New Frontiers in Marine Science

PICES
Early Career Scientists

Early Career Scientists Conference • 26-29 June, 2007

Baltimore, Maryland USA

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School of Fisheries and Ocean Sciences, University of Alaska Fairbanks

United States Delegation to ICES, National Science Foundation

ACKNOWLEDGEMENTS

First and foremost, we thank Skip McKinnell and Adi Kellermann for their efforts to bring this conference into existence. Without their guidance and dedication, it would not have been possible. In addition, we thank Julia Yazvenko and all of the PICES and ICES staff members whose hard work behind the scenes, web pages, data bases, and finances was essential. Many thanks to Alex Curtis for helping participants with the visa application processes Last, but certainly not least, we thank the multi-talented Jane Hawkey of UMCES IAN for coordinating all local logistics and designing this program. A building is only as sturdy as its foundation: Jane, you are a rock! Thank you all so much.

~ Elizabeth North on behalf of the Scientific Steering Committee

Cover Photos

Off-loading the menhaden catch, North Carolina 1969. NOAA Photo Library

Thousands of lobster krill swim off the coast of New Zealand. Maria Stenzel, National Geographic Society

NOAA Bottom Fish Camera (BOTCAM). http://celebrating200years.noaa.gov/visions/fisheries_sci_tech/BotCam.html

New Frontiers in Marine Science

Early Career Scientists Conference
26-29 June, 2007
Baltimore, Maryland USA

BACKGROUND AND OBJECTIVES

The International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES) initiated this conference to encourage greater involvement of young scientists in international scientific activities and to foster their involvement in the management of the marine environment. The goal of this conference is to facilitate the development of contacts, collaborations, and associations among early career scientists that will persist for decades, and to establish personal and institutional networks that will help advance our understanding of the marine environment. The conference builds on the success of the ICES Young Scientist Conference in Denmark in 1999 and provides an opportunity for scientists who are at the beginning of their careers to meet colleagues from around the globe who share similar interests in marine science.

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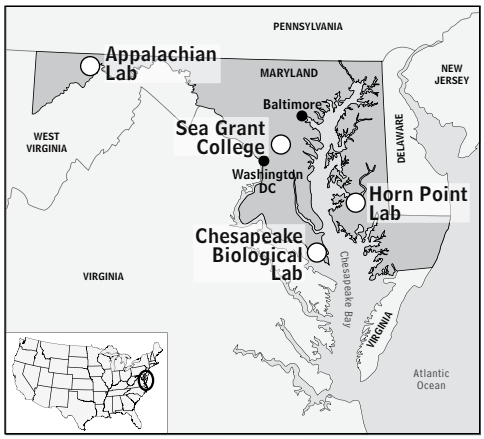
Local Conference Host: University of Maryland Center for Environmental Science

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

The University of Maryland Center for Environmental Science (UMCES) is one of 13 constituent institutions of the University System of Maryland. Led by President Donald F. Boesch, the Center's programs are carried out at three laboratories located across the state: the Appalachian Laboratory in western Maryland, the Chesapeake Biological Laboratory, in southern Maryland and the Horn Point Laboratory on the Delmarva Peninsula (see map). UMCES is also responsible for the administration of the Maryland Sea Grant College program, which supports research throughout the state.



UMCES is the most prominent single institution involved in scientific discoveries about the Chesapeake Bay and its watershed. Although focusing more than 2/3 of its research on this region, the Center's activities are global, involving research from the poles to the tropics. UMCES' scientists include biologists, ecologists, physicists, chemists, geologists, engineers, and economists who work together in a truly transdisciplinary community.

Dr. Elizabeth North, UMCES Horn Point Laboratory, is the local contact. She is assisted by Jane Hawkey, UMCES Integration and Application Network (see below).

WWW.UMCES.EDU

Local Conference Facilitation: Integration & Application Network

Integration & Application Network

The Integration and Application Network (IAN), part of the University of Maryland Center for Environmental Science, is a collection of scientists interested in solving, not just studying environmental problems. The intent of IAN is to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. IAN is an initiative of the faculty of the University of Maryland Center for Environmental Science, but will link with other academic institutions, various resource management agencies and non-governmental organizations. For more information, see Workshops on Day 2 (page 16).

WWW.IAN.UMCES.EDU

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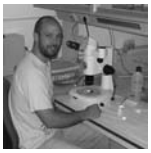

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INTERNATIONAL LIAISON

K. Alexandra Curtis, AAAS Science Policy Fellow, US Department of State

Conference at a Glance

MEALS: Breakfasts, lunches, and dinners are served in the *CCMIT Main Dining Room, Building #2, lower level*. Morning and afternoon coffee breaks will be served at the Plenary meeting room, *Classroom #2, Building #3*.

Day 0 - Monday 25 June

16:00 P/ICES Welcome Desk - *CCMIT Front Desk, Building #2*
20:00 P/ICES Welcome Desk closes until next morning

Day 1 - Tuesday 26 June

07:30 P/ICES Welcome Desk - *Classroom #2, Building #3*

08:40 Plenary - *Classroom #2*

11:00 Sessions - *Classroom #2 & Room A-302*

18:00 Social and Banquet Dinner with Speakers - *CCMIT Main Dining Room—private room, Building #2*

Day 2 - Wednesday 27 June

09:00 Mini-symposium - *Classroom #2*
Workshops - *Room A-302*

13:30 Conference Excursion - *buses depart CCMIT*
(see page 11 for details)

22:00 Conference Excursion - *buses arrive back at CCMIT*

Day 3 - Thursday 28 June

08:45 Plenary - *Classroom #2*

11:00 Sessions - *Classroom #2 & Room A-302*

16:00 Poster Session - *Classroom #1*

17:00 Poster Session Social - *Classroom #1*

18:30 Banquet Dinner - *CCMIT Main Dining Room—private room*

Day 4 - Friday 29 June

08:45 Plenary - *Classroom #2*

11:00 Sessions - *Classroom #2 & Room A-302*

12:20 Closing Remarks - *Classroom #2*

12:40 Lunch - *CCMIT Main Dining Room*

Venue: the *Conference Center at the Maritime Institute* (CCMIT)

Venue

The *Conference Center at the Maritime Institute* (CCMIT) is located at 692 Maritime Boulevard, Linthicum Heights, MD 21090-1952, USA. The phone is 410-859-5700 and the fax is 410-859-2893.

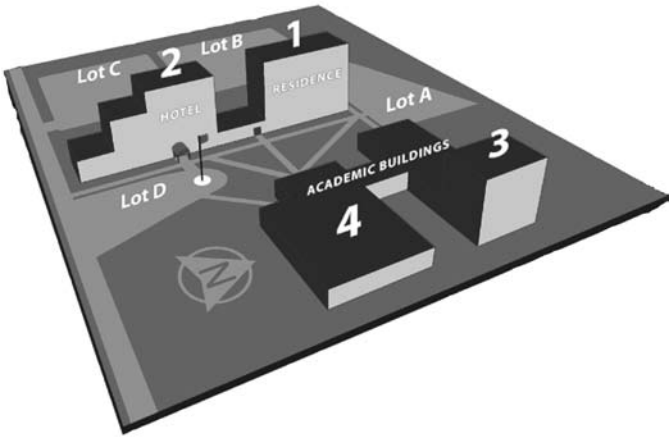
Computers and Internet

CCMIT has a few desktop computers with printers and wired internet available in Buildings 2 and 3 for conference guests. If you have your own laptop, complimentary internet is available in the overnight guest rooms (wired), and in the public areas and meeting rooms (wireless). Access instructions are available at CCMIT Front Desk, Building #2, when you check in.

Building #1 **North Residence Building**
Pool and Exercise Facilities

Building #2 **South Residence Building**
Front Desk - check in
P/ICES Welcome Desk (Day 0)
Overnight Rooms
Main Dining Room

Building #3 **North Academic Building**
P/ICES Welcome Desk (Day 1)
P/ICES Meeting Rooms:
Classrooms 1 & 2, Room 302



Small tuna are landed by fishermen, Sicily, Italy, 1999. United Nations Food and Agriculture Organization

Agenda

CONFERENCE STRUCTURE

Scientific information exchange between conference participants is the focus of activities on Days 1, 3 and 4. Keynote speakers will introduce topics during the morning plenary session before participants separate into two parallel sessions. Contributed papers have been split between oral and poster presentations. Speakers offering contributed papers will be given 20 minutes (15 minutes for presentation, 5 minutes for questions). Oral presentations should be saved as a 2003 or earlier MS PowerPoint file (.ppt), saved on CD media or a USB drive, and turned in at the Welcome Desk when you arrive. Posters will be displayed for the entire conference and highlighted during the poster session on the evening of Day 3.

A mini-symposium and 2 workshops will occur on the morning of Day 2 of the conference. The mini-symposium on international and interdisciplinary collaboration features presentations and discussions related to major international research initiatives in marine science. Workshop topics will include scientific communication and integrated environmental assessment.

Social activities are planned to enhance the opportunity for interaction and foster the development of new contacts and collaborations. Evening social receptions will be held on Day 1 and 3. The afternoon and evening of Day 2 is dedicated to an off-site excursion to St. Michaels, a historic town on the Miles River, a tributary of the Chesapeake Bay (see page 11).

THEME SESSIONS (*see page 14 for session descriptions and page 18 for abstracts*)

- S1: Biodiversity and productivity of marine organisms from pole to pole
- S2: Processes at ocean margins
- S3: The last frontier: The deep sea
- S4: The role of behavior in marine biological processes
- S5: The effect of climate on basin-scale processes and ecosystems
- S6: Humans and the marine environment

MINI-SYMPOSIUM (*see page 16 for full description*)

International Oceanographic Programs and Organizations

WORKSHOPS (*see page 17 for full description*)

- W1: Effective Science Communication
- W2: Integrated Environmental Assessment

Day 0 (June 25)

	CCMIT Front Desk
16:00	**P/ICES Welcome Desk** *(sign in, pick up program and name tag)*
20:00	**P/ICES Welcome Desk closes** *(re-opens Day 1 in Classroom 2)*

Day 1 (June 26) Agenda

07:30	**breakfast** *- CCMIT Main Dining Room, Building #2, lower level*	
	Classroom 2, Building #3	
07:30	**P/ICES Welcome Desk** *(sign in, pick up program and name tag)*	
08:40	Plenary - Welcome	
09:00	Keynote Speaker (Session 2): John Simpson	
09:45	Keynote Speaker (Session 4): Mark Baumgartner	
10:30	**coffee break**	
	SESSION 2 - Classroom 2	*SESSION 4 - Room A-302*
11:00	Melanie J. Bishop	Frode Vikebo
11:20	Gil Rilov	James J. Pierson
11:40	Anthony R. Kirincich	Susana Garrido
12:00	Sarah E. Dudas	Benjamin D. Walther
12:20	**lunch** *- CCMIT Main Dining Room*	
13:25	**announcements**	**announcements**
13:30	Ryan R. Rykaczewski	Sarah Kolesar
13:50	Stephanie Henson	Robert Campbell
14:10	Chaolun Li	Anik Brind'Amour
14:30	Juan Pablo Zwolinski	Tomas Didrikas
14:50	**coffee break**	
15:10	Cindy Palinkas	Karsten Zumholz
15:30	Yong Hoon Kim	Daniel Stepputtis
15:50	Michael S. Wetz	Karen Pehrson Edwards
16:10	Afonso Souza	Gareth L. Lawson
	SESSION 5 - Classroom 2	*SESSION 6 - Room A-302*
16:35	Introduction	Introduction
16:40	Stephanie K. Moore	Hae-Cheol Kim
17:00	Dmitry D. Kaplunenko	Jennifer N. Putland
17:20	David G. Kimmel	Andrey P. Chernyaev
17:40	Guimei Liu	John Ryan Peter
	CCMIT Main Dining Room - private room	
18:15	**pre-dinner social with appetizers and open bar**	
	guest speakers: Edward Houde, Professor, UMCES CBL Steven Murawski, Director of Scientific Programs, NOAA NMFS	
19:15	**banquet dinner**	

Agenda — Day 2 (June 27)

07:30	**breakfast** *- CCMIT Main Dining Room, Building #2, lower level*	
	MINI-SYMPOSIUM - Classroom 2	***WORKSHOPS - Room A-302***
09:00	Susan Weiler The challenges and rewards of international and interdisciplinary collaboration in marine science	Tim Carruthers Effective science communication
09:15	Elizabeth Gross Scientific Committee on Oceanic Research (SCOR)	
09:30	Skip McKinnell North Pacific Marine Science Organization (PICES)	
09:45	Adi Kellermann International Council for the Exploration of the Sea (ICES)	
10:00	Philippe Cury European Network of Excellence for Ocean Ecosystems Analysis (EUR-OCEANS)	
10:15	Cisco Werner Global Ocean Ecosystem Dynamics (GLOBEC)	
10:30	**coffee break**	
11:00	Kyung-Il Chang East Asian Seas Time Series (EAST-1)	Bill Dennison Integrated environmental assessment
11:15	Mike Roman Integrated Marine Biogeochemistry and Ecosystem Research (IMBER)	
11:30	Panel discussion Franz Mueter, moderator	
12:20	**lunch** *- CCMIT Main Dining Room*	

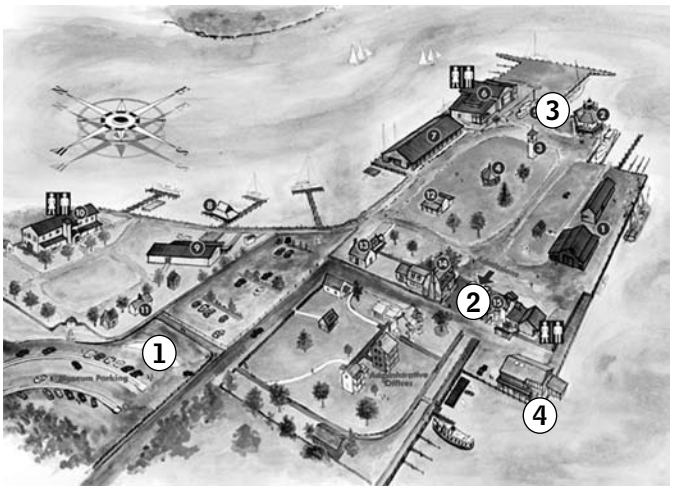
***CONFERENCE EXCURSION* - a social outing to historic St. Michaels, Maryland**

IMPORTANT:

1) tours and dinner are active and outdoors—please dress accordingly.
2) buses will depart promptly at the appointed times—please do not be late.
3) conference name tags must be worn for admittance to museum and dinner

13:30	buses depart CCMIT (*meet at CCMIT Front Desk, Building #2*)
15:00	museum tours #1: *Chesapeake Bay Maritime Museum* boat tours #1: historic Chesapeake skipjack cruise of Miles River
16:30	museum tours #2: *Chesapeake Bay Maritime Museum* boat tours #2: historic Chesapeake skipjack cruise of Miles River
18:30	Maryland crab feast dinner on the dock at the *Crab Claw* Restaurant
20:30	buses depart *Chesapeake Bay Maritime Museum*
22:00	buses arrive CCMIT

Chesapeake Bay Maritime Museum campus



Captain Wade Murphy

Skipjack *Rebecca T. Ruark*, built 1886.

① **bus parking - arrival and departure point**

② ***Museum* entrance - meet here for museum tours**

③ **boat dock - meet here for skipjack tours**

④ ***Crab Claw* restaurant - dockside dinner**

Agenda — Day 3 (June 28)

07:30	**breakfast** ***- CCMIT Main Dining Room, Building #2, lower level***	
	Classroom 2	
08:45	Plenary	
09:00	Keynote Speaker (Session 5): Emanuele Di Lorenzo	
09:45	Keynote Speaker (Session 6): Philippe Cury	
10:30	**coffee break**	
	SESSION 5 (continued) - Classroom 2	***SESSION 6 (continued) - Room A-302***
11:00	Mark D. Scheuerell	Jason M. Cope
11:20	Olav A. Ormseth	Jae Bong Lee
11:40	Emmanuel Chassot	Chih-hao Hsieh
12:00	Robert M. Suryan	Coilín Minto
12:20	**lunch** ***- CCMIT Main Dining Room***	
	SESSION 1 - Classroom 2	***SESSION 6 - continued***
13:35	Introduction	**announcements**
13:40	TaeKeun Rho	Melissa A. Haltuch
14:00	Mamoon M.D. Al-Rshaidat	Teresa A'mar
14:20	Hui Liu	Paul de Bruyn
14:40	Linda O' Higgins	Barbara Paterson
15:00	Yan Jiao	Michelle L. Davis
15:20	A. Berenike Sophia Diekmann	
15:40	**coffee break**	
	Classroom 1	
16:00	**poster session**	
17:00	**poster session social with appetizers and cash bar**	
	CCMIT Main Dining Room - private room	
18:30	**banquet dinner**	

Day 4 (June 29) Agenda

07:30	**breakfast** - ***CCMIT Main Dining Room, Building #2, lower level***	
	Classroom 2	
08:45	Plenary	
09:00	Keynote Speaker (Session 1): Hyung Chul Shin	
09:45	Keynote Speaker (Session 3): S. Kim Juniper	
10:30	**coffee break**	
	SESSION 1 - Classroom 2	***SESSION 3 - Room A-302***
11:00	Anastasia Khrustaleva	Günter Försterra
11:20	Michelle Paddack	Toufiek Samaai
11:40	Sazlina Sallej	Henry A. Ruhl
12:00	Kohei Mizobata	Tadanori Fujino
	Classroom 2	
12:20	Plenary - closing remarks	
12:40	**lunch** - ***CCMIT Main Dining Room***	

European Community, 2006

EU fisheries inspectors measure the gauge of a fishing net.

Scientific Theme and Sessions

The scientific theme "New Frontiers in Marine Science" was chosen to encourage contributions that explore processes at oceanic extremes, apply innovative approaches and cutting-edge technologies, develop new ideas, or tackle current or upcoming global or regional environmental issues. The six sessions' topics are below. See page 18 for abstracts by session for each invited speaker.

SESSION 1: *Biodiversity and productivity of marine organisms from pole to pole*

Sukyung Kang (Chair), Elizabeth North (Co-chair)

Keynote Speaker: Hyung Chul Shin (Korea Polar Research Insitute, Korea)

Marine biological diversity and productivity play a vital role in the global climate and carbon cycle, and provide much of the world's protein. Marine biodiversity also is recognized as an important source of medicines and raw materials. Understanding diversity and productivity is critical to the conservation and management of living marine resources. This session will address regional to large-scale patterns in diversity and productivity at all trophic levels from bacteria to marine mammals. Preference will be given to papers addressing (1) global patterns in diversity and productivity and the processes that give rise to them, (2) diversity in poorly sampled regions such as the deep sea and the polar seas, (3) effects of fisheries and climate change on marine biodiversity and ecosystem function, and (4) innovative theories, sampling techniques, indicators, and statistical models for assessing diversity and productivity.

SESSION 2: *Processes at ocean margins*

Julie Keister (Chair), Sukyung Kang (Co-chair)

Keynote Speaker: John Simpson (University of Wales, UK)

Ocean margins play a key role in the global ecosystem by supporting the majority of the world's fisheries, while being directly impacted by multiple human uses. These boundary areas are critical habitat for many species and are important in the transfer of energy and materials between oceans and continents. Ocean margins are areas where biological, physical, and chemical processes are tightly coupled and where multidisciplinary research is essential. This session aims to provide a forum for such interdisciplinary discussion and invites contributions covering all areas of nearshore and continental shelf research. Topics may include the effects of circulation on sediment transport, chemistry, and biology, interaction between estuaries and the nearshore environment, effects of river plumes on coastal oceans, characterization of the nearshore ecology and environment, ocean margin productivity, and the mechanisms of energy transfer between the nearshore and the deep ocean. Contributions may address processes that occur on scales from tens of meters to thousands of kilometers, from the very nearshore to the continental slope region. Especially encouraged are interdisciplinary contributions.

SESSION 3: *The last frontier: The deep sea*

Angel Lopez-Urrutia (Chair), Julie Keister (Co-chair)

Keynote Speaker: S. Kim Juniper (University of Victoria, Canada)

The deep sea is regarded by many as the ultimate frontier for marine research. New organisms and geochemical processes are continuously being discovered at the deep seafloor and in extreme ocean environments. At the same time, there has been a rapid increase in deep sea trawling and hydrocarbon exploration in these largely unknown ecosystems, which are now believed to be much more dynamic and diverse than previously assumed. A better understanding of the geochemical processes, life forms, and community dynamics in these environments, from the continental rise to the abyssal zone, is urgently needed. Recent advances in submersibles (e.g. smart sensors) and marine communication (e.g. telemetry for remote exploration) have greatly improved our ability to sample and monitor extreme systems. We invite

contributions on the geological, geochemical, biochemical, and biological processes that shape the deep sea environment. Examples include, but are not limited to, seismic and volcanic activities at mid-ocean ridges, chemosynthetic food webs at hydrothermal vents, adaptations of deep sea organisms, and unique microbial communities at cold vents and in subseafloor sediments.

SESSION 4: *The role of behavior in marine biological processes*

Elizabeth North (Chair), Franz Mueter (co-Chair)

Keynote Speaker: Mark Baumgartner (Woods Hole Oceanographic Institution, USA)

From single-cell plants to marine mammals, behavior in response to physical, chemical and biological cues is a common trait whose significance is increasingly recognized. Behaviors as simple as vertical migration can cause differential transport and aggregations in frontal zones, with implications for predator-prey interactions and energy transfer in ocean ecosystems. More complex behaviors such as schooling and long-distance spawning migrations influence a population's vulnerability to predation and exploitation as well as its reproductive potential, stock structure, and ability to recover from overharvest and habitat loss. Advances in *in-situ* measurement capabilities (e.g., acoustics, tagging, laser and video optical methods, holography), coupled bio-physical and bio-geochemical numerical models, and otolith and genetic approaches have provided insights into the complexity of behavior, its role in structuring populations and ecosystem processes, and its impact on survey design and sample variability. We solicit contributions that further our understanding of the role of behavior in marine biological processes with an emphasis on methods that apply recent advances in technology.

SESSION 5: *The effect of climate on basin-scale processes and ecosystems*

Julie Keister (Chair), Alexandra Curtis (co-Chair)

Keynote Speaker: Emanuele Di Lorenzo (Georgia Institute of Technology, USA)

Recent advances in earth monitoring systems and global climate models indicate that basin-scale phenomena profoundly influence physical, geochemical and biological systems in the world's oceans. Interacting processes between the oceans and the atmosphere, such as El Niños and decadal-scale oscillations, impact circulation patterns, nutrient cycling, and ecosystem structure and productivity within and across basins. In this session, we welcome contributions that apply global datasets and recent technological advances (e.g., satellites, gliders and floats, and global climate models) to further our understanding of these basin- and global-scale processes. In particular, we invite papers that address effects of large-scale climate forcing on physical and chemical processes, mechanistic linkages between climate forcing and the dynamics of marine ecosystems, and advances in modeling and predictive capabilities for oceanic ecosystems at basin-wide scales.

SESSION 6: *Humans and the marine environment*

Franz Mueter (Chair), Angel Lopez-Urrutia (co-Chair)

Keynote Speaker: Philippe Cury (Centre de Recherche Halieutique Méditerranéenne et Tropicale, France)

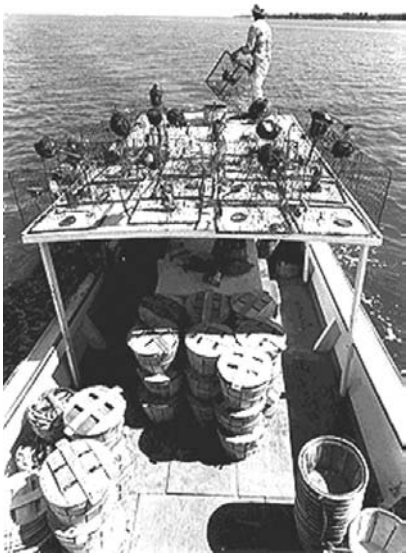
The marine environment is subject to a variety of human impacts, including the introduction of contaminants, habitat disturbance, species invasions, and effects of increasing CO_2 levels in the atmosphere. These impacts result from activities both on land and in the ocean such as increased coastal development, oil and gas exploration, fishing, and shipping. This session will explore how people impact the oceans, how changes in the oceans impact the lives and livelihoods of people, and how these impacts can be managed to ensure both healthy oceans and healthy human societies in the future. We seek contributions that (1) quantify large-scale impacts of human activity on ocean ecosystems, including novel ways to monitor and assess such impacts, (2) provide examples of how communities and societies are impacted by changes in the ocean, and (3) develop new approaches to support ecosystem-based management, including the development of ecosystem indicators and reference points.

MINI-SYMPOSIUM

International and Interdisciplinary Collaboration

Invited Speakers: Susan Weiler, Elizabeth Gross, Skip McKinnell, Adi Kellermann, Philippe Cury, Cisco Werner, Kyung-Il Chang, Mike Roman

International oceanographic organizations and research programs play an important role in coordinating marine research activities, sharing information, knowledge, and technology, and setting research priorities for collaborative research across borders and disciplines. This mini-symposium features speakers from various regional or global organizations to provide a very brief overview over their goals and activities. More importantly, speakers will discuss how their organization can help early career scientists get involved in collaborative research, provide suggestions on what new investigators can do to get involved, and share their personal insights and advice on effective international collaborations. Individual presentations will be followed by a panel discussion on the challenges of successful collaborative research and on approaches to overcoming these challenges.



Maryalnd Sea Gratn Program

Maryland blue crab fishermen, USA.

Maryalnd Sea Grant Program

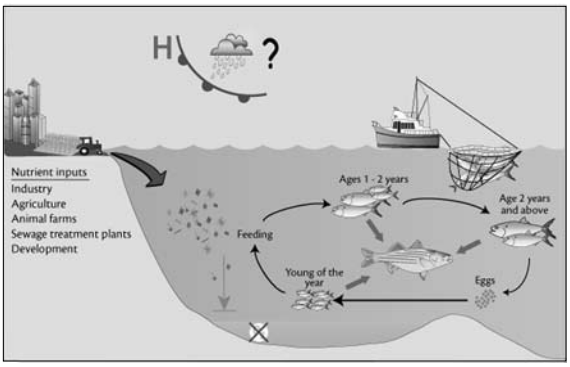
In the USA, the Chesapeake Bay's biggest catch—beyond striped bass, blue crabs and bluefish—is menhaden, some 200,000 tons a year.

WORKSHOP 1

Effective Science Communication
(http://ian.umces.edu/books/)

Invited Speaker: Tim Carruthers (Integration & Application Network, University of Maryland Center for Environmental Science, Cambridge, MD, USA)

To have an impact, even excellent science needs to be effectively communicated. This workshop will detail how to incorporate visual elements into print and electronic media—to expand on traditional peer reviewed journal formats—and more effectively communicate to managers, the general public, as well as fellow scientists (http://ian.umces.edu/communication.php). Participants will be introduced to conceptual diagrams, one of the key tools used to synthesize information and therefore facilitate effective communication (http://ian.umces.edu/conceptualdiagrams_page.php).



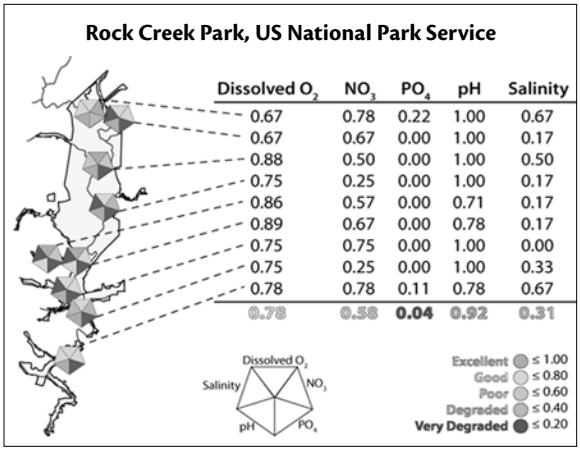
Conceptual diagram illustrating some of the key elements of menhaden ecosystem-based fisheries management.

WORKSHOP 2

Integrated Environmental Assessment

Invited Speaker: Bill Dennison (Integration & Application Network, University of Maryland Center for Environmental Science, Cambridge, MD, USA)

In our current scientific climate of mass data collection and a large and productive scientific community, the challenge is how to synthesize a mass of diverse information to answer apparently simple questions such as 'how healthy is a system?' and 'is the system getting better or worse?'. This workshop will provide tools for such syntheses and examples of where these approaches have been effective. Such issues as how to choose metrics, how to determine thresholds and how to combine metrics will be discussed and presented in practical exercises. See examples: http://www.ncrvitalsigns.net/ and http://www.eco-check.org/.



To determine vital sign metric scores, the percentage of time each metric meets its threshold is calculated. Site-specific metric scores are then averaged to calculate the park-wide metric score (bottom row of table). The park-wide scores are compared to the qualitative legend (bottom right) as a measure of park health.

Abstracts are listed by session, oral/poster, and alphabetical order by first author's last name. Presenters' names are in bold. The Author Index at the back of this program provides an alphabetical listing of all authors and page numbers of relative abstracts.

SESSION 1: *Biodiversity and productivity of marine organisms from pole to pole*

Shin, Hyung Chul (Keynote Speaker)

POLAR MARINE ECOSYSTEMS: DRIVER, DETECTOR AND DEPOSITORY OF GLOBAL CHANGES AND THEIR RECORDS

Polar marine ecosystems, although less explored and poorly sampled, represent a critical element of the continuum of the biosphere around the globe, and are to be understood with the rest of the Earth. Polar marine ecosystems play a pivotal role in altering climates and biogeochemical cycles at regional and global scales. Biological productivity in polar oceans, particularly in Southern Ocean, does not always match the potential of high nutrients, but can sometimes parallel that of other temperate waters, particularly in the vicinity of seasonal sea ice and in some coastal areas, resulting in draw-down and regulation of atmospheric carbon and also supporting a variety of species along a few trophic levels that can be harvested by human. In addition to low temperature, low light for part of a year and the changing cover of sea ice are the principal factors that govern the structure and functioning of polar marine ecosystems. Therefore polar marine ecosystems are inherently sensitive to global climate changes. Advance and retreat of the sea ice extent, in combination with local weather and topography can generate a multi-level variability of marine ecosystems, which is again linked to environmental variability occurring at wider, spatial and temporal scale. Examples will be taken and illustrated from the southwest Atlantic sector of Southern Ocean, where warming is taking place at an unusual rate. Polar ecosystems, both marine and terrestrial, are also home to many un-described species and may harbour ancient species preserved in isolation. Some bioactive compounds produced by polar organisms in the process of adaptation will help to illustrate the evolutionary history of the system and the inhabitants. Cases from some prokaryotes and also from antifreeze compounds will be discussed. Opportunities exist to investigate the role of these unique systems since their formation in global contexts. Polar marine ecosystems will also serve as a natural laboratory to gauge how human effects and natural force will interact to shape our future.

Al-Rshaidat, Mamoon M.D., Tracy A. Villareal, Heather Singler, Rob M. Sherrell, and R. Michael L. McKay (Oral)

IRON PHYSIOLOGICAL AUTECOLOGY OF THE VERTICALLY MIGRATING DIATOMS *ETHMODISCUS* SPP. AND *RHIZOSOLENIA* SPP. IN THE CENTRAL NORTH PACIFIC (CNP) GYRE

Low iron availability constrains algal primary production in numerous oceanic provinces, including some ultraoligotrophic regions. Although not numerically abundant, the diatom microplankton (>20 µm) is an important contributor to new production in these regions. To better understand the contributions made to production by diatoms in iron-depleted waters, we examined the iron-specific physiological and biochemical autecology of these taxa during research cruises in 2002 and 2003 along a transect at 29°N spanning the eastern half of the CNP gyre. Across the transect, *Ethmodiscus* provided near maximal values of F_v/F_m, a measure of photochemical energy conversion efficiency, whereas the mean F_v/F_m for *Rhizosolenia* was 0.61 in 2002 and only 0.48 in 2003. The higher F_v/F_m associated with *Ethmodiscus* was supported in part by an enhanced Ferredoxin Index, a biochemical measure of iron status. By comparison, the Fd Index for *Rhizosolenia* was consistently depressed. Determination of cellular iron quotas on oxalate-rinsed cells of both diatoms demonstrated comparable Fe:C ratios (means of 5.4 and 9.2 µmol Fe:mol C) for *Ethmodiscus* and *Rhizosolenia*, respectively. This was consistent with the presumed low dissolved iron content of these ultraoligotrophic waters. These cellular iron quotas represent among the first such measurements for oceanic diatoms. A Fd protein-coding gene (*petF*) was partially sequenced from *Rhizosolenia fallax*, an isolate from the CNP gyre. Application of bioinformatics tools validated the cross reactivity of Fd protein with the antibodies used for immunoblotting in this study. This *petF* gene sequence represents among the first *petF* gene sequences for open ocean diatom isolates.

Diekmann, A. Berenike S., Robert W. Campbell, Myron A. Peck, and Michael A. St. John (Oral)

SIGNIFICANCE OF ALGAL BLOOM TEMPORAL DYNAMICS ON ZOOPLANKTON VITAL RATES—VARIATION IN DIATOM BIOCHEMICAL COMPOSITION DURING A SIMULATED BLOOM AND ITS EFFECT ON COPEPOD REPRODUCTION

The biochemical quality of phytoplankton is a function of nutrient status and may play a role in its quality as a food to grazers. In order to examine how nutrient availability might influence the biochemical status of phytoplankton, bloom dynamics of the marine diatom *Thalassiosira weissflogii* were investigated. *T. weissflogii* was cultured in two ways: Four cultures simulated a bloom (B) and another two were maintained in exponential growth (E). Nutritional variations on the basis of the foodweb can indirectly influence higher trophic levels. Therefore, *Acartia tonsa* (Copepoda, Calanoida) egg production and egg hatching success were related to the biochemical composition of their food source; either B- or E-algae. The biochemical composition of the B- and E-algae differed during the experiment. B-algae were silicate limited at day three, and their biochemical composition changed as the growth phase of the culture changed from exponential, through stationary and scenescent phases. Protein levels per algal cell increased during exponential and stationary phase but decreased in the senescent phase, while carbohydrate levels increased with silicate depletion. Fatty acid contents changed during the simulated bloom and showed significant differences between the B and E treatments when B was in stationary and senescent phase. There was a response in copepod egg production rates to the different food sources: Egg production rates by copepods fed the B-culture in the senescent phase were half of those of copepods fed the E-culture, although egg hatching success was never below 99% regardless of bloom phase treatment. A crossover experiment verified the findings of this study: Egg production rates by copepods decreased when the E-fed copepods food source was changed to B-algae and vice versa. These results highlight how nutritional variations within a foodweb can indirectly influence higher trophic levels.

Jiao, Yan (Oral)

MODELING POPULATION DYNAMICS OF HAMMERHEAD SHARK COMPLEX USING A HIERARCHICAL BAYESIAN PRODUCTION MODEL

The hammerhead shark complex (*Sphyrna* spp.) is managed within the large coastal complex, and is composed of three species: scalloped hammerhead (*S. lewini*) and great hammerhead (*S. mokarran*), with the occasional catch of smooth hammerhead (*S. zygaena*). Baum et al. (2003) estimated an 89% decline in scalloped hammerheads populations since 1986 based on the U.S. pelagic long-line fleet logbooks. A lack of resources and the inability to easily identify individual species prevent species-specific assessments of these hammerhead sharks. With very different life history characteristics, some shark species are inevitably more productive than others. In mixed-stock fisheries, the populations of more productive species can often withstand moderate fishing pressure, while populations of less productive species tends to decline. Bayesian stock assessments have been used increasingly in assessing and managing fisheries stocks because of their flexibility in incorporating data from different sources, their ability to provide results for risk analyses of alternative management strategies, and their ability to incorporate prior knowledge of the fisheries into the assessment. A Bayesian hierarchical production model was developed to model the population dynamics of the complex of hammerhead sharks. The hierarchical structure of the population growth rate simulated the possible difference of population growth rates of different species in the complex which is obviously true. This modeling analysis will be useful for future hammerhead sharks assessment of the Northwestern Atlantic Ocean. It also provides insights for multi-species population dynamics modeling.

Khrustaleva, Anastasia M. (Oral)

APPLICATION OF MICROSATELLITE ANALYSIS TO THE STUDY OF THE POPULATION STRUCTURE AND POPULATION ASSIGNMENT OF ASIAN SOCKEYE SALMON (*ONCORHYNCHUS NERKA*)

The comparative study of the structure of the largest Asian sockeye salmon populations was carried out. Microsatellite DNA variation at six microsatellite loci (One-108, One-109, One-111, One-114, OtsG253b, OMM-1082) was examined in approximately 570 sockeye salmon sampled in 2003 and 2004 from seven stocks on the east and west coasts of Kamchatka (Ozernaya River, Bolshaya River, Palana River, Kamchatka River (early run and late run)), Chukotka (Vaamochka Lake),

North Kuril Islands (Shumshu Island, Bettobu Lake), and west coast of the Sea of Okhotsk (Okhota River). The analysis of annual variation in allele frequencies at surveyed loci was conducted in Bolshaya River samples (West Kamchatka) collected in 2003 and 2004 as well as in two adjacent generations (four-year and five-year returning adults) in 2003. No significant annual variability in Bolshaya River population was observed so the variability could be neglected over the time frame of interest. All surveyed loci were highly polymorphic and Hardy-Weinberg equilibrium was observed in most groups. The microsatellite analysis revealed well-defined genetic differentiation among the local populations. Significant differences in allele frequencies were found out between Chukotka, Okhota River, North Kuril populations, and Kamchatka populations as well as among Kamchatka stocks, with the exception of those located near the Ozernaya River and Bolshaya River populations. Assignment test of simulated mixed-stock samples showed that six microsatellite loci would enable relatively accurate individual identification.

Liu, Hui and Russell R. Hopcroft (Oral)

MODELING COPEPOD GROWTH RATES IN THE NORTHERN GULF OF ALASKA

We present a composite nonlinear model on copepod growth rates developed using traditional as well as Bayesian statistical approaches for dominant species in the northern Gulf of Alaska (GoA). Parameter estimates from two methods match well. This composite model, incorporating body size into the classical Michaelis-Menten function, was first developed for *Metridia pacifica* in appreciating the synergic effects of chlorophyll and body size on copepod growth, and then employed for *Neocalanus flemingeri*/*plumchrus*, *Calanus marshallae*/*pacificus* and *Pseudocalanus* spp. For each species, this model demonstrates its great appeal for describing copepod growth rates except for moderate overestimation at copepodite C5. The utility of this model for broadcasting species with inter- and intra-family (e.g. Calanidae and Metridinidae) still holds well. Preliminary results also show that further addition of developmental stage into this model has a profound impact on the model efficacy. We conclude that the composite nonlinear model has shown a great promise for predicting copepod growth rates in the subarctic Pacific waters and this study lays a foundation for further synthesis study of the GoA ecosystem.

Mizobata, Kohei and Jia Wang (Oral)

PHYTOPLANKTON DYNAMICS FLUCTUATED BY THE ICE-OCEAN CIRCULATION IN THE CHUKCHI AND BEAUFORT SEAS

The phytoplankton dynamics and the ice-ocean circulation in the western Arctic Ocean during ice-melting season were investigated using satellite multi-sensor dataset and a Coupled Ice-Ocean Model (CIOM). Since 2002, areas with low chlorophyll-*a* (chl-*a*) area and open water have been increased in the Chukchi and Beaufort Seas. In the Chukchi Sea, relatively high sea surface temperature (>4Co) and a long duration of open water were also captured by the satellite imagery. The emerging patterns of low chl-*a* area detected by the ocean color images were consistent with the pathway of Pacific water simulated by the CIOM. Satellite chl-*a* images show strong chl-*a* front at the Siberian coastal area indicating nutrient-poor water in the Alaska Coastal Current (ACC). Those results suggest that the Pacific water transported by the ACC results in stable and low-nutrient stratified surface layer suppressing the open water bloom in the Chukchi Sea. There was an ice-edge bloom only in July 2004, when sea surface wind was weak, indicating that strong wind will destruct and deepen mixed layer at the ice edge, resulting in less ice-edge bloom. In the Beaufort Sea, open water and rapid sea ice retreat have been found in the deep basin since 2002. However, chlorophyll-rich water was seen in the deep basin, when ice edge was close to the northern Alaskan Coast like in 2001. Satellite images and the NCEP wind dataset imply that open water due to rapid sea ice retreat induce deep polar mixed layer that suppresses the phytoplankton bloom. On the other hand, the low chl-*a* area in the Chukchi/Beaufort Sea revealed highly productive surface water advected from the continental shelf to the deep basin. Our analysis shows that the jet flow at the Barrow Canyon and mesoscale eddies along the narrow Beaufort shelves are responsible for carbon export to the deep basin.

Paddack, Michelle J. (Oral)

FUNCTIONAL DIVERSITY IN CORAL REEF HERBIVORES AND IMPACT UPON ECOSYSTEM STRUCTURE

Research on ecosystem stability has largely focused on species richness and diversity. However, it is the nature of species

interactions, rather than numbers of species alone that shapes ecological systems. Given the increasing threat of altered ecosystems around the globe, a process-oriented understanding of the functional roles of individual organisms and their impact upon the ecosystem is critically needed. On coral reefs, fishing, disease, and habitat loss have led to in declines in macro-herbivore populations (urchins and fishes) and there is concern that this is resulting in decreased resilience of these systems. This is particularly so in the Caribbean where biodiversity is relatively low and reefs have recently undergone drastic shifts in structure. This study examines functional diversity within the Caribbean reef herbivore guild by assigning the 22 herbivorous coral reef fish species to specific groups based upon extensive grazing and behavioral observations. The strength of the interaction between herbivore functional diversity and benthic community structure is investigated by analyzing a large-scale database containing fish and benthic data from 16 Caribbean countries. Results reveal that the relative importance of functional groups varies among reefs and explains much of the variation in benthic structure. Variation in species and functional group composition among reefs appears to be driven by differential fishing impacts and variable responses of individual species to changes in the reef environment. A single functional group is identified as the dominate driver of benthic structure, yet has extremely low species diversity and contains species particularly vulnerable to fishing pressure.

Peterson, William T. and **Linda O'Higgins** (Oral)

ABUNDANCE, BIOMASS AND BIODIVERSITY OF PHYTOPLANKTON AT STATION NH05 OFF THE CENTRAL OREGON COAST: 2001 TO 2005

Temporal variations in phytoplankton population structure were examined at station NH05 along the Newport Hydrographic (NH) Line between 2001 and 2005. This is a well studied coastal ecosystem with clearly described higher trophic levels however study of lower trophic levels and, in particular, phytoplankton population dynamics have been limited to measurements of chlorophyll *a*. Here we present results of a floristic survey of phytoplankton population structure and examine the effects of various physiochemical parameters on species composition, dominance and diversity. The central Oregon coast is known to experience regular periods of intense seasonal upwelling however periodic regime shifts due to the effects of El Niño and the Pacific Decadal Oscillation (PDO) can result in increased surface temperatures, decreased upwelling and reduced productivity. During such events the zooplankton community has been shown to shift from a pattern of low species diversity and high biomass to one of high biodiversity with accompanying low biomass (Hoof and Peterson, 2006).

Rho, TaeKeun, Sei-Ichi Saitoh, and Terry E. Whitledge (Oral)

SPATIAL AND TEMPORAL VARIATION OF PRIMARY PRODUCTION IN THE SOUTHEASTERN BERING SEA SHELF: MERGING FIELD DATA AND SATELLITE ESTIMATES

To better understand temporal and spatial variability of primary production in the southeastern Bering Sea shelf, we used field primary production data and satellite estimates using SeaWiFS (chlorophyll-*a*), Sea surface temperature (SST), and PAR during 1998-2004. Field data showed gradual progression of phytoplankton bloom from the inner shelf toward the middle shelf and outer shelf, the shelf break, and the oceanic region. An early phytoplankton bloom developed in March over the inner shelf, and gradually progressed over the middle shelf and the outer shelf in May and over the shelf break and oceanic region in June. Satellite estimates of primary production rates agreed well with field measurement and confirmed seasonal progression of primary production and the gradual progression of phytoplankton bloom across the southeastern Bering Sea shelf. Interannual variability of sea ice dynamics over the southeastern Bering Sea shelf may change the timing of phytoplankton bloom over the southeastern Bering Sea shelf. When warm winter causes less sea ice extent over the shelf, an early phytoplankton bloom develops over the inner shelf and late phytoplankton bloom occur over the middle shelf. When cold winter causes more sea ice extent and it retreats later in season, late development of phytoplankton bloom occurs over the inner shelf and an early ice edge related phytoplankton bloom develops over the middle shelf. Seasonal cycle of primary production across the shelf showed latitudinal difference between the southern and the northern parts of the southeastern Bering Sea shelf. Annual primary production from field measurement and satellite estimates showed no elevation over the shelf break regions, but were much higher from satellite estimates than

field measurements. This may result from the incomplete seasonal measurement of primary production in field data while satellite data include from March to October over the southeastern Bering Sea shelf.

Salleh, Sazlina and Andrew McMinn (Oral)

EFFECT OF TEMPERATURE ON PHOTOINHIBITION OF ANTARCTIC BENTHIC MICROALGAE

Global warming is likely to have a major impact on Antarctic benthic ecosystems. Elevated temperature effects photosystems of marine benthic algae by reducing growth, limiting the transport of electrons from photosystem II and reducing carbon fixation which all reduce the ability of the cell to use light. This resulting excess light energy may cause photoinhibition due to damage to the PSII. Photosystems of benthic microalgal communities from Casey, eastern Antarctic were relatively unaffected by significant changes in temperature. Temperatures up to 8°C, along with high irradiance levels (450 µmol photons m^{-2} s^{-1}) were found to have little to no effect on rETRmax, photosynthetic efficiency or photoacclimation. At this light level and temperature state rETRmax, the photoacclimation index (E_k), photosynthetic efficiency (α) and effective quantum yield ($F_{v'}/F_{m'}$) were 22.002 ± 1.870, 103.352 ± 31.352 µmol photons m^{-2} s^{-1}, 0.22 ± 0.044 and 0.433 ± 0.042 respectively. Temperatures down to −5° with high PAR level were likewise found to have little impact on these parameters. The photosynthetic parameters under these conditions were rETRmax (19.010 ± 10.003), photoacclimation index (E_k) (112.856 ± 70.215), photosynthetic efficiency (α) (0.183 ± 0.051) and effective quantum yield (Fv'/Fm') (0.415 ± 0.042). Recovery from saturating and photoinhibiting irradiances was not significantly influenced by temperature in the −5-8° C temperature range. These responses are consistent with those recorded by past experiments on Antarctic benthic diatoms and temperate diatoms and suggest that climate change will not have a significant impact on the ability of benthic microalgae to recover from photoinhibitory temperature stress.

Costa, Pedro R., Susana Garrido, and Maria João Botelho (Poster)

HARMFUL ALGAL BLOOM EVENTS AND DETECTION OF MARINE BIOTOXINS IN SARDINES (*SARDINA PILCHARDUS*)

Phytoplankton is responsible for primary productivity of the oceans, but certain few species can be prejudicial and synthesize toxic compounds known as marine biotoxins. Harmful Algal Blooms (HAB) are today increasingly frequent in coastal waters not only due to scientific and technologic advances in their detection but also due to eutrophication and algae stimulation by unusual climate conditions. Besides public safety concerns and economic losses on seafood related industries marine biotoxins also promote adverse effects on living marine resources. Although bivalves are considered the primary toxin vectors, fishes might be more exposed to toxic algae than bivalves because HABs occur for several instances only offshore and do not reach the coast. Sardines (*Sardina pilchardus*) are planktivorous fish with high social and economic value in many countries including Portugal, and due to their filter-feeder behaviour on the presence of algal blooms they can act as biotoxin vectors. Here we reveal sardines as vector of 3 different groups of biotoxins, namely diarrheic, paralytic and amnesic shellfish poisoning toxins (DSP, PSP and ASP). Okadaic acid, dinophysistoxin-2, saxitoxin and their analogues, and domoic acid and their isomers were detected in sardine guts during occurrence of blooms including *Dinophysis acuta* and *D. acuminata*, *Gymnodinium catenatum* and *Pseudo-nitzschia australis*. Changes on phytoplankton species community were observed when comparing to historical data and as consequence PSP toxins produced by *G. catenatum* were detect in marine fauna, including sardines, for the first time in the last 9 years, which may cause impacts on ecosystem stability and human health.

Dippenaar, Susan M. (Poster)

THE DIVERSITY OF SYMBIOTIC SIPHONOSTOMATOIDA (COPEPODA) OF MARINE FISH FROM SOUTHERN AFRICA

Worldwide there are 11 500 known species of copepods of which more than 4224 are symbiotic. Most of these belong to two orders, Poecilostomatoida (>1771 species) and Siphonostomatoida (>1840 species). The Siphonostomatoida consists of 37 families that are mostly marine and infect invertebrates (20) as well as vertebrates (17). Most studies done on the Siphonostomatoida from South African marine waters have been fragmented taxonomic studies of symbiotic copepods in museum collections. To date, representatives of 14 of the 17 families infecting vertebrates have been recorded from

southern Africa. These include 63 genera and 186 species, a mere 10% of the known symbiotic Siphonostomatoida, collected from 185 hosts (68 elasmobranchs). Collected specimens from South African waters include members of 53 genera and 136 species, representing only 7% of the known symbiotic Siphonostomatoida. Considering the richness of marine fish species, estimated at 2500 in southern Africa with more than 2400 species just for South Africa, an extensive investigation of all possible fish hosts is bound to increase the number of recorded siphonostomatoids considerably and thus also our knowledge of a small part of the invertebrate marine biodiversity.

Häussermann, Verena and G. Försterra (Poster)
A HOTSPOT IN THE COLD – OUTSTANDING BIODIVERSITY IN THE CHILEAN PATAGONIAN FJORD REGION
Formed from two parallel mountain ranges, the Patagonian coast in the south of Chile is the most structured fjord region in the world. Vast and extremely fragmented archipelagos in combination with large continental fjords result in a total coastline of more than 80 000 km. A multitude of different coast types and bottom morphologies in combination with a complex interference pattern of hydrographic gradients and strong dynamics produce an enormous number of habitats and niches. Therefore it does not surprise that this region forms a diversity hotspot with an outstanding high number of biocenoses and exceptional overall species richness. Due to historic, climatic, logistic and technical reasons the marine environment of the entire region is extremely poorly studied and certain habitat types, like the subtidal rocky slopes, are practically unprobed. Recent inventory efforts by the new Huinay Scientific Field Station, in the context of a first multi-taxa benthic field guide project, revealed a high number of new registers, new species and higher taxa and even entire benthic communities that were new to science. Due to the fact that the taxonomic knowledge within Chile is low, international cooperation is needed to inventory the Chilean fjord region. Such inventory data are the urgently needed base for further studies that can help to create sound management plans for the fast growing exploitation of this part of the world's oceans and prevent its irreversible destruction.

Lopez-Urrutia, Angel, Elena San Martin, Roger P. Harris, and Xabier Irigoien (Poster)
SCALING THE METABOLIC BALANCE OF THE OCEANS
Oceanic communities are sources or sinks of CO_2, depending on the balance between primary production and community respiration. The prediction of how global climate change will modify this metabolic balance of the oceans is limited by the lack of a comprehensive underlying theory. Here, we show that the balance between production and respiration is profoundly affected by environmental temperature. We extend the general metabolic theory of ecology to the production and respiration of oceanic communities and show that ecosystem rates can be reliably scaled from theoretical knowledge of organism physiology and measurement of population abundance. Our theory predicts that the differential temperature-dependence of respiration and photosynthesis at the organism level determines the response of the metabolic balance of the epipelagic ocean to changes in ambient temperature, a prediction that we support with empirical data over the global ocean. Furthermore, our model predicts that there will be a negative feedback of ocean communities to climate warming because they will capture less CO_2 with a future increase in ocean temperature. This feedback of marine biota will further aggravate the anthropogenic effects on global warming.

Miller, Sara E., James N. Ianelli, and Terrance J. Quinn II (Poster)
ESTIMATION OF MOVEMENT IN A SPATIALLY-EXPLICIT STOCK ASSESSMENT OF EASTERN BERING SEA WALLEYE POLLOCK (*THERAGRA CHALCOGRAMMA*)
The age-structured stock assessment model for managing Eastern Bering Sea (EBS) walleye pollock (*Theragra chalcogramma*) is spatially aggregated. A spatially-explicit migration model was developed to evaluate walleye pollock dynamics on finer spatial and temporal scales. The model was extended allow two regions: northwest (NW) and southeast (SE) EBS, and two seasons. The model included movement, and allowed population parameters to be region-specific. Hypotheses of age-and year-specific movement between the NW and SE were tested. Robustness of the migration model was tested using simulation experiments. Under moderate assumptions, reasonable estimates of most population and movement parameters could be obtained from existing disaggregated assessment survey and fishery data. However, the addition of mark-recapture data would reduce model uncertainty and hence be more suited for management application.

Piyanova, Svetlana V. and Andrey F. Petrov (Poster)
THE OOGENESIS CHARACTERISTICS OF ANTARCTIC TOOTHFISH *DISSOSTICHUS MAWSONI* NORMAN 1937 (PERCIFORMES NOTOTHENIIDAE) CAUGHT BY THE BOTTOM LONGLINE IN THE ROSS SEA
The results of the histological analysis of the Antarctic toothfish (*Dissostichus mawsoni*) reproductive system, caught in December-February, 2004-2005 by the longliner VOLNA in subareas 88.1 and 88.2 in the Ross Sea are presented. The morphological parameters, indices of gonads have been described. The histological criteria of the assessment of the ovary maturity stages and cytological parameters of oocytes and type of the toothfish oogenesis have been determined. Under the maturing of toothfish ovaries from the stages II to IV show a slow increase in oocyte diameter. It was shown that for Antarctic toothfish during the fishing period the individuals with gonads of the III late stage of maturity were dominated. Their ovaries contained three size groups of oocytes: cytoplasmic group and two groups of vitellogenous oocytes. The type of the toothfish oogenesis has been defined as intermitted. The large oocytes of the nearest spawning season with average diameter 1000-1200 mcs have composed 5.4% of total cell number. The oocytes in the ovaries of analyzed fish did not reach the maximum size; consequently Antarctic toothfish was not matured for spawning in the Ross Sea.

Zilniece, Dace, Maris Plikss, Danute Uzars, Didzis Ustups, and Barbel Muller-Karulis (Poster)
THE STRUCTURE AND DYNAMICS OF FISH COMMUNITIES IN THE COASTAL ZONE OF THE CENTRAL-EASTERN BALTIC SEA
The Baltic Sea is a semi-closed brackish water basin. The fish fauna of the Baltic Sea is relatively young, including the species both of marine and freshwater origin, and diadromous forms. To compare with other brackish water basins the central-eastern Baltic coastal areas salinity vary from 5-7 psu and are open exposed with no estuaries or lagoons. This comprises extremely dynamic circulation of water masses depending from climatic factors. The fish biodiversity in the central-eastern Baltic coastal area was analyzed from 1986 based on research surveys by beach seines. The coastal fish communities reveal a strong temporal variation. In spring, juveniles and adult marine fishes migrate from depths to the nursery, spawning or feeding grounds located in the coastal waters. This is caused mainly by the spring increase of water temperature. Further increase of temperature in summer has lead to increase of marine and diadromous fish larvae as well as the freshwater species. The freshwater species migrate to the coastal areas from adjacent freshwater basins to extend the feeding area. The present paper examines the seasonal and annual variation in fish community structure in the open Baltic Sea coast during last 20 years depending from climatic changes and hydrological regime shift in the Baltic.

SESSION 2: *Processes at ocean margins*

Simpson, John H. (Keynote Speaker)
TRANSPORT AND MIXING AT THE SHELF EDGE: A KEY CHALLENGE FOR OCEANOGRAPHERS
The shallow seas of the continental shelf are characterised by a high energy regime which contrasts sharply with that of the deep ocean where energy levels are much lower and the flow in the interior is relatively tranquil. Research over the last century has culminated in a reasonable first order understanding of the way that these two contrasting regimes operate and we now have rather good models for predicting their behaviour. Where they meet, however, in a narrow region over the steep topography of the continental slope, there has to be a zone of mutual adjustment. The dynamical processes involved in this adjustment are not well understood and are of vital importance because of their crucial role in controlling biogeochemical exchanges between shelf and deep ocean, exchanges which are critical in relation to climate change. Observing and modelling circulation and water column structure is, therefore, a key priority for Oceanographers in the next decade and beyond. In this presentation, I will review our current limited knowledge of shelf edge exchange processes and indicate how we might best respond to the challenge ahead.

Bishop, Melanie J., Brendan P. Kelaher, Ralph Alquezar, Paul H. York, Peter J. Ralph, and C. Greg Skilbeck (Oral)
CUL-DE-SACS OF DETRITUS-BASED FOOD-WEBS: LARGE GASTROPODS, *PYRAZUS EBENINUS*, SHORT-CIRCUIT TROPHIC TRANSFER
The importance to food-webs of trophic cul-de-sacs, species that channel energy flow away from higher trophic levels,

is seldom considered outside of the pelagic systems in which they were first identified. On intertidal mudflats, large detritivorous invertebrates with hard shells that protect from predators may short-circuit trophic transfer by directly or indirectly decreasing the abundance of softer-bodied macroinvertebrates that are important nutritional sources for commercially-important fish and threatened birds. A fully orthogonal three-factor experiment manipulating the density of the abundant detritivorous gastropod, *Pyrazus ebeninus*, detritus and macrobenthic predators on a Sydney mudflat revealed large deleterious effects of the gastropod, irrespective of detrital loading or the presence of predators. Two months after experimental manipulation, the standing-stock of microphytobenthos in plots with high (44 per m^2) densities of *P. ebeninus* was 20% less than in plots with low (4 per m^2) densities. Increasing densities of *P. ebeninus* from low to high halved the abundance of macroinvertebrates and the average number of species. Over the two-months of our experiment, no predatory mortality of *P. ebeninus* was observed and high densities of *P. ebeninus* decreased impacts of vertebrate predators on macroinvertebrate abundances. Thus, in reducing microphytobenthos and the abundance of macrofauna, high abundances of the detritivore *P. ebeninus* may severely limit the flow of energy up the food chain to commercially-important species. This study therefore suggests that trophic cul-de-sacs are not limited to the eutrophied pelagic systems in which they were first identified, but may exist in other systems as well.

Dudas, Sarah E., Brian A. Grantham, Anthony R. Kirincich, Bruce A. Menge, Jane Lubchenco and John A. Barth (Oral)

THE INFLUENCE OF NEARSHORE CURRENT REVERSALS ON INTERTIDAL INVERTEBRATE RECRUITMENT ALONG THE CENTRAL OREGON COAST

To test the 'current reversal' hypothesis as a cause of intertidal invertebrate recruitment pulses, we carried out a study that aimed at understanding intermittent upwelling effects on barnacle and mussel recruitment at regional and local scales. Over two summers moorings were deployed at 4-5 sites 600-1000 m from shore to record temperatures and currents (4-13 m depths), while recruitment was measured at adjacent intertidal sites. In 1998 upwelling periods were punctuated by periodic wind reversals, and widespread increases in nearshore temperatures while 1999 was characterized by more frequent, shorter wind reversals. In 1998 the highest recruitment occurred at the site experiencing more frequent reversals of the predominantly equatorward currents, higher poleward velocities and coincident temperature increases. In 1999 maximum barnacle recruitment occurred at the site with higher poleward current velocities while maximum mussel recruitment occurred at the site with consistent deep (10 m) onshore currents. Barnacle recruitment was generally positively correlated with onshore surface currents and temperature; mussel recruitment showed variable, weaker correlations. These data indicate that substantial decreases or complete reversals of upwelling-driven alongshore currents may be necessary for barnacle recruitment events, but topographically driven differences in ocean current response to wind changes may generate local recruitment differences. These results have important consequences for the establishment of marine reserves and similar spatially oriented management strategies as even relatively straight coastlines may have enhanced recruitment zones due to local oceanography. Further, the inter-annual differences observed in current reversals and recruitment patterns highlight the importance of upwelling variation to onshore communities.

Henson, Stephanie A. and Andrew C. Thomas (Oral)

PHYSICAL-BIOLOGICAL INTERACTIONS IN THE COASTAL GULF OF ALASKA

The interactions between physical forcing and biological response are explored for the coastal Gulf of Alaska region. Nine years of satellite chlorophyll data allow the interannual variability in timing and magnitude of the phytoplankton spring bloom to be quantified. At this high latitude, light is expected to limit phytoplankton growth in early spring. Establishing a stable, stratified water column will therefore be essential for a bloom to start. Stratification in this region relies on a balance between processes which mix the water column, and those that stabilize it. Mixing arises primarily from wind stress, whilst surface heating and freshwater input encourage stratification. We define a 'stability ratio' which parameterises the competition between buoyancy and mixing. The timing of the spring bloom corresponds closely to the switch from unstable to stratifying conditions. Additionally, years in which the spring bloom starts earlier than usual experience a more intense bloom than in late starting years. We speculate on the consequences of interannual, basin-scale changes in forcing for biological productivity in the Gulf of Alaska region.

Kim, Yong Hoon and George Voulgaris (Oral)

ROLE OF LATERAL CIRCULATION ON SUSPENDED SEDIMENT TRANSPORT IN ESTUARIES

Along- and cross-channel flows and suspended sediment concentrations collected along three cross-sections of a partially stratified estuary, Winyah Bay (South Carolina, USA), are used to study lateral circulation and cross-channel material transport processes. Analysis of the transient cross-channel momentum balance equation showed that the balance between the centrifugal forcing and baroclinic pressure gradients controls lateral circulation. In a curved, non-symmetrical channel section, the transient momentum analysis showed that the centrifugal forcing dominates over baroclinic pressure gradient. During ebb, centrifugal acceleration forces water mass transport toward the outside of the curve at the surface layer and toward the inside in the bottom layer. This leads to the creation of a counterclockwise lateral circulation (looking up-estuary) in a left curved section. A centrifugal forcing results in a clockwise lateral circulation during flood due to maximum along-channel currents in the mid-depth.

The observed pattern of lateral currents controls the cross-channel transport of suspended sediments at the non-symmetrical channel section. Sediments resuspended on the gentle, broad right shoal during ebb are transported to the middle layer of the channel by the leftward surface currents. Conversely, during flood, leftward-directed near-bed currents deliver a significant amount of sediments from the left shoal, which, along with resuspended sediments from the channel bed, contribute to the development of the estuarine turbidity maximum (i.e., mud reaches). Lateral sediment fluxes averaged over a tidal cycle represents convergence of suspended sediments to the center of the channel. Tidal decomposition results show that this convergence attributes mostly to oscillatory tidal component.

Kirincich, Anthony R. and John A. Barth (Oral)

SPATIAL AND TEMPORAL VARIABILITY OF INNER-SHELF CIRCULATION ALONG THE CENTRAL OREGON COAST DURING SUMMER

The nature and variability of inner-shelf circulation along the central Oregon coast are examined using measurements obtained in water depths of 15 m during the summer of 2004. Although wind forcing and bathymetry are spatially uniform in the inner-shelf, distinct differences in circulation existed among four along-shelf stations. Upwelling circulation at the northernmost station, north of an offshore submarine bank, is similar to classic two-dimensional (2D) upwelling with along-shelf bottom stress and acceleration balancing the along-shelf wind stress. In contrast, onshore of the bank at the southern three stations, the 2D balance is poor and inclusion of the pressure gradient and nonlinear terms improves the along-shelf momentum balance. During downwelling events the 2D balance holds well at the southern sites, but poorly at the northern site. The dominant mode of variability, found using EOF analysis of pressure, along-shelf velocity, across-shelf surface transport, and density, was correlated to the local wind forcing and seen at all stations. A second mode, seen only to the north of the bank, drives additional upwelling or downwelling. The observed temporal and spatial differences result from region-wide flow-topography interactions which leave the on-bank stations in a lee. By late summer, inner-shelf flow during upwelling is strong and southward north of the bank, weak and onshore on the northern part of the bank, and increasingly southward on the southern part of the bank. These results agree favorably with previous outer- and mid-shelf studies conducted in the region, while offering new insight into physical and ecological interactions in the inner-shelf.

Li, Chaolun, Shiwei Wang, Song Sun, and Bo Yang (Oral)

SEASONAL VARIATIONS IN REPRODUCTION OF A PLANKTONIC COPEPOD *CALANUS SINICUS* RELATED TO THE PHYSICAL AND BIOLOGICAL ENVIRONMENTS IN THE YELLOW SEA, CHINA

In situ egg production rates (EPRs), egg hatching success (HS) and naupliar survival (NS, to the first feeding stage) of Calanus sinicus were measured during one spring (April) and two autumn (September and October) cruises in Yellow Sea. The whole survey area was well mixed and the spring phytoplankton developed in the northern area during the April cruise. EPRs varied geographically between 0 to 23.7 eggs female^{-1} d^{-1}, and generally increased with chlorophyll *a* concentration. Geographical differences in gonad development, body size and oil storage of females also suggested that food availability, rather than temperature, determined fecundity in the spring. In autumn, the Yellow Sea Cold Water Mass (YSCWM) had well developed in the shelf waters, which had great impact on the reproduction of *C. sinicus*. Females

residing inside the YSCWM had larger body size, immature gonads, and no spawning activity, while those outside had smaller body size, mostly mature gonads, and considerable spawning. Analysis of the integrated physical and biological parameters indicates that the seasonal YSCWM provides suitable shelter rather than a desirable breeding nursery.

Palinkas, Cindy M. and Andrea S. Ogston (Oral)
EVENT-SCALE ANALYSIS OF SHELF SEDIMENTARY PROCESSES
Previous studies of deposition and erosion on ocean margins have largely used radionuclide analyses of sediment cores. While useful to describe long-term trends (seasonal to decadal), these analyses are temporally limited by lifetime of the radionuclides and cannot resolve event-scale (hourly to daily to weekly) processes, which likely have a large influence on the benthic community. This study describes a new approach to examine event-scale sedimentation by establishing a connection between water-column signals and changes in the seabed. The Po River shelf in the Adriatic Sea was chosen as a case study due to the dominance of winter storm events on sediment transport and the availability of coincident water-column and seabed measurements during the EUROStrataForm project. Several deployments of an instrumented bottom-boundary tripod occurred at the study site from January 2001-May 2003, producing a nearly continuous record of sediment transport. Sediment cores were collected approximately every 3 months during this time, and seabed inventories of ^{7}Be (half-life 53.3 d) were used to determine sediment deposition or erosion during each deployment. Comparison of these values with those obtained from the tripod altimeter record agrees well, varying from ~2 cm deposition to ~1 cm erosion during a seasonal deployment. Within each event, analysis of the altimeter record has proved challenging due to the change in sediment porosity that likely occurs during a storm event. However, the pre- and post-storm porosity values should be similar, and the net erosion recorded by the altimeter should be valid. To determine the maximum erosion that occurs at the peak of storm events, suspended-sediment data and bottom shear stress calculations were used to determine the resuspension depth.

Rilov, Gil (Oral)
BENTHIC-PELAGIC DECOUPLING IN THE ROCKY INTERTIDAL BY SUBTIDAL PREDATORS: THE EFFECT OF SEASCAPE ON SPECIES INTERACTIONS AND ONSHORE RECRUITMENT
Recent "benthic-pelagic coupling" models predict that intertidal prey recruitment rates are tightly and positively correlated to predation intensity on that prey. The models also suggest that oceanographically-driven processes promote this coupling at large and meso-scales and produce high but largely predictable variability in community structure and function among sites. In contrast, using a multiscale comparative-experimental approach, I demonstrate that very local-scale variability in recruitment rates and predation intensity—that is mostly seascape-dependent—may be linked to high variability in community structure among wave-exposed sites, and that predation intensity can be decoupled from prey recruitment. In New Zealand, subtidal predators (fish and crabs) can exert intense predation pressure on small mussels during high tide on intertidal rocky benches with continuous subtidal reefs (R-R sites) even in sites where mussel recruitment is extremely low. On isolated rocky benches located in sandy beaches with no extensive subtidal reefs (R-S sites) subtidal predators are usually rare and predation pressure is lower. Mussel recruitment, however, can show an opposite trend with often greater recruitment to R-S than to R-R sites. Furthermore, measurements in New Zealand and Oregon suggest that the nearshore larval pool is often decoupled from recruitment rates onshore, and this decoupling may be related to the vertical distribution of the larvae and to the local seascape. I argue that local, context-depended, processes can be accountable for as much variability in community structure as large-scale processes, and much more detailed knowledge is required on local conditions before predictions of general models can become reliable.

Rykaczewski, Ryan R. and David M. Checkley Jr. (Oral)
FROM PHYSICS TO FISH: INFLUENCE OF WIND STRESS CURL ON PACIFIC SARDINE
High productivity in the world's eastern boundary currents is sustained by upwelling of nutrient-rich, subsurface water. These ecosystems support a rate of fish harvest nearly 100 times the global mean and account for more than 20% of the world's marine fish catch. Two atmospheric processes induce different types of upwelling in these ecosystems: alongshore wind stress, resulting in rapid upwelling; and wind-stress curl, resulting in slower upwelling. We show that wind-stress

curl is responsible for the majority of upwelling in the southern California Current Ecosystem, and the extent of isopycnal shoaling and concentrations of nutrients and chlorophyll correlate positively with wind-stress curl. The size structure of plankton assemblages is related to the rate of wind-forced upwelling, and Pacific sardine (*Sardinops sagax*) feed efficiently on the smaller plankton generated by slow upwelling. Different environmental parameters were used to modulate a surplus production model for sardine, and the predictive ability of each environmental parameter was assessed over the 1984-2005 period. Two environmental measures consistently outperformed all others: 1) vertical transport by open-ocean upwelling during June, July, and August; and 2) spatial extent of open-ocean upwelling rates ranging from 4 to 6m day^{-1} during the same months. These measures of upwelling successfully predicted the variation observed in sardine productivity during the past two decades and were able to hindcast the population collapse in 1950. Understanding of biological mechanisms relating fisheries production to environmental variability is essential for wisely managing our marine resources.

Souza, Afonso and Tamara K. Pease (Oral)

EFFECT OF ORGANIC ENRICHMENTS ON BACTERIAL POTENTIAL HYDROLYTIC ACTIVITY IN ORGANIC-POOR ESTUARINE SEDIMENTS

In coastal ecosystems, organic matter decomposition and preservation is influenced by bacterial capacity to produce extracellular enzymes. To determine limiting factors of enzymatic hydrolysis, microbial enzymatic activities' response to the addition of organic compounds was examined in sandy organic-poor estuarine sediments of Aransas Bay, TX, USA. Enzymatic rates and bulk sediment characteristics were measured in both phytoplankton-amended and control sediments. The activities of ß-glucosidase and leucine-aminopeptidase were measured as proxies for hydrolysis of polysaccharides and proteins, respectively. During 55 incubation days, total organic carbon content decreased in phytoplankton-amended sediment while no significant change occurred in controls; total nitrogen content did not change in either treatment. Both protein and carbohydrate concentrations in phytoplankton-amended sediment decreased to control levels. Ammonium concentrations increased by a factor of 20 in phytoplankton-amended sediment and remained constant in the controls. ß-glucosidase and peptidase activities decreased in phytoplankton-amended sediment and activity remained constant in control sediments. After 55 days, both treatments were enriched with laminarin and casein and hydrolytic potentials were tracked for an additional 10 days. Both laminarin and casein enrichments increased peptidase activities from below-detection to ~5µM analog/g.h in phytoplankton-amended sediment and from 2 to 5µM analog/g.h in control sediments. Laminarin addition stimulated glucosidase activity to ~1.3µM analog/g.h in both control and amended sediments, while casein addition only induced activity to 0.7µM analog/g.h in control sediments. These results indicate that bacteria increase enzymatic activity in organic-poor anoxic sediments when polymeric compounds become available, suggesting a pump-priming mechanism for degradation of organic matter.

Wetz, Michael S. and Hans W. Paerl (Oral)

IMPACT OF LARGE STORMS (HURRICANES, TROPICAL DISTURBANCES) ON PHYTOPLANKTON AND MICROZOOPLANKTON IN A LARGE ESTUARINE ECOSYSTEM: A GLIMPSE INTO THE EFFECTS OF A PERIOD OF ELEVATED HURRICANE ACTIVITY

Estuaries are among the most productive ecosystems on Earth, providing food resources and critical habitat for ecologically and commercially important fish and shellfish. Estuarine primary productivity, nutrient fluxes and food web dynamics are strongly influenced by passage of large storms (i.e., hurricanes), which in the US Gulf and East Coasts have increased in frequency and magnitude in the past decade and are further expected to increase with global warming. Results from several pre- and post storm samplings in North Carolina's Neuse River Estuary (NRE) show that the response of phytoplankton and their main grazers, the microzooplankton, varies depending on a storm's meteorological characteristics. For instance, windy storms with little rainfall had only minimal impacts on phytoplankton and microzooplankton biomass along the axis of the NRE. In contrast, storms that were accompanied by significant rainfall caused short-term (i.e., days post-storm) reductions and/or downstream advection of phytoplankton, as well as shifts in the phytoplankton community composition. The response of the microzooplankton community was more variable, with some localized reductions and increases in both ciliate and heterotrophic dinoflagellate biomass. In the longer-term (i.e., weeks post-storm), the

response of the phytoplankton community was dependent on the degree of flushing associated with a particular storm. Storms accompanied by extreme rainfall led to prolonged reductions in phytoplankton biomass, largely by flushing out local phytoplankton communities and by preventing phytoplankton re-growth through reductions in water column light levels from particle loading. In contrast, storms accompanied by moderate rainfall, but which did not completely freshen the NRE, actually led to significant longer-term increases in phytoplankton biomass, as well as shifts in phytoplankton community composition. These results will play a central role in helping to develop a better regional and global understanding of key environmental drivers (i.e., hurricanes) and biotic properties underlying ecological change of estuarine ecosystems.

Zwolinski, Juan P., Paulo B. Oliveira, Alexandre Morais, Victor Quintino, and Yorgos Stratoudakis (Oral)
SARDINE POTENTIAL HABITAT AND ENVIRONMENTAL FORCING OFF WESTERN PORTUGAL
Relationships between sardine (*Sardina pilchardus*) distribution and the environment off western Portugal were explored using data from six acoustic surveys (spring and autumn of 2000, 2001 and 2005). Four environmental variables (sub-superficial salinity, temperature, chlorophyll content and planktonic acoustic backscatter over the water column - proxy for macro-zooplankton density) were related to the acoustic presence of sardine. Univariate quotient analyses revealed sardine preferences for waters with high chlorophyll content, low temperature and salinity and low planktonic scattering. Regression of sardine presence on the principal component rotated environmental variables confirmed quantitatively the above trends. These results are in line with a sardine diet based mainly on phytoplankton and small zooplankton that usually concentrate in productive, cooler and less saline coastal waters. Generalized additive models were used to construct multi-annual synoptic relations to map sardine potential habitat (SPH), revealing a clear seasonal effect in the bathymetric and along-shelf extension of SPH off western Portugal. During autumn, SPH occupied a large part of the northern Portuguese continental shelf but was almost absent from the southern region, while in spring SPH extended further south but was reduced to a narrow band of shallow coastal waters in the north. This seasonal pattern agrees with the spatio-temporal variation of primary production off western Iberia and the corresponding ocean circulation. The northerly concentration of SPH during autumn can be linked to the onset of the downwelling season that coincides with the settlement of oligotrophic waters in the narrow southern shelf and the maintenance of higher production associated to nutrient input from river runoffs in the wider northern shelf. Shelf-wide spring phytoplankton blooms provide a suitable habitat for sardine across western Iberia, but the penetration of the Iberian poleward current onto the outer shelf of northwestern Iberia constrains spring production (and SPH) to the inner shelf.

Goto, Daisuke and William G. Wallace (Poster)
THE IMPORTANCE OF METAL STORAGE BY PREY AND DIGESTIVE PROCESSES IN PREDATORS TO METAL TROPHIC TRANSFER IN COASTAL BENTHIC FOOD CHAINS
Urban estuarine and coastal ecosystems in the New York/New Jersey Harbor Estuary (NY/NJ-HE) are chronically exposed to various potentially toxic metals due to human activities. In this study, mummichogs (*Fundulus heteroclitus*) were used as a model predator in a typical benthic food chain in NY/NJ-HE to evaluate the importance of two key factors that may influence metal trophic transfer to higher trophic-level predators; 1) prey metal compartmentalization, and 2) predator digestive processes. The gut contents of mummichogs from the field were examined to determine typical prey items. *Palaemoenetes* spp., *Leptocheirus pulmulosus*, *Chironomidae*, and *Nereis* spp. were chosen as representative prey to be radiolabelled with ^{109}Cd and $CH_3{}^{203}Hg$. Cytosolic proteins and organelles fractions (collectively trophically available metals—TAM) were isolated from prey to estimate the potentially available portion of metals in prey. Additionally, prey organisms were incubated *in vitro* with gut fluid extracted from mummichogs to estimate the solubilizable metals in prey. TAM in prey and metals solubilized from prey were compared with metal assimilation efficiencies estimated through feeding experiments. TAMs in most prey organisms were relatively similar for both ^{109}Cd and $CH_3{}^{203}Hg$ (58-71%). The solubilizable metals, however, were relatively variable ranging from 65-85% for ^{109}Cd, and from 46-70% for $CH_3{}^{203}Hg$. These results were concordant to $CH_3{}^{203}Hg$ assimilated by mummichogs (52-89%), while ^{109}Cd was assimilated significantly less (6.2-9.3%) than both TAM and solubilizable metals in all prey. This study may suggest a highly biologically driven mechanism controlling CH_3Hg cycling in coastal environments.

Koropitan, Alan F., Motoyoshi Ikeda, Ario Damar, and Yasuhiro Yamanaka
INFLUENCES OF PHYSICAL PROCESSES ON THE ECOSYSTEM OF JAKARTA BAY: A COUPLED HYDRODYNAMIC-ECOSYSTEM MODEL EXPERIMENT
A coupled hydrodynamic-ecosystem (ammonium, nitrate, phytoplankton, zooplankton, and detritus) model has been applied in Jakarta bay to investigate the role of physical processes on nitrogen cycling. The physical processes consisted of tidal, river discharges and wind. The potential sources of nitrogen to the Jakarta Bay are considered in the coupled model, such as, riverine inputs, wet deposition flux of rainwater and bottom detritus. Monitoring of water quality showed that nutrient concentrations in Jakarta Bay generally increased during 30 years and was caused by increased human population/activities. Generally, the nitrogen (ammonium and nitrate) riverine inputs are higher during northwest monsoon (rainy season) than southeast monsoon (dry season). However, the modeled nitrogen distributions show that the concentrations are low in Jakarta Bay during northwest monsoon and reversely during southeast monsoon caused by the monsoonal flow pattern. The highest riverine input (from the Citarum River which is located in the eastern bay), is well-distributed by westward currents during southeast monsoon and eastward currents during the northwest monsoon. The calculated nitrogen budget shows that the riverine input and benthic regeneration are significant sources in the whole bay. However, since river discharges are low, the effect of the riverine input only occurs near the coastline, as shown by the simulated chlorophyll-*a* distribution. Our results agree well with previous research that reported hyper-eutrophic conditions near the coastline. Comparisons between model results and field observations are mostly reasonable.

Seo, Hyunju, Suam Kim, Sukyung Kang, Kibeik Seong, Hideaki Kudo, and Masahide Kaeriyama (Poster)
VARIABILITY IN GROWTH AND SURVIVAL OF CHUM SALMON IN RELATION TO ENVIRONMENTAL CHANGES IN THE WESTERN PACIFIC OCEAN
Growth and survival of Korean chum salmon population was investigated in relation to environmental changes. The Korean coastal area is the southern limit of chum salmon distribution in the northwestern Pacific where seawater temperatures have consistently increased during the last century. Data sets used in this study were the return rate, growth of chum salmon, and SST in different habitats in the Korean coastal area (fry stage), the Okhotsk Sea (young stage during the first summer), and the Bering Sea (immature) during 1980s-1990s. Growth condition was estimated assuming proportionality between annuli increments in scale and fish length,. SST in the forementioned areas gradually increased, and, especially in the Korean waters, often went higher than 14° C, the upper thermal limit for young chum salmon. Spawners' return rate was negatively correlated with SST in the Korean waters. Growth rates varied with respect to time period and habitat areas. The estimation of annual growth rate in Korean waters in the 1980s was lower than that in the 1990s, and growth patterns in the Okhotsk Sea and the Bering Sea were opposite. Therefore, although high mortality due to high coastal water temperatures occurred, an abrupt increase in zooplankton biomass during the 1990s and/or enhanced tolerance of bigger fish may have contributed to higher growth rates. Young salmon that fail to reach a certain size by the end of their 1st marine summer do not survive the following winter. Critical size and period hypothesis seems to work on Korean chum salmon populations in relation to increased SST.

Suntsov, Andrey V. and Richard D. Brodeur (Poster)
TROPHIC ECOLOGY OF DOMINANT MICRONEKTONIC FISH SPECIES IN THE NORTHERN CALIFORNIA CURRENT
In addition to a number of commercially-important species, the productive California Current off Oregon hosts a diverse assemblage of micronektonic fishes—small actively moving fish within the 2-10 cm size range. In order to better understand the role of the principal micronektonic components in the dynamics of the entire pelagic community, we investigated feeding habits of three dominant myctophid species (*Diaphus theta*, *Tarletonbeania crenularis* and *Stenobrachius leucopsarus*) and co-occurring Pacific hake (*Merluccius productus*) juveniles, an important commercial species with recent northward expansions into the area. In total, diets of 483 specimens were analyzed, all collected in 2006 with midwater trawls during pelagic surveys. A total of 32 identified prey taxa were recorded. The three myctophids had a significantly more diverse diet (12-22 prey types) than hake juveniles (5). Overall, the most important prey was the euphausiid, *Euphausia pacifica*, present in 43% of all fish specimens examined and also was dominant by biomass, followed by copepods (41%), hyperiid amphipods (28%) and gelatinous zooplankters such as salps (11%). Among different

crustacean groups, the most diverse were calanoid copepods, represented by 13 species, and hyperiid amphipods by 4 species. Patterns of feeding selectivity emerging in the course of this study include *D. theta* consuming larval bivalves, the piscivorous habits of large *T. crenularia*, all lanternfishes but not hake predating on pteropods and ostracods, and only *T. crenularis* and *D. theta* feeding on salps. Three myctophid species also displayed various degrees of trophic specialization and overlap in terms of prey selectivity, dominance and biomass.

Wu, Di and Meng Zhou (Poster)
ZOOPLANKTON OFFSHORE TRANSPORT AND POPULATION DYNAMICS IN CALIFORNIA CURRENT OFF OREGON IN JUNE 2002
A survey of the zooplankton distribution was conducted in the California Current off Oregon in late spring (June 1-17) 2002 as a part of the US Global Ocean Ecosystem Dynamics Program (GLOBEC) Northeast Pacific Study (NEP) to understand the effects of mesoscale physical fields on zooplankton distribution during the upwelling season. The survey was conducted using a vertically undulating vehicle (SeaSoar) mounted with CTD, fluorometer, and Optical Plankton Counter (OPC) for temperature, salinity, chlorophyll, and zooplankton size and abundance measurements. The shipboard 153 KHz narrowband ADCP provided the circulation field. The survey quantitatively examined the relationship between zooplankton biomass and mesoscale physical features of fronts, jets and eddies in the California Current. Zooplankton biomass was higher in coastal upwelling areas and lower in the offshore areas. High cross-shelf transport of zooplankton biomass associated with mesoscale eddy and jet features occurred mainly at irregular topographic features. Physical entrapment and retention of zooplankton was on the same order as local growth processes. The retention time scale of the biomass gradient transport was calculated at Heceta Bank, a submarine bank. The biomass spectrum anomaly with respect to the mean in the area of high physical retention showed that the biomass propagated from small to large sizes over time.

SESSION 3: *The last frontier: The deep sea*

Juniper, S. Kim (Keynote Speaker)
THE NEPTUNE CANADA SEAFLOOR OBSERVATORY PROJECT
In 2007-2008, NEPTUNE Canada will install the first stage of a regional cabled observatory (RCO) in the northeast Pacific Ocean. Stage 2 of the RCO is being developed by the US-based ORION Project Office, through the National Science Foundation's Ocean Observatory Initiative (OOI) for installation in 2012. Funding for Stage 1 ($80M) will permit the deployment of a deep-sea observational network linked by a 800km fiber-optic cable that will loop out from a shore station on Vancouver Island to the Juan de Fuca volcanic spreading ridge. Five seafloor nodes are planned to support studies of: 1) benthic ecology and oceanography of the inner continental shelf (Folger Passage); 2) submarine canyon and outer shelf processes (Barkley Canyon); 3) dynamics of subsurface gas hydrates (ODP site 889); 4) tsunami propagation and crustal hydrology (ODP site 1027); 5) tectonic, hydrothermal and biological activity on a mid-ocean ridge (Endeavour); and 6) seismic and tsunami activity at the scale of the Juan de Fuca plate (all nodes). Addition of a sixth node at a sedimented hydrothermal site (Middle Valley) is pending further funding. Each node will provide power and Ethernet communications to instruments that comprise multi-disciplinary community science experiments. There have been technological challenges that we have faced in developing this project and the initial community science experiments will be enabled by the NEPTUNE infrastructure. NEPTUNE Canada's open data policy, which is designed to encourage scientists everywhere to participate in project, requires only an internet connection to access real-time and archived data.

Försterra, Günter and V. Häussermann (Oral)
WHERE THE DEEP SEA COMES INTO REACH—DEEP-WATER EMERGENCE IN THE CHILEAN FJORD REGION
The phenomenon that organisms typical for deep-water habitats can be found in shallow water is called deep-water emergence. In the shallow, eurybathic species often mix with or even replace shallow-water species or form entire deep-water-like assemblages. Although deep-water emergence is known from several areas, the phenomenon seems to be

typical for fjord regions. The best known examples are the glass sponges from British Columbia, the *Lophelia* coral reefs from Norway and the black corals from New Zealand. In Chilean Patagonia, despite comparably low research activity, within the last three years, several species, genera and assemblages formerly only known from light-less depth have been discovered to exist in the euphotic zone where they can be studied by means of SCUBA diving. Examples span from reef-like structures of hydrocorals over *Desmophyllum* coral banks to *Thioploca* bacteria mats in less than 25m depth. The current data sets do not yet allow for detailed quantitative analyses, but some general conclusions can be drawn: 1. within the Chilean fjord region, deep-water emergence seems to become stronger along a north-south gradient; 2. within the Chilean fjord region, deep-water emergence occurs across zoogeographic limits; 3. eurybathic species can be found in many taxa, but dominance varies between fjord regions; and 4. none of the current hypotheses alone is suitable to explain deep-water emergence in all fjord regions. Comparative studies between fjord regions may help to reveal common patterns and the causes of deep-water emergence.

Fujino, Tadanori, Kazushi Miyashita, Hiroki Yasuma, Tsuyoshi Shimura, Shunichi Shimoyama, and Shinya Masuda (Oral)

SEASONAL CHANGE IN DISTRIBUTION CHARACTERISTICS OF MESOPELAGIC FISH IN THE SEA OF JAPAN

Mesopelagic fish play an important role in the marine food-web due to their huge abundance and diurnal vertical migration. However, little is known about their regional and seasonal distribution. We examined the distribution of a unique mesopelagic fish *Maurolicus japonicus* in the southwest Sea of Japan around the Oki Islands using a quantitative echosounder (38 kHz). *M. japonicus* was 1.2 - 4.6 times more abundant at the eastern side of Oki Islands than at the western side. In both regions, *M. japonicus* was concentrated near the continental shelf slope in spring and widely dispersed in summer. The abundance near the continental shelf slope was 1.1 - 20.3 times higher in spring than in summer. *M. japonicus* generally resides in a wide temperature range (1 - 19° C), so the change in its distribution does not seem to be temperature dependent. The seasonal change in its distribution was probably due to the seasonal change in the distribution of copepods, its main prey. The main prey in spring is *Calanus sinicus* (a temperate species), which occurs near the continental slope. In summer, the main prey are *Oncaea venusta* and *O. meditteranea* (two temperate-subtropical species), which occur preferentially in nearshore and offshore waters. Changes in regional abundance might be due to the presence of warm core eddies to the east of the Oki Islands, which may provide an environment rich in prey.

Ruhl, Henry A. and Kenneth L. Smith Jr. (Oral)

SURFACE CLIMATE AND MEGAFAUNA COMMUNITY CHANGE IN THE ABYSSAL NE PACIFIC

The effects of climatic variation on deep-sea communities remain poorly described. However, timeseries data collected since 1989 in the abyssal NE Pacific has indicated that the mobile epibenthic megafaunal community has varied in abundance over interannual timescales. These changes in abundance and community structure have been linked to changes in the sinking particulate organic carbon food supply and ultimately to surface climate conditions. Increased (decreased) food supply during the La Niña (El Niño) phases of the El Niño Southern Oscillation correlate to changes in species composition and abundance equitability within the studied community. These results give support to long-hypothesized connections between interannual scale climatic fluctuations and abyssal megafauna populations thousands of meters below the ocean surface.

Samaai, Toufiek and Kerry Sink (Oral)

THE USE OF SPONGE BATHYMETRIC DISTRIBUTION PATTERNS IN DEFINING DEPTH ZONES IN THE GSWLP

The deep reefs environment is one of the least known marine habitats despite the recognition that these environments support diverse and abundant biological assemblages. The African Coelacanth Ecosystems Program has conducted three submersible-based expeditions in the submarine canyons of the greater St Lucia Wetland Park (GSWLP) in South Africa. Video footage, photographs and observer reports were analysed to examine sponge diversity patterns in different habitats of the deep reefs and canyons. Patterns in sponge community structure between the different depth zones were investigated and revealed the following: Sponge fauna decrease between 110 and 300 m; the deeper areas are dominated

by Lithistid, Astrophorid and Hexactinellid sponges, whereas the shallow areas between 10-100 m have an assortment of species belonging to a wide range of orders. Certain sponge communities were typical of specific depth zones and were used as a proxy in defining depth zones along the GSWLP. Four zones were recognised within the canyon, based on the sponge community patterns, and these were the margins, upper slope, lower slope and thalweg. The canyon sponge community is distinct from that of the adjacent inshore reefs. The margin habitat supports the most diverse sponge fauna. These results highlight the importance of offshore marine protected areas in conserving representative deeper water habitats.

SESSION 4: *The role of behavior in marine biological processes*

Baumgartner, Mark (Keynote Speaker)

COMPARATIVE STUDIES OF BALEEN WHALE FORAGING ECOLOGY

Baleen whales have evolved to feed relatively low on the marine food chain (copepods, euphausiids, small bait fish), and their high metabolism and large body size imply that these whales need to consume enormous quantities of prey. Prior to exploitation, baleen whales were likely important components of the marine ecosystem throughout the temperate, sub-polar, and polar seas. The need to efficiently capture small organisms spurred the evolution of baleen, which acts as a sieve to separate prey from seawater. Yet not all whales use their baleen in the same way: right and bowhead whales continuously strain copepods by simply opening their mouths and swimming forward (much like a plankton net), blue and fin whales engulf entire aggregations of euphausiids in a single mouthful and then slowly strain these prey through their small baleen, and humpback whales engage in elaborate behaviors to corral bait fish into a tight aggregation before engulfing them. These predator behaviors are adapted to the kind of prey the whales are targeting, the behavior of the prey, and the particular relationship between each prey species and its environment. Documenting these behaviors has been challenging, since much of it occurs below the sea surface and out of view. Concomitant advances in tagging and tracking technology and instrumentation to measure prey distribution have enabled novel studies of baleen whale foraging ecology that can improve our understanding of how these whales find and exploit prey resources and what impact, if any, these large predators have on the marine ecosystem. I will discuss the application of these new tools to investigations of right and humpback whale foraging behavior and the relationship between those behaviors and that of their prey.

Brind'Amour, Anik, Daniel Boisclair, Stéphane Dray, and Pierre Legendre (Oral)

MULTI-SCALE ASSESSMENT OF THE FUNCTIONAL RELATIONSHIPS BETWEEN SPECIES TRAITS AND ENVIRONMENTAL CONDITIONS FOR LITTORAL FISH COMMUNITIES

Determination of the habitat characteristics required by fish to complete their life cycle is of primary importance to predict the effect of habitat perturbations or losses on fish communities and to identify the environmental conditions that should be protected for conservation purposes. We assessed the relationship between fish spatial distribution, fish morphological and behavioral traits, and habitat characteristics in the littoral zone of two Canadian Shield lakes across multiple spatial scales, using a recently enhanced statistical method, the fourth corner analysis. We observed associations among species traits, suggesting the presence of three functional groups of species defined by the positions of the mouth and the feeding location within the water column (superior-surface, terminal-mid-water, and inferior-benthic). Species traits within a same functional group were consistent across spatial scales and varied similarly with habitat conditions. For instance, habitat depth, macrophyte densities (emergent and submersed), rocky and woody substrates discriminated the three functional groups at the very broad spatial scale (corresponding to 40% of the total perimeter of a lake). Density of emergent macrophytes and presence of rocky substrate discriminated the same three functional groups at the broad spatial scale (corresponding to 10-20% of the total perimeter of a lake). Our study suggests that it may be possible, for littoral fish communities and potentially elsewhere, to detect the mechanisms underlying the relationship between species traits, community organization, and environmental complexity. From a management perspective, the development of fish-habitat relationships based on species traits may provide habitat models that are more transferable among species and among ecosystems than the typical one species-one model approach.

Campbell, Robert W. and Morten Holtegaard Nielsen (Oral)

MESO- AND SMALL-SCALE DISTRIBUTIONS OF PLANKTON AND MARINE SNOW IN THE SOUTHEASTERN NORTH SEA IN RELATION TO FRONTS

Distributions of phytoplankton, zooplankton and marine snow, and their relation to the physical environment (temperature, salinity, turbidity and *in situ* mixing) were observed with *in situ* (Video Plankton Recorder: VPR) and shipboard (ADCP) instruments in the Southeast North Sea during early and late summer, 2005. Individual particles are imaged by the VPR, which allows small-scale distributions to be observed; in some cases, multiple particles may even be imaged in a single frame. The pelagic ecosystem shifted from a diatom-dominated one in early summer (late May), to *Noctiluca scintillans*/marine snow aggregates in late summer (July). Transects across a persistent tidal front in the German Bight and the estuarine front at the mouth of the Elbe River showed a close correspondence between biological features and physical ones. Aggregation by the very abundant *N. scintillans* and the presence of marine snow was also related to shear rates in the upper water column.

Didrikas, Tomas and Sture Hansson (Oral)

EFFECTS OF LIGHT INTENSITY ON THE VERTICAL DISTRIBUTION AND ACTIVITY OF PELAGIC FISH—STUDIES WITH A SEABED-MOUNTED ECHO SOUNDER

Animal activity is often strongly influenced by the diel light cycle, which also influences other aspects of behavior. We used a seabed-mounted, upwards-pinging echo sounder to study fish activity and vertical distribution in relation to light and water temperature. Four phases of the fish distribution were distinguished over the diel cycle. By using acoustic tracking, we could estimate individual fish size and swimming speed. The speed varied among all diel phases and the greatest difference was observed between day and night, with twice as high swimming speed during the day. Regression models were developed to investigate effects of fish size and environmental factors (water temperature, light intensity at the sea surface and light intensity at the depth of a fish – i.e. *in situ* light intensity) on swimming speed. For all phases combined, the model explained 48% of the variation in swimming speed, with fish size, sea surface light intensity and temperature being the significant variables. In analyses of the different phases separately, fish size was always the most important variable. At night and in the morning, the sea surface light was a better predictor of activity than the *in situ* light intensity. Contrary to this, by day and in the evening, the *in situ* light intensity explained more of the variation in swimming speed than did the surface light intensity. These results have clear implications for fish bioenergetics models. Such models should account for seasonal, light-driven cycles in the activity-induced respiration estimates, in particular when modeling populations at high latitudes.

Edwards, Karen P., Jonathon A. Hare, and Francisco E. Werner (Oral)

MARINE POPULATION CONNECTIVITY AND DISPERSAL: THE ROLE OF SPAWNING BEHAVIORS, OR WHY DO PARENTS KNOW BEST?

In the marine environment, pelagic dispersal acts as an important determinant of the distribution and abundance of populations, as well as provides connections between populations. Thus, estimates of larval dispersion from spawning grounds is important for determining recruitment success in fisheries and for elucidating spatial patterns in recruitment that may be important to the dynamics of the population. In a case study providing a realistic look at the dispersal of *Centropristis striata* (black sea bass) larvae on the Southeast US continental shelf, we compare the relative importance of the timing and location of spawning to that of larval vertical migration through a coupled larval behavior - 3D circulation model. Using the results of field data examining larval vertical distributions, we consider the dispersal potential of virtual 'larvae' with ontogenetic changes in vertical swimming behavior and of particles fixed near the surface and near the bottom. Larvae were released at potential spawning sites at four times throughout the spawning season (February through May) for several years (2002-2004) and tracked for the assumed larval duration (from 27 to 37 d including the egg stage). Our results indicate that adult behavior, in the form of spawning time and location, may be more important than larval behavior in determining larval dispersal and successful settlement on the inner- and mid- shelves in this region.

Garrido, Susana, Ana Marçalo, Juan Zwolinski, and Carl D. van der Lingen (Oral)

LABORATORY INVESTIGATIONS ON THE EFFECT OF PREY SIZE AND CONCENTRATION ON THE FEEDING BEHAVIOUR OF *SARDINA PILCHARDUS*

Laboratory experiments were conducted to study the effects of different prey types and concentrations on the feeding behaviour of Iberian sardine (*Sardina pilchardus*). Experiments consisted of providing known concentrations of different prey types (both single prey type and a mixture of prey types were used) to a shoal of sardines acclimated to laboratory conditions and observing their feeding behaviour. Data on feeding mode choice, feeding selectivity, and filtration efficiency were collected, and clearance rates for different prey types and sizes were estimated. Sardines use two feeding modes and switch between the two depending on prey size; filter-feeding was used to capture prey ≤724 µm and particulate feeding to capture prey ≥780 µm, therefore the feeding mode switch occurs within these limits. Sardine are able to feed on nanoplankton and can retain prey items as small as 4 µm, and filtration efficiency increases from 20% at this prey size to close to maximum for prey >200 µm. Sardines show selective feeding; they preferentially ingest fish eggs compared to other prey types (even larger fish larvae) when fed cultured, mixed prey assemblages, and select copepods and decapods over other zooplankton prey when fed wild-collected, mixed prey assemblages. Clearance rates were generally low compared to other clupeids, arising from the smaller mouth gape and lower swimming speed of this species. Results obtained from this study suggest that filter-feeding is the dominant feeding mode of sardines, indicate that sardines are able to efficiently utilize microplankton prey, and corroborate previous dietary studies that show small zooplankton and chain-forming diatoms dominated stomach contents.

Kolesar, Sarah E., Kenneth A. Rose, and Denise L. Breitburg (Oral)

THE EFFECT OF HYPOXIA ON INTRAGUILD PREDATION IN AN ESTUARINE FOOD WEB: AN INDIVIDUAL-BASED MODEL OF CTENOPHORES, FISH LARVAE, AND COPEPODS

Differences in predator and prey tolerances to low dissolved oxygen (DO) are important to food webs in seasonally hypoxic estuaries. Hypoxia alters field distributions, encounter rates, and trophic interactions between tolerant ctenophores, *Mnemiopsis leidyi*, and less tolerant ichthyoplankton and zooplankton. To examine hypoxia's effect on estuarine food webs, we conducted laboratory experiments, field sampling, and collaborated on individual-based model (IBM) development, focusing on ctenophore-larval fish dynamics. Results from laboratory and field studies parameterized a spatially explicit IBM of a ctenophore-ichthyoplankton-copepod intraguild predation food web in the summertime Chesapeake Bay system. Model results addressed three questions concerning ichthyoplankton survival and growth: 1) what is the effect of hypoxia?; 2) is competition or predation the more important effect?; and 3) what is the effect of hypoxia on the relative importance of competition and predation? Results from replicate model simulations showed that low DO decreased larval fish survival and increased growth rates. Ctenophore predation had a bigger effect on modeled ichthyoplankton survival than did competition for zooplankton, but competition more strongly affected ichthyoplankton growth rates. Hypoxia did not alter the relative importance of ctenophore predation and competition. These results suggest that DO effects on behaviorally mediated processes such as vertical distribution and species overlap are more important to predation than direct DO effects. Increased occurrence of hypoxia in the Chesapeake Bay system would favor tolerant ctenophores over larval fish, increasing predation; decreased vertical overlap between ctenophores and larval fish at low DO might benefit larval fish. Complexity may confound trophic responses to hypoxia.

Lawson, Gareth L., Andre M. Boustany, Andreas Walli, Steven L.H. Teo, and Barbara A. Block (Oral)

DISTRIBUTION AND MOVEMENTS OF ATLANTIC BLUEFIN TUNA IN THE NORTHWESTERN ATLANTIC STUDIED USING ELECTRONIC TAGS

Populations of Atlantic bluefin tuna (*Thunnus thynnus*) in the western Atlantic have been in acute decline for twenty-five years. Effective management of the bluefin tuna fishery will require a detailed understanding of the distribution and movements of this commercially-valuable top predator species. Recent advances in electronic tagging technologies are allowing such behaviors to be quantified at unprecedented resolution in both space and time. Here we use a combination of pop-up satellite (PAT) and implantable archival tags to study the movements and behaviors of bluefin tuna during their summer and fall feeding period in the Gulf of Maine and southern Canadian waters. These tags collect data on

depth, ambient and internal temperatures, and light intensity. Movement trajectories can then be estimated using light- and sea surface temperature-based algorithms for longitude and latitude, respectively. Between 1996 and 2006, 301 tuna were tagged with PAT tags in the western Atlantic, mostly off North Carolina, and 560 with implantable archival tags. Of these, 260 PAT tags successfully transmitted data to satellite, while 105 implantable tags were recovered via the tuna fishery, providing over 15,000 days of movement data. 131 tagged fish visited the Gulf of Maine or Canadian shelf waters during the summer or fall. The movements and distribution of these tuna will be examined in relation to fish age/size, season, and satellite-collected environmental data. Particular attention will be given to relating inter-annual variability in distribution to oceanographic conditions, the physiological thermal limits of tuna of different sizes, and prey availability.

Pierson, James J., Bruce W. Frost, and Andrew W. Leising (Oral)
FORAY FORAGING BEHAVIOR IN MARINE COPEPODS
Vertical migration patterns of marine zooplankton are well documented, but do not provide information on the nature of the behaviors that lead to the observed patterns. For example, although many copepods reside at depth during the day and ascend to the surface at night, at any given time there may be some individuals found throughout the water column, and individuals found below the surface mixed layer often have chlorophyll in their guts representative of the surface mixed layer phytoplankton community. We used "zooplankton traps", plankton nets, and high frequency acoustics to explore how individual behaviors and physiological condition of zooplankton affected observed vertical distributions and migration patterns. Individuals collected throughout the night migrating upward or downward into traps, as well as those collected with nets, were assessed for gut fullness, gut fluorescence, prosome length, reproductive state, and carbon content. Differences in these measurements were found between upward and downward migrating individuals as well as between individuals collected from different depth strata. Comparing these data with model results gives us insight into how individual behaviors and physiology affected observed distribution patterns, and also suggests that the time scales of individual copepod migration behaviors are much shorter than one day.

Stepputtis, Daniel, Uwe Böttcher, Thomas Neumann, and Jörn Schmidt (Oral)
DISTRIBUTION OF BALTIC SPRAT (*SPRATTUS SPRATTUS* L.)—OBSERVATIONS, MODELS AND CONSEQUENCES
Sprat (*Sprattus sprattus* L.) is the most abundant pelagic fish species in the Baltic Sea and constitutes, with cod (*Gadus morhua* L.) and herring (*Clupea harengus* L.), 95% of the Baltic commercial fish landings. Since the Baltic Sea is highly stratified along horizontal and vertical scales, predator-prey interactions strongly depend on their environmental preferences. The distribution and the behaviour of adult Baltic sprat were investigated with hydroacoustics. The investigation covers short-term to seasonal events on the temporal scale, as well as metres to basin-wide distributions at the spatial scale. The study was conducted within the framework of the interdisciplinary GLOBEC-Germany project. The key hydrographic factors, influencing the distribution on all scales and their relevant threshold were identified. Key factors are temperature, vertical temperature gradient, oxygen and light. These findings were used to develop two distribution models for Baltic sprat that predict the vertical distribution of sprat. These models can be used to investigate the ecology (e.g. predator-prey-overlap) of sprat.

Vikebø, Frode, Trond Kristiansen, Gert Dingsor, Svein Sundby, Christian Jorgensen, and Øyvind Fiksen (Oral)
DRIFT, GROWTH AND DISTRIBUTION IN NORTHEAST ARCTIC COD DURING THE1980s—PREDICTIONS FROM A BIOLOGICAL INDIVIDUAL-BASED MODEL EMBEDDED IN A GENERAL CIRCULATION MODEL
Laboratory experiments and process-based modelling enable a mechanistic understanding of key factors of larval fish. Recent studies under the project ECOBE have compiled such knowledge in a coupled bio-physical model system for growth, drift and spatial distribution of pelagic Northeast Arctic cod *Gadus morhua*. The model system describes individual, virtual larvae advecting from their respective spawning grounds by temporal and spatial varying flow fields from the ocean circulation model ROMS. Larvae are allowed to influence their growth, drift and survival by migrating vertically in the water column according to specific behavioural rules. If there is a vertical velocity shear this vertical habitat selection will not only affect instantaneous growth and survival, but also future growth and survival as determined by the resulting individual drift routes. Defining success criteria allows us to sort out successful behavioural strategies and

spawning grounds. Here we explore the robustness of such behavioural strategies across a range of spawning grounds and different years. Given initial conditions of eggs according to observations, a circulation model that captures the main features of flow in the habitat of larval cod, and simple caricatures of larval vertical behaviours, are we able to capture main features of post-larval distributions? To answer this, we compare model predictions to data on horizontal distributions of settled juveniles.

Walther, Benjamin D. and Simon R. Thorrold (Oral)
MARINE MIGRATORY PATTERNS OF IMMATURE ANADROMOUS FISH: AN OTOLITH CHEMISTRY APPROACH
Migratory patterns and mixed-stock compositions of immature fish in the marine environment are difficult to determine using traditional mark-recapture techniques. We report on the successful use of natural geochemical tags in the otoliths (ear bones) of American shad (*Alosa sapidissima*) to accurately estimate the rivers of origin for fish captured in coastal habitats. We assembled a large database of otolith chemical signatures using juvenile fish and water samples collected from all major spawning rivers of American shad throughout their native range from Florida to Quebec. Signatures were based on a suite of elemental (Sr:Ca and Ba:Ca) and isotopic ($\delta^{18}O$ and ^{87}Sr: ^{86}Sr) ratios that together yielded indelible signatures recorded in the otoliths of each fish. Cross-validated classification accuracies based on these signatures were very high at 93% on average. We used these unique signatures to identify immature marine migrants captured in the upper Gulf of Maine during their spring and summer residency in the region. Mixed-stock compositions were dominated by only two to three rivers for all collections and there was a distinct lack of southern populations in the mixtures. Estimates of mixed-stock compositions for these immature fish differ significantly from those reported for older age classes. These patterns suggest American shad may exhibit ontogenetic niche shifts in their migratory strategies after their transition to marine habitats. Otolith chemistry approaches allow powerful assessments of American shad migratory patterns that can add new information about the strategies employed by immature fish.

Zumholz, Karsten, Eva Jakob, and Reinhold Hanel (Oral)
FLEXIBLE MIGRATION BEHAVIOUR OF EUROPEAN EEL (*ANGUILLA ANGUILLA*) DETERMINED BY OTOLITH MICROCHEMISTRY
For the reconstruction of migration pathways of eels, their otolith chemistry was analysed by three spatially resolved methods, namely EPMA (electron probe micro-analysis), LA-ICP-MS (laser ablation-inductively coupled plasma mass spectrometry), and SYXRF (Synchrotron x-ray Fluorescence) microprobe analysis. Eels from different habitats (marine, brackish and freshwater) in northern Germany were investigated. Results indicate that their migration behaviour is much more complex than formerly assumed. Multiple habitat shifts were found regularly. This behaviour probably influences the general fitness and potential spawner quality of individual eels. Therefore these investigations provide substantial new information for recovery plans for this highly endangered species. All three micro-chemical techniques used in the current study provide potential for trace element analyses of biomineralized tissues. Both the differentiation between residence in freshwater and seawater and between different river systems via isotopic fingerprints seems possible.

Annis, Eric R. (Poster)
IN SITU SWIMMING BEHAVIOR OF LOBSTER POSTLARVAE: IMPLICATIONS FOR TRANSPORT AND SETTLEMENT
Planktonic lobster postlarvae (*Homarus americanus*) are strong swimmers and their behavior in response to environmental cues may contribute significantly to transport and settlement to the benthos. I used direct observation of individuals in the field to quantify vertical and horizontal swimming behavior with respect to environmental and developmental variables. Postlarvae spent an average of 65% of the time near the surface (0-0.5 m depth), which is less than expected based on previous plankton net surveys. The proportion of time spent at the surface decreased over the season (~0.80 to ~0.57) and was correlated with increasing depth of the 12°C isotherm. Postlarvae remained in waters above 12°C suggesting that it may serve as a minimum temperature threshold. This threshold may play an important role in shaping settlement patterns in the Gulf of Maine where bottom temperature in many areas rarely exceeds 12°C. Postlarvae swam horizontally at an average speed of 19 cm s-1 but no significant directional component with respect to environmental cues was detected. As such, the potential contribution of swimming to larval transport is great and postlarvae should

not be considered passive particles. However, we need to improve our estimates of the duration and consistency of the observed swimming behavior before the horizontal swimming behavior can be incorporated in individual-based models of larval transport.

Hosia, Aino and Ulf Båmstedt (Poster)

VERTICAL DISTRIBUTION OF PHYSONECT SIPHONOPHORES IN WESTERN NORWEGIAN FJORDS

In recent decades, advances in optical surveying technologies have allowed the study of the detailed vertical distribution of gelatinous macrozooplankton in the water column. It has been revealed that many species are distributed in restricted layers of varying thickness, often corresponding to the physical structure of the water column. We present results on the vertical distribution of siphonophores in several western Norwegian fjords. A remotely operated vehicle (ROV) was used to film vertical transects over the entire water column. The recordings were analyzed for colonies of agalmid physonects. Although species identification from the recordings was frequently impossible, both the ROV footage and separate net sampling indicated that the predominant physonect in Norwegian fjords is *Nanomia cara*. The observed mean depth of the physonect distribution varied depending on the fjord. A large portion of the population in each fjord was located below sill depth, significantly reducing the risk of advection out of the fjord system. Preliminary results suggest that the distribution of physonect siphonophores is negatively correlated with the occurrence of the mid-water medusa *Periphylla periphylla*. Physonect siphonophores were virtually absent from fjords in which abundant and persistent populations of *P. periphylla* occur throughout the water column. In Sognefjord, where physonect siphonophores and *P. periphylla* co-occur, the vertical distributions of the two show little overlap, with physonects generally found above the depths known to be inhabited by *P. periphylla*. The physonects in Sognefjord were also distributed shallower than those in other deep fjords lacking abundant *P. periphylla* populations.

Huebert, Klaus B. (Poster)

CAN PELAGIC CORAL REEF FISH LARVAE REGULATE THEIR SWIMMING DEPTHS VIA HYDROSTATIC PRESSURE CUES?

Some pelagic fish larvae maintain distinct vertical distributions and undertake synchronized diel and ontogenic vertical migrations. This requires individual larvae to actively regulate their swimming depths with respect to external environmental cues. The proximate behavioral mechanisms underlying depth regulation are poorly understood. Here, the role of hydrostatic pressure cues in depth regulation was examined by conducting behavioral experiments with pelagic coral reef fish larvae from the families Acanthuridae (surgeon fishes), Balistidae (trigger fishes), Monacanthidae (file fishes) and Pomacanthidae (angel fishes). Larvae were collected from 0-25m, 25m-50m, 50m-75m and 75m-100m depth ranges with stratified plankton net tows during several research cruises in the Florida Straits. At sea, larvae were individually placed within vertical cylinders inside a hyperbaric chamber and observed with an infrared camera system. Pressure was systematically varied between levels corresponding to water column depths of 0 to 66 m of seawater. 9 of 12 surgeon fishes, 8 of 9 trigger fishes, 6 of 21 file fishes and 11 of 12 angel fishes showed statistically significant responses: downward swimming under low-pressure conditions and upward swimming under high-pressure conditions. *In situ*, these behaviors would result in larvae regulating their swimming depths to intermediate or preferred pressure levels. Experimental pressure preferences were calculated and compared to actual swimming depths at the time of capture. Among larvae of the families Balistidae and Pomacanthidae there was a statistically significant correspondence between capture depths and pressure preferences.

Jakob, Eva, Karsten Zumholz, and Reinhold Hanel (Poster)

HABITAT DEPENDENT PARASITE INFESTATIONS AND VIRUS INFECTIONS OF THE EUROPEAN EEL *ANGUILLA ANGUILLA* (L.) IN NORTHERN GERMANY

Declining stocks of European eel (*Anguilla anguilla*) since the 1980s have lead to a high scientific interest in this migratory fish species. Because of their peculiar life cycle many factors may directly affect their health status and therefore a successful spawning migration to the Sargasso Sea. The east-Asian swim bladder nematode *Anguillicola crassus*, imported to Europe in the early 80s, and the EVEX (Eel Virus European X) has been shown to impair spawner quality by preventing

successful eel spawning migrations to the Sargasso Sea. Within this study a comparative examination is carried out on the metazoan parasite communities and viral infections of eels from freshwater, brackish and marine localities. Life history information derived from otolith microchemistry enables us to determine the duration of residence of individual eels in fresh, brackish and marine water bodies. First results are presented for the comparison of the parasite communities and virus infections of eels from seven sampling sites in northern Germany along a steep salinity gradient. The comparative examination of the parasite fauna in different habitats shows distinct differences in parasite species composition and diversity and a distinct negative correlation between species diversity and salinity gradient. Further, the infestation with *Anguillicola crassus* decreases with increasing ambient salinity. These results suggest that eels that do not enter freshwater and stay in brackish- and saltwater habitats avoid an *Anguillicola crassus* infection and may have a better chance of accomplishing their spawning migration.

Kristiansen, Trond, Frode Vikebø, Svein Sundby, Geir Huse, and Øyvind Fiksen (Poster)
GROWTH AND FEEDING OF LARVAL COD (*GADUS MORHUA*) IN LARGE-SCALE LATITUDINAL ENVIRONMENTAL GRADIENTS
The spawning strategy of cod is tuned to give larvae a good start in life. Therefore, larval drift, growth and survival are key processes for understanding spawning strategies. Spawning of Northeast Arctic (NA) cod occurs from late February to early May over 1500 km along the Norwegian coast and hatching occurs from late March to late May. During the latter period the number of daylight hours increases from 12 to 21. Larval feeding opportunities are constrained by availability of prey abundance, while temperature determines the maximum growth potential. Feeding of larval cod that hatches early in the season is limited by the low number of daily foraging hours, and this makes them particularly susceptible to food limitation. Here, we study constraints on larval cod growth by combining a bio-physically coupled model (NPZ-model) providing input on nauplii production and development (*Calanus finmarchicus*), a 3D physical model (ROMS) providing flow- and temperature-fields, and an individual-based model (IBM) of larval cod feeding ecology and physiology. Our aim is to better understand spatio-temporal constraints of larval ecology on the spawning strategy of adults. Results show that larval cod have low chance of survival if hatched early in the season (prior to mid-April) when the foraging hours are few. Larval cod hatched in early May experience good growth conditions due to the increased day-length, and the given temperature range. Peak spawning appears well timed to the seasonal variation in light, and we propose that light-availability modifies the importance of prey availability to larval success.

Llopiz, Joel K. and Robert K. Cowen (Poster)
TROPHODYNAMICS OF LARVAL BILLFISHES AND TUNAS: ARE THE CONSTRAINTS OF THE LOW-LATITUDE OPEN OCEAN ACTUALLY CONSTRAINING?
Since the larvae of oceanic pelagic species have no need to reach suitable settlement habitat, survival should depend more heavily upon the nutrition-mediated processes of starvation, growth, and predation. Yet, there is a notable lack of focus on larval feeding for species such as billfishes and tunas, and low-latitude oceanic larvae in general. Monthly sampling within the Straits of Florida over two years allowed for a temporal, spatial and ontogenetic investigation into the trophodynamics of larval sailfish, blue marlin and five genera of scombrids. Larval diets were narrow and often taxon-specific, even among co-occurring larvae, illustrating evolved selective feeding and potentially niche separation. The diets of several scombrid genera almost exclusively comprised appendicularians, but despite such diet overlap these genera may still exhibit niche separation due to differences in both horizontal and vertical distributions. All taxa had feeding incidence values near 100%, indicating levels of starvation-induced mortality are likely low. Piscivory was characteristic of all taxa and first exhibited around 5 mm SL. Piscivory in conjunction with high larval scombroid densities in this region suggest there is the potential for top-down forcing upon other larval fishes, although a bottom-up effect may also exist if optimal larval growth and survival requires piscivory. Such high feeding incidence values, the ability to be selective, and the precocious and prevalent behavior of piscivory all seem paradoxical when considering the planktonic environment of the low-latitude open ocean that is generally characterized by metabolism-accelerating warm temperatures and low productivity.

Moeller, Klas O., Robert W. Campbell, Morten Holtegaard Nielsen, and Michael A. St. John (Poster)
IN SITU DISTRIBUTION AND VERTICAL MIGRATION OF PLANKTON IN THE NORTH SEA (GERMAN BIGHT)
Plankton distribution and migration patterns are very complex and may vary due to many different factors in relation to the environment. We describe and quantify the vertical distribution of the major plankton taxa and behavioural patterns (e.g. vertical migration and predator-prey avoidance) in relation to the prevailing physical environment at scales appropriate to the organisms. The data was collected during two cruises in May and June/July 2005 using the Video Plankton Recorder over a 48h period at a permanent station near a frontal zone in the German Bight (southern North Sea). Images of plankton and particles were identified with a dual classification system consisting of a Support Vector Machine and a Neural Network followed by a manual correction step to obtain accurate abundance estimates for low abundant taxa. During the first cruise diatoms dominated the phytoplankton, while on the second cruise a bloom of the heterotrophic dinoflagellate *Noctiluca scintillans* occurred. *N. scintillans* has a broad prey spectrum and is known to feed on eggs of copepods, one of the key species in the North Sea. We expect to find seasonal differences in the species composition and abundance as well as differences between bloom- and non bloom-conditions. Adaptive behaviour to *N. scintillans* bloom conditions, like reverse vertical migration or avoidance of the upper layers, might be visible by small copepod species directly due to predation pressure and indirectly due to food competition. Additionally, adaptive behaviours like changes in the feeding behaviour between solitary, raptorial feeding and mucoid filtration by aggregated cells during sinking as well as vertical migration might also be shown by *N. scintillans*.

North, Elizabeth W., Z. Schlag, R.R. Hood, M. Li, L. Zhong, T. Gross, and V.S. Kennedy (Poster)
THE INFLUENCE OF LARVAL BEHAVIOR ON OYSTER LARVAE TRANSPORT AND SETTLEMENT: A NUMERICAL APPROACH
Because planktonic organisms have swimming speeds that are orders of magnitude lower than horizontal current velocities, it is unclear whether behavior of weak-swimming bivalve larvae could influence population-level processes like dispersal distance, benthic settlement success, and subpopulation connectivity. A numerical approach was applied to determine if these processes could be affected by species-specific differences in larval behavior of two oyster species (*Crassostrea virginica* and *C. ariakensis*) in Chesapeake Bay, a partially-mixed estuary. A coupled particle-tracking and hydrodynamic model was employed that was forced with observed winds and freshwater flow and included the best available estimate of present-day oyster habitat. Model scenarios were conducted with hydrodynamic predictions from 5 years (1995-1999) to simulate a range of physical conditions. Stage-dependent vertical swimming velocities were parameterized with preliminary results from laboratory experiments and the literature. Behavior was the only biological process represented in the model in order to isolate the effect of circulation, settlement habitat and species-specific behavior on the spatial trajectories of particles. Results indicated that differences in behavior had significant consequences for larval transport in the Chesapeake Bay by influencing dispersal distances, settlement success, and the degree of connectivity between 'subpopulations' in different tributaries. Most particles (>96%) did not return to the same bar on which they were released, and species-specific spatial patterns in 'producer' and 'sink' characteristics of oyster bars were apparent. Model results have implications for fisheries management and oyster restoration activities.

Parks, Susan E., Christopher W. Clark, and Peter L. Tyack (Poster)
EVIDENCE FOR A LONG-TERM CHANGE IN THE ACOUSTIC BEHAVIOR OF THE NORTH ATLANTIC RIGHT WHALE (*EUBALAENA GLACIALIS*) IN RESPONSE TO NOISE
The North Atlantic right whale is a highly endangered species of baleen whale. They live in an urbanized environment with their known habitat extending along the east coast of the US and Canada. These whales are regularly exposed to noise from vessels, both chronic levels of noise from distant shipping and shorter-term higher intensity transient exposures when vessels pass close to the whales. Right whales produce a variety of sounds for social communication and it is likely that the increased level of noise in the same frequency range of their vocalizations impacts their ability to communicate. This study describes using passive acoustic monitoring technology to document both short- and long-term behavioral changes in right whale sound production that are associated with increased noise levels. The fundamental frequency (Hz)

of the most stereotyped right whale call type, the 'upcall', increased from the late 1950s through 2000 by 2/3 of an octave. A comparison of the upcalls recorded from the North Atlantic right whale and the Southern right whale (*Eubalaena australis*) indicate a significant difference in fundamental frequency, which, given the previous findings, may be a result of differing ambient noise conditions between the two habitats. These data indicate the value of both long-term and passive-acoustic monitoring studies to document trends in noise and the behavior of marine organisms.

Ustups, Didzis and Maris Plikss (Poster)
THE INFLUENCE OF ENVIRONMENTAL CONDITIONS ON THE YEAR-CLASS STRENGTH OF THE EASTERN-GOTLAND FLOUNDER (*PLATICHTHYS FLESUS*) IN THE BALTIC SEA
Flounder *Platichthys flesus* is a temperate marine fish that is well adapted to the brackish waters of the semi-enclosed Baltic Sea. One population of the flounder is found in the Eastern-Gotland Basin. This stock spawn on the slops of Gotland deep and in the past has shown great variation in abundance. The flounder eggs are pelagic. For successful egg survival and development salinities above 10.6 PSU and dissolved oxygen above 1 ml l^{-1} are necessary. Water masses in the deep parts of the Baltic basins are situated below a permanent halocline that greatly inhibits the role of vertical mixing and renewal of oxygen levels in the deep layers. The main process that can reverse this situation is the occasional inflow of oxygen-rich and saline waters from the North Sea. In the absence of such inflows, stagnation processes develop and oxygen and salinity concentrations below the halocline progressively decrease. These observations suggest that environmental conditions at the spawning ground during stagnation periods can limit the flounder reproduction success.
The aim of the present investigation is: 1) to quantify the thickness of the layer of water that has suitable salinity and oxygen conditions for flounder reproduction, and 2) to examine whether variations in "reproduction volume thickness" can explain the fluctuations in flounder recruitment that have occurred over the past 20 years. We test this hypothesis by comparing reproduction success (recruits/viable egg production) under assumption of environmental heterogeneity at Eastern-Gotland flounder spawning sites.

Xu, Yi, Fei Chai, Lei Shi, Yi Chao, Kenneth Rose, Francisco Chavez, and Richard T. Barber (Poster)
SEASONAL CYCLE, INTERANNUAL AND DECADAL VARIABILITY OF PERUVIAN ANCHOVY POPULATION DYNAMICS: A MODEL STUDY
The coastal waters of Peru are among the richest and the most productive of ocean ecosystems and include the world's largest single-species fishery, the Peruvian anchovy (*Engraulis ringens*). Coastal upwelling brings cool, nutrient-rich deep water into the euphotic zone and thus enhances biological production at all levels of the food web. The Peruvian anchovy biomass and catch vary dramatically in responding to El Niño Southern Oscillation, and Pacific Decadal Oscillation. In this paper, we establish a bioenergetic model to investigate how natural climate variability affecting Peruvian anchovy growth, distribution, and abundance and incorporate more detailed physical, nutrients and plankton dynamics. The model studies the Peruvian anchovy life history, including the spawning, egg hatching, larva development, growth and reproduction through the entire life span. The model considers temperature and multiple plankton groups as essential growth factors, and estimates the anchovy growth length and weight for each life stages. The results tend to agree with field and laboratory research, as well as species comparison study. Sensitivity analyses of environmental variation and food availability present a believable evaluation of model robustness.

SESSION 5: *The effect of climate on basin-scale processes and ecosystems*

Di Lorenzo, Emanuele (Keynote Speaker)
LINKING NORTH PACIFIC OCEAN CLIMATE VARIABILITY TO ECOSYSTEM CHANGES: THE INTERPLAY BETWEEN A GYRE-SCALE MODE AND THE PACIFIC DECADAL OSCILLATION
Understanding past climate fluctuations in the North Pacific is critical to predicting the ocean's physical-biological response to 20th century climate change. We find that previously unexplained decadal variations of salinity and nutrient distributions in the California Current reflect an oscillation in the North Pacific gyre-scale circulation (NPGO), which is independent of the Pacific Decadal Oscillation (PDO). In the subsurface, NPGO controls the input of subarctic nutrient-

rich waters to the coastal upwelling and therefore may play a key role in ecosystem variability. Indeed, major North Pacific ecosystem shifts (eg. 1976, 1999) may be explained and predicted by the interplay of NPGO and PDO.

Chassot, Emmanuel, Sylvain Bonhommeau, Frédéric Mélin, Olivier Le Pape, and Didier Gascuel (Oral)
WORLD FISH CATCH DRIVEN BY PRIMARY PRODUCTION
We used primary productivity data derived from satellite images associated with global fisheries landings datasets to characterize the productivity of large marine ecosystems (LME) and to analyze the strength of the spatial trophic linkage between primary production (PP) and marine fish production worldwide. We showed a significant positive correlation between PP, estimated in each LME and long-term average catches of resident fish species. In addition, a significant positive relationship was found between annual PP and catches of small pelagic species during the period 1998-2003 in the Guinea Current, Humboldt Current and Iberian Coastal LMEs. Fisheries production in these upwelling ecosystems is mainly due to young of the year small pelagic fishes (e.g. *Engraulis* spp.) whose recruitment dynamics rely on annual marine productivity. Small pelagics in these 3 LMEs represent about 50% of small pelagic and more than 10% of total world catches and support higher trophic level fisheries by providing food for top-predators. These findings suggest that bottom-up forcing regulates the production of marine living resources worldwide, i.e. fisheries production levels in LMEs are largely determined by the PP of the underlying marine ecosystems. Hence, the advent of ocean color remote sensing allowed us to show the strong spatial dependency of global fisheries production on environment with a particular emphasis on specific highly productive LMEs. Our results have an important bearing for an ecosystem approach to fisheries in a context of global change, particularly to estimate the capacity of eco-regions with regards to sustainable exploitation.

Kaplunenko, Dmitry D., Olga O. Trusenkova, and Viacheslav B. Lobanov (Oral)
FEATURES OF SEASONAL AND INTRA-ANNUAL VARIABILITY OF JAPAN SEA SST FROM SATELLITE DATA
The Japan Sea, as one of the largest marginal seas in the world, has specific variability characteristics (circulation pattern, boundary currents, mesoscale eddy activities, etc.) most of which resemble those of larger oceans. The subject of this study was to analyse the variability of Sea Surface Temperature (SST) on different scales, ranging from the Northern area of the sea (with respect to the Liman current region) to the whole basin. Our study was based on two different temperature datasets covering the periods from1993-2006 and 2002-2006: of (1) the Daily Sea Surface Temperature data set provided by the Japan Meteorological Agency (JMA, DailySST) and the daily New Generation Sea Surface Temperature data set (NGSST) for the Northwestern Pacific provided by the group of professor Hiroshi Kawamura from the Tohoku University (Japan). Using these datasets we have analyzed anomalies of SSTs derived from the principal components decomposition by the Complex Empirical Orthogonal Functions (CEOF). As the result of the study seasonal and half-annual components have been obtained for temporal modes and spatial patterns. Regional similarities were revealed in both data sets.

Kimmel, David G., W. David Miller, Lawrence W. Harding, Edward D. Houde, and Michael R. Roman (Oral)
REGIONAL SCALE CLIMATE FORCING OF CHESAPEAKE BAY ECOSYSTEM DYNAMICS
Chesapeake Bay is characterized by seasonal and interannual variability in species abundance and spatial distribution. These changes are the result of hydroclimatic variability driven by variability in the type and frequency of regional weather systems during the winter season. Strong variability in freshwater flow during winter and early spring results in strong variability in the Bay's food web structure. To demonstrate this, we classified winter climate for the northeastern United States using gridded, sea level pressure data for the period 1950-2002. The analysis revealed that the regional winter climatology can be characterized by ten dominant synoptic scale weather patterns. Interannual variability in these weather patterns is correlated to spring freshwater input. Weather patterns influence the timing, location and magnitude of the spring phytoplankton bloom, which in turn, strongly influences the Bay's food web. Both the bloom characteristics and hydrologic conditions determine spring zooplankton community composition and abundance, summer zooplankton abundance and summer gelatinous zooplankton composition and biovolume and multi-species fisheries recruitment patterns. Characterizing and quantifying interannual climate variability provides a means to distinguish between climate forcing and the effects of land use and policy changes in influencing ecosystem conditions.

Liu, Guimei (Oral)

A THREE-DIMENSIONAL PHYSICAL-BIOGEOCHEMICAL MODELING STUDY ON PRODUCTIVITY AND CARBON CYCLE IN SOUTH CHINA SEA

The South China Sea (SCS) exhibits strong variations of climate and physical processes ranging from meso-scale to ENSO dynamics, which influence carbon cycle and biological productivity in the region. We have developed and applied a Pacific basin-wide physical-biogeochemical model to investigate physical variations, ecosystem responses, and biogeochemical consequences. The Pacific basin-wide circulation model, based on the Regional Ocean Model Systems (ROMS) with 50 km spatial resolution, was forced with daily air-sea fluxes derived from the NCEP reanalysis between 1990 and 2004. The biogeochemical processes were simulated with the Carbon, $Si(OH)_4$, Nitrogen Ecosystem (CoSINE) model consisting of multiple nutrients and phytoplankton groups and detailed carbon cycle dynamics. The ROMS-CoSINE model was capable of reproducing many observed features and their variability in the SCS. We analyzed the model results with focusing on the factors controlling air-sea CO2 flux in the SCS. The integrated air-sea CO_2 flux over the entire SCS showed a strong seasonal cycle, where the SCS releases CO_2 to the atmosphere during the summer, and takes CO_2 from the atmosphere during the winter. Model sensitivity studies indicate ocean temperature was the most important factor controlling pCO2 in the surface water, which in turn determined the air-sea CO_2 flux variability in SCS. The modeled primary production also varied seasonally with the highest value of 400 mg C/m^2/day during the winter, and the lowest value of 150 mg C/m^2/day during the summer. The factors controlling the primary, new, and export productivity in several key regions of the SCS was discussed.

Moore, Stephanie K., Nathan J. Mantua, Vera L. Trainer, and Barbara M. Hickey (Oral)

CLIMATE IMPACTS ON PUGET SOUND OCEANOGRAPHY AND HARMFUL ALGAL BLOOMS

Climate impacts on Puget Sound oceanographic properties are investigated on seasonal to interannual timescales using continuous profile data from the Washington State Department of Ecology's Marine Waters Monitoring Program from 1993 to 2002. Principle component analysis identified indices representing 42, 58 and 56% of the total variability at depth-station combinations for temperature, salinity and density, respectively, and 22% for water column stratification. Long term records of sea surface temperature and salinity from a single location (Race Rocks) extend the time series of the leading principal components to 1950 and allow an examination of climate impacts on decadal timescales. In general, regional climate forcings strongly influence oceanographic properties with significant relationships between air and water temperature, and between streamflow, salinity and density. Large scale patterns of climate variability, such as El Niño/Southern Oscillation and Pacific Decadal Oscillation, also significantly influence oceanographic properties but relationships are less pronounced and exist only during winter and fall. Patterns of ocean-climate variability are compared with indices describing paralytic shellfish toxin (PST) concentrations in shellfish determined by the Washington Department of Health Marine Biotoxin Program. PSTs are produced by the harmful dinoflagellate species *Alexandrium catenella* and can be used as a proxy for blooms. Exceptionally toxic events are preceded by low streamflow, weak winds and small tidal variability. This combination of environmental conditions typically occurs in early fall following seasonal warming of surface layer temperatures. On decadal timescales, toxicity covaries with warm phases of the Pacific Decadal Oscillation and the window of optimal growth conditions for *A. catenella* as determined by sea surface temperatures warmer than 13°C. This study demonstrates the linkages between climate, oceanography and the frequency, duration and magnitude of harmful algal blooms. Results will be used to develop PST risk forecasts and to evaluate the potential influence of global warming on the occurrence of future toxic events in Puget Sound.

Ormseth, Olav A. and Brenda L. Norcross (Oral)

LATITUDE, TEMPERATURE, AND GROWTH: IMPLICATIONS FOR LIFE HISTORY STRATEGIES OF COD IN THE PACIFIC AND ATLANTIC OCEANS

Geographically separated populations of the same fish species often display variation in life history and other traits. Comparing such populations is useful for studying the effects of ocean climate and climate change on marine fishes. We characterized the life history strategies of four Pacific cod (*Gadus macrocephalus*) stocks separated along a latitudinal gradient in the eastern North Pacific Ocean. Southern stocks grow and mature quickly, but reach a smaller size and have

a shorter lifespan than northern stocks. Despite these differences, lifetime egg production (a proxy for evolutionary fitness) is equivalent across all stocks and is on the order of 1 x 10^6 eggs. Differential life histories in Pacific cod appear to be driven by environmental constraints on growth. Growth is highly dependent on latitude and less on temperature. Our results suggest that a certain level of egg production may be required for transmission of an individual's genes to the next generation. Life history strategies of Pacific cod populations in different environments may have evolved to maintain that level by compensating for environmental constraints. Comparisons to Atlantic cod (*Gadus morhua*) revealed similar latitude/growth relationships to Pacific cod, but only among stocks influenced by common oceanographic conditions. We discuss the implications of our Pacific cod analysis for Atlantic cod, as well as the potential for climate change to alter cod life history strategies.

Scheuerell, Mark D. and John G. Williams (Oral)

FORECASTING CLIMATE-INDUCED SHIFTS IN THE MARINE SURVIVAL OF PACIFIC SALMON (*ONCORHYNCHUS* SPP.)

Effective conservation and management of natural resources requires accurate predictions of ecosystem responses to future climate change, but environmental science has largely failed to produce these reliable forecasts. The future response of Pacific salmon (*Oncorhynchus* spp.) to a changing environment and continued anthropogenic disturbance is of particular interest to the public because of their high economic, social, and cultural value. While numerous retrospective analyses show a strong correlation between past changes in the ocean environment and salmon production within the north Pacific, these correlations rarely make good predictions. Using a Bayesian time series model to make successive one-year-ahead forecasts, we predicted changes in the ocean survival of Snake River spring/summer chinook salmon (*O. tshawytscha*) from indices of coastal ocean upwelling with a high degree of certainty (R^2 = 0.71). Furthermore, another form of the dynamic times series model that used all of the available data indicated an even stronger coupling between smolt-to-adult survival and ocean upwelling in the spring and fall (R^2 = 0.96). This suggests that management policies directed at conserving this threatened stock of salmon need to explicitly address the important role of the ocean in driving future salmon survival.

Suryan, Robert M. (Oral)

ENVIRONMENTAL FORCING OF LIFE HISTORY STRATEGIES: MULTI-TROPHIC LEVEL RESPONSE AT OCEAN BASIN SCALES

Variation in life history traits of organisms is thought to reflect adaptations to environmental forcing occurring from bottom-up and top-down processes. Such variation occurs not only among, but also within species, indicating demographic plasticity in response to environmental conditions. Between North Atlantic and North Pacific Oceans, intra-specific variation in life history traits has been observed among trophic levels from zooplankton to sharks and seabirds. In all these cases, species in the Northeastern Pacific exhibited later maturation and lower fecundity, but greater annual survival, than conspecifics in the Atlantic. Captive studies of fishes have shown that differences in growth and age of reproduction can indeed be a function of environmental control rather than genetic variation. Similar parallel occurrences also have been observed in adjacent seas; zooplankton and seabird species in cooler North Sea waters exhibit lower fecundity and greater annual survival than conspecifics in the Atlantic. Furthermore, a shift toward shorter reproductive intervals (resulting in greater annual fecundity) has been observed within a species in response to warming of an inland lake. These examples show system-wide adaptations in life history strategies resulting from environmental forcing and provide a framework for comparisons of ecosystem function among oceanic regions (or regimes) and may prove valuable in modeling ecosystem response to environmental change.

Bi, Hongsheng, William T. Peterson, Jesse Lamb, and Edmundo Casillas (Poster)

CHARACTERIZING PELAGIC OCEAN HABITAT FOR JUVENILE SALMON USING GENERALIZED LINEAR MIXED MODEL

The abundance of yearling Chinook (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*) populations were sampled concurrently with physical and biological variables in marine waters of Washington and Oregon in June

1998-2004. Generalized linear mixed models with negative binomial distributions were used to identify factors that could predict the abundance and distribution of yearling Chinook and coho salmon at any location, and thus serve as metrics defining juvenile salmon habitat. Water depth and chlorophyll a concentration were related to the abundance of both salmon species. Temperature had a significant effect on yearling coho abundance. Indices of copepod species composition derived from principal factor analysis were found to be related with the abundance of both salmon species. Three other copepod indices (total copepod abundance, three cold water copepod species, and seven cold neritic copepod species) were related only to yearling Chinook abundance. The selected models for yearling Chinook generally performed better than for yearling coho. Suitable habitat areas for both species showed large spatial variations with more available habitat off Washington and the Columbia River mouth than off Oregon. The location and size of suitable habitat for yearling Chinook and yearling coho varied temporally as well. Availability of suitable habitat for yearling Chinook was most expansive in 1999 and 2003 while the least amount of habitat was observed in 2001, and 2000 excluding 1998. Similarly, availability of suitable habitat for yearling coho was highest in 2004 and 2001 while the least amount was observed in 1999 and 2000.

Hunt, Brian P.V. and Graham W. Hosie (Poster)

ZOOPLANKTON IN THE INDIAN AND PACIFIC BASINS OF THE SOUTHERN OCEAN SOUTH OF AUSTRALIA: HOTSPOTS AND INTER-ANNUAL VARIABILITY (1997-2004)

Over 75 years of sampling with the Continuous Plankton Recorder (CPR) in the North Sea and North Atlantic have provided one of the most comprehensive long-term marine data sets and yielded significant insights into the impact of climate change on populations, communities and ecosystems. The CPR enables rapid ocean-basin scale sampling while not requiring dedicated ship time and is therefore an ideal instrument for long term ecosystem monitoring. In 1991 the Australian Antarctic Division (AAD) began sampling with CPRs in the Antarctic seasonal ice zone south of Australia. Subsequently, sampling was extended into the permanently open ocean zone, on both research voyages and re-supply voyages to Australian Antarctic bases, and by 1997 the Southern Ocean CPR Survey had became fully operational. Since 1999 sample coverage has been further increased through the support of the Japanese, German and New Zealand Antarctic programs. Thus far data analysis has focussed on quantifying sampling methodology and the intra-annual (spatial and seasonal) variability of zooplankton communities. Here we provide the first multi-year analysis, investigating inter-annual variation in zooplankton abundance, the contribution of major zooplankton groups and communities, and the distribution of density and diversity hotspots at the basin scale.

Kang, Sukyung and Suam Kim (Poster)

CLIMATE-INDUCED VARIATION IN THE DISTRIBUTION AND ABUNDANCE OF MACKERELS IN THE NORTHWESTERN PACIFIC

To delineate the impact of climate variability on fisheries resources, interannual oceanographic/climatic/fisheries data have been widely explored in recent years, and we investigated mackerel populations in relation to climate variability in the marginal seas of the northwestern Pacific Ocean. Sea surface temperature (SST) in the Yellow Sea (YS), the East China Sea (ECS) and East/Japan Sea (EJS) and national landings of mackerels (China, Japan, Korea, and Taiwan) were extracted from NOAA NODC and FAO catch statistics, respectively. Korean and Japanese large purse seine fisheries data since 1950s were analyzed for detecting responses in spatial and temporal distribution and abundance of mackerels to climate variability. A quasi-decadal signal in the SST anomalies seemed to have a negative link with the Pacific Decadal Oscillation index (PDO) before and after 1981. Furthermore, an inverse phase relationship in SST anomalies was evident concurrently in the eastern (130°E) and western (123°E) ECS. Catch fluctuations of mackerels tracked the changes in SST showing high values in the 1970s, low ones in the 1980s, and again high values in mid the 1990s, though the catches in the 1990s were still well below those from two to three decades ago. Due to the SST increase in 1990s the habitat of mackerels seemed to have expanded to the north. More fishing activities were found in the southern YS and EJS during the warm periods.

Keister, Julie E., William T. Peterson, P. Ted Strub, and Timothy J. Cowles (Poster)

CLIMATE EFFECTS ON ZOOPLANKTON BIOMASS, SPECIES COMPOSITION, AND CROSS-SHELF DELIVERY OF CARBON IN A COASTAL UPWELLING SYSTEM

In coastal upwelling ecosystems, the export of biological production from nearshore to the deep ocean feeds the global carbon cycle and productivity of the oceanic ecosystem while also playing an important role in zooplankton population dynamics. Typically, wind-driven Ekman transport has been considered the dominant mechanism of cross-shelf transport during upwelling, but more recently, mesoscale circulation features such as 'squirts,' filaments, and eddies are recognized as potentially much more important contributors. Such features are common in the California Current System (CCS) and may persist several months, delivering large amounts of nearshore water and the associated biology to the deep sea. As part of the US GLOBEC Northeast Pacific Program, we study climate effects on zooplankton species composition, biomass, and distribution and the timing and intensity of mesoscale circulation in the CCS. We use satellite altimetry to study interannual variability in circulation; we use zooplankton collected off Oregon and northern California during summers 1998-2003 to study zooplankton variability. Our results indicate that climate effects on cross-shelf transport of zooplankton are a complex interaction of physical forcing on both circulation and population dynamics. Zooplankton biomass and the intensity of mesoscale circulation peaked in summer in most years, but the timing and amplitude of the peaks in energy and biomass varied interannually. In this presentation, we explore the complexities of ecosystem variability including changes in climate, circulation, and zooplankton species composition and biomass, all of which contribute to interannual variability in the delivery of zooplankton biomass to deep regions of the CCS.

Lee, Yong-Woo, Bernard A. Megrey, and S. Allen Macklin (Poster)

DEVELOPMENT OF ENVIRONMENT-BASED RECRUITMENT FORECASTING MODELS AND EVALUATION OF FORECAST ACCURACY USING A RESAMPLING STRATEGY

Environment-based recruitment forecasting models were developed based on the time series of 41 years of spawner biomass and environmental covariates for Gulf of Alaska walleye pollock (*Theragra chalcogramma*). Multiple linear regression, general additive models and artificial neural network statistical models were employed in the development of forecasting models and were compared according to their ability to forecast future recruitment. The examined covariates included sea surface temperature, wind mixing energy, freshwater runoff, Northeast Pacific Pressure Index, Pacific Decadal Oscillation index and Southern Oscillation Index. Influential covariates were identified by building the best explanatory model on the first 35 observations in time series (the training set). The model's ability to forecast was tested by applying the trained model to a segment of the time series (last 6 observations) that had not been used to fit the models (the forecasting set). Models were then further tested in a resampling experiment of 300 trials by reserving 6 random recruitment data points (two from each recruitment level of high, medium and low) to compare with the model's forecast. The remaining 35 data points were used to train the models. Results show that artificial neural networks performed better during the model training process, i.e., fit the data better. For forecasting, however, multiple linear regressions and general additive models statistically performed better than artificial neural networks.

Tananaeva, Yulia N. and Marat A. Bogdanov (Poster)

SST AND ICE CONDITIONS' VARIABILITY, ITS INFLUENCE ON PRIMARY PRODUCTION AND FISHERY RESOURCES OF NORTH WEST PACIFIC

The beginning, duration and ending of the phenological seasons are the important factors determining the development of production processes in the ocean. The analysis of the weekly sea surface temperature (SST) and ice cover maps allowed to distinguish a number of important features and regularities in the interannual variability of the beginning and duration of cold and warm seasons in the North West Pacific, Bering and Okhotsk seas. Also the analysis of monthly satellite chlorophyll maps for this region was carried out.

Changes in duration of the cold and warm seasons may impact strongly on the biological and fish productivity. So, the earlier the warming-up begins, the longer it will continue. As a result the euphotic layer will be thicker and it will contain more nutrients. The phytoplankton bloom starts earlier and lasts longer in such a case. Also we have given some examples of thermic conditions' influence on fish productivity. There is evidence for a connection between winter SST

and the returning ratio of the pink salmon, and also between the ice conditions in the Bering and Okhotsk Seas and the pollock harvest.

SESSION 6: *Humans and the marine environment*

Cury, Philippe (Keynote Speaker)

SCIENTIFIC CHALLENGES TO RESPOND TO A SHARED VISION: THE ECOSYSTEM APPROACH TO MARINE RESOURCES

Marine ecosystems are at a critical turning point due to global changes (climate change, overexploitation, biodiversity, etc.). The ecosystem approach to marine resources that is internationally acknowledge is aimed at creating a shared vision of sustainable and desirable marine ecosystems that can provide prosperity to a fair and equitable society, to other species and to future generations. The ecosystem approach represents today an utopia in the sense that no formalisation of integrating frameworks has been achieved, no unified approach has been undertaken. This shared vision does not exist yet, except in our mind, and science is not ready to address this challenge as it lacks integration. In this presentation, I discuss several ways of integrating our piecemeal approaches and show that they will require, may be not evolution but revolution in the way we envisage scientific objectives and methods. I discuss three challenges: How to integrate so many ecosystem-based indicators that have been developed in fisheries management? How to integrate ecosystem models and ecological studies to understand controls in marine ecosystems? And finally, how early career scientists should build their careers knowing these new challenges and contexts?

A'mar, Z. Teresa, A.E. Punt, and M.W. Dorn (Oral)

THE MANAGEMENT STRATEGY EVALUATION APPROACH AND THE FISHERY FOR WALLEYE POLLOCK IN THE GULF OF ALASKA

Management strategy evaluation (MSE) is the process of using simulation testing to examine the robustness of candidate management strategies to error and uncertainty. MSE involves using a model (the "operating model") to represent the true underlying dynamics of the resource and to generate future data, an estimation model to assess the state of the stock relative to agreed target and limit reference points based on the data simulated using the operating model, and a decision rule to determine management actions (e.g. the Acceptable Biological Catch, ABC) given the results of the estimation model. The latter two steps constitute the management strategy. The parameters of the management strategy can be selected to attempt to satisfy desired (but conflicting) management goals and objectives. The results of an MSE are performance measures that quantify the effectiveness of the estimation model and, more generally, the management strategy. MSE is used in this paper to evaluate the extent to which the current management strategy for the fishery for walleye pollock, *Theragra chalcogramma*, in the Gulf of Alaska is able to satisfy the management objectives of avoiding low stock size and achieving high, stable catches, given error and uncertainty regarding the data used for assessment purposes, and the form of the stock-recruitment relationship.

Chernyaev, Andrey P. (Oral)

DISTRIBUTION OF PETROLEUM HYDROCARBONS IN USSURIYSKIY BAY (JAPAN/EAST SEA)

Ussuriyskiy Bay is located in the north-western part of Peter the Great Bay (Japan/East Sea) and is subject to high anthropogenic pollution. Petroleum hydrocarbons (PH) are the most important group of pollutants. Marine oil pollution has arisen in recent years from frequent oil spills and has negatively influenced biological and recreational resources of this area. Samples of sea water and bottom sediments were collected at 34 stations in Ussuriyskiy Bay in May 2006 and were analyzed by IR-spectroscopy. PH concentration did not exceed the maximum permissible concentration (0.05 mg/l in Russian Federation) over 40% of the bay area. Average PH concentration in seawater was 0.15 mg/l. Minimum concentrations were detected in the inner part of the bay (<0.01 mg/l). Maximum PH concentrations were observed in Gornostay Bay (1.5 mg/l) near a trash dump area, and in Bolshoy Kamen Bay near a large ship repair factory. The analysis of interannual dynamics (2003-2006) of PH contents in the bay have shown a decrease in pollution levels, which correlates strongly with waste discharge decreases in Ussuriyskiy Bay. The average PH concentration in sediments was 24.4

mg/kg, and maximum levels were detected in Bolshoy Kamen Bay (90 mg/kg) also. Minimum PH content was registered near Reyneke island (2.5 mg/kg) in the open part of the bay. Thus, modern levels of PH in Ussuriyskiy Bay are not high and don't affect marine organisms significantly.

Cope, Jason M. and André E. Punt (Oral)

DRAWING THE LINES: RESOLVING FISHERY MANAGEMENT UNITS WITH SIMPLE FISHERIES DATA

The task of assessing marine resources should begin with defining management units. This step is often overlooked or defined in relation to temporal scales not comparable to those required of management (i.e. evolutionary vs. ecological). In addition, traditional methods for defining stock structure can either be data intensive or cost prohibitive, especially in emerging and data-limited fisheries. We introduce an approach that uses commonly-collected and available fisheries data—catch-per-unit-effort (CPUE)—to delineate management units that appear to be demographically independent of each other. Spatially-explicit standardized CPUE indices of abundance are grouped using a hierarchical partitioning cluster analysis that accounts for the uncertainty of the abundance indices themselves. This estimator is tested via simulation and found to generally recover the true number of populations across abundance indices of different temporal length, sample size, and quality. Applications of this method are then illustrated for several fishes using catch and effort data from the California commercial passenger fishing vessels. Defining the management unit explicitly using the relative abundance trajectory allows one to incorporate changes in population connectivity in relation to current removals, and reduce contradictory information introduced into fishery assessments. This robustness to index uncertainty also demonstrates the potential usefulness of indices of abundance even when uncertainty about the index potentially renders it uninformative for conventional fishery assessment purposes.

Davis, Michelle L. and Brian R. Murphy (Oral)

HARVEST IMPACTS ON POPULATION DYNAMICS OF SEX-CHANGING FISHES

Many species of commercially and recreationally important reef fishes are protogynous hermaphrodites and change sex from female to male during their lives. In the northwest Atlantic Ocean, five of the ten most commercially valuable snapper and grouper species are protogynous. Fisheries often remove the largest individuals from the population; for a protogynous species, these large fish are all males. Removing these large males may cause females to change sex at smaller sizes, potentially reducing population fecundity and productivity. Although understanding the effects of protogyny on population dynamics is crucial to effective management, few stock assessments or management approaches explicitly include hermaphroditism. We developed population models to evaluate how protogyny affected population dynamics of red porgy (*Pagrus pagrus*), a commercially important reef fish in the northwest Atlantic Ocean that has been substantially depleted by overfishing. We incorporated data from long-term surveys of the harvest and from fishery-independent sampling. Since little was known about the mechanisms that initiate the female-to-male transition, we modeled both internal factors (age, length, and weight) and external factors (sex ratio, abundance of males, and mean age of population) as potential sex change triggers. We also evaluated a suite of management approaches, including maximum and minimum size limits, slot limits, and quotas, to see which of these approaches would be best suited for red porgy. This modeling approach can be applied to other protogynous species, allowing managers to include the impacts of protogyny into stock assessments and management decisions. With a better understanding of how protogyny affects population dynamics, we will improve the ability to assess and minimize detrimental human impacts from fishing on protogynous species.

de Bruyn, Paul A., M.H. Schleyer, and C.L. Moloney (Oral)

A NOVEL APPLICATION OF OPERATIONAL MANAGEMENT PROCEDURES IN THE FISHERIES MANAGEMENT OF THE OYSTER (*STRIOSTREA MARGARITACEA*) IN KWAZULU-NATAL, SOUTH AFRICA

The commercialisation of many fisheries in South Africa has resulted in the need for revised management of these resources. In KwaZulu-Natal, an Operational Management Procedure (OMP) was deemed necessary for the edible oyster (*Striostrea margaritacea*) as it supports both commercial and recreational fisheries. The oyster fishery in KwaZulu-Natal is relatively small and utilises low-technology harvesting methods. This resource is considered unique as it has been managed using a rotational harvesting strategy since its commercialisation, although this strategy has been modified

over the years to incorporate additional zones. The effectiveness of this spatial management system for small-scale invertebrate fisheries was investigated. The parameters and relationships derived from biological studies were integrated with fisheries catch and effort data into models that were used to assess the status of the oyster stock. After attempting several stock assessment models, a spatially explicit age-structured production-model was found to be the most suitable for stock assessment purposes. The outputs from this model indicate that, although the population was depleted in the early 1980s, the current levels of harvesting are sustainable. Projection modelling, incorporating both deterministic and stochastic recruitment, indicates that, although current levels of harvesting are sustainable, any increase may render the populations susceptible to over-exploitation. Based on these projection models, two separate OMPs were derived, incorporating catch feedback regulation mechanisms. The final OMP will be decided in consultation with the relevant management and enforcement authorities. Rotational harvesting of the fishery within regions remains central to its sustainability. The application of a rotational harvesting management strategy for similar small-scale fisheries targeting sessile invertebrates was also recommended.

Haltuch, Melissa A., Andre E. Punt, and Martin Dorn (Oral)
EVALUATING ALTERNATIVE ESTIMATORS FOR FISHERIES BIOMASS REFERENCE POINTS: HOW CLOSE ARE WE?
The control rules used to determine fishery harvest levels depend on estimates of 'biological reference points'. Commonly-used biological reference points include the level of unfished spawning biomass (B_0), the spawning biomass corresponding to maximum sustainable yield (B_{MSY}), and the current size of the stock in relation to B_0 and B_{MSY}. Although several methods exist for estimating these quantities, it is unclear which methods perform best. Simulation is therefore used to evaluate alternative estimators for B_0, B_{MSY}, current biomass relative to B_{MSY}, and current biomass relative to B_0. These estimators differ in terms of whether a stock-recruitment relationship is estimated, and whether a Bayesian derived prior is used as a penalty on steepness, a critical parameter of the stock-recruitment relationship. The simulations consider three life histories: a long-lived unproductive rockfish, a moderately long-lived and productive flatfish, and Pacific hake, which is also moderately long-lived and productive, but has highly variable recruitment. Results indicate that estimator performance varies among both reference points and species life history characteristics. The performance of estimators of biological reference points was generally better for rockfish and flatfish life histories than for hake life history.

Hsieh, Chih-hao, Christian S. Reiss, Roger P. Hewitt, and George Sugihara (Oral)
SPATIAL ANALYSIS SHOWS FISHING ENHANCES THE CLIMATIC SENSITIVITY OF MARINE FISHES
We compare the changes in geographic distribution of exploited fish species versus unexploited ones living in the same environment. For this comparative study, we use the 50-year-long larval fish time series from the California Cooperative Oceanic Fisheries Investigations, which allows us to view fishing as a treatment effect in a long-term ecological experiment. Our results indicate that exploited species show a clearer distributional shift in response to environmental change than unexploited species, even after accounting for life history and ecological traits, and phylogeny. The enhanced response (improved signal/noise ratio) to environmental change in exploited species may be a consequence of reduced spatial heterogeneity caused by fishery-induced age (size) truncation and the constriction of geographic distribution that accompanies fishing pressure. We suggest that reduced spatial heterogeneity can cause exploited populations to be more vulnerable to climate variability, an effect that could have considerable importance in the management of fish stocks. This is the first study to compare the geographic distributions of a large suite of fish species from the northeastern Pacific in response to climate.

Kim, Hae-Cheol, Xuyong Li, Charles L. Gallegos, Donald E. Weller, Thomas E. Jordan, and Patrick J. Neale (Oral)
PREDICTED ECOLOGICAL RESPONSES OF SUBESTUARINE ECOSYSTEMS TO DIFFERENT WATERSHED LOADINGS IN THE CHESAPEAKE BAY: A MODELING STUDY
Ecological responses of shallow-water habitats to anthropogenic and natural forcing were investigated using a coupled watershed and subestuary ecosystem model. The structure of the generic ecosystem model includes multiple ecosystem components such as nutrients, bacteria, phytoplankton, and zooplankton, as well as standard water quality indicators (e.g., chlorophyll, suspended solids, light attenuation, and dissolved oxygen). For model application purposes we chose

60 watersheds in the coastal plain of Chesapeake Bay and ran a watershed model (Generalized Watershed Loading Functions) to create 28-year averaged time series of organic and inorganic nutrients for each watershed. A subestuary ecosystem model was then run, using watershed outputs as upstream boundary conditions. Simulated results of standard water quality indicators were categorized with a wide range of watershed loadings influenced by anthropogenic activities and episodic storm events. Results showed that precipitation and land use changes elevated nutrient loadings and subsequently increased phytoplankton biomass, which resulted in depletion of dissolved oxygen and eutrophication. Based on these preliminary results, we also investigated the future-projected ecological response of the subestuarine ecosystem in the Chesapeake Bay area. A 30-year projected simulation was performed based on a climate change model (Intergovernmental Panel on Climate Change) and future land use scenarios (growth simulation model). We hope that our approach could address management questions (e.g., 'How will water clarity in subestuaries respond to increasing suburban development when there is increasing frequency of severe storm events?') with definitive answers (e.g., 'Dissolved oxygen will be reduced in second-order subestuaries in the polyhaline zone'), and provide a management tool for quantitative prediction and interpretation of existing and emerging indicators of the ecological condition in shallow water habitats.

Lee, Jae Bong, Anne Hollowed, and Chang-Ik Zhang (Oral)

COMPARING ECOSYSTEM VARIATIONS BETWEEN THE EASTERN AND WESTERN NORTH PACIFIC USING SIZE-BASED INDICATORS

The integrative effects of fishing on community structure and function were examined using size-based indicators (SBI), such as fish reproduction potential (FRP) and fish community health (FCH) in this study. The indices were used to quantify the reproductive probability and trophic level of fish communities, and to contribute to the development of ecosystem-based fisheries management (EBFM) in practical ways in the North Pacific. At a population level, the FRP index was estimated from data on total catch, catches (in metric tons) by species and by ecosystem, and fishing effort (in horse power per metric ton) to describe the reproductive probability of adult fish resources. At the community level, the FCH index was developed by combining the trophic level of the catch by species group with FRP in order to quantify changes in the trophic structure of fish communities. We distinguished FRPs from FCHs in three ecosystems around Korean waters, that is, the East Sea ecosystem (ESE), the Yellow Sea ecosystem (YSE), and the East China Sea ecosystem (ECSE). Reference directions of changes (RD), analogous to the single-species' reference points (RP), under heavy fishing pressure and damaged trophic structure were going down since the basis reference year of 1975. Based on a regime shift analysis, the FCH indices in each ecosystem showed three regimes during this period. Although the patterns of decline were similar, shift times were significantly different among the three ecosystems. The first decrease in the indices occurred simultaneously in the ESE, YSE, and ECSE after 1985 (to 0.45, 0.89, and 0.60, respectively). The second decline occurred in different years among the three ecosystems; in the ESE and ECSE the FCH indices decreased to 0.40 and 0.17 after 1994, respectively, while in the YSE the index declined to 0.55 after 1992. The patterns of variation between FRPs and FCHs in the three ecosystems were similar with correlation coefficients of 0.935, 0.982, and 0.962, respectively, while the magnitude of declines differed between the two indices. SBIs offer a cost-effective approach to help explain changes in the underlying ecosystem processes to policy makers and non-scientists, by integrating a number of data sources and providing intuitive summaries of the state and functioning of exploited ecosystems.

Minto, Coilín, Joanna Mills Flemming, Boris Worm, and Ransom A. Myers (Oral)

META-ANALYTICAL APPROACHES TO UNDERSTANDING SPECIES INTERACTIONS

The ability to predict the abundance of, and interactions amongst, species is paramount to an ecosystem-based approach to the stewardship of natural resources. Predictions require both an understanding of the dynamics of the species involved and also an explicit incorporation of how we measure the variables used to estimate abundance. These population estimates contain both process noise i.e. natural random variation in the population, and measurement error resulting from how well we measure these quantities. Many clear trends in population ecology, including species interaction strengths, can be masked by unsatisfactory measurements in the field. We address this problem by presenting a coherent state space analysis framework that explicitly accounts for process noise and measurement error when estimating

population abundances and or species interactions. This framework encompasses non-linear, non-normal process and data structures. The resulting estimates are combined over multiple populations in a meta-analytical fashion to produce comprehensive results for the interactions amongst species. A concrete example illustrating the usefulness of this novel technique for ecosystem based management is drawn from the "pelagic fish inhibiting cod recovery" hypothesis.

Paterson, Barbara, Coleen L. Moloney, Astrid Jarre, Tracy Fairweather, Carl van der Lingen, Lynne J. Shannon, and John G. Field (Oral)

A FUZZY LOGIC EXPERT SYSTEM FOR MONITORING THE IMPLEMENTATION OF AN ECOSYSTEM APPROACH TO FISHERIES IN THE SOUTHERN BENGUELA

The ecosystem approach to fisheries (EAF) aims to achieve the collective sustainability of all uses and impacts on an ecosystem. Consequently individual issues cannot be addressed independently because attempts to manage any one issue are likely to have impacts on other issues. This paper presents a fuzzy logic knowledge based decision support system to assist in multi-criteria decision-making in the context of EAF. The system was developed using commercially available NetWeaver software. The prototype system integrates the multiple goals and objectives that constitute an ecosystem approach to the sardine *Sardinops sagax* fishery in the southern Benguela and provides intuitive visual outputs to communicate results to managers and stakeholders. The structure of the system follows the hierarchical tree approach recommended in the FAO guidelines for responsible fisheries. The prototype was developed in a consultative process with key experts. Input parameters are based both on quantitative data and expert opinion. We evaluated the system in terms of robustness to input changes, influence of system structure and appropriateness of input scales for parameters based on expert opinion. Results show that the system is robust and conservative. The strength of the approach lies in the ability to include variables which are difficult to measure. It provides a means of rendering value judgments explicit and transparent. The tool synthesizes a large amount of information and aims at improving understanding rather than achieving precision. The process of prioritizing and structuring the main factors in EAF has helped to bring into focus the gaps in the way the social dimension for the South African small pelagic fishery is addressed at present. The system has the potential to have wide application in the context of EAF.

Peter, John R. and Victor M. Peddemors (Oral)

RESPONSES OF INDIAN OCEAN BOTTLENOSE DOLPHINS TO ACTIVE ACOUSTIC DEVICES (PINGERS) IN SOUTH AFRICA

Debate surrounding shark nets set off the KwaZulu-Natal coast of South Africa is longstanding. Shark nets along the Durban coastline have historically experienced frequent catches of the Indo-Pacific bottlenose dolphin, *Tursiops aduncus*. Seasonal and yearly analysis of catch data records for Durban from 1990-2004 indicate strong correlations between dolphin captures and (1) changed current directions; (2) incidences of nets floating at times of entanglement; and (3) the depths at which bottlenose dolphins were caught during both non-pinger years and pinger years. Additionally, catch data indicate a high frequency of catches within 5 meters of active acoustic devices installed on shark nets. Observations of the behaviour and movement patterns were carried out during daylight hours via digital theodolite. Comparisons between experimental control periods and active alarm days were made. Results indicate that 84% of bottlenose dolphin observations included approaches of <50m form shark nets. Feeding (45%) and slow travel (31%) were the most frequent behaviours recorded during periods that nets included active pingers, whereas an increased travel speed (29%) was observed when no warning devices were attached to the nets. Analysis of movement patterns provided evidence of a "preferred path" by resident groups during both pinger-active and pinger-inactive experimental periods, as well as a definitive response to activated pingers. This suggests that pingers may heighten the awareness of the presence of nets, confirming recorded reduced bycatch during years of pinger deployment. However, results indicate that bottlenose dolphins exhibit significantly different responses to pingers compared to those for harbour porpoises.

Putland, Jennifer N. and Richard L. Iverson (Oral)

ECOLOGY OF MICROZOOPLANKTON IN A SUBTROPICAL ESTUARY AND IMPLICATIONS OF RIVER WATER DIVERSION

Microzooplankton, on average, ingested ten times more phytoplankton productivity than Acartia tonsa, which dominates the mesozooplankton community in Apalachicola Bay. Microzooplankton ingested <75% and >75% of phytoplankton productivity during winter and summer, respectively. Ciliates, particularly ciliates <20 µm in size, were abundant in all samples. Phytoplankton was the main (>50%) component of the microzooplankton diet during the summer high productivity period. Because microzooplankton are prey for organisms occupying higher trophic levels, such as copepods, fish larvae, and oysters, we propose that energy and mass flow mainly from phytoplankton through microzooplankton to higher trophic levels in Apalachicola Bay. A reduction in discharge from the Apalachicola River during our study period led to reductions in rates of grazing, ingestion, and production of microzooplankton at a particular salinity. Reduced river discharge also increased the areal extent of higher salinity water where ingestion and production of microzooplankton were relatively low. Because microzooplankton are key constituents of the estuarine food web in Apalachicola Bay, upstream water diversion can be expected to lower microzooplankton production and therefore reduce higher trophic level productivity in the Bay.

Aleshko, Svetlana A. (Poster)

ANTIOXIDANT DEFENSE SYSTEM IN FISH AND MUSSELS FROM POLLUTED AREAS OF PETER THE GREAT BAY (JAPAN/EAST SEA)

Among the regions of the Russian Far East, the internal parts of Peter the Great Bay (Japan/East Sea), Amursky and Ussuriysky Bay, are under the strongest anthropogenic stress. The main sources of pollution are shipping, industrial and municipal sewage and, via many rivers, agricultural chemicals. The biomarker approach is a useful tool for assessing the impacts of pollution on marine organisms. Flounder (*Liopsetta pinnifasciata*) inhabits shallow near-shore waters and forms stable groups in each bay. Mussels (*Crenomitilus grayanus*) are representative species for marine biomonitoring. The aim of this work was to evaluate the effects of anthropogenic exposure on antioxidant status and some metabolic-related parameters in fish liver and mussel digestive gland. Fish and mussels were collected in summer 2005 and 2006 in these two bays. The activity of phase II of the biotransformation enzyme glutathione-S-transferase in flounder from Amursky Bay was approximately 15 % higher compared to flounder from Ussuriysky Bay. The activity of the antioxidative enzymes superoxide dismutase (SOD) was enhanced in flounder males from Amursky Bay. The activity in females was within 120-160 U/min/mg protein. The activity of catalase in fish from Amursky Bay was increased in June (by 26%) compared to Ussuriysky Bay, whereas in August it was equal in both areas (about 20 U/min/mg protein). In mussels the activity of antioxidant and biotransformation enzymes was higher in the inner parts of the bays and lower in the open parts. Lipid peroxidation, measured as malondialdehyde (MDA) levels, did not differ significantly between animals from the two bays, and was about 1-3 nmol MDA/mg protein in fish, and up to 5 nmol MDA/mg protein in mussels. Our results show that pollution leads to a pro-oxidant situation and activation of cellular defense mechanisms. The activity of the antioxidant system provides an adaptation of fish and mussels to the environmental conditions in polluted bays.

Barbosa, Susana, Ana C. Fernandes, Laura Wise, Dina Silva, and Graça Pestana (Poster)

FISHING AND DISCARDING PRACTICES IN THE PORTUGUESE TRAWL, LONGLINE AND PURSE SEINE FLEET

The Portuguese discard sampling programme, included in the EU DCR/NP, is based on a quasi-random sampling of co-operative commercial vessels. It started in 2003 in the fish and crustacean trawl fleet, since these two métiers are the main source of by-catch and discards along the Portuguese coast, and was later expanded to longliners and purse seiners. The aim of this work is to characterize the fishing procedures of those fleets and their discarding practices. Around one hundred trawlers, 15 longliners and 135 purse seiners with very distinct characteristics operate along the Portuguese coast. The crustacean trawl fleet is restricted to the south, from Sines to V. Real Sto António, the latter being the usual landing harbor. The fish vessels work along the entire coast and it is difficult to attribute fishing grounds to this particular fleet or allocate vessels to particular harbors, because they change their behavior very often according to market prices. They also differ in the days spent at sea, fishing hours, depth, and target species. The longline deep sea fishery was

sampled in the three fishing grounds (Peniche, Sesimbra and Cabo da Roca) and the seasonality of the purse seine fishery was accounted for. Onboard discarding procedures of the three fleets, such as the ways in which sorting is conducted and what motivates the discharge of caught animals, are also discussed.

Bravo, Claudia F., Joseph Dietrich, Deborah Boylen, Bernadita Anulacion, Gina Ylitalo, Frank J. Loge, Tracy K. Collier, and Mary R. Arkoosh (Poster)

TRANSCRIPTIONAL PATTERNS IN HEAD KIDNEY OF POLYBROMINATED DIPHENYL ETHERS (PBDE) EXPOSED FALL CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSHA*) CHALLENGED WITH THE MARINE PATHOGEN *LISTONELLA ANGUILLARUM*

To determine the effects of polybrominated diphenyl ethers (PBDEs) on the response of immune system genes, juvenile fall Chinook salmon were exposed to an environmentally relevant concentration (0.1861 ng/g) of a PBDE mixture (BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154) introduced through diet over a 40-day period. The specific chemical composition was designed to reflect the stomach contents of juvenile Chinook salmon previously collected at contaminated sites in the Columbia River. The fish were then challenged by water bath exposure for a 1-hour period to *Listonella anguillarum*, a marine pathogen and causal agent of vibriosis. Mortalities were monitored post-challenge for 21 days. Fish exposed to PBDEs were more susceptible to *L. anguillarum* infection than fish fed a control diet. At defined periods post-challenge (0, 1 and 7 days), fish were sampled destructively and portions of their head kidney were analyzed with a DNA microarray composed of 1600 immunologically and toxicologically relevant genes. Preliminary results show that gene mediators of toxicological function, immune response and regulation of metabolism appear to be differentially expressed under pathogen challenge and PBDE exposure. The genes were identified by comparing fish challenged with *L. anguillarum* and fed either the control or PBDE treated diet. This study provides a comprehensive profile of transcriptional response in Chinook salmon after exposure to PBDE and L. anguillarum that can be used to explore mechanistically PBDE-induced immunosuppression and potentially predict the effect of these chemicals in human and other animal immune response.

Chavanich, Suchana, Larry G. Harris, Jong-Geel Je, and Rae-Seon Kang (Poster)

DISTRIBUTION PATTERN OF THE GREEN ALGA CODIUM FRAGILE IN ITS NATIVE RANGE, KOREA: IS IT SIMILAR TO INVADED HABITATS?

The examination of native habitats of newly introduced species is one of the factors that can provide information for predicting and preventing invasion success. In this study, we investigated the distribution patterns of a green macroalga, *Codium fragile*, in its native range in Korea. There were two distinct patterns for *Codium* spp. within their native habitat. In undisturbed communities, *Codium* species were members of the understory assemblage below the dominant canopy species. In disturbed habitats, where native algae have been harvested for food, the activity created major gaps in the community structure where opportunistic algae expanded their abundance within the community. *Codium fragile* not only becomes a dominant canopy species in disturbed habitats, but it also colonizes new habitats such as fouling communities. Thus, the distribution patterns of *Codium fragile* in its native range suggests that it has the capability of taking advantage of disturbed habitats, which may help to explain why it has been such a successful invader in other regions of the world. One interesting finding was the lack of specialized sacoglossan herbivores associated with the Korean populations studied while such herbivores do feed on introduced populations in other regions, and may limit their distribution at some locations.

Enever, Robert, A. Revill, and A. Grant (Poster)

DISCARDING AROUND THE UK—NEW INFORMATION AND ANALYSES: ENGLISH CHANNEL, WESTERN APPROACHES, CELTIC AND IRISH SEA (ICES SUBAREA VII)

The Cefas catch and discard data collection programme has been conducting sampling operations on English and Welsh registered fishing vessels in ICES subarea VII since 2002. Within this subarea, these vessels were found to mainly fish in the English Channel, Western approaches, Celtic and Irish Sea. This paper presents the findings of this work and estimates the annual quantities of discards (fish and cephalopods) in terms of number and weight. The analysis was conducted

on 3 643 hauls from 306 trips (142 different vessels) aboard commercial fishing vessels. An estimated 186 million (72 000 t) fish and cephalopods were caught every year, of which 117 million (24 500 t) were discarded. Beam trawlers and otter trawlers were together responsible for more than 90% of these discards. Trawlers targeting *Nephrops* discarded the greatest proportion (by number) of fish caught (92%) followed by beam trawlers (71%) and otter trawlers (65%). In all, 182 fish and cephalopod species were caught, yet just 10 species constituted more than 50% (61.5 million) of the annual discards. We estimate that discarding levels in the region are much higher (x 4) than recently reported by the FAO. Catch per unit effort (CPUE) data are used to describe spatial, temporal and gear-related patterns of discarding. A two-step cluster analysis (TSC) of the discard data revealed that most (97%) of the haul's species composition and corresponding CPUE were similar in pattern. The remaining (3%) indicated discarding "hotspots", most notably in the Irish Sea and Western English Channel.

Murphy, Kathleen R., Gregory M. Ruiz, W.T.D. Dunsmuir, and T. David Waite (Poster)

VERIFICATION OF MID-OCEAN BALLAST WATER EXCHANGE USING FLUORESCENCE SPECTROSCOPY

Mid-ocean ballast water exchange is mandatory for ships discharging foreign ballast in US territorial waters as a control measure to reduce the risk of biological invasions. However, a reliable tool for verifying that the procedure was performed is presently lacking. One method for verifying exchange relies upon comparing the concentrations of naturally occurring tracers in ballast tanks with their known distributions in the oceans. We investigated chromophoric dissolved organic matter (CDOM) as a tracer of mid-ocean exchange on trading ships operating between ports in Asia, Europe and the USA. During nine commercial cruises of duration several days to weeks, samples were collected from the ambient ocean and from ballast tanks before and after mid-ocean exchange. Especially challenging source conditions (high-salinity, low-CDOM) were deliberately selected for these experiments. Using parallel factor analysis, we found nine mathematically and chemically independent fluorescent components to be present in varying concentrations in the ocean and in ballast water, together explaining >99% of dissolved organic matter fluorescence. For most ballast water samples, it was possible to deduce whether they had been ballasted in port or in the ocean on the basis of a single component. Across nine cruises, thresholds at two fixed wavelength pairs (C2*: excitation = 320 nm/ emission = 414 nm and C3*: excitation = 370 nm/ emission = 496 nm, respectively) enabled successful discrimination of coastal versus oceanic source in >95% of ballast water samples (N = 514). These results suggest that relatively simple single or dual channel fluorometers could be optimized to enable rapid, *in situ* verification of mid-ocean exchange.

Wilberg, Michael J. and James R. Bence (Poster)

USE OF BAYESIAN MODEL SELECTION TO IMPROVE STOCK ASSESSMENT ADVICE

Assessment of the impacts of fishing is an important component of fisheries management around the world. Fishery stock assessment often involves fitting alternative models and using what is thought to be the best among them to provide management advice. However, the "best" model is often selected by *ad hoc* criteria with unknown performance characteristics. In some cases, results from several models will be reported to managers, but quantitative estimates of the relative likelihood a particular model being best are typically not provided. Objective methods of model selection are necessary because estimated quantities important for management, such as exploitable biomass, can be extremely sensitive to alternative model structures. Our objectives were to determine if using Bayesian model selection methods (deviance information criterion [DIC] and Bayes factors) resulted in choosing an appropriate model structure and level of complexity. Also, we evaluated whether using formal model selection methods provided more accurate estimates of important fishery management quantities, such as fishing mortality rate and biomass in the last year of the assessment. To achieve these objectives, we designed a simulation study and challenged the model selection criteria with three estimation models and three scenarios of data accuracy and time-varying catchability. In cases where the data-generating model was also an estimation model, DIC generally selected the correct model. Using the model selected by DIC resulted in lower mean square error of biomass and fishing mortality rate than using any single model. Of particular importance, DIC was useful for determining whether fishery effort data were uninformative.

Yemane, Dawit, Yunne-J. Shin, and John G. Field (Poster)

EXPLORING THE CONSEQUENCES OF INTRODUCING MARINE PROTECTED AREAS FOR THE DYNAMICS OF FISH COMMUNITIES IN THE SOUTHERN BENGUELA ECOSYSTEM: AN INDIVIDUAL BASED MODELLING APPROACH

The establishment of Marine Protected Areas (MPAs) is one of the measures that are currently advocated as part of an Ecosystem Approach to Fisheries (EAF) management. MPAs are implemented as a bet-hedging strategy against uncertainty in fisheries management. The choice on the size and location of potential MPAs should be based on consideration of various factors: migration patterns, multi-species interactions, and residence times of different life-history stages of the populations. Prior to introducing MPAs, it is crucial to investigate their potential consequences on the dynamics of the protected components as well as indirect effects on the whole ecosystem. One way of achieving this is to test different simulation scenarios using spatial and multi-species models of fish community dynamics. In this study, we use the Individual Based Model OSMOSE, which is a spatial and size structured multi-species model that includes the main biological processes in the life cycle of fish (i.e. reproduction, growth, and predation). We investigate the likely consequences of the introduction of three different MPAs, either individually or as a network, off the coast of South Africa. We found that in general the introduction of the MPAs in the different scenarios results in a relative increase in the biomass of large predatory fishes whereas the biomass of small pelagic fish species tends to decrease.

http://www.paleodirect.com

Typical Dutch North Sea fishing boat.

Mother and juvenile bottlenose dolphins (*Tursiops truncatus*) head to the seafloor.

OAR/National Undersea Research Program (NURP)

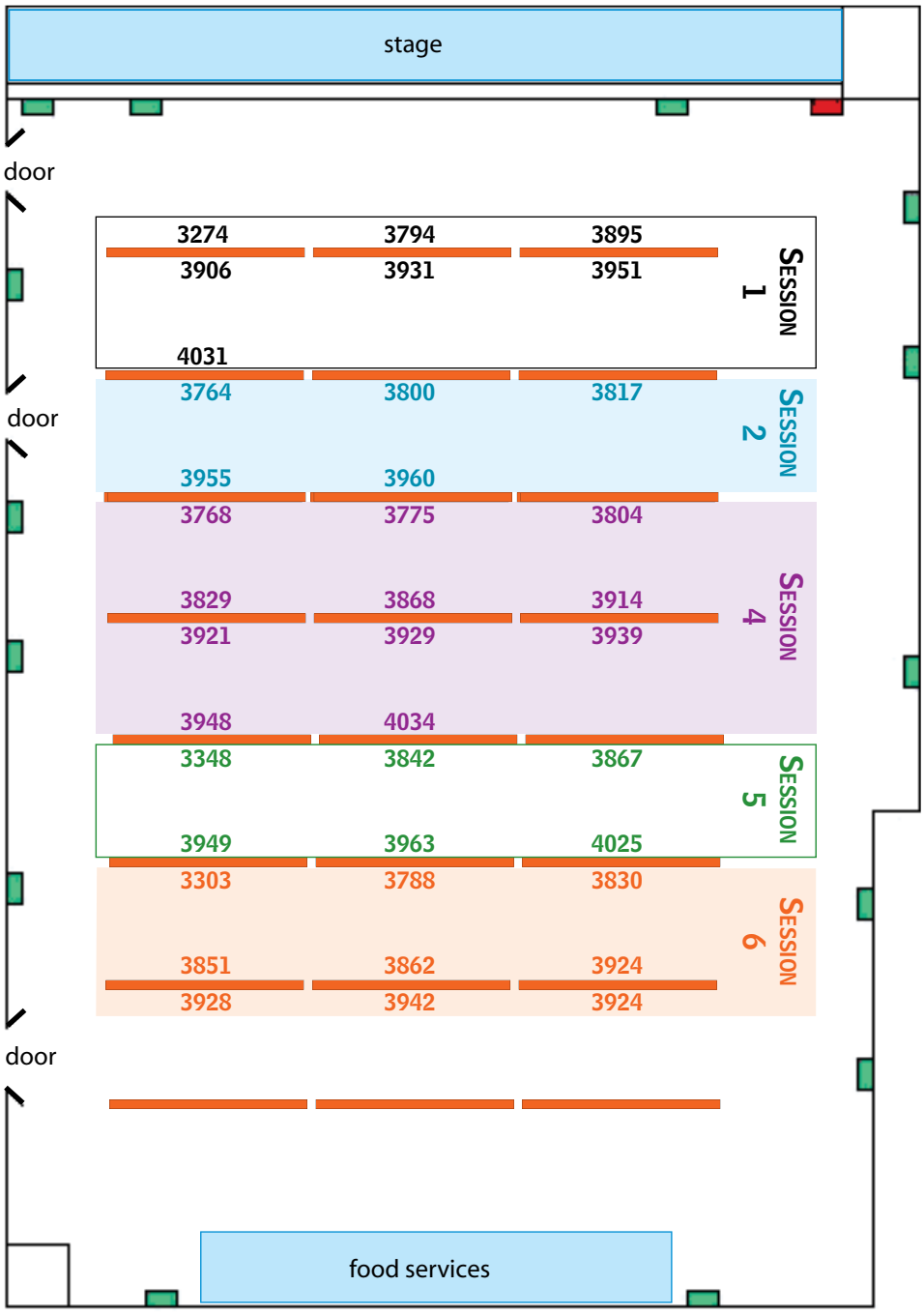
Poster Session

The map below shows where to hang your poster in Classroom #1 (note the Paper ID # on your name tag). The room will be open and available as of 14:00, 25 June (Day 0). Please hang your poster as you arrive.

The Poster Session will be held from 16:00-18:00 on 28 June (Day 3). Please plan on attending your poster for the duration of the session.

Posters may be removed anytime the morning of 29 June (Day 4), but must be removed no later than 14:00 on that day. Any posters remaining after 14:00 will be discarded.

Classroom #1, Building #3



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Midwater trawl coming on board the fisheries research vessel Delaware II. The trawl catch is used to verify the species composition of acoustic backscatter and for biological information such as fish length, weight, maturity, age, sex, and diet.

Ian MacDonald, Texas A&M University

Ice divers use a quadrat to study the density of creatures living on the underside of ice floes. Their research has shown higher densities of amphipods and other creatures in under ice areas with more physical relief; the little holes and crevices in the ice provide habitat and protection from predators.

www.oceanexplorer.noaa.gov

A wildlife observer from the Department of Fisheries and Oceans Canada drills through the pack ice. The ice core was analyzed and the water samples collected from the hole left in the ice.

Woods Hole Oceanographic Institution

The *Alvin*, a US Navy deep submergence vehicle, is deployed via the A-frame crane off the stern of the US Navy's research vessel *Atlantis*.

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Chesapeake Bay Maritime Museum

Historic photo of Chespeake Bay recreational catch of striped bass.