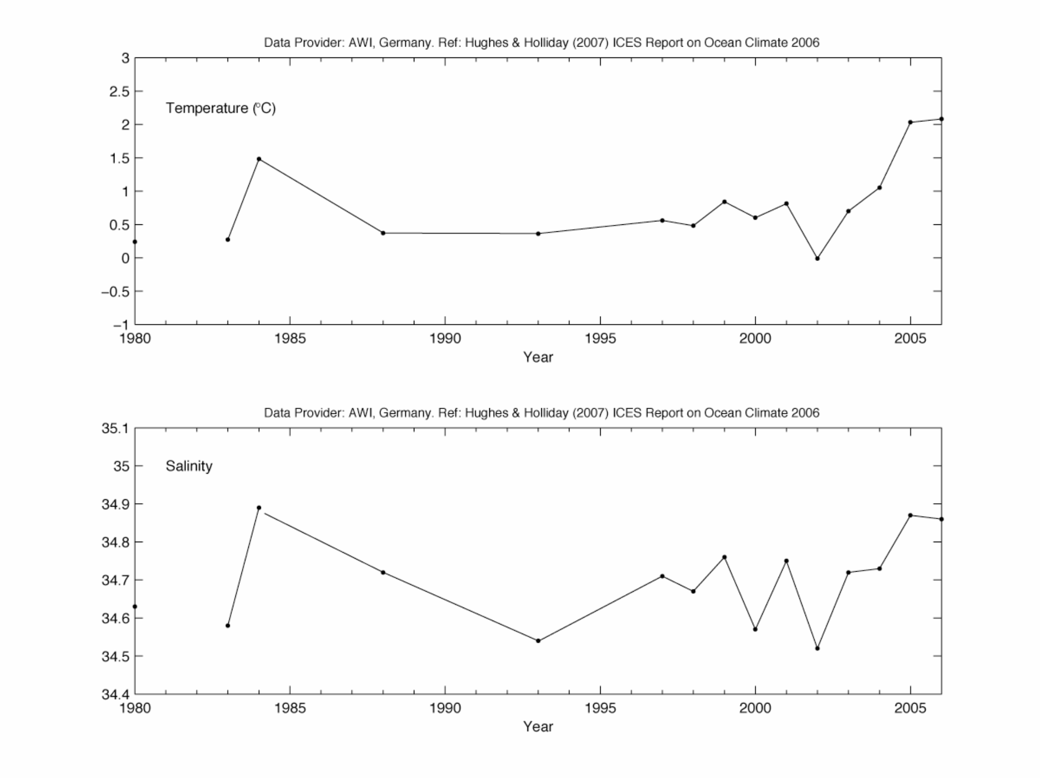


Figure 10. Temperature and Salinity averaged over depth range 50–500 m in East Greenland Current at the Fram Strait Section (data file D8).

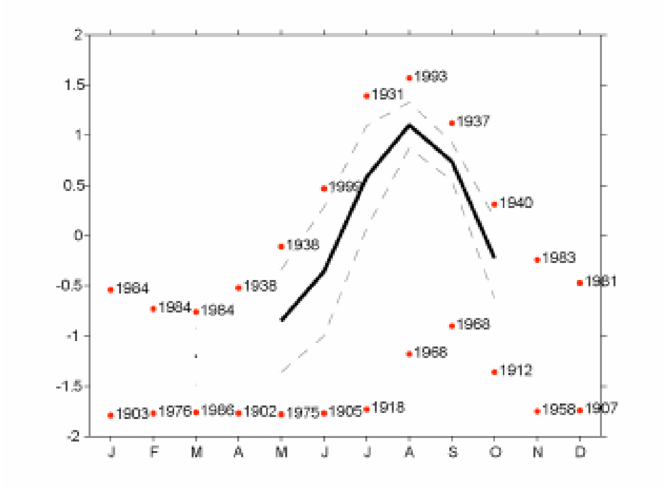


Figure 11. Sea Surface Temperature at 78°N, 4°W from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

II Greater North Sea

The North Sea is heavily influenced by conditions in the wider North Atlantic and by atmospheric forcing. The Helgolands Road time-series (54.19°N 7.9°E) is in the southern North Sea where additional factors such as river run-off become important, but which shows the interannual and longer patterns of variability in the southern North Sea. The time-series is annual temperature and salinity from surface waters, 1950–2006.

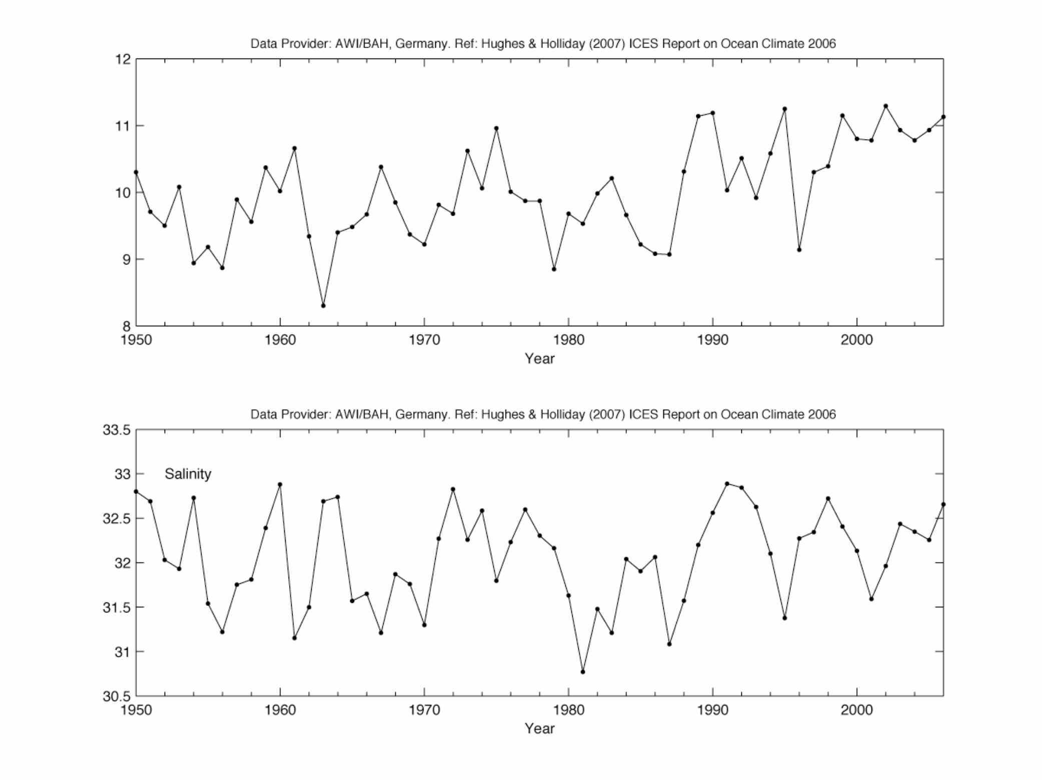


Figure 12. Temperature and Salinity in surface waters at Helgoland Roads, 54.19°N 7.9°E (data file D9).

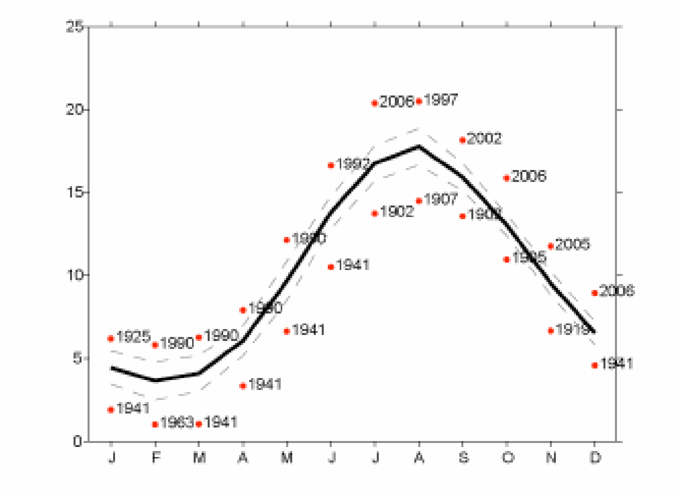


Figure 13. Sea Surface Temperature at 54°N 8°E from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

III Celtic Seas

The Celtic Sea sub-region is represented here by continental shelf stations taken as part of the Ellett Line hydrographic section (stations from 8.8°W, the shelf break, to Barra Head; ELS in Figure 5). The annual time-series is constructed from the mean of those stations in the depth range 90–110m and may be aliased by under-sampling of the seasonal cycle.

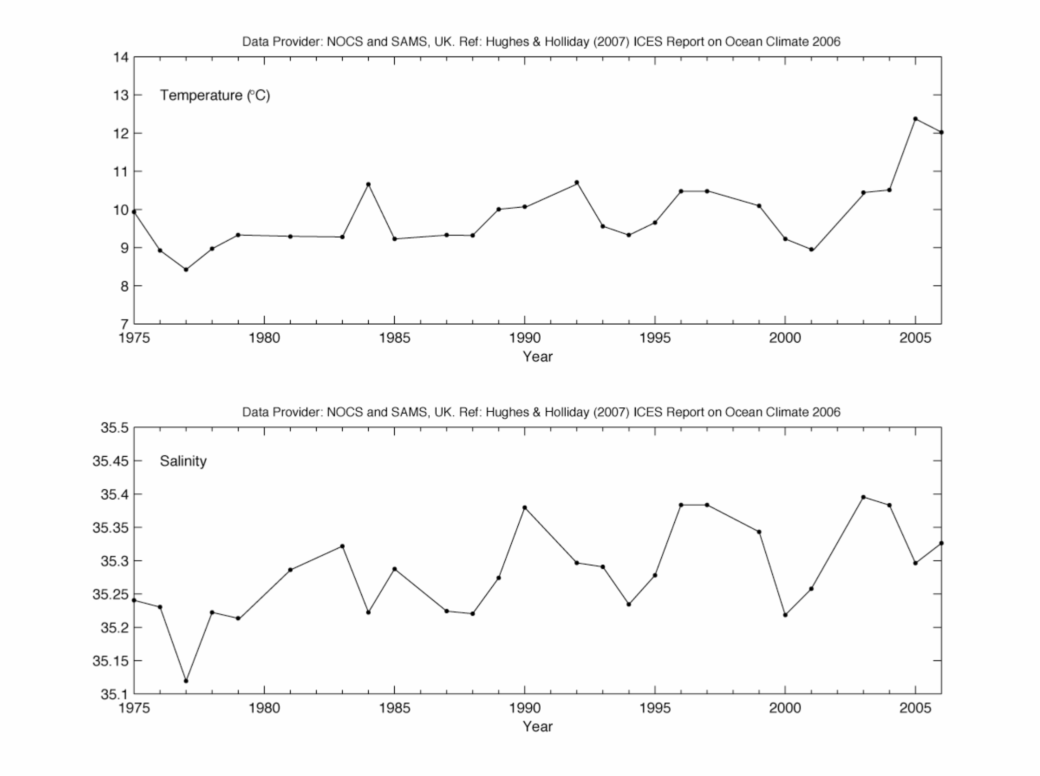


Figure 14. Temperature and Salinity averaged over depth range 90–110 m at shelf stations on the Ellett Line (data file D10).

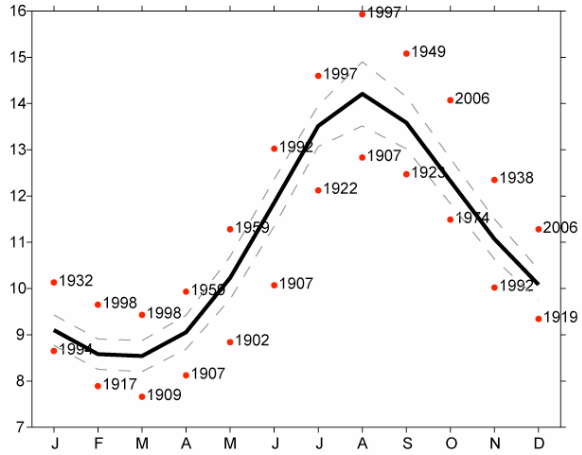


Figure 15. Sea Surface Temperature at 56°N 8°W from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

IV Bay of Biscay and Iberian Coast

The Bay of Biscay can be represented by the Santander hydrographic section, which runs from the coast across the continental shelf and rapidly reaches deep water. Station 6 (43.7°N 3.78°W, SS6 in Figure 5) is situated on the shelf break and represents the open ocean water influenced by a periodic shelf edge current. The time-series is of annual temperature and salinity at Station 6 averaged over the depth range 5–300 m, 1993–2006.

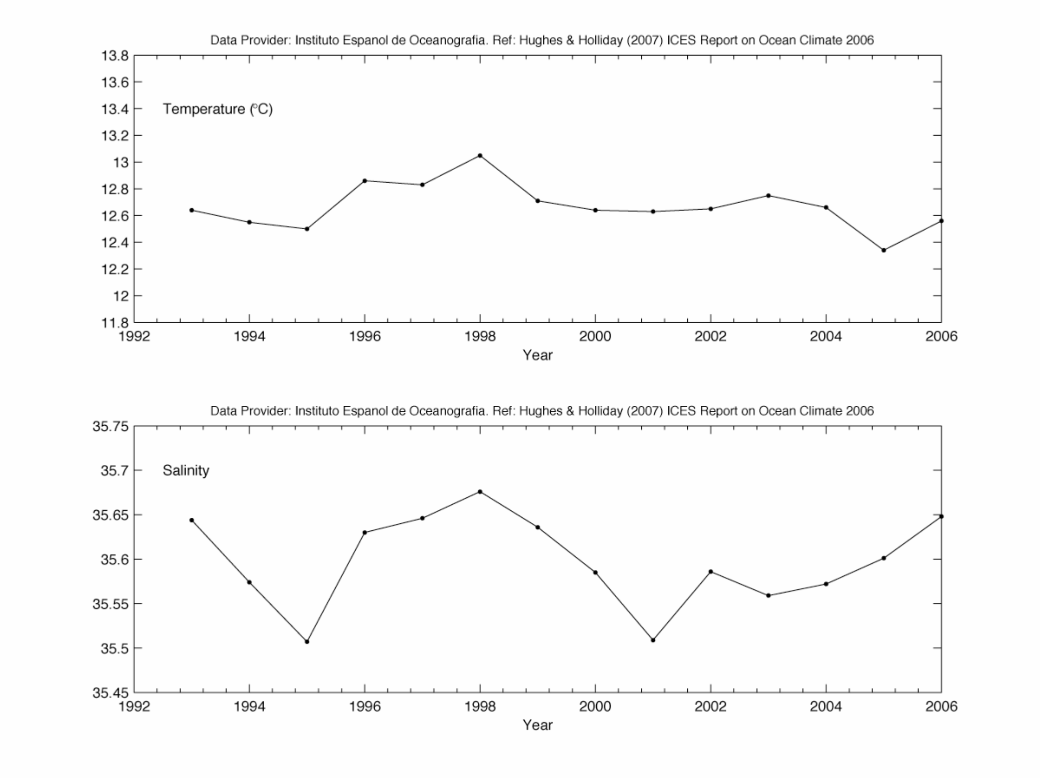


Figure 16. Temperature and Salinity averaged over depth range 5–300 m at Santander Section Station 6, 43.7°N 3.78°W (data file D11).

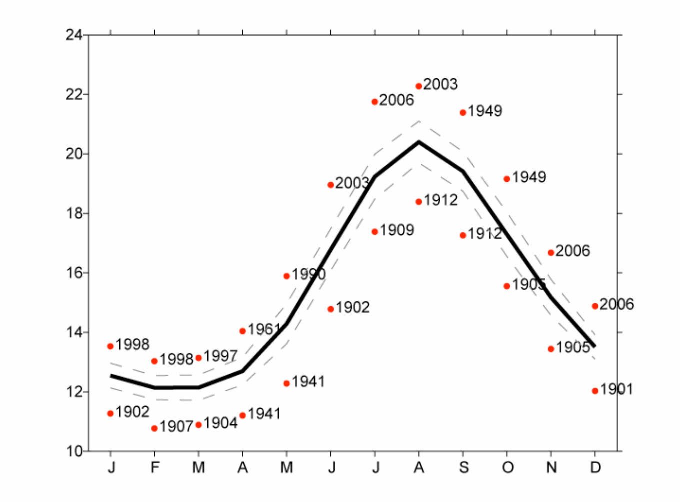


Figure 17. Sea Surface Temperature at 44°N 4°W from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

V Wider Atlantic

The Rockall Trough (at the Ellett Line hydrographic section) represents the waters on the eastern side of the Atlantic subpolar gyre. It is the warmest and most saline water type of the sub-region but patterns of interannual variability there are consistent with those in the Iceland Basin. The time-series is of annual temperature and salinity across the section from shelf break to Rockall averaged over the depth range 0–800 m, 1975–2006.

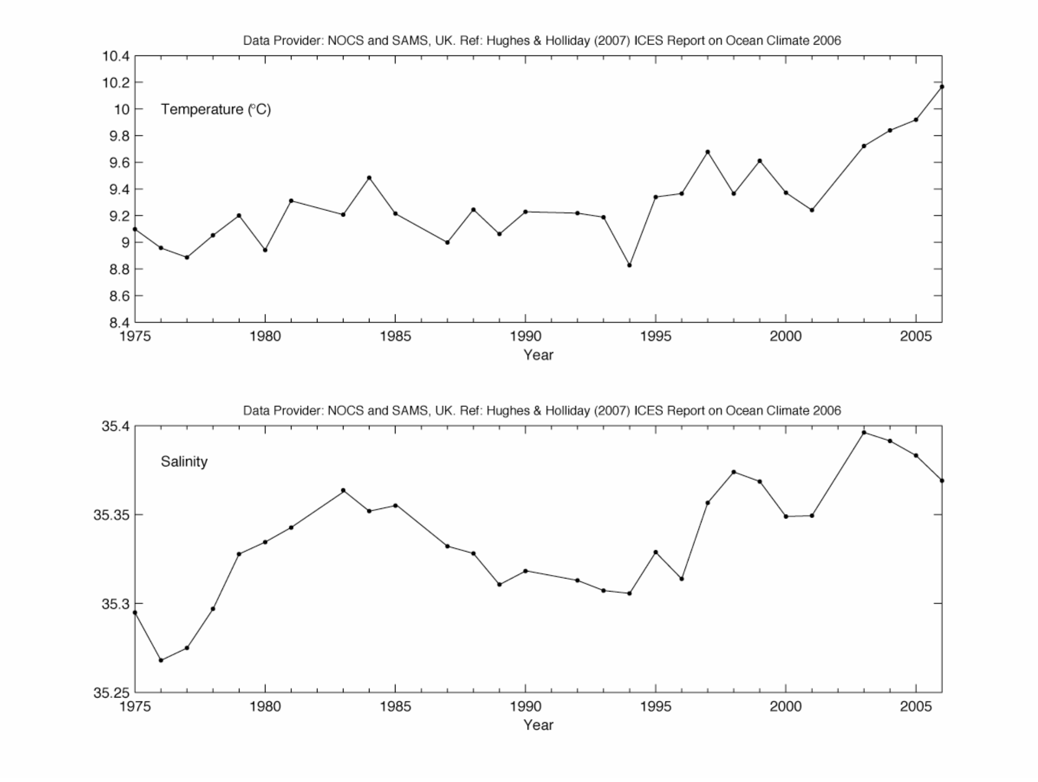


Figure 18. Temperature and Salinity averaged over depth range 0–800 m at the Ellett Line (data file D12).

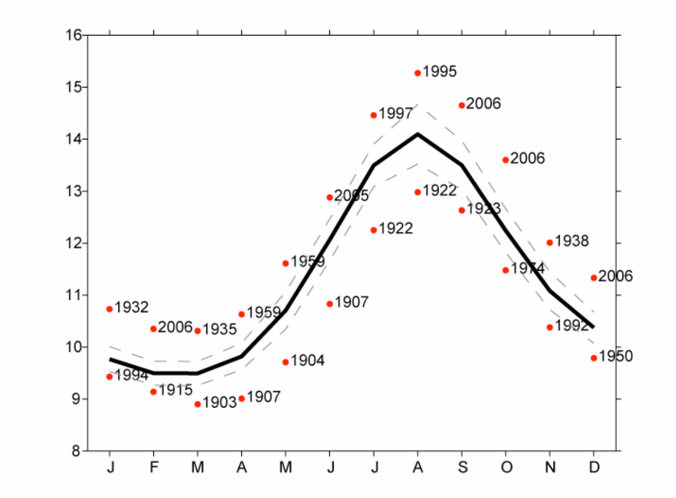


Figure 19. Sea Surface Temperature at 56°N 12°W from Extended Reynolds data product (data file D5). Monthly mean and monthly standard deviations are calculated for period 1971–2000. Dashed lines indicate one standard deviation above/below mean. Red dots indicate maximum and minimum values observed over period 1900–2006.

5. Supplementary Information

We request that users of the information and data within this report provide suitable acknowledgement of the sources.

Data credits and Further Reading

Hughes. S.L. and Holliday, N.P. (Eds), 2007, ICES Report on Ocean Climate 2006, ICES Cooperative Research Report No. 289, 55pp.

More data from the IROC 2006 (additional time-series and higher temporal resolution time-series) can be found at:
http://www.ices.dk/marineworld/oceanclimate.asp

Sea Surface Temperature Data: NOAA Smith and Reynolds Extended Reconstructed SST (ERSST.v3) at the NOAA-CIRES Climate Diagnostics Center, USA:
http://www.cdc.noaa.gov/oa/climate/research/sst/sst.php

Smith, T.M., R.W. Reynolds, Thomas C. Peterson, and Jay Lawrimore 2007: Improvements to NOAA's Historical Merged Land-Ocean Surface Temperature Analysis (1880–2006). In press. Journal of Climate.

Norwegian Sea (OWS M): S. Østerhus (Svein.Osterhus@gfi.uib.no), Geophysical Institute, University of Bergen, Norway.

Barents Sea: H. Loeng (harald.loeng@imr.no), Institute of Marine Research, Norway.

Greenland Sea: A. Beszczynska-Moeller (abeszczynska@awi-bremerhaven.de), AWI, Alfred Wegener Institute for Polar and Marine Research, Germany.

North Sea: K. Wiltshire (kwiltshire@awi-bremerhaven.de), Alfred-Wegener-Institut / Biologische Anstalt Helgoland, Germany

Celtic Seas: N. P. Holliday (nph@noc.soton.ac.uk), National Oceanography Centre Southampton and Scottish Association for Marine Science, UK.

Bay of Biscay and Iberian Coast: A. Lavín (alicia.lavin@st.ieo.es), Instituto Español de Oceanografía, Spain.

Rockall Trough: N. P. Holliday (nph@noc.soton.ac.uk), National Oceanography Centre Southampton and Scottish Association for Marine Science, UK.

Data Files

Data files are provided for most of the time-series shown in this report. All data files are plain text ascii comma delimited files. They are as follows:

D1. Winter (DJF) NAO index (D1_winter_NAO_index.csv)

D2. Winter (DJF) AO index (D2_winter_AO_index.csv)

D3. Barents Sea ice extent index (D3_barentssea_ice_index.csv)

D4. Arctic Sea ice extent for August (D4_arctic_ice_aug_extent.csv)

D5. Sea Surface Temperature at selected locations from ERSST.v3 (D5_E_SST3.csv). "NaN" values represent absent data due to ice cover.

D6. Norwegian Sea Temperature and Salinity (D6_Norway_OWSM_50_Timeseries.csv)

D7. Barents Sea Temperature and Salinity (D7_Barents_BearIsland_Annual.csv)

D8. Greenland Sea Temperature and Salinity (D8_FramStrait_EGC_Annual.csv)

D9. North Sea. This data file has distribution restrictions. Permission to obtain the data should be sought from Karen Wiltshire (kwiltshire@awi-bremerhaven.de); when permission is obtained you can request the data file from Sarah Hughes (s.hughes@marlab.ac.uk).

D10. Celtic Seas Temperature and Salinity (D10_Celtic_Ellett_annual.csv)

D11. Biscay Temperature and Salinity (D11_Biscay_Santander6_Annual.csv)

D12. Rockall Trough Temperature and Salinity (D12_Rockall_Ellett_Upper_Annual.csv)

We provide one extra data file for those interested in changes in seasonal patterns:

D13 (D13_E_SST3_anom.csv) contains normalised anomalies of SST from long-term means (1971–2000), i.e. each value gives the number of standard deviations that month's value is over the 1971–2000 average value for that month. It is derived from the ERSST.v3 data set. "NaN" values represent absent data due to ice cover.

Figure Files

We also provide electronic versions of the figures in this report. Each one is given as high resolution "eps" format, and the lower resolution "png" suitable for importing into Microsoft Office applications. The files are numbered to match the figure numbers in the report, e.g. Figure 1 is called F1_winter_AO_index.png, Figure 2 is F2_winter_NAO_index.png, etc.

Annex 6: Regional Reports – Area 9b – Skagerrak, Kattegat and the Baltic

Karin Borenäs and Jan Piechura

As Sweden is located almost in the centre between Skagerrak/Kattegat and the Baltic, the weather here can be taken as representative for area. The mean air temperature during 2007 was 1.5–2°C above normal in most parts of Sweden, but not quite as high as in 2006. January, March and April were warmer than normal and in June a heat wave set in. As for the previous year December 2007 was unusually warm and in the northern parts the temperature was even higher than in 2006. For the south of Sweden windy conditions characterized the beginning of the year and on January 14 the most severe storm of the year hit the coast. These weather conditions are reflected in the diagram in Figure 1 which shows the observed significant wave height at Väderöarna on the Swedish west coast.

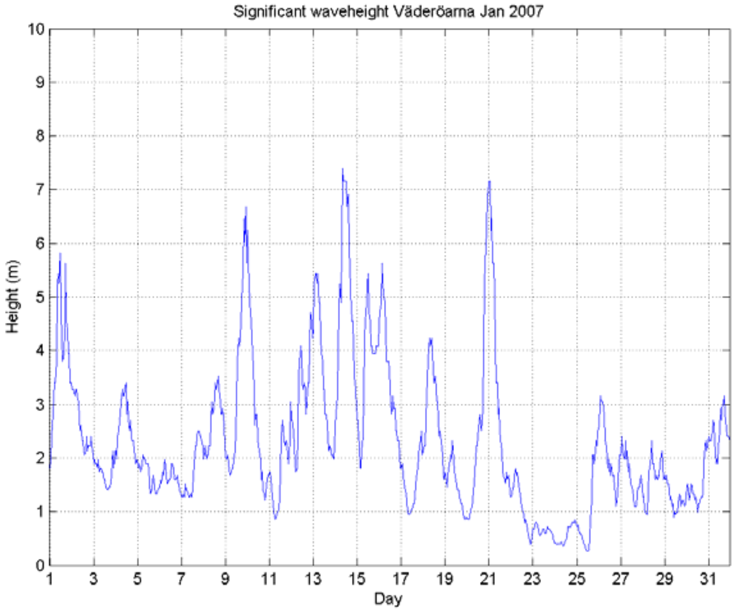


Figure 1. Significant wave height observed at Väderöarna on the Swedish west coast during January 2007. Courtesy of the SMHI.

The precipitation was above normal in the south and north of Sweden. The freshwater supply to Skagerrak/Kattegat was large during January-March and in July.

Annual cycles of surface temperature and salinity

A large number of hydrographic stations are regularly visited in the Baltic Sea, the Kattegat and the Skagerrak, as exemplified in Figure 2. The sea surface temperature was well above normal at the beginning of the year (see i.e. the plot for station Anholt E in Figure 3) in the whole area except in the Bothnian Bay. This was a continuation of the warm conditions found at the end of 2006. The warm weather in the first half of June also gave rise to higher than normal sea surface temperatures. This heating period ended in late June, earlier in the north than in the south. For the rest of the year the temperatures were close to normal.

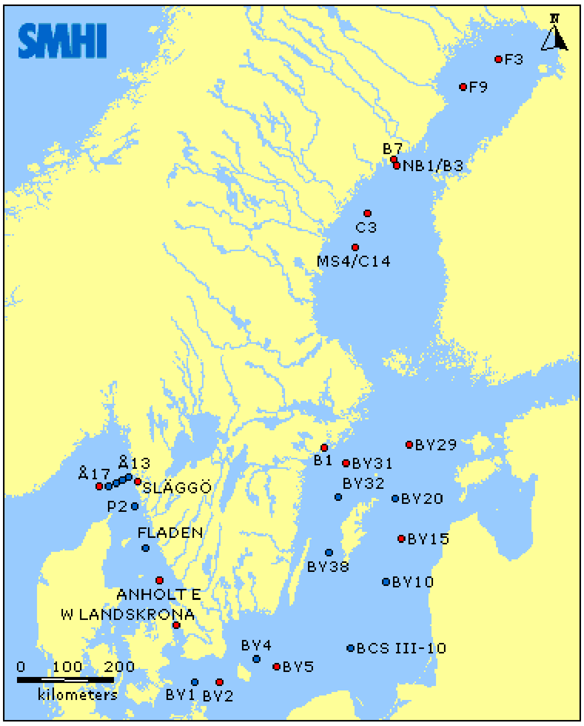
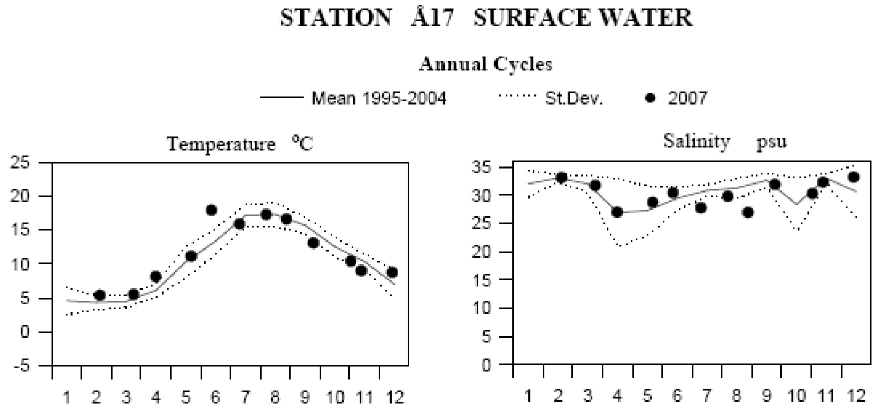
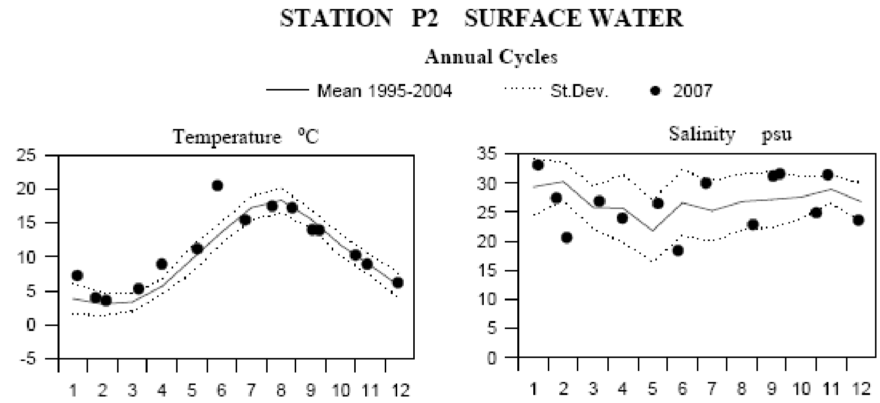


Figure 2. Position of stations visited on a regular basis. Stations marked with red pertain to the Swedish National Monitoring Programme while stations in blue are additional stations sampled by SMHI.


STATION Å17 SURFACE WATER
Annual Cycles
Mean 1995-2004
St.Dev.
● 2007
Temperature °C
25
20
15
10
5
0
-5
1 2 3 4 5 6 7 8 9 10 11 12
Salinity psu
35
30
25
20
15
10
5
0
1 2 3 4 5 6 7 8 9 10 11 12


STATION P2 SURFACE WATER
Annual Cycles
Mean 1995-2004
St.Dev.
● 2007
Temperature °C
25
20
15
10
5
0
-5
1 2 3 4 5 6 7 8 9 10 11 12
Salinity psu
35
30
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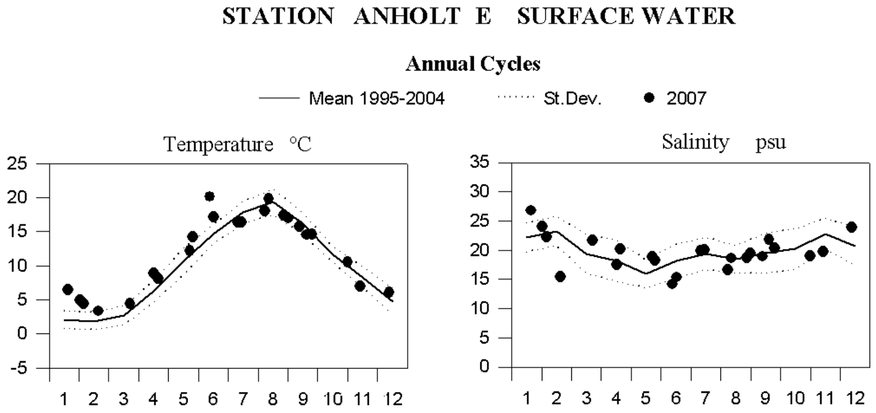
1 2 3 4 5 6 7 8 9 10 11 12


STATION ANHOLT E SURFACE WATER
Annual Cycles
Mean 1995-2004
St.Dev.
● 2007
Temperature °C
25
20
15
10
5
0
-5
1 2 3 4 5 6 7 8 9 10 11 12
Salinity psu
35
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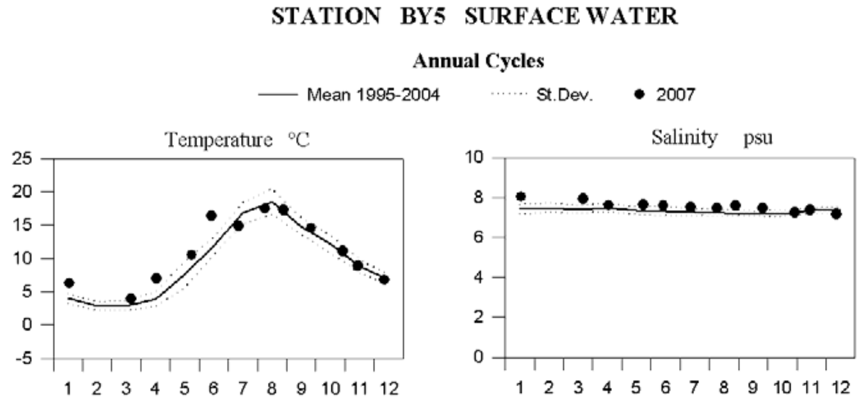
1 2 3 4 5 6 7 8 9 10 11 12


STATION BY5 SURFACE WATER
Annual Cycles
Mean 1995-2004
St.Dev.
● 2007
Temperature °C
25
20
15
10
5
0
-5
1 2 3 4 5 6 7 8 9 10 11 12
Salinity psu
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12

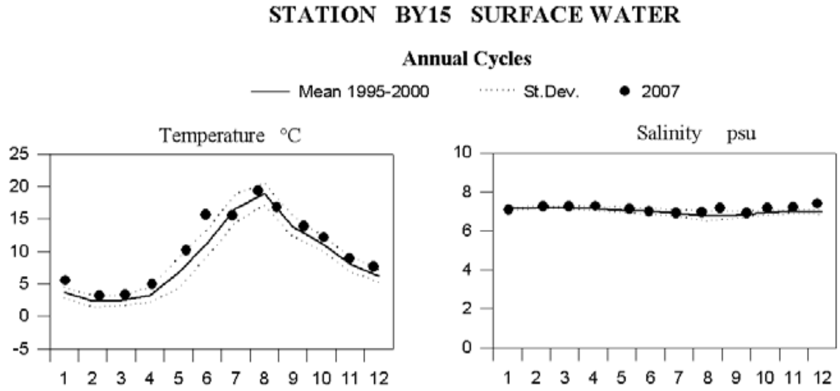


Figure 3. Annual cycles of temperature and salinity, see Figure 2 for station positions.

Long term observations

At station BY15, east of Gotland, the mean surface temperature for 2007 was the same as for 2006 and the warming of the surface water, which has taken place since 2003, was put to a halt. However, the anomaly relative to the 10-year period 1990–1999 was still close to 2°C. The surface salinity increased and the five-year running mean shows now a weak positive trend (Figure 4).

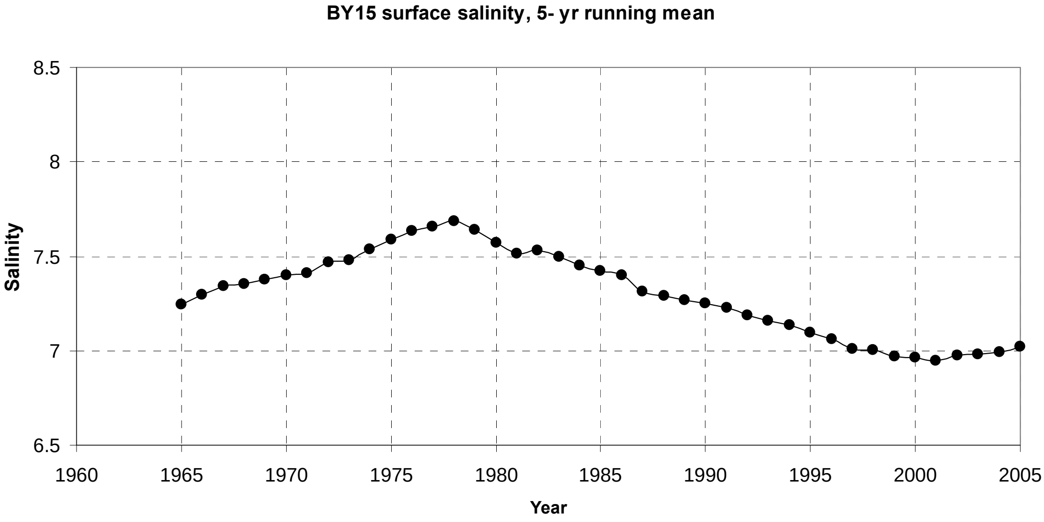


Figure 4. Surface salinity at BY15 (see Figure 2) in the Baltic proper (5-year running mean).

Water exchange

There were minor inflows through the Danish Straits of salty and oxygen rich water to the Baltic in January, March, November and December (Figure 5). Although the effect of these inflows was observed in the Arkona Basin, none of them reached the deeper parts of the Baltic Proper where the water was stagnant.

An increase of the near bottom salinity in the Arkona Basin to over 19 psu was observed in November (Figure 6) but it was a short lasting event and had no consequences for areas farther to the east. October and November data show evidence of baroclinic inflows. Very warm water (with temperature 11–15°C) appeared first in the bottom layer of Arkona Basin (Figure 7) and then moved to the

Bornholm Deep and Slupsk Channel were it was found in the intermediate/halocline layer (Figure 8).

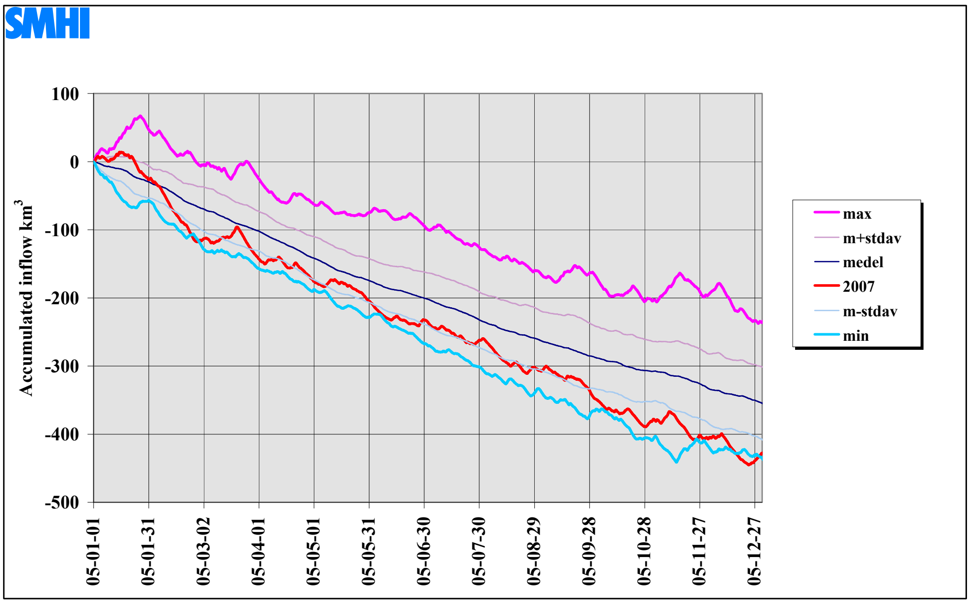


Figure 5. Accumulated inflow km³ flow through the Öresund to the Baltic in 2007 compared to 1977–2006 (SMHI).

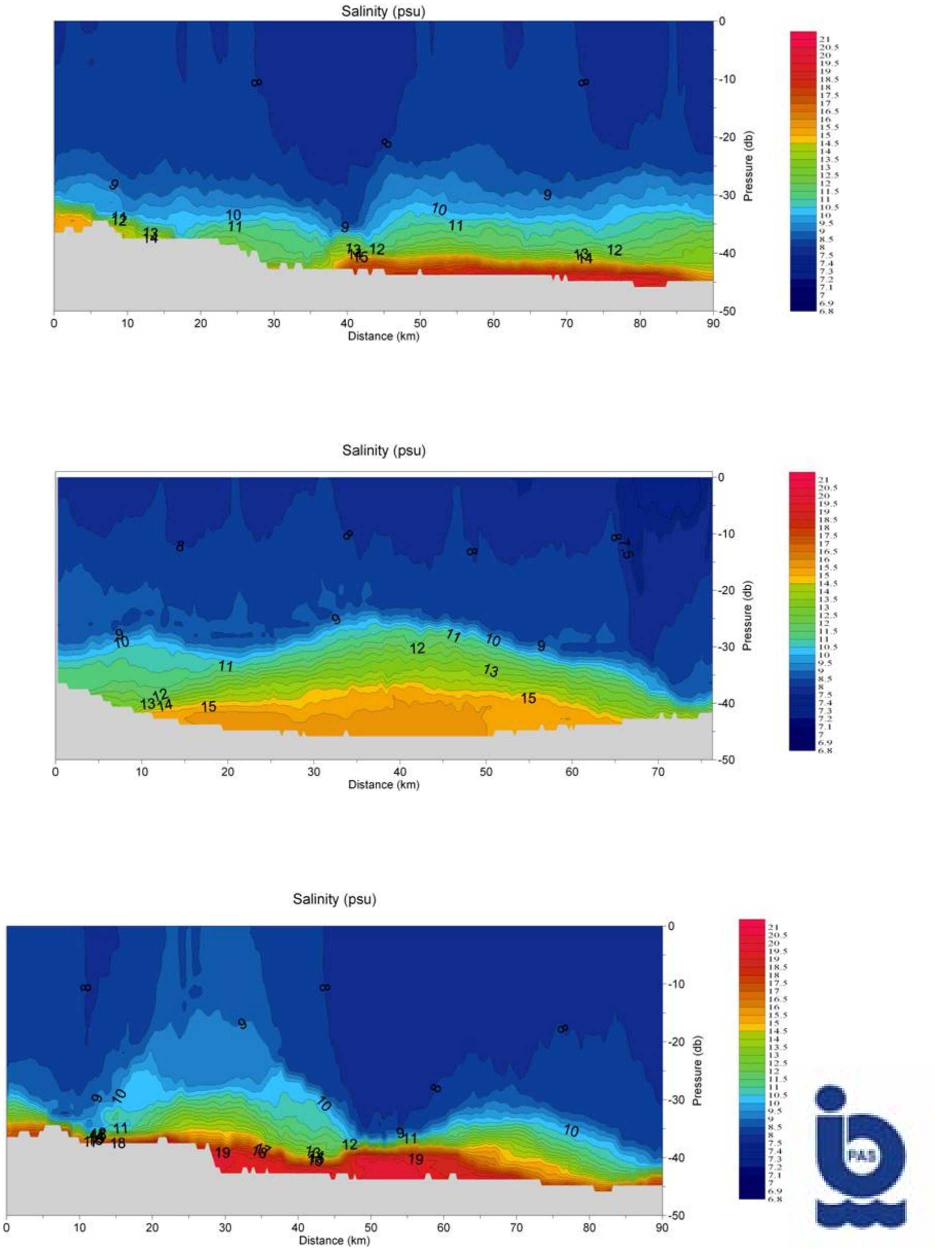


Figure 6. Salinity section in the Arkona Basin. Upper panel) April 2007; middle panel) October 2007; bottom panel) November 2007.

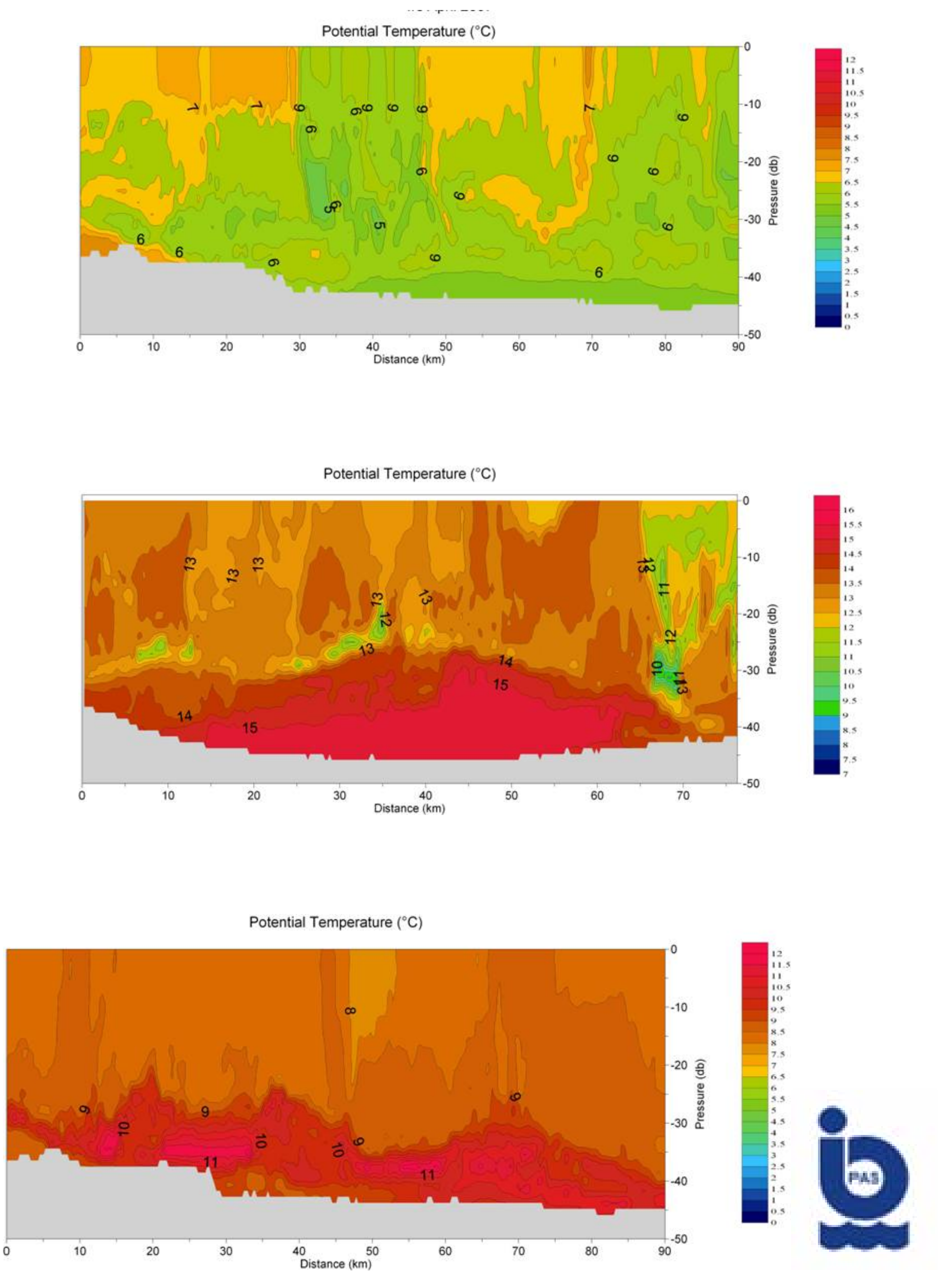


Figure 7. Temperature section in the Arkona Basin. Upper panel) April 2007; middle panel) October 2007; bottom panel) November 2007.

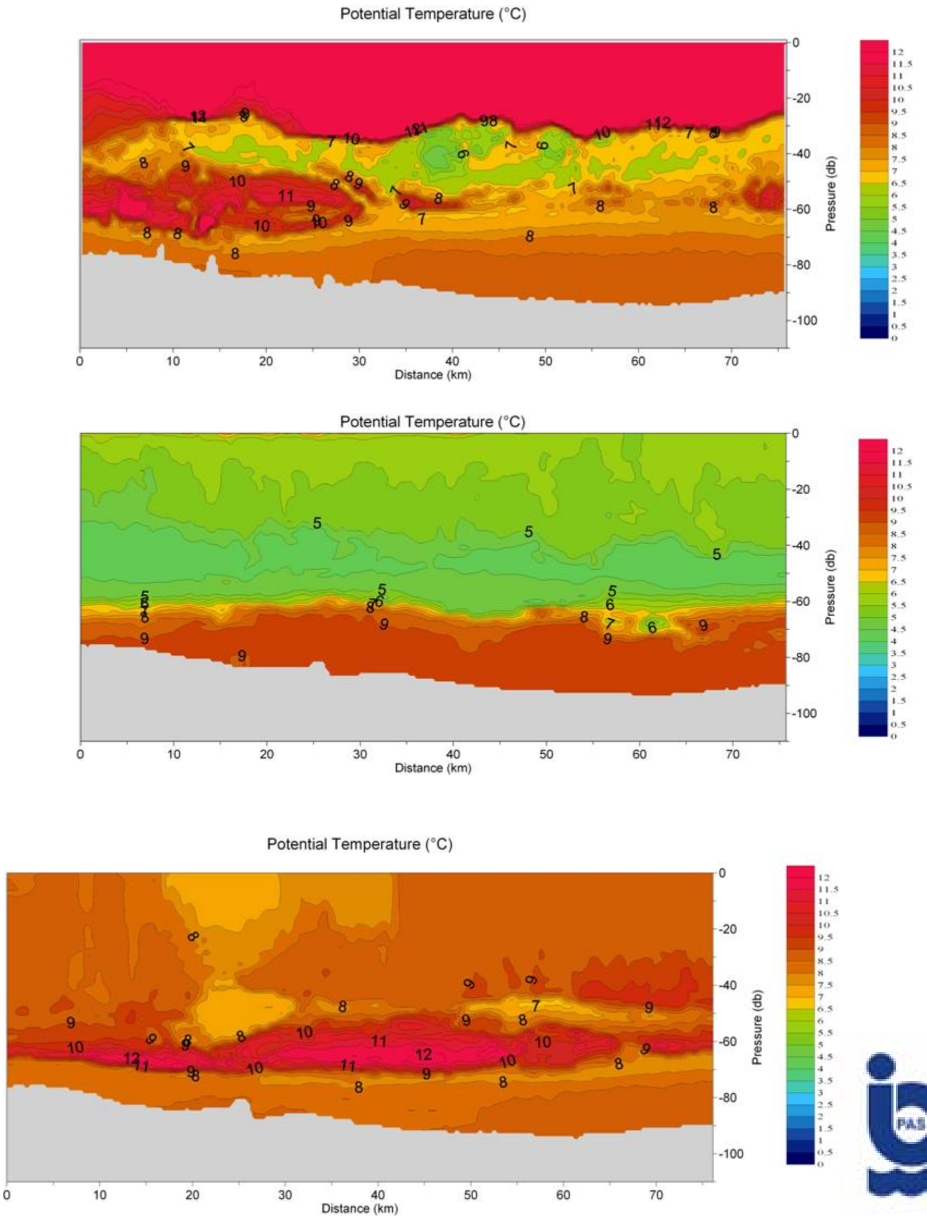


Figure 8. Temperature section in the Bornholm Deep. Upper panel) April 2007; middle panel) October 2007; bottom panel) November 2007.

Ice conditions

The freeze-up was late during the winter 2006/2007, as it was the previous ice season. In January the ice cover was small but at the end of the month and in February cold weather in the north accelerated the ice growth. The maximum ice extent was obtained already on 23 February which is several weeks earlier than normal (Figure 9). The ice winter was classified as mild. In Figure 10, the ice extent since 1961 is shown.

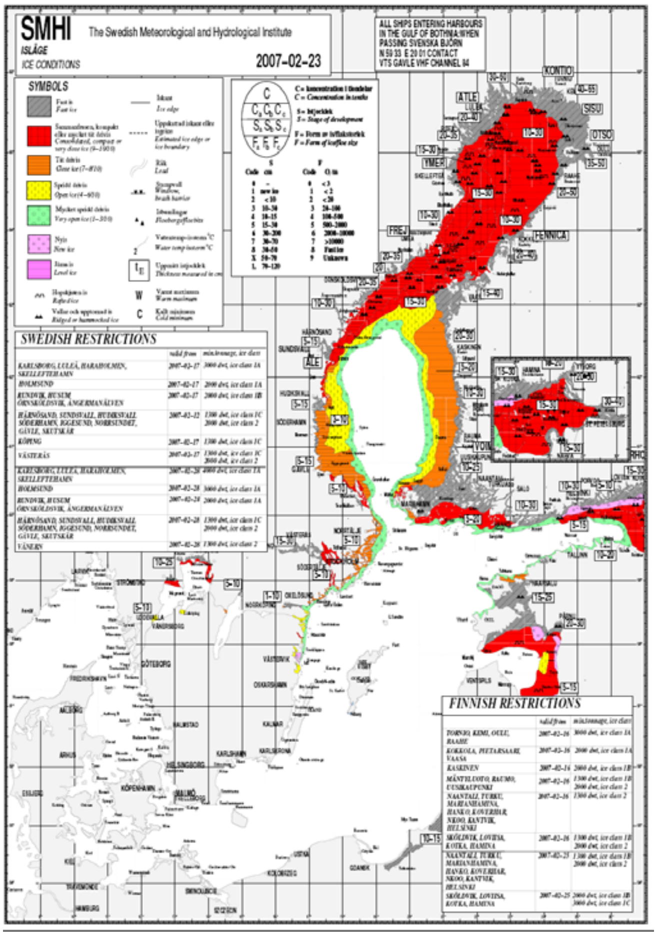


Figure 9. The maximum ice extent in the Baltic Sea during the winter 2006/2007. The map was constructed by the Ice Service at SMHI.

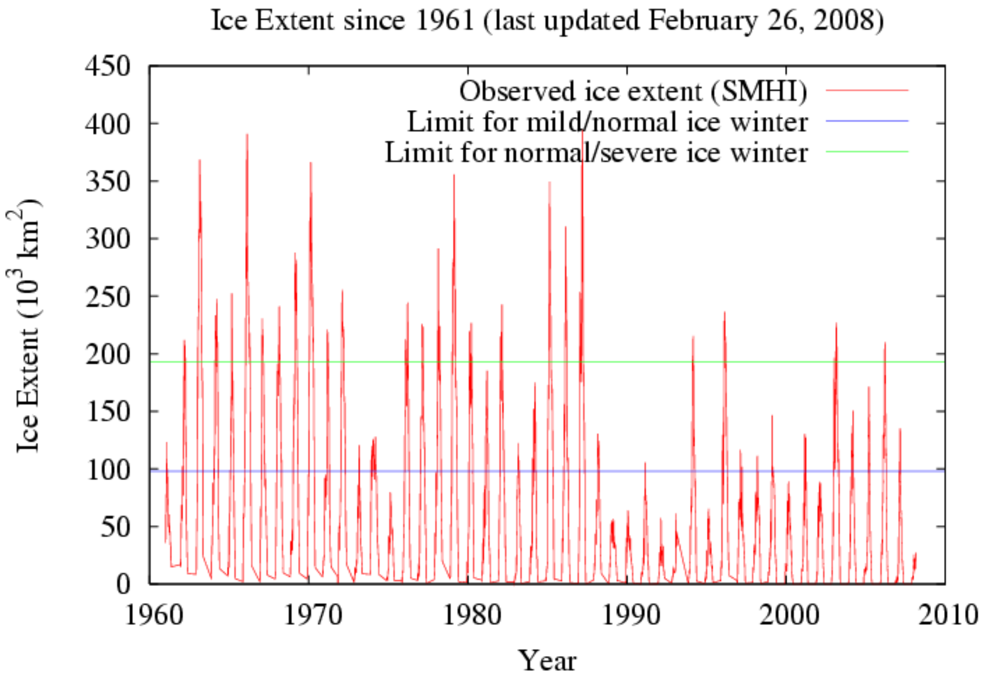


Figure 10. The ice extent in the Baltic starting from 1961. The last value is from March 21 2007. Graph constructed by Lars Axell (SMHI).

Annex 7: Hydrographic conditions in the Greenland Sea and Fram Strait (ICES Area 12)

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In summer 2007 the hydrographic measurements in the Greenland Sea (section along 75°N) and in Fram Strait (section along 78°50′N) were continued by Alfred Wegener Institute and Norwegian Polar Institute. These two sections allow monitoring the northward flow of Atlantic Water along the eastern boundary of the investigated area as well as the AW return flow located farther westward. Both sections cover also the outflow of Polar Water to the south. The section at 75°N intersects the Greenland Gyre to investigate the variability of its ventilation due to the winter convection.

Bottom water renewal in the Greenland Sea by deep convection in interplay with ice coverage and atmospheric forcing is a major element of the water mass modification in the Arctic Mediterranean. It influences both the waters of the central Arctic Ocean and the overflow waters in the North Atlantic. However, since the hydrographic observations became more frequent in 1980s no bottom water renewal by winter convection took place. The vertically homogenous deep water dome structure in the Greenland Gyre, reaching close to the surface was replaced by the two layer arrangement with an intermediate layer decoupled from deep waters by enhanced salinity and density gradient. Nowadays the ventilation activity is affected by a present stratification. Under a sufficient meteorological forcing and depending on the existing halocline, i.e. amount of Polar Water advected into the gyre, two ventilation scenarios are possible: deepening of a mixed layer and the plume convection (Ronski and Budeus, 2005).

The Atlantic water enters the Arctic Ocean either through the shallow Barents Sea or through the deep Fram Strait. The transfer of heat and freshwater is affected by the different ocean-atmosphere interaction over both regions and the spreading of Atlantic water along the different pathways affects the climatic conditions in the Arctic. During transition through the Barents Sea, the warm Atlantic Water is exposed to strong surface cooling and mixing and finally enters the Arctic Ocean with temperature below zero. Thus the AW inflow through Fram Strait is the main source of heat for the Arctic Ocean. The Atlantic water has a strong influence on the stratification and internal circulation in the Arctic Ocean and the outflow from the Arctic Ocean is either transferred south by the East Greenland Current or enters and affects the water mass modification in the Nordic Seas. The complicated topographic structure of the Fram Strait leads to a splitting of the West Spitsbergen Current into at least three branches. One part follows the shelf edge and enters the Arctic Ocean north of Svalbard. It constitutes the AW source for the interior of the Arctic Ocean as it continues in the boundary current along the Eurasian Basin slope. A second branch flows northward along the north-western slope of the Yermak Plateau and the third branch re-circulates immediately in the northern part of Fram Strait. The size and strength of the different branches largely determine the input of oceanic heat to the inner Arctic Ocean. The East Greenland Current, carrying water from the Arctic Ocean southward has a concentrated core above the continental slope, west of Greenland.

In the central Greenland Sea a long-term zonal CTD section at 75°N was performed in August 2007 with a regular station spacing of 10 Nm onboard RV 'Maria S. Merian' in August. The following cruise devoted to the Fram Strait CTD section and mooring work was cancelled due to the severe failure of ship's engines. The Fram Strait section as well as partially the exchange of moorings took place in late September from board of RV 'Lance. The CTD stations (Figure 1) were measured the eastern and central part of the strait while heavy ice conditions prevented the ship from accessing the western area. Unusually thick and compact sea ice was drifting swiftly southward, covering all the area west of the Greenwich meridian at 78°50'N (Figure 2) while at the same time, the ice extent in the Arctic Ocean reached the record minimum. The increased southward sea ice drift, observed in Fram Strait in September 2007 the most likely resulted from the strong atmospheric pressure gradient. Due to that, the standard Fram Strait section has continued along at 78°50'N only to the 0° and later deviated to the south-west, following the ice edge until 5°W. The shelf area west of 5°W could not be reached, despite of the repeated attempts to break through the ice. All moorings west of the Greenwich meridian could not be recovered and were left in water for the second year.

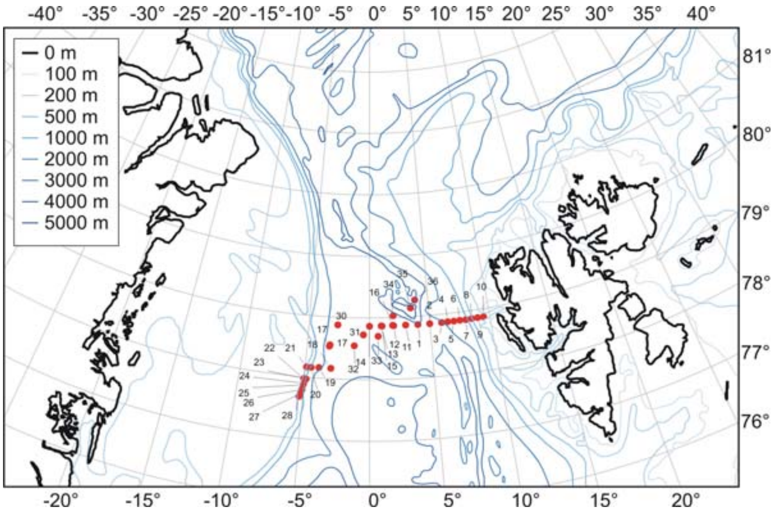

Figure 1. Location of CTD stations in Fram Strait in 2007.

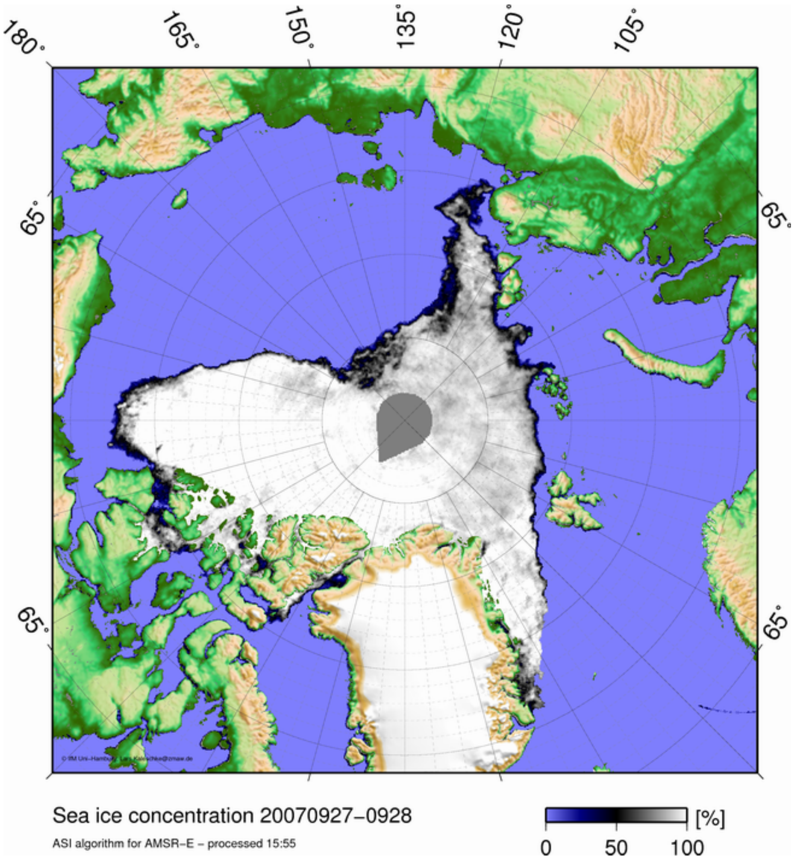

Figure 2. Sea ice concentration in the Arctic Ocean and Fram Strait in September 2007. Data source: IUP, University of Bremen, (Spreen *et al.*, 2008).

The obtained time-series of temperature and salinity in the Greenland Sea and Fram Strait were compiled from the AWI sections combined with the earlier data sets to describe the long-term variability of different water masses. Time series of the currents, temperature and salinity were also provided by recovering 8 of 16 moorings, deployed in autumn 2006. Since 1997 the year-round measurements at the array of moorings have been carried out in Fram Strait with the aim to estimate mass, heat and salt/freshwater fluxes between the Nordic Seas and Arctic Ocean. Until 2000 the observations were done in the framework of the VEINS project, in 2003–2005 the work was carried out as a part of international programme ASOF-N and since 2006 it has been continued in a frame of the EU DAMOCLES project. The moorings array covers the entire deep part of Fram Strait from the eastern to the western shelf edge. Altogether 18 moorings are deployed along 78°50'N and twelve of them maintained by AWI. The Norwegian Polar Institute operates the remaining 6 moorings in the western part of the strait (Schauer *et al.*, 2008).

The general situation at the section in the Greenland Sea at 75°N in 2006 was characterized by summer conditions with a low salinity surface layer. The subsurface layer in the central Greenland Gyre was strongly influenced by Atlantic Water as compared to previous years. Patches of warm and salty AW were found across the whole section (Figure 3). Due to summer heating the warm surface water with T>0°C occupied ca. upper 100 m, while in areas with patches of AW isotherm 0°C deepened to 200–300 m. These AW patches were also characterized by high salinity exceeding 34.9. However the AW layer extent at the eastern rim of the Greenland Basin was smaller and shallower than in 2006. The area occupied by the Return Atlantic Water (RAW) at the western edge of the section decreased significantly since 2006 while the southward flowing, low salinity Polar Water in the surface layer was observed much farther towards the central basin the year before.

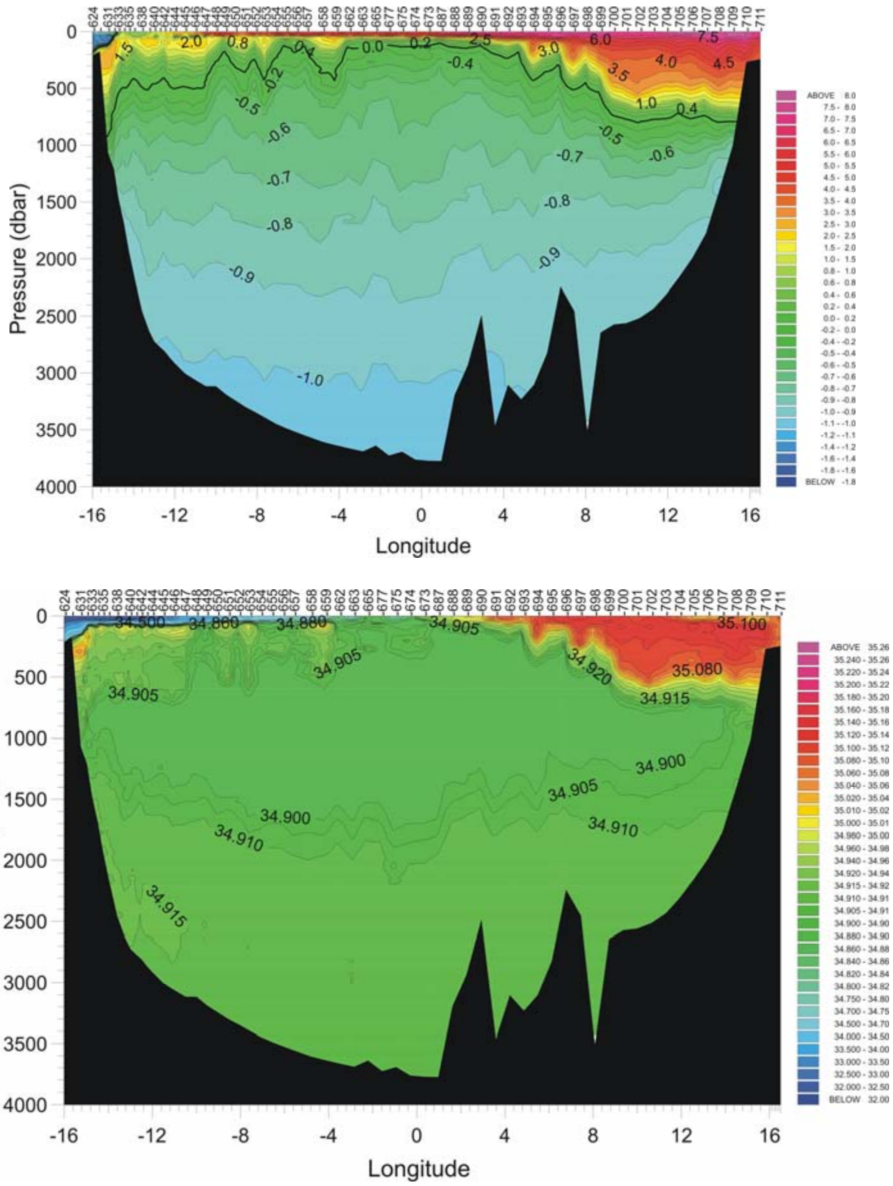

Figure 3. Distributions of potential temperature (upper fig.) and salinity (lower fig.) at the section across the Greenland Sea measured in summer 2007 (G. Budeus, S. Ronski).

The averaged properties of the Atlantic Water observed at the Greenland Sea section at 75°N (Figure 4) decreased in 2007 but still remained higher the long-term average after recovery from the extremely low values in 2003. The properties of the Atlantic Water are given as temperature and salinity averages over the depth range from 50 to 150 m of the stations between 10° and 13°E while the Return Atlantic Water is characterized by the temperature and salinity maximum below 50 m averaged over 3 stations west of 11.5°W. In the AW domain temperature decreased by 0.26° and in the RAW domain by 0.4° as compared to 2006. In both domains temperature exceeded the long term mean. A temperature drop was also accompanied by a decrease in mean salinity in both domains. Especially strong drop of salinity was observed in the RAW after reaching maximum the year before. Both AW and RAW mean salinities were close to their long-term means.

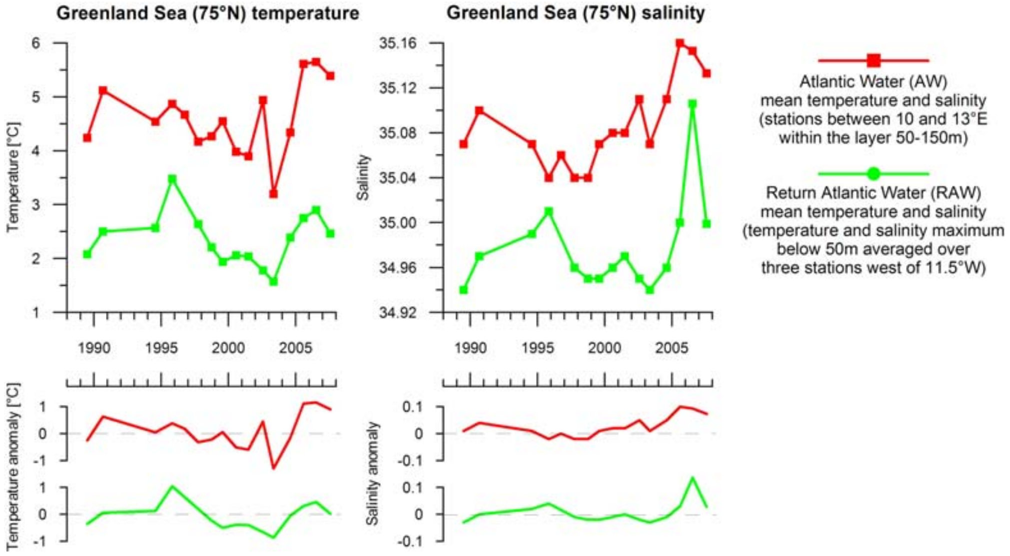

Figure 4. Time series of mean properties of the Atlantic Water and Return Atlantic Water in the Greenland Sea at the section along 75°N (G. Budeus, S. Ronski). Anomalies from the long term means shown at the bottom plots.

Time development of temperature and salinity in the central Greenland Basin, within the Greenland Gyre is shown on Figure 5. Both temperature and salinity developments in the upper layer are dominated by the interplay between convection and advective modifications. For the subsurface layer the advection of AW plays a more prominent role than the atmospheric heat input confined to the surface layer under summer conditions. Salinity development shows several periods of salinity increase, after the strongest signal found in 2006, the salinity decreased in upper 200m in 2007. Freshening/salinification of the upper layer are related to two different type of the winter convection and the mixed layer type ventilation is favourable for the deepening of AW and salinity increase (Ronski and Budeus, 2005). The absence of a steady trend is visible in the temperature development where periods of cooling and warming alternate. However, after 2 years are characterized by significantly higher temperatures and a deeper warm layer, a significantly shallower and less warm AW was found in 2007. The interface with enhanced temperature, salinity and density gradient has steadily descended since the beginning of measurements in 1993 by more than 1000 m.

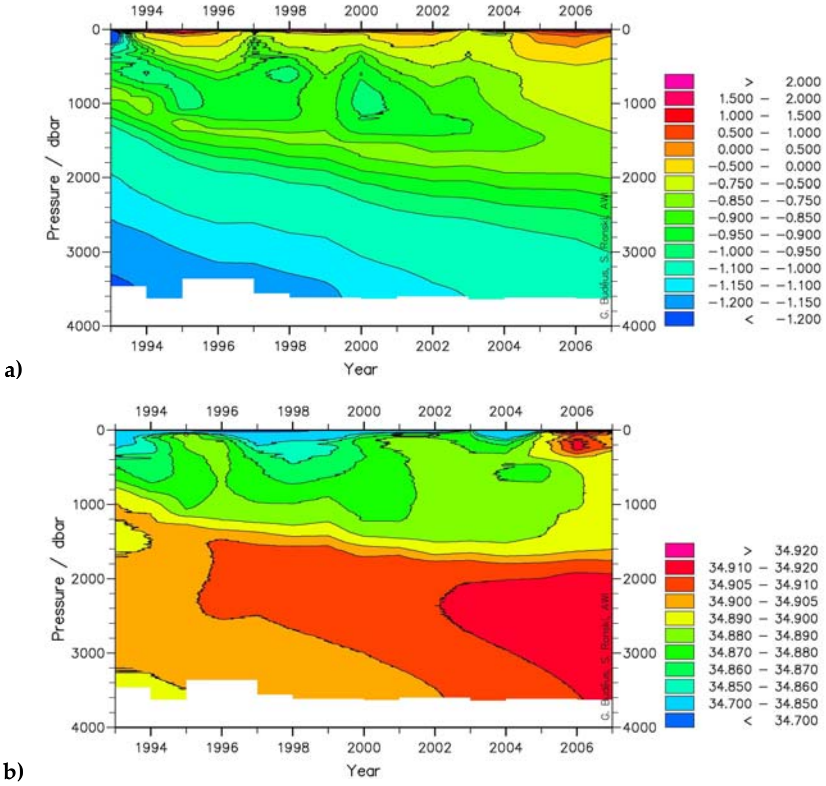

Figure 5. Time development of a) temperature and b) salinity in the central Greenland Gyre in 1993–2007 (G. Budeus, S. Ronski).

The winter convection depths (Figure 6) have been determined by means of the multiparameter method proposed by Ronski and Budeus (2005). Convection in the Greenland Sea can be detected by comparison of two successive years when the direction of modification of the upper layer in the gyre can be defined. If temperature and salinity decrease, density increase or homogenization is observed in comparison to the previous year, they can only be caused by a winter convection and serve as possible criteria for the convection depth. In winter 2005/2006 the winter convection depth was estimated on 1200m, the same as in the previous winter, which was significantly deeper than 2 preceding years but still less the maximum depths in period from winter 1999/2000 to 2002/2003 (between 1400 and 1600 m). Mean properties of the deep water (3000m) in the center of the Greenland Gyre shown on Figure 7 reveal steady increase both in temperature (from -1.18°C to -1.0°C) and salinity (from 34.9013 to 34.914) over last 15 years.

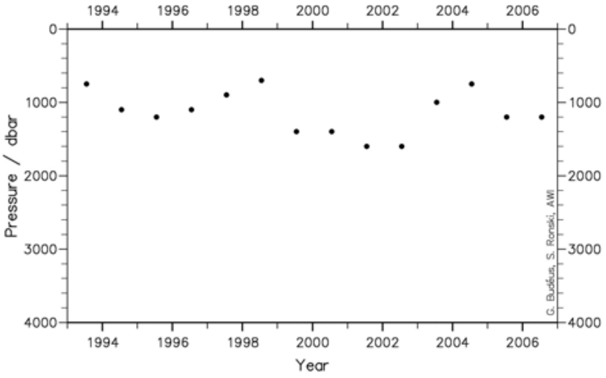

Figure 6. Time series of the winter convection depths in the Greenland Sea in 1993–2007, obtained with the multiparameter method by Ronski and Budeus (2005).

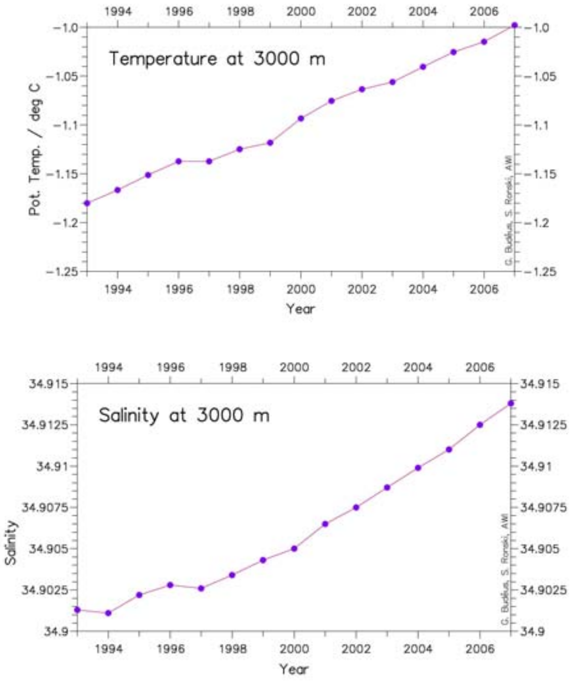

Figure 7. Time series of temperature (left panel) and salinity (right panel) of the deep water (3000 m) in the central Greenland Sea in 1993–2007 (G. Budeus, S. Ronski).

In late 2006 and through 2007 the significantly decreased SST was observed in the eastern part of Fram Strait after the last positive anomaly which had dominated since late 2005 (Figure 8). In winter 2007 the minimum SST was lower than the year before. Also SST summer anomaly in 2007 was ca. 1° lower than in 2006. On the interannual time scale after a strong rise of SST in 2003–2004, the decrease has been observed since 2006.

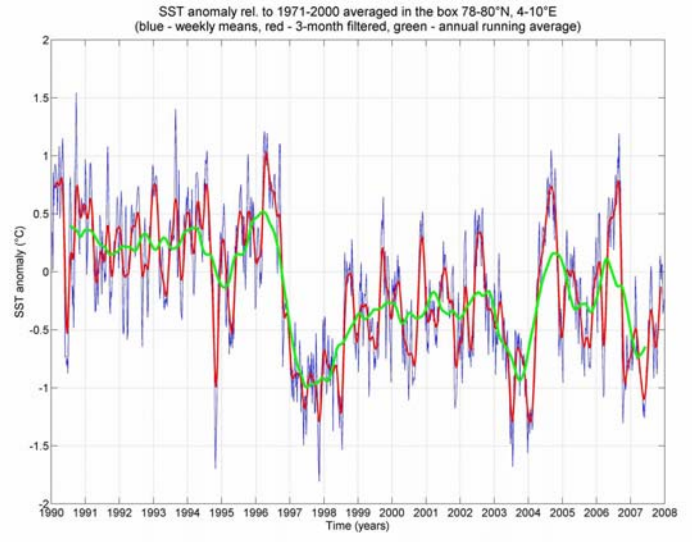

Figure 8. SST anomaly relative to the long-term average in the northern Fram Strait in the WSC domain (averaged in the box 78°–80°N and 4°–10°E). Data source: NOAA_OI_SST_V2 data set provided by the NOAA/OAR/ESRL PSD from the web site at http://www.cdc.noaa.gov/ (Reynolds *et al.*, 2002).

In 2007 the significant cooling was observed in the entire Fram Strait and freshening was found in the WSC domain (Figure 9). The lower boundary of AW warmer than 0°C was shifted up to ca. 800 m as compared to 1000m observed in 2006 and the depth of AW was similar in the eastern and central part of the strait. The westward range of the AW and the AW layer thickness at its western boundary was smaller than in 2006. The extent of the cold Polar Water (PW) in the western part of the section was similar as the year before however, it might be biased due to the deviation of the standard section. Much lower salinity was found in the WSC in 2007 than the year before and salinity distribution also indicates the decrease in the AW layer thickness. The surface layer of low saline water covered the entire section with only one small surface outcrop of the AW in the eastern part, most likely due to the passing eddy. This was similar to 2004 and 2005 when the low salinity surface water was nearly continuous across the whole section. Difference of temperature between 2007 and 2006 shows also significant cooling in the whole water column in the eastern part and most of the upper layer in the central part of Fram Strait.

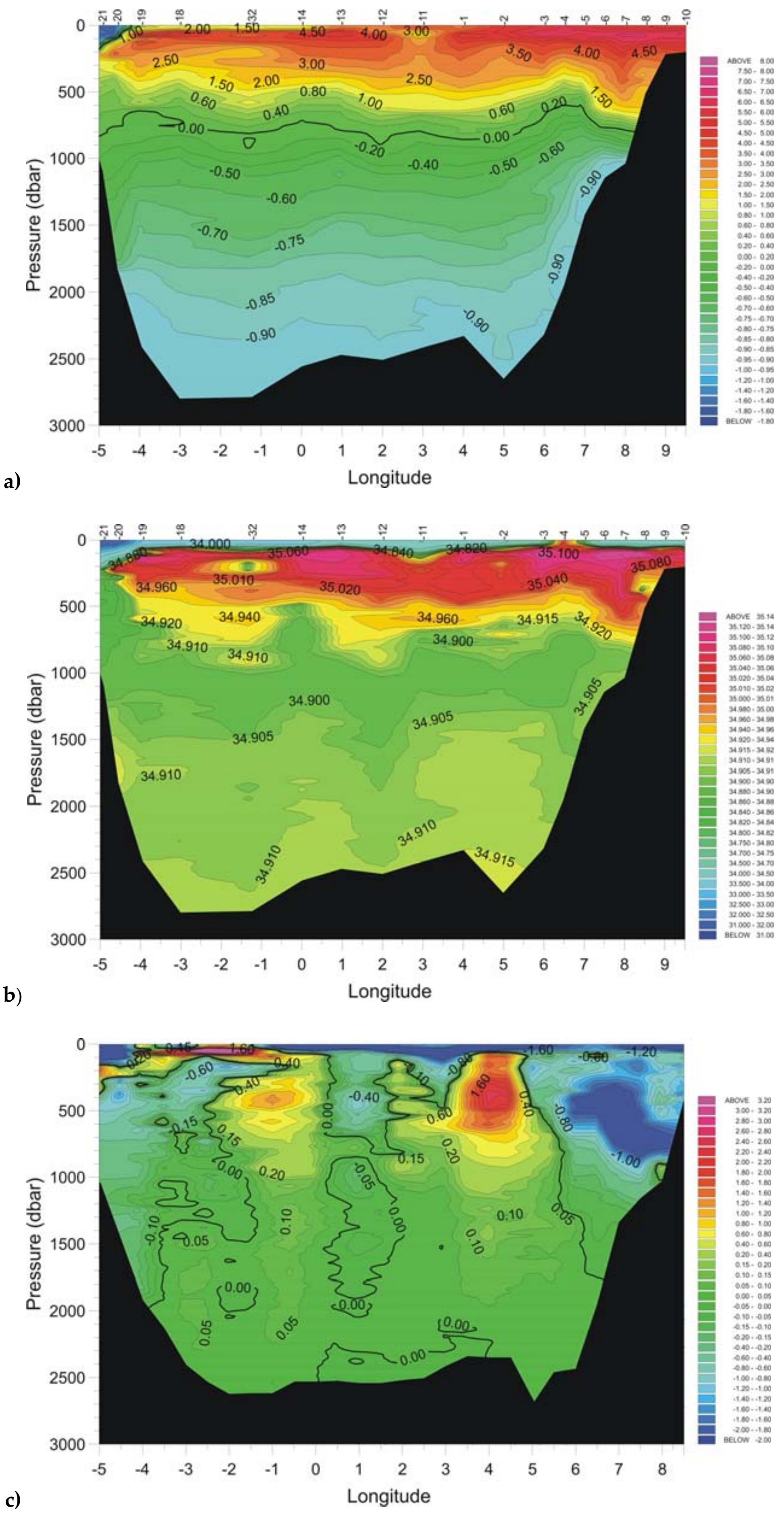

Figure 9. Vertical distribution of (a) potential temperature and (b) salinity at the section through Fram Strait at 78°50'N measured in 2007 and (c) temperature difference between 2007 and 2006.

Time series of mean temperature and salinity in Fram Strait were determined for three characteristic areas, distinguished in relation to the main flows: the West Spitsbergen Current (WSC) between the shelf edge and 5°E, the Return Atlantic

Current (RAC) between 3°W and 5°E, and Polar Water in the East Greenland Current (EGC) between 3°W and the Greenland shelf (Figure 10). After reaching the record high maxima in 2006, the mean temperature and salinity in the layer 50–500m in the WSC domain significantly decreased in 2007 (by 1.4° and 0.06 respectively). Despite of that, both were still higher than their long-term means. The mean temperature observed in RAC in 2007 was slightly higher than in 2006 and the mean salinity remained nearly the same while in the EGC domain the small increase in salinity was observed (however it might be attributed to the south-west deviation of the section which covered the smaller extent of the PW above the shelf).

The mean hydrographic properties of the warm Atlantic water in the entire Fram Strait (defined as water mass with T>2°C and S>34.92) which have been increasing since 2004 (AW spatial coverage since 2003) all dropped significantly in 2007 (Figure 11). After reaching their record high values in 2006 the mean temperature of the warm AW in 2007 came back to the value from 2005 while the mean salinity was even lower. Together with the smaller spatial extent of the warm AW it resulted in the decreased heat content as compared to the maximum from 2006.

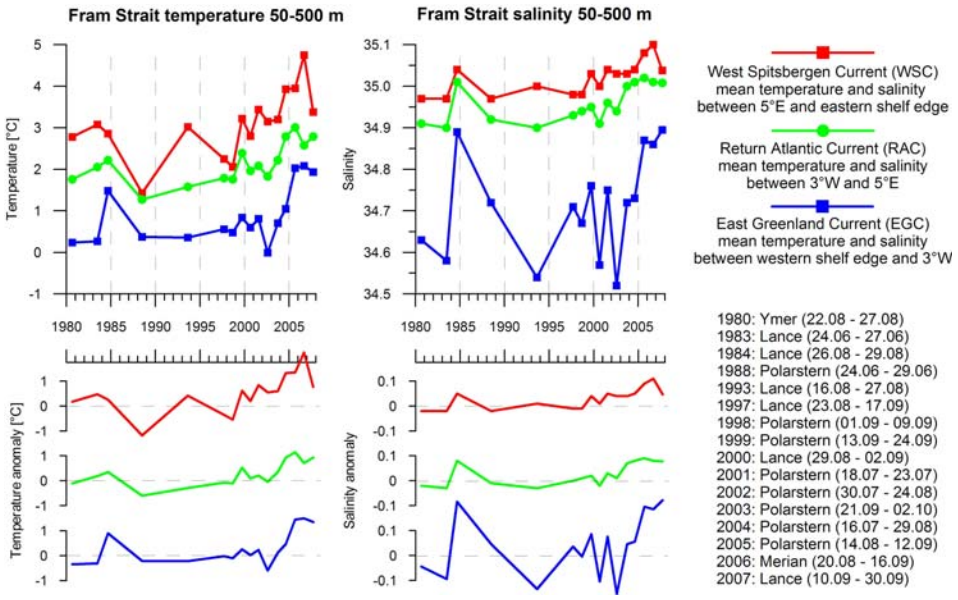

Figure 10. Time series of the mean temperatures and salinities in Fram Strait in the West Spitsbergen Current (WSC), Return Atlantic Current (RAW) and East Greenland Current (EGC) in the layer 50–500m. Anomalies from the long term averages (1980–2000) shown at the bottom plots.

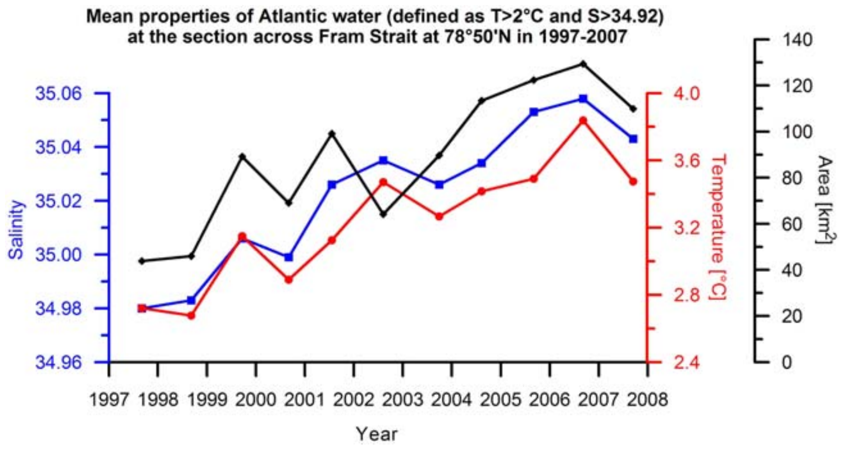

Figure 11. Mean properties of Atlantic Water (T>2°C, S>34.92) based on CTD sections in 1997–2007.

Time series of temperature and current velocities, recorded at the array of moorings since 1997 are used to calculate volume and heat fluxes through Fram Strait. However in 2007 only six easternmost moorings and two of moorings in the center of Fram Strait were recovered. The deseasoned temperature observed in the AW layer at the mooring F2 (the WSC core) and mooring F4 (the offshore WSC branch) confirm a decrease found from the CTD section (Figure 12). After reaching a maximum in the second half of 2006, temperature has started to drop in both WSC branches. However since the beginning of measurements the positive trends were observed in the AW in the WSC core (0.12°C/year) as well as in the WSC offshore branch (0.14°C/year). At two recovered central moorings (fig. not shown) the AW temperatures were similar in 2006–2007 as during the previous deployment year (2005–2006) with maxima in the late autumn and spring minima. The cross-section current in the WSC core was significantly lower in 2007 after a stronger peak in autumn 2006 while in the offshore branch the relatively strong northward flow in winter and spring was followed by a prevailing southward flow in summer and autumn 2007. No significant trends were found in the cross-section current velocities in both locations.

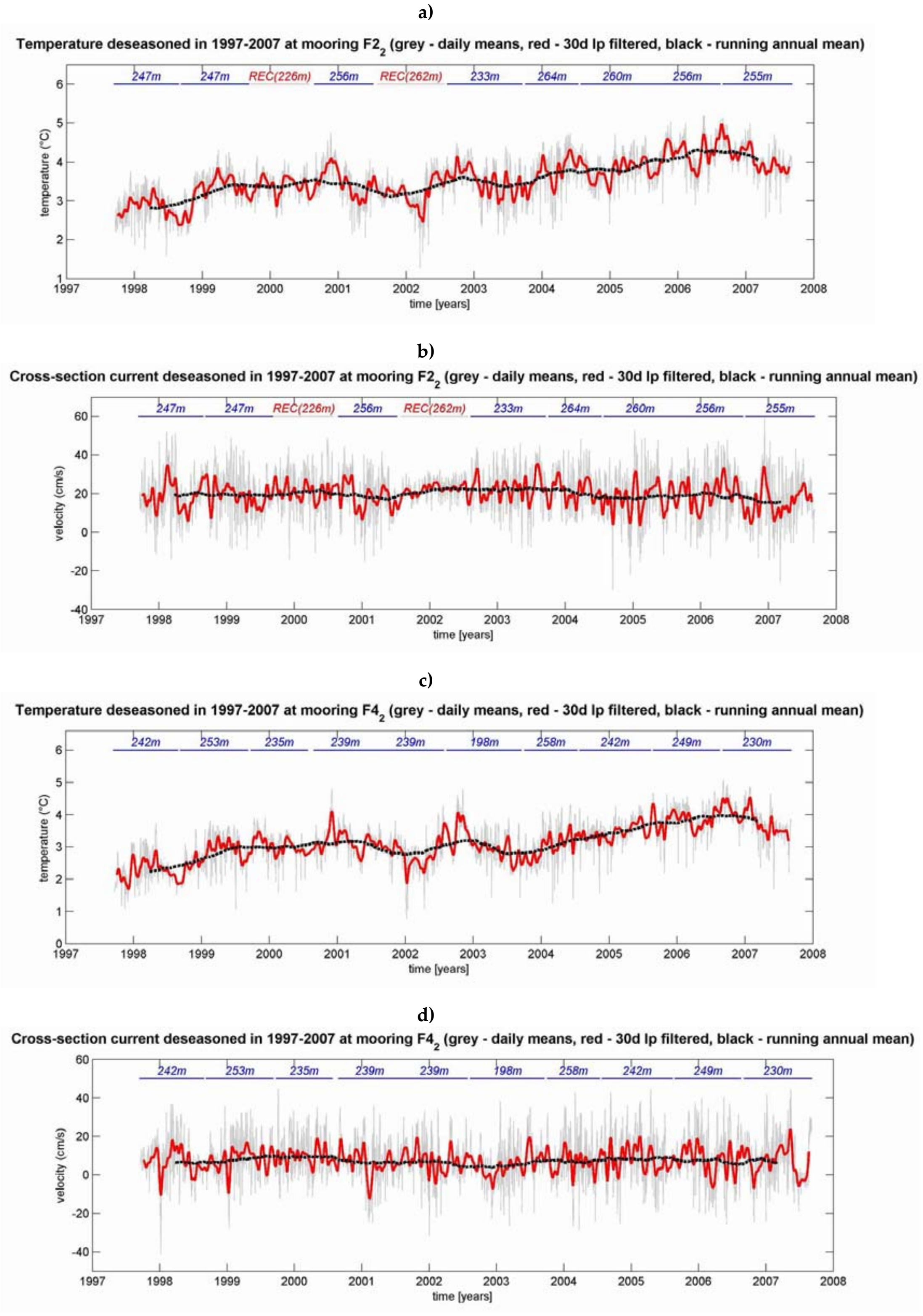

Figure 12. Time series of deseasoned temperature (fig. a, c) and cross-section current (fig. b, d) at the mooring F2 (the WSC core) and F4 (the off-shore WSC branch).

The weaker flow in the WSC core together with the southward flow in the offshore branch resulted in the unusual situation in June 2007 when the net transport in the entire WSC (Figure 13a) was southward (the only observed case since the beginning of observations). Stronger current observed in winter and spring 2007 produced the maximum northward transport in the WSC comparable to winter maximum from 2005. After that a strong decrease in the volume transport was registered. Because a part of moorings in the central and western Fram Strait was not exchanged in 2007 due to the ice conditions, it is not possible to estimate the total volume and heat transport through the strait in 2006–2007. The method of calculating the heat transport in the volume balanced part of Fram Strait proposed by Schauer *et al*. (2008) gives the estimate of 40–50 TW on the interannual scale after an increase since 2002 (Figure 13b) with maxima reaching ca. 70 TW in winters 2004 and 2005.

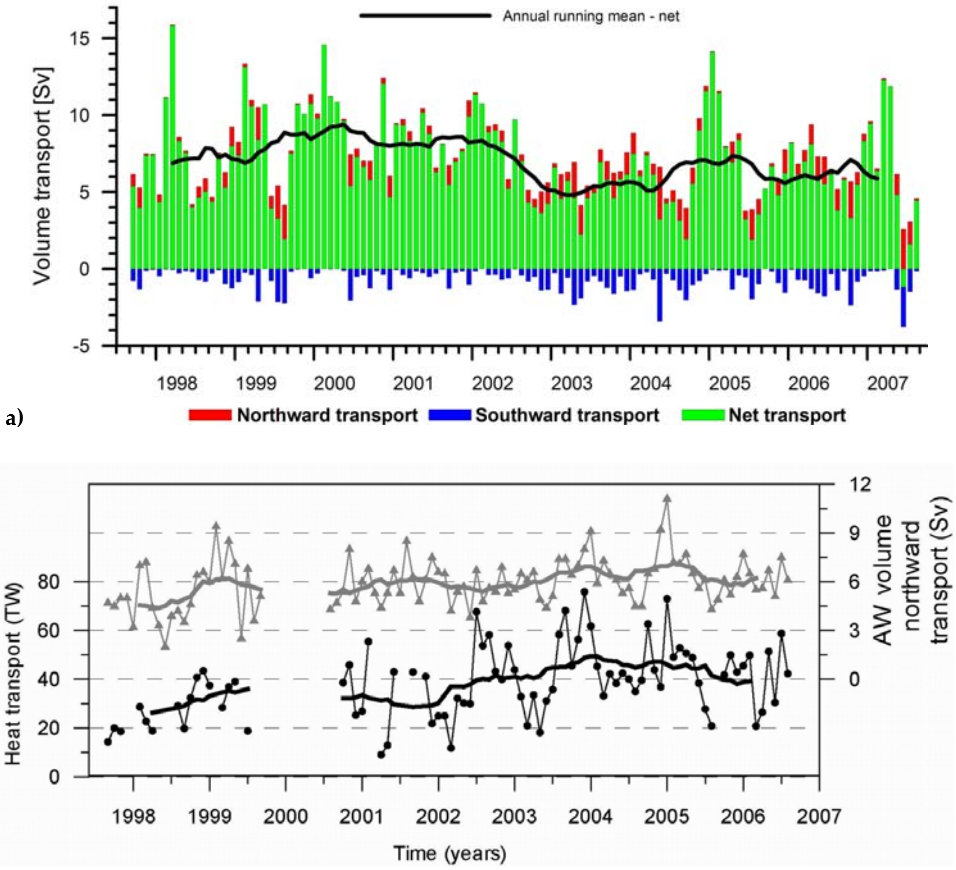

Figure 13. Monthly means of the northward, southward and net volume transport in the West Spitsbergen Current in 1997–2007 (Figure 13a) and heat transport with AW northward transport through Fram Strait in 1997–2006 (Figure 13b).For the details of the heat transport calculations see Schauer *et al.*, 2008.

The general conclusion for 2007 is that temperature and salinity of the Atlantic water in the Greenland Sea and Fram Strait were lower than their record high maxima in 2006 but still higher than their long term averages. The strongest decrease of temperature was observed in the inflowing AW both at the eastern rim of the Greenland Sea as well as in the eastern Fram Strait. The air temperatures and sea surface temperatures were low in 2007 as compared to their long-term means, suggesting an increased heat loss in Fram Strait. The unusually large sea ice extent was observed in autumn 2007 in Fram Strait, resulting in cooling and freshening of the surface layer. The AW re-circulating in Fram Strait had properties similar to observed in 2006 while farther to the south, at the western rim of the Greenland Sea, the colder and less saline re-circulating AW was found in smaller amount than in 2006. The convection depth in winter 2006/2007 remained the same as the winter before and further warming and salinification were observed in the deep layers of the Greenland Sea.

References:

Reynolds, R.W., N.A. Rayner, T.M. Smith, D.C. Stokes, and W. Wang, 2002. An improved in situ and satellite SST analysis for climate. J. Climate, 15, 1609–1625.

Schauer U., A. Beszczynska-Möller, W. Walczowski, E. Fahrbach, J. Piechura, E. Hansen, 2008. Variation of Measured Heat Flow through the Fram Strait between 1997 and 2006. In: Arctic-Subarctic Ocean Fluxes: Defining the Role of the Nordic Seas in Climate. Eds. R.R. Dickson, J. Meincke and P. Rhines. Springer.

Spreen, G., L. Kaleschke, and Heygster, G. 2008. Sea ice remote sensing using AMSR-E 89 GHz channels, J. Geophys. Res., doi:10.1029/2005JC003384.

Annex 8: Oceanographic Status Report, North Sea 2007

Working Group on Oceanic Hydrography

Aberdeen, 3– 5 March, 2008

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Bundesamt für Seeschifffahrt und Hydrographie, Hamburg
(Federal Maritime and Hydrographic Agency)

Global Radiation

In March and April 2007 the monthly means of global radiation at the East Frisian island Norderney (Figure 1) exceeded the long-term mean significantly. In Germany and Belgium April 2007 was the warmest, most sunny, and most arid April since the beginning of regular weather observations in 1901.

In May and June the values decreased and fell below the long-term mean. During the second half of the year the global radiation was close to the long-term mean. This pattern is also visible in the area-averaged monthly SST values shown below.

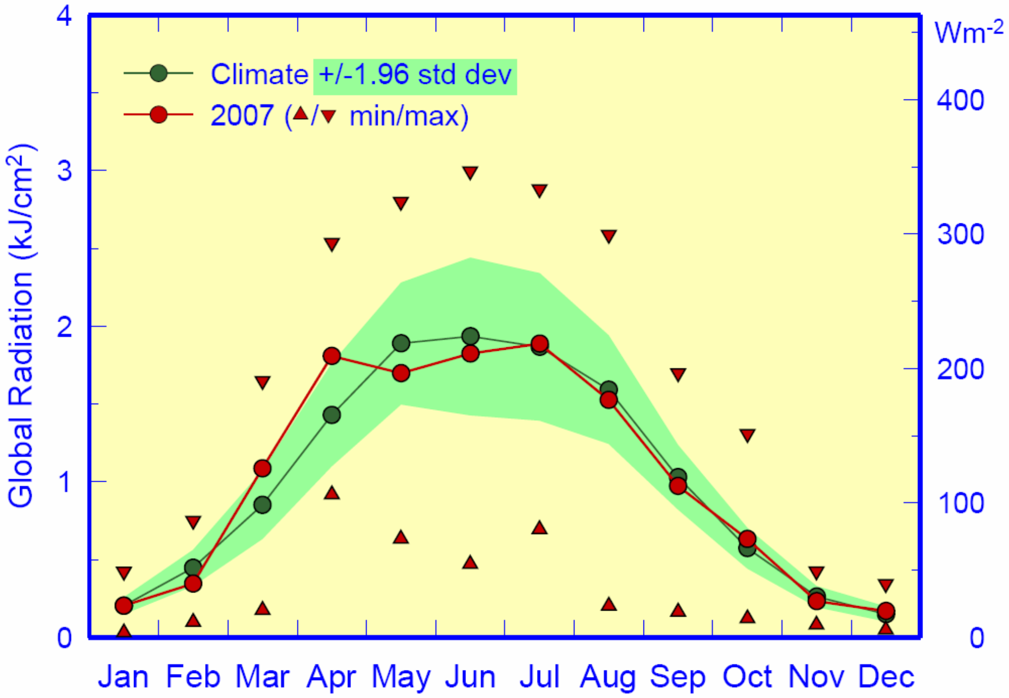

Figure 1. Monthly averaged global radiation at Norderney in 2007 [kJ/cm²]. Data kindly provided by DWD (German Weather Service).

Elbe River Run-Off

In 2007 the monthly Elbe river run-off was below the long-term mean between March and June (Figure 2). April was the most arid April since 1901 in Germany; some areas had no precipitation at all. However, there were no significant variations compared to the long-term mean. As in 2006, the 2007 annual mean run-off of the Elbe River

(Figure 3) was very close to the long-term mean of about 22 km³/year. The data were kindly provided by the WSA Lauenburg.

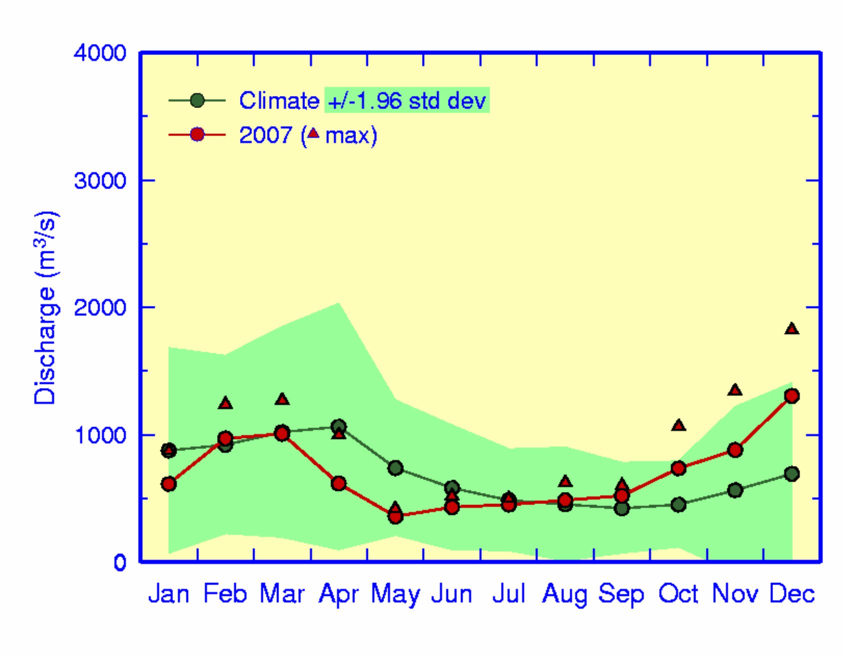

Figure 2. Monthly means of Elbe discharge in 2007 (WSA Lauenburg).

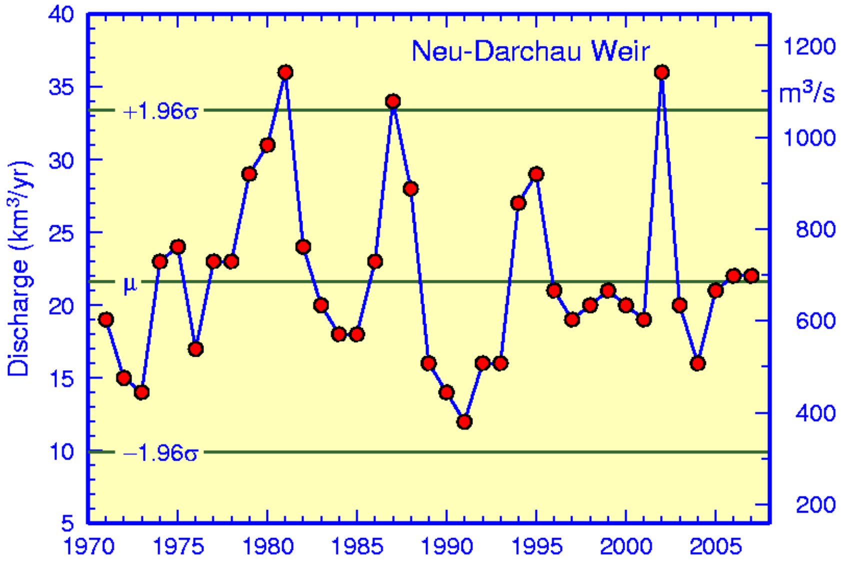

Figure 3. Yearly averaged Elbe run-off 1971–2007 (WSA Lauenburg).

North Sea SST

During the first months of 2007 the area averaged North Sea SSTs exceeded the long term mean (climatology 1971–1993) distinctively due to the extreme temperatures during the last months of 2006 (Figure 4). January and April are the warmest since the beginning of these observations in 1971. During the second half of the year the anomalies were moderate, ranging between +0.5 and +1.0°C.

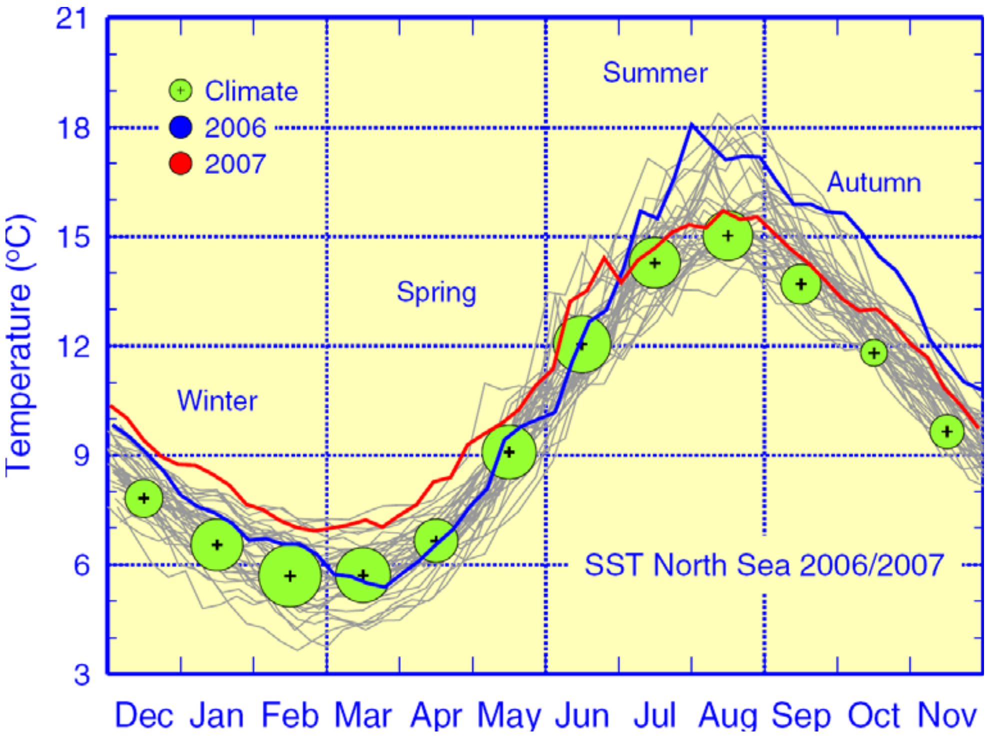

Figure 4. Weekly means of averaged North Sea SST from December 2006 until November 2007 (red line) and from December 2005 until November 2006 (blue line). The black lines are the annual cycles back to 1968. The green circles give the long-term monthly mean; the radius gives the inter-annual standard deviation for the period 1971–1993.

The linear trend of 0.3±0.1 K/decade (Figure 5) doesn't describe the real history of the mean SST adequately. In fact, this history is characterised by spontaneous jumps between warm and cold regimes.

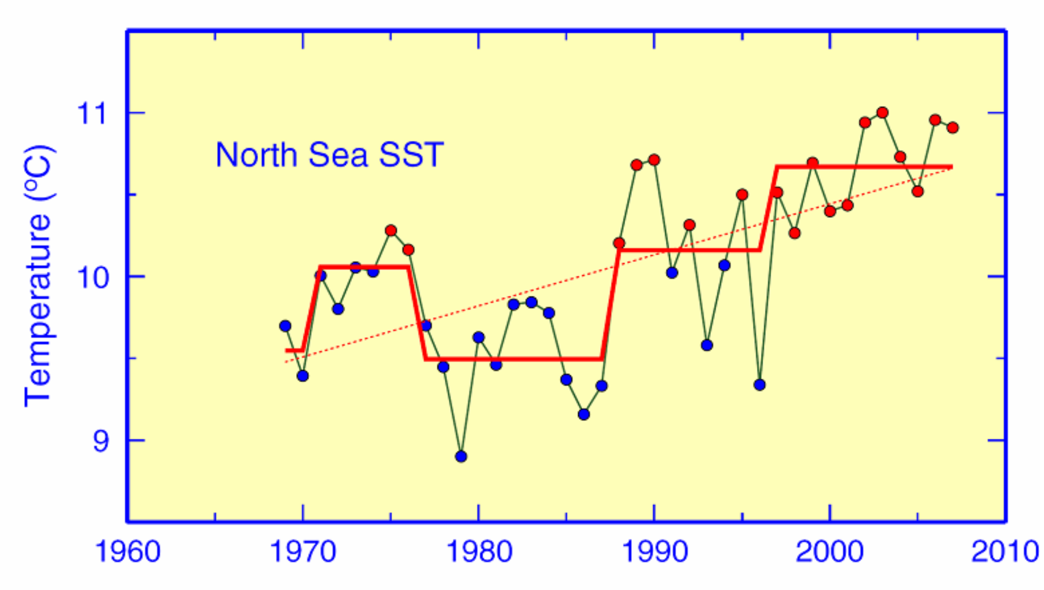

Figure 5. North Sea SST regime shifts 1968–2007.

North Sea Temperatures

Temperature distributions discussed in this section are based on vertical CTD profiles (stations) and data of the towed CTD-system DELPHIN which was oscillating between near-surface and near-bottom depths during the transits between CTD stations marked by dots in Figure 6.

The near-surface temperature in Figure 6 exhibits the typical gradient with increasing temperatures from the open northern boundary towards the inner German Bight. The spatial pattern is comparable to 2006 but the temperatures are generally about 1–2°C cooler. The monthly averaged SST for August 2007 has a positive anomaly of only 0.5°C compared to +2.2°C in 2006.

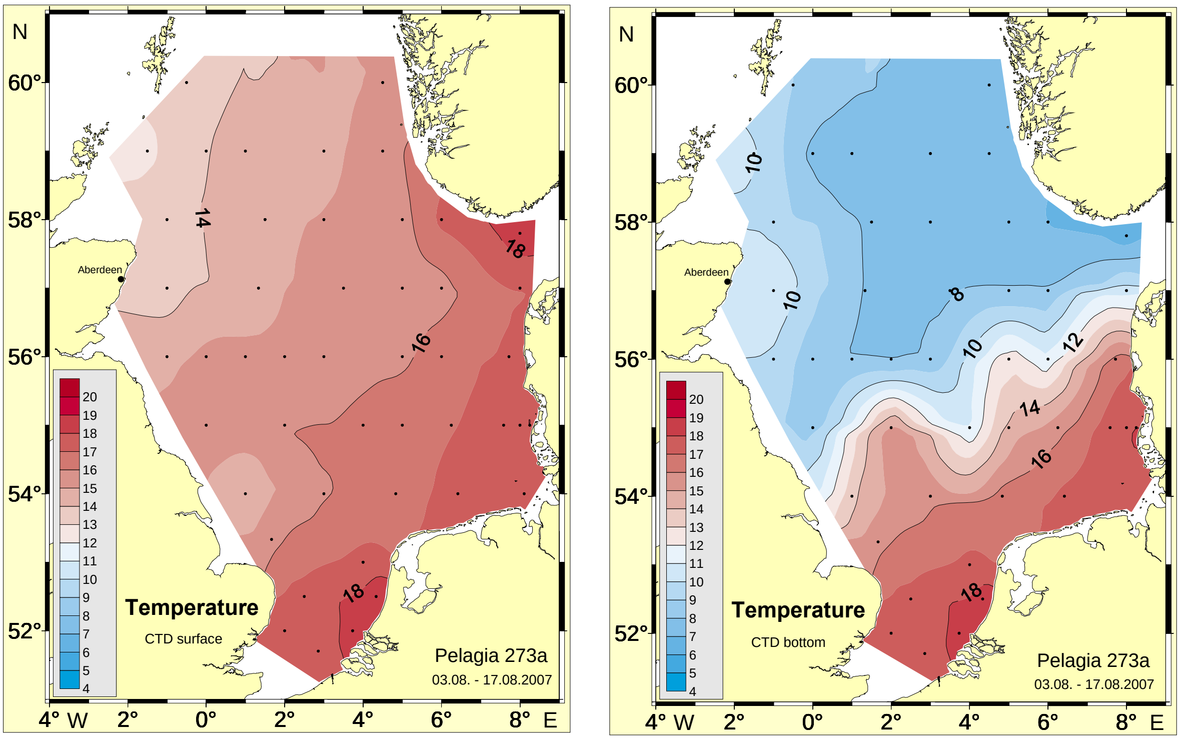

Figure 6. Horizontal surface (left) and bottom (right) temperature distribution [°C], PELAGIA cruise 273a, 3–17 August 2007.

Compared to 2006 the near-bottom temperature in 2007 (Figure 6, right) shows higher values along the Norwegian coast and in the central North Sea (about +1°C) but lower values (about –1–2°C) at the vertically mixed southern coast. However, near-bottom temperatures are generally still above the long-term mean.

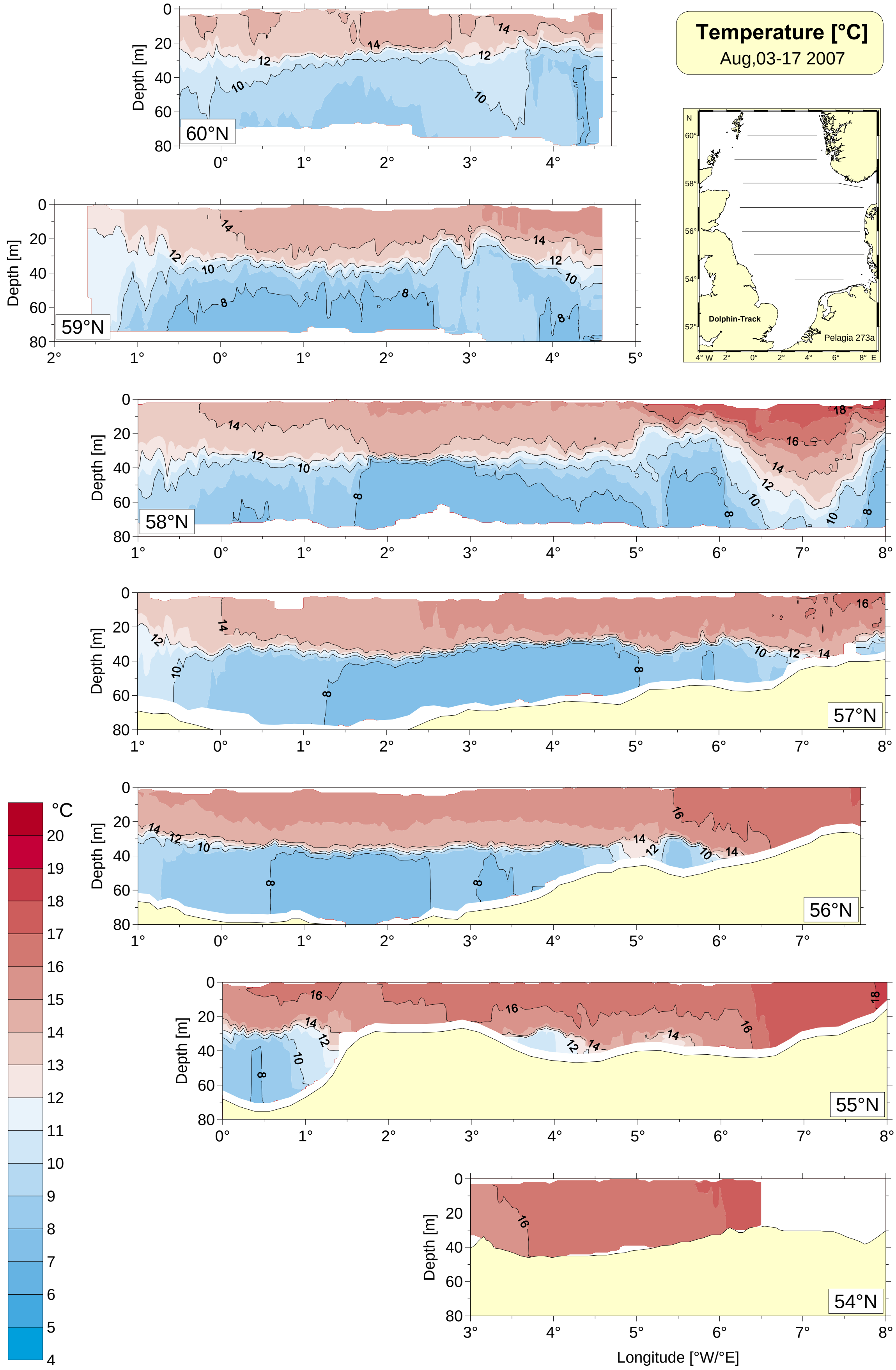

Figure 7. Temperature section from PELAGIA cruise 273a, 3–17 August 2007.

Zonal (east-west) temperature sections shown in Figure 7. In 2006 the 54°N section had a sharp thermocline at 20 m depth west of 6°E and the total 55°N section had a sharp thermocline with the exception of the Dogger Bank area between 1.5 to 3.5°E. In 2007 the 54°N section was completely vertically mixed and the 55°N section was vertically mixed respectively weakly stratified only east off 1.5°E.

Due to the outstanding warm temperatures in April the warm surface layer was much thicker compared to previous years, especially in the eastern part of the North Sea. Along the 58°N section in the range of the Baltic outflow the vertical gradient is very smooth and the warm surface layer exhibits with 60 m its deepest extension. As already mentioned, the temperature in the top layer is about 1–2°C cooler compared to 2006, but due to the larger vertical extension of the top layer the heat content is larger (see next section). A comparison of all 58°N temperature sections from 1999 to 2007 is given in Figure 8. Obvious is a great year to year variation concerning the sharpness of the thermocline and the thickness of the upper mixed layer. Striking is the 2003 section with a mighty and very warm mixed layer and with high temperatures extending far to the west compared to other years. However, in 2007 the vertical extension in the east part of the section exceeds the thermocline depth of 2003.

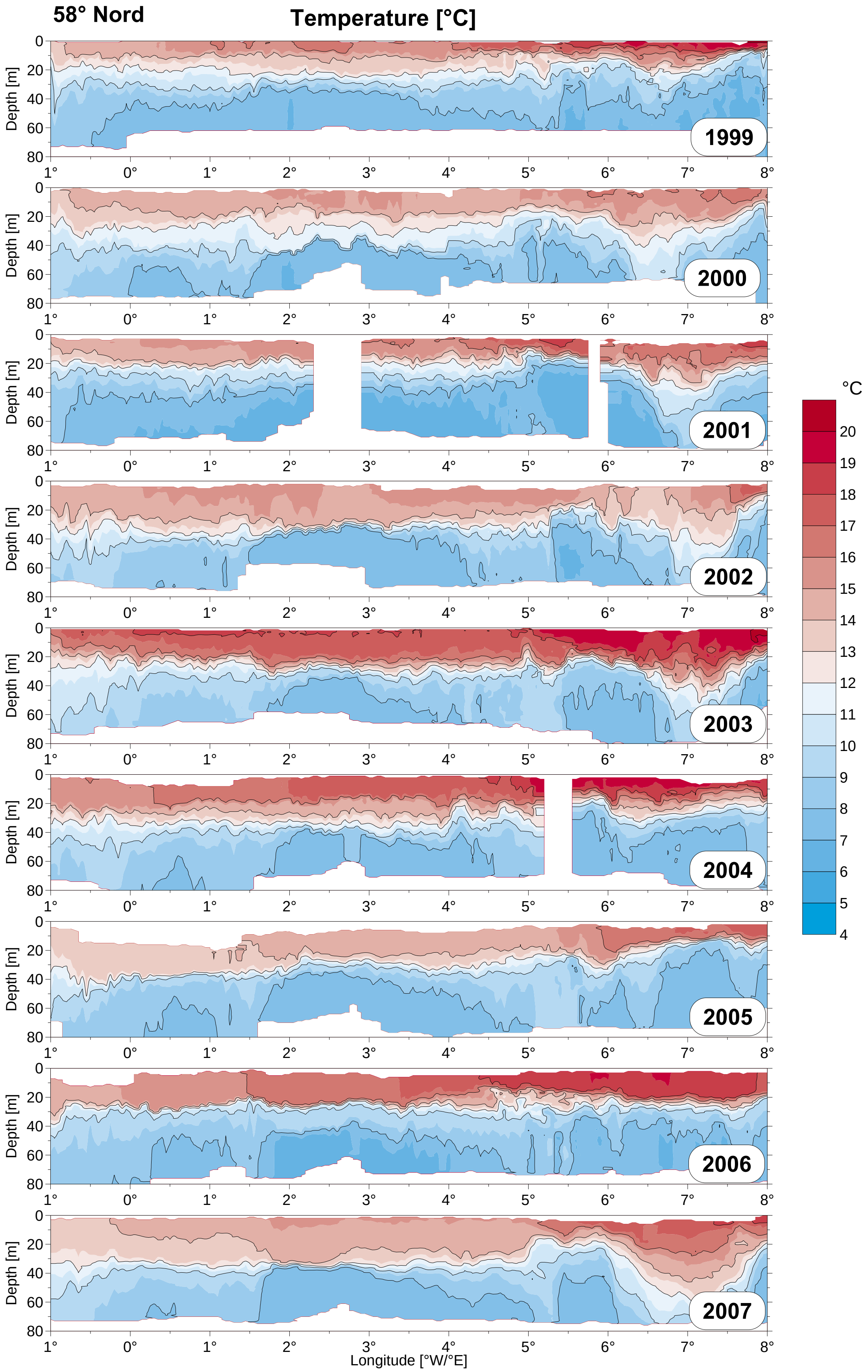

Figure 8. Temperature sections along 58°N from 1999 until 2007.

Total Heat Content

The total heat content is a climate relevant index which integrates the effects of solar radiation, advection of Atlantic Water, seasonal stratification and atmospheric heat exchange.

Figure 9 shows the heat content per unit volume for the 2006 and 2007 summer cruises, related to the masked area. Table 2 gives the total North Sea heat content for the last nine years which was steadily decreasing from 2003 until 2006 but rising again in 2007.

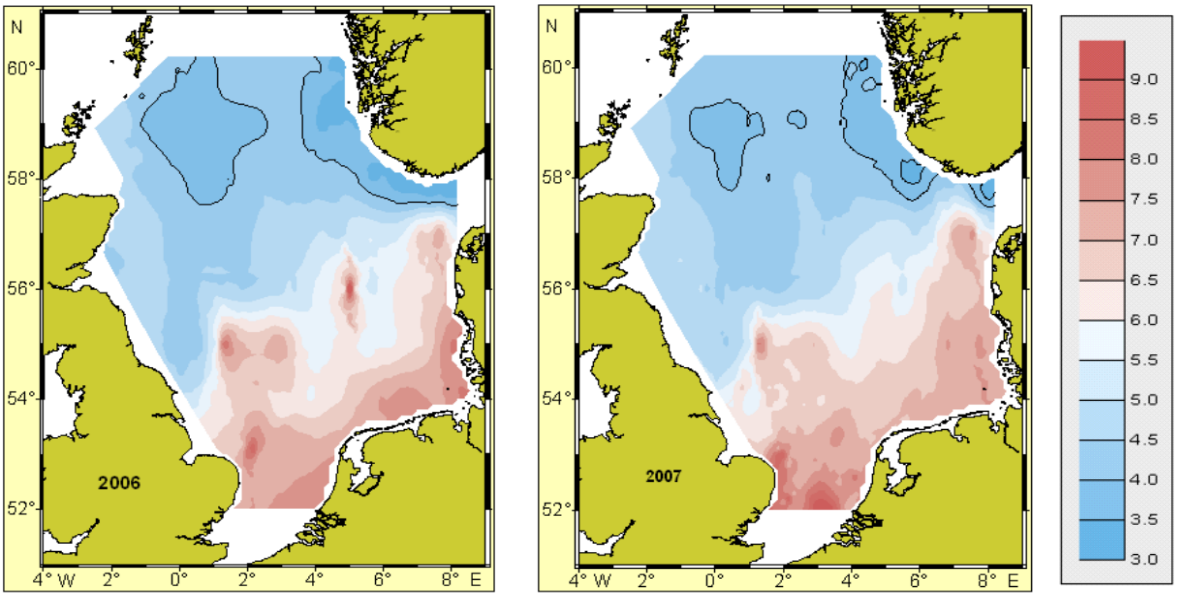

Figure 9. Heat content per unit volume in J x $10^7/m^3$, evaluated from GAUSS summer cruise 2006 and PELAGIA summer cruise 2007.

Table 2: Total heat content during Gauss summer cruises from 1999–2007.

TIME	TOTAL HEAT CONTENT [J]	CRUISE	RANK
09. July 1999	1.359 x 1021	G335	9
16. Aug 2000	1.497 x 1021	G353	7
27. July 2001	1.364 x 1021	G370	8
25. July 2002	1.517 x 1021	G385	6
04. Aug 2003	1.625 x 1021	G405	1
12. Aug 2004	1.594 x 1021	G425	2
23. Aug 2005	1.550 x 1021	G446	4
11. Aug 2006	1.520 x 1021	G446	5
10. Aug 2007	1.567 x 1021	P273	3

Figure 10 shows the monthly mean temperature of the total North Sea between 2000 and 2007 based on results of the BSH model 'BSHcmod'. Besides the pronounced warming during the last years the data show the increasing length of the summer season: Seasonal warming starts earlier and cooling much later. This is already known from the Helgoland Roads SST data, but is also valid for the total North Sea volume.

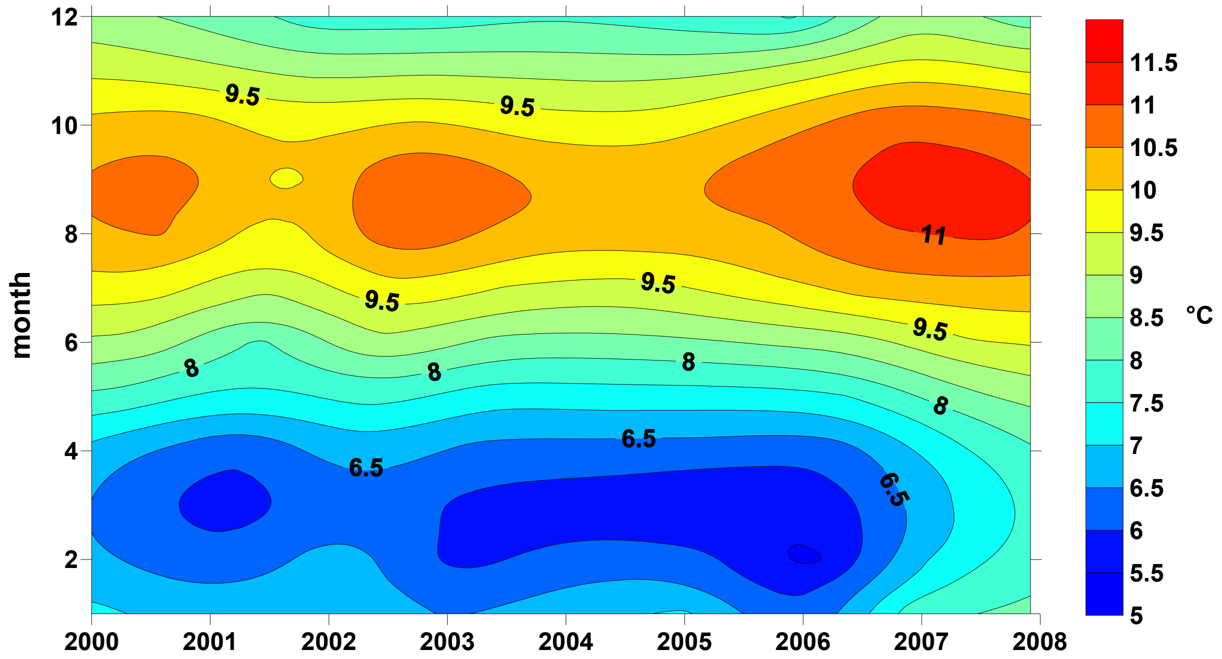

Figure 10. Monthly mean temperature of the total North Sea volume (BSHcmod model data).

North Sea Salinity and Total Salt Content

The salinity distributions and total salt contents shown in this section are also based upon vertical CTD profiles (stations) and *Delphin* data.

Compared to 2006 the tongue of Atlantic Water at the surface with salinity S>35 in the near-surface layer is much smaller and restricted to the northern part of the North Sea (Figure 11, left). In 2006 this tongue was much broader and expanded southwards until about 55°N. The ribbon of less saline water (S<34) generated by continental river run-off and Baltic outflow is roughly comparable to 2006 regarding its horizontal extension, but is regionally deeper as in 2006 north of 56°N (see Figure 13).

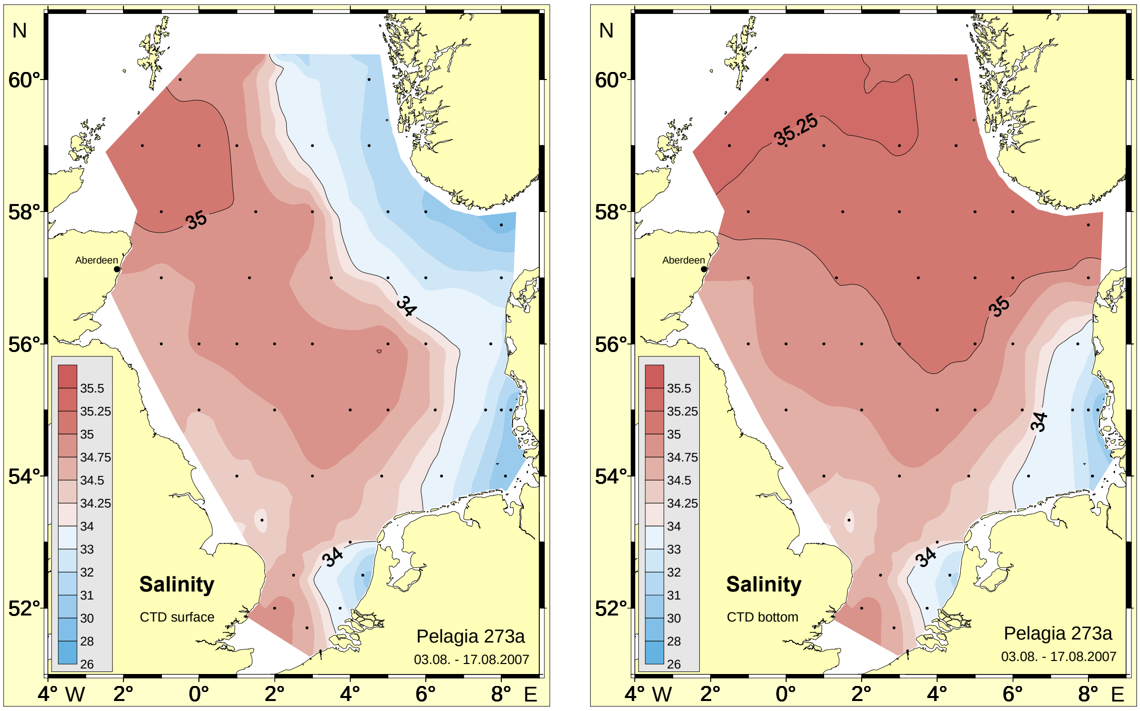

Figure 11. Horizontal surface (left) and bottom (right) salinity distribution, PELAGIA cruise 463a, 3–17 August 2007.

Near the bottom (Figure 11, right) the area covered by the 35-isohaline is comparable to 2006, but in the southern part of the North Sea the bottom water is saltier as in the year before. Therefore, the total salt content, which was increasing from 2002 until 2005 and decreasing between 2005 and 2006, was slightly increasing between 2006 and 2007 (see Table 3). In 2007 the advection of Atlantic Water was stronger in the bottom layer than in the surface layer. This is also evident from Figure 12 where the salt content in the southern North Sea is higher in 2007 compared to 2006.

Table 3. Total salt content, summer cruises from 2002–2007.

TIME	TOTAL SALT CONTENT [T]	CRUISE	RANK
25. July 2002	1.135 x 1012	G385	4
04. Aug 2003	1.138 x 1012	G405	3
12. Aug 2004	1.148 x 1012	G425	2
23. Aug 2005	1.153 x 1012	G446	1
11. Aug 2006	1.138 x 1012	G463	3
10. Aug 2007	1.143 x 1012	P273	

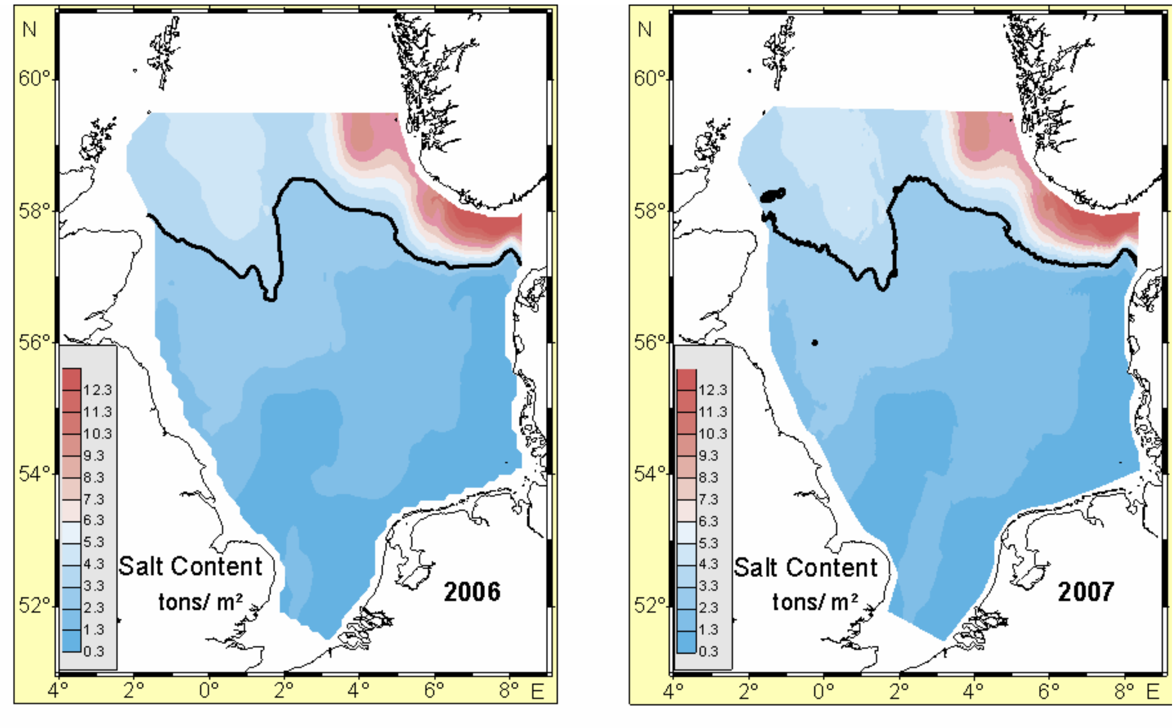

Figure 12. Salt content in tons/m² in 2006 (left) and 2007 (right) from GAUSS and PELAGIA cruises.

The zonal (east-west) salinity sections of Figure 13 show a distinctive stratification between the fresher Baltic outflow (S<34, 58–60°N) and North Sea Water. Especially along 58° N the vertical gradient is much smoother compared to the previous years. (See the salinity sections 1999–2007 along 58°N in Figure 14).

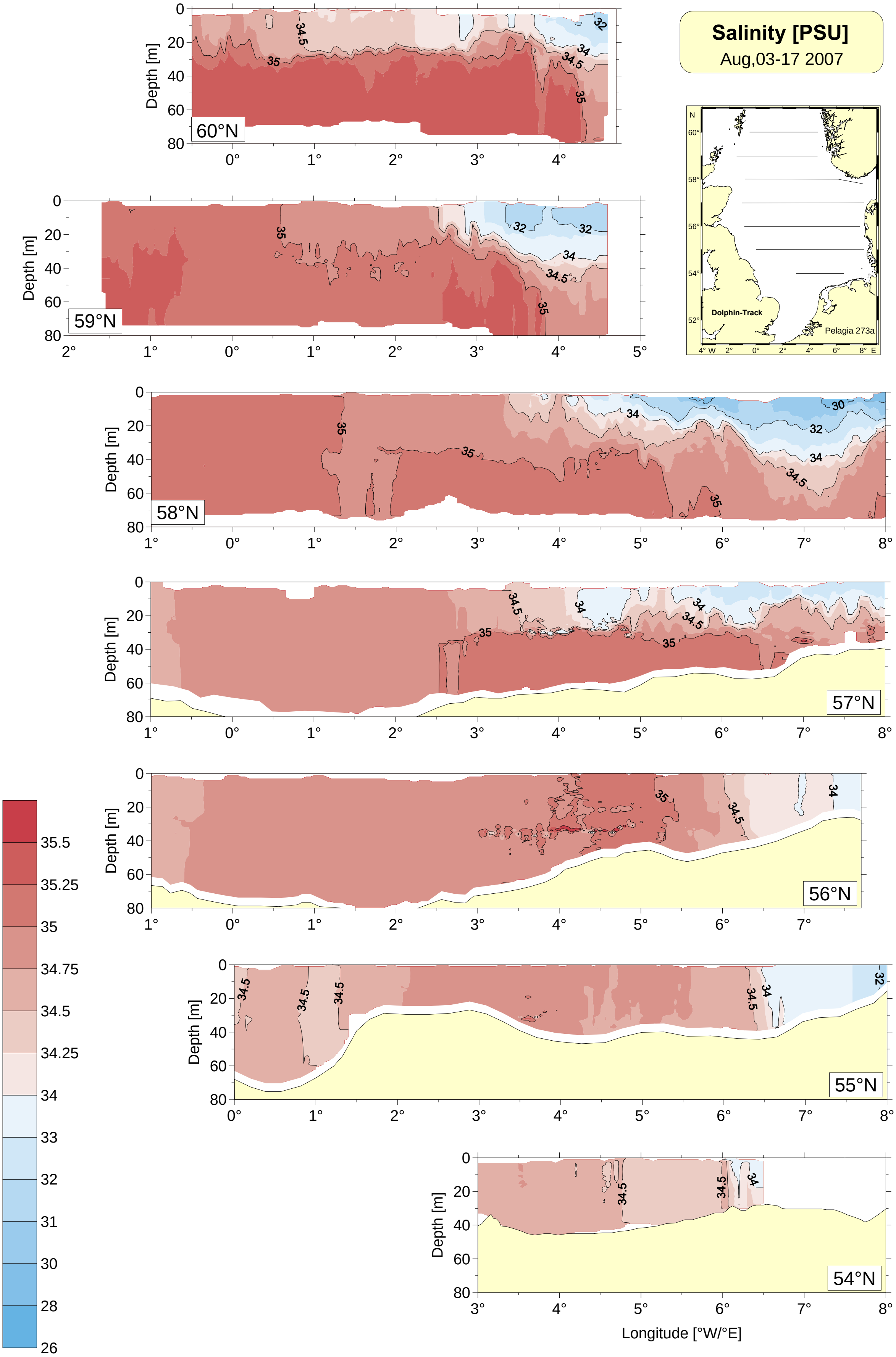

Figure 13. Salinity sections from PELAGIA cruise 273a, 3–17 August 2007.

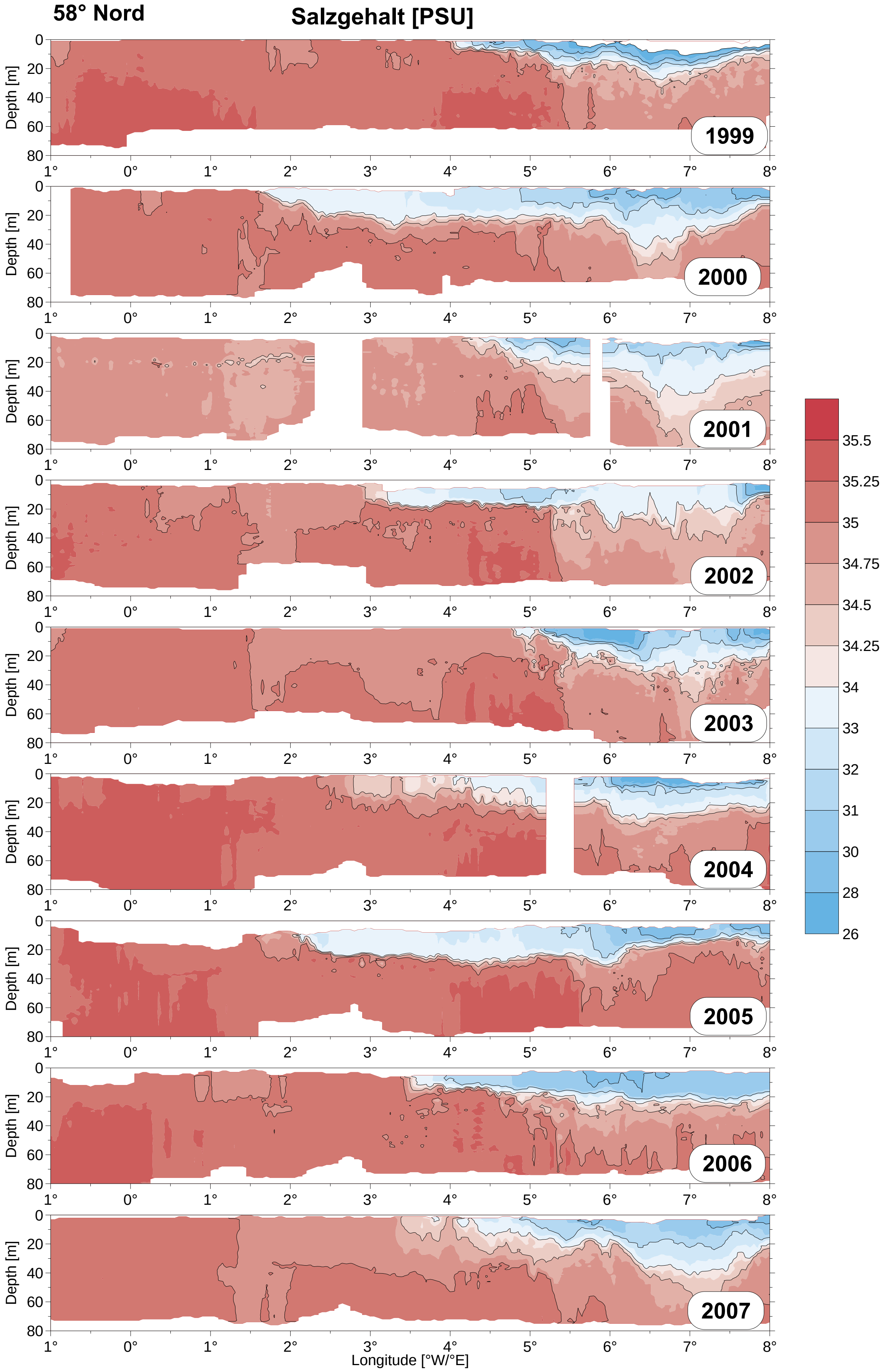

Figure 14. Salinity sections along 58°N from 1999 until 2007.

Oxygen Saturation

The oxygen saturation below the thermocline was high for August. Only small patches west off Jutland exhibit a saturation below 80% with a local minimum of less than 70%. Not until oxygen saturation falls below 40% marine life experience substantial stress.

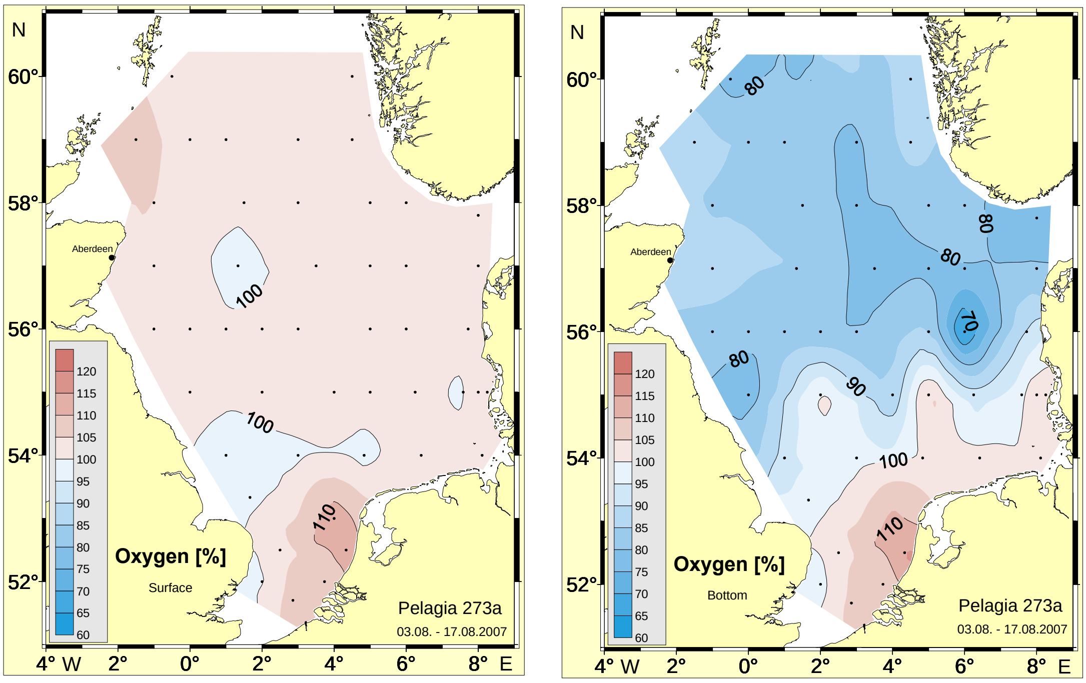

Figure 15. Surface (left) and bottom (right) oxygen distribution [%]. PELAGIA cruise 273a, 3–17 August 2007.

Secci-Depth

Figure 16 shows the Secchi-depth during the PELAGIA summer cruise. Satellite data reveal, that the area of high Secchi-depths coincides with regions of low chlorophyll, yellow substance, and suspended matter concentrations.

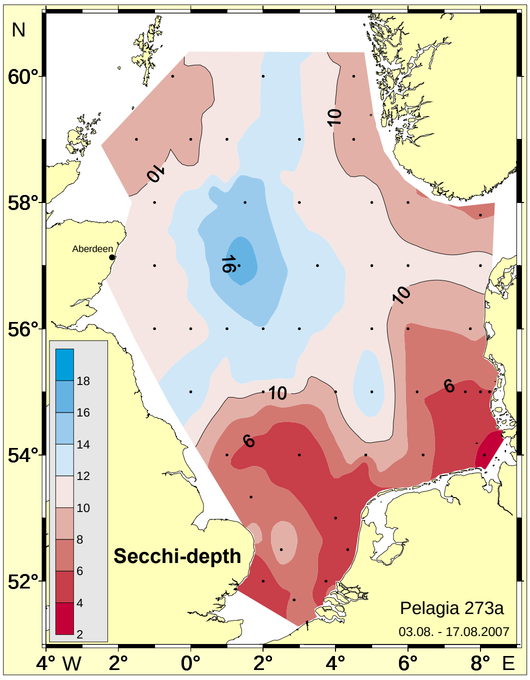

Figure 16. Secchi-depth [m]. PELAGIA cruise 273a, 3–17 August 2007.

Monthly Averaged Chlorophyll A Distribution

The monthly averaged near-surface chlorophyll A concentration of the North Sea for March, April, May, and June is shown in Figures 17. The data are from the Medium Resolution Imaging Spectrometer Instrument (MERIS) of the ENVISAT satellite. To improve the resolution a logarithmic scale is used.

There are no data in January and December due to cloud coverage and there are greater spatial gaps due to clouds in February and November. A noticeable chlorophyll production starts in March along the coast of the southern North Sea and in the German Bight. The maximum chlorophyll extension occurs in April and Mai, however, the blooms are restricted to near-coastal area. In 2006 the blooms covered the whole German Bight.

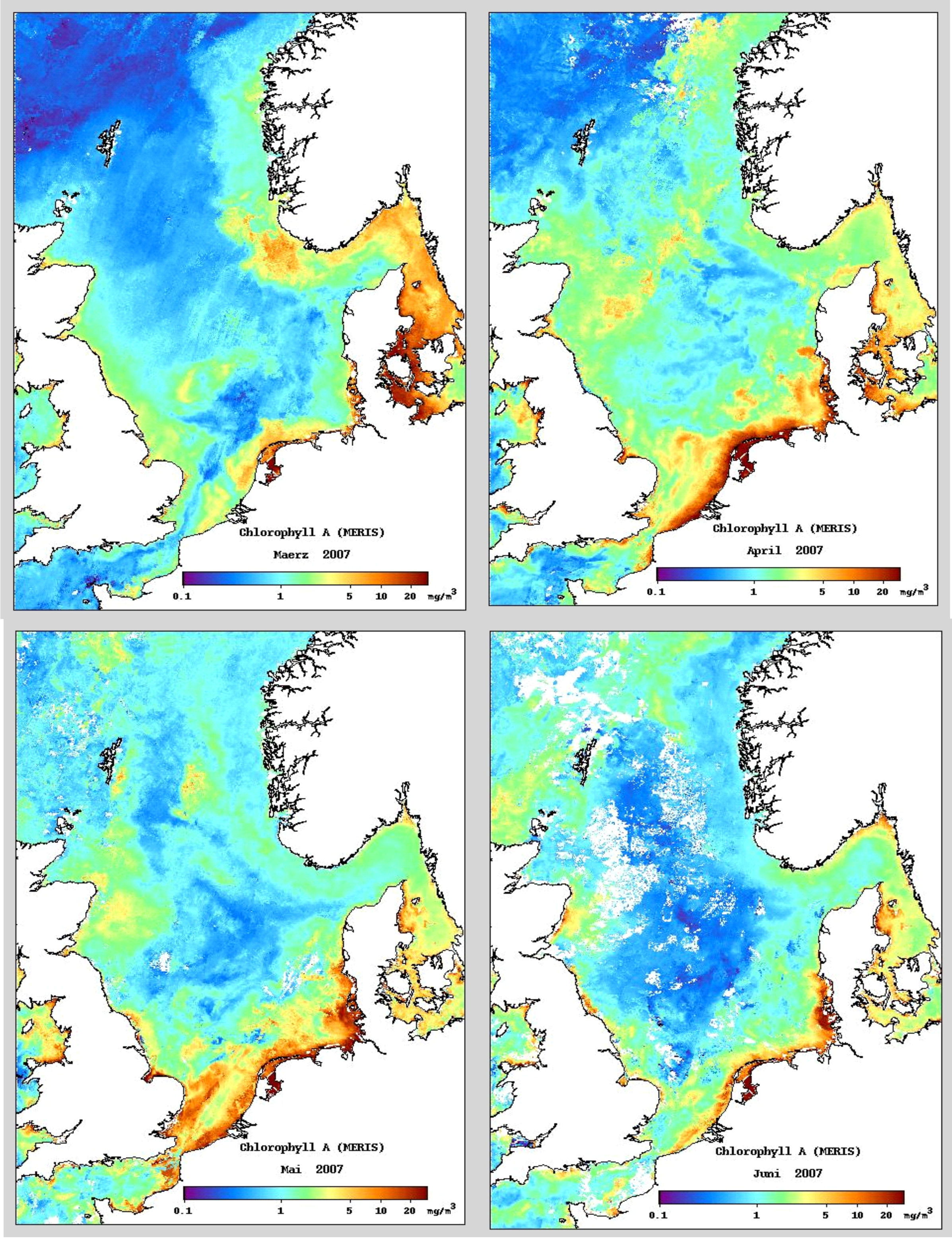

Figure 17. Monthly averaged Chlorphyll A concentration (MERIS) during March, April, May, and June 2007.

The effect of temperature changes in the Northeast Atlantic

Since 1989 the BSH operates the AX-03 XBT section between Europe and North America in the frame of the Ship of Opportunity Programme (SOOP). The nominal latitude of the section is 48°N, but actual measurements are performed along a great circle. XBT measurements from the AX-3 section have been grouped in 1°x1° bins for each year and the heat content of the upper 800 m has been computed for each bin. To minimise the influence of the seasonal cycle the upper 100 m have been set to a constant value given by the temperature at 100 m depth.

The temporal evolution of the heat content (Figure 18) shows major changes at the western and eastern end of the section. At the western end of the section the calculated heat content was relatively low (<20 GJ/m^2) at the beginning of the time-series, but exhibited a strong continuous increase during the entire observation period. This part of the section is influenced by the Gulf Stream which separates the cold waters of subpolar origin from warmer waters of subtropical origin. Obviously, the position of the Gulf Stream has shifted during the observation period and a more pronounced presence of the Gulf Stream is evident along the section since 2000 while in the earlier part of the observation period the area was strongly influenced by cold subpolar waters. Smaller changes can be observed in the north-eastern Atlantic, but higher temperatures and thus higher heat content are evident at the end of the observation period. The increase of heat content in the eastern Atlantic is found in many time-series within the basin and has implications for the waters entering the North Sea from the northern boundary.

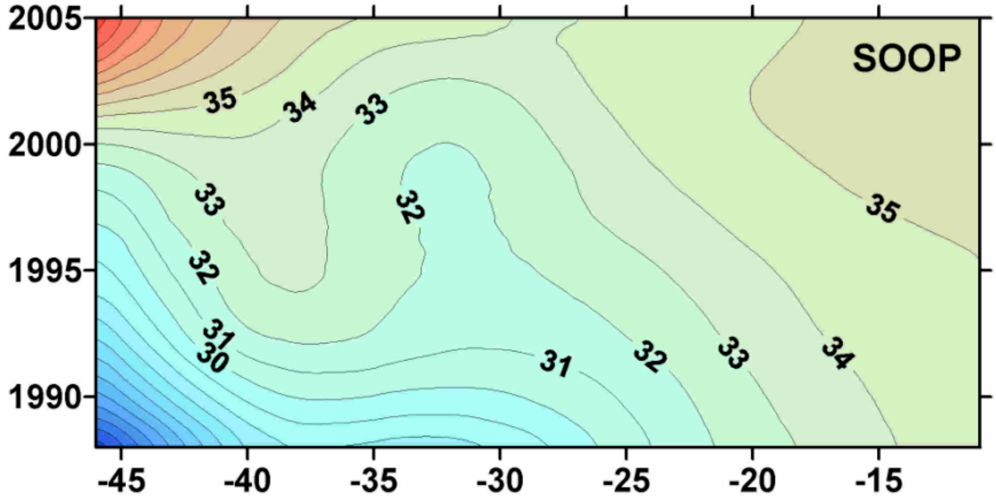

Figure 18. Mean heat content [GJ/m^2] along the 48°N SOOP XBT section.

Annex 9: Environment Conditions on the Newfoundland and Labrador Shelf during 2007 (ICES Area 2)

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ABSTRACT

Oceanographic observations on the Newfoundland and Labrador Shelf during 2007 are presented in relation to their long-term (1971–2000) means. At Station 27 off St. John's, the depth-averaged annual water temperature decreased from the record high observed in 2006 to about normal. Annual surface temperatures at Station 27 also decreased from the 61-year record of 1.7°C above normal in 2006 to 0.2°C above normal in 2007. Bottom temperatures decreased from 0.8°C above normal in 2006 to 0.4°C above normal in 2007. Annual surface temperatures on Hamilton Bank and the Flemish Cap were 0.5°C above normal and on St. Pierre Bank they were about normal. Upper-layer salinities at Station 27 were above normal for the 6th consecutive year. The area of the Cold-Intermediate-Layer (CIL) water mass on the eastern Newfoundland Shelf during 2007 was below normal for the 13th consecutive year and the 14th lowest since 1948. Bottom temperatures during the spring of 2007 remained above normal on the Grand Banks but were below normal on St. Pierre Bank. During the fall they were significantly above normal in NAFO Div. 2J and 3K and most of 3L, but were below normal in the shallow areas of 3NO. The area of bottom habitat on the Grand Banks covered by sub-zero water decreased from >50% during the first half of the 1990s to near 15% during 2004–2006 but increased to near-normal at about 30% in 2007. In general, water temperatures on the Newfoundland and Labrador Shelf decreased from 2006 values but remained above normal in most areas. Notable exceptions were on St. Pierre Bank during spring where temperatures were below normal and in northern areas of NAFO Div. 2J and 3K where bottom temperatures were significantly above normal during the fall of 2007.

INTRODUCTION

Meteorological and oceanographic conditions during 2007 are presented referenced to a standardised base period from 1971–2000 where the data permit. The data were collected by a number of researchers in Canada and compiled into time-series for the standard sections and stations. Recognising the usefulness of standard oceanographic indices for monitoring ocean climate variability the Canadian Department of Fisheries and Oceans started occupying a series of cross-shelf hydrographic sections and stations beginning in the late 1940s. In 1976 the International Commission for the Northwest Atlantic Fisheries (ICNAF) adopted a suite of standard oceanographic stations along sections in the Northwest Atlantic from Cape Cod (USA) to Egedesminde (West Greenland) (Anon. 1978). Several of these sections are occupied seasonally on oceanographic surveys conducted by the Canadian Department of Fisheries and Oceans (Figure 1a).

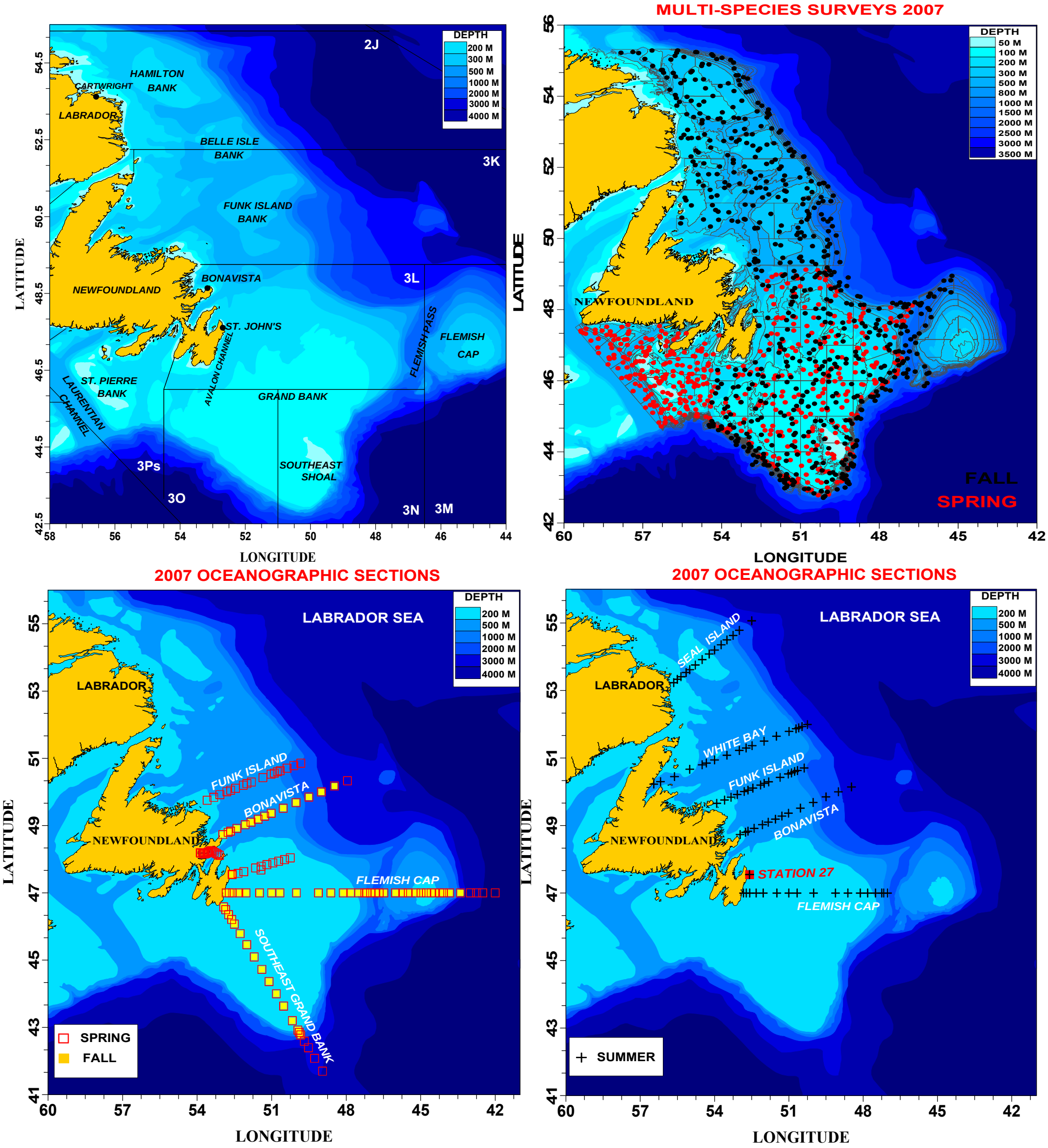


Figure 1a. Maps showing bathymetric features, Station 27, the positions of trawl-mounted CTD profiles obtained from multi-species assessment surveys and standard sections sampled during 2007 on the NL Shelf.

Climate conditions in the northwest Atlantic are largely determined by the strength of the winter atmospheric circulation (Colbourne *et al.*, 1994; Drinkwater 1996). In general, when the normal cyclonic circulation is weak during the winter months, usually corresponding to a negative NAO index, warm-saline ocean conditions predominate and conversely when the NAO is positive. Water properties on the Newfoundland and Labrador Shelf are influenced by several factors including the Labrador Current (Figure 1b), cross-shelf exchange with warmer continental slope water and bottom topography. Superimposed on these oceanic processes are large seasonal and inter-annual variations in solar heat input, ice cover and storm-forced mixing. The resulting water mass on the shelf is characterised by large annual cycles with strong horizontal and vertical temperature and salinity gradients that exhibit significant inter-annual variations.

This manuscript presents an overview of the physical oceanographic environment in the Newfoundland and Labrador (NL) Region during 2007, in relation to long-term average conditions based on historical data. The information presented for 2007 is derived from three principal sources; (1) observations made at the fixed AZMP site (Station 27, Figure 1a) throughout the year from all research and assessment surveys, (2) measurements made along standard NAFO and AZMP cross-shelf sections from seasonal oceanographic surveys and (3) oceanographic observations made during spring and fall multi-species resource assessment surveys (Figure 1a). Data from other research surveys and ships of opportunity are also used to help define the long-term means and conditions during 2007. These data are available from archives at the Fisheries and Oceans Integrated Scientific Data Management (ISDM) Branch in Ottawa and maintained in regional databases at the Bedford Institute of Oceanography (BIO) in Dartmouth, Nova Scotia and at the Northwest Atlantic Fisheries Centre (NAFC) in St. John's Newfoundland.

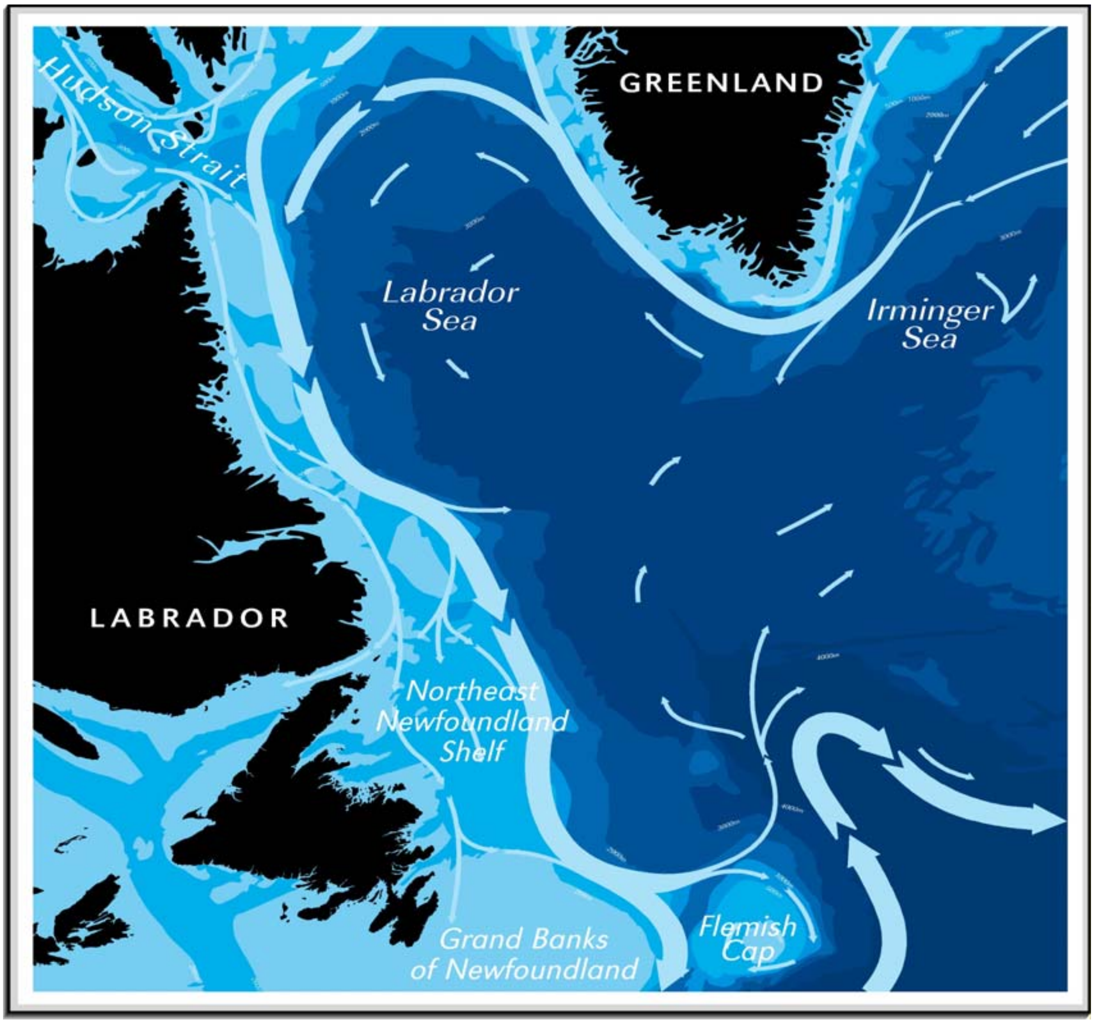


Figure 1b. Map showing the general circulation features of the Northwest Atlantic. The Labrador Current is shown as two separate branches, the strongest flowing south eastward along the Labrador and Newfoundland Shelf and a weaker inshore component.

Time series of temperature and salinity anomalies and other derived climate indices were constructed by removing the annual cycle computed over the standard base period. It is recognized that monthly and annual estimates of anomalies that are based on a varying number of observations may only approximate actual conditions;

caution therefore should be used when interpreting short time scale features of many of these indices. 'Normal' is defined here as the average over the base period. For shorter time-series the base period included data up to 2006. Annual or seasonal anomalies were normalized by dividing the values by the standard deviation of the data time-series over the indicated base periods, usually 1971–2000 if the data permit. A value of 2 for example indicates that the index was 2 standard deviations higher than its long-term average. As a general guide, anomalies within ±0.5 standard deviations in most cases are not considered to be significantly different from the long-term mean. Normalized water property time-series and derived ocean climate indices from fixed locations and standard sections sampled in the Newfoundland and Labrador region during 2007 are presented as coloured cells with gradations of 0.5 standard deviations (SD) and summarized in tables. Blues represent cold-fresh environmental conditions and reds warm-salty conditions (Table 1). In some instances (NAO, ice and water mass areas or volumes for example) negative anomalies indicate warm conditions and hence are coloured red. More details on oceanographic monitoring programs, data analysis and long-term trends in the environment are presented in Colbourne *et al*. (2005).

Table 1. Standardized anomalies colour coding scale in units of 0.5 standard deviations.

			←	COLD/FRESH		WARM/SALTY		→			
<-2.5	-2.5 to -2.0	-2 to -1.5	-1.5 to -1.0	-1.0 to -0.5	-0.5 to 0.0	0.0 to 0.5	0.5 to 1.0	1.0 to 1.5	1.5 to 2	2.0 to 2.5	>2.5
🟦	🟦	🟦	🟦	🟦	🟦	🟥	🟥	🟥	🟥	🟥	🟥

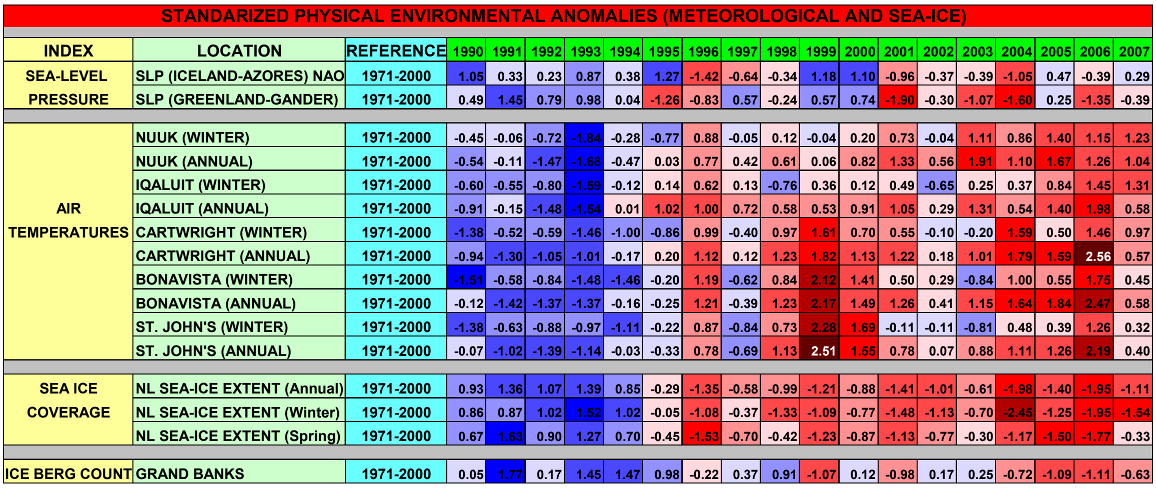
Meteorological and Sea-Ice Conditions

The North Atlantic Oscillation (NAO) Index as defined by Rogers (1984) is the difference in winter (December, January and February) sea level atmospheric pressures between the Azores and Iceland and is a measure of the strength of the winter westerly and northwesterly winds over the Northwest Atlantic. A high NAO index results from an intensification of the Icelandic Low and Azores High. In most years this creates strong northwest winds, cold air and sea temperatures and heavy ice conditions on the NL Shelf regions. During both 1999 and 2000 the NAO was well above normal. However, the colder-than-normal winter conditions usually associated with high NAO values did not extend into this region due to shifting anomalies in the sea level pressure (SLP) fields. The NAO index for 2001 to 2004 was below normal indicating a reduced Arctic outflow to the Northwest Atlantic during the winter months. In 2005, the index was slightly above normal whereas in 2006, it was slightly below normal and in both cases, the spatial patterns in the SLP fields during the winter months resulted in very weak northwesterly winds over the Newfoundland and Labrador area. In 2007 the index returned to slightly above normal, indicating slightly colder conditions. The difference in SLP between Nuuk in West Greenland and Gander NL show similar patterns and correlation with local ocean conditions on the NL Shelf (Table 2).

Air temperature anomalies at five sites in the Northwest Atlantic, Nuuk Greenland, Iqaluit Baffin Island, Cartwright Labrador, Bonavista and St. John's Newfoundland are also shown in Table 2. The predominance of warmer-than-normal annual air temperatures at all sites from the mid-1990s to 2007 is evident, with 2006 annual and seasonal values ranging from 1–2 standard deviations (SD) above normal with some cooling noted for 2007. Annual temperature at Cartwright on the mid-Labrador Coast broke a 73-year record at 2.6 SD above normal in 2006, but was only slightly above 0.5 SD in 2007. Other recent extremes included 1999 which saw the second highest air temperatures at Cartwright (1.8 SD above normal) and a 126 year record at St. John's (2.5 SD above normal). The coldest overall air temperatures in the Northwest Atlantic since the early 1990s occurred in 1993, when the annual anomalies were all at least 1 SD below normal.

The spatial extent and concentration of sea ice are available from the daily ice charts published by the Canadian Ice Service of Environment Canada. The time-series of the sea-ice extent (defined by 1/10 coverage) on the NL Shelf (between 45°-55°N) show lower than normal areas covered by ice during 2007 for the 13th consecutive year (Table 2). The spring of 2006 had the lowest extent of sea-ice on the NL Shelf since record keeping began in 1963, whereas the 2007 spring value was only slightly below the long-term mean. In general, during the past several years, the sea ice season was shorter than normal in most areas of the NL Shelf. For 2007 in contrast, it extended into June, particularly in the inshore areas. Iceberg counts obtained from the International Ice Patrol of the US Coast Guard indicate that 324 icebergs drifted south of 48°N onto the Northern Grand Bank during 2007 compared to 0 in 2006 and 11 in 2005 and the 106-year average of 477. In some years during the cold periods of the early 1980s and 1990s, over 1500 icebergs were observed south of 48°N with an all time record of 2202 in 1984. Years with low iceberg numbers on the Grand Banks generally correspond to warmer than normal meteorological and oceanographic conditions on the NL Shelf. A more extensive analysis of meteorological, sea ice and sea-surface temperature data in the Northwest Atlantic, including the Newfoundland and Labrador Shelf, are presented by Petrie *et al*. (2008).

Table 2. Atmospheric and ice standardized anomalies from several locations in the Northwest Atlantic during 1990 to 2007. The anomalies are normalized with respect to their standard deviations over the indicated base period.



STANDARIZED PHYSICAL ENVIRONMENTAL ANOMALIES (METEOROLOGICAL AND SEA-ICE)

INDEX	LOCATION	REFERENCE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SEA-LEVEL PRESSURE	SLP (ICELAND-AZORES) NAO	1971-2000	1.05	0.33	0.23	0.87	0.38	1.27	-1.42	-0.64	-0.34	1.18	1.10	-0.96	-0.37	-0.39	-1.05	0.47	-0.39	0.29
	SLP (GREENLAND-GANDER)	1971-2000	0.49	1.45	0.79	0.98	0.04	-1.26	-0.83	0.57	-0.24	0.57	0.74	-1.90	-0.30	-1.07	-1.60	0.25	-1.35	-0.39
AIR TEMPERATURES	NUUK (WINTER)	1971-2000	-0.45	-0.06	-0.72	-1.84	-0.28	-0.77	0.88	-0.05	0.12	-0.04	0.20	0.73	-0.04	1.11	0.86	1.40	1.15	1.23
	NUUK (ANNUAL)	1971-2000	-0.54	-0.11	-1.47	-1.68	-0.47	0.03	0.77	0.42	0.61	0.06	0.82	1.33	0.56	1.91	1.10	1.67	1.26	1.04
	IQALUIT (WINTER)	1971-2000	-0.60	-0.55	-0.80	-1.59	-0.12	0.14	0.62	0.13	-0.76	0.36	0.12	0.49	-0.65	0.25	0.37	0.84	1.45	1.31
	IQALUIT (ANNUAL)	1971-2000	-0.91	-0.15	-1.48	-1.54	0.01	1.02	1.00	0.72	0.58	0.53	0.91	1.05	0.29	1.31	0.54	1.40	1.98	0.58
	CARTWRIGHT (WINTER)	1971-2000	-1.38	-0.52	-0.59	-1.46	-1.00	-0.86	0.99	-0.40	0.97	1.61	0.70	0.55	-0.10	-0.20	1.59	0.50	1.46	0.97
	CARTWRIGHT (ANNUAL)	1971-2000	-0.94	-1.30	-1.05	-1.01	-0.17	0.20	1.12	0.12	1.23	1.82	1.13	1.22	0.18	1.01	1.79	1.59	2.56	0.57
	BONAVISTA (WINTER)	1971-2000	-1.51	-0.58	-0.84	-1.48	-1.46	-0.20	1.19	-0.62	0.84	2.12	1.41	0.50	0.29	-0.84	1.00	0.55	1.75	0.45
	BONAVISTA (ANNUAL)	1971-2000	-0.12	-1.42	-1.37	-1.37	-0.16	-0.25	1.21	-0.39	1.23	2.17	1.49	1.26	0.41	1.15	1.64	1.84	2.47	0.58
	ST. JOHN'S (WINTER)	1971-2000	-1.38	-0.63	-0.88	-0.97	-1.11	-0.22	0.87	-0.84	0.73	2.28	1.69	-0.11	-0.11	-0.81	0.48	0.39	1.26	0.32
	ST. JOHN'S (ANNUAL)	1971-2000	-0.07	-1.02	-1.39	-1.14	-0.03	-0.33	0.78	-0.69	1.13	2.51	1.55	0.78	0.07	0.88	1.11	1.26	2.19	0.40
SEA ICE COVERAGE	NL SEA-ICE EXTENT (Annual)	1971-2000	0.93	1.36	1.07	1.39	0.85	-0.29	-1.35	-0.58	-0.99	-1.21	-0.88	-1.41	-1.01	-0.61	-1.98	-1.40	-1.95	-1.11
	NL SEA-ICE EXTENT (Winter)	1971-2000	0.86	0.87	1.02	1.52	1.02	-0.05	-1.08	-0.37	-1.33	-1.09	-0.77	-1.48	-1.13	-0.70	-2.45	-1.25	-1.95	-1.54
	NL SEA-ICE EXTENT (Spring)	1971-2000	0.67	1.63	0.90	1.27	0.70	-0.45	-1.53	-0.70	-0.42	-1.23	-0.87	-1.13	-0.77	-0.30	-1.17	-1.50	-1.77	-0.33
ICE BERG COUNT	GRAND BANKS	1971-2000	0.05	1.77	0.17	1.45	1.47	0.98	-0.22	0.37	0.91	-1.07	0.12	-0.98	0.17	0.25	-0.72	-1.09	-1.11	-0.63

Time Trends in Temperature and Salinity

Station 27, located in the Avalon Channel off Cape Spear NL (Figure 1), was sampled 54 times (48 CTD profiles, 6 XBT profiles) during 2007. Depth versus time contours of the annual temperature cycle and the corresponding anomalies for 2007 are displayed in Figure 2. The cold, near-isothermal water column during late January to late April has temperatures ranging from near 0° to –1.5°C. These temperature persisted throughout the year below 100 m. Upper layer temperatures warmed to >1°C by mid-May and to >14°C by late August, after which the fall cooling commenced with temperatures decreasing to 2°C by the end of December. The seasonally heated upper-layer was limited to only about 30 m depth by the end of the summer but increased to about 90 m during the fall months. This resulted in a significant sub-surface cold anomaly during the summer months with temperatures reaching as much as 4°C below normal.

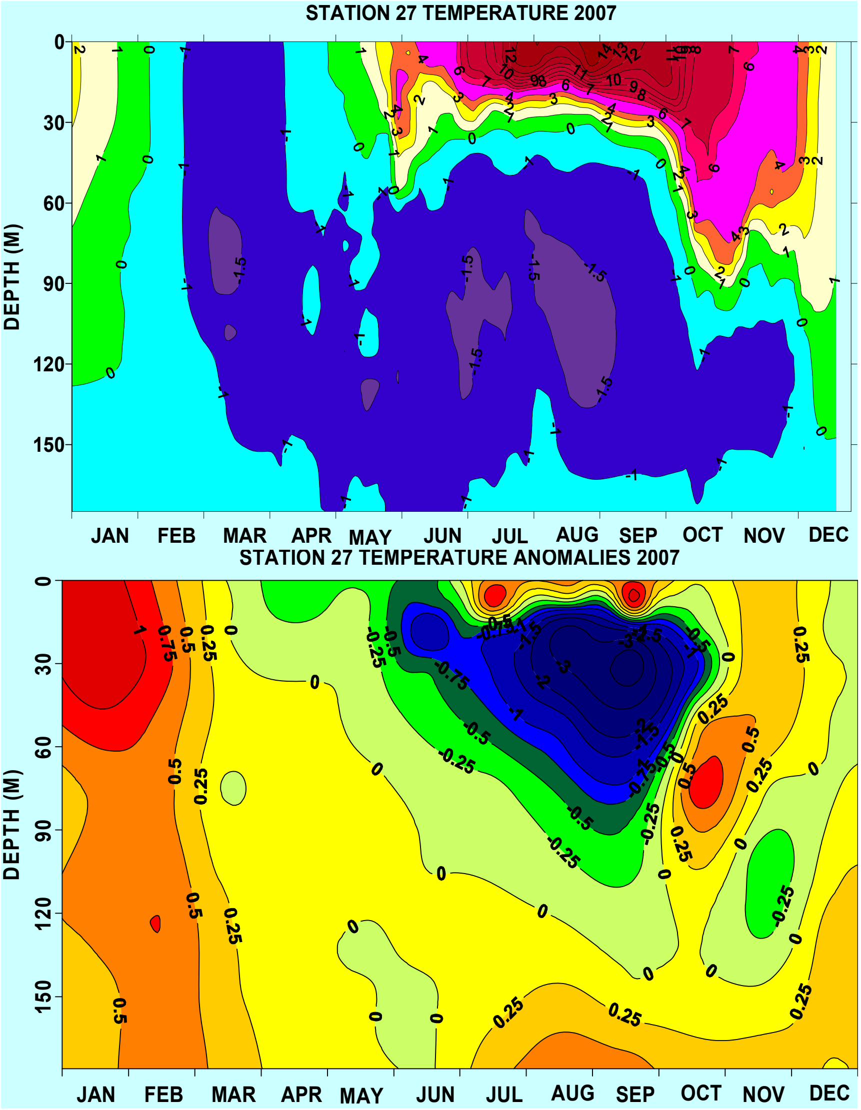


Figure 2. Contours of temperature and temperature anomalies (in °C) as a function of depth at Station 27 for 2007.

In general, Station 27 temperatures were below normal from 1990 to 1995, reaching minimum values in 1991 when they dipped to 2–3 SD below normal (Table 3). Bottom temperatures have remained above normal for the past 12 years but have decreased from the 3rd highest rank in 2006 (2.7 SD) to 16th highest (+1.2 SD) in 2007. The annual surface temperatures at Station 27 have been above normal since 2002, reaching a 61-year high of 3.2 SD above their long-term mean in 2006 but decreased to <0.5 SD above normal in 2007. Vertically averaged values over various depths also set record highs >3 SD above normal in 2006 but decreased to below normal values at other depths in 2007 (Table 3). At other locations, (Hamilton Bank, Flemish Cap and St. Pierre Bank) surface temperatures remained above normal in 2007 but decreased significantly from the 2006 values. On St. Pierre Bank, near-bottom temperatures decreased to 0.7 SD below normal Temperature data obtained from thermographs deployed at inshore sites at 10-m depth show considerable variability about the mean due to local wind driven effects. In general however, they show similar patterns, with mostly below normal anomalies during the first half of the 1990s and above normal during the latter half up to 2006. In 2007, 5 out of the 6 sites with data reported significant negative anomalies (Table 3).

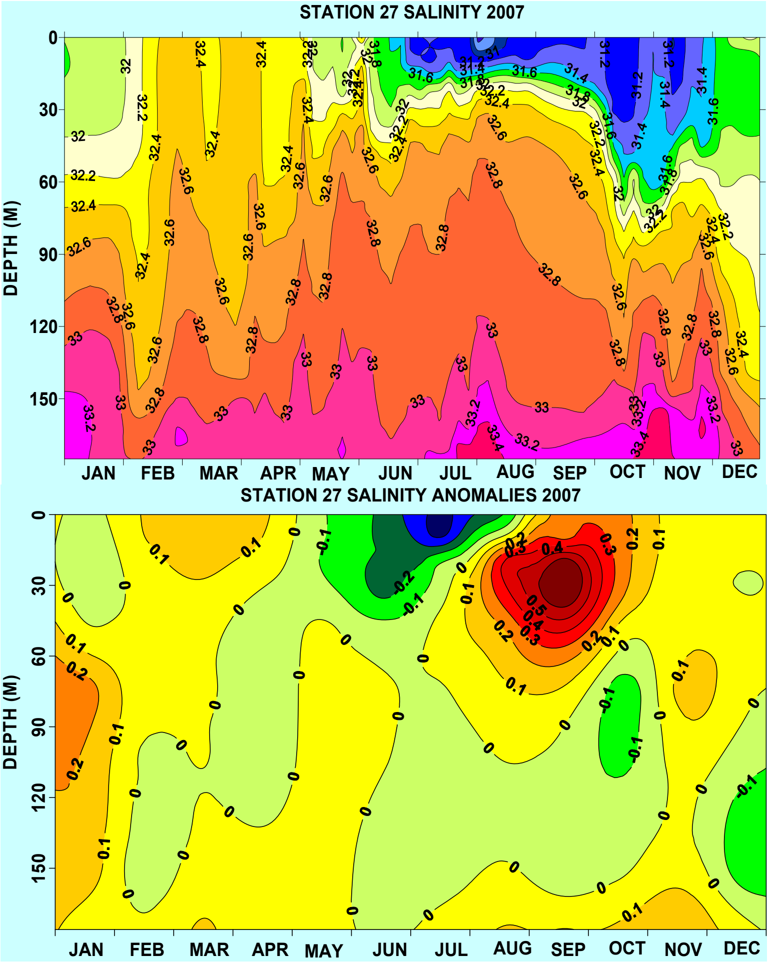


Figure 3. Contours of salinities and salinity anomalies as a function of depth at Station 27 for 2007.

Depth versus time contours of the annual salinity cycle and the corresponding anomalies for 2007 are displayed in Figure 3. Surface salinities reached maximum values in late winter and early spring (>32.4) and decreased to minimum values by early August (<31). From 50–100-m, salinities ranged from 32.2 – 32.8; near bottom they varied throughout the year between 33 and 33.4. The period of low, near-surface salinity values occurred from early summer to late fall, somewhat earlier than usual. This prominent feature of the salinity cycle on the Newfoundland Shelf is due largely to the melting of sea-ice off the coast of Labrador earlier in the year followed by advection southward onto the Grand Banks. Annual surface salinities at Station 27 decreased from the pervious 5 years to about normal in 2007. The depth averaged values decreased from 2006 but remained slightly above normal. Upper-layer salinities during the past 6 years have ranged from near-normal to saltier-than-normal in contrast to the mainly fresher-than-normal values that dominated most of the 1990s (Table 3).

Table 3. Water property anomalies and ocean climate indices derived from temperature and salinity data collected on the Newfoundland and Labrador Shelf. The anomalies are normalized with respect to their standard deviations over the indicated base period. The grey shaded cells indicate no data.

STANDARIZED PHYSICAL ENVIRONMENTAL ANOMALIES (FIXED SITES)

INDEX	LOCATION	REFERENCE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SURFACE TEMPERATURE	HAMILTON BANK	1971-2000	0.38	-0.87	-0.56	0.34	0.15	-0.19	-0.52	0.12	2.82	-0.01	1.75	0.05	-0.23	2.50	2.03	2.73	1.43	0.67
	FLEMISH CAP	1971-2000	-0.51	-1.30	-1.54	-1.66	-0.73	0.01	0.17	0.32	2.50	0.13	0.85	0.48	-0.66	0.20	0.53	1.97	2.29	0.44
	STATION 27	1971-2000	0.05	-2.49	-1.40	-1.37	0.32	-0.60	0.32	-0.39	0.86	1.81	1.15	0.92	-0.08	1.34	2.00	2.00	3.22	0.43
	ST. PIERRE BANK	1971-2000	-1.81	-0.01	-1.24	-0.40	-0.72	0.74	0.39	-0.41	1.13	1.21	1.51	-0.82	-0.08	-0.43	0.44	2.85	2.79	0.09
SURFACE SALINITY	HAMILTON BANK	1971-2000	-0.40	0.07	-0.29	-1.06	-1.01	0.74	0.56	1.04	-0.21	-0.46	-0.06	0.13	-0.51	-0.35	-0.09	0.73	0.02	-1.40
	FLEMISH CAP	1971-2000	0.75	0.47		0.00	-1.38	0.80	0.60	1.14	-0.06	0.82	-0.29	1.26	1.49	2.27	1.46	1.20	0.56	1.36
	STATION 27	1971-2000	1.48	-1.85	-0.96	-0.04	-0.33	-1.82	0.22	-0.26	-0.29	-0.37	-0.23	-0.56	1.06	1.01	0.58	0.44	0.65	0.00
BOTTOM TEMPERATURE	STATION 27	1971-2000	-0.76	-1.42	-0.95	-1.37	-1.16	-0.38	1.24	0.83	1.36	1.43	1.31	1.50	0.60	0.63	2.95	2.65	2.70	1.23
	FLEMISH CAP	1971-2000	-2.30	-1.02	-0.66	-0.41	-2.59	-0.51	-0.48	-0.11	0.82	1.78	0.36	-0.16	0.11	0.84	1.08	2.12	1.40	0.18
	HAMILTON BANK	1971-2000	-1.19	-0.45	-0.96	-1.29	-0.64	0.49	0.67	1.71	0.65	1.56	0.28	1.79	1.72	1.19	2.25	1.86	0.66	1.82
	ST. PIERRE BANK	1971-2000	-1.26	0.20	-0.47	-0.69	-1.78	-1.07	-0.21	-0.21	-0.61	0.67	0.70	-0.53	-0.62	-1.11	1.29	2.91	1.70	-0.70
VERTICALLY AVERAGED TEMPERATURE	STATION 27 (0-20 M)	1971-2000	0.26	-2.40	-1.10	-1.22	0.62	-0.31	0.67	-0.10	1.00	2.10	1.00	1.25	0.18	1.53	2.11	1.97	3.46	0.52
	STATION 27 (0-50 M)	1971-2000	-0.18	-3.04	-0.57	-0.54	0.63	-0.13	1.62	0.03	0.18	1.26	0.95	1.73	-0.11	1.48	1.96	1.94	3.91	-0.88
	STATION 27 (0-100 M)	1971-2000	0.20	-2.71	-0.59	-0.89	0.59	-0.34	2.24	-0.33	-0.28	1.23	0.87	1.12	0.56	1.30	2.61	1.89	3.21	-0.38
	STATION 27 (0-175 M)	1971-2000	-0.13	-2.46	-0.69	-1.04	0.16	-0.40	2.47	-0.05	-0.05	1.18	1.14	1.25	0.68	1.18	2.95	1.98	3.27	0.01
	ST. PIERRE BANK (0-75 M)	1971-2000	-2.46	0.45	-0.26	-0.87	-1.47	-1.27	-0.49	-1.01	-0.36	1.94	0.75	-0.65	-0.14	-0.59	0.31	2.66	1.33	-0.65
VERTICALLY AVERAGED SALINITY	STATION 27 (0-20 M)	1971-2000	1.57	-1.81	-0.95	0.02	-0.26	-1.77	0.17	-0.31	-0.24	-0.35	-0.19	-0.62	1.10	1.08	0.61	0.48	0.66	0.08
	STATION 27 (0-50 M)	1971-2000	1.82	-0.88	-1.34	-0.38	-1.14	-1.72	-0.07	0.32	0.32	-0.44	0.43	-0.88	1.15	0.52	0.93	0.99	0.91	0.97
	STATION 27 (0-100 M)	1971-2000	1.91	-1.37	-1.57	-0.07	-0.63	-1.00	-0.74	0.16	0.08	-0.32	-0.71	-0.78	0.77	0.85	-0.31	0.01	0.77	0.44
	STATION 27 (0-175 M)	1971-2000	1.61	-1.41	-1.54	0.15	-0.63	-0.65	-1.07	0.08	0.16	-0.32	-0.50	-0.90	0.49	0.29	-0.49	-0.10	0.77	0.36
MIXED-LAYER	STATION 27 (WINTER)	1990-2006	-0.87	-1.18	-0.93	-1.01	1.13	-0.96	0.66	0.48	-0.88	-0.28	-0.99	0.51	0.71	-0.42	1.64	0.57	1.82	0.04
MIXED-LAYER	STATION 27 (ANNUAL)	1990-2006	-1.04	-1.45	0.08	-0.08	1.16	-1.72	0.60	-0.67	-0.32	-0.21	-0.57	0.44	1.21	-0.32	2.27	0.06	0.57	1.17
MIXED-LAYER	STATION 27 (SPRING)	1990-2006	-0.71	-0.79	-0.09	-0.10	0.45	-1.23	-0.43	-1.22	1.67	-1.13	-0.09	1.08	1.00	0.07	2.19	-0.63	-0.02	1.54
STRATIFICATION	STATION 27 (ANNUAL)	1971-2000	-0.92	0.07	-0.11	-0.79	-0.12	1.55	-1.09	0.56	1.22	1.44	0.68	1.44	-0.17	0.03	-0.35	0.27	1.36	0.69
STRATIFICATION	STATION 27 (SPRING)	1971-2000	-1.31	-0.63	-0.93	-0.22	-0.51	1.60	-0.75	0.05	0.92	0.73	-0.22	0.02	-0.91	-0.89	-0.28	0.21	0.57	0.09
STRAT ONSET	ONSET (25% OF MAX)	1993-2006				-0.46	0.77	-2.10	0.50	-1.01	-1.01	-0.46	0.63	0.22	0.91	0.91	1.09	0.36	0.04	-0.46
STRAT PHASE	TIME OF MAX AMPLITUDE	1993-2006				0.48	0.23	-1.35	1.72	-0.43	-1.10	-1.35	0.56	-0.60	0.39	1.39	0.06	0.64	0.64	-1.34
10 M TEMPERATURE	STOCK COVE BB	1971-2000	0.44	-1.73	-0.36	-1.76	0.98	0.09	0.53	-0.70	0.96	0.90	1.18	1.33	1.08	1.32	1.05	1.44	1.81	-0.80
10 M TEMPERATURE	COMFORT COVE NDB	1982-2004	1.14	-1.98	-0.73	-1.75	0.11	-1.07	0.77	-0.62	-0.11	0.92	1.08		0.70	0.82		0.38	-0.02	
10 M TEMPERATURE	ARNOLDS COVE PB	1981-2006	0.75	-1.95	-1.32	-1.51	0.50	-0.75	0.66	-0.33	0.50	2.29	0.97	0.45	0.53	1.04	-0.19	0.37	1.12	0.58
5 M TEMPERATURE	BRISTOL'S HOPE	1989-2006	-0.70	-2.94		-0.64	0.52	0.02	0.10	-0.06	-0.66	1.03	0.71	0.66	0.06	0.91	0.25	0.87	0.95	-0.62
9 M TEMPERATURE	HAMPDEN WB	1992-2006			-0.41	0.18	-1.43	-2.09	-0.37	-0.86	0.40	0.18	1.36	-0.87	0.54	0.30	0.80	0.89	1.38	-0.63
10 M TEMPERATURE	OLD BONAVENTURE	1991-2006		-1.91	-1.25	-1.12	1.95	0.05	0.50	-0.14		-0.59	-0.03	1.14	0.24	0.08	-0.54	0.52	1.09	-2.38
10 M TEMPERATURE	UPPER GULLIES CB	1990-2004	-1.47	-1.59	0.80	-0.54	0.15	0.25	-1.11	-0.20	-1.29	1.38	-0.33	0.00	0.24	0.92	-0.18	1.44	1.52	-2.49

On the Flemish Cap, surface salinities were higher than normal during 2007, while on Hamilton Bank they were below normal. Salinities on the Flemish Cap have been above normal from 2001 to 2007. During the past several decades, cold ocean temperatures and fresher-than-normal waters were associated with strong positive NAO anomalies, colder-than-normal winter air temperatures, and heavy sea-ice conditions on the continental shelf (Colbourne *et al.*, 1994; Drinkwater 1996). The magnitude of negative salinity anomalies (up to 1.8 SD) on the inner Newfoundland Shelf during most of the early 1990s is comparable to that experienced during the 'Great Salinity Anomaly' of the early 1970s (Dickson *et al.*, 1988), however, the spatial extent of the fresh water was mainly restricted to the inner Newfoundland Shelf.

The stratification index, defined as the density gradient between 0 and 50 m, i.e. $\Delta\rho/\Delta z$ was computed from temperature and salinity data collected at Station 27. The annual average stratification index was generally below normal in the early 1990s, increased to above normal from 1997–2001, varied about the mean from 2002 to 2005 increased to 1.4 SD above normal in 2006 and continued slightly above normal in 2007. The spring values show similar patterns, however they were significantly below normal in 2002 and 2003. Both the time of the spring onset of stratification and of its maximum amplitude were slightly later than normal from 2000 to 2006 but earlier than normal in 2007. The mixed layer depth (MLD), estimated as the depth of maximum density gradient is highly variable on the inner NL Shelf. During 2004 the annual averaged MLD was significantly (>2 SD) deeper than normal but shoaled to near normal depths during 2005 and deepened again in 2006 and 2007. Spring values were slightly shallower than normal in 2005 and 2006 but also deeper than normal in 2007 (Table 3).

Standard Sections

Beginning in the early 1950s several countries of the International Commission for the Northwest Atlantic Fisheries (ICNAF) carried out systematic monitoring along sections in Newfoundland and Labrador Waters. In 1976, ICNAF standardized a suite of oceanographic monitoring stations along sections in the Northwest Atlantic Ocean from Cape Cod (USA) to Egedesminde (West Greenland) (ICNAF 1978). Beginning in 1998 under the AZMP program, the Bonavista and Flemish Cap sections are occupied during the spring, summer and fall and a section crossing the Southeast Grand Bank was added to the spring and fall monitoring surveys. In 2007, the Southeast Grand Bank section was sampled during April and December, the Flemish Cap section during April, and November, the Bonavista section during April, August and November and the White Bay and Seal Island sections during August (Figure 1).

The water mass characteristics observed along the standard sections crossing the Newfoundland and Labrador Shelf (Figure 1) are typical of sub-polar waters with a sub-surface temperature range on the shelf of -1° - 2°C and salinities of 32–33.5. Labrador Slope Water flows southward along the shelf edge and into the Flemish Pass region, this water mass is generally warmer and saltier than the sub-polar shelf waters with a temperature range of 3^o – 4^oC and salinities in the range of 34 – 34.75. Surface temperatures normally warm to 10^o – 12^oC during late summer, while bottom temperatures remain <0^oC over much of the Grand Banks but increase to 1^o – 3.5^oC near the shelf edge below 200 m and in the deep troughs between the banks. In the deeper (>1000 m) waters of the Flemish Pass and across the Flemish Cap, bottom temperatures generally range from 3^o – 4^oC. In general, the water mass characteristics encountered along the standard sections undergo seasonal modification due to the seasonal cycles of air-sea heat flux, wind forced mixing and ice formation and melt which leads to intense vertical and horizontal gradients, particularly along the frontal boundaries separating the shelf and slope water masses.

Throughout most of the year, the cold, relatively fresh water overlying the shelf is separated from the warmer higher density water of the continental slope region by a strong temperature and density front (Figure 4). This winter formed shelf water mass is commonly referred to as the cold intermediate layer or CIL (Petrie *et al*. 1988) and its area or volume bounded by the 0^oC isotherm is generally regarded as a robust index of ocean climate conditions off the eastern Canadian continental shelf. While the area of the CIL water mass undergoes significant annual variability, the changes are highly coherent from the Labrador Shelf to the Grand Banks. This shelf water mass remains present throughout most of the year as summer heating and salinity changes increases the stratification in the upper layers to a point where heat transfer to the lower layers is inhibited, although it continues to undergo a gradual decay during late summer reaching a minimum in late fall, due mainly to wind forced mixing. The seasonal variation in the cross-sectional area of this winter-chilled water mass is evident in the contour plots of the temperature along the Bonavista section in 2007 (Figure 4). The area of the cold water extended to the surface during April, was below normal in the summer and was at a minimum at mid-depths by late November of 2007. Seasonal cross sections of salinity for 2007 show remarkable similarities from spring to fall with slightly fresher upper-layer inshore values occurring during the summer and fall (Figure 4).

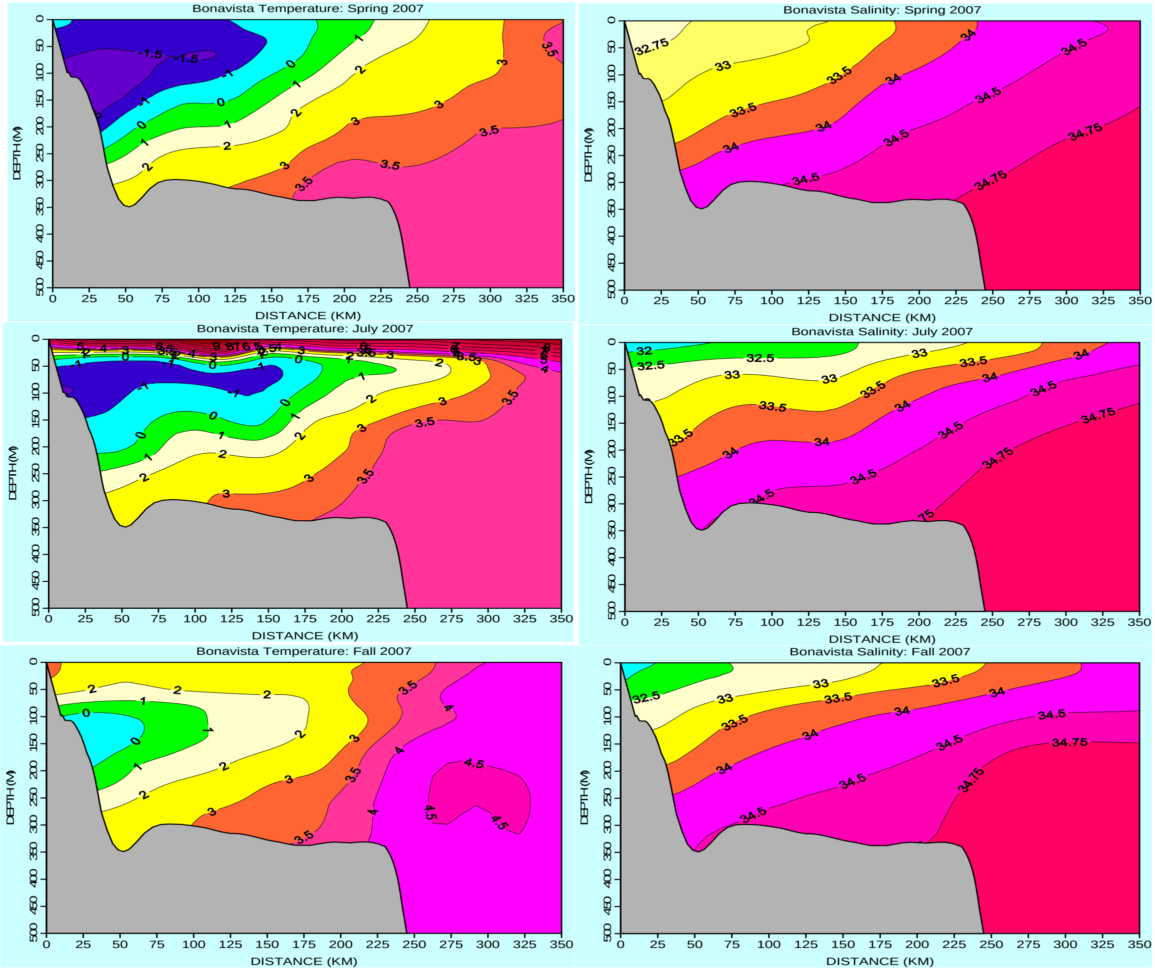


Figure 4. Contours of temperature (°C) and salinity across the Newfoundland Shelf along the Bonavista Section (Figure 1) during the spring, summer and fall of 2007.

Climate indices based on temperature and salinity data collected along sections from southern Labrador to southern Newfoundland are displayed in Table 4 for the years 1990–2007. On the southern Labrador Shelf and south to eastern Newfoundland, temperature and salinity have been increasing since 2000, reaching near-record high values in 2004 and continuing warm and salty during 2005–2007. From 1990 to 1994, conditions were significantly below normal in these areas. Farther south on the Grand Bank and St. Pierre Bank, conditions have been more variable with near-record cold conditions during the spring of 2003. During 2004 to 2006 however, ocean conditions in this area have also become generally warmer and saltier than normal, although the magnitude of the anomalies are lower than those observed farther north. In 2007, a slight cooling was evident particularly along the southeast Grand Bank and St. Pierre Bank sections.

In 2007, the CIL areas along most sections during spring, summer and fall were below normal, implying warmer-than-normal water temperatures on the continental shelf. The exceptions were the three southern sections during the spring. Summer sections are common to four areas. Along the Bonavista section, the summer CIL area was below normal for the 13th consecutive year (1995–2007) ranking 14th lowest in the 59 year time-series. The summer CIL area expanded in 2007 compared with the previous three years which were among the smallest on record. The overall average temperature along the Bonavista section also decreased from >2 SD in the previous three years to 1.3 SD above normal in 2007.

On the Grand Bank along the 47°N section, the summer CIL area was below normal for the tenth consecutive year (1998–2007) and along the southeast Grand Bank section the spring CIL area was above normal after the record low value of the spring of 2006. On St. Pierre Bank the spring CIL area decreased sharply during 2004 and 2005 from the record high value during the cold spring of 2003. No data were available for 2006 and by the spring of 2007 the CIL area was once again above normal. Salinities continued to be above normal along all sections sampled in 2006 and 2007. The baroclinic transport in the offshore branch of the Labrador Current was above normal during 2007 off southern Labrador and off the Grand Bank through the Flemish Pass, continuing an 8-year trend. Along the Bonavista Section however, where a significant component of the flow is in the offshore direction, there are no apparent patterns in the estimates of transport in recent years with 2006 and 2007 showing a below normal estimate.

Multi-Species Survey Results

Canada has been conducting stratified random bottom trawl surveys in NAFO Sub-areas 2 and 3 on the NL Shelf since 1971. Areas within each division, with a selected depth range, were divided into strata and the number of fishing stations in an individual stratum was based on an area-weighted proportional allocation (Doubleday 1981). Temperature profiles are available for fishing sets in each stratum and since 1989, trawl-mounted CTDs have provided profiles of salinity. These surveys provide 2 large spatial-scale oceanographic data sets annually for the Newfoundland Shelf, one during the spring from 3Pn in the west to 3LNO on the Grand Bank and one during the fall from 2J in the north to 3NO in the south. The hydrographic data collected on the surveys are now routinely used to assess the spatial and temporal variability in the thermal habitat of several fish and invertebrate species. A number of data products based on these data are used to characterize the oceanographic habitat. Among these are contoured maps of the bottom temperatures and their anomalies, the area of the bottom covered by water in various temperature ranges a 'thermal habitat' index, spatial variability in the volume of the cold intermediate layer and water-column stratification and mixed-layer depth spatial maps. In this section, an analysis of the near-bottom temperature fields and their anomalies based on these data sets are presented for the spring and fall surveys.

Spring Conditions

Maps of bottom temperatures and their anomalies during the spring of 2007 are displayed in Figure 5 for NAFO Div. 3LNO. Spring bottom temperatures in Div. 3L ranged from <0°C to 1°C in the inshore regions of the Avalon Channel and parts of the Grand Bank and from 1° to >3°C at the shelf edge. Over the central and southern areas bottom temperatures ranged from 1°C – 5°C. There was a significant increase in the area of St. Pierre Bank and the Grand Banks covered by water with temperatures

<0°C during the spring of 2007 compared with the previous three years (Figure 5). Bottom temperature anomalies were highly variable with values ranging from 0.8° – 2°C above normal over most of the 3L region and in southern areas of 3NO. In western areas of Div. 3Ps, negative anomalies dominated, particularly in the deeper areas of the Laurentian Channel.

Table 4. Temperature and salinity anomalies and ocean climate indices derived from data collected along standard sections from southern Labrador to southern Newfoundland. The anomalies are normalized with respect to their standard deviations over the indicated base period.

STANDARIZED PHYSICAL ENVIRONMENTAL ANOMALIES (AZMP STANDARD SECTIONS)

REGION/SECTION	INDEX	REFERENCE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
SOUTHERN LABRADOR SEAL ISLAND SECTION (SUMMER)	COLD-INTERMEDIATE-LAYER AREA	1971-2000	1.26	1.36	0.55	0.71	0.61	-1.22	-0.51	-1.46	-0.63	-1.91	0.26	-0.52	-1.07	-0.43	-1.41	-1.09	-0.65	-0.81
	MEAN CIL TEMPERATURE	1971-2000	-1.42	-0.87	-1.11	-1.30	-0.79	1.25	0.27	0.31	0.11	1.13	-0.48	0.62	0.54	-0.09	0.58	1.01	0.42	0.07
	MINIMUM CIL TEMPERATURE	1971-2000	-0.45	-0.71	-0.46	-0.82	-0.18	2.39	0.11	-0.16	0.06	1.48	-0.06	1.42	-0.13	1.08	2.68	1.42	1.53	0.33
	MEAN SECTION TEMPERATURE	1971-2000	-1.74	-1.64	-1.39	-1.32	-0.76	0.66	0.32	1.10	0.95	1.39	0.29	0.54	0.86	1.22	2.32	1.59	1.74	1.30
	MEAN SECTION SALINITY	1971-2000	-0.90	-1.03	1.12	-0.32	-0.58	0.86	-0.32	0.92	0.40	0.99	-0.58	0.40	1.31	0.21	1.51	0.86	0.66	0.34
	INSHORE SHELF SALINITY	1971-2000	0.07	-0.77	0.98	1.05	-0.54	0.71	-0.54	0.67	0.48	1.05	-1.11	0.29	0.67	0.18	0.22	1.21	0.33	0.26
	LABRADOR CURRENT TRANSPORT	1971-2000	0.64	0.84	1.32	-1.54	-0.52	0.43	0.84	0.50	1.18	-0.11	0.98	1.18	1.59	1.46	1.05	1.59	0.98	0.43
NORTHEAST NEWFOUNDLAND WHITE BAY SECTION (SUMMER)	COLD-INTERMEDIATE-LAYER AREA	1977-2000	1.69	0.95	1.02	0.83	0.96	-0.69	-0.10	-0.50	-1.03	-1.10	0.10	-0.64	-0.98	-0.54	-1.90	-1.29	-1.81	-1.09
	MEAN CIL TEMPERATURE	1977-2000	-1.14	-0.54	-0.66	-1.08	-0.42	0.42	0.42	-0.24	0.42	1.55	-0.18	0.66	0.95	0.06	2.45	1.13	1.25	0.48
	MINIMUM CIL TEMPERATURE	1977-2000	-0.41	-0.68	-0.66	-0.94	-0.34	-0.16	0.80	-0.24	-0.20	1.20	0.29	0.15	0.22	0.37	4.65	0.75	2.25	0.52
	MEAN SECTION TEMPERATURE	1977-2000	-1.46	-0.84	-1.65	-1.29	-1.31	0.01	-0.11	1.00	1.22	1.50	0.55	0.53	0.60	1.00	1.92	2.00	2.11	1.48
	MEAN SECTION SALINITY	1977-2000	-1.07	-0.77	-0.66	-0.15	-0.77	0.57	-1.38	1.49	0.77	-0.25	-0.46	0.36	1.49	0.46	1.59	0.98	1.28	1.18
	MEAN SHELF SALINITY	1977-2000	0.17	-0.65	-1.21	0.98	-0.75	0.17	-0.90	1.59	0.07	-1.67	-0.60	0.07	1.19	-0.34	0.88	-0.09	0.93	0.78
EASTERN NEWFOUNDLAND BONAVISTA SECTION	CIL AREA (SPRING)	1977-2000	1.90	1.11	0.55	0.53	1.05	-0.74	-0.44	-0.44	0.14	-0.94	-0.14	-0.90	-0.34	-0.01	-1.02	-1.41	-1.44	-0.61
	CIL AREA (SUMMER)	1971-2000	1.66	1.78	-0.01	0.55	-0.03	-0.99	-0.49	-1.03	-0.35	-0.93	-0.17	-1.24	-0.98	-0.58	-1.72	-1.41	-1.67	-1.03
	CIL AREA (FALL)	1979-2000	1.46	0.45	0.84	1.33	0.92	-0.63	-0.45	-1.17	-0.76	-1.43	-0.19	-0.53	-0.93	-1.17	-1.43	-1.40	0.24	-1.15
	MEAN CIL TEMPERATURE (SUMMER)	1971-2000	-0.95	-1.51	-0.40	-1.09	-0.47	0.71	1.41	-0.40	-1.02	-0.19	0.09	1.34	-0.26	-0.26	1.62	1.48	1.89	0.92
	MINIMUM CIL TEMPERATURE (SUMMER)	1971-2000	-0.41	-0.79	-0.25	-0.78	-0.48	0.19	0.88	-0.06	-0.09	0.62	0.34	1.22	0.54	0.28	2.78	1.73	3.02	0.54
	MEAN SECTION TEMPERATURE (SUMMER)	1971-2000	-1.68	-1.61	-1.30	-0.97	-0.83	0.30	-0.10	1.01	0.87	1.41	0.75	0.56	0.66	0.99	2.48	2.05	2.33	1.32
	MEAN SECTION SALINITY (SUMMER)	1971-2000	-1.18	-1.18	-0.32	0.04	0.53	1.63	-1.54	1.51	0.04	0.41	0.41	0.29	2.61	1.14	2.49	1.51	2.49	1.63
	INSHORE SHELF SALINITY (SUMMER)	1971-2000	0.74	-1.19	-1.10	0.30	0.56	-1.19	0.13	0.13	-0.31	-1.81	0.74	-0.40	2.32	0.04	1.00	1.09	1.80	1.36
	LABRADOR CURRENT TRANSPORT (SUMMER)	1971-2000	-0.16	1.49	1.49	0.39	-0.24	-0.24	0.47	0.08	-0.32	1.73	0.63	-1.02	0.39	0.70	-0.16	0.23	-0.95	-0.40
GRAND BANK FLEMISH PASS FLEMISH CAP 47 ^{O}N SECTION	CIL AREA (SPRING)	1971-2000	0.95	0.90	0.77	1.02	0.87	0.42	-0.50	-0.10	-0.94	-2.17	-0.36	0.05	1.22	1.44	-1.57	-1.14	-1.77	1.08
	CIL AREA (SUMMER)	1971-2000	-0.03	1.68	0.62	1.26	-0.01	0.26	-0.80	0.26	-0.72	-1.37	-1.25	-0.54	-0.80	-0.41	-2.72	-1.06	-2.70	-0.15
	CIL AREA (FALL)	1973-2000	0.47	0.66	0.02	0.09	0.76	-0.36	-0.28	-0.33	0.04	-1.37	0.01	-0.17	-0.62	-0.54	-1.50	-0.57	-0.69	-0.31
	MEAN CIL TEMPERATURE (SUMMER)	1971-2000	-1.07	-1.83	-1.30	-1.70	-0.22	-0.85	0.86	0.27	0.59	1.39	0.99	0.90	0.14	-0.40	1.30	0.86	1.62	0.27
	MINIMUM CIL TEMPERATURE (SUMMER)	1971-2000	-0.11	-0.86	-0.25	-0.79	-0.55	-0.05	1.97	0.69	-0.08	1.06	0.93	2.34	-0.42	0.39	0.66	1.13	1.33	0.73
	MEAN SECTION TEMPERATURE (SUMMER)	1971-2000	-0.64	-1.31	-1.58	-2.47		-0.67	0.18	-0.12	0.82	1.59	0.45		-0.20	2.41	1.29	1.19	2.60	
	MEAN SECTION SALINITY (SUMMER)	1971-2000		-0.15	0.05	0.15		0.54	0.34	1.12	0.73	0.83	-0.05		1.32	2.29	1.12	-0.44	1.61	
	INSHORE SHELF SALINITY (SUMMER)	1971-2000		-0.54	-0.83	-0.42	-0.18	-0.42	-0.71	0.12	0.18	-0.06	-0.83	-0.83	0.47	0.06	-0.12	-0.30	0.95	0.59
	LABRADOR CURRENT TRANSPORT (SUMMER)	1971-2000		0.18	1.45	0.81		1.13	0.07	0.39	1.24	-0.14	1.13	1.24	1.45	2.51	1.13	1.13	0.18	0.92
SOUTHEAST GRAND BANK SECTION	CIL AREA (SPRING)	1972-2000	1.54	1.78	0.40	-0.21	-0.36	-0.83	-0.81	-0.19	-0.55	-0.87	-0.73	-0.21	0.79	2.98	-0.85	-0.94	-1.40	0.51
	MEAN CIL TEMPERATURE (SPRING)	1972-2000	-0.08	-0.38	-0.38	-1.81	-0.94	-1.50	0.40	0.09	0.65	-0.60	0.70	1.39	0.74	0.09	2.38	0.78	2.90	0.18
	MEAN TEMPERATURE (SPRING)	1972-2000	-1.77	-1.40	-0.89	-0.48	-0.29	-0.47	0.03	-0.17	0.29	1.46	0.20	-1.21	-1.61	-2.34	-0.07	-0.26	-0.07	-0.97
	CIL AREA (FALL)	1990-2004	-0.51	1.47	-0.41	0.68	2.18	1.21	-0.54	-0.50	-0.38	-0.59	-0.38	-0.45	-0.57	-0.50	-0.70	-0.44	-0.44	-0.29
	MEAN CIL TEMPERATURE (FALL)	1990-2004	-1.28	0.79	-0.77	0.42	-0.17	1.98	0.64	-1.14	-0.99	0.57	0.20	0.05	-1.06	-1.28	2.05	1.38	1.38	1.09
	MEAN SECTION TEMPERATURE (FALL)	1990-2004	-0.95	-0.46	-1.27	-0.43	-0.67	0.92	-0.64	-0.10	1.44	1.52	0.99	0.35	-0.44	-0.48	0.22	-0.39	0.93	-0.63
ST. PIERRE BANK SECTION (SPRING)	CIL AREA	1993-2004				1.16	0.95	0.40	-1.03	1.09	-0.84	-1.16	-1.16	0.55	-0.09	1.20	-1.09	-1.16		0.65
	MEAN TEMPERATURE (< 100 M)	1993-2004				-1.00	-0.82	-0.22	0.29	-0.96	0.80	1.81	1.45	-0.43	-0.16	-1.31	0.55	1.16		-0.49
	MEAN SECTION TEMPERATURE	1993-2004				-0.81	-1.45	0.47	0.16	-0.74	0.54	1.88	1.42	-0.81	0.10	-0.96	0.19	1.36		-1.35
	MEAN SALINITY < 100 M	1993-2004				0.99	-1.64	0.48	-0.68	-0.42	1.12	0.60	-1.64	1.12	-0.74	0.48	0.35	-0.55		1.37
	MEAN SECTION SALINITY	1993-2004				1.60	-2.00	0.97	-0.92	-0.47	0.43	1.15	-0.47	-0.11	-0.65	-0.02	0.52	0.07		0.61

Climate indices based on the temperature data collected on the spring and fall multi-species surveys for the years 1990–2007 are displayed in Table 5 as normalized anomalies. In both 3Ps and 3LNO, bottom temperatures were generally lower than normal from 1990 to 1995 with anomalies often exceeding 1 SD below the mean. By 1996, conditions had moderated to near-normal values but decreased again in the spring of 1997 to colder than normal in both 3Ps and 3LNO. In 3LNO temperatures were above normal from 1998 to 2007, with the exception of 2003, with 1999 and 2004 among the warmest years on record. The spring of 2004 had the lowest area of <0°C water in Division 3L since the surveys began in the early 1970s at 2.1 SD units below normal. In 2007, this area increased to just slightly below normal (Table 5).

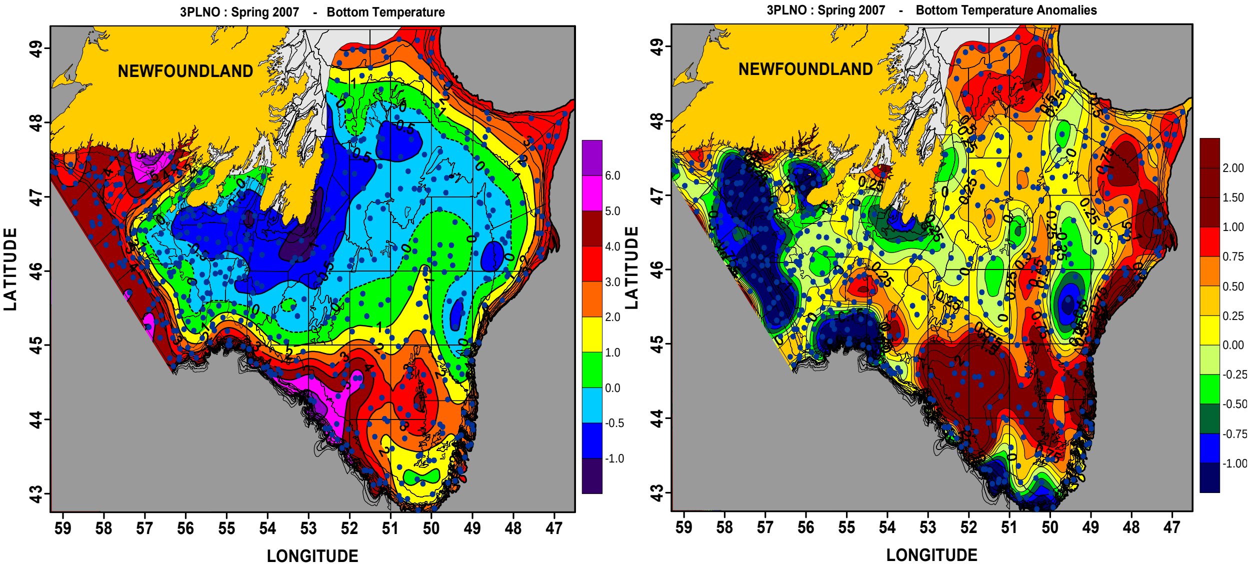


Figure 5. Contour maps of bottom temperature and their anomalies (in °C), during the spring of 2007 in NAFO Div. 3PLNO. The blue dots indicate sampling positions.

In 3P bottom temperatures were below normal from 1990 to 1995, moderated in 1996, decreased again in 1997 but increased to above normal values by 1999 and 2000. Beginning in 2001 temperatures again decreased, reaching near-record cold conditions in 2003 with bottom temperatures on St. Pierre Bank (depths <100 m) reaching 1.6 SD below normal, the coldest since 1990. During 2004 and 2005 temperatures again increased to above normal values with 2005 the highest on St. Pierre Bank since 2000 (1.1 SD). No data were available for 2006 and by 2007 spring temperatures across the 3P area returned to below normal conditions (Table 5).

Fall Conditions

Bottom temperature and temperature anomaly maps for the fall of 2007 in NAFO Div. 2J, 3K and 3LNO are displayed in Figure 6. Bottom temperatures during the fall of 2007 in Div. 2J ranged from <2°C inshore to >3.5°C offshore at the shelf break. Over Hamilton Bank they ranged from 2° – 3°C, increasing significantly from 2006. Most of the 3K region is deeper than 200 m, as a result relatively warm slope water floods through the deep troughs between the northern Grand Bank and southern Funk Island Bank and between northern Funk Island Bank and southern Belle Isle Bank. Bottom temperatures on these banks during the fall of 2007 ranged between 3° to 3.5°C. Near the edge of the continental shelf in water depths >500 m, temperatures were near normal around 3.5°C.

Fall bottom temperatures in Div. 3LNO generally ranged from <0°C on the northern Grand Bank and in the Avalon Channel to 3.5°C along the shelf edge. Over the southern areas, bottom temperatures ranged from 1° – 3.5°C during 2007 and to >3.5°C along the edge of the Grand Bank. During 2007, bottom temperatures were predominately above normal from Hamilton Bank to the northern Grand Bank but varied about the mean in southern areas with an area of below normal values in the shallow waters of the southeast shoal of the Grand Bank (Figure 6). Overall, fall bottom temperatures increased from 2006 values, except over most of the Grand Bank.

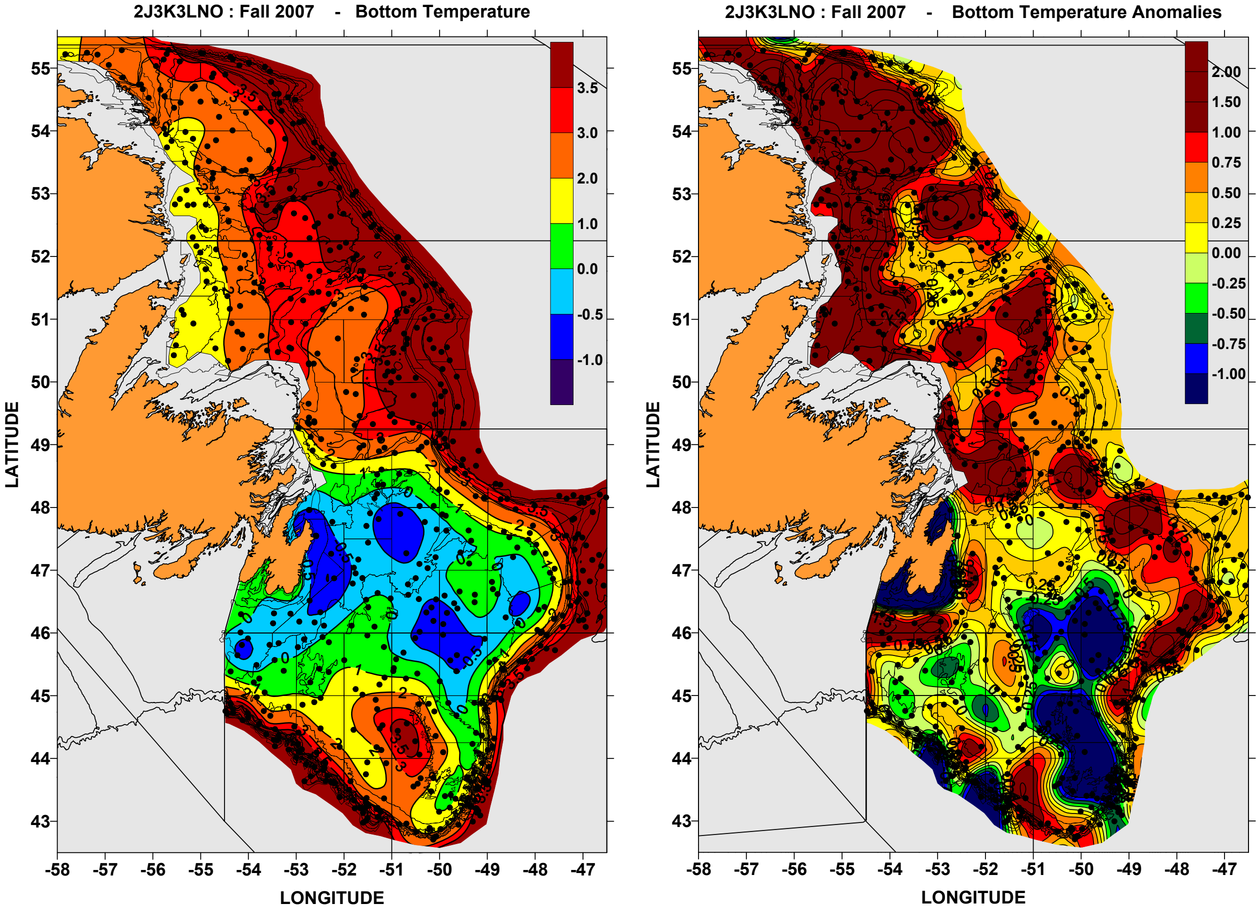


Figure 6. Contour maps of bottom temperature and temperature anomalies (in °C) during the fall of 2007 in NAFO Div. 2J, 3KLNO. The black dots indicate sampling locations.

The normalized temperature anomalies and derived indices based on data collected on the fall multi-species surveys for the years 1990–2007 are displayed in Table 5. In 2J, bottom temperatures were generally colder than normal from 1990 to 1995, with the coldest anomalies observed in 1992 when they reached >1.7 SD units below normal on Hamilton Bank (<200 m depth). From 1996 to 2007 bottom temperatures were above normal reaching record high values in 2007 (2.6 SD units above normal). From 1998 to 2005 and again in 2007 near-bottom water with temperatures <0°C disappeared from the Hamilton Bank during the fall with a corresponding increase in the area covered by water >2°C. During the fall of 2006 however, a small area of <0°C water was present on Hamilton Bank. In 3K, conditions were very similar to 2J with the 3 warm years in 1999, 2004 and 2005, followed by slightly cooling in 2006 and record high (>2 SD) values in 2007.

In Div. 3LNO during the fall bottom temperatures were somewhat cooler than that farther north in 2J and 3K with record high values in 1999, near normal values in 2000–2003 and above normal temperatures during 2004 and 2005 and slight cooling in 2006 and 2007. The total volume of CIL water remaining on the shelf during the fall was the lowest in the 27-year record during 1999 (1.8 SD below normal), followed by 2004 (1.5 SD below normal) and 2007 (0.9 SD below normal) (Table 5).

Table 5. Temperature anomalies and derived indices from data collected during spring and fall multi-species surveys on the Newfoundland and Labrador Shelf. The anomalies are normalized with respect to their standard deviations over the indicated base period. The deep red cells without numbers indicate the absence of <0°C water in these years.

STANDARIZED PHYSICAL ENVIRONMENTAL ANOMALIES (MULTI-SPECIES SURVEYS)

REGION	INDEX	REFERENCE	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
NAFO DIV. 2J FALL	BOTTOM TEMPERATURES	1978-2000	-0.40	-0.04	-1.11	-0.61	-0.47	-0.39	1.38	0.74	1.05	1.91	1.25	1.74	1.43	2.28	2.56	2.51	1.54	2.39
	BOTTOM TEMPERATURES < 200 M	1978-2000	0.08	-0.32	-1.68	-1.71	-0.71	-0.45	1.01	0.39	0.32	1.36	0.47	1.78	0.81	1.44	2.28	2.35	1.09	2.57
	THERMAL HABITAT AREA >2°C	1978-2000	-0.76	-0.37	-0.96	-0.50	-0.28	0.45	0.92	1.01	0.73	1.28	0.54	1.53	1.14	1.57	2.17	2.70	0.65	2.96
	THERMAL HABITAT AREA <0°C	1978-2000	0.05	-0.32	1.15	0.80	-0.14	0.59		-0.58									-0.51	
NAFO DIV. 3K FALL	BOTTOM TEMPERATURES	1979-2000	-0.67	-0.34	-1.51	-1.32	-0.83	0.43	0.52	1.17	0.80	1.96	0.64	0.86	1.11	1.35	1.91	1.82	0.86	2.63
	BOTTOM TEMPERATURES < 300 M	1979-2000	-0.69	-0.38	-1.27	-1.80	-1.39	0.42	0.46	1.04	1.17	1.47	0.32	0.51	0.94	1.31	1.74	1.60	0.37	2.33
	THERMAL HABITAT >2°C	1979-2000	-1.19	-0.23	-1.34	-1.26	-0.79	0.37	0.53	1.17	1.10	1.87	0.79	0.62	1.21	1.29	1.32	1.67	0.74	2.25
	THERMAL HABITAT AREA <0°C	1979-2000	0.33	0.70	1.28	0.93	0.56	-1.11	-1.07		-0.38		-0.78	-0.99		-1.04			-1.09	-1.14
NAFO DIV. 3LNO FALL	BOTTOM TEMPERATURES	1990-2006	-0.49	-0.20	-1.32	-1.73	-1.62	-0.04	-0.01	0.16	0.36	2.09	-0.06	0.15	-0.01	0.06	0.84	1.76	0.06	0.11
	BOTTOM TEMPERATURES <100 M	1990-2006	-0.05	-1.03	-0.94	-1.34	-1.52	0.29	0.63	0.41	0.63	2.46	0.01	-0.38	-0.57	-0.16	0.42	1.45	-0.32	-0.93
	THERMAL HABITAT AREA >2°C	1990-2006	-1.15	-0.41	-0.90	-1.78	-0.85	-0.08	0.33	0.25	0.81	2.86	0.16	0.23	-0.39	-0.04	0.53	0.51	-0.06	-0.10
	THERMAL HABITAT AREA <0°C	1990-2006	0.35	1.26	1.32	1.65	1.56	-0.72	-0.15	0.29	-0.51	-1.26	0.49	-0.11	-0.56	-0.02	-1.31	-1.05	-1.23	-0.09
NAFO DIV 2J3KL	CIL VOLUME (SUMMER)	1980-1999	1.90	1.16		0.74	0.32	-1.23	-0.61	-0.81	-0.70	-1.28								
	CIL VOLUME (FALL)	1980-2006	1.01	1.13	1.54	1.63	0.81	-0.29	-0.81	-0.81	-0.54	-1.80	-0.41	-0.72	-0.53	-0.74	-1.45	-0.83	-0.45	-0.88
NAFO DIV. 3LNO SPRING	BOTTOM TEMPERATURES	1976-2000	-1.66	-1.49	-1.11	-0.72	-0.71	-0.70	-0.24	-0.53	0.23	0.60	0.58	0.05	0.00	-0.50	0.99	0.43		0.36
	BOTTOM TEMPERATURES <100 M	1976-2000	-1.17	-1.54	-1.22	-0.42	-0.99	-0.26	0.12	-0.81	0.98	1.82	0.57	-0.14	0.20	-0.98	1.25	0.75	0.58	0.18
	THERMAL HABITAT AREA >2°C	1976-2000	-1.54	-1.39	-1.13	-0.44	-0.46	-0.27	0.06	-0.17	0.82	2.00	0.90	-0.08	0.04	-0.10	2.05	1.18		0.91
	THERMAL HABITAT AREA <0°C	1976-2000	1.02	1.46	1.01	1.11	0.76	0.44	-0.44	0.58	-1.10	-1.65	-0.80	-0.66	-0.41	0.43	-2.13	-1.38	-1.81	-0.17
NAFO DIV. 3PS SPRING	BOTTOM TEMPERATURES	1971-2000	-1.56	-0.93	-0.94	-0.56	-0.42	-0.93	-0.03	-0.58	-0.30	0.46	0.65	-0.69	-0.19	-1.34	-0.25	0.38		-0.98
	BOTTOM TEMPERATURES <100 M	1971-2000	-1.65	-0.94	-1.07	-1.01	-0.73	-0.60	0.40	-0.46	0.45	1.29	1.58	-0.53	-0.30	-1.57	0.40	1.14		-0.58
	THERMAL HABITAT AREA >2°C	1971-2000	-1.49	-1.02	-0.72	-0.79	-0.96	-0.86	-0.21	-0.61	-0.06	0.77	1.15	-0.62	-0.50	-0.85	-0.48	0.17		-0.63
	THERMAL HABITAT AREA <0°C	1971-2000	1.66	0.95	1.20	1.27	0.77	1.02	-0.38	0.75	-0.03	-0.52	-0.88	0.67	0.47	1.48	-0.98	-0.88		0.70

Summary

The North Atlantic Oscillation index for 2007 was slightly above normal at 0.3 SD, as a consequence, outflow of arctic air masses to the Northwest Atlantic was stronger than in 2006 resulting in a broad-scale cooling of air temperatures throughout the Northwest Atlantic from West Greenland to Baffin Island to Labrador and Newfoundland. Sea-ice extent and duration on the Newfoundland and Labrador Shelf increased slightly but remained below average for the 13th consecutive year. As a result water temperatures on the Newfoundland and Labrador Shelf generally cooled compared to 2006 but remained above normal in most areas in 2007, continuing the warmer than normal conditions experienced since the mid-to-late 1990s. The main exception appeared in data collected during late fall, which showed an increase in sub-surface temperatures as warmer slope water moved southward over the area. Salinities on the NL Shelf, which were lower than normal throughout most of the 1990s, increased to the highest observed since the early 1990s during 2002 and have remained mostly above normal during the past 6 years.

A summary of selected temperature and salinity time-series and other derived climate indices for the years 1950–2007 are displayed in Figure 7 (top panel) as colour-coded normalized anomalies. Different climatic conditions are readily apparent from the warm and salty 1960s and early 2000s to the cold-fresh early 1970s, mid-1980s and early 1990s. Following Petrie *et al.* (2007) a mosaic or composite climate index was constructed from the 26 time-series as the sum of the standardized anomalies with each time-series contribution shown as stacked bars (Figure 7 bottom panel).

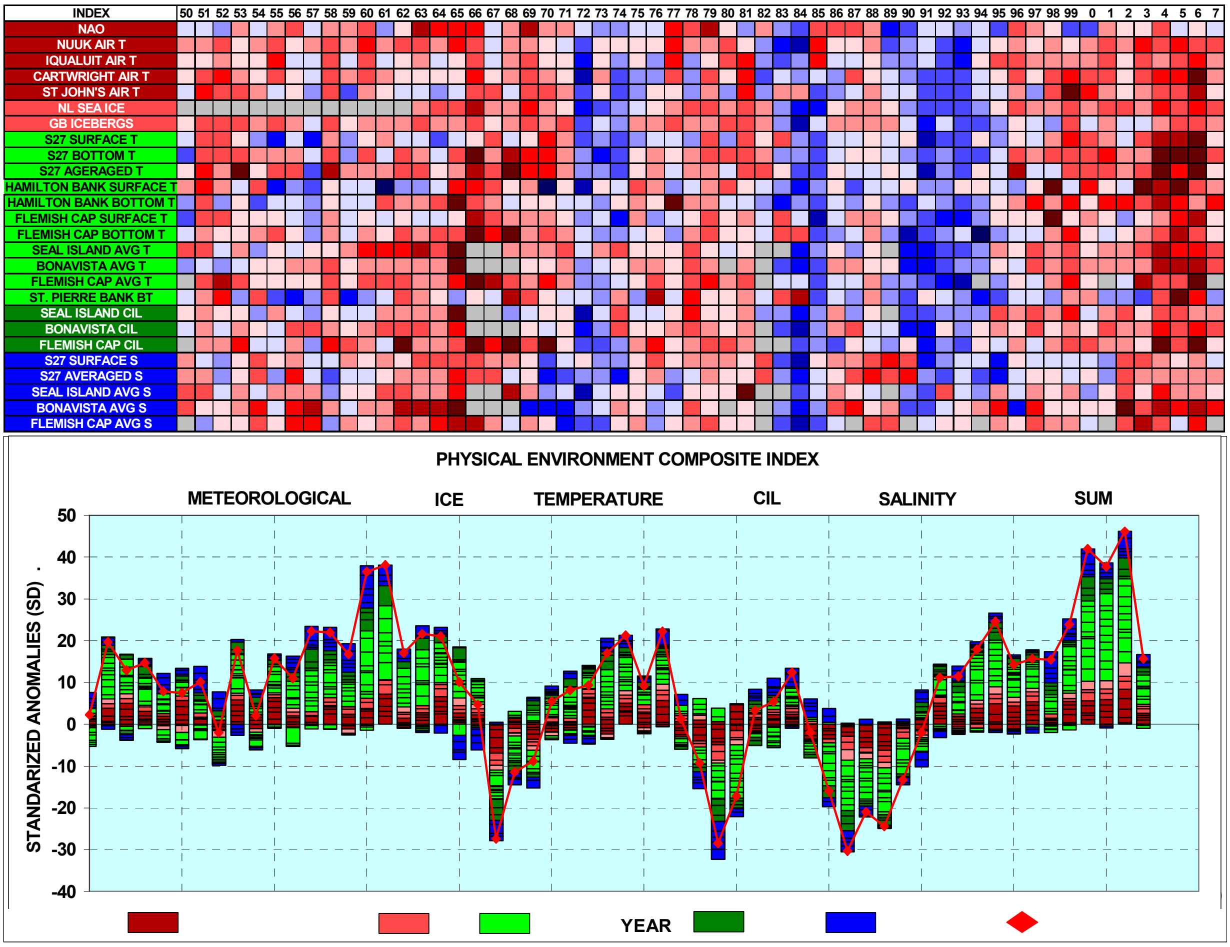


Figure 7. Standardized anomalies of NAO, air temperature, ice, water temperature and salinity and CIL areas from several locations in the Northwest Atlantic colour-coded according to Table 1. The anomalies are normalized with respect to their standard deviations over a base period from 1971–2000 (top panel). The sum of the anomalies is shown in the bottom panel together with the individual components.

To further visualize the components, each time-series was then grouped according to the type of measurement, meteorological, ice, water temperature, CIL area and salinity. The composite index is therefore a measure of the overall state of the climate system with positive values representing warm-salty conditions and negative representing cold-fresh conditions. The plot also indicates the degree of correlation between the various measures of the environment. In general, most time-series are correlated, but there are some exceptions as indicated by the negative contributions during a year with an overall positive composite index and conversely during a year with a negative composite index. The results show that 2006 was the warmest in the 58 years of data, followed by 2004 and 1966. These were also the only years when all of the time-series contributed positively to the overall index. The coldest year in the record occurred in 1991 followed by 1984 and 1972. In 2007, it appears that climate conditions cooled significantly over the previous 3-years with 2007 ranking 22nd warmest in 58 years.

Highlights for 2007:

- Annual air temperatures were above normal in Newfoundland and Labrador by 0.7°C (0.6 SD) at Cartwright, 0.5°C (0.6 SD) at Bonavista and by 0.3°C (0.4 SD) at St. John's, a significant decrease over the record highs of 2006.

- The annual, sea ice extent on the NL Shelf remained below normal for the 13th consecutive year. The ice extent was the 7th lowest in the winter months of 2007 since 1963.
- 324 icebergs were detected south of 48°N on the Northern Grand Bank, up from 0 in 2006 and 11 during 2005.
- The Station 27 depth-averaged annual water temperature decreased from the record high observed in 2006 to about normal.
- Annual surface temperatures at Station 27 also decreased from the record high observed in 2006 to <0.5 SD above normal.
- Bottom temperatures at Station 27 have been above normal for the past 12 years. From 2004 to 2006, they were >2.5 SD above normal but decreased to 1.2 SD above normal in 2007.
- Annual surface temperatures on Hamilton Bank were 0.5 SD above normal and were <0.5 SD above normal on the Flemish Cap and St. Pierre Bank.
- Near surface (0–50 m) summer salinities at Station 27 were above normal (1 SD) for the 6th consecutive year. The average salinity along the Bonavista section has remained significantly (>1 SD) above normal since 2002.
- The area of <0°C (CIL) water mass on the eastern Newfoundland Shelf was below normal for the 13th consecutive year and the 14th lowest since 1948.
- The upper layer baroclinic transport of the shelf-slope component of the Labrador Current off southern Labrador showed an increasing trend from 2000 to 2005 but has decreased during 2006 and 2007.
- Bottom temperatures during the spring of 2007 remained above normal on the Grand Banks but were below normal on St. Pierre Bank. During the fall they were significantly above normal in 2J3K and most of 3L, but were below normal in the shallow (<100 m) areas of 3NO.
- The area of bottom habitat on the Grand Banks covered by <0°C water decreased from >50% during the first half of the 1990s to near 15% during the period 2004–2006 but increased to near-normal at about 30% in 2007.

Acknowledgments

We thank the many scientists and technicians at the Northwest Atlantic Fisheries Centre for collecting and providing much of the data contained in this analysis and to the national Integrated Scientific Data Management (ISDM) branch in Ottawa for providing most of the historical data and Environment Canada for meteorological data. We thank Ingrid Peterson at the Bedford Institute of Oceanography for providing the NL Shelf monthly sea ice data. We also thank the captains and crews of the CCGS Teleost, Templeman and Hudson for three successful oceanographic surveys during 2007.

References

Colbourne, E. B., Fitzpatrick, C., Senciall, D., Stead, P., Bailey, W., Craig, J. and Bromley, C. 2005. An assessment of the physical oceanographic environment on the Newfoundland and Labrador Shelf during 2004. DFO Can. Sci. Advis. Sec. Res., Doc. 2005/14, 36 p.

Colbourne, E. B., S. Narayanan, and S. Prinsenberg. 1994. Climatic change and environmental conditions in the Northwest Atlantic during the period 1970–1993. ICES Mar. Sci. Symp., 198:311–322.

Dickson, R.R., Meincke, J., Malmberg, S. A. and Lee, A. J. 1988. The "Great Salinity Anomaly" in the northern North Atlantic 1968–82. Progr. Oceanogr., 20: 103–151.

Doubleday, W. G., Editor. 1981. Manual on groundfish surveys in the Northwest Atlantic. NAFC. Sco. Coun. Studies, 2: 56p.

Drinkwater, K.F. 1996. Climate and oceanographic variability in the Northwest Atlantic during the 1980s and early-1990s. J. Northw. Atl. Fish. Sci., 18: 77–97.

ICNAF. 1978. List of ICNAF standard oceanographic sections and stations. ICNAF selected papers #3.

Petrie, B., R.G. Pettipas, and W.M. Petrie. 2008. An overview of meteorological, sea ice and sea surface temperature conditions off eastern Canada during 2007. DFO Can. Sci. Advis. Sec. Res. Doc. 2008/In Prep.

Petrie, B., R.G. Pettipas, and W.M. Petrie. 2007. An overview of meteorological, sea ice and sea surface temperature conditions off eastern Canada during 2006. DFO Can. Sci. Advis. Sec. Res. Doc. 2007/022.

Petrie, B., S. Akenhead, J. Lazier and J. Loder. 1988. The cold intermediate layer on the Labrador and Northeast Newfoundland Shelves, 1978–1986. NAFO Sci. Coun. Studies 12: 57–69.

Rogers, J.C. 1984: The Association between the North Atlantic Oscillation and the Southern Oscillation in the Northern Hemisphere. Mon. Wea. Rev., 112, 1999–2015.

Annex 10: Hydrographic Status Report 2007: Spanish Standard Sections.

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The Spanish Standard Sections cover the area of the shelf and shelf-break of the Eastern Atlantic and North Iberian Peninsula. Five sections are sampled monthly by the Instituto Español de Oceanografía, located in Santander (43.5°N, 3.8°W), which is the largest, two in Asturias (43.6°N, 6.2°W) and from 2001 (43.6°N, 5.6°W), A Coruña (43.40°N, 8.3°W) and Vigo (42.1°N, 9.0°W). Additionally to the area covered by the Instituto Español de Oceanografía, AZTI collected oceanographic data at 43.30°N, 2°W (San Sebastián Section) over the continental shelf of the SE Bay of Biscay from 1986 (Figure 1).

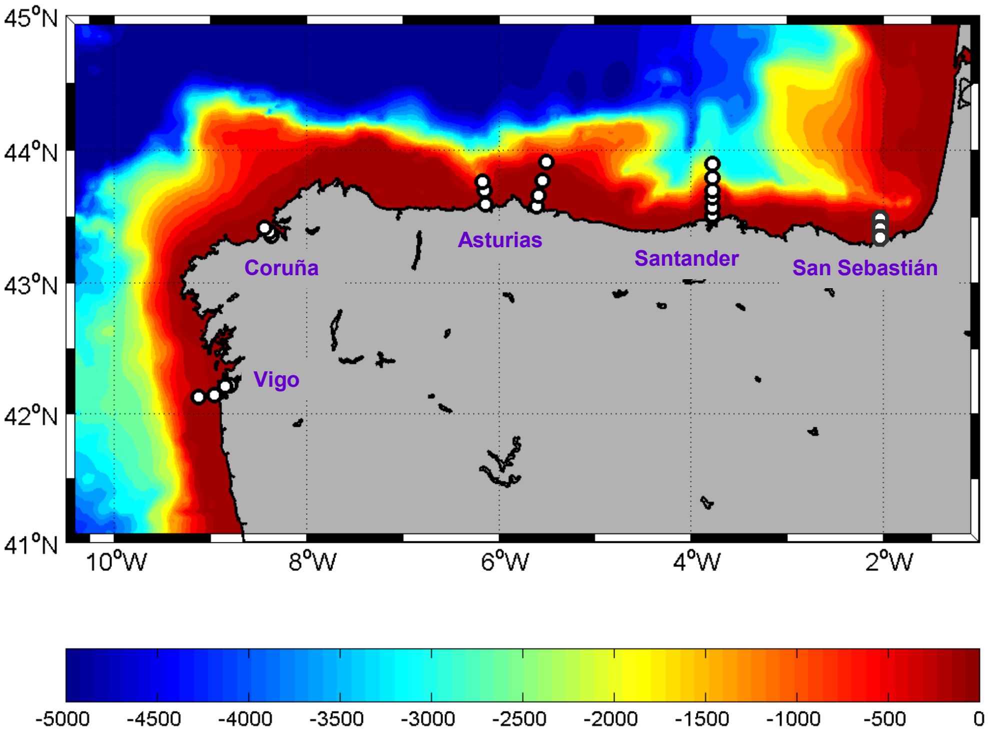


Figure 1. Spanish Standard Sections from the 'Instituto Español de Oceanografía' (Vigo, Coruña, Asturias, Santander) and from AZTI (San Sebastián).

The Bay of Biscay lies almost adjacent to the Atlantic, located between the eastern part of the subpolar and subtropical gyres. The region is affected by both gyres, depending upon latitude. However, the general water circulation in the area follows mainly the subtropical anticyclonic gyre, in a relatively weak manner (1–2 cm·s^{-1}).

Because of the east to west orientation of the Basque coast, together with the north to south orientation of the French coast, onshore Ekman transport dominates clearly in autumn and winter due to the westerly and southerly winds. In spring and summer, easterly winds produce weak coastal upwelling events that compensate partly the convergence and downwelling

In the SE corner of the Bay of Biscay, relatively strong continental influence modifies both the temperature and salinity of the shelf waters. Nevertheless, the changes in salt and heat content in the water column, over the continental shelf and slope, cannot be explained fully by the local modification of the water masses (e.g., the increase of the heat content in the shelf waters, from summer to early autumn, as opposed to the atmospheric and sea surface cooling, should be explained by accumulation and downwelling of warm waters into the shelf area).

Meteorological Conditions

Atmospheric temperature

Meteorological conditions in the north of the Iberian Peninsula in 2007 (source: Centro Meteorológico Zonal de Cantabria y Asturias, Instituto Nacional de Meteorología) indicate that it was an average year relative to the period 1961–2007. The annual mean air temperature over the southern Bay of Biscay during 2007 was 14.6°C, practically the same than the 1961–2007 average, but well down the last twenty-year mean, being only 1991 and 1992 colder than 2007. Figure 2 shows the plot of the annual means and total average.

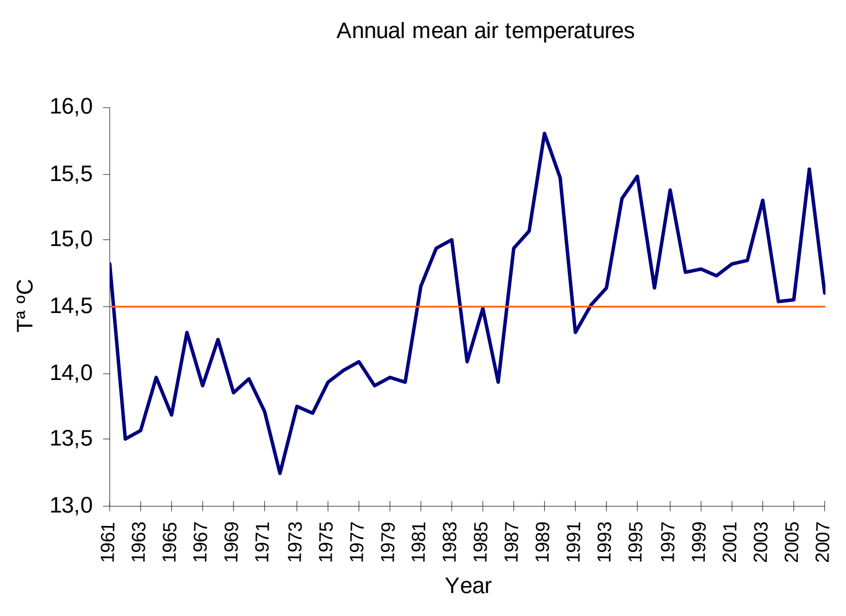


Figure 2. Annual mean temperatures in Santander (43.5°N, 3.8°W) Courtesy of the 'Instituto Nacional de Meteorología'

In the annual cycle can be seen positive anomalies appearing in the winter (January-February), and spring (April to June) and negative anomalies for the rest of the year beginning in July and finishing in December. Especially important are the positive anomalies in January and February more than one standard deviation and the negative between September and November around one standard deviation again.

The seasonal cycle amplitude was 8.9° C from August (19.5°C) to December (10.6), with a small annual cycle due to a cold summer and warm winter (January and February).

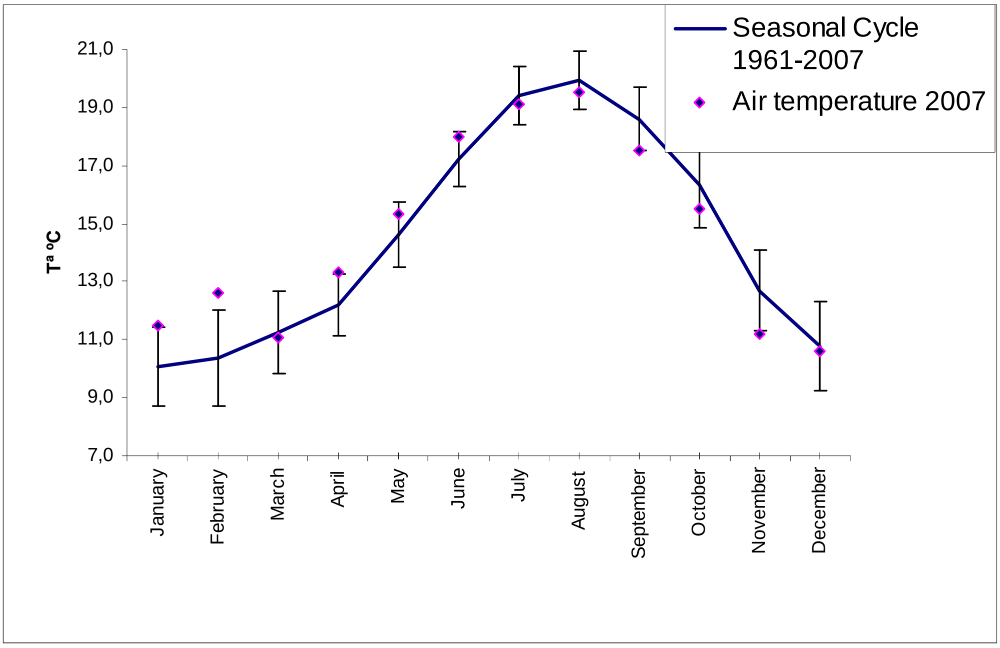


Figure 3a. Air temperatures in 2007 in Santander (43.5°N, 3.8°W) and mean value (1961–2007) and standard deviation. Courtesy of the 'Instituto Nacional de Meteorología'

Meteorological conditions in the SE Bay of Biscay in 2007 (Observatorio Meteorológico de Igeldo, San Sebastián, Instituto Nacional de Meteorología) are characterised by a warm winter (around the mean+standard deviation for 1986–2007), with the exception of March; a warm spring; a cold summer (around the mean-standard deviation for 1986–2007), excluding July (Figure 3b); and a cold autumn. The annual mean air temperature was 13.33° C, 0.31° C below the 1986–2007 average.

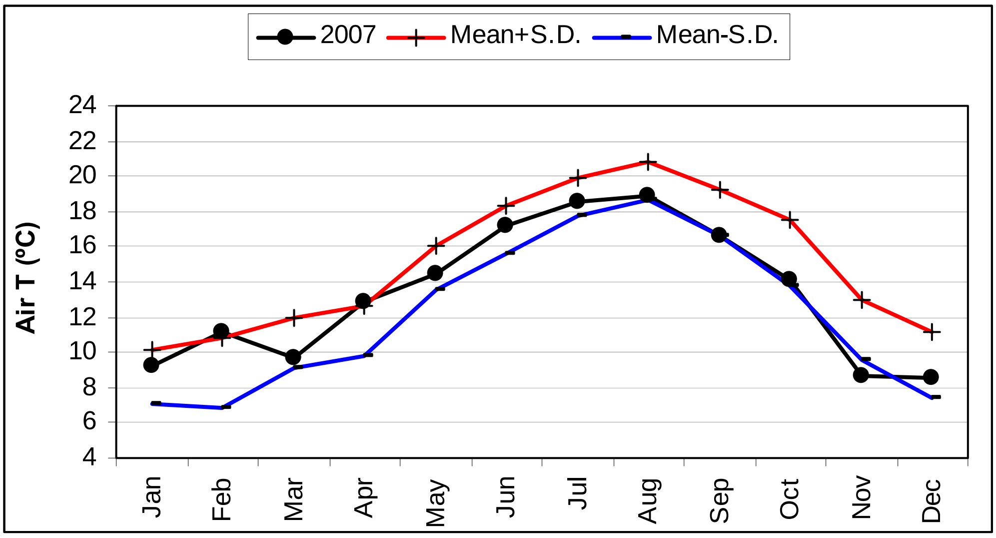


Figure 3b. Monthly mean air temperature (°C) in San Sebastián (43°18.5′N, 02°2.37′W) in 2007 compared with the mean ± standard deviation for the period 1986–2007. Courtesy of the 'Instituto Nacional de Meteorología'

The peculiarities of the air temperature in 2007 can be observed in the context of the monthly mean temperatures of the period (1986–2007) and the evolution of the accumulated anomalies (Figure 4).

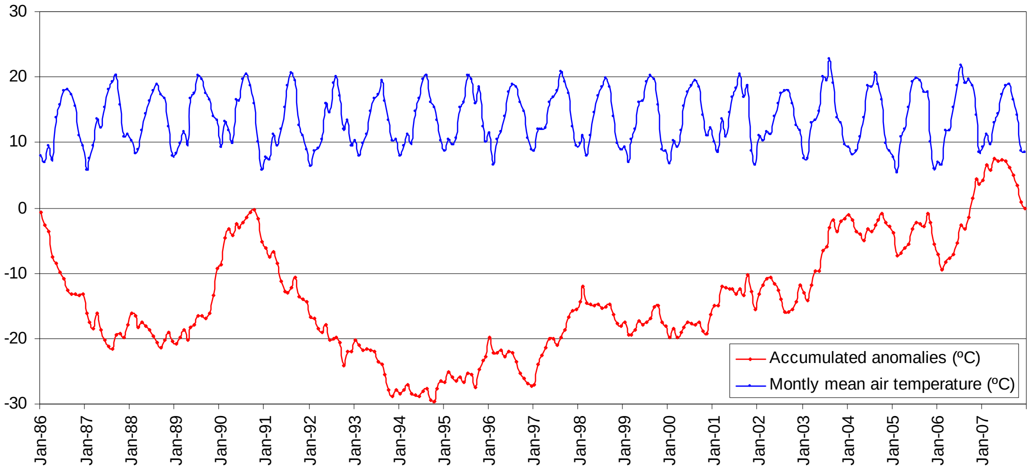


Figure 4. Monthly mean temperatures in San Sebastián (43°18.5′N, 02°2.37′W) in 1986–2007 and accumulated anomalies. Data Courtesy of the 'Instituto Nacional de Meteorología'.

Precipitation and evaporation

In San Sebastián, 2007 can be characterised for being a medium year, concerning the precipitation regime. Thus, only March and August were over the mean plus standard deviation for the period 1986–2007; conversely, November was below the mean minus standard deviation for the period 1986–2007 (Figure 5).

With regard to water balance, the year 2007, within the context of the previous years, shows a decrease in the precipitation, in terms of accumulated anomalies (Figure 6). In addition, the precipitation minus evaporation balance shows a decreasing trend, in terms of water balance (Figure 7).

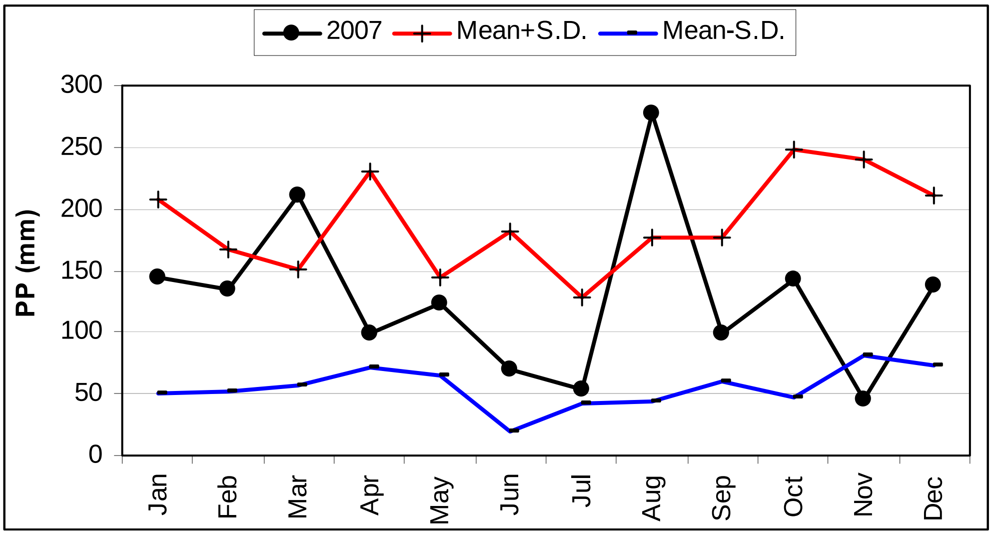


Figure 5. Monthly precipitation (mm) in San Sebastián (43°18.5′N 02°2.37′W) in 2007 compared with the mean ± standard deviation for the period 1986–2007. Data Courtesy of the 'Instituto Nacional de Meteorología'.

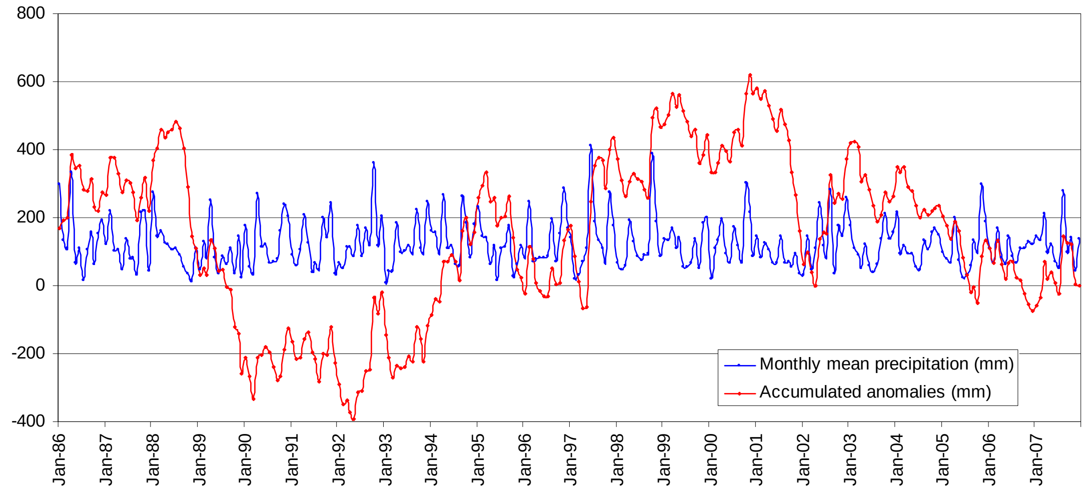


Figure 6. Monthly precipitation (mm) in San Sebastián (43°18.5′N 02°2.37′W) in 1986–2007 and accumulated anomalies. Data Courtesy of the 'Instituto Nacional de Meteorología'.

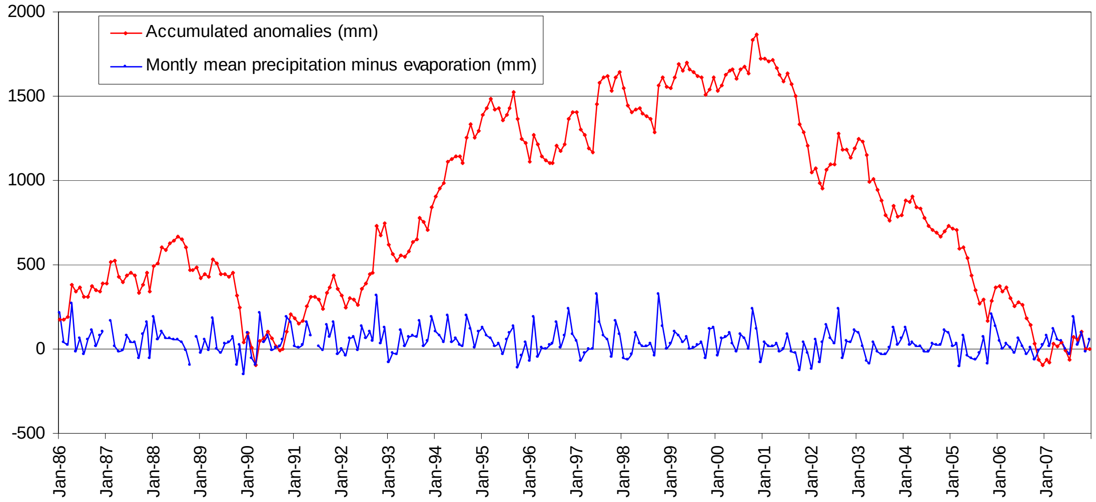


Figure 7. Monthly precipitation minus evaporation (mm) in San Sebastián (43°18.5′N 02°2.37′W) in 1986–2007 and accumulated anomalies. Data Courtesy of the 'Instituto Nacional de Meteorología'.

Continental runoff

The Gironde river runoff values represent well the water inputs of continental origin into the SE Bay of Biscay. In a quarterly basis, the Gironde River flow correlates significantly with the precipitation in San Sebastián as well as with the flow of the Adour River and the other small Cantabrian rivers incoming into the SE Bay of Biscay (Table 1).

Table 1. Correlation matrix for the Gironde river flow, precipitation in San Sebastián (PP) and precipitation minus evaporation balance in San Sebastián (PP-EV) in a quarterly basis, for the period 1986–2007. NS: not significant; *P=0.01; **P=0.005 ***P=0.001.

	FLOW WINTER	FLOW SPRING	FLOW SUMMER	FLOW AUTUMN
PP WINTER	0.71***			
PP-EV WINTER	0.69***			
PP SPRING		NS		
PP-EV SPRING		NS		
PP SUMMER			0.61**	
PP-EV SUMMER			0.59**	
PP AUTUMN				0.65**
PP-EV AUTUMN				0.66***

The Gironde River flow was low along 2007; the annual mean River flow was 676 $m^3 \cdot s^{-1}$, 150 $m^3 \cdot s^{-1}$ below the 1986–2007 average. Only August was around the monthly mean + the standard deviation for the period 1986–2007, in response to the increase of precipitations in August 2007. In this context, the Gironde River flow is in agreement with the precipitation in San Sebastián except for the local precipitation events during January (Figures 5 and 8).

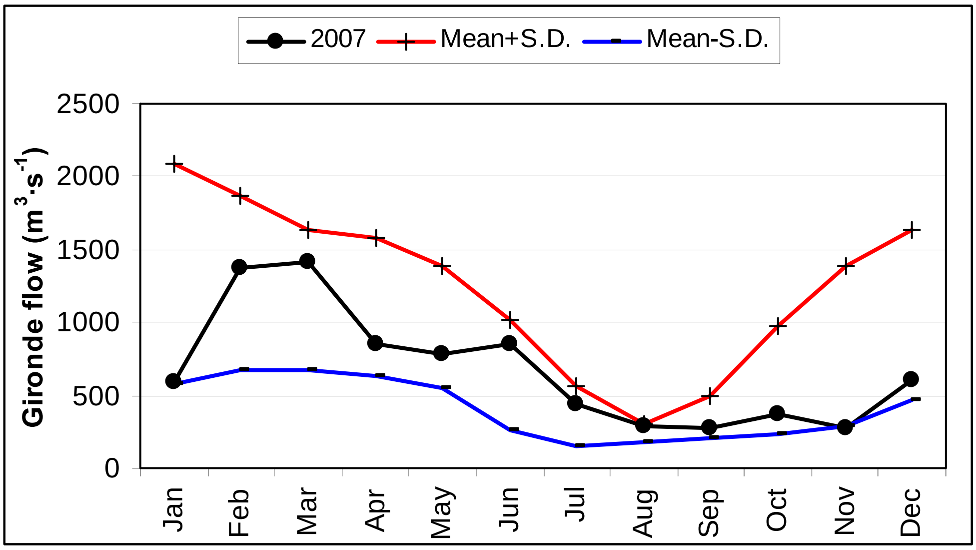


Figure 8. Monthly mean flow (m^3 s^{-1}) of the Gironde River in 2007 compared with the mean ± standard deviation for the period 1986–2007. Data Courtesy of the 'Bordeaux Harbour Authority'.

The peculiarities of the Gironde river flow in 2007 can be observed in the context of the monthly mean values of the reference period (1986–2007) and the evolution of the accumulated anomalies (Figure 9).

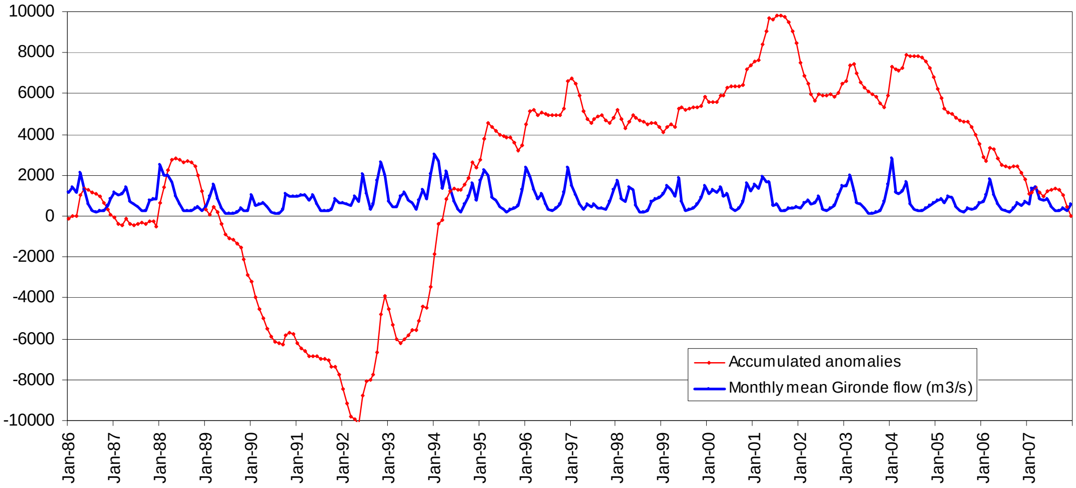


Figure 9. Monthly mean flow of the Gironde river ($m^3 \cdot s^{-1}$) in 1986–2007 period and accumulated anomalies. Data Courtesy of the 'Bordeaux Harbour Authority'.

Hydrography

Coastal and shelf waters

In order to obtain a first approximation of the hydrographic conditions in 2007, a TS diagram representing the waters over the continental shelf of the Bay of Biscay (43°30′N 02°00′W) is shown in Figure 10.

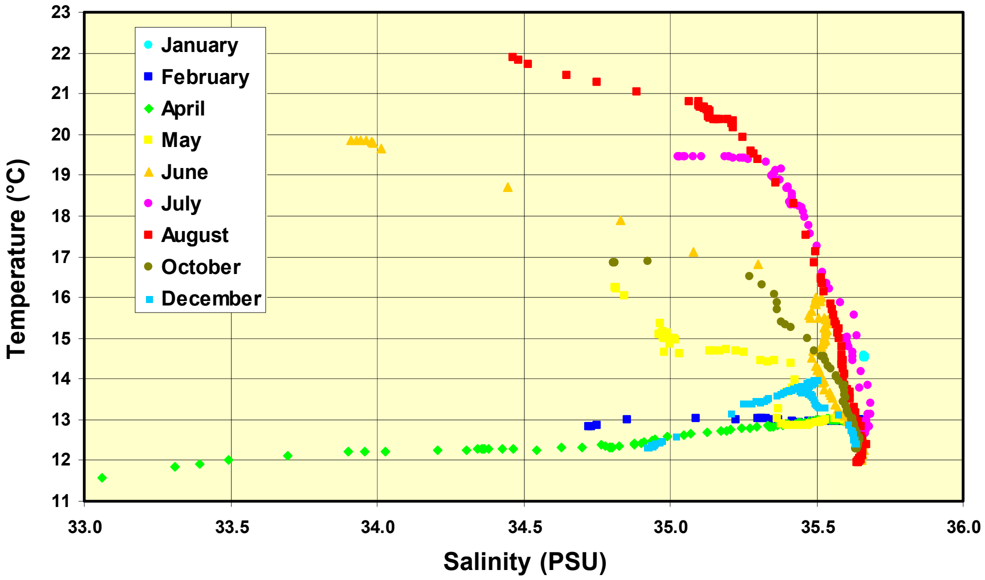


Figure 10. TS diagram of the waters over the continental shelf of the SE Bay of Biscay (43°30′N 02°00′W) in 2007.

The response of temperature and salinity of the upper layers to the meteorological factors described above is clearly observable in Figure 10. As a result of the high air temperatures in January, thermal content of the water column was high. Moreover, the TS diagram is characterised by a thermal inversion in February and April, to a great extent, according to the relatively high precipitation and river runoff. May is characterised by high precipitation, contributing to the development of haline stratification as well as to the beginning of the spring warming. Thermal stratification develops between May and October. Moreover, more or less extended haline stratification is present throughout almost all the year. The TS diagram shows also the variability in the temperature and salinity values and in the T-S relationships for the waters located below the seasonal thermocline.

Figure 11 shows the evolution of the monthly averaged sea surface temperature (SST) in 2007 (on the basis of a time-series obtained from the Aquarium of the Sociedad Oceanográfica de Gipuzkoa). In general, warm sea surface temperatures (above the mean plus standard deviation value) can be observed in winter and spring; whilst, the pattern is opposite in summer and autumn. The annual averaged SST in San Sebastián in 2007 (16.31°C) was similar to that of the 1986–2007 period (16.15°C).

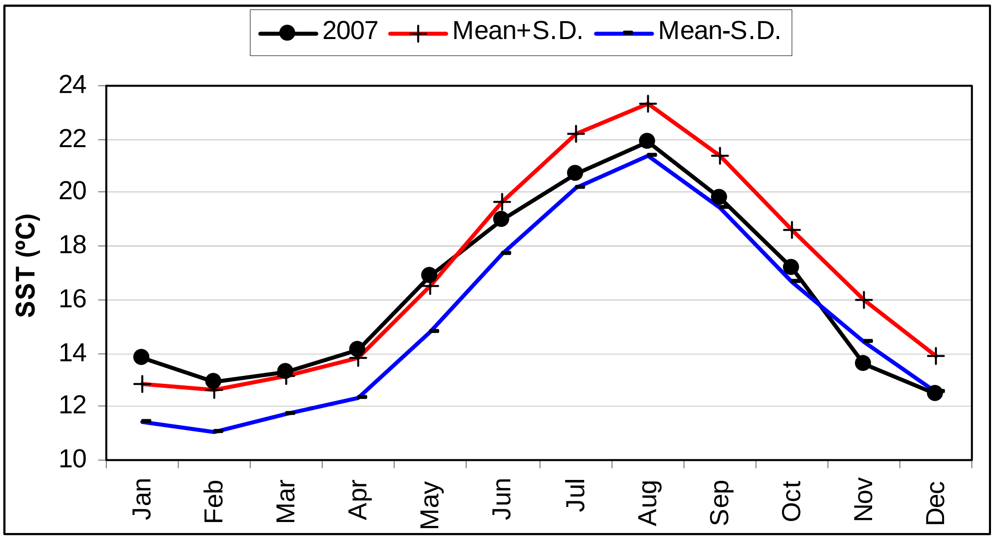


Figure 11. Monthly averaged sea surface temperature (°C) in San Sebastián (43°20′N 02°00′W) in 2007 in comparison with the mean ± standard deviation for the period 1986–2007 period. Data Courtesy of the 'Sociedad Oceanográfica de Gipuzkoa'.

The peculiarities of the SST in 2007 can be observed within the context of the monthly mean temperatures of the reference period (1986–2007) and the evolution of the accumulated anomalies (Figure 12).

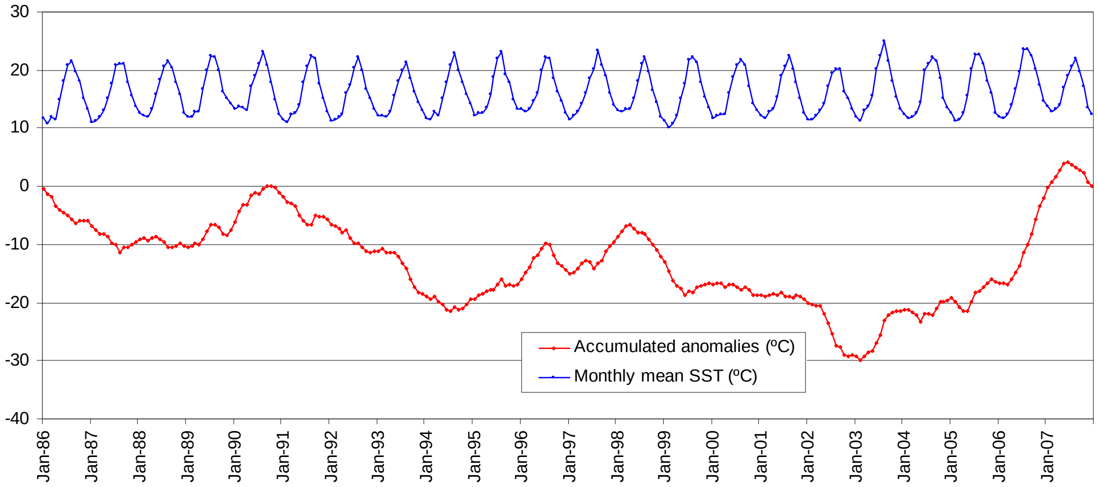


Figure 12. Monthly averaged SST (°C) in San Sebastián (43°20′N 02°00′W) during the 1986–2007 period, together with accumulated anomalies. Data Courtesy of the 'Sociedad Oceanográfica de Gipuzkoa'.

In a similar way, the evolution of the heat content (in terms of mean temperature) and the salt content (in terms of mean salinity minus 35) of the water column (100 m) over the continental shelf of the SE Bay of Biscay can be observed in Figures 13 and 14, respectively.

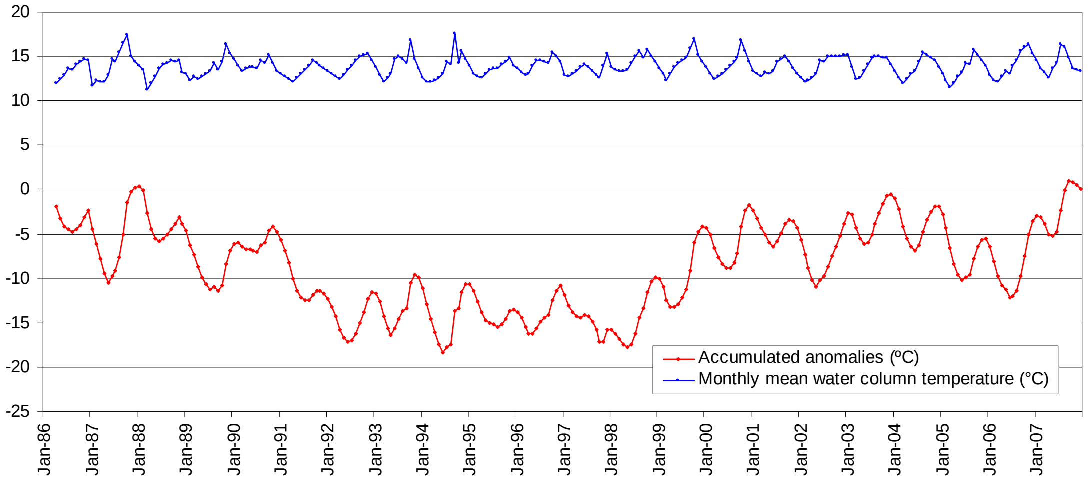


Figure 13. Monthly averaged water column temperature (°C) in San Sebastián (43°30′N 02°00′W) in the period 1986–2007, together with accumulated anomalies.

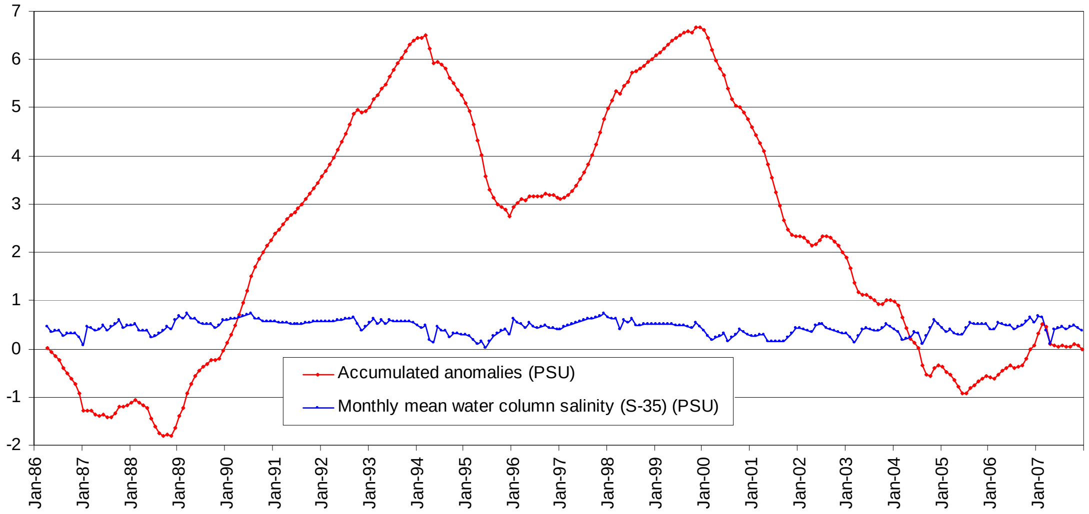


Figure 14. Monthly averaged corrected salinity (S-35) in 100 m water column in San Sebastián (43°30′N 02°00′W) in the period 1986–2007, together with accumulated anomalies.

Aspects related to the hydro-meteorological conditions during 2007, over the SE Bay of Biscay, are listed in Table 2. The SST in winter and spring 2007 remains around the mean plus standard deviation for the period 1986–2007 (Figure 11) due to the vertical mixing, with relatively high air temperatures for this period. In contrast, this pattern changed in summer and autumn. Thus, the SST in summer and autumn 2007 remains around the mean minus standard deviation for the period 1986–2007, as a result of the low air temperature (Figure 3b) as well as result of a significant reduction of sunny hours along the year 2007 (22% lower than the average for the period 1986–2007). April is characterised by thermal inversion of the water column, resulting from the presence of cold waters of continental origin. After the increase in air temperature in April, the warming of the sea surface and the water column began to be evident in May. Haline stratification was perceptible throughout all the year, excluding January. Thermal stratification remains until October 2007 due to weak winds favourable for upwelling. In November, cooling and some increase of turbulence develop the vertical mixing. December is characterised by a thermal inversion, related to the conjunction of cooling and freshwater inputs.

In the SE Bay of Biscay, the 14°C isotherm represents the mean annual temperature and also the lower layer of the thermocline, during the spring and summer stratification. In May, the 14°C isotherm depth was 35 m and, from June to August, this layer was placed at around 52–69 m. This is consistent with the relatively high dominance of downwelling processes in spring and summer. In contrast, October was characterised by the prevalence of upwelling events; whilst downwelling processes were favoured in December (Table 2, Figure 10).

Table 2. Hydro-meteorological data in the shelf waters of San Sebastián (43°30′N 02°00′W) in 2007. Mean temperature and salinity calculated for 100 m water column.

2007	Air T (°C)	PP (mm)	Gironde flow (m3 s-1)	SST (°C)	SSS (PSU)	Mean temperature (°C)	Mean salinity (PSU)	Bottom temp. (°C)	Bottom salinity (PSU)	14°C isotherm depth (m)
January	9.2	145	596	13.8	35.662	14.55	35.664	14.51	35.664	T>14
February	11.2	135	1376	12.9	35.619	13.68	35.649	13.65	35.677	T<14
March	9.7	210	1410	13.3		13.18	35.373			
April	12.9	99	851	14.1	33.061	12.67	35.097	12.83	35.642	T<14
May	14.4	123	784	16.9	34.813	13.65	35.391	12.54	35.640	35
June	17.2	70	857	19.0	33.913	14.33	35.432	12.01	35.651	52
July	18.6	54	436	20.7	35.027	16.34	35.465	12.64	35.653	69
August	18.9	278	285	21.9	34.464	16.12	35.415	11.96	35.642	60
September	16.6	99	274	19.8		14.92	35.446			
October	14.1	143	368	17.2	34.809	13.71	35.477	12.28	35.637	33
November	8.7	45	269	13.6		13.56	35.422			
December	8.5	138	604	12.5	34.921	13.42	35.366	12.69	35.622	48

In similar way, contours of temperature and salinity (over the shelf, 100 m depth) in the Santander section are shown in Figure 15a and b. The seasonal cycle in temperature is clearly marked in the upper layers. Stratification develops between April-May and October-November, and during the rest of the period the water column is mixed. 2007 present a reduction in the winter cold period (February-March) and a notable warm previous autumn similar to 1997–1998. The colder signal of winter 2005 and 2006 has despaired. On the other hand, summer and autumn were colder than the average and warm water only reach 40–50 m.

Salinity contours show high salinity at the beginning of the winter due to the poleward current and in spring and autumn due to seasonal upwelling events. In summer low salinity appeared in the upper layers due to the advection from the east of warm surface water from river discharges in the corner of the Bay of Biscay. The tendency observed in the last years since 2001 continues in 2007. Salinity contours present strong signal of high salinity water in the upper 30m. The strong high salinity signal appears all over the water column due to a strong episode of Iberian Poleward Current developed in December 2006 and January 2007.

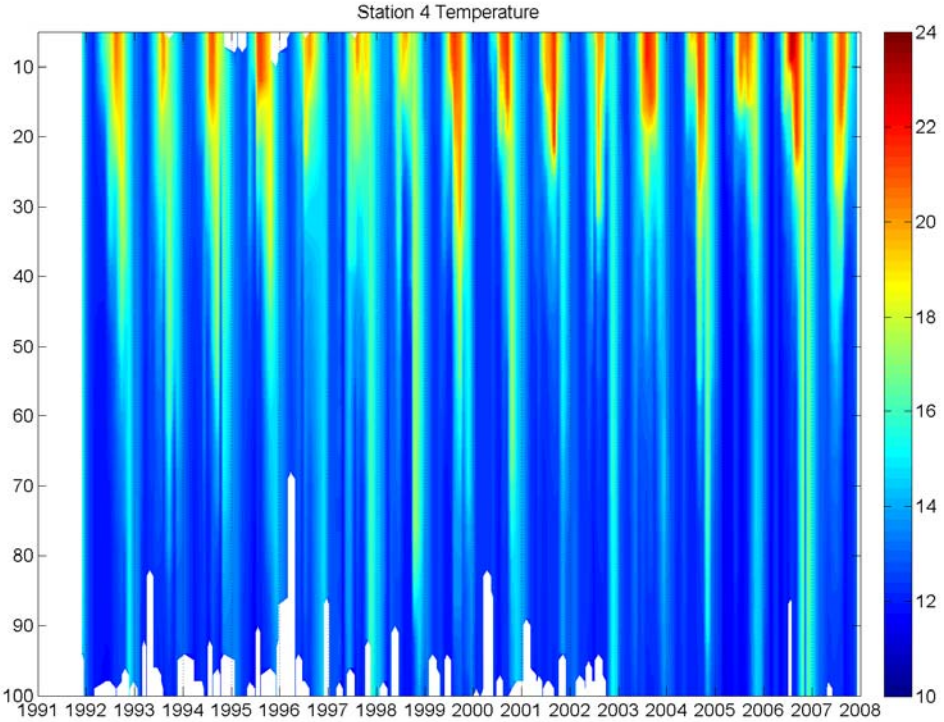


Figure 15a. Temperature evolution at Santander station 4 (shelf).

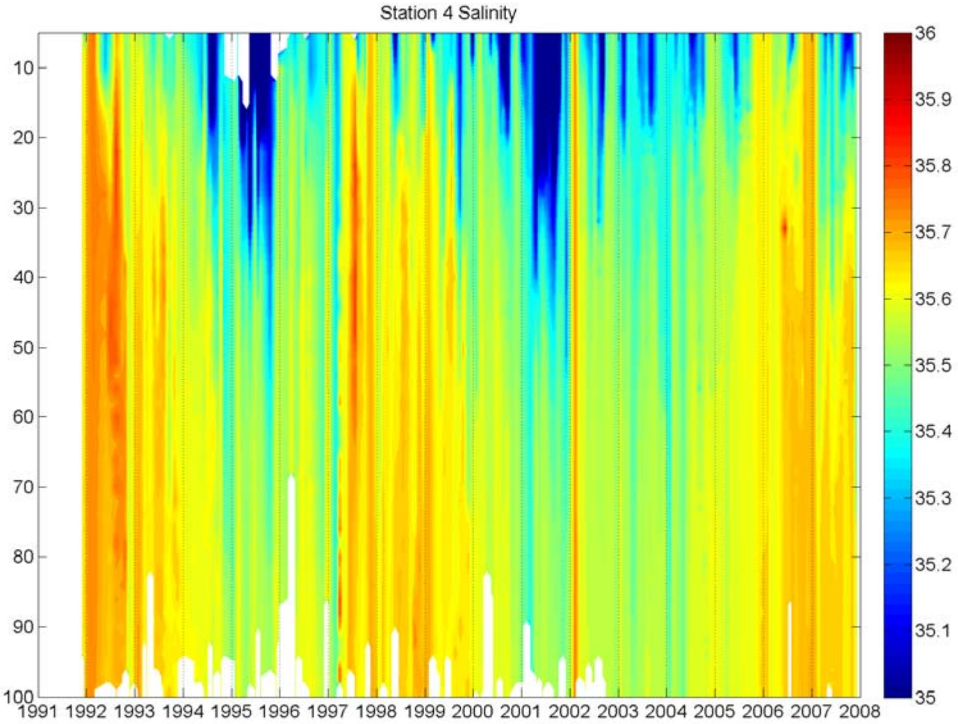


Figure 15b. Salinity evolution at Santander station 4 (shelf).

As a consequence of the different geographical location and coast orientation the mean hydrographical features the annual cycle at the Vigo standard section is moderately different of the standard cycles in Santander and San Sebastián. The differences are related mostly with a stronger influence in this area of the main advection mechanisms (winter poleward current and summer upwelling). Anyway, even if the range of the anomalies may be different because of local climatic and morphologic peculiarities, the anomaly patterns and the general trends can be considered referable to those described for the sections located in the southern Bay of Biscay.

Contours of temperature and salinity and fluorescence over the shelf in the Vigo section from 1994 to 2006 are presented in Figure 16. In summer cold waters were present at depth due to upwelling, while warm waters were at the surface in summer due to insolation. In autumn-winter there is a coastal poleward surface current that transports warm water. Salinity contours still continue show above normal values due to Eastern Atlantic general trend to salinity increase and also to the drought year until September.

Year 2007 is normal toward could with respect of the water thermohaline seasonal characteristics.

Regarding the fluorescence, related to chlorophyll, 2006 are the most productive since 1994, that also are noted in the zooplankton biomass. 2007 keeps having high values until the sampled period.

Coastal processes: variability of the Poleward current strength in winter and the upwelling in summer seem to have more influence in the west of Iberian Peninsula that the general warming trend observed in other areas of the eastern Atlantic.

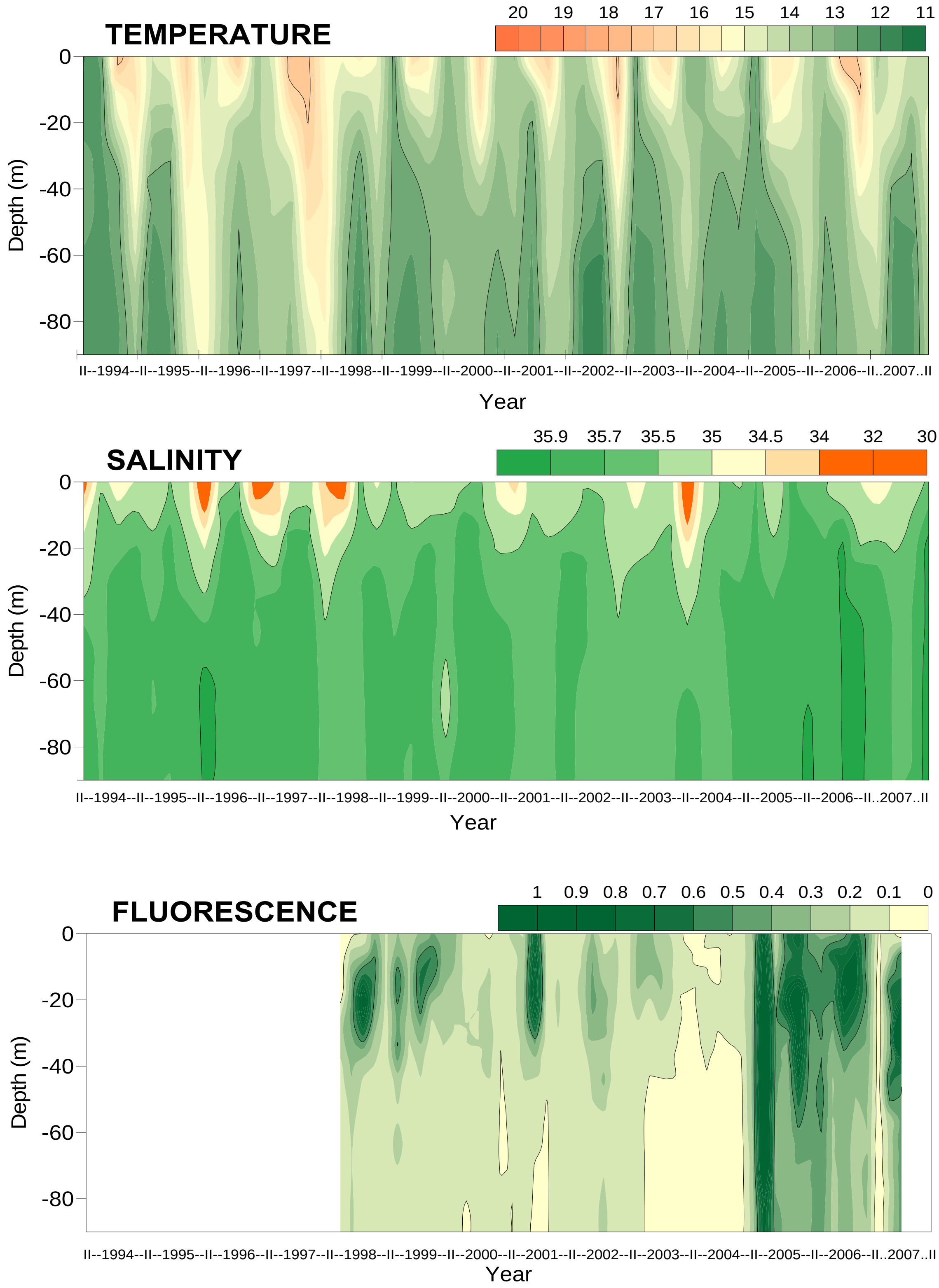


Figure 16 a, b and c). Seawater evolution at Vigo (42.1°N, 9.0°W) station of temperature, salinity and fluorescence.

Offshore and Slope waters

Contours of temperature and salinity over the shelf-break (600 m depth) in the Santander section are presented in Figure 17a and b. During the first period (1992–1994) only upper layers were sampled. The warm autumn 2006/ winter 2007 is well represented in the temperature contours where warm water reach nearly 300m depth. This fact was only shown in the previous Iberian Poleward Current events of 2002 and 1998. As happened over the shelf and it has been seen in years before, the period of low salinity in the upper waters (1994–1995 and 2000–2001) was reduced in a greater extent from 2002 to 2006 but was increased again in 2007. This water could come from the French rivers and extended further away throw the Cantabrian Sea.

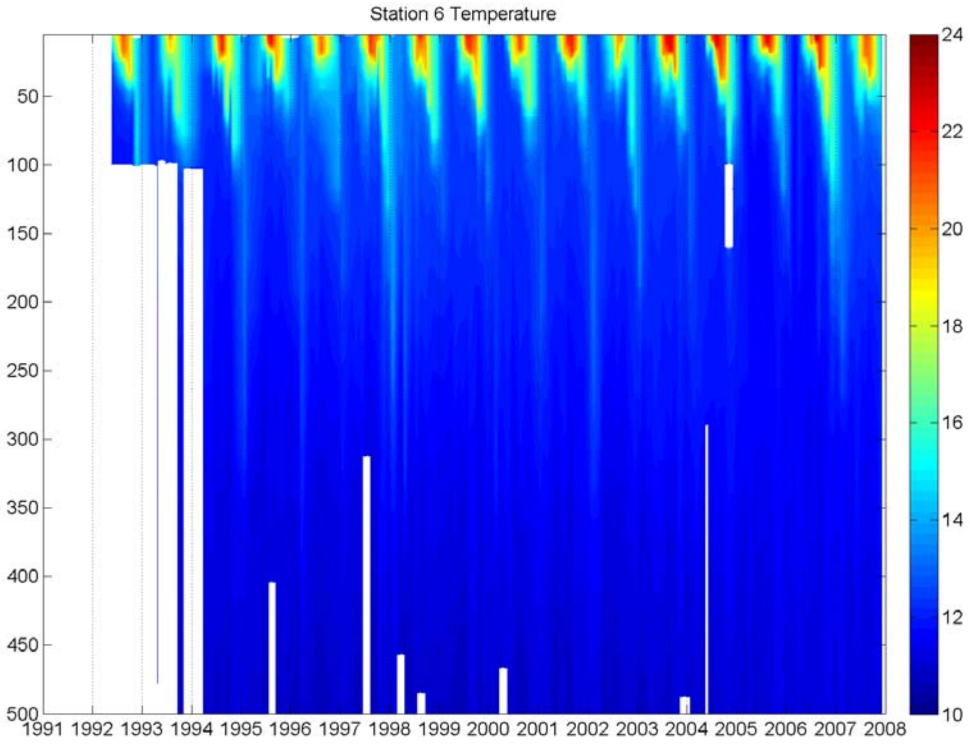


Figure 17a. Temperature evolution at Santander station 6 (shelf-break).

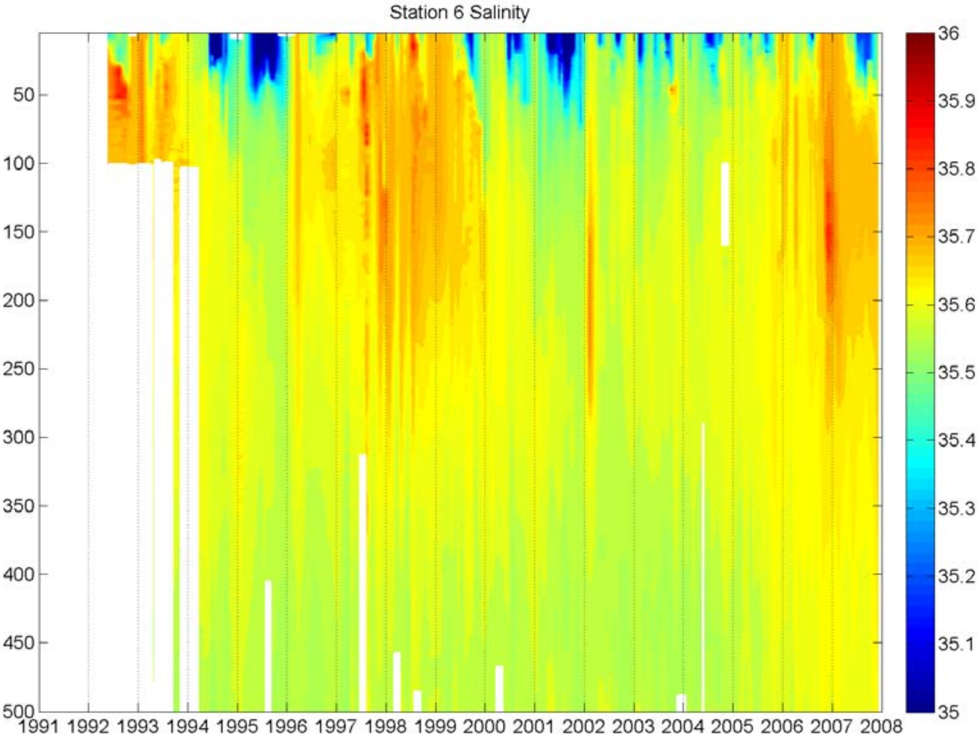


Figure 17b. Salinity evolution at Santander station 6 (shelf-break).

Below the mixed layer, salinity fell from 1992 to 1995 and increased to 1997/1998 before falling almost continuously until the end of 2004 except for the increase in salinity in the upper 300 m during the 2002 winter. This episode of salinity increase disappeared in spring and was caused by the poleward current observed during that winter. During 2005 and 2006 the causes of the maintaining the increase in salinity could be related to atmosphere forcing at the area of formation of this water mass specially during the extreme cold and dry 2005 winter (Gonzalez-Pola *et al.*, 2006).

The deep winter mixing layer that occurs in the Bay of Biscay on 2005 and 2006 produced an increase of Salinity and decrease of temperature the NACW. But in autumn 2006 winter 2007, a strong IPC reached Santander section with increase salinity in a large amount between surface and 300m depth, with strong signal between 100 and 200m.

Stratification develops between April-May and October-November, mainly reaching 100 m depth. 2007 stratification concerned both temperature and salinity. Not too high temperatures and low salinity produced thick stratification reaching between 100 and 50m.

If we look at thin layer superficial waters, we expect to find an approximate mirror of atmospheric forcing. Due to the thermal inertia of the seawater surface, the temperature seasonal cycle does not follow a sinusoidal cycle but presents a rapid warming period in late spring, whereas the autumn cooling is less abrupt.

Fitting the temperature signal by two harmonic terms plus a linear trend, we can reproduce the signal approximately (Figure 18). Taking this into account, we can compare the year 2007 with the climatological mean for surface waters. SST was over the mean value for the winter and the beginning of the spring. January was the warmest for the time-series and from February to April were also nearly the warmest of the time-series. After that, a rapid increase in temperature it is produced and for the rest of the year SST was lower than the average, especially at July when it is reached the lowest value of the time-series in the monthly July SST (also due to the early sampling)

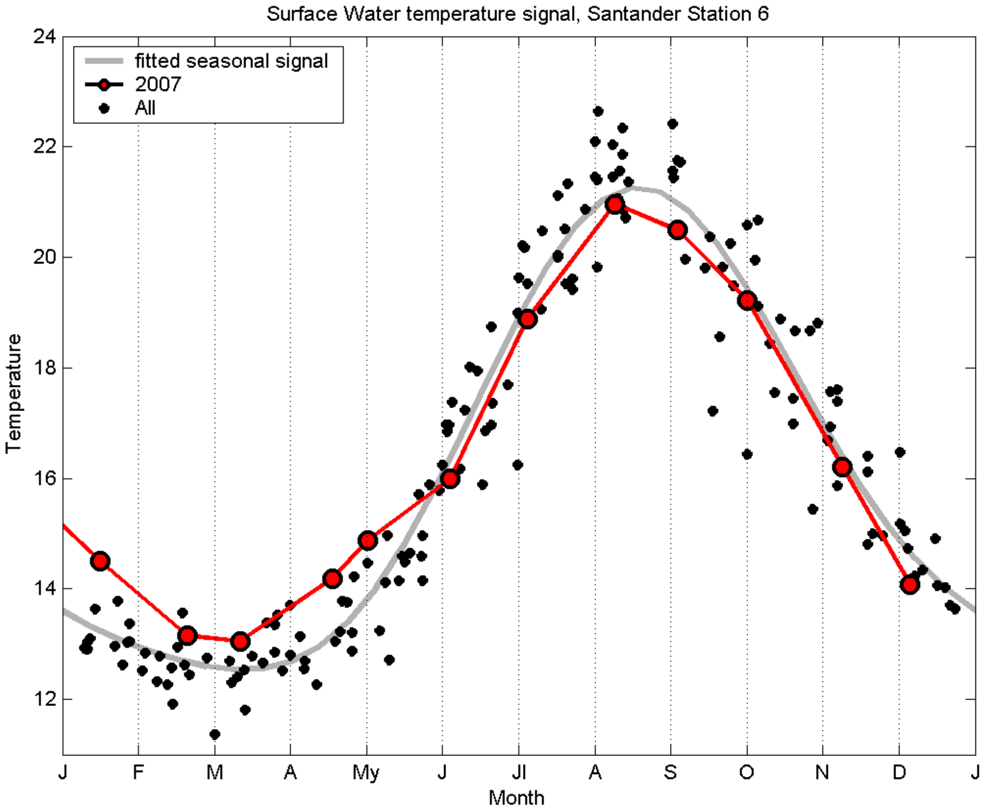


Figure 18. Seawater Surface Temperature at Santander station 6 (shelf-break).

The amplitude of the seasonal cycle of SST was of 7.6°C, quite close to the air temperature seasonal cycle for the year (8.9°C) and both of then lower than the long term mean 8.7 and 9.8°C respectively.

The anomalous warm winter and cold summer produced a yearly temperature close to the average sea Surface Temperature (Figure 19). The consequences of the deep winter anomaly in the mixed layer and upper Central Waters in 2005 are still observed during the 2006 winter but this inertia seem to be lost during the summer, at least in the most superficial waters during 2006, when it is registered the highest positive anomaly in SST of the time-series. After the warm summer and autumn 2006 and winter 2007, this anomaly disappeared.

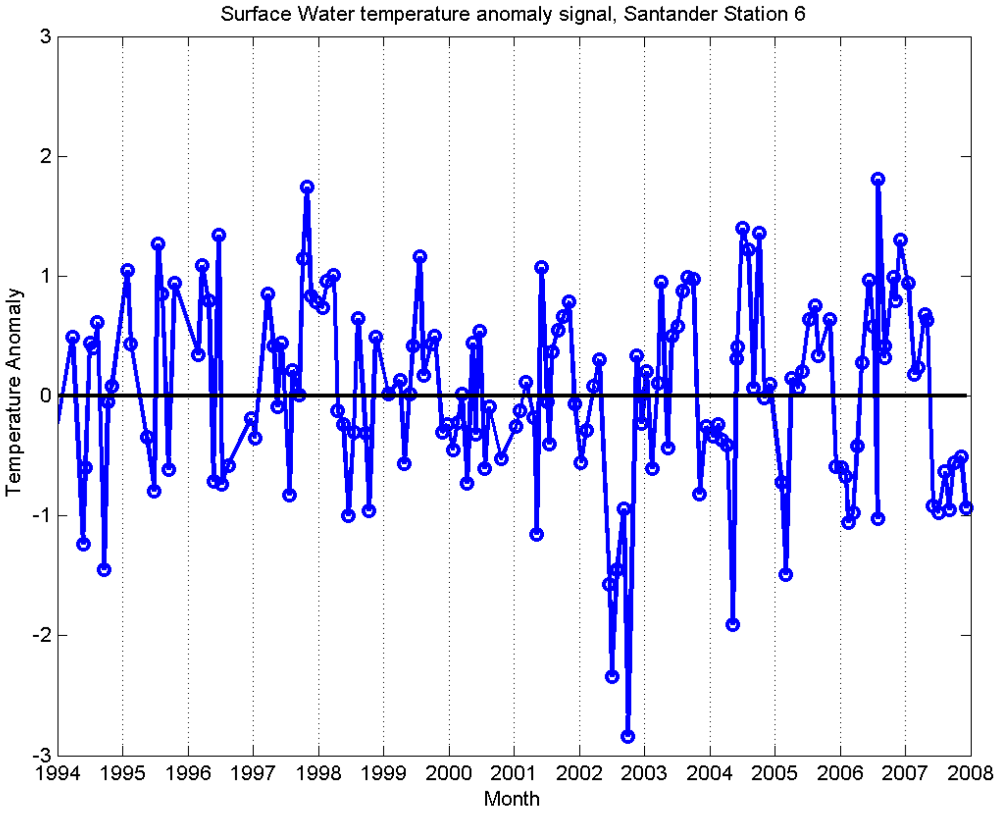


Figure 19. Seawater Surface Temperature anomalies at Santander station 6 (shelf-break).

When the analysis is produced all over the upper waters to 200m depth, 2007 due to the warm winter and the Iberian Poleward Current event present as a warm year (Figure 20). The mean temperature value was 13.5, the warmer year after 1998.

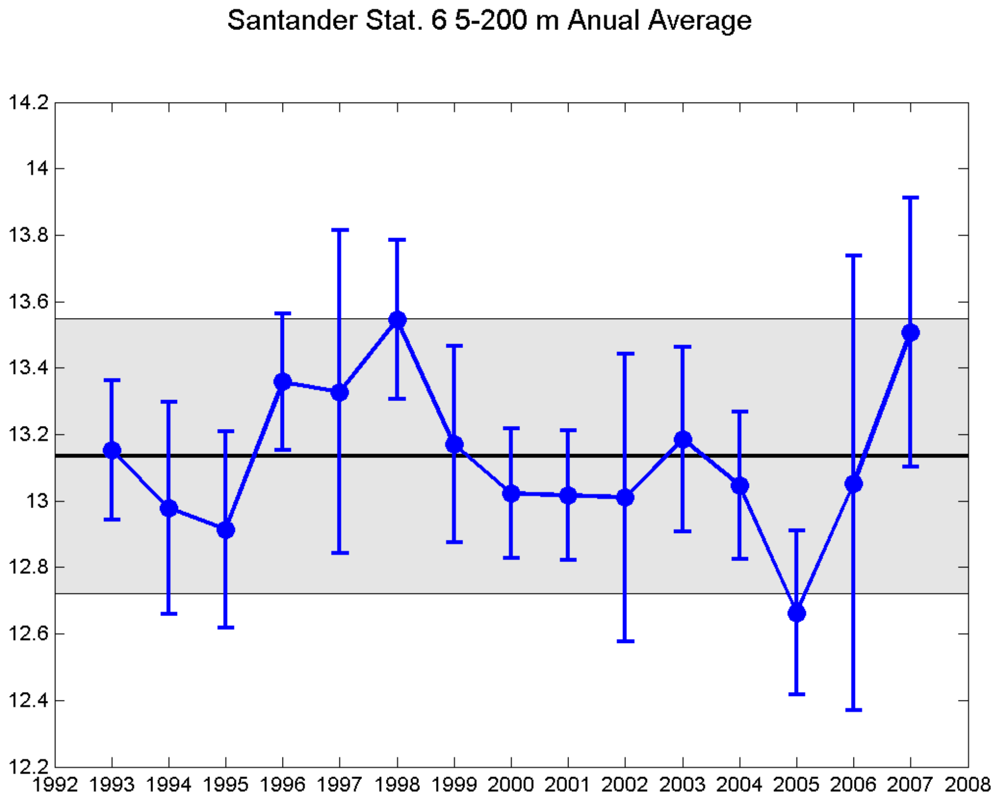


Figure 20. Annual average temperature (5–200) m. at Santander station 6 (shelf-break).

A salinity average of this layer (5–200 m) is shown in Figure 21 for station 6. The 2007 mean value are in the limit of one standard deviation above the mean. Between 1998 and 2001, evidence of a decline in salinity was found up to a depth of 200 m. In 2002 this trend was inverted, especially during the Iberian Poleward Current episode at the beginning of the year. During the end of 2006 and beginning of 2007 an important increase in salinity has been observed in the upper 200 meters (Figure 9 a and b). This increase reach the maximum of the trend started in 2003. But values decreasing during 2007 after the maximum value reached in winter. The salinity behaviour of the complete time-series seems to be related with the atmospheric forcing in the area of formation of the ENACW, as it has been mentioned before and specifically with the difference between precipitation and evaporation.

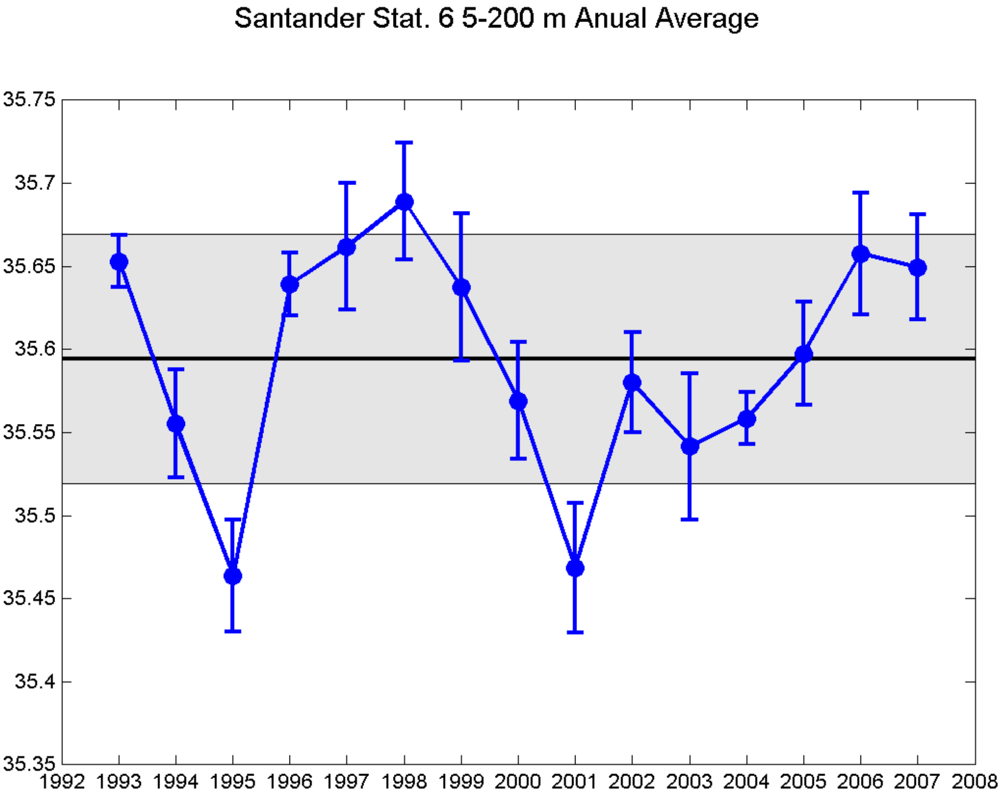


Figure 21. Annual average salinity (5–200m) at Santander station 6 (shelf-break).

In figure 22 distributions of potential temperature and salinity at 300–600 meters and 600–950 meters corresponding to ENACW and MW (Mediterranean Water) respectively is presented at the over the slope (St 7). A warming trend is observed in ENACW and MW but beginning since the start of the time-series in the case of MW and after in ENACW. A reduction on temperature is detected in 2004 and 2006 in ENACW but not so clearly in MW. The intense increase in salinity in ENACW, observed in the figure, for the years 2004 to 2006 seems to be stabilized in 2007 whereas in MW the tendency of salt increase is kept since the beginning of the time-series as in the case of temperature. The shallower level of MW it isn't represented here, but it seems to accelerate this processes maybe related for the first time in the series with mixing from above.

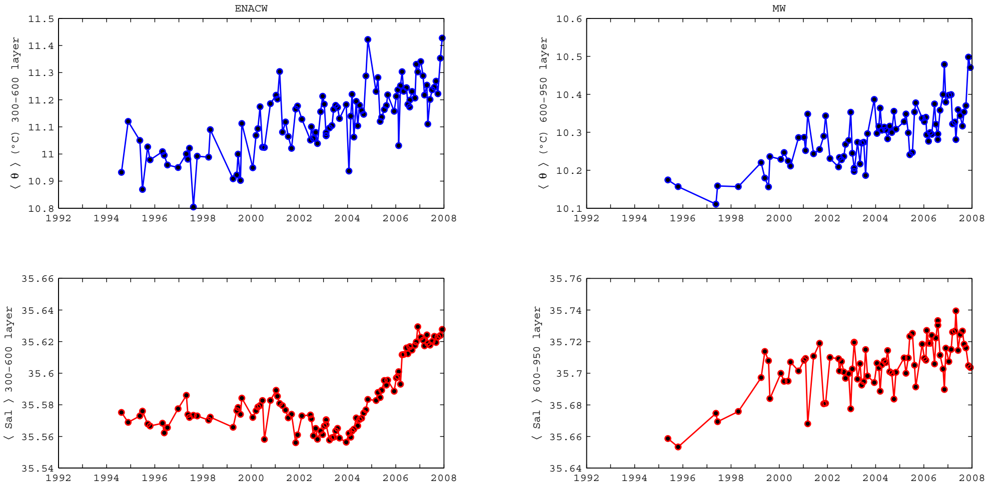


Figure 22. ENACW (300–600m) and MW (600–950m) water properties at Santander station 7(43° 48′N, 3° 47′W) (slope). Temperature in the upper panels and salinity in the lower panels.

Water Masses

The consequences of the deep winter anomaly in the mixed layer and upper Central Waters in 2005 and the 2006 winter it is not detected in 2007. In 2005 the mixed layer depth was greater than 300 dbar and in winter 2006 the mixed layer reaches practically the same depth. The existence of a very low stratified water column below the seasonal termocline, developed during the 2005 summer, has favoured the formation of a very deep mixed layer again in winter 2005–2006. The warm winter 2007 has produced again a shallow mixing layer.

In the figure 23 it can be seen the θS diagram of water masses at the southern Biscay from the Santander Standard Section data set, the sequential colour code also provides a first approach to the interannual variability. ENACW is found just below the mixed layer (typically less than 200 dbar) and it is described by a straight line which ends in a Salinity Minimum level located about 500 dbar. Below this level it is found progressively the Mediterranean Water (MW) which has its core about 1000 dbar the limit of our sampling. From the data set it can be observed that MW has increased its temperature and salinity compensating its density, whereas the variability in the ENACW is not so evident in the θS diagram. The main changes evident in ENACW are the increase in salinity since 2005 onwards and the interruption of the θS straight line below the 27:1 isopycnal level in the last years and the recovering again during the warm winter of 2007.

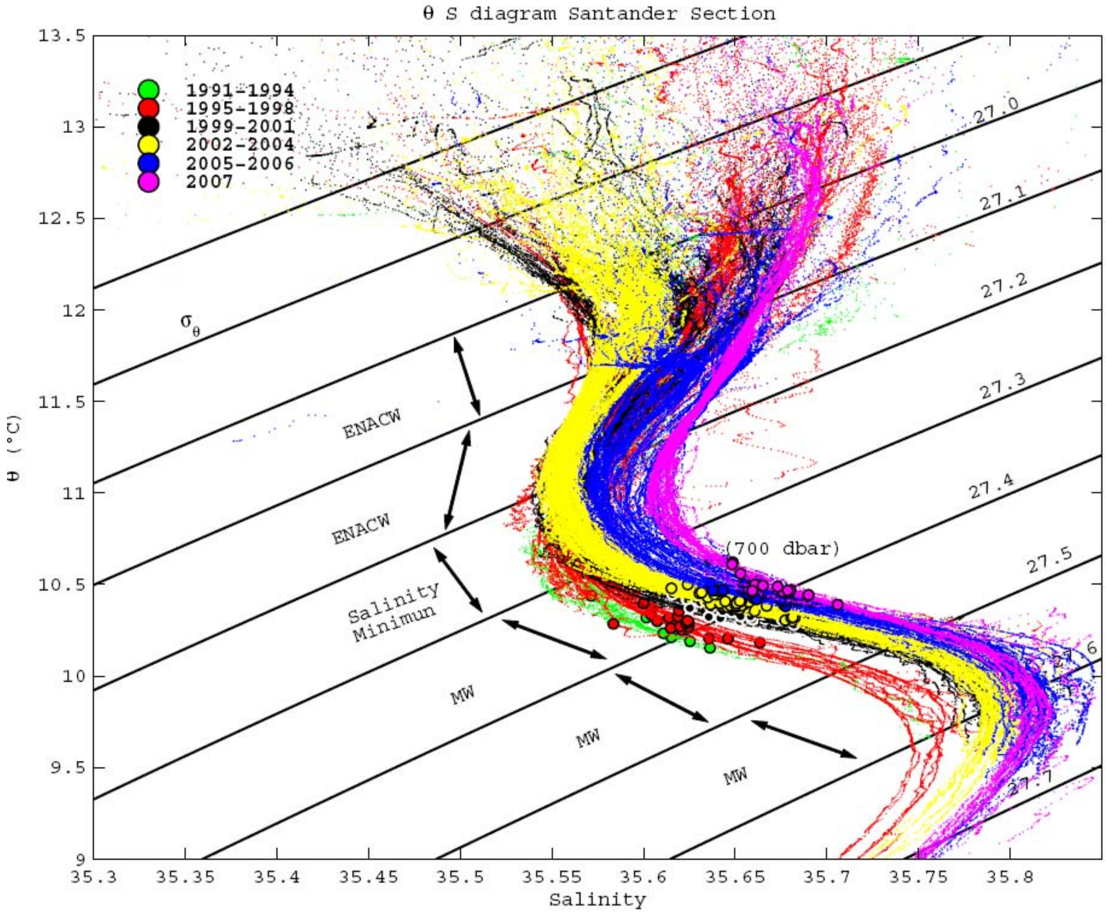


Figure 23. Water masses at Santander stations 6 and 7 presented in a TS diagram.

Annex 11: Annual report 2007 Finland,

Bert Rudels

The Finnish working group for monitoring the Baltic Sea produced is report for 2007 in the beginning of 2008. The major findings are summarised below. For additional information the full report, FIMR Monitoring of the Baltic Sea Environment – Annual Report 2007, Riitta Olsonen (Editor), MERI, 62, 109pp. should be consulted. Furthermore, the FIMR hydrographic observations are available at: http://www.fimr.fi/en/palvelut/bmp/bmp-data.html.

The average sea level was exceptionally high along the Finnish coastline in January 2007, about 50cm above the long-term average, and was at its highest in the middle of the month. In the Gulf of Finland and in the Archipelago Sea the sea level was higher than normal unusually long. During the remaining part of the year the sea level was 5–25cm above average except in June, when it was about 5cm lower and in October when it was about average.

Waves were measured in the Gulf of Finland and in the northern Baltic Proper. In these areas the waves were higher than normal in January, April, July, September and December. In February and October the sea was calmer than normal.

The ice season 2006–2007 was mild. Air temperatures were exceptionally high in December and March. Only February was cold in the north. The first ice developed in the beginning of November, but only towards the end of January did the sea begin to freeze to any large extent. The maximum ice cover extent was reached in late February (23/2), when the ice covered 33% of the Baltic Sea. The duration of the ice season was about average in the northern Bothnian Bay, but more than a month shorter than average in the southern Bothnian Bay and a month and a half shorter than average in the other sea areas. In the Baltic proper no ice was present at all.

In general, Baltic Sea temperature, salinity and oxygen conditions were around average. The temperatures of the Finnish coastal waters were about normal most of the year. Nevertheless, the beginning of January was clearly warmer than normal and a colder than normal period occurred in July. Sea surface temperatures were highest in mid-August. Near-bottom oxygen concentrations were comparatively low in late summer. In the Gulf of Finland the waters were to a large extent mixed down to the bottom in 2006–2007 winter. There were no major saline pulses entering the Baltic Sea in 2007.

Outside the Baltic Sea FIMR has actively conducted oceanographic research in the North Atlantic and in the Arctic Mediterranean. The observations collected during the ASOF programme (Arctic-Subarctic Ocean Fluxes) have been analysed and fieldwork has been conducted in the Arctic Ocean within the DAMOCLES (Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies) during the International Polar Year (IPY). These studies included ice research in spring and early summer from the ice camp established close to the drifting ship Tara, oceanographic studies on the LOMROG expedition (LOMonosov Ridge Off Greenland), and oceanographic observations from Rv Polarstern during the SPACE cruise (Synoptic Pan-Arctic Climate and Environmental studies). The observations from these field efforts are presently being analysed.

Annex 12: Faroe waters

by Bogi Hansen

Hydrographic conditions in Faroe waters are monitored by regular CTD cruises along four standard sections, usually four times a year. In addition, a total of 8 ADCPs are moored on three of these sections (Figure 1). These activities are designed to monitor the properties (T and S) and volume transport of the Faroe Bank Channel (FBC) overflow and two Atlantic inflow branches: the Faroe Current north of the Faroes, and inflow through the Faroe-Shetland Channel (FSC) (together with the Marine Laboratory in Aberdeen).

Time series plots of the temperature (Figure 2) and the salinity (Figure 3) of the Atlantic water on the section across the FBC and northwards from the Faroes show that the increased temperatures and salinities from the mid-1990s still persist, although conditions in 2007 were slightly cooler and fresher than in the earlier years of this century.

The conditions still remain exceptionally warm and probably also saline in a century-long perspective as indicated by the Faroe coastal temperature time-series (Figure 4), although, like all coastal and shelf time-series, it is affected by atmospheric and terrestrial effects.

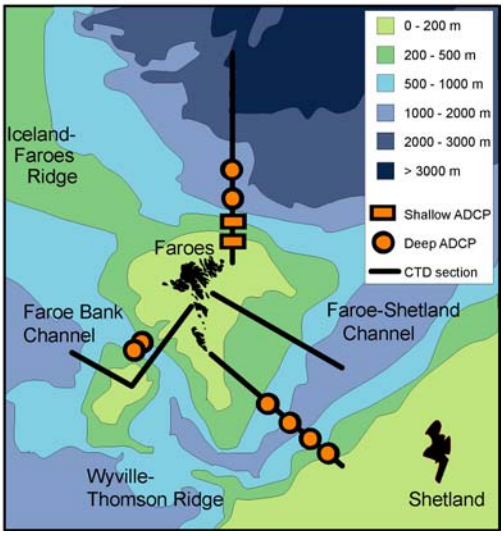


Figure 1. Standard sections (black lines) and moored ADCPs at the top of traditional moorings (yellow circles) or in trawl-protected frames (yellow rectangles). The two FSC standard sections are identical to those monitored by the Marine Laboratory in Aberdeen. That laboratory also operates the two ADCP moorings (Figure 1) closest to the Scottish shelf.

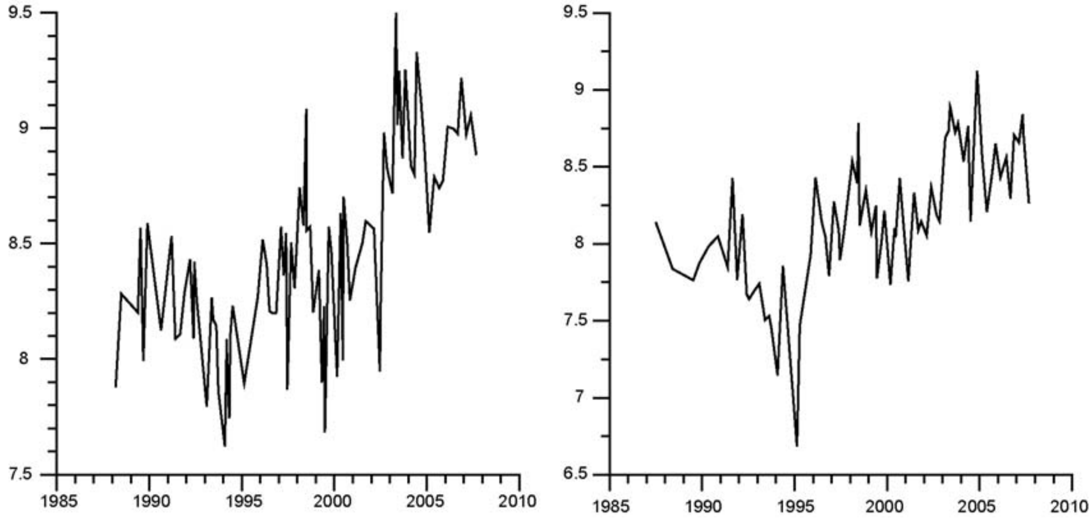


Figure 2. De-seasoned temperature from individual cruises in the FBC (left panel) and the core of the Faroe Current (right panel). In the FBC, the figure represents the average temperature in the 100–300 m layer from the two deepest stations. In the Faroe Current, the figure represents the average temperature in that 50 m depth layer on the section that has the highest salinity (the core).

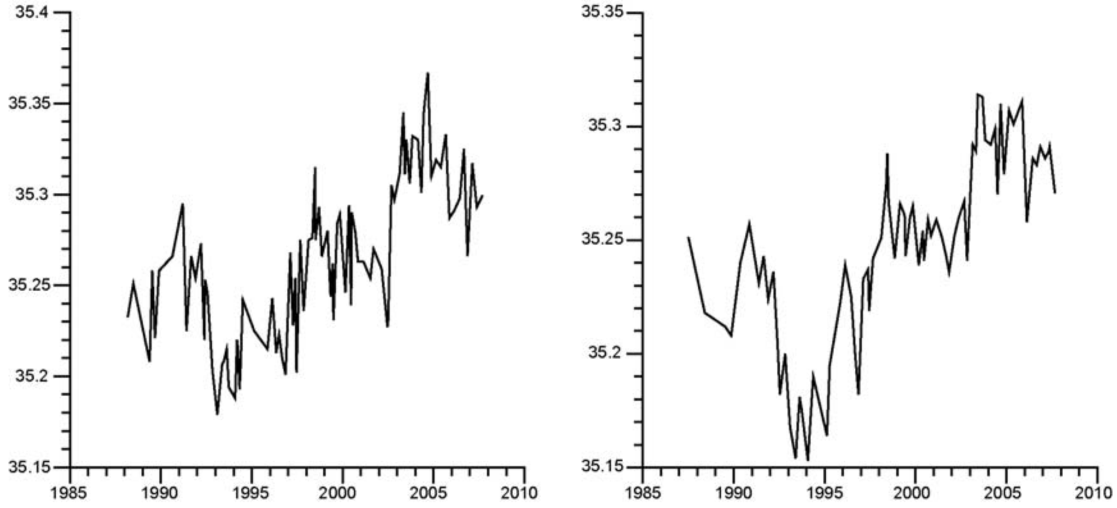


Figure 3. De-seasoned salinity from individual cruises in the FBC (left panel) and the core of the Faroe Current (right panel). In the FBC, the figure represents the average salinity in the 100–300 m layer from the two deepest stations. In the Faroe Current, the figure represents the average salinity in that 50 m depth layer on the section that has the highest salinity (the core).

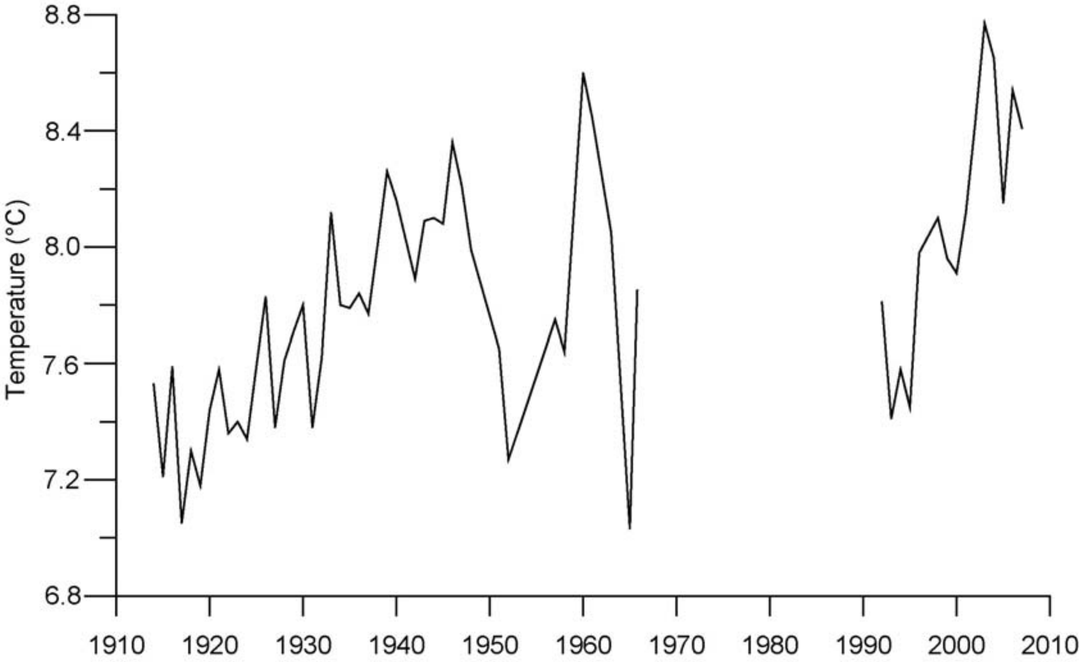


Figure 4. Annually averaged Faroe coastal temperature monitored daily in Mykines 1914–1969 and several times daily at the neighbouring site Oyrargjógv from 1992. Inter-comparison experiments support that the two sites represent the same water mass (Faroe Shelf Water).

Annex 13: Hydrographic conditions in Atlantic Domain of the Nordic Seas (Areas 8,10,11) – Summer 2007

Waldemar Walczowski, Jan Piechura, Ilona Goszczko

Institute of Oceanology Polish Academy of Sciences, Sopot, Poland

1. Observations 2007

AREX2007 cruise of Institute of Oceanology Polish Academy of Sciences (IOPAS) vessel R.V Oceania was performed in period of June 08 2007 – July 23 2007. 172 CTD casts along 11 sections were done (Figure 1). The SBE 9/11 device was used. Measurements of currents were done by means of lowered Acoustic Doppler Current Profiler (LADCP). The self-recording 300 kHz RDI device was used to profile entire water column during the standard CTD casts. During the whole cruise continuous currents measurements by the ship-mounted ADCP, RDI 150 kHz were conducted.

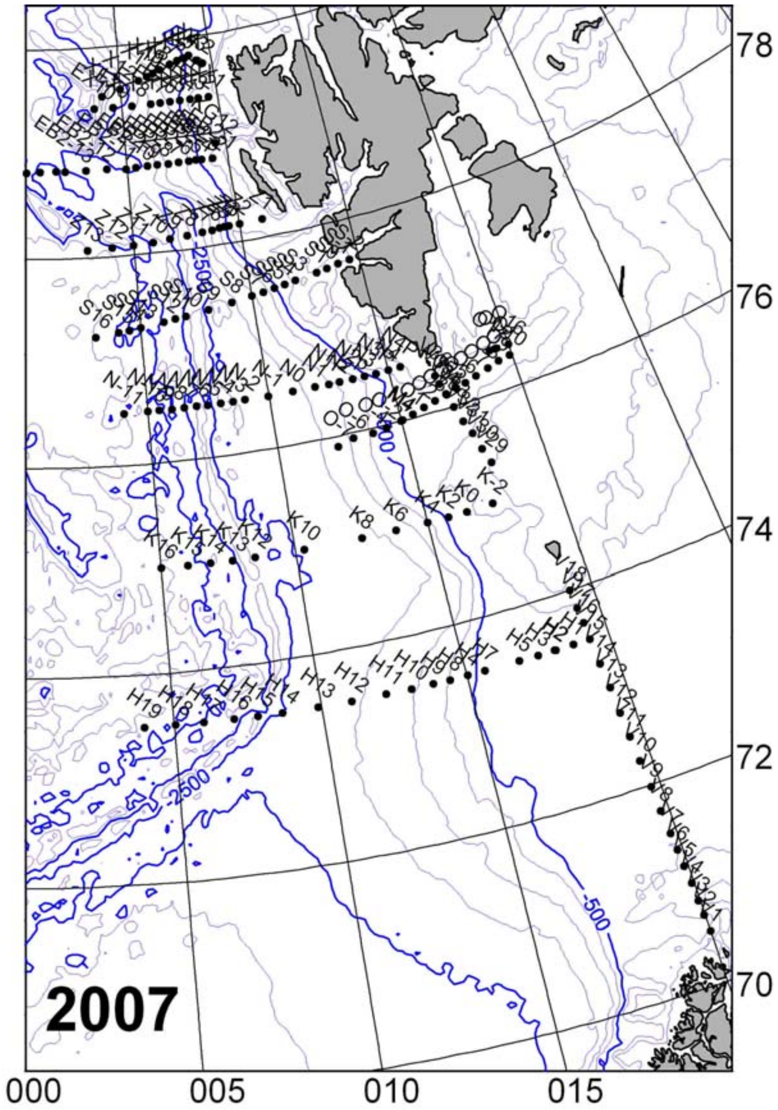


Figure 1. Stations grid performed during R.V 'Oceania' cruise, summer 2007.

2. Hydrographic conditions

In summer 2007 Atlantic Water was colder than in 2006 (Figures 2, 3, 4). At standard section 'N' along the 76°30' latitude, between meridians 009–012°E the most significant differences occurred in the layer 50 – 250 dbar (Figure 3). In 2007 in the whole selected region we could observe characteristics similar to those specific for water which was found in 2006 on the western side only (red, marked by bold line, profile on Figure 3a, 3b and 3c). This indicates a narrower core of the West Spitsbergen Current (Figure 5b) flowing above the slope in 2007 than in 2006. In the layer 300 – 600 dbar in 2007 there is strong diversification in comparison to more homogeneous profiles in 2007, especially in temperature.

At section N mean temperature and salinity at 200 dbar was in 2006 respectively 4.50°C and 35.13, in 2007 has dropped to 3.84°C and 35.11. However at this level temperature value was still 0.69°C higher than 1996–2007 mean and both temperature and salinity trends for this period are positive.

Measurements at all sections of the area between northern Norway and Fram Strait investigated in summer 2007, show decreasing of the AW temperature and salinity. In 2006 the extreme, high temperatures of the West Spitsbergen Current core were observed, and lower temperatures of the West Spitsbergen Current in 2007 was not so surprising. Also the extreme northward extension of the warn Atlantic Water was observed in 2006 (Figure 5a). In 2007 the 5° isotherm at 100 dbar moved back to position from 2005 (Figure 5b).

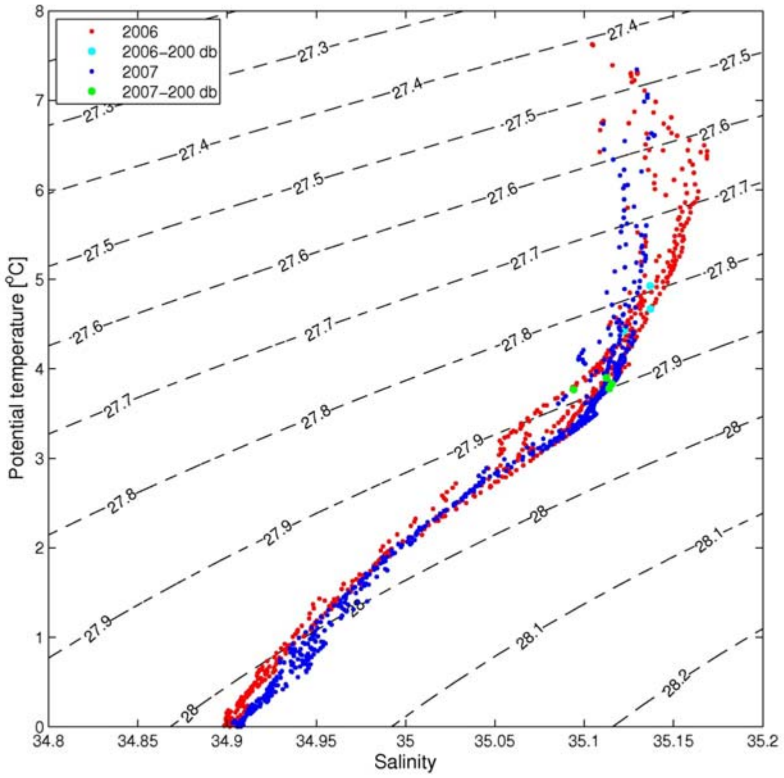


Figure 2. T-S diagram for stations at section 'N' along the 76°30' latitude, between meridians 009–012°E in summer 2006 (red dots) and 2007 (blue dots). Cyan dots indicate level of 200 dbar in 2006, green dots – level of 200 dbar in 2007.

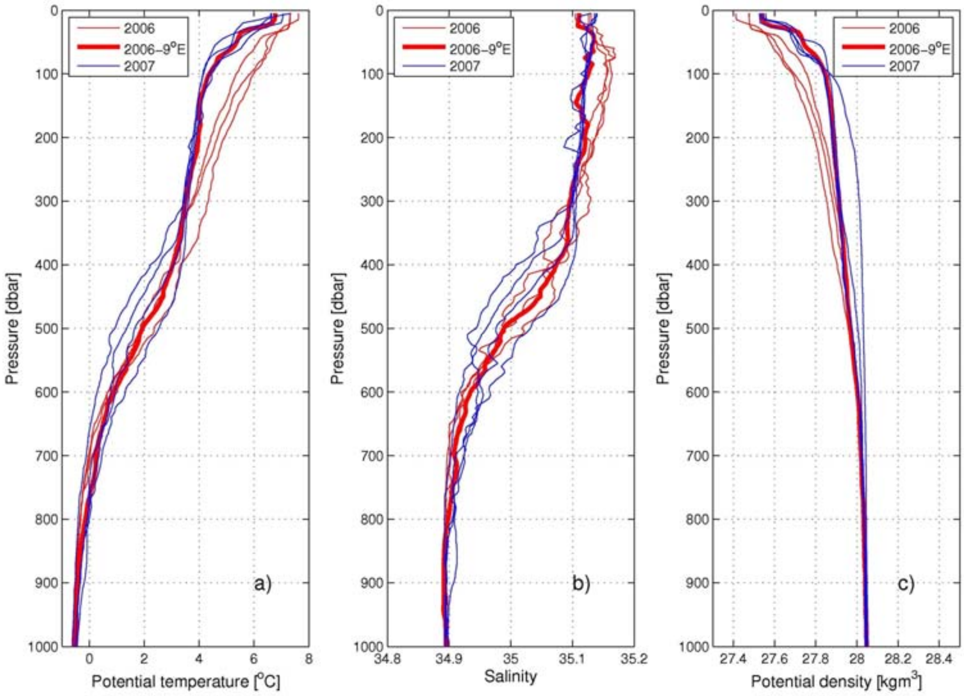


Figure 3. Profiles of potential temperature, salinity and potential density at section ‘N’ (76°30′ N), between 009°–012° E in summer 2006 (red lines) and 2007 (blue lines).

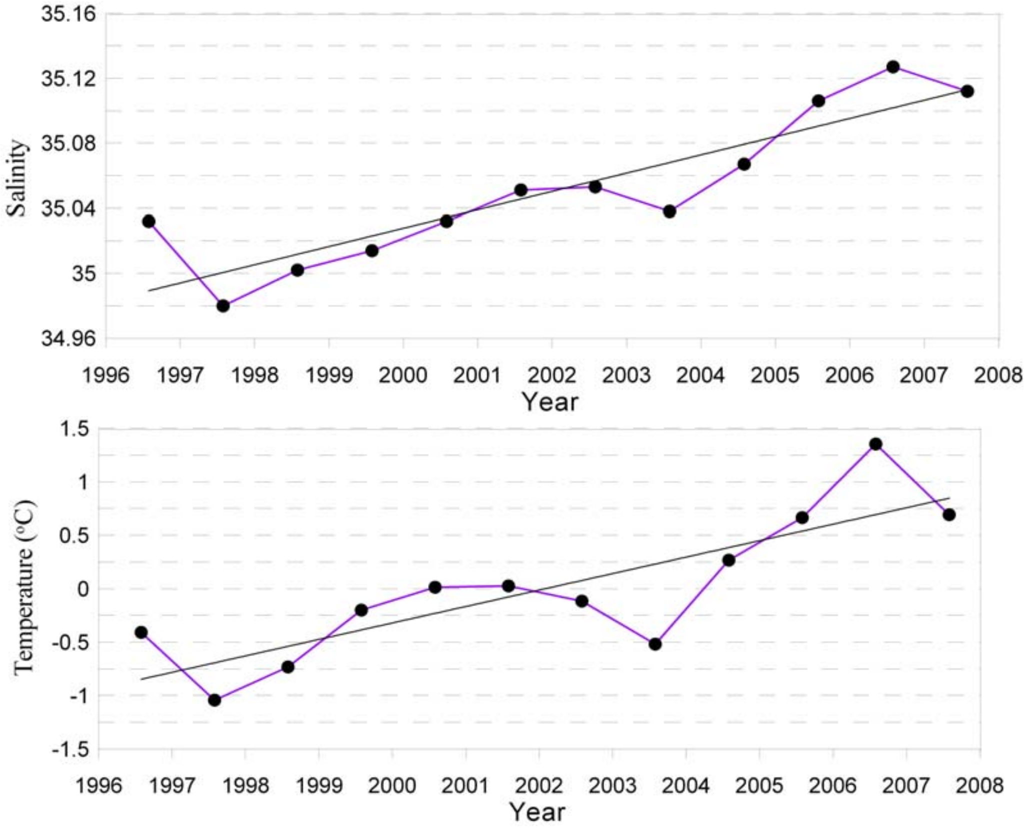


Figure 4. Mean salinity (upper panel) and mean temperature in summer (July) at section ‘N’ (76°30′ N) at 200 m, between 009°–012° E.

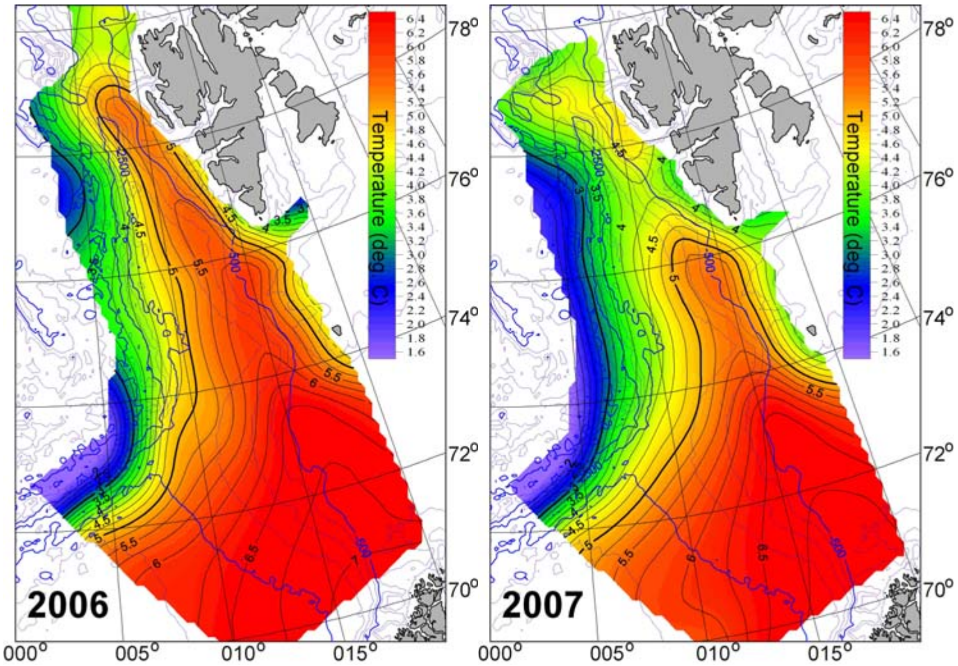


Figure 5. Temperature at 100 dbar in June-July 2006 (left hand side) and 2007.

3. Dynamics

Figure 6 presents the distribution of baroclinic currents kinetic energy and baroclinic currents at 100 dbar (calculated for the reference level of 1000 m.) during summer 2007. Intensive inflow into the Greenland Sea over the Mohna Ridge and dividing this inflow is well visible.

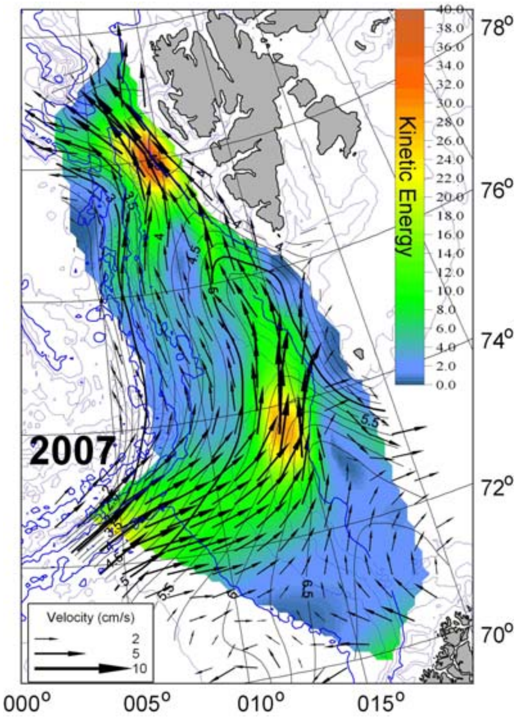
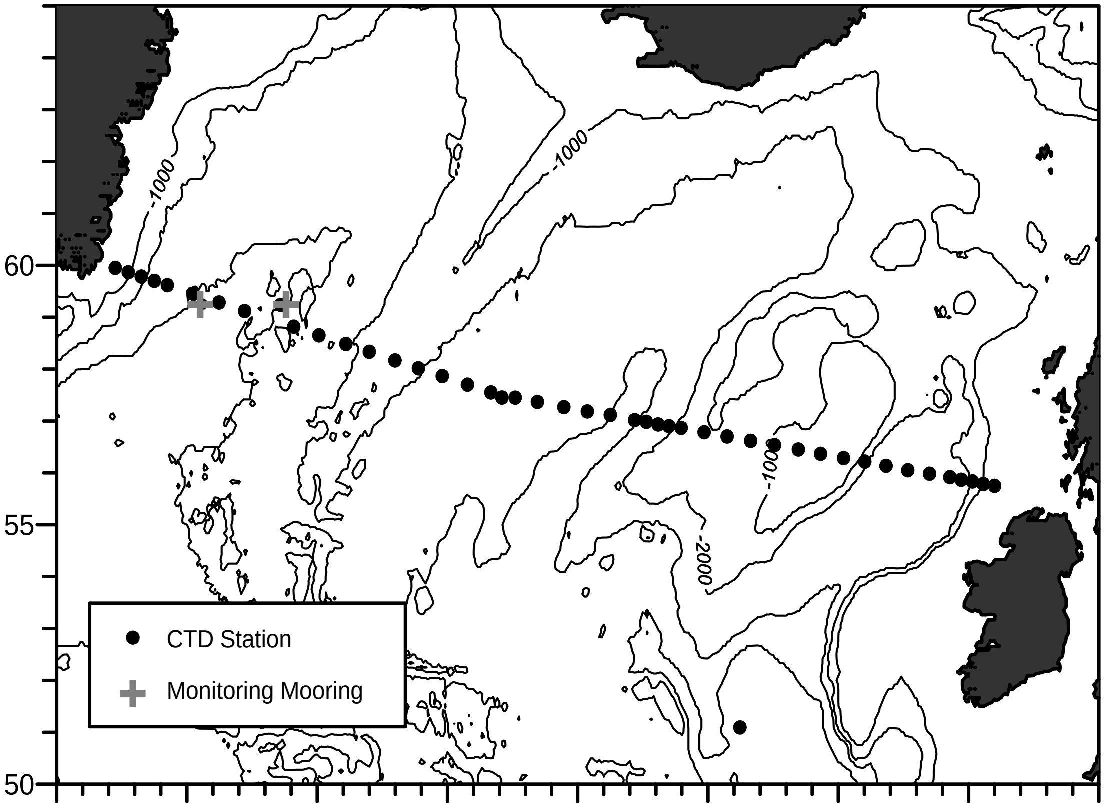


Figure 6. June-July 2007. Baroclinic flow kinetic energy distribution (colour scale), and baroclinic currents at 100 dbar. Reference level 1000 m.

Annex 14: National report The Netherlands, 2007,

Hendrik van Aken

The Royal Netherlands Institute for sea Research (Royal NIOZ) re-surveyed the former WOCE section AR7E between Cape Farewell (Greenland) and the continental shelf north of Ireland. This section has been surveyed since 1990 by Dutch, German and British ships. The distance between successive hydrographic stations amounted to 30 miles, reduced to 15 miles over steep slopes. At each station a CTD cast from the sea surface to close to the bottom (10 m) was recorded while during the up-casts water samples were taken for the determination of dissolved nutrients (phosphate, nitrate and silicate), oxygen, carbon dioxide and alkalinity. Ship time was also used for the recovery, service and re-deployment of two monitoring moorings in the Irminger Sea. They contain daily T-S profiles between 180 and 2400 m, ADCP data from the upper 600 m and the lowest 500 m of the water column, and T-S data near the bottom (~3000 m). Now 4 successive years of data from these moorings are available.



Annex 15: Norwegian Waters

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Summary

The temperature in the southern Barents Sea was in 2007 above normal but less that in 2006 and there was a record-low sea-ice cover about similar as in 2006. In 2007 the Atlantic water in the Norwegian Sea was 0.5–0.8 °C warmer than normal with highest anomaly to the north. At the beginning of 2007, the temperatures in the North Sea were very high until fall when it dropped to normal.

Figure 1 shows all Norwegian standard sections and fixed oceanographic stations.

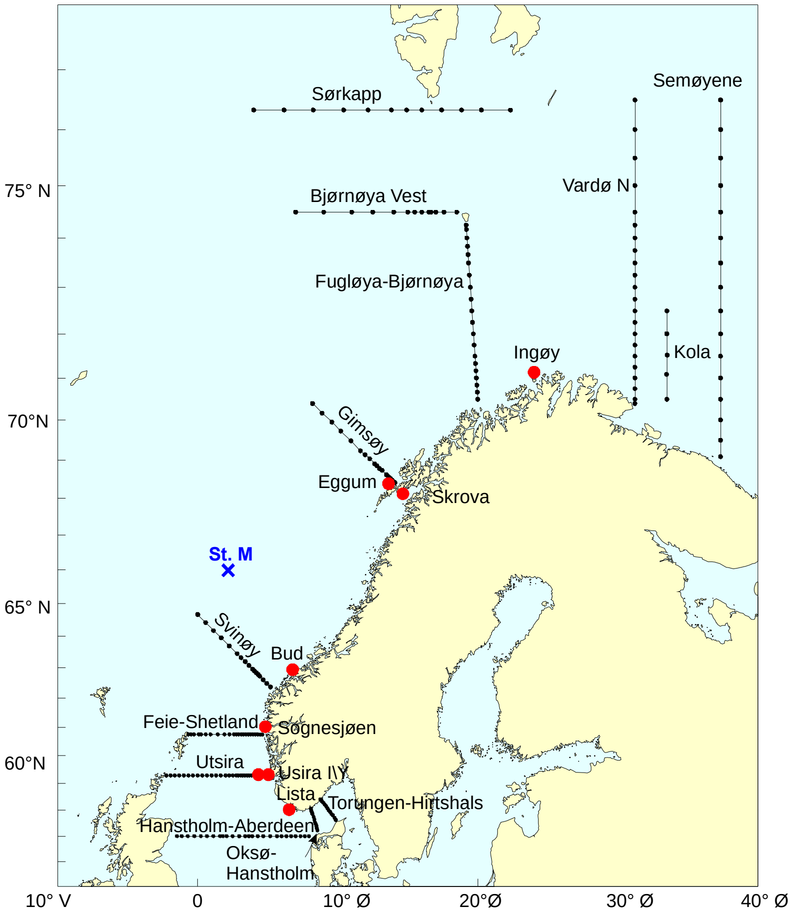

Figure 1. Standard sections and fixed oceanographic station worked by the Institute of Marine Research, Bergen. The University of Bergen is responsible for station M, while the Kola section is operated by PINRO, Murmansk (Anon., 2002).

The Norwegian Sea

During the past six years, the north-flowing Atlantic water in the eastern Norwegian Sea has been extraordinarily warm and saline. In 2007, along the Norwegian continental slope, the core of Atlantic Water was 0.5–0.8°C warmer than normal with highest anomaly in the south.

The hydrographic condition in the Norwegian Sea is characterized by relatively warm and salt water in the east due to the inflow of the Atlantic water from the south. In the west, however, the hydrographic condition is also influenced by the fresher and colder Arctic water that arrive from the Iceland and Greenland Seas. Figure 2 shows the development in temperature and salinity in the core of Atlantic Water for three different sections from south to north in the eastern Norwegian Sea (Figure 1). There has, in general, been an increase of temperature and salinity in all three sections from the mid-1990s to present. From 2000 the annual temperature averages were above normal in both the Svinøy and the Gimsøy section. As Atlantic water flows northward the temperature increase can also be observed further north, in the Sørkapp section. In 2007, the annual temperature averages were 0.8°C and 0.**5°C** above the long-term-mean for the time-series in Svinøy and Gimsøy sections, respectively. In the Sørkapp section the summer temperature was 0.5°C above the long term mean. The salinity has the last years also increased in all three sections. In the Svinøy section the salinity has since 2003 been nearly constant 0.05 above normal while it in the Gimsøy section decreased from 0.07 above the mean in 2006 to about 0.03 above the mean in 2007. In the Sørkapp section the salinity was in 2007 also above the long term mean, about 0.06. The large salinity values that are observed in the sections are a result of a saltier inflow of AW to the Norwegian Sea through the Faroe-Shetland Channel.

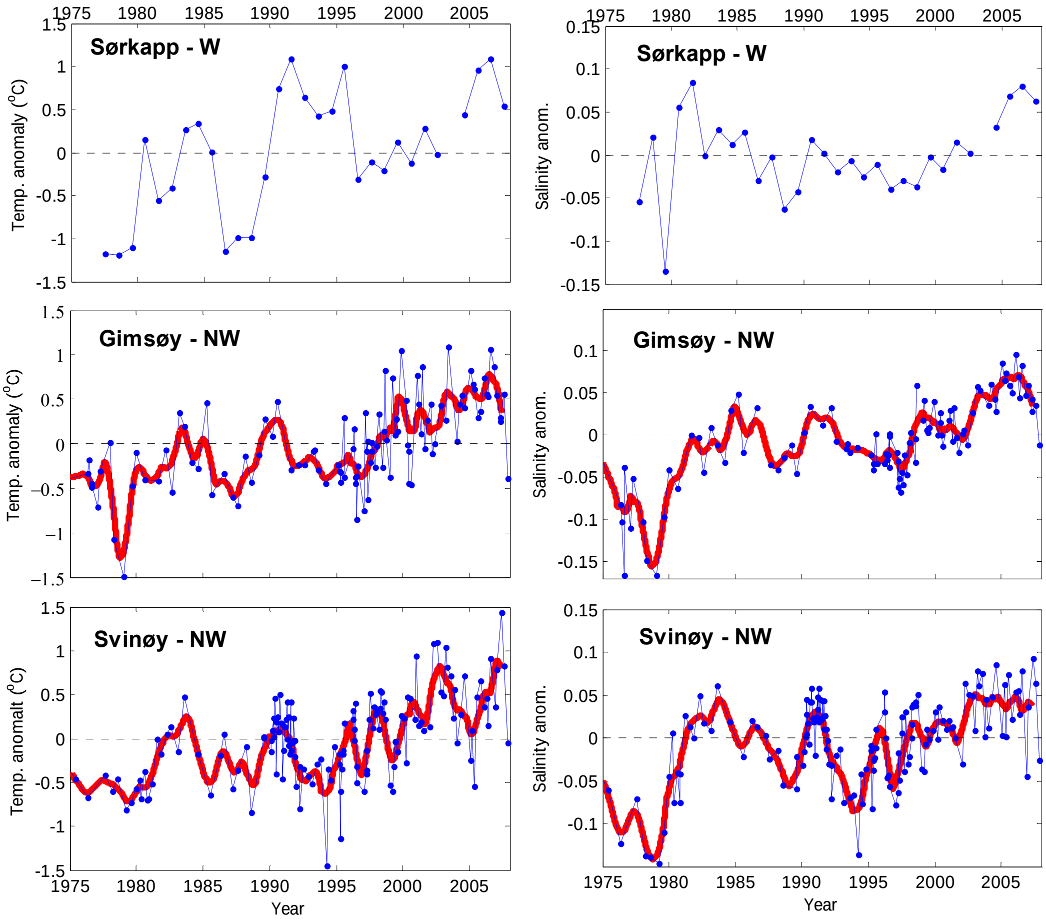

Figure 2. Temperature and salinity anomalies in the core of Atlantic water for the sections Svinøy-NW, Gimsøy-NW and Sørkapp-W, averaged between 50 and 200 m depth. Blue lines are actual values (only summer values in the Sørkapp section) while red lines are one year averages.

The area of Atlantic water (defined with S>35.0) in the Svinøy-section has been calculated. The mean temperature within the limited area has also been calculated, and the results for spring and summer are shown in Figure 3. Large values in the area are due to larger distribution of Atlantic water in the section. This is due to a more westerly or/and vertical distribution of Atlantic water. There are considerable variations both in the area of Atlantic water distribution and its temperature. The distribution area of Atlantic water decreased since the beginning of 1980s to mid 1990s and increased from there to present. The temperature has shown a steady increase. Since 1978 the Atlantic water has been about 0.8°C warmer. In 2007 the temperature was the highest ever in the time-series, 0.7°C higher than the long-term-mean. However in 2008 it dropped and was then close to the long term mean. The area of Atlantic water has increased the last years and in 2007 it had the second largest value in the time-series.

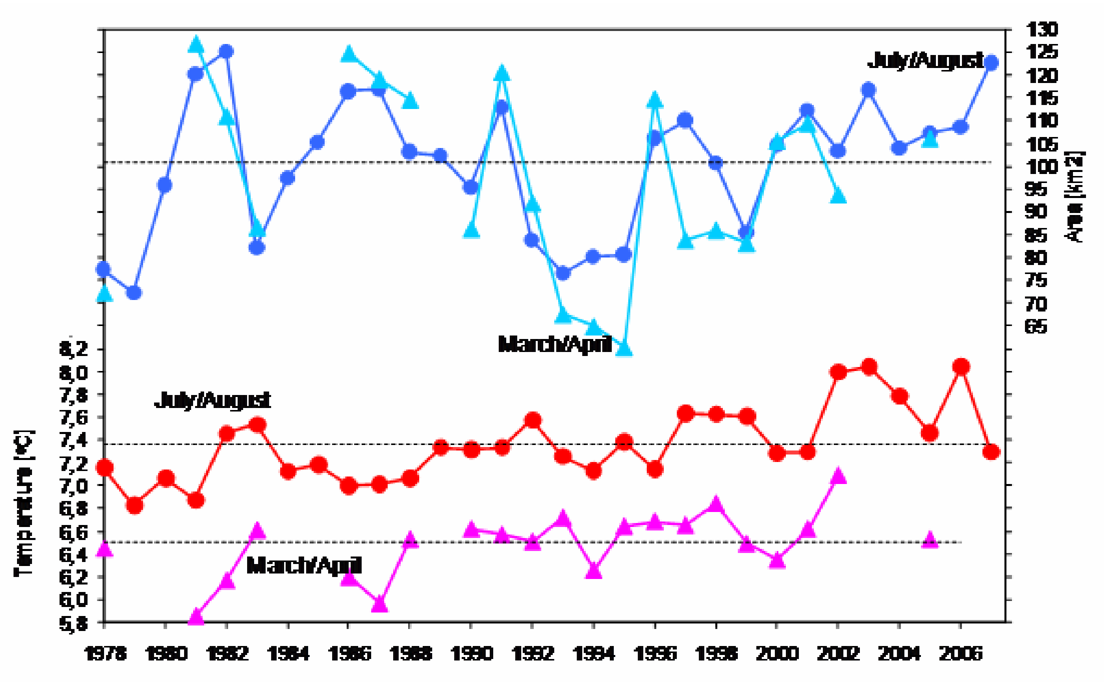

Figure 3. Time series of area (in km2) and averaged temperature (red) of Atlantic water in the Svinøy section, observed in March/April and July/August, 1978–2007.

The Barents Sea

The Barents Sea is a shelf area, receiving inflow of Atlantic water from the west. The inflowing water demonstrates considerable interannual fluctuations in water mass properties, particularly in heat content, which again influence on winter ice conditions. The variability in the physical conditions is monitored in two sections. Fugløya-Bear Island is situated where the inflow of Atlantic water takes place; the Vardø-N section represents the central part of the Barents Sea. In both sections there are regular hydrographic observations, and in addition, current measurements have been carried out in the Fugløya- Bear Island section continuously since August 1997.

The hydrographic observations were carried out according to the plan. Figure 4 shows the temperature and salinity anomalies in the Fugløya-Bear Island section in the period from 1977 through 2007. In the period 1977–1997 there were distinct warm and cold periods alternating with a period of 3–5 years. After that the temperatures has stayed above the long-term mean, and since 1997 the temperature has increased with almost 1.5ºC. The period 2001–2005 was in fact the warmest 5-year period since the beginning of last century, and the 2 last years were even warmer.

In January 2007, a positive temperature anomaly of 1.55°C was observed, which is all time high. The temperature decreased rapidly during spring. They stayed well above the long-term mean throughout 2007, and in October they were about 0.7°C above. The annual mean temperature for 2007 is well above the long-term mean, but below the annual mean temperature of 2006. The salinity variations are similar to those in temperature, and there has been a high salinity in the last 6 years.

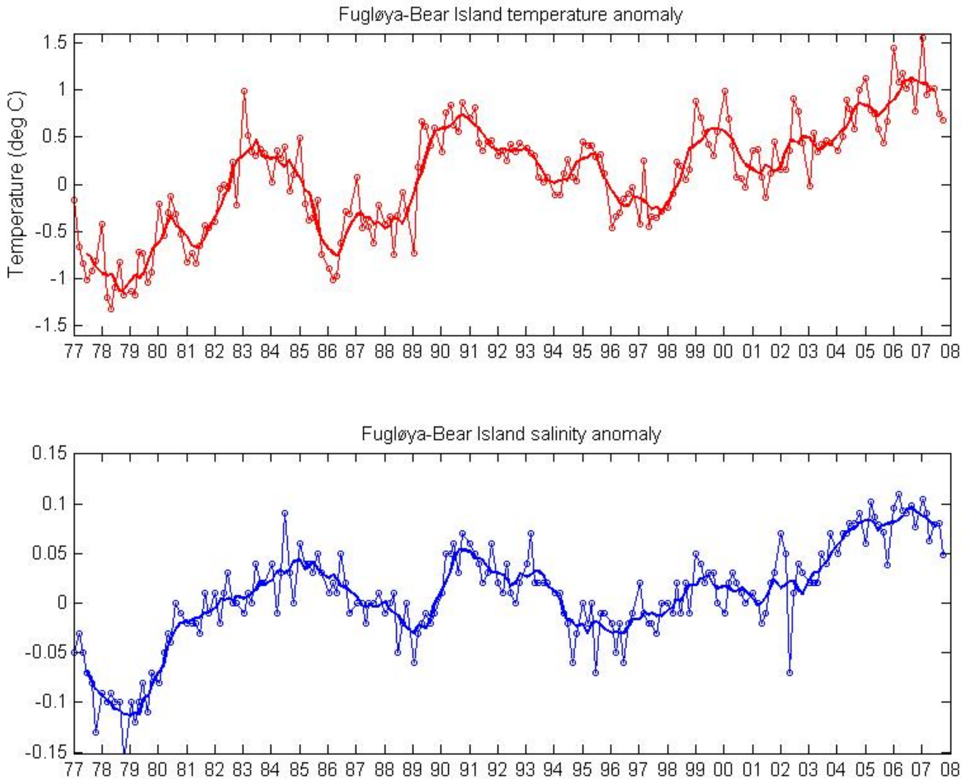

Figure 4. Temperature anomalies (upper panel) and salinity anomalies (lower panel) in the section Fugløya – Bear Island section.

Figure 5 shows an ice area anomaly for the Barents Sea. The variability in the ice coverage is closely linked to the temperature of the inflowing Atlantic water. The ice has a relatively short response time on temperature change (about one year), but usually the sea ice distribution in the eastern Barents Sea respond a bit later than in the western part. Due to the high temperatures there has been little ice in the last years. Since 2003 the winter ice edge has had a substantial retreat towards north-east, and most of the Barents Sea has been ice free during winter for the last few years (Figure 6). Averaged over the year 2007 had a slightly higher ice cover than 2006.

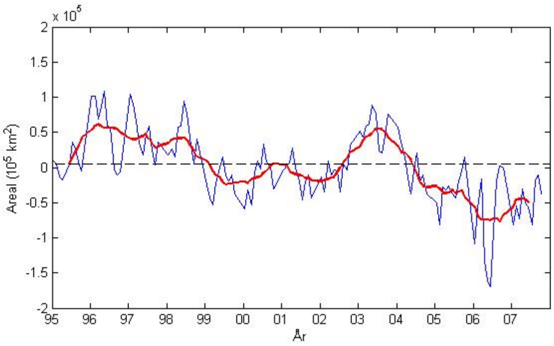

Figure 5. Ice area anomaly for the sector 25–45°E in the Barents Sea, which is the area with the highest variability in ice cover. Monthly mean (blue line) and 1 year moving average (red line) is shown relative to the mean ice area for the period 1995–2007.

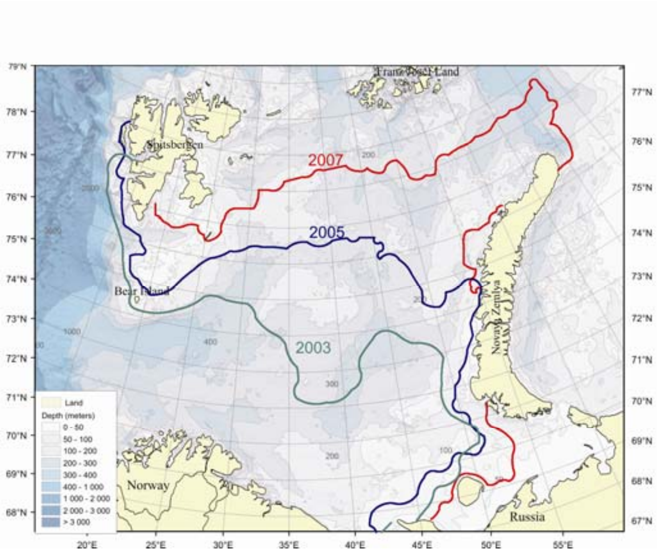

Figure 6. The ice edge (40% ice concentration) in late March/early April 2003, 2005 and 2007.

The current measurements that started in August 1997 as part of the EU-VEINS project showed that the observed current in the section Fugløya-Bjørnøya is predominantly barotropic, and reveals large fluctuations in both current speed and lateral structure (Ingvaldsen *et al.*, 2002, 2004). The inflow of Atlantic water may take place in a wide core located in the area 72°30′-73°N with outflow further north, but it may also be split in several cores. Between the cores there might be a weaker inflow or a return flow. The outflow area may at times be much wider than earlier believed, stretching from 73°30′N south to 72°N. This phenomenon is not only a short time feature; it might be present for a whole month. These patterns are most likely caused by horizontal pressure gradients caused by a change in sea-level between the Barents Sea and the Arctic or the Norwegian Sea by accumulation of water and/or by an atmospheric low or high.

There seems to be seasonality in the structure of the current. During winter the frequent passing of atmospheric lows, probably in combination with the weaker stratification, intensify the currents producing a structure with strong lateral velocity-gradients and a distinct, surface-intensified, relatively high-velocity, core of inflow. During the summer, when the winds are weaker and the stratification stronger, the inflowing area is wider, and the horizontal shear and the velocities are lower. In the summer season there is in inflow in the upper 200 m in the deepest part of the Bear Island Trough.

The time-series of volume transport reveals fluxes with strong variability on time scales ranging from one to several months (Figure 7). The strongest fluctuations, especially in the inflow, occur in late winter and early spring, with both maximum and minimum in this period. The recirculation seems to be more stable at a value of something near 1 Sv, but with interruptions of high outflow episodes.

The time-series of volume transports shows a relatively high inflow during 1997 and 1998, before the transport decreased and reached a minimum in end of 2000. Then there was a strong increase in the transport until beginning of 2003. The inflow was low in 2004, but increased substantially towards the winter of 2006. During fall 2006 the flux dropped to a minimum and a local minimum also appeared in spring 2007. Compared to the previous years the inflow in 2007 was low.

Comparing the temperature and the volume flux, it is evident that these two parameters do not have to vary in phase (Figure 7). This is because the temperature of the inflowing water depends on the temperatures upstream in the Norwegian Sea, while the volume flux depends mainly on the local wind field. The heat flux closely resembles the volume flux, i.e. the heat flux does not vary in phase with the temperature.

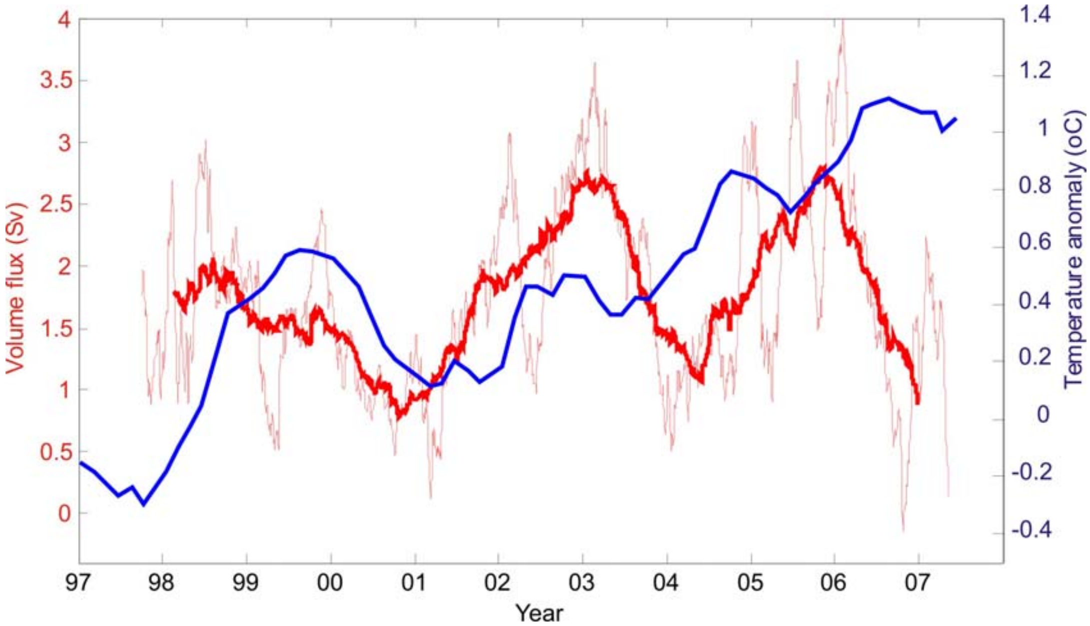

Figure 7. The red line show Atlantic Water volume flux across the section Norway-Bear Island and the blue line show temperature anomalies the Fugløya – Bear Island section. Time series are 3 and 12 months running means.

The North Sea

At the beginning of 2007, the temperatures in the North Sea were very high. In the northern North Sea the temperature was 0–1 degrees above the normal, while in the southeastern part it was 2–4 degrees above. The temperatures remained high until fall when it normalized in the surface waters. At the end of the year it is about normal along the Norwegian coast, while it still is very high 1–1.5 degrees (more than one standard deviation) above the normal in the deeper parts of Skagerrak.

Figure 8 shows the development of temperature and salinity at two positions, one (A) near bottom in the north-western part of the North Sea and the second (B) in the core of Atlantic water at the western shelf edge of the Norwegian Trench. The measurements are carried out during summer and represent the last winter situation. The average temperature at the plateau is 1–2°C lower than in the core of the inflowing Atlantic water (Figure 8). Also the salinity is slightly lower at the plateau. In both places there was extremely high temperature and salinities in 2004. This is a result of very high salinity in the inflowing Atlantic water and the effect of a mild winter. The relatively cold winters and springs of 2005 and 2006 has lead to quite normal temperatures in the deep layers of the North Sea, while the salinities still are quite high due to high salinities of the inflowing Atlantic water. The temperatures are higher in 2007 than in 2006 due to reduced winter cooling, while there is a decrease in salinity probably due to a reduced inflow of Atlantic water.

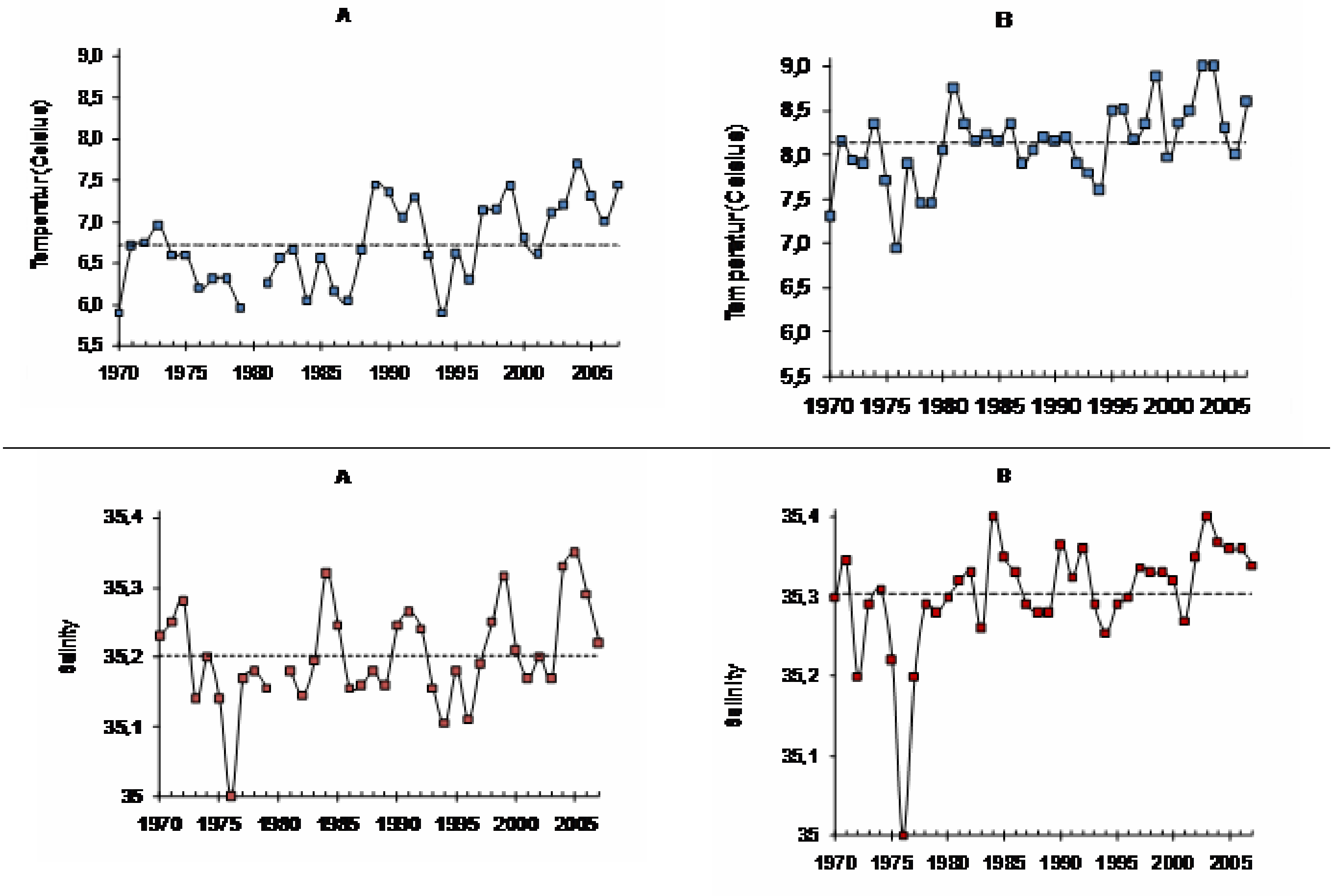

Figure 8. Temperature and salinity near bottom in the northwestern part of the North Sea (A) and in the core of Atlantic water (B) at the western shelf edge of the Norwegian Trench during the summers of 1970–2007 (Anon., 2008).

Estimates from a numerical ocean circulation model (NORWECOM, Figure 9) shows that the annual mean inflow of Atlantic water is the lowest ever (1985–2007) both from the north (through the section Orkney-Utsira) and through the English Channel. Through the channel the transport was low throughout the whole year, while from north the inflow were especially low in the 2nd and 3rd quarter.

The catches of horse mackerel during the autumn in the North Sea have for many years been strongly linked with the northern modelled inflow of Atlantic water during winter (1. quarter) approximately half a year earlier. However, in 2007 the model prognosis was about 60000 tons, while the catches were only 5000 tons.

There has been no renewal of Skagerrak deep water since 2005. As predicted in 2006 there was in the Skagerrak no renewal of the deep water in 2007, and also for 2008 we do not expect a new renewal to occur.

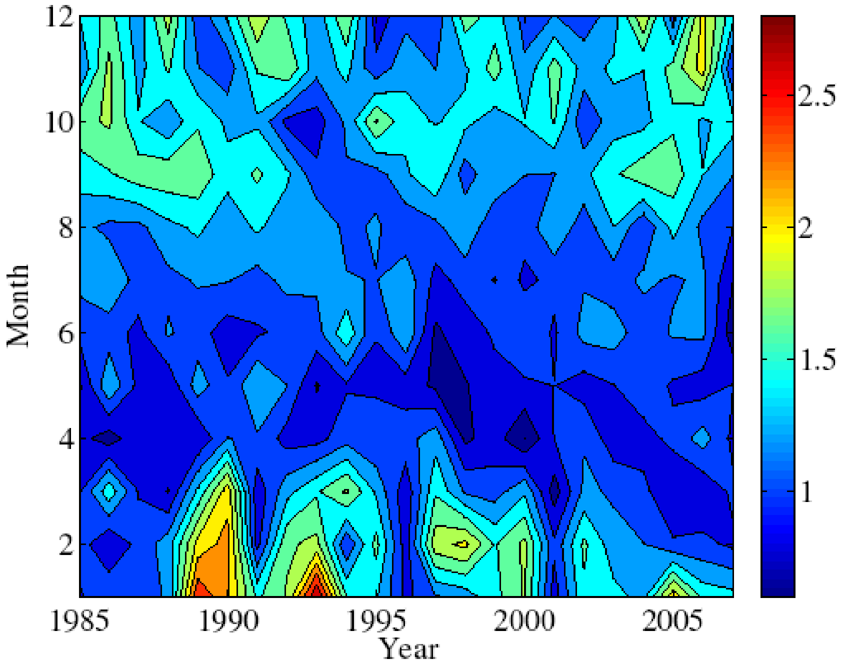

Figure 9. Time series (1985–2007) of modelled monthly mean volume transport of Atlantic water into the northern and central North Sea southward between the Orkney Islands and Utsira Norway. 1 Sv = $10^6 m^3 s^{-1}$. (Anon., 2007).

Annex 16: Russian standard sections in the Barents, Norwegian and Irminger Seas, 2007

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The Barents Sea

The analysis of hydrographic conditions in the Barents Sea is based on the available observations along standard sections and the data from fish stock assessment surveys. The total number of hydrographic stations made by PINRO in 2007 was 1,296 including 327 stations at the standard sections.

Figure1 presents the main Russian standard sections in the Barents Sea the data from which are discussed further.

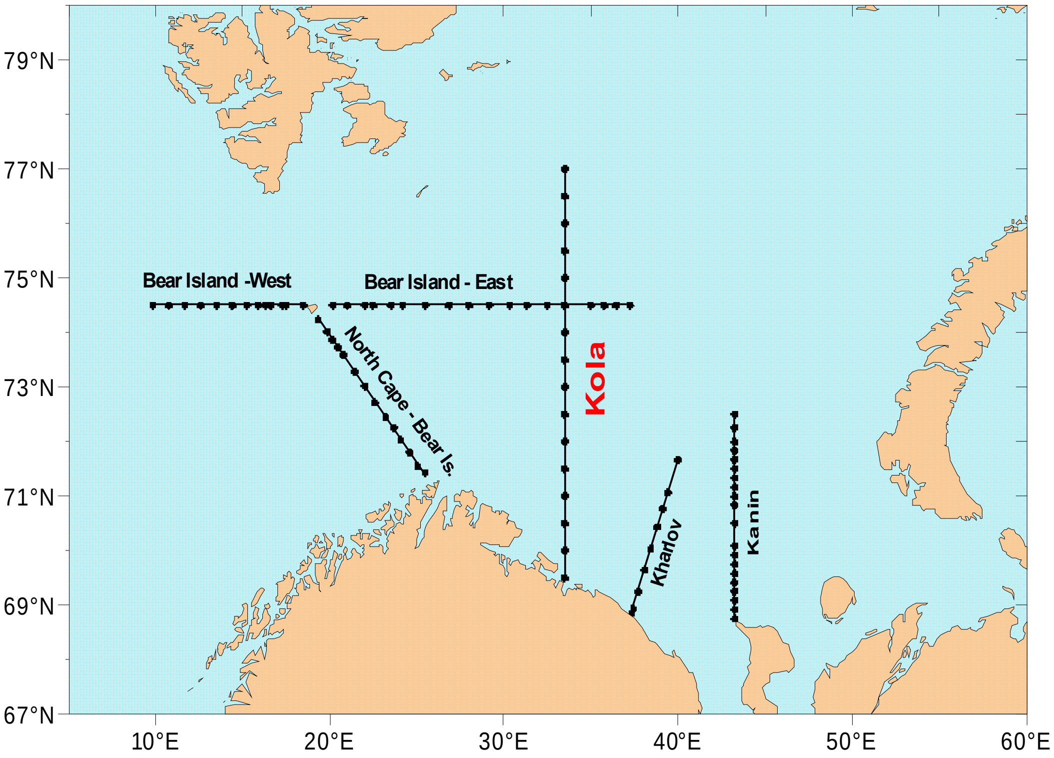

Figure 1. Main Russian standard sections in the Barents Sea.

The observations along these hydrographic sections have been made since the first half of the last century (the Kola Section – since 1900, the North Cape – the Bear Island Section – since 1929, the section Bear Island – West – since 1935, the section Bear Island - East and the Kanin section – since 1936). The Kola Section has been occupied more than 1,100 times by now.

Published time-series from the main standard sections (Bochkov, 1982; Tereshchenko, 1997, 1999) are also used in this analysis.

The weather over the Barents Sea was influenced by the cyclonic activity caused by an intensification of the Iceland Low in the beginning and the end of the year and its weakening in the summer season. In January-February, May-June, prevailing were easterly winds, in April and July-October, - northerly winds dominated, and, in March, southwesterlies dominated over the sea.

Air temperature dada were taken at http://nomad2.ncep.noaa.gov and averaged over western (70–76°N, 15–35°E) and eastern (69–77°N, 35–55°E) parts of the sea. In the first half of 2007, the air temperature over the Barents Sea was well above normal, with maximum positive anomalies (6.0–7.0°C) in the eastern sea in February-April. In summer and autumn temperature anomalies decreased to their long-term means. In November-December, over most of the sea, air temperature was, on average, 2.0–3.0°C higher than the long-term means.

Sea surface temperature (SST) data were taken at http://iridl.ldeo.columbia.edu and averaged over the Bear Island – Spitsbergen area (74–79°N, 08–25°E), central (71–74°N, 20–40°E) and southeastern Barents Sea (69–73°N, 42–55°E). In winter and spring, over most of the Barents Sea, SST was higher than normal, with maximum anomalies of 0.2–1.1°C in the central and eastern areas. In May-June, a weaker than usual atmospheric warming of the sea surface caused a decrease in SST anomalies. As a result, there was a transition from positive to negative SST anomalies in the eastern Barents Sea in June. At the second half of the year, SST anomalies increased again to well above normal values all over the sea with maximum in October (0.5–1.7°C).

During the year, the sea ice extent was generally much less than the long-term mean (Figure 2). The greatest ice coverage was observed in February, 36% of the sea area, that was 21% less than normal. Minimum ice extent was in September when there was no ice in the sea. Ice edge was located to the north of 81°N. In October ice coverage amounted only 1% of the sea areas, i.e. 16% lower than normal. In November it was the lowest for the corresponding month since 1951.

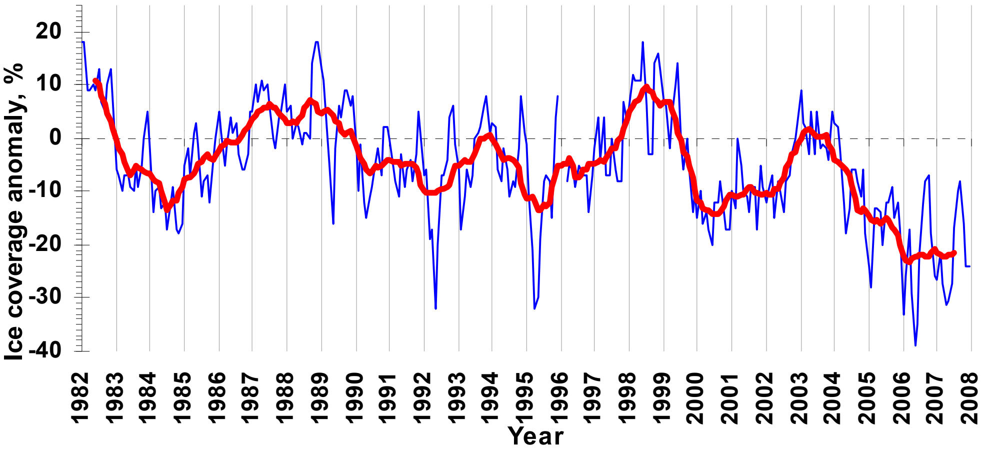

Figure 2. Anomalies of mean monthly ice extent in the Barents Sea in 1982–2007. A blue line shows monthly values, the red one – 11-month moving average values (Anon., 2008).

According to the observations along the Kola Section, which was made 9 times in 2007, sea temperature in the active layer (0–200 m) of the southern Barents Sea was significantly higher than the long-term means throughout the year (Figure 3). From

February through May, the temperature of the coastal waters (St. 1–3) as well as in the Murman Current (St. 3–7) was about 1.2–1.3°C warmer than normal. In March and April it was maximal during the whole period of observations since 1951. In the coastal waters, positive anomalies of temperature decreased to 0.7–08°C in August-September and rose to 1.0–1.2°C in October-December. In the Murman Current (St. 3–7), a decrease of temperature anomaly (to 0.9–1.0°C) was observed from June to December.

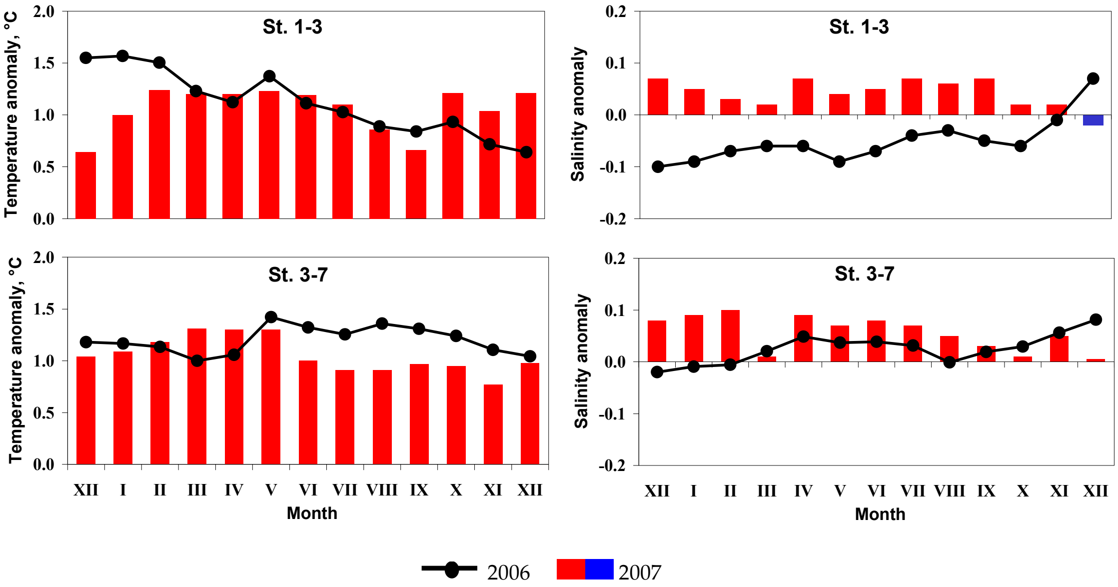

Figure 3. Monthly mean temperature (left) and salinity (right) anomalies in the 0–200 m layer of the Kola section in 2006 and 2007. St.1–3 – coastal waters. St.3–7 – Murman Current (Anon., 2008).

In the southern Barents Sea in 2007, water salinity was typical for warm years. Both in the coastal waters and in the Murman Current salinity was higher then the long-term means. Some decrease in positive salinity anomalies was observed in September-December (Figure 3).

On the whole, in 2007, in the upper 200 m layer of the Kola section, the mean annual water temperature was close to that of 2006, which was highest on record for more than 100 year history of observations along the section (Figure 4). Mean annual salinity in the 0–200 m layer of the section was higher than usual and higher than in 2006.

In the North Cape - Bear Island Section, the observations were made in February, June and September. Positive anomalies of temperature in the North Cape Current, in the 0–200 m layer, decreased from 1.4°C in February to 1.1°C in June and further to1.0°C in September.

In 2007, the section Bear Island – West (along 74°30′N) was occupied 3 times. Temperature in the eastern branch of the Norwegian Current (74°30′N, 13°30′-15°55′E), in the 0–200 m layer, was significantly warmer than normal. The positive anomalies increased from 0.7°C in February to 1.2°C in November.

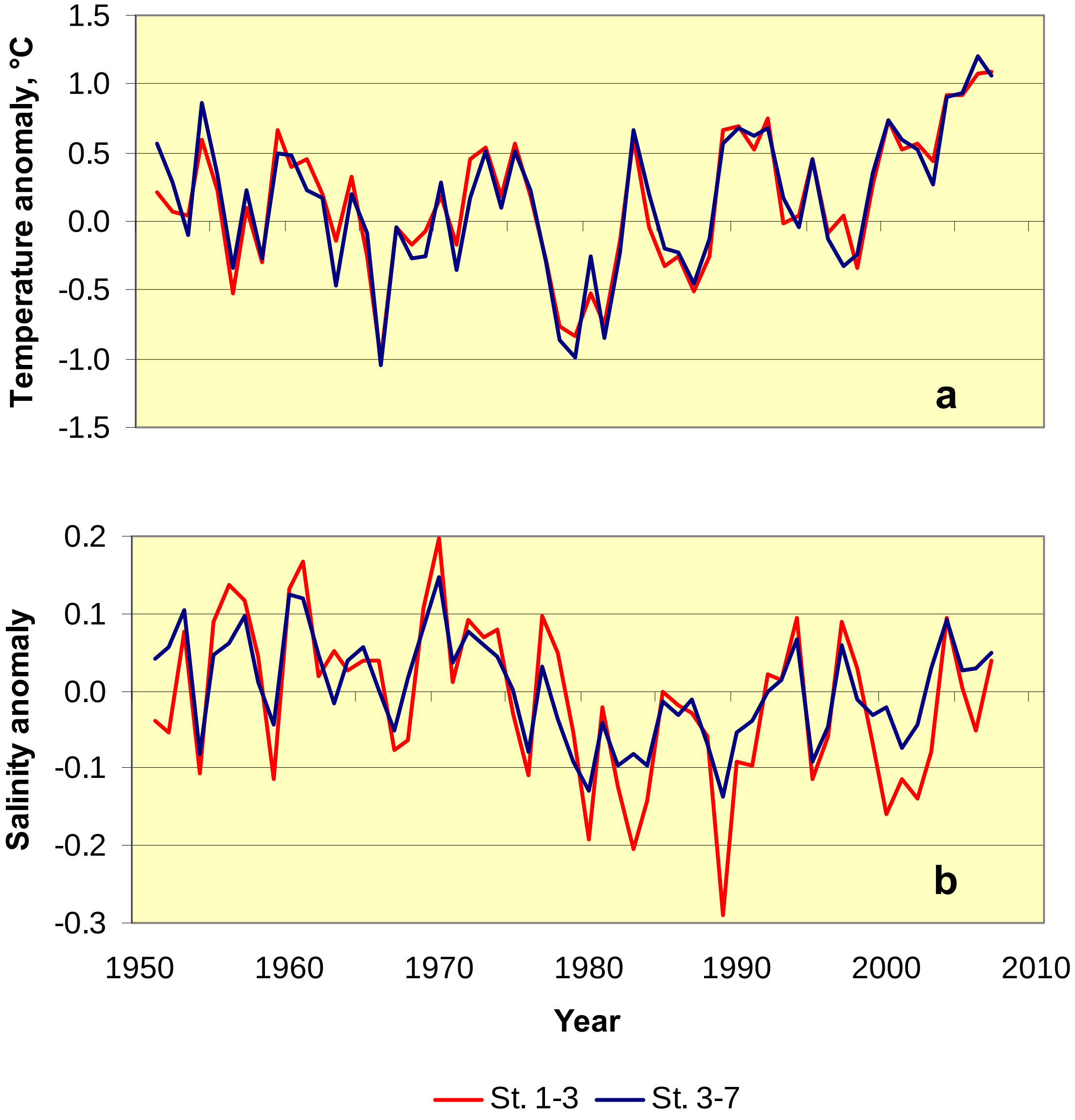

Figure 4. Mean annual temperature (a) and salinity (b) anomalies in the 0–200 m of the Kola section in 1951–2006. St. 1–3 – coastal waters, St. 3–7 – Murman Current (Anon., 2008).

During 2007, the section Bear Island – East (along 74°30′N) was made 5 times. Temperature in the 0–200 m layer of the northern branch of the North Cape Current (74°30′N, 26°50′- 31°20′E), was significantly higher than the long-term average, with the maximum positive anomalies (1.4 - 1.5°C) registered in February, March and June. In August and October, the temperature of Atlantic waters remained high, however positive anomalies of temperature decreased to 1.1 – 1.2°C.

In the eastern Barents Sea, in the Kanin section (along 43°15′E), the observations were made in August. In the Novaya Zemlya Current (71°00′- 71°40′N, 43°15′E), in the 0–200 m layer, water temperature was warmer than normal by 1.3°C.

In August-September 2007, in the bottom layer of the Barents Sea, water temperature, on the whole, corresponded to that one in anomalous warm years. Waters with positive anomaly of bottom temperature occupied more than 90% of the surveyed area (Figure 5), and at about 35% of it, the anomalies were maximal for the period since 1951 (Figure 5). The highest anomalies of temperature in bottom layer (>2°C) were observed in the North Cape and Murman Currents.

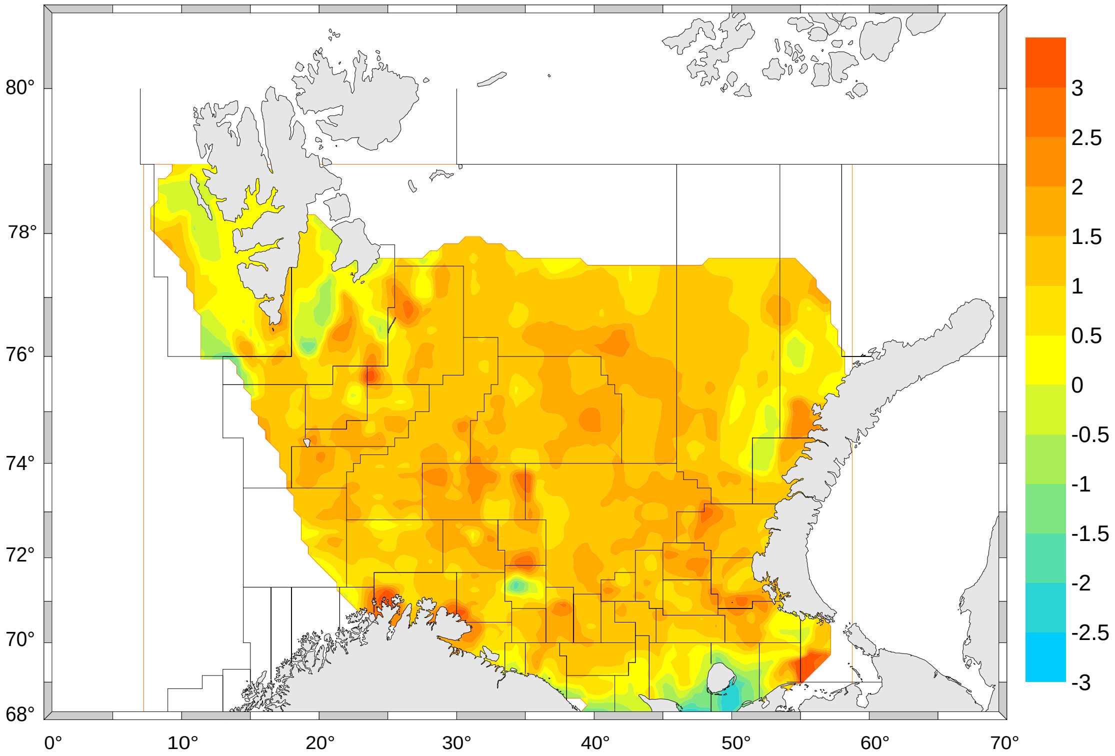

Figure 5. Bottom temperature anomalies in the Barents Sea in August-September 2007 (Anon., 2008).

The Norwegian Sea

In 2007, the weather over the Norwegian Sea was influenced by cyclonic atmospheric circulation. During the year, with the exception of June and July, southwesterly winds dominated. Air temperature over the central Norwegian Sea was close to long-term mean. In the southern part of the sea the positive anomalies (close to 1°C) took place in the beginning and at the end of the year.

Sea surface temperature (SST) in the first half of the year was higher than the long-term mean with significant positive anomalies in the central Norwegian Sea in July. The monthly averaged SST was 0.3–0.7°C warmer than in 2006 (with the exception of August-October).

Figure 6 shows Russian standard sections in the Norwegian Sea occupied by PINRO in June 2007.

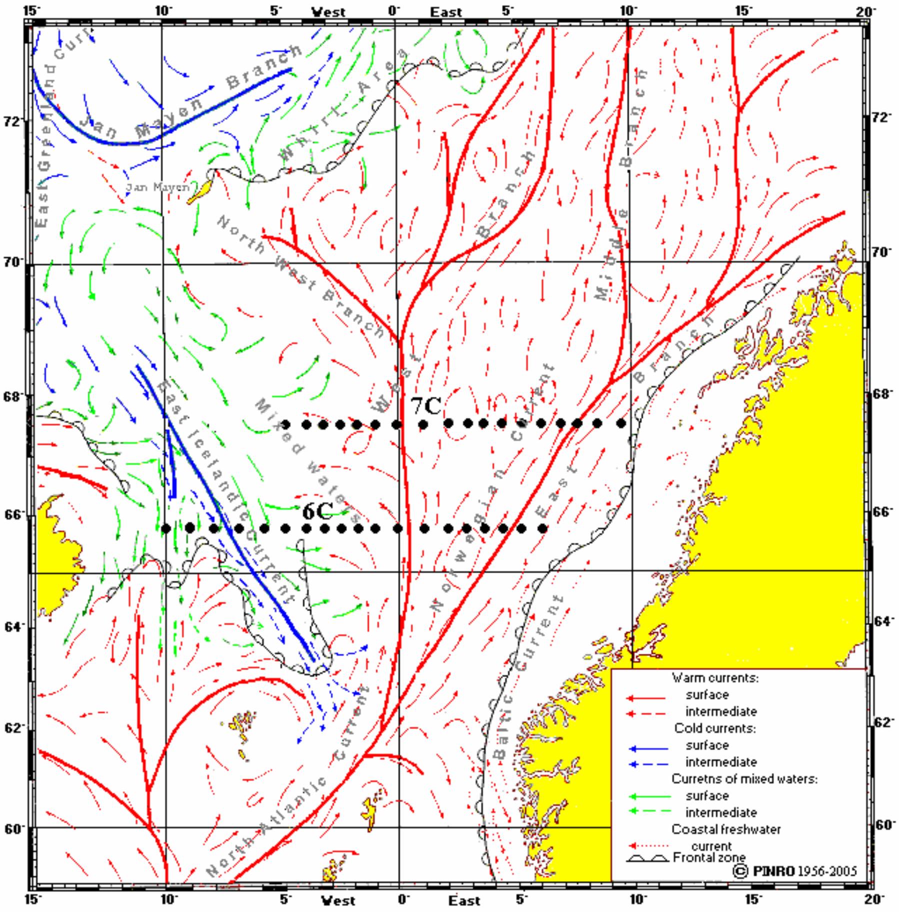

Figure 6. Russian standard sections in the Norwegian Sea occupied in June 2007 and the currents in the Norwegian and Greenland Seas (Alekseev and Istoshin, 1956).

Hydrographic data from these sections show that the temperature of the upper 50-m layer was 0.9–1.1°C higher than the long-term means (1971–2000). In the layer 0–200 m, Atlantic waters of the Eastern branch of the Norwegian Atlantic Current (NWAC) was 0.8–0.9°C warmer than normal (Figure 7). The temperature of the Western branch of NWAC was 0.3°C above the long-term mean at the section along 65°45′N (6C). Positive anomalies in the area to the north of 67°N (section 7C) were 1.2°C higher than normal. The time-series of temperature anomalies show a decrease from 2002–2003 and 2005 to 2007 in temperature of Atlantic waters in the section 6C and an increase of temperature from 2005 to 2007 in the section 7C.

The temperature of mixed waters in the section 7C (67°30′N, 04°00′W-01°45′W) was 0.4°C higher the long-term mean due to a wider extension of Atlantic waters and a westward shift of the frontal zone separating Atlantic and mixed waters. The temperature of mixed waters to the south of 66°N (section 6C: 65°45′N, 04°00′W-02°30′W) declined to anomalous low level, and the anomaly was close to that of cold 1983, 1995 and 1997 (Figure 2b).

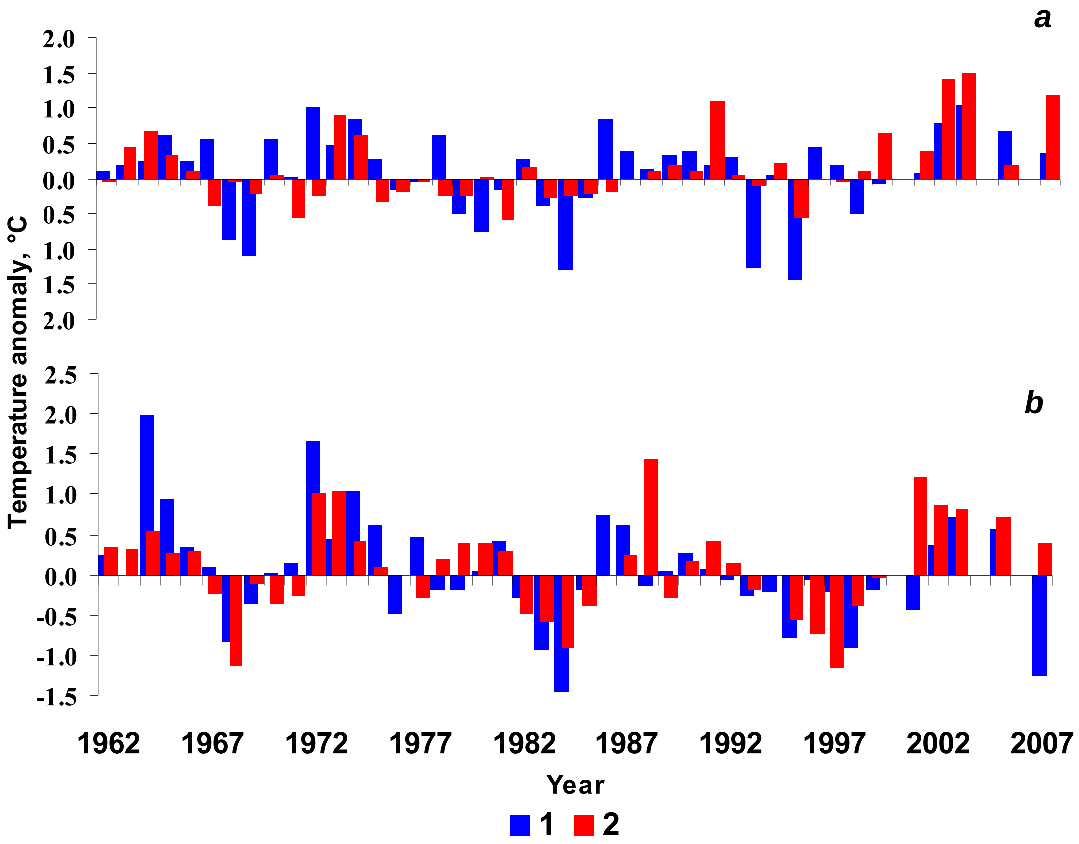

Figure 7. Temperature anomalies (relative to 1971–2000 means) in the upper 200 m layer of the Norwegian Atlantic Current (a) and mixed waters in the central Norwegian Sea (b) in the Russian standard sections 6C (1) and 7C (2) in June 1962–2007.

The salinity of Atlantic waters in the upper 200-m layer was higher than normal, close to 2001–2003, but significantly lower than 2005 (Figure 3a). The salinity of mixed waters in the section 7C was close to the long-term mean. In the section 6C, salinity was lower than usually, a negative anomaly of salinity in this section wasn't observed since the end of 1990s (Figure 3b).

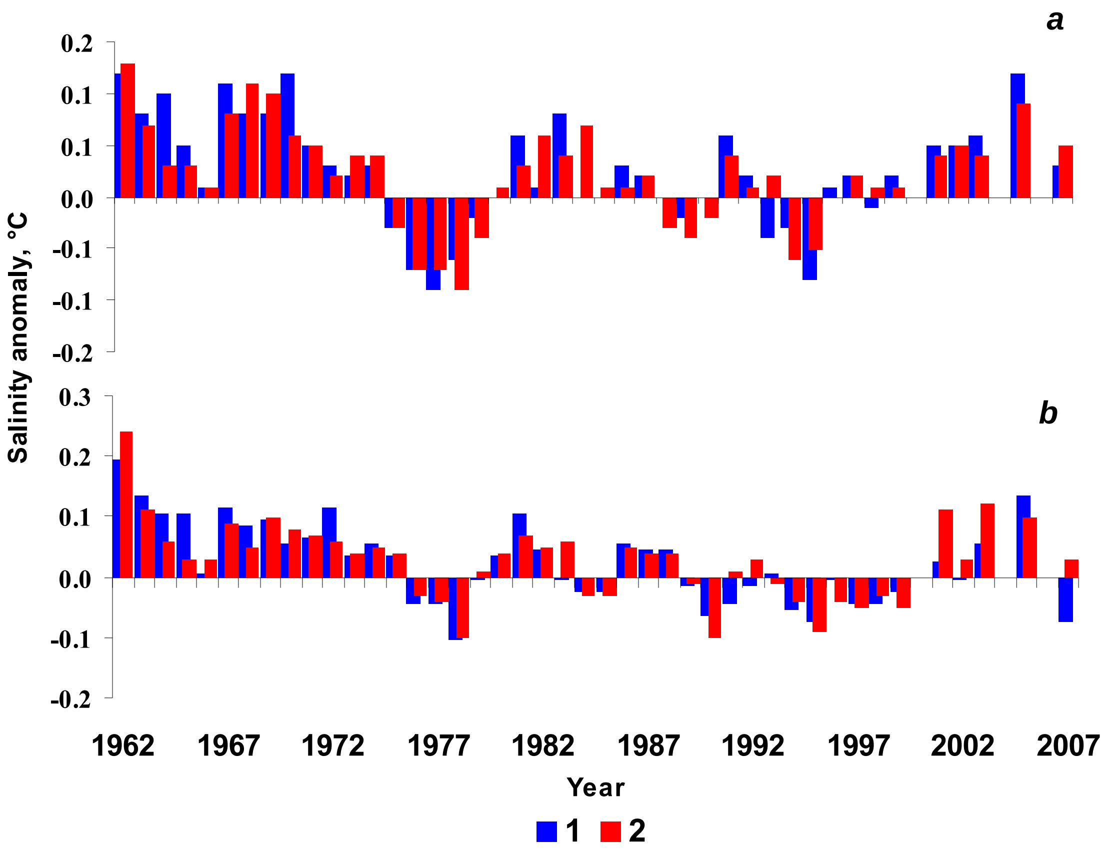

Figure 8. Salinity anomalies (relative to 1971–2000 means) in the upper 200 m layer of the Norwegian Atlantic Current (a) and mixed waters in the central Norwegian Sea (b) in the Russian standard sections 6C (1) and 7C (2) in June 1962–2007.

On the whole in 2007, temperature and salinity of NWAC were higher than the long-term mean values, but lower than in anomalously warm 2002–2003. The temperature and salinity of mixed waters to the north of 67°N stayed above the long-term mean, to the south of 66°N temperature and salinity decreased to the level of anomalously cold years.

The Irminger Sea

PINRO carries out regular oceanographic investigations in the Irminger Sea from the beginning of redfish (*Sebastes mentella)* fishery in 1981. Hydrographic observations along standard sections over the Reykjanes Ridge have been carried out since 1968. At present the Institute continues a series of observations in summer (June) only in the section 3K, which crosses the Reykjanes Ridge approximately at 60°N. It had been occupied annually since 1990 till 1997, and since 1999 the section has been carried out every second year. Data of observations in the section reflects well the interannual variations of hydrographic conditions in the Irminger Sea. They are used in the analysis of spatio-temporal variability of oceanographic factors in the Irminger Sea in addition to data of observations in the area of Russian and international trawl-acoustic surveys of redfish stock.

In June-July 2007, the Russian RV *Smolensk* and Icelandic RV *Arni Fridriksson* carried out hydrographic observations in the Irminger Sea and adjacent areas of the Labrador Sea. The surveyed area and standard section 3K are shown in Figure 9.

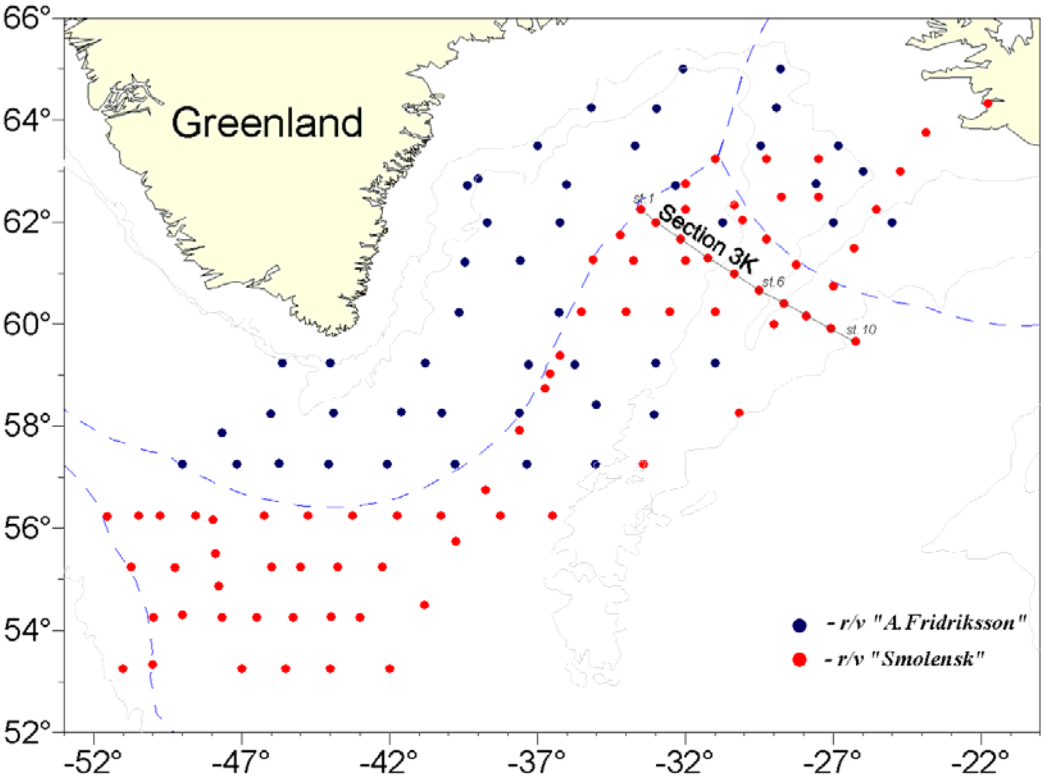

Figure 9. Surveyed area in the Irminger Sea and adjacent areas of the Labrador Sea in June-July 2007 and the standard section 3K (ICES, 2007).

The weather in the area in 2007 was characterized by the increased number of days with storm winds. High positive anomalies of the air temperature and SST were registered. The air temperature over the sea was higher than the long-term mean during the whole year. The positive anomaly of the mean annual temperature constituted 1.5°C. During the year SST in the Irminger Sea and in adjacent areas was 0.6–2.0°C higher than the long-term average. The mean annual anomaly of SST in the Irminger Sea in 2007 was 1.3°C; however it was colder than that in 2006 by 0.2°C.

In accordance with the data of deepwater observations, the temperature of the Irminger Sea waters between 53° and 66°N from 24° to 52°W was higher than long-term mean (1954–2003). The highest positive temperature anomalies (to 7.5°C) were observed in the surface layer (Figure 10). In the layer from the seasonal thermoclyne to 600 m, anomalies ranged from 0.5 to 2.0°C. The negative anomalies to 1.5°C were registered in local areas in the northeast of the surveyed area and to the southeast of Greenland. The temperature in the layer 200–400 m increased by 0.5–1.5°C compared to 2005.

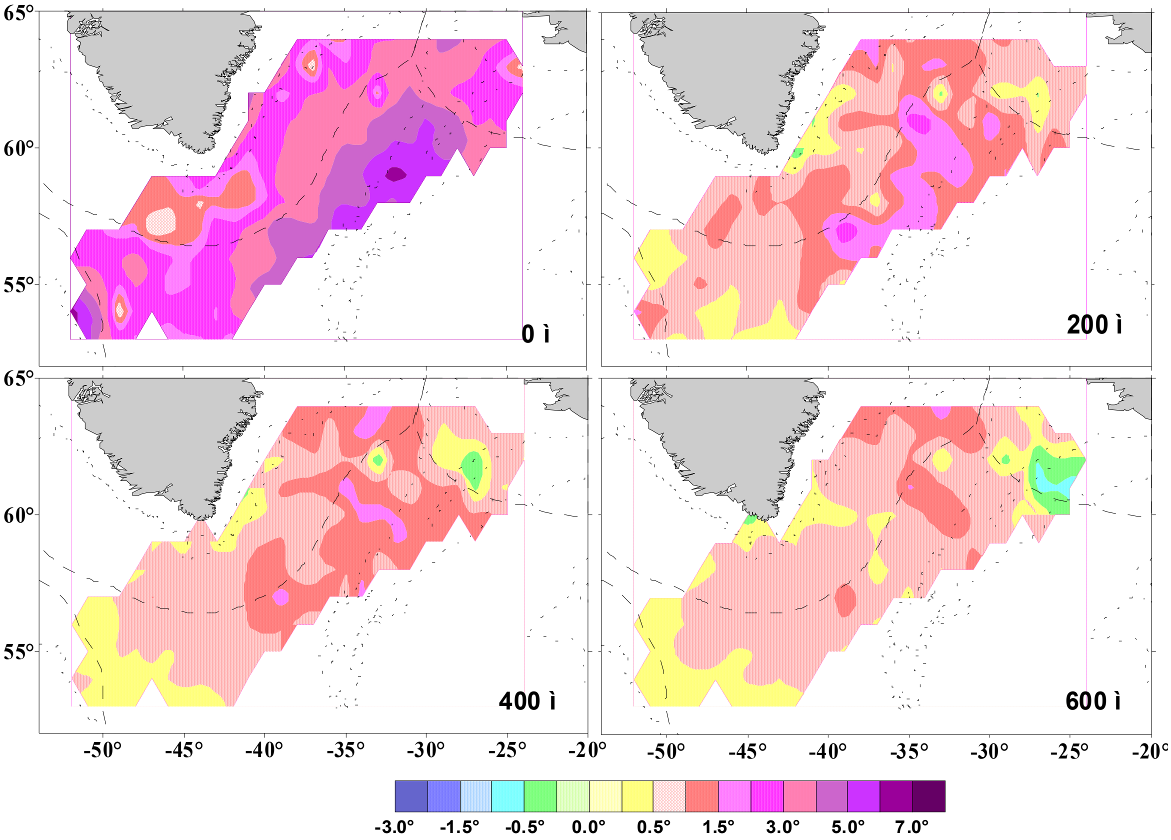

Figure 10. Temperature anomalies in the Irminger Sea and adjacent areas in June-July 2007.

Hydrographic data from the section 3K revealed a retaining of positive anomalies of temperature and salinity in Atlantic waters of the Irminger Current in June-July 2007 (Figure 11). In the layers 0–200, 200–500 and 500–1000 м, temperature was higher than the long-term means (1990–2005). However positive anomalies were lower than those in 2005. Figure 11 shows highest salinity anomalies in the Irminger Current at the eastern edge of the Subpolar Gyre in 2005 and a decrease of salinity in 2007.

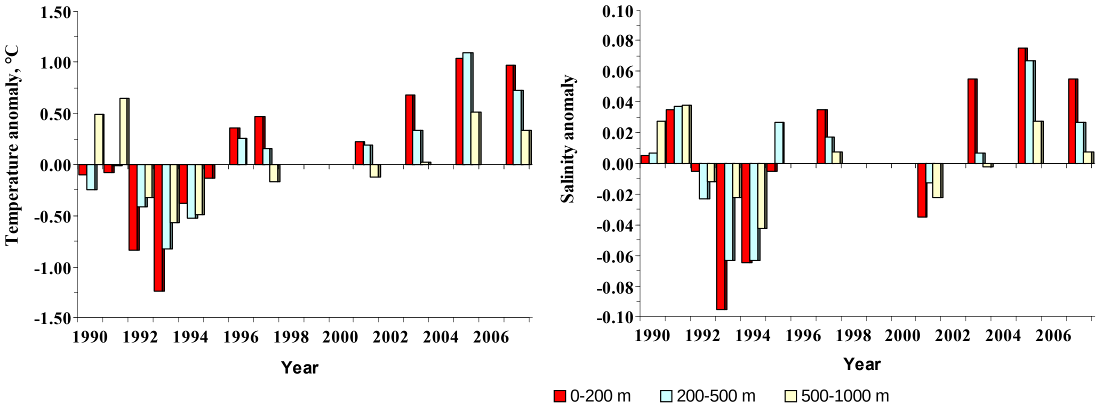

Figure 11. Temperature and salinity anomalies in the section 3K (St. 1–6).

References

Alekseev, A. P., and Istoshin, B. V. 1956. Scheme of stable currents in the Norwegian and Greenland Seas. Trudy PINRO, No. 9: 62–68 (in Russian).

Anon. 2008. Status of biological resources in the Barents Sea and North Atlantic for 2008. Yu. M. Lepesevich (Ed.). Collected Papers. PINRO Press, Murmansk: 102 p. (in Russian)

Bochkov, Yu. A. 1982. Historic data on water temperature in 0–200m layer on the Kola Section in the Barents Sea (1900–1981). Trudy PINRO. 1982. p.113–122 (in Russian)

ICES. 2007. Report of the Study Group on Redfish stocks. ICES CM 2007/RCM:12, 50 pp.

Terescchenko, V.V. 1997. Seasonal and year-to-year variations of water temperature and salinity in the main currents on the Kola Section in the Barents Sea. Murmansk: PINRO Press. 1997. 71 pp. (in Russian)

Tereshchenko, V.V. 1999. Hydrometeorological conditions in the Barents Sea in 1985–1998. Murmansk: PINRO Press. 1999, 176 p. (in Russian)

Annex 16: Technical Minutes from the WGECO Meeting

Review report of Section 6 of Working Group of Oceanic Hydrography (WGOH):

The review took place during the WGECO meeting (6–13 May 2008).

Reviewers: Jake Rice (Chair)

Catherine L. Scott

Ellen L. Kenchington

Gerjan Piet

Keith Brander

Stuart I. Rogers

Øystein Skagseth

Secretariat: Cristina Morgado

The reviewers provided written comments to Section 6 of the WGOH report. This section is related to WGOH ToR c)

General comments

The RG considered that Section 6 of WGOH report was not as useful as it could be, in light of the analysis performed by WGECO in 2007. The RG are aware of ongoing work within WGOH of a comparison between the *in situ* observations and the reanalysis of the gridded dataset. The results of this work will be very important for a request of this kind.

The RG considered that the IROC 2007 report on the ocean climate to be very useful.

It is fairly clear that future requests of this kind will require more detailed dialogue between the WG and the group carrying out the overview and analysis in order to ensure that there is a common basis and methodology and that the WG is clear about what information is required.