Spring Quarter 2009 - Ocean 506B/497B - 3 credit graduate course
THE CHANGING ARCTIC OCEAN
- an interdisciplinary perspective after IPY
(International Polar Year 2007-2009)

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Monday and Wednesday 11:00-12:20
OTB (Ocean Teaching Building) 205

http://psc.apl.washington.edu/ArcticChange09.html

• Recent years show unprecedented change in the ice-covered Arctic Ocean.

• What is currently known about the complex Arctic Ice-Ocean system and the ecosystems it supports?

• What will be the impacts of continuing change within and beyond the Arctic?
In this interdisciplinary course, we will explore the interacting physical, chemical and biological components of the Arctic System, including:
- riddles of Arctic Ocean circulation
- defining roles of the sea-ice cover
- likely shifts in nutrient regimes and ecosystem
- and recent explorations of the seafloor

and consider the impacts of Arctic Change on global climate, native communities, and future exploration of an ice-free summer ocean

The aims of the course are to develop:
- an understanding of how the Arctic Ocean system works
- an understanding of observed and potential changes in the Arctic and impacts of these changes in the Arctic and beyond
- an appreciation of why we should care about Arctic Change

Skill development: To thrive in research (and other careers) needs skills beyond scientific data analysis, for example:
- discerning inquiry
- coherent communication (written and oral)
- competence in more than one discipline.

Homework and class assignments will be aimed at developing these skills, and the art/science of productive scientific debate.
Assignments/grading

Grades: will be based on both written and oral assignments (no tests or final exam).
- 2 written homeworks (each 30% of the grade)
- 1 team-presented oral review of a published paper (20% of the grade)
- class participation, especially in weekly paper reviews (20% of the grade)

Written assignments:
- essay, due end of week 5 (1 May), to include some literature review (reference list of at least 5 papers) and thoughtful analysis (with original graphic, flow diagram, table, etc. to help convey your analysis)
- proposal of an experimental plan, due end of week 10 (5 June), suitable for a one-year follow-up IPY project

Oral assignments:
- Each Wed (starting week 2, excluding weeks when written assignments are due), there will be a 30-min student-led discussion of a published paper (selected a week in advance). The main points of the paper will be presented by a pair of students in a 10-min oral presentation, followed by a 20-min class debate. Each student will help to lead one such presentation during the course.
- Every student reads the assigned paper each week; all students are involved in each weekly debate.
# Draft Syllabus

<table>
<thead>
<tr>
<th>WEEK</th>
<th>Monday 11:00</th>
<th>Wednesday 11:00</th>
<th>Deadlines</th>
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<tbody>
<tr>
<td>1 Mar 30 - Apr 3</td>
<td>Course overview</td>
<td>Arctic Atmospheres and Oceans</td>
<td></td>
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<tr>
<td>2 Apr 6 - 10</td>
<td>Sea-ice - the physics</td>
<td>Sea-ice - continued, and climate change. Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>3 Apr 13 - 17</td>
<td>Sea-ice - biology</td>
<td>Sea-ice - biology continued Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>4 Apr 20 - 24</td>
<td>Arctic Entrances and Exits - what goes in and out?</td>
<td>Going round the Arctic - upper ocean circulation ... Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>5 Apr 27 - May 1</td>
<td>.. getting things off the slope, tracers , and biology ..</td>
<td>Upper Ocean Arctic biology continued</td>
<td>Friday 1st May first written assignment due</td>
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<tr>
<td>6 May 4 - 8</td>
<td>.. over and off the shelves</td>
<td>&quot;Atlantification&quot;? - the role of Atlantic waters in the Arctic Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>7 May 11 - 15</td>
<td>Interdisciplinary case study - Arctic Polynyas: biological refuges, hotspots and bellwethers of change</td>
<td>.. continued, with ecosystem comparisons Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>8 May 18 - 22</td>
<td>Interdisciplinary case study - the changing Bering Sea - physical processes</td>
<td>Bering Sea Ecosystem Paper Discussion</td>
<td>Wednesday paper talk</td>
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<tr>
<td>9 May 25 - 29</td>
<td>Memorial Day -- no class --</td>
<td>The Arctic as others see it - far field effects of the Arctic and Arctic Change Paper Discussion</td>
<td>Wednesday paper talk</td>
</tr>
<tr>
<td>10 Jun 1 - 5</td>
<td>Class visit to USCGC HEALY</td>
<td>The human face to the Arctic - geopolitics and larger ramifications</td>
<td>Friday 5th June second written assignment due</td>
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</tbody>
</table>
Guided tour of the USCGC *Healy*
Monday class time, 1 June

The USCGC *Healy* is the leading US research icebreaker. She has extensive laboratory and deck space for science and state of the art oceanographic equipment. She can break 4.5 ft of ice at 3 knots and 8 ft of ice backing and ramming. She can carry a (usually interdisciplinary) science team of 35 scientists. Her home port is Seattle. We have arranged for a science tour of the vessel on Monday, 1 June, following her return to Seattle after the spring field season. The tour will take place during class hours. Transport will be provided to and from UW. Further details will be provided as the date approaches.

http://www.uscg.mil/pacarea/cgcHealy/
Welcome to SEARCH

A system-scale, cross-disciplinary, long-term arctic research program

What's New?

March 2009 Sea Ice Outlook Workshop
A small Sea Ice Outlook workshop was held 10 March 2009 in Boulder, Colorado. Participants discussed lessons learned from the 2008 Sea Ice Outlook and planned for the 2009 Sea Ice Outlook. (more)

What's SEARCH?

SEARCH is an interagency effort to understand the nature, extent, and future development of the system-scale change presently seen in the Arctic. These changes are occurring across terrestrial, oceanic, atmospheric and human systems, including:

- increased air temperatures over most of the Arctic;
- changing ocean circulation and rising coastal sea level;
- reduced sea ice cover; and
- thawing permafrost.

The core aim of SEARCH is to understand the recent and ongoing complex of interrelated pan-arctic changes. These changes are affecting ecosystems, living resources, and the human population, and are impacting local and global economic activities.

Currently nearly 70 projects are funded as SEARCH activities by U.S. agencies. Many more SEARCH-related projects are supported through other programs.

Learn about the history and development of the SEARCH program. (more)

More information about SEARCH science, program planning, meetings, and resources are available through the links to the left.
Providing information on the present state of Arctic ecosystems and climate in historical context.

Data and information from reputable scientific sources are presented with easy to read and understand narratives.

The objective is to inform dialog, raise issue awareness, and support decision making.


These reports provide an update to some of the data records of physical processes discussed in the Arctic Climate Impact Assessment (ACIA 2004, 2005).

Featured!

- Global Temperature Trends: 2008 Summation
- Arctic Passage: Relive two legendary expeditions - one tragic, one triumphant - to pioneer a route through the Northwest Passage (NOVA PBS special, February 28, 2006)

Learn more about the Arctic: Visit the NOAA Arctic Theme Page

This site is a contribution to the Study of Environmental Arctic Change (SEARCH) project.
There continues to be widespread and, in some cases, dramatic evidence of an overall warming of the Arctic system.

**Atmosphere**
5°C temperature increases were recorded in autumn

**Sea Ice**
Near-record minimum summer sea ice extent

**Biology**
Fisheries and marine mammals impacted by loss of sea ice

**Ocean**
Observed increase in temperature of surface and deep ocean layers

**Greenland**
Records set in both the duration and extent of summer surface melt

**Land**
Permafrost temperatures tend to increase, while snow extent tends to decrease

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About the Report Card
Printable Handout :: Full Arctic Report Card (PDF)
NOAA Arctic Theme Page
Figure S1. Sea ice extent in (left) September 2007, (center) March 2008 and (right) September 2008, illustrating the respective winter maximum and summer minimum extents. The magenta line indicates the median maximum and minimum extent of the ice cover, for the period 1979–2000. The September 2007 minimum extent marked a record minimum for the period 1979–2008. [Figures from the National Snow and Ice Data Center Sea Ice Index: nsidc.org/data/sealice_index]
Figure S2. Daily ice extents 2005, 2007, and 2008, and averaged over the 5-yr periods 1980–84 through 2000–04. Values are derived from satellite passive microwave data from NASA’s SMMR and the Department of Defense's SSM/I. (Adapted from Comiso et al. 2008.)

Figure S3. Time series of the difference in ice extent in Mar (the month of ice extent maximum) and Sep (the month of ice extent minimum) from the mean values for the time period 1979–2007. Based on a least squares linear regression, the rate of decrease for the Mar and Sep ice extents was −2.8% and −11.1% per decade, respectively.

Figure S4. Time series of area of perennial sea ice extent in March of each year estimated by the Drift-Age Model and observed by QuikSCAT satellite scatterometer within the model domain. In each year, the model result was an average over March, and the satellite observation was on the spring equinox (21 Mar). (Adapted from Nghiem et al. 2007)
WHAT IS IPY?

The International Polar Year is a large scientific programme focused on the Arctic and the Antarctic from March 2007 to March 2009. [Learn more about IPY](http://www.ipy.org/)

» Contact IPY
» National IPY Committees
» Youth and Early Career
» Get Involved
» Who's Who
» IPY History
» IPY Site Contributors
» IPY Project Database
» Data and Information

HIGHLIGHTS

**Polar Oceans Week reaches around the globe!**

Karen Edwards, Mar 26, 2009

The 8th Polar Day (topic: Polar Oceans) elicited so much interest that it turned into a full week of events that took place across the globe from some likely places such as Edinburgh, Winnipeg and Nuuk to some not so likely places like Brazil & Malaysia. [More...](http://www.ipy.org/)

**International Polar Day - Polar Oceans**

March 2009 marks the eighth quarterly International Polar Day, this time focusing on Polar Oceans. [More...](http://www.ipy.org/)

**IPY in Google Earth**

Learn more about IPY projects using Google Earth [More...](http://www.ipy.org/)

**Featured Multimedia**

ICED IPY investigates the effects of the increase of CO2 on marine ecosystems [More...](http://www.ipy.org/)

All multimedia content
The International Polar Year is a large scientific programme focused on the Arctic and the Antarctic from March 2007 to March 2009.

IPY, organized through the International Council for Science (ICSU) and the World Meteorological Organization (WMO), is actually the fourth polar year following those in 1882-3, 1932-3, and 1957-8. In order to have full and equal coverage of both the Arctic and the Antarctic, IPY 2007-8 covers two full annual cycles from March 2007 to March 2009 and will involve over 200 projects, with thousands of scientists from over 60 nations examining a wide range of physical, biological and social research topics. It is also an unprecedented opportunity to demonstrate, follow, and get involved with, cutting edge science in real-time.

**IPY History:**
On three occasions over the past 125 years scientists from around the world banded together to organize concentrated scientific and exploring programs in the polar regions. In each major thrust, or “year,” scientific knowledge and geographical exploration were advanced, thereby extending understanding of many geophysical phenomena that influence nature’s global systems. Each polar year was a hallmark of international cooperation in science. The experience gained by scientists and governments in international cooperation set the stage for other international scientific collaboration. International scientific cooperation also paved the way for several political accords that gained their momentum from the polar years. IPY 2007-2008 will expand upon this legacy of scientific achievement and societal benefits.
First International Polar Year (1882-1883): The idea of International Polar Years was the inspiration of the Austrian explorer and naval officer Lt. Karl Weyprecht who was a scientist and co-commander of the Austro-Hungarian Polar Expedition of 1872-74.

From his experiences in the polar regions Weyprecht became aware that solutions to the fundamental problems of meteorology and geophysics were most likely to be found near the Earth’s poles. The key concept of the first IPY was that geophysical phenomena could not be surveyed by one nation alone; rather, an undertaking of this magnitude would require a coordinated international effort. 12 countries participated, and 15 expeditions to the poles were completed (13 to the Arctic, and 2 to the Antarctic). Beyond the advances to science and geographical exploration, a principal legacy of the First IPY was setting a precedent for international science cooperation. Unfortunately Weyprecht did not live to see his idea come to fruition.

Second International Polar Year (1932-1933): The International Meteorological Organization proposed and promoted the Second IPY (1932–1933) as an effort to investigate the global implications of the newly discovered “Jet Stream.” 40 nations participated in the Second IPY, and it heralded advances in meteorology, magnetism, atmospheric science, and in the “mapping” of ionospheric phenomena that advanced radio science and technology. Forty permanent observation stations were established in the Arctic, creating a step-function expansion in ongoing scientific Arctic research. In Antarctica, the U.S. contribution was the second Byrd Antarctic expedition, which established a winter-long meteorological station approximately 125 miles south of Little America Station on the Ross Ice Shelf at the southern end of Roosevelt Island. This was the first research station inland from Antarctica’s coast.
The International Geophysical Year (1957-58): The International Geophysical Year (IGY), 1 July 1957 to 31 December 1958, celebrated the 75th and 25th anniversaries of the First and Second IPYs. The IGY was conceived by a number of post-WWII eminent physicists, including Sydney Chapman, James Van Allen, and Lloyd Berkner, at an informal gathering in Washington, DC in 1950. These individuals realized the potential of the technology developed during WWII (for example, rockets and radar), and they hoped to redirect the technology and scientific momentum towards advances in research, particularly in the upper atmosphere. The IGY’s research, discoveries, and vast array of synoptic observations revised or “rewrote” many notions about the Earth’s geophysics.

One long disputed theory, continental drift, was confirmed. A U.S. satellite discovered the Van Allen Radiation Belt encircling the Earth. Geophysical traverses over the Antarctic icecap yielded the first informed estimates of the total size of Antarctica’s ice mass. For many disciplines, the IGY led to an increased level of research that continues to the present. The world’s first satellites were launched. A notable political result founded on the IGY was ratification of the Antarctic Treaty in 1961. The success of the IGY also fostered an additional year of research through the International Geophysical Cooperation. The Special Committee for the IGY became the model on which three post-IGY Scientific Committees developed, for Antarctic, Oceanic, and Space Research, and several focused research efforts including the International Year of the Quiet Sun. The scientific, institutional, and political legacies of the IGY endured for decades, many to the present day.
About ICSU

Founded in 1931, the International Council for Science (ICSU) is a non-governmental organization representing a global membership that includes both national scientific bodies (103 members) and international scientific unions (27 members).

ICSU’s extensive membership network constitutes an international forum for scientific research and policy development.

In broader terms, because of its representative and diverse membership, the Council is increasingly called upon to speak on behalf of the global scientific community and to act as an advisor in matters ranging from ethics to the environment.


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