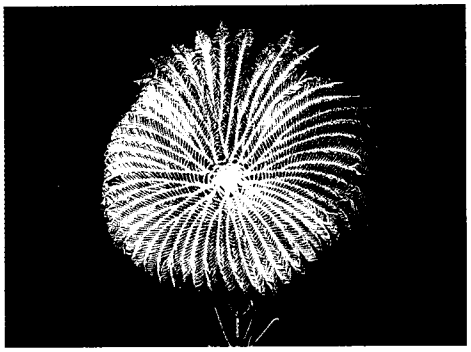
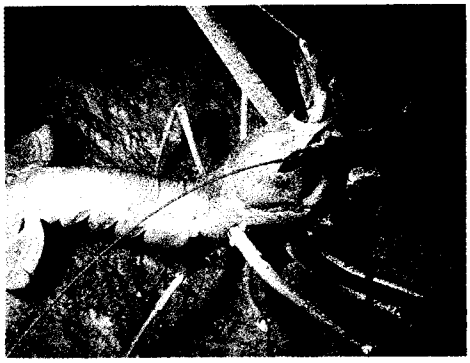
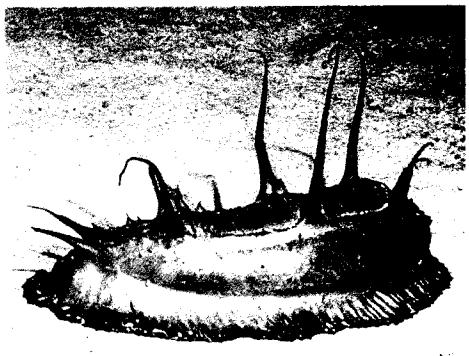
10th Deep-Sea Biology Symposium

Coos Bay, Oregon
August 25-29, 2003







Sponsored by

Oregon Institute of Marine Biology,
University of Oregon

Held at

Southwestern Oregon
Community College

10th Deep-Sea Biology Symposium

Program and Abstracts

Coos Bay Oregon
August 25-29, 2003

Sponsor: Oregon Institute of Marine Biology,
University of Oregon

Venue: Southwestern Oregon Community College

Organizing Committee:

Prof. Craig M. Young (chair)
Dr. Sandra Brooke
Prof. Anna-Louise Reysenbach
Prof. Emeritus Andrew Carey
Prof. Robert Y. George
Prof. Paul Tyler

CONTENTS

ACKNOWLEDGMENTS

Many individuals in addition to the organizing committee assisted with the preparations and logistics of the symposium. Mary Peterson and Torben Wolff advised on matters of publicity and advertizing. The web site, conference logo and t-shirt were created by Andrew Young of Splint Web Design (http://www.splintmedia.com/). Marge LeBow helped organize housing and meals at OIMB, and Pat Hatzel helped format the participant list. Shawn Arellano, Isabel Tarjuelo and Ahna Van Gaest assisted with the formatting and reformatting of abstracts and made decisions on housing assignments. Larry Draper, Toby Shappell, Mike Allman and Melanie Snodgrass prepared the OIMB campus for visitors. Local graduate students and postdocs Tracy Smart, John Young, Ali Helms, Michelle Phillips, Mike Berger, Hope Anderson, Ahna Van Gaest, Shawn Arellano, and Isabel Tarjuelo assisted with last-minute logistics, including transportation and registration. We thank Kay Heikilla, Sarah Callison and Paul Comfort for assistance with the SWOCC venue and housing arrangements, Sid Hall, David Lewis and Sharon Clarke for organized the catering, and Sharron Foster and Joe Thompson for facilitating the mid-conference excursion. Sandra Brooke tracked registrations, corresponded with participants, kept track of money, and organized numerous other details. Her efforts deserve special recognition. Finally, and perhaps most importantly, Robyn Young helped keep the organizational chaos in its proper perspective.

PROGRAM & ACTIVITY SCHEDULE

Sunday, August 24

18:00-21:30 Registration desk open at the SWOCC performing arts center.

Monday, August 25

8:00-9:00 Registration desk open (also open during breaks throughout the day)

9:00 **Young, C.M.** Welcome to Oregon and general introduction.

Session 1. Physiological ecology of deep-sea and midwater organisms

Chairpersons: Ben Wigham, Jorundur Svavarsson

9:15 **Bailey, D.M., P.M. Bagley, A.J. Jamieson, A. Cromarty, M.A. Collins, B. Genard, J.-F. Rees, A. Tselepidis and I.G. Priede.** Integrated studies of deep-sea animal physiology and activity: experiments on the eel *Synaphobranchus kaupi* and the shrimp *Acanthephyra eximia*.

9:30 **Genard, B., A. Dekerchove, D.M. Bailey, S. Dupont, M.A. Collins, I.G. Priede and J.-F. Rees.** Seasonal, ontogenical and depth-dependent variations in metabolic enzyme activities and protein content in muscles of deep-sea demersal fish.

9:45 **Bernhard, J.M. and S.S. Bowser.** The peroxisome puzzle: do foraminifers living in sulfide-enriched sediments respire using peroxisomal oxygen?

10:00 **Wigham, B.D., B.J. Bett, D.S.M. Billett and A.J. Gooday.** Patterns of megabenthic community structure and activity in relation to oxygen minima on the Oman continental slope, NW Arabian Sea.

10:15 **Kemp, K., A. Jamieson, P.M. Bagley and I.G. Priede.** Physical time signals in the deep sea, and the behavioural and physiological response of the fish community.

10:30 Refreshment Break

11:00 **Stowasser, G., R. McAllen, G.J. Pierce, C.F. Moffat, M.A. Collins and I.G. Priede.** Fatty acids and stable isotopes: a new approach to the trophic ecology of the deep-sea ichthyofauna.

11:15 **De Kerchove, A, B. Genard, M.A. Collins, I.G. Priede and J.-F. Rees.** Muscles metabolic enzymes and swimming speeds in *Antimora rostrata* and *Coryphaenoides (N.) armatus*, two deep-sea demersal fish.

11:30 **Jörundsdottir, K. and J. Svavarsson**. Eyelessness among the Gnathiidae (Crustacea, Isopoda).

11:45 **Herring, P.J., E.A. Widder and C. Cope.** Fishes with red lights: different structures, different mechanisms.

12:00 **Battle, E.J.V., M.A. Collins, J.C. Partridge, P.M. Bagley and I.G. Priede.** Observations of pelagic and benthic deep-sea bioluminescence in the North East Atlantic Ocean using an ISIT camera.

12:15 Lunch

Session 2. Physiology and ecology of vent and seep organisms.

Chairpersons: Jozee Sarrazin, Yoshihiro Fujiwara

13:15 **Prieur, D., D. Flament, G. Henneke, G. Erauso, C. Geslin, E. Jolivet, M. Le Romancer, S. Lucas, V. Marteinsson, J.-P. Raffin and J. Querellou.** New biological microbial models from deep-sea hydrothermal vents.

13:30 **Le Bris, N., M. Zbinden, P.-M. Sarradin and F. Gaill.** Chemical constraints in the *Alvinella pompejana* environment: new insights.

13:45 **Skebo, K.** Distribution of zooplankton and nekton above hydrothermal vents on the Juan de Fuca and Explorer Ridges.

14:00 **Fujiwara, Y., M. Kawato, K. Uematsu, S. Arakawa, T. Miwa, Y. Suzuki, T. Sato and C. Kato.** Dual "symbiont transmission mechanisms" of a hadal thyasirid clam, *Maorithyas hadalis.*

14:15 **Yancey, P.H., N.K. Rosenberg, R.W. Lee, K.M. Kemp and D.M. Bailey.** Unusual organic osmolytes in abyssal and hydrothermal-vent animals: adaptations to hydrostatic pressure and sulfide metabolism?

14:30 **Dreyer, J. and C.L. Van Dover**. Time-series comparison of hydrothermal-vent mussel bed communities on the East Pacific Rise between 1999 and 2001.

14:45 **Sarrazin, J., S.K. Juniper, C. Levesque, M.K. Tivey, G. Massoth and P. LeGendre.** Mosaic community dynamics on Juan de Fuca Ridge sulfide edifices: refining a model of community succession.

15:00 **Levin, L.A., W. Ziebis and G. Mendoza .** Metazoan response to sulfide stress at Pacific methane seeps: distribution, community structure, nutrition, and recruitment.

15:15 Refreshment Break

Session 3. Methods, approaches and tools in deep-sea research

Chairperson: Karen Stocks

15:45 **Horton, T. and Bett, B.** A comparative trial of macrobenthos samplers—the box corer versus the megacorer.

16:00 **Jamieson, A., P.M. Bagley, D. Bailey, M.A. Collins and I.G. Priede**. Bentho-pelagic fish behavioural responses to autonomous lander platforms.

16:15 **Bagley, P.M, A. Jamieson, E. Battle, D. Bailey, M. Player and I.G. Priede.** New approaches to observations of deep-sea mid-water fauna using free-fall, profiler and drifter vehicles.

16:30 **Grassle, J.F., Y. Zhang and K. Stocks.** The ocean biogeographic information system: a new tool for deep-sea biology.

16:45 **Billett, D.S.M.** Deep-sea sediment biodiversity: results of the Census of Marine Life Hatfield Workshop.

17:15-19:00 Welcoming reception (Lakeview Rooms in the SWOCC Performing Arts Center).

18:00-21:30 Shuttle transportation to downtown Coos Bay, Charleston and North Bend.

Tuesday, August 26

Session 4. Human impacts and marine protected areas.

Chairpersons: Hjalmar Thiel, Bob George

8:30 **Blake, J.A., N.J. Maciolek and I.P. Williams.** Rapid recolonization of infaunal benthos at a deep-sea disposal site.

8:45 **Narayanaswamy, B.E. and J.D. Gage.** Time-series monitoring of deep-water environments.

9:00 **Barry, J.P., J.C. Drazen, K.R. Buck, B.A. Seibel, M.N. Tamburri, C. Lover and L. Kuhnz.** Field experiments on the biological impacts of deep-sea Co_2 injection.

9:15 **Thistle, D., K.R. Carman, L. Sedlacek, J.P. Barry, P.G. Brewer and J.W. Fleeger.** Consequences for the deep-sea fauna of injection of liquid carbon dioxide: preliminary results.

9:30 **Baker, K. and R.L. Haedrich.** Could some deep-sea fishes be species-at-risk?

9:45 **Stocks, K.I. and G.W. Boehlert**. Seamounts and submarine canyons: the known, the unknown, the unknowable, and future steps.

10:00 **Schlacher, T.A., M.A. Schlacher-Hoenlinger, B.R. De Forges and J.A. Hooper.** Elements of richness and endemism in sponge assemblages on seamounts.

10:15 **Howard, C.** APEC Fisheries Working Group and deep-sea fisheries.

10:30 Refreshment Break

11:00 **George, R.Y.** Deep-sea *Lophelia* coral reefs and gorgonian forests in the North Atlantic Ocean as marine protected areas.

11:15 **Colaço, A, F. Tempera, F. Cardigos and R. Serrão Santos**. Offshore marine protected areas on the Azores: why, where and what for?

11:30 **Christiansen, S.** Tackling the conservation of deep-sea biota—the way forward.

11:45 **Gianni, M.** Seamounts and the biodiversity of the Deep Sea: United Nations General Assembly initiatives to protect the wealth of species on the high seas.

12:00 **Thiel, H.** Protection of high-seas areas—status report.

12:30 lunch

Session 5. Benthic-pelagic coupling: Short-term responses

Chairperson: Ursula Witte

13:30 **Witte, U.** The fate of organic carbon settling at the deep-sea floor: an experimental approach.

13:45 **Sommer, S.** Meiobenthic response to the pulsed deposition of phytodetritus—an *in situ* experiment in the Porcupine Abyssal Plain.

14:00 **Buehring, S.I., N. Lampadaiou, L. Moodley, A. Tselepides and U. Witte.** Benthic response to varying food input: *in situ* experiments in the oligotrophic Mediterranean.

14:15 **Aspetsberger, F., A. Ahke, T. Ferdelman, M. Zabel and U. Witte.** Influence of organic carbon quality on benthic mineralization: *in situ* experiments in a high-productivity area.

14:30 **Gage, J.D., R.D. Anderson, P.A. Tyler, R. Chapman and E. Dolan.** Ravenous for phytodetritus: can brittle star opportunists prevent phytodetrital mass accumulation in the N.E. Atlantic?

14:45 **Billett, D.S.M., B.J. Bett and B.D. Wigham.** Jelly lakes in the abyssal Arabian Sea—massive food falls?

15:00 **Debenham, N.J., P.J.D. Lambshead, T.J. Ferrero and C.R. Smith.** Do whale fall events increase nematode abundance?

15:15 **Hughes, D.J., L. Brown, G.T. Cook, G. Cowie, J.D. Gage, E. Good, H. Kennedy, A.B. MacKenzie, S. Papadimitriou, G.B. Shimmield, J. Thomson and M. Williams.** Using biology to inform geochemistry: analysis of burrow contents from two sites in the bathyal N.E. Atlantic.

15:30 Refreshment Break

Session 6. Benthic-pelagic coupling: long term responses

Chairperson: Tassos Tselepides

16:00 **Smith, K.L. Jr., R.J. Baldwin, H.A. Ruhl, B.G. Mitchell and M. Kahru.** Climate change and benthic boundary layer processes at 4,100 m depth in the N.E. Pacific: a 13-year time-series study.

16:15 **Gooday, A.J. and G. Malzone.** Long-term (decadal) changes in 'live' benthic foraminiferal assemblages at an abyssal site in the NE Atlantic.

16:30 **Ruhl, H.A. and K.L. Smith, Jr.** Variation in deep-sea epibenthic megafauna distribution and abundance, and particle flux in the N.E. Pacific.

16:45 **Hudson, I.R., B.D. Wigham, D.S.M. Billett, D.W. Pond, P.A. Tyler and G.A. Wolff.** Deep-sea biology, food for thought? Seasonal and reproductive aspects of food availability in deep-sea holothurians.

17:00 **Tselepides, A., E. Hatziyanni, N. Lampadariou and C. Corselli.** Benthic community structure in the deep hypersaline anoxic basins of the Eastern Mediterranean Sea.

17:15 **Johnson, N.A., J.W. Campbell, T.S. Moore, C.R. McClain, M.A. Rex and M.D. Dowell.** Surface-benthic coupling and the structuring of deep-sea communities.

17:30 **Snelgrove, P.V.R., P.A. Ramey and B. Oake**. Regulation of deep, cold ocean, benthic infauna by surface processes.

Session 7. Discussion on human impacts and marine protected areas.

Discussion leaders: Hjalmar Thiel, Bob George

17:45-18:30 Open discussion for all interested participants.

18:00-21:30 Shuttle transportation to downtown Coos Bay, Charleston and North Bend.

Wednesday, August 27

Session 8: Benthic-pelagic coupling at high latitudes.

Chairperson: Paul Snelgrove

8:15 **Smith, C.R., S. Mincks, A. Glover, D.J. DeMaster and P.Y. Sumida.** Food banks of the deep Antarctic shelf: the impact and fate of summer bloom material at the seafloor.

8:30 **Galley, E., P.A. Tyler, A. Clarke and C. Smith.** Responses of benthic organisms on the deep Antarctic continental shelf to a highly seasonal food supply.

8:45 **Mincks, S.L., C.R. Smith, D.J. Demaster and C.J. Thomas.** Benthic response to seasonal phytodetritus deposition on the west Antarctic Peninsula shelf.

9:00 **Schewe, I. and Soltwedel, T.** Living on the (ice-) edge: first results from inter-annual and seasonal studies at an Arctic deep-sea benthic station.

9:15-11:45 Poster Session (and break)

12:15 Buses depart for mid-conference excursion.

12:15-13:00 Tour of Cape Arago, Simpsons Reef, Shore Acres

13:00-13:30 Buffet Lunch at Sunset Bay

13:30-15:30 Tour of southern Oregon coast, Coos Bay to Gold Beach

15:30-21:00 Rogue River mail boat run (includes dinner at Singing Springs Resort, Agness)

21:00-23:00 Bus ride home.

Thursday, August 28

Session 9. Population genetics, evolution and systematics

Chairpersons: Amy Baco, Scott France

8:15 **Rogers, A.D. and M. Le Goff**. Genetic structure of *Lophelia pertusa* populations in the NE Atlantic

8:30 **Baco, A.R.** Population genetic structure of Hawaiian precious corals using microsatellites.

8:45 **France, S.C.** Patterns of mitochondrial DNA sequence variation in deep-sea octocorals.

9:00 **Shank, T.M.** Genetic structure of nascent biological communities at Galápagos rift vent fields

9:15 **Vrijenhoek, R.** A new look at evolutionary pathways and the age of deep-sea hydrothermal vent taxa.

9:30 **Martin, J.W. and T. Shank.** Decapod crustaceans from hydrothermal vents and cold seeps: an update.

9:45 **Mah, C.** Species-level phylogenies in the Goniasteridae (Asteroidea: Echinodermata): patterns of evolution in deep-sea starfish.

10:00 **Santini, F.** Phylogeny and historical biogeography of the Triacanthodidae (Tetraodontiformes, Teleosti), with comments on the role of island arcs systems and Pleistocene sea level changes in causing the present-day distribution of this clade.

10:15 **Boyle, E.E., R.J. Etter and M.A. Rex.** Phylogeography of the deep-sea rissoid gastropod *Benthonella tenella.*

10:30 Refreshment Break

Session 10. Biology of the deep Gulf of Mexico

Chairpersons: Tracey Sutton, Charles Blend

11:00 **Schroeder, W.W.** Observations of hard substrate and epibenthic megafauna at an upper slope site in the Gulf of Mexico.

11:15 **Sutton, T., T. Hopkins and S. Burghart.** Who is eating most of the zooplankton in the oceanic Gulf of Mexico? The impact of mesopelagic fishes.

11:30 **Blend, C.K. and N.O. Dronen**. Helminth parasites of deep-sea fishes from the Gulf of Mexico and Caribbean Sea.

11:45 **Carney, R.S., S. MacAvoy, S.A. Macko and C.H. Fisher.** Isotopically traced scenarios of background/foreground trophic interaction at Gulf of Mexico hydrocarbon seeps: exporting or importing?

12:00 **Rowe, G., J. Morse, M. Wicksten, J. Deming, E. Escobar Briones, R. Haedrich and P. Montagna.** Structure and function of benthic communities in the deep Gulf of Mexico.

12:15 **Wilson, G.D.F**. Benthic isopod diversity in the Gulf of Mexico.

12:30 lunch

Session 11. Patterns of abundance and diversity

Chairpersons: Angelika Brandt, Kurt Buck

13:30 **Rex, M.A., C.R. McClain and N.A. Johnson.** A source-sink hypothesis for abyssal biodiversity.

13:45 **Brenke, N.** Faunal diversity and zoogeography of the abyssal asellota (Crustacea: Isopoda) in the Southeast Atlantic deep sea.

14:00 **Brandt, A., H.-G. Andres, N. Brenke, S. Brix, J. Guerrero-Kommritz, U. Mühlenhardt-Siegel and W. Wägele.** Abundance, diversity and community patterns of peracarid crustaceans (Malacostraca) from the abyssal plain of the Angola Basin.

14:15 **Gage, J.D., P.J.D. Lambshead, J.D.D. Bishop, N.S. Jones and B.E. Narayanaswamy.** Large-scale biodiversity pattern of cumacea in the deep Atlantic.

14:30 **VanReusel, A., A. Muthumbi, M. Raes, S. Van Gaever, S. VanHove and H. Vermeeren.** High nematode species diversity in the deep sea: correlations and causes for diversification within genera?

14:45 **Glover, A.G., C.R. Smith, G.L.J. Paterson and G.D.F. Wilson**. The worm's turn: species diversity on the Central Pacific Abyssal Plain.

15:00 **Haddock, S.H.D.** Natural history of deep-sea tuscarorid radiolarians.

15:15 **Buck, K.R., K.R. Carman, D. Thistle, L. Kuhnz, C. Lovera and J.P. Barry.** Sediment standing stocks from an abyssal site in Monterey Canyon, California.

15:30 **Rowden, A.A., M.R. Clark, S. O'Shea and D.G. McKnight.** Biodiversity of the Kermadec Volcanic Arc seamounts: an opportunity to answer long-asked questions.

15:45 Refreshment Break

Session 12. History of deep-sea biology.

Chairperson: Craig Young

16:15 **Campos-Creasey, L.S, H.P. Lavrado, P. Costa and A.P.C. Falcão.** Brazilian deep-sea biology research: a recent history overview.

16:30 **Wolff, T.** The Danish *Dana* Expeditions: Purpose and Accomplishments.

17:00 **Morita, R.Y.** Early and recent history of deep-sea microbiology.

18:15 Buses depart for Banquet at OIMB

Friday, August 29

Session 13. Reproduction, development and larval biology.

Chairpersons: Eva Ramirez, Florence Pradillon

9:00 **Drazen, J.C., S.K. Goffredi, B. Schlining and D.S. Stakes.** Aggregations of egg brooding deep-sea fish and cephalopods on the Gorda Escarpment: a reproductive hotspot.

9:15 **Voight, J.R.** The biggest baby octopus in the world: hatchlings of *Graneledone*.

9:30 **Benitez Villalobos, F. and P.A. Tyler.** Temperature and pressure tolerances of embryos and larvae of the Atlantic seastar *Asterias rubens* (Echinodermata Asteroidea): potential for deep-sea invasion from shallow water.

9:45 **Brooke, S.D. and C.M. Young.** Embryogenesis and larval biology of the ahermatypic scleractinian coral *Oculina varicosa*: implications for ecosystem recovery.

10:00 **Hilario, A., P.A. Tyler and C.M. Young.** Why do female vestimentiferans store sperm?

10:15 **Järnegren, J., C.M. Young, C.R. Tobias and S.A. Macko.** Oophagous lifestyle in *Acesta bullisi*, a bivalve associated with cold-seep tube worms

10:30 Refreshment Break.

11:00 **Waller, R.G. and P.A. Tyler.** The reproductive ecology of two deep-water reef building corals in the N.E. Atlantic Ocean.

11:15 **Tyler, P.A., E. Dolan, M. Baker and C.M. Young.** Gametogenic periodicity in the genus *Bathymodiolus*.

11:30 **Howell, K.L., A.D. Rogers, P.A. Tyler and D.S.M. Billett.** Reproductive isolation among morphotypes of the Atlantic seastar species Zoroaster fulgens (Asteroidea: Echinodermata).

11:45 **Geiger, D.L. and C.L. Thacker**. Colonization patterns of the deep sea: insights from basal snails (Vetigastropoda) using molecular phylogenetics.

12:00 .**Pradillon, F., M. Zbinden and F. Gaill.** Reproductive patterns in *Alvinella pompejana* (Polychaeta: Alvinellidae) colonies from 9°N and 13°N EPR hydrothermal vents.

12:15 Lunch

Session 14. Distribution and Zonation

Chairpersons: Gritta Veit-Köhler, Craig McClain

13:15 **C.G. Messing.** Biozonation on deep-water carbonate mounds and associated hardgrounds along the western margin of Little Bahama Bank, with notes on other deep Bahamian bank-margin assemblages.

13:30 **Osborn, K.** Distribution and feeding of munnopsid isopods in the deep water column of the Gulf of California, Mexico.

13:45 **Veit-Köhler, G.** Typical shallow water Copepoda Harpacticoida in the Atlantic deep sea.

14:00 **Yeh, H.M. and S. Ohta.** Modified concept of faunal zonation suggested from the horizontal and vertical trend of zonation of deep-sea demersal fish around Japan.

14:15 **Henriques, C., I.G. Priede, M.A. Collins and P.M. Bagley.** Scavenging fishes of the deep Eastern Atlantic Ocean: a comparison of behaviour and distribution at latitudes 49°N to 10°S

14:30 **Ingole, B.** Distributional Pattern of Deep-sea Macrofauna in the Indian Ocean.

14:45 **Moore, J.A.** Biogeography of the deep-sea fish fauna off New England.

15:00 **McClain**, C.R. A new hypothesis for bathymetric size clines in the deep sea.

15:15 Refreshment Break

Session 13: Cold seeps and allied ecosystems.

Chairperson: Thomas Soltwedel

15:45 **Soltwedel, T., N.-V. Quéric & I. Schewe.** Gradients in activity and biomass of the small-sized benthic biota around the Håkon Mosby Mud Volcano, SW Barents Sea slope.

16:00 **Sibuet, M., J.C. Caprais, P. Crassous, S. Duperron, M.C Fabri, A. FIFIS, J. Galéron, A. Khripounoff, L. Menot, T. Nadalig, K. OLU-Le Roy, A. Vangriesheim, A. Andersen, and R. Von Cosel.** Rich and complex deep sea ecosystems on the equatorial African margin: general objectives and results of the BIOZAIRE environmental program.

16:15 **Olu-LeRoy, K., T. Nadalig, J.C. Caprais, A. Fifis, M.C. Fabri, H. Ondréas and M. Sibuet.** Spatial variability of the chemosynthetic fauna, chemical environment and microbial communities on a giant pockmark in the Gulf of Guinea.

16:30 **Galeron, J., N. Cam, J.C. Caprais, P. Crassous, M.C. Fabri, A. Fifis, A. Khripounoff, L. Menot, M. Moison,**

T. **Nadalig, K. Olu, M. Sibuet and A. VanGriesheim.** Macrofauna communities in detritic and chemosynthetic based ecosystems in the Gulf of Guinea.

16:45 **Mills, A., C. Ruppel and C.L. Van Dover.** Windows to the deep: explorations of the Blake Ridge methane hydrate reservoir.

17:00 Business Meeting

ABSTRACTS OF ORAL PRESENTATIONS

Aspetsberger, F., A. Ahke, T. Ferdelman, M. Zabel, and U. Witte
Geosciences Faculty, University of Bremen, Germany and Max Planck Institute For Marine Microbiology, Bremen, Germany

INFLUENCE OF ORGANIC CARBON QUALITY ON BENTHIC MINERALIZATION: *IN SITU*-EXPERIMENTS IN A HIGH-PRODUCTIVIY AREA

Particulate organic carbon (POC) arriving at the sea floor has been altered by vertical transport from surface waters, resuspension in the benthic boundary layer or lateral transport along the slope. Accordingly, the proportion of refractory components varies, together with changing contributions of initially autochthonous or terrigeneous material. Both source and availability of POC play key roles for microbially mediated organic-carbon turnover, thereby being critical for carbon cycling and transfer through the ocean. To investigate the influence of the quality of POC arriving at the sea floor on this turnover, a series of *in situ*-experiments was carried out using a benthic chamber lander. In the Benguela Upwelling Region, several sites were selected to cover gradients of depth and TOC-content. Both fresh and degraded ^{13}C-labelled algal material as well as shelf sediment was injected into the chambers to simulate a POC pulse of varying quality and follow its benthic response. Supplementing *on board*-incubations allowed for longer incubation times of up to 15d. Total benthic mineralization of POC was measured via sediment community oxygen consumption (SCOC) and $DI^{13}C$ concentration in the chamber water. Sediment $TO^{13}C$ and porewater $DI^{13}C$ indicated the profile and penetration-depth of added material. Chlorins characterized its reactivity. Following evidence that microorganisms as well as macrofauna play a major role in the early diagenesis of POC, bacterial productivity and ^{13}C-incorporation rates into those compartments were investigated. First results of uptake and incorporation variables and nutrient analysis display conspicuous differences between the different enrichments and settings, indicating a criticial role of quality of POC settling at the deep sea floor for the sediment community response.

Baco, A.R.
Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA, U.S.A.

POPULATION GENETIC STRUCTURE OF HAWAIIAN PRECIOUS CORALS USING MICROSATELLITES

Hawaiian deep-sea precious corals support an extremely profitable fishery, yet little is known about the life history and dispersal of the exploited species. Recent studies indicate significant genetic structure between shallow-water coral populations, including several species capable of long distance dispersal. If significant genetic structure exists in populations of precious corals, this could suggest that the elimination (through overharvesting) of a bed of precious corals would result in loss of overall genetic diversity in the species. The goal of this study is to determine the appropriate management units (or "stocks") for Hawaiian deep-sea precious corals. Stocks are identified for *Corallium laauense* based on 6 microsatellite loci. Microsatellites are segments of DNA that consist of repeated units of short (di- or tri-nucleotides) sequences. Microsatellites are highly variable, making them ideal for kinship and population-level studies. By determining the stock structure of the harvested species and providing information on dispersal and recruitment in these species as a function of life history, this project will substantially improve our ability to manage the Hawaiian coral fishery as a sustainable resource. This project will also provide insights into dispersal and gene flow of seamount fauna.

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NEW APPROACHES TO OBSERVATIONS OF DEEP SEA MID-WATER FAUNA USING FREE-FALL, PROFILER, AND DRIFTER VEHICLES

Observation of intact mid-water animals is difficult to achieve; some are very delicate gelatinous organisms that are easily damaged by sampling gear and others are mobile and rapidly escape on the approach of the vehicle. Traditionally, mid-water fauna have been sampled using mid-water trawls such as the RMT or multiple nets such as the MOCNESS. These do not allow elucidation of the natural 3D relationships between organisms or their individual orientations.

A new approach is the free-fall vehicle with an impact mesh screen placed beneath a downward-looking ISIT camera. As the system falls from the surface to the sea floor it intercepts organisms which are stimulated to luminesce, and detailed profiles are obtained of the vertical distribution of bioluminescent fauna. This has been applied in a number of areas of the NE Atlantic Ocean. This system is complementary to video profiling system such as French Underwater Video Profiler (Gorsky *et.al*, 2000), and off Norway comparisons were made between video data and bioluminescence data. However, descent of a vehicle through the water either on a wire or in free-fall mode does generate a disturbance. Sonar observations are presented of vehicle avoidance by mobile fauna.

Much progress has been made in mid-water observations using ROVs such as the MBARI system (Robison, 2000) but these have limited duration on site requiring the presence of a mother ship. We present here a Lagrangian vehicle that can hover indefinitely in mid water creating no shear stresses, thus providing a stealthy platform for *in situ* observation. Further, environmental conditions could be followed, such as light levels, to observe the effect on the local community.

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INTEGRATED STUDIES OF DEEP-SEA ANIMAL PHYSIOLOGY AND ACTIVITY: EXPERIMENTS ON THE EEL *SYNAPHOBRANCHUS KAUPI* AND THE SHRIMP *ACANTHEPHYRA EXIMIA*

Measuring the physiological characteristics of deep-sea animals and putting these results into an ecological and behavioural context is challenging due to difficulties in observing animals in their natural habitats and in obtaining them alive for experimentation.

One approach to this problem is to undertake studies of a measurable trait in many species and to correlate these data to known environmental gradients. Building up a full understanding of the biology of a species from these data can often only be attempted by assembling data from a multitude of studies often from different depths, seasons, or oceans. Unfortunately for demersal species this may be inappropriate due to the great spatial and temporal heterogeneity of the benthic environment.

We attempted several different studies on single species within a small temporal and spatial range. Deep-water trawling and *in situ* experiments on swimming and foraging behaviour, muscle performance, and metabolic rate were performed in the Atlantic Ocean and Mediterranean Sea. These provided multiple measurements of *in vivo* biology and *in vitro* muscle metabolism for the Eel *Synaphobranchus kaupi* and the shrimp *Acanthephyra eximia*.

Both species had higher metabolic rates and activity levels than expected, probably due to current regime and energy supply in *S. kaupi* and water temperature in *A. eximia*. The combination of current velocity, temperature, oxygen consumption and activity data collected *in situ*, and the *in vitro* analysis of trawl-caught samples obtained within a short distance of the lander stations was essential to understanding the biology of these animals. This study was supported by NERC grant GR3/12789

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COULD SOME DEEP-SEA FISHES BE SPECIES-AT-RISK?

Because they are widespread and therefore exist in large numbers, deep ocean fishes are usually not considered as potentially endangered species. Nonetheless, their slow growth rates, late maturity, and long life span are characteristics that make them susceptible to severe disturbances such as over-fishing. Dramatic decreases in abundance have already been documented in some exploited deep-ocean species. Data from a 16-year scientific survey time series were used to determine the change in abundance of five important deep shelf and continental slope fishes in the northwest Atlantic. Two species, *Coryphaenoides rupestris* and *Macrourus berglax*, have been exploited and three, *Antimora rostrata, Bathyraja spinicauda,* and *Notacanthus chemnitzi*, have been taken as significant bycatch. All, with the possible exception of *Antimora* whose depth range extends considerably below commercial fishing depths, qualify as "critically endangered" under The World Conservation Union's (IUCN) criterion of population decline exceeding 80% over three generations. Fishery exclusion zones, such as those proposed to protect deep-sea corals and the northern cod in Canadian offshore waters, could benefit these and other species. Biodiversity maps based on the fish surveys suggest candidate areas for deepwater Marine Protected Areas (MPAs) in the region.

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FIELD EXPERIMENTS ON THE BIOLOGICAL IMPACTS OF DEEP-SEA CO_2 INJECTION

Methods to sequester fossil fuel carbon by geologic or deep-sea injection of liquid CO2 are now under serious scrutiny to mitigate the rapid rise in atmospheric greenhouse gases. Fossil carbon emissions to the atmosphere, presently near 6 $GtCy^{-1}$, will increase through this century, possibly leading to atmospheric CO_2 concentrations 2-3 times greater than pre-industrial levels. In addition to the well-publicized effects on global climate, approximately 1/3rd of the fossil fuel CO_2 released enters the surface ocean through air/sea exchange. The pH of the ocean's surface has decreased by 0.1 units over the past 100 y, and continued acidification is certain over the next 1-2 centuries.

Deep-ocean environments have an enormous sequestration potential for CO_2, but the sensitivity of many deep-sea organisms to environmental perturbations (including pH) suggests that large scale CO_2 injection would have important ecosystem impacts. To date, however, there have been very few direct experiments on the effects of low pH conditions on deep-sea animals. We evaluated the potential biological impacts of direct ocean CO_2 sequestration for deep-sea species during deep-sea field experiments off California recently using small-scale (<100 liter) releases of liquid CO_2. Animals (echinoderms, crustaceans, and meiofaunal groups) exposed to low pH plumes (~pH 6-6.5) resulting from the dissolution of liquid CO_2 experienced high rates of mortality. Milder pH changes had few detectable effects. These results indicate that damage to deep-sea ecosystems from large-scale ocean carbon sequestration will be substantial near release sites, with large-scale impacts depending on the volume and duration of CO_2 injection.

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OBSERVATIONS OF PELAGIC AND BENTHIC DEEP-SEA BIOLUMINESCENCE IN THE NORTH EAST ATLANTIC OCEAN USING AN ISIT CAMERA.

An ISIT camera, mounted on an autonomous lander system has been used to record bioluminescent events *in situ* in the Porcupine Seabight and Abyssal Plains regions of the north-east Atlantic Ocean down to 4800m depth. Benthic observations have been made of bioluminescent animals attracted to bait. Spatial analysis was carried out to examine distribution of events in the field of view. Greatest response was observed at 1000m, with an average of 5 events per minute, compared to only 0.5 events per minute at 4000m over a 3 hour period. The bioluminescent organisms are most likely infaunal species including polychaete worms or burrowing ophiuroids.

The deepest vertical profiles of bioluminescence have also been made on the Porcupine Abyssal Plain using the freely falling ISIT lander, recording from just below the surface to 4800m. These videos show an exponential decrease in the number of stimulable bioluminescent animals with increasing depth. A seasonal difference between deployments in spring and autumn of 2001 and 2002 has been observed for the first time. Bioluminescence data will be presented along with various environmental parameters collected from current meter data and CTD profiles.

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TEMPERATURE AND PRESSURE TOLERANCES OF EMBRYOS AND LARVAE OF THE ATLANTIC SEASTAR *ASTERIAS RUBENS* (ECHINODERMATA ASTEROIDEA): POTENTIAL FOR DEEP-SEA INVASION FROM SHALLOW WATER.

Eggs of the shallow-water asteroid *Asterias rubens* were fertilized *in vitro* and incubated through the early embryonic cleavages until the larval stage. Early embryos, blastulae, gastrulae, and swimming bipinnaria were subjected to a temperature/pressure regime of 5, 10, 15 and 20° C and 1, 50, 100, 150 and 200 atm. Early embryos were able to tolerate pressures up to 150 atm at 15° C and 100 atm at 10° C. Survivorship of swimming bipinnaria remained high (> 70 %) after incubation at all the pressure/temperature combinations. The higher number of swimming larvae was 98 % at 10° C/100 atm and the lower was 72 % at 15° C/200 atm. The survivorship decreased as the pressure increased; nevertheless the larvae generally tolerated the pressures of 200 atm although they appeared smaller and more compact on or after 150 atm. Data for the temperature and pressure effects on the later stages of development suggest that the all the larval stages are more temperature/pressure tolerant than the early embryos and survivorship become wider with larval age, and that all the developmental stages have a potentially wider depth distribution than their respective adults. Therefore, the larvae of the shallow water species *Asterias rubens* could survive transport to deeper waters and this species may be capable of sending colonists to the deep sea.

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THE PEROXISOME PUZZLE: DO FORAMINIFERS LIVING IN SULFIDE-ENRICHED SEDIMENTS RESPIRE USING PEROXISOMAL OXYGEN?

In many taxa, two major functions of peroxisomes are the beta-oxidation of long chain and polyunsaturated fatty acids and the conversion of the reactive oxygen species (ROS) hydrogen peroxide to water and oxygen. Peroxisome complexes (PC) are a striking ultrastructural feature in the cytoplasm of *Nonionella stella*, the major eukaryotic biomass contributor in the bathyal oxygen-depleted, sulfide-enriched Santa Barbara Basin. *Nonionella* peroxisomes contain crystalline catalase, the enzyme necessary to convert H_2O_2 to water and oxygen, and numerous mitochondria are seen vesting PCs, but the physiological significance of this unique arrangement is unknown. Besides being a byproduct of the oxidation pathway, H_2O_2 is also produced during oxidation of environmental H_2S. PCs can be voluminous in *Nonionella*'s environmentally accessible youngest chamber, so they are potentially a physiological defense against environmental, as well as metabolic, ROS. Because its habitat includes H_2O_2 and only trace [O_2], we hypothesize that *N. stella* respires oxygen liberated from peroxisomes. Results indicate that *N. stella* survives exposure to 9 µM H_2O_2, a concentration known to be detrimental to other eukaryotes. Additional results, including cytochemical localization of peroxide production, will be presented from a series of experiments designed to solve this peroxisome puzzle.

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DEEP-SEA SEDIMENT BIODIVERSITY: RESULTS FROM THE CENSUS OF MARINE LIFE HATFIELD WORKSHOP

The Census of Marine Life (CoML) is organising a small workshop on the biodiversity of deep-sea sediments immediately before the Deep-Sea Biology Symposium. The workshop is being held at the Hatfield Marine Science Center, Newport, Oregon from 20 to 24 August 2003. The workshop aims to 1) review our knowledge of biodiversity in deep-sea sediments, 2) identify key questions that need to be addressed by the international scientific community over the next 10 years, 3) determine gaps in our present and planned activities and 4) agree upon an international CoML sampling specification. The workshop will divide into two sub groups. One will focus on continental slopes and the other on abyssal plains. This talk will review the results of the workshop in order to stimulate debate in thewider deep-sea biology community. A draft document of the results from theworkshop will be available for comment and views expressed at the Deep-SeaBiology Symposium will be used to modify the document before it is submitted to the CoML Steering Committee ahead of the launch of the international programme in October 2003.

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JELLY LAKES IN THE ABYSSAL ARABIAN SEA – MASSIVE FOOD FALLS?

Dense swarms of the jellyfish *Crambionella orsini* have occurred in the northern Arabian Sea in the last two years. Their abundance has been so high that they have affected fishing operations off Iran and have blocked the seawater intake pipes of desalination plants in Oman. During work in the Gulf of Oman, December 2002, the DEEPSEAS group used the SHRIMP (Seabed High Resolution IMaging Platform) camera system to view the seabed between depths of 300 and 3300m. Numerous canyons cut the underwater landscape of the continental slope off Oman. Our video observations suggest that the canyons act as traps and conduits for the rapid passage of moribund jellyfish into deep water. Great numbers of jellyfish were seen tumbling downslope. Moreover, at the base of the slope, c. 3300m, the jellyfish were gathered in "lakes" tens of metres in diameter and about 10cm thick, forming an amorphous layer of slime. Elsewhere the seabed was covered with many individual jellyfish corpses. The jellyfish carcasses appeared to be being broken down by white, mat-forming bacteria. There was little evidence of any other fauna feeding directly on the jellyfish carcasses. When the surfaces of the "lakes" were disturbed a black layer was revealed, suggesting that the jellyfish slime had resulted in anoxic conditions at the sediment surface. We consider further what these observations mean for carbon transport to the deep sea and what the long-term consequences may be for the benthic fauna.

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RAPID RECOLONIZATION OF INFAUNAL BENTHOS AT A DEEP-SEA DISPOSAL SITE

The San Francisco Deep Ocean Disposal Site in 2700-3000 m was designated in 1994. Until 2002, the biological samples collected during monitoring surveys were archived, with only sediment profile images and chemistry samples analyzed. Analysis of the 2002 benthic samples was authorized along with archived samples from five of the seven previous years to reassess monitoring thresholds. Results from 2002 demonstrate that despite seven years of dredged material disposal, the benthic infauna is rich and clearly zoned in the same manner established in baseline surveys (1990 and 1991). Fifteen samples from September 2002 yielded a total of 405 species, comparable with 458 species from 28 samples collected during the baseline period. Approximately 50 species collected in 2002 were not recorded in 1990-1991. We estimate that 67% of the species are new to science. The lower slope sites in 2850-3136 m were dominated by long and thin-bodied polychaetes such as *Prionospio delta*, *Levinsenia flava*, and species of *Cossura*. Stations from about 2450 to 2775 m included more robust polychaetes such as *Aricidea simplex* and *Chaetozone* sp.1. Benthic community parameters, i.e., density, species richness, and diversity were high and consistent with baseline conditions. A station from the center of the disposal site had 57 species present. Preliminary results from analysis of 1998 samples following periods of heavy dredged material disposal indicate that the fauna was heavily impacted. However, the fauna appears to rapidly recolonize the disposal areas when disposal volumes are reduced. Stations on the boundary of the disposal site in 2002 exhibited a very rich and diverse fauna, not unlike that found at reference sites. These results suggest that if disposal were terminated, the disposal site would rapidly return to a pre-disposal assemblage.

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HELMINTH PARASITES OF DEEP-SEA FISHES FROM THE GULF OF MEXICO AND CARIBBEAN SEA

Parasitism can been defined as an intimate heterospecific association, temporary or permanent, where there exists some metabolic dependence of one partner, the parasite, on the other partner, the host. In terms of traditional parasites, it has been estimated that over 50% of extant species are parasitic in at least some stage of their life histories, but if known taxa of fungi, bacteria, and viruses are also included estimates range from 70-80%. Generally, most healthy ecosystems have a high diversity of parasitic species; however, little is known about the parasites of deep-sea habitats. In a study of the helminth parasites of over 1,000 deep-sea fish representing 28 genera and 48 species collected from depths of 200-2,000+ m from the Gulf of Mexico and Caribbean Sea, trematodes from the families Derogenidae, Fellodistomidae, Hemiuridae, Lepocreadiidae, and Opecoelidae were heavily represented, while 1 family of acanthocephalans (Echinorhynchidae) and at least 3 families of monogeneans (Dactylogyridae, Diclidophoridae, Microcotylidae) were also found. Among the most prevalent of helminths are cestodes, represented by larval species of the orders Tetraphyllidea and Trypanorhyncha and adults of the order Pseudophyllidea, and nematodes, represented by larval species of the family Anisakidae and adults of the families Trichuridae, Cucullanidae, Camallanidae, Cystidicolidae, and Rhabdochonidae. Life cycles for parasites found will be hypothesized, and some ecological and zoogeographical observations of parasitism in the deep sea will be discussed. Studies focusing on the helminth fauna of deep-sea organisms are rare and without a better understanding of their biodiversity in deep-sea ecosystems, our understanding of biodiversity as a whole will be incomplete.

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PHYLOGEOGRAPHY OF THE DEEP-SEA RISSIOD GASTROPOD *BENTHONELLA TENELLA*

We know little about how evolution unfolds in the deep sea. Distance, depth, ocean currents, topography (e.g. the Mid-Atlantic Ridge) and evolutionary history can all influence the genetic architecture of deep-sea organisms. To identify the scales of population differentiation and the mechanisms that may isolate gene pools, we quantify genetic variation within and among populations of *Benthonella tenella* , a common benthic gastropod distributed throughout the Atlantic- with a broad bathymetric distribution (200-5000m). A 206bp fragment of the mitochondrial COI gene was amplified and sequenced in 87 individuals that were derived from formalin-fixed or dried museum samples. We found 23 haplotypes distributed among 6 ocean basins; the Gulf of Mexico, North American, West European, Mediterranean, Argentine, and Guyana Basins. There were significant associations between haplotypes and geography indicating populations have diverged. We used nested clade analysis to distinguish between restricted gene flow and historical factors (e.g. fragmentation or range expansion) as potential explanations for population differentiation. There was no significant population differentiation between related haplotypes from the Argentine, Guyana, North American, and Gulf of Mexico Basins. Significant geographic associations between related haplotypes from the West European Basin and shallow North American Basin (800-1200m) suggest continuous range expansion. Population divergence within the deep North American Basin and between the deep North American Basin (3800-5000m) and Gulf of Mexico also appears to be due to range expansion. Population divergence in this species occurs at ocean-wide scales and probably reflects range expansion rather than fragmentation.

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ABUNDANCE, DIVERSITY AND COMMUNITY PATTERNS OF PERACARID CRUSTACEANS (MALACOSTRACA) FROM THE ABYSSAL PLAIN OF THE ANGOLA BASIN

During the expedition DIVA-1 (DIVersity of the abyssal Atlantic Ocean) samples were taken at six stations in July 2000 by means of an epibenthic sledge between 5162-5497 m depth east of the Walfis Ridge in the Angola Basin off Namibia. The macrofauna was dominated by polychaetes, peracarids, and bivalves. Peracarid crustaceans were picked from the samples and sorted to species level. Most of the species found were new to science, in some peracarid families 100% of the species, in total about 98% of the specimens belonged to new species. Dominant elements of the peracarid fauna were Isopoda (99 species), followed by Tanaidacea (49 species), and Cumacea (45 species), Amphopoda were less frequent (<11 species), Mysidacea were rarest (7 species). A cluster analysis and multidimensional scaling of these species and stations were performed on the background of biotic and abiotic factors. Results will be discussed. While depth did not play a major role in structuring peracarid community patterns, sediment parameters, water masses and food supply were more importatant.

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FAUNAL DIVERSITY AND ZOOGEOGRAPHY OF THE ABYSSAL ASELLOTA (CRUSTACEA: ISOPODA) IN THE SOUTH-EAST ATLANTIC DEEP SEA.

Due to fact that the Atlantic deep sea covers about 65 Million km², the number of species, endemits and their distribution is important for the worldwide marine species estimate. For various benthic deep-sea taxa, in contrast to the availability of nutrients and the low number of biological niches, a high species diversity is proved. In different deep sea regions the ratio of new species is between 50 and 100%. However these assumptions are based on a very low number of observations.

The *"DIVA 1"* Expedition to the Angola Basin (southeast Atlantic: 5°-25°S and 5°W-8°E) in July 2000, started with the aim to characterize the invertebrate faunal community of a typical abyssal deep-sea region. Along a 700km long transect 12236 benthic invertebrates from 20 different taxa have been collected. Because of the worldwide distribution and the high diversity, the isopods, in particular the Asellota (21 familys; ~1650 Species) are of high interest. Beside the copepoda (23,5% of all specimens) and polychaeta (23,8%) the asellota rank third (13,2%) with 106 species from 18 families. After identification to species of about half the material it is already evident that the ratio of new species is much lower than in the literature. The typical south polar faunal elements are absent. It could be assumed that the Mid-Atlantic Ridge and the Walvis Ridge act as a barrier for faunal dispersal from the Antarctic regions. On the other hand, a lot of species have a center of distribution in the north Atlantic suggesting a wide horizontal distribution and a lower species turnover in the Atlantic than generally supposed. As a result the estimations for the worldwide marine species richness must be reduced.

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EMBRYOGENESIS AND LARVAL BIOLOGY OF THE AHERMATYPIC SCLERACTINIAN *OCULINA VARICOSA*: IMPLICATIONS FOR ECOSYSTEM RECOVERY

The Ivory Tree Coral *Oculina varicosa*, forms extensive reefs of azooxanthellate colonies at depths of 70-100m along the edge of the Florida Hatteras slope. Healthy reefs support diverse invertebrate and fish communities and are a critical spawning habitat for some commercial fisheries species. In 1984, 92 NM² of the *Oculina* banks were designated the "*Oculina* Habitat of Particular Concern" (OHAPC), but despite legislation the reefs have been badly damaged, (probably by illegal trawling) with little evidence of recovery. Larval survival, behavior and recruitment impact adult population structure but little is known about the effect of environmental factors on the embryos and larvae of ahermatypic corals. Temperature and turbidity levels across the shelf are extremely variable, especially during periodic upwelling events. Although low temperatures (<17°C) inhibited embryogenesis, larval survival was high over a wide range of temperatures (11°C-31°C). An ontogenetic change in geotaxis was observed; newly ciliated larvae swam to the water surface and remained there for approximately 18 hours; after which they swam briefly throughout the water column then became demersal. Early larvae showed no response to light stimulation, but older larvae exhibited negative phototaxis, ensuring that competent larvae are close to the benthos to facilitate settlement. Natural recruitment rates of *O. varicosa* are unknown, but young colonies have been observed on restoration blocks within the OHAPC protected area. Lack of reef re-colonization is most probably a function of repeated impact from trawling and lack of suitable substrate rather than low larval supply. Supported by a grant from the National Marine Fisheries Service and by NSF Grant OCE-0243688.

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SEDIMENT STANDING STOCKS FROM AN ABYSSAL SITE IN MONTEREY CANYON, CALIFORNIA

Estimates of the standing stocks of various faunal components inhabiting surficial sediments are important elements in determining carbon flow within benthic communities and the degree of coupling between pelagic and benthic processes. Due to logistic/methodological constraints, direct measurements of the standing stocks of all faunal fractions inhabiting abyssal sediments has rarely been conducted synoptically. Previous reports concluded that benthic biomass is dominated overwhelmingly (98%) by bacterial carbon with the remainder attributable to foraminifera and metazoans. During a cruise conducted in Dec. 2002 as part of a carbon sequestration experiment, we collected control cores from within lower Monterey Canyon at 3260m off central California. We have made direct measurements of bacteria and nano-, micro-, meio-, macro- and megafauna from this site using a variety of techniques. Here we present details concerning the compartmentalization of carbon at this site and compare our findings with estimates from other abyssal locations.

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BENTHIC RESPONSE TO VARYING FOOD INPUT: *IN SITU* EXPERIMENTS IN THE OLIGOTROPHIC MEDITERRANEAN

The deep Eastern Mediterranean Sea is considered one of the most oligotrophic regions of the world oceans. The scarcity of food and resulting food limitation make it very suitable to investigate the response pattern of deep-sea benthic communities to a varying carbon input. Recent experiments demonstrated a fast benthic response of deep-sea communities supplied with a very high carbon load. The relationship between the amount of carbon added and the speed and amplitude of the benthic response, however, remains yet to be determined. For this purpose a series of *in situ* enrichment experiments using a chamber lander system was performed in the deep Cretan Sea (1500 m, South Aegean Sea, NE Mediterranean; 35°45'N and 25°07'E).

^{13}C-labelled diatom food pulses of 0.05 (A) and 0.5 gC/m^2 (B) were simulated in benthic chambers deployed for 36 h (B is equivalent to the mean annual vertical POC flux to the deep ocean in the study area). The stable isotopes served as tracer in order to track the transport, uptake, incorporation and remineralization of the carbon added by the different functional groups of organisms. All experiments revealed a fast reaction of the deep-sea benthic community in total, confirming that deep-sea communities are well adapted to changing conditions in food availability. Significant differences in sediment community oxygen consumption (SCOC) were recorded between type A and B experiments, with higher SCOC in exp. B. Both the remineralization of algal carbon to $^{13}CO_2$ and the incorporation of ^{13}C -tracer into bacterial fatty acids increased in type B as compared to type A experiments, as did the penetration depth of ^{13}C -tracer into the sediment.

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BRAZILIAN DEEP-SEA BIOLOGY RESEARCH: A RECENT HISTORY OVERVIEW

The first reports on the bathyal and abyssal fauna from Brazil were obtained at the end of the nineteenth century through the Hassler, Challenger and Albatross expeditions. The number of deep-sea stations accomplished by these was very limited, and since then until the 1980's the rare deep-water samples had only an occasional and qualitative character. Only in 1987, a Franco-Brazilian Expedition MD55 carried out a series of deep-water biological samples in the South Atlantic off the southeastern Brazilian slope from 200 to 5155 m depth. This was to track the faunistic evolution from Cabo Frio, where the upwelling of sub-Antarctic water occurs, to the Abrolhos Continental Slope situated at the limit of tropical coralline ecosystems. Still in the late 1980's an integrated research programme off São Paulo state down to 600 m generated information on the slope faunistic composition. Other programmes occurred from the mid to late 1990's, mainly the "Talude" Programme, Brazilian-German JOPS II, PADCT-2, and the Brazilian EEZ (REVIZEE). These have produced deep-sea biological information from offshore mainly from the S, SE, and NE Brazil. Recent cruises from the REVIZEE programme sampled pelagic and benthic fauna from the margin of the continental shelf down to 2000 m. Through requirements from the regulating agencies and the oil and gas exploration offshore beginning in 1984-85, a number of cruises for environmental assessment and monitoring began, and have produced some valuable biological information, mainly on macrofauna. A significant bathymetric variation in relation to the benthic community structure generally occurs from 800 to 1900 m. Diversity may be highest between 800-1000 m, but depth ranges may vary considering different taxa. Like other worldwide deep-sea areas, the major components of the macrofauna concentrate in the first 5 cm with a high percentage of rare species (30-40% with one individual). Comparison of results from all these different cruises is difficult because samples have been collected with different sets of equipment and /or different sampling strategies across the Brazilian continental margin. Identification resolution is not yet calibrated across the country and this is an area that reflects the need for investment. Appropriate biological data sampling, analyses, and curation for the Brazilian deep sea are necessary. Also, future deep-sea biology research in Brazil may require involvement of industry, environmental agencies and the scientific community, taking account of national interests for deep-sea exploration.

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ISOTOPICALLY TRACED SCENARIOS OF BACKGROUND/FOREGROUND TROPHIC INTERACTION AT GULF OF MEXICO HYDROCARBON SEEPS: EXPORTING OR IMPORTING?

There is a dramatic contrast between the low benthic standing-stock biomass of the typical deep benthos with seep and vent populations of tubeworms and bathymodiolid mussels in seep and vent communities. Reasoning by analogy to chemical gradients, the 3 orders of magnitude greater biomass at seeps and vents should drive considerable export between the chemosynthetic and surrounding heterotrophic systems should be expected. Our results from the upper-slope hydrocarbon seeps in the Gulf of Mexico suggest that export is limited to a very small suite of consumers. Those species that we consider to have great spatial fidelity to the seeps show isotopic values attributable to unexpectedly large percentages of phytoplankton-derived food. The possibility that some systems import more food from the normal benthos than chemosynthetic production is explored. Upper-slope systems (500 - 1000m) may represent a special case since detrital influx is relatively, and seep-based consumers can obtain substantial non-seep food by means of foraging over small areas. At much greater depths (>3000m) detrital influx is much lower and the seafloor adjacent to seeps and vents affords little in the way of resources. We hope to add the deep component to this study two weeks following the Deep-Sea Biology Meeting.

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TACKLING THE CONSERVATION OF DEEP SEA BIOTA - THE WAY FORWARD

In legal terms, most of the deep sea is in the high seas, which means in waters outside the jurisdiction of a coastal state. According to the UN Law of the Sea Convention, for these waters, the freedom of access and navigation prohibits any spatial sovereignty - making it a challenge to think about spatial protection measures, for example marine protected areas, in order to counteract harmful effects of human activities on species and habitats. In view of the increasing risks to biota far offshore, WWF and IUCN jointly initiated an action plan in 2003 to stimulate and accelerate the implementation of the global targets set by i.e. the World Summit on Sustainable Development in Johannesburg 2002: to "*develop ... programmes for halting the loss of marine biodiversity, in particular fragile ecosystems*" the "*tools including ... the elimination of destructive fishing practices, ... and the establishment of a well-managed, ecologically representative network of marine and coastal protected areaswithin and beyond national jurisdiction by 2012*".

The presentation aims at presenting the current state of developments with regard to deep sea protection and calls on scientists to contribute with their expertise and initiative in creating and communicating the knowledge base required for designing adequate protection measures.

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OFFSHORE MARINE PROTECTED AREAS ON THE AZORES: WHY, WHERE AND WHAT FOR?

Marine Protected Areas (MPAs) are an important tool for the conservation of marine habitats and associated biodiversity. The Azores is an oceanic archipelago in the Macaronesia region with an EEZ sub-area that spans 1 million km^2. The islands are located in close proximity and divided by the Mid-Atlantic Ridge which provides a unique location to study hydrothermal vents and seamounts. With this natural background and as the knowledge and pressure over the features and ecosystems of the wider Atlantic increase, the Azores have been taking one of the leading roles in establishing offshore MPAs.

The first Special Area of Conservation (NATURA 2000 network) beyond territorial waters has been designated in D. Joao de Castro Bank – a shallow seamount and hydrothermal vent field in between Terceira and São Miguel islands. Concurrently, the EU-funded OASIS project on seamounts was started and included the Sedlo Bank (also in the Azorean EEZ sub-area) as one of its study areas. Among its deliverables there are a management plan for this area and the proposal of the bank as an OSPAR MPA. Lucky Strike and Menez Gwen are two offshore hydrothermal vent fields also within the Azorean EEZ sub-area. Due to their proximity to the islands and relatively shallow location, numerous scientific expeditions and programmes have been focusing their research on their geological and biological variability. The lack of site-specific measures to regulate the anthropogenic use and impact and the small surface of this vent sites has called for management of the ongoing and potential prospective activities. In June 2002, draft management plans for these two fields were developed at a workshop where all the stakeholders were present. The workshop report and the management plan are currently under consideration by regional and central governments.

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DO WHALE FALL EVENTS INCREASE NEMATODE ABUNDANCE?

Little is known about the effects of high-pulsed organic enrichment events on deep-sea meiofauna but modest organic enrichment through phytodetritus input is known to increase nematode abundance.

Deep-sea sediments surrounding an experimentally implanted sub-adult gray whale (Eschrichtius robustus) at 1675 m depth near to Santa Cruz Island in the Pacific Ocean were investigated for free-living nematodes. *Alvin* tube-core samples were taken at varying distances radiating away from the carcass in 1998 and 1999, and the top 0-1cm horizon analysed for total nematode abundance.

The results from this study are consistent with increased nematode abundance in response to an organic enrichment at station 9 m and further away from the carcass. However, nematode abundance is suppressed in the immediate vicinity.

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MUSCLES METABOLIC ENZYMES AND SWIMMING SPEEDS IN *ANTIMORA ROSTRATA* AND *CORYPHAENOIDES (N.) ARMATUS*, TWO DEEP-SEA DEMERSAL FISH.

The Blue-hake, *Antimora rostrata* (1000-3000 m depth), and the rattail *Coryphaenoides (N.) armatus* (2000-4800 m depth) are the most active scavengers in their respective depth range. In this work, we investigated the activities of key metabolic enzymes (pyruvate kinase, lactate dehydrogenase, malate dehydrogenase and citrate synthase) in both white and red muscles. Both glycolysis and citric acid cycle enzymes were present at high levels in white muscles compared to many other deep-sea species. Significant scaling relationships were observed for all enzymes in white muscle but not in red muscle. Enzyme levels were higher in *C. armatus* than in *A. rostrata*. These date indicate that the metabolic potential of *C. armatus* white muscle is superior to that of *A. rostrata* despite the lower dietary resources available to this species. As *in situ* observations reveal higher swimming speeds in *A. rostrata*, this suggests a more efficient swimming mode in this species than in the grenadier. Anaerobic and aerobic enzyme activities were very high in red muscles. These muscles could also play an important role in the roving behaviour of large specimens in both species.

This work was supported by grants from the Fonds National de la Recherche Scientifique (Belgium) and by UK NERC Grant N° GR3/12789. We thank the Captain and Crewmembers of RRS Discovery.

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AGGREGATIONS OF EGG BROODING DEEP-SEA FISH AND CEPHALOPODS ON THE GORDA ESCARPMENT: A REPRODUCTIVE HOTSPOT

Localized areas of intense biological activity or hot spots in the deep sea are infrequent but important features in an otherwise sparsely occupied habitat. Reproductive aggregations where conspecifics concentrate for the purposes of spawning and/or egg brooding could be thought of as transient hot spots. However, only a few deep-sea reproductive aggregations have ever been documented demonstrating the paucity of present day information regarding reproductive behavior of deep-sea animals.

We document a unique multispecies reproductive aggregation located on the Gorda Escarpment, California. Extremely high fish and octopus densities were observed, with a majority of both species brooding eggs. The nesting behavior of the blob sculpin, *Psychrolutes phrictus*, and the egg brooding behavior of the octopus, *Graneledone* sp., during annual ROV dives on the Gorda Escarpment will be discussed. The animals are concentrated at the crest of the local topography and near cold seeps where they may benefit from enhanced current flow and local productivity. These findings provide new information on the reproductive behaviors of deep-sea animals. More importantly they highlight how physical and bathymetric heterogeneity in the environment can result in reproductive hot spots, which may be a critical resource for reproductive success in some deep-sea species.

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TIME-SERIES COMPARISON OF HYDROTHERMAL-VENT MUSSEL BED COMMUNITIES ON THE EAST PACIFIC RISE BETWEEN 1999 AND 2001

Deep-sea hydrothermal vents on mid-ocean ridges are ephemeral habitats that result from volcanic and tectonic activity. Vent communities on the East Pacific Rise (EPR) have been studied with photo-imaging techniques since an eruption early in 1991, but quantitative samples have been lacking. The EPR is a fast-spreading center and vent fields are short lived; they can form and die in a period of days to 20 years. Mussel-bed community structure is therefore directly related to, and affected by, these cycles. At vent fields, mussel beds form discrete habitats that allow us to make biodiversity comparisons with quantitative samples. In December 1999, multiple "pot" samples were collected from each of the three sites on the EPR (East Wall, Train station, Biovent) to determine biodiversity of the invertebrates associated with mussel-bed communities. In December 2001, a second set of samples was taken at the same 3 sites. Preliminary results show no change in the number of species, in the dominant species or in overall species richness between 1999 and 2001. There was little difference in taxonomic composition and abundance between the two years, with the exception of the abundance of mussel recruits (< 5 mm). In 1999, mussel recruits made up 70 $\pm$ 5% of the total number of mussels sampled; in 2001, mussel recruits accounted for <1% of the total, despite comparable sampling efforts. This is consistent with episodic rather than continuous recruitment of mussels at these sites.

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PATTERNS OF MITOCHONDRIAL DNA SEQUENCE VARIATION IN DEEP-SEA OCTOCORALS

Mitochondrial DNA has been a widely-used molecular genetic marker of evolutionary patterns both within and among species. Its popularity can be attributed to its relatively rapid rate of evolution, ease of analysis, and the requirement for small amounts of starting tissue. Several studies have shown that archival material may also be used as a source of tissue for mitochondrial DNA analysis. For these reasons, I have focussed on analyzing DNA sequence variation of several mitochondrial genes of deep-sea octocorals, in particular species in the families Coralliidae, Isididae, Paragorgiidae, and Primnoidae, to address questions of larval dispersal and species evolution. Samples were collected from North and South Pacific, and North Atlantic, seamounts and canyons. A gene unique to octocorallian mitochondrial genomes, *msh1*, proved to be most variable. However, no intraspecific variation was observed in any species examined, including between specimens of *Paragorgia arborea* collected in Australia and Iceland. The widespread geographic distribution of haplotypes cannot be used to infer widespread dispersal of larvae, but rather is likely a result of very low rates of mutation in the octocoral mitochondrial genome. Interspecific differentiation of mitochondrial gene sequences was also low compared to other metazoans. The *msh1* gene may have utility as a species-specific marker, but mitochondrial genetic markers will not be useful for studies of octocoral population genetics.

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DUAL "SYMBIONT TRANSMISSION MECHANISMS" OF A HADAL THYASIRID CLAM *Maorithyas hadalis*

The thyasirid clam *Maorithyas hadalis* is a conspicuous species in cold seep environments at depths of 7,200-7,400 meters in the Japan Trench and the deepest-yet recorded chemosymbiotic invertebrate. Two distinct phylotypes of endosymbiotic bacteria were shown and spatial partitioning between the phylotypes was observed within the gill tissues. One type of symbiont (symbiont I) was affiliated with the thioautotrophic symbionts of vesicomyid clams and deep-sea mussels and the other type (symbiont II) was distantly related to the free-living chemoautotrophic bacteria.

Here we report, using morphological and molecular techniques, on a symbiont transmission mechanism of *M. hadalis*. (1) Bacterium-like particles were observed within the oocytes in the host ovaries by TEM observations. (2) Successful amplifications of bacterial 16S ribosomal RNA gene (16S rDNA) sequences were obtained from ovaries of *M. hadalis* using a symbiont I-specific and a universal eubacterial (EUB27F) primer. Amplification of bacterial 16S rDNA sequences using a symbiont II specific primer and EUB27F was unsuccessful from the ovaries. (3) A symbiont II specific sequence was amplified from sediments associated with *M. hadalis* but this was not the case with the symbiont I specific sequence. Additionally, the phylogenetic relatives of symbiont I (symbionts of vesicomyid clams and deep-sea mussels) are transmitted vertically and those of symbiont II are free living. Therefore, we concludes that symbiont I is transmitted vertically and symbiont II environmentally. Fluorescence *in situ* hybridization (FISH) on sections of ovaries of *M. hadalis* using symbiont-specific probes will be performed and the results will be shown.

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RAVENOUS FOR PHYTODETRITUS: CAN BRITTLE STAR OPPORTUNISTS PREVENT PHYTODETRITAL MASS ACCUMULATION IN THE N.E. ATLANTIC?

The probably cosmopolitan abyssal species *Ophiocten hastatum* shows seasonal reproduction, with spawnout in late winter followed by probably planktotrophic early development in spring, and a depth-related pattern in individual growth interpreted from skeletal growth markers. A highly variable size structure in samples also suggests recruitment varies from year to year. A large population increase observed in the late 1990s in the Porcupine Abyssal Plain, part of the so-called "*Amperima* event", coincided with a period when seasonal mass deposition of phytodetritus was not observed. It followed a period when mass depositions occurred every year but when *Ophiocten* was sparse. Analysis of skeletal growth bands suggests that the population increase derived from a single or small number of successful recruitments during this period. The much increased population density of *Ophiocten,* and some other holothurian opportunists, and evidence from other data, suggest that these opportunists prevented phytodetritus accumulating on the seabed during the later 1990s. It remains to be seen whether this is part of a natural cycle.

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LARGE-SCALE BIODIVERSITY PATTERN OF CUMACEA IN THE DEEP ATLANTIC

Large-scale biodiversity pattern is best known on land, and to a lesser extent in shallow water, as a general pole wards decline in species richness from the equator, and seems to be associated with solar energy input (as temperature, evapotranspiration or productivity). In the deep-sea, discovery of latitudinal species diversity gradients (LSDG) among five speciose major taxa of the deep-sea (isopods, gastropods, bivalves nematodes and foraminifera) is unexpected because of the remoteness of this environment from the surface. For the first 4 of these taxa, observations do not fit the classical pattern while that for the foraminifera has been related to seasonally fluctuating food supply rather than solar temperature gradients. We here test for the occurrence of LSDG in another speciose group, the Cumacea using data from 225 species from 86 epibenthic sled stations in the N and S Atlantic lying between 500 and 4000 m depth and yielding more than 50 individuals. In the N Atlantic a trend of polewards declining diversity was pivotally dependent on inclusion of samples from the isolated Arctic basins, which are known to be faunally impoverished as a result of Quaternary glaciation. We conclude that the 3 main patterns seen among deep-sea benthic taxa suggest different structuring processes, although apart from the residual effect of glaciation depressing diversity at high latitudes, these remain enigmatic.

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MACROFAUNA COMMUNITIES IN DETRITIC AND CHEMOSYNTHETIC BASED ECOSYSTEMS IN THE GULF OF GUINEA

Two types of ecosystems coexist in the Gulf of Guinea, a sedimentary ecosystem based on detritic inputs originating from the ocean euphotic layer, and/or from the continent, and a chemosynthetic based ecosystem linked to cold-seeps. The BIOZAIRE programme developped an integrated study of the biological, physical and chemical parameters on selected areas in order to understand the structure and functioning of the benthic ecosystems. Three areas were selected, one at bathyal depth, and two at abyssal depth to study the influence of the Zaïre canyon on the detritic based ecosystem. The study of the chemosynthetic ecosystem focussed on a pockmarks field, at 3200 m depth and aimed to look for the variability of macrofauna linked to megafauna clusters.

In the sedimentary ecosystem, the macrofauna varies in terms of density between the bathyal and the deep stations and not among the deep stations, in relation with the variation of trophic input. The taxonomic structure varies between the deep stations, probably in relation with physical conditions. The macrofauna shows a large vertical distribution in the sediment column and a trend for more of the community deeper in the sediment near the Zaïre canyon, probably due to the instability of trophic and physical conditions in this area.

In the chemosynthetic ecosystem, the macrofauna associated to the megafauna clusters shows a great variability in terms of density, global structure (phylum, class, order) and composition of polychaetes in families, probably linked to the great variability in sediment physico-chemical parameters.

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RESPONSES OF BENTHIC ORGANISMS ON THE DEEP ANTARCTIC CONTINENTAL SHELF TO A HIGHLY SEASONAL FOOD SUPPLY

Primary production in Antarctic coastal waters and the subsequent flux of biogenic material to the deep continental shelf (600m depth) is intense and highly seasonal. Benthic organisms have been shown to exhibit certain physiological responses to a seasonal food supply. These include reproductive periodicity, feeding rates and food storage. It was hypothesised that organisms living on the Antarctic continental shelf may have certain reproductive and energetic responses coupled to the seasonal pulse of phytodetritus. Five species of echinoderm were sampled from two locations on the west Antarctic Peninsula shelf during five separate cruises between November 1999 and March 2001. Reproductive strategies were determined by histological analyses of gonad tissue, and CHN analyses were used to predict the nutritional and energetic status of the body tissues. Highly opportunistic reproductive strategies were observed from two species of holothurian, *Peniagone* sp. and *Protelpidia murrayi*, in which initiation of gametogenic cycles are clearly linked to the delivery of phytodetritus. Both a brooding echinoid (*Amphipneustes lorioli*) and a free spawning echinoid (*Sterechinus antarcticus*) also show seasonally driven aspects to their reproductive cycle. In contrast the asteroid, *Psilaster charcoti*, which shows a seasonal reproductive cycle in shallow-water, shows no such periodicity on the deep Antarctic continental shelf.

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COLONIZATION PATTERNS OF THE DEEP SEA: INSIGHTS FROM BASAL SNAILS GASTROPODA:VETIGASTROPODA) USING MOLECULAR PHYLOGENETICS

The basal gastropod group Vetigastropoda includes such familiar organisms as abalone, top snails, and key hole limpets. Some unique deep sea groups are also among Vetigastropoda, such as Pleurotomariidae, Lepetodrilidae, Peltospiridae, Neomphalidae, Clypeosectinae/Clypeosectidae, Sutilizoninae/Sutilizonindae, and the enigmatic Melanodrymia. Based on patters observed in the fossil record of Pelmatozoa and Monoplacophora, the on-shore/off-shore pattern suggests that major groups originate in the shallow water and are competitively pushed into the deep sea. The standing of this pattern is currently being investigated on the inter-familial to inter-generic level using molecular phylogenetics. Three markers — COI, Histone 3, and 18sRNA — were used. The colonization pattern of the deep sea does not follow the on-shore/off-shore pattern, particularly the colonization of the hydrothermal vent environment seems rather to be a stochastic process. Additional material of particularly deep-sea, non-vent vetigastropods is sought.

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SEASONAL, ONTOGENICAL AND DEPTH-DEPENDENT VARIATIONS IN METABOLIC ENZYME ACTIVITIES AND PROTEIN CONTENT IN MUSCLES OF DEEP-SEA DEMERSAL FISH

Physiological studies of deep-sea fish are still largely hampered by our inability to obtain deep-sea animals alive at the surface. Beside *in situ* observations, one possible approach is to measure biochemical indicators of the fish activity and physiological status on caught individuals and look for variations with environmental and ontogenical variables. As part of an integrated study of demersal fish physiology and activity, we measured key metabolic enzymes activities (pyruvate kinase, PK ; lactate dehydrogenase, LDH; malate dehydrogenase, MDH ; citrate synthase, CS) and protein contents of white muscle taken from individuals belonging to 5 species (*Coryphaenoides (N.) armatus, C. guntheri, C. rupestris, Syphanobranchus kaupi,* and *Antimora rostrata*) caught at various depths (750-4845 m) in the Porcupine Seabight (NE Atlantic) at two seasons (September and April). Important differences were found among species. Cluster analysis based on biochemical parameters, fish size and season indicate differences in biochemical patterns between *C. armatus* and the other macrourid species, whereas size-dependent patterns were observed in the two latter species. In these two grenadier species, significant changes were observed between individuals caught at the two seasons. In both species muscle of specimens caught in autumn had a lower protein content and lower activities of some metabolic enzymes. On the other hand, depth had no influence on any of the tested biochemical parameters in any species. This demonstrates that temporal and ontogenical variations in physiological status occur in deep-sea fish, most probably in response to food availability and feeding strategies. This work was supported by grants from the Fonds National de la Recherche Scientifique (Belgium) and by UK NERC Grant N° GR3/12789. We thank the Captain and Crewmembers of RRS Discovery.

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DEEP-SEA *LOPHELIA* CORAL REEFS AND GORGONEAN FORESTS IN THE NORTH-ATLANTIC OCEAN AS MARINE PROTECTED AREAS (MPAs)

Multibeam high resolution mapping and side–scan sonar surveys of *Lophelia* coral reef ecosystems in the deep-sea on both sides of the North Atlantic ocean confirmed the existence of spectacular and unique hard-bottom communities at bathyal depths (400 to 1600 m) with moderate species diversity (> 850 associated species) and high biomass. *Lophelia pertusa* bioherms over the Blake Plateau in a south-north latitudinal stretch from Florida to North Carolina, named as 'Agassiz Coral Hills' in the first international symposium on cold corals in Halifax, (George, 2002), differ significantly from *Lophelia* reefs off Sweden (Koster Fjord), Norway (Sula Ridge and Trondheheim Fjord), northeast of Scotland (Darwin mounds) and Ireland (western wall of Porcupine basin) and *Bathypssamia* reefs in the northern Blake plateau in terms of (A) composition of sessile associated species (B) composition of motile peracarid crustaceans in the eco-space above and near the *Lophelia* reefs (C) deep-sea fishes of commercial importance and (D) Physiological plasticity or rigidity of geographically separated populations of *Lophelia pertusa*, in particular reference to metabolic responses to thermal acclimation. This paper also focuses on the ecological distinction of *Lophelia* reefs over the Blake plateau from the *Lophelia* patches over carbonate mounds in the northeast Gulf of Mexico, the gorgonean forests between Georges and Brown Bank in the northwest Atlantic ocean and south of Alaska in the northeast Pacific ocean, dominated by octocorals (Paragorgidae, Primnoidae, Corallidae), hydrocorals (Stylasteridae) and hexacorals (Antipatheridae, Oculindae and Caryophyllidae). The justification of designating "Agassiz Coral Hills" over Blake Plateau as high-seas MPAs (Marine Protected Areas) to the South Atlantic Fisheries Management Council (SAMFC) is discussed. This paper represents two manuscripts to be submitted to the proceedings of the 2003 "Second international deep-sea coral symposium" in Erlangen, Germany.

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SEAMOUNTS AND THE BIODIVERSITY OF THE DEEP SEA: UNITED NATIONS GENERAL ASSEMBLY INITIATIVES TO PROTECT THE WEALTH OF SPECIES ON THE HIGH SEAS.

Research into the biodiversity of deep ocean areas over the past several years has revealed high levels of endemism associated with seamount ecosystems. At the same time, industrial fishing fleets are increasingly developing fisheries in deep ocean areas, including bottom trawl and longline fisheries on seamounts in both national waters and on the high seas. Bottom trawling has been shown to be highly destructive to seamount ecosystems, and several studies have concluded that there is a significant risk of adverse impacts on deep-sea biodiversity associated with this practice.

The United Nations General Assembly in 2002 called on relevant UN agencies and organizations to "consider urgently ways to integrate and improve on a scientific basis the management of risk to marine biodiversity of seamounts and certain other underwater features within the framework of the United Nations Convention on the Law of the Sea". With respect to fisheries, there is a clear mandate, under international fisheries policy and law, to apply the precautionary approach, in conjunction with the best scientific information available, to protect biodiversity from the adverse impacts of fishing.

The UN General Assembly's oceans committee (the United Nations Open-ended Informal Consultative Process on Oceans and the law of the Sea), in June 2003 recommended continued action by the General Assembly on this issue. The General Assembly will decide, in late 2003, on what further information is necessary, particularly scientific information, with a view to potentially deciding on concerted international action in 2004, including the possibility of a some form of a moratorium on bottom trawling in international waters. The scientific community has an important role to play in the process as many countries have insisted that any action recommended by the UN General Assembly be clearly grounded on the best scientific information available as the to the nature of deep-sea biodiversity associated with seamounts and related ecosystems, and its potential vulnerability to trawling or other forms of bottom fishing.

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THE WORM'S TURN: SPECIES DIVERSITY ON THE CENTRAL PACIFIC ABYSSAL PLAIN

Polychaete worms are abundant and species-rich in all the soft-sediment marine habitats, and exceptionally so at the deep-sea floor, the largest continuous habitat on the planet. Deep-sea abyssal plains are also one of the most ecologically threatened habitats in the deep ocean, with the future potential impacts of marine mineral extraction and carbon dioxide sequestration ahead. With this in mind we have been addressing two main questions with regard to deep-sea abyssal polychaetes: (1) what is the relationship between productivity (in terms of food input) and diversity at the abyssal seafloor? and (2) do abyssal polychaetes show broad (cosmopolitan) distributional ranges and hence relatively low regional diversity?

To try and answer these questions, we present data on polychaete species diversity from 8 sites in the central equatorial Pacific abyss. The sites span a 4-fold difference in seafloor productivity (measured by organic carbon flux), and lie between 200 and 3000km apart. Our results challenge two widely held beliefs: (1) that the relationship between productivity and diversity is unimodal and (2) that polychaetes have extraordinarily high regional and hence global diversity. We outline a new research program that will be attempting to test these findings using molecular techniques.

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LONG-TERM (DECADAL) CHANGES IN 'LIVE' BENTHIC FORAMINIFERAL ASSEMBLAGES AT AN ABYSSAL SITE IN THE NE ATLANTIC

Although seasonally pulsed food inputs to the ocean floor are known to trigger a variety of species and community-level responses among benthic organisms, very few studies have documented faunal changes over longer (decadal) time scales. We analysed live foraminiferal assemblages in multiple corer samples (0-1 cm layer, >63mm fraction) collected on the Porcupine Abyssal Plain ('PAP'; 4850 m water depth) between 1989 and 2002. During this period, there has been no obvious change in overall species richness and diversity. Clear shifts have occurred, however, in the abundance of some dominant species. Between 1989 and 1994, a small calcareous species (*Epistominella exigua*) that feeds on phytodetritus was very abundant. Since 1994, *E. exigua* has declined sharply and *Trochammina* sp., a small agglutinated species that was rare in the earlier samples, has replaced it as the dominant foraminiferan. *Quinquiloculina* sp. suddenly rose to prominence in September 1996 and then declined rapidly while *Alabaminella weddellensis* has fluctuated in abundance over the time series. There is a striking coincidence between these foraminiferal patterns and major changes in the metazoan megafauna at the PAP, in particular the dramatic increase since 1996 in abundance of the holothurian *Amperima rosea* and the ophiuroid *Ophiocten hastatum*. These animals ingest seafloor deposits of phytodetritus, assimilating some of it and rendering the remainder unavailable to smaller organisms. This may explain the decline in abundance of *E. exigua*. *Trochammina* sp., on the other hand, is possibly a disturbance opportunist that responds to the increase in surface megafaunal activity since 1996.

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THE OCEAN BIOGEOGRAPHIC INFORMATION SYSTEM: A NEW TOOL FOR DEEP-SEA BIOLOGY

The Ocean Biogeographic Information System (OBIS) is an international science program building a free public internet resource for data and tools relevant to marine biogeography and species distributions in the oceans (www.iobis.org). Through a quick demo of the system we will show how users can get lists of where particular species have been found globally, get species lists for particular locations, visualize point locations on a map, and predict species ranges using point data and environmental layers. OBIS contains or will soon get datasets of particular relevance to deep-sea biology including the Southampton Oceanography Center's bathypelagic holdings, a global dataset on seamount biota, and data from Census of Marine Life field projects on abyssal communities (CeDAMar), chemosynthetic systems (ChEss), and the Mid-Atlantic Ridge (MAR-ECO).

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NATURAL HISTORY OF DEEP-SEA TUSCARORID RADIOLARIANS

Radiolaria are unique marine protists that form siliceous skeletons. Although their fossils are of great interest to micropaleontologists, because they are fragile and live in the deep sea they are rarely observed alive. Most species of phaeodarian radiolarians in the family Tuscaroridae were described more than a hundred years ago, and since that time we have learned very little about their biology, taxonomy, and ecology. Using remotely-operated vehicles, it has been possible to collect representatives of most deep-living tuscarorid genera. These collections of intact specimens have yielded many surprises in the feeding ecology and taxonomy of these abundant members of the deep-sea fauna.

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SCAVENGING FISHES OF THE DEEP EASTERN ATLANTIC OCEAN: A COMPARISON OF BEHAVIOUR AND DISTRIBUTION AT LATITUDES 49°N TO 10°S

A comparison of the behaviour and distribution of deep demersal fishes attracted to bait in the Eastern Atlantic Ocean is made from data obtained using autonomous free-fall vehicles equiped with photographic and fish tracking equipment. Observations were made at seven stations (depths 1000-4500m) at different latitudes: Eutrophic areas-Porcupine Seabight (49°30´N), Porcupine Abyssal Plain (48°50´N); Oligotrophic area- Madeira Abyssal Plain (31°N); Upwelling areas-Canaries (27°20´N), Cape Verde Terrace (17°45´N), Cape Verde Abyssal Plain (15°N) and Angola (10°S). These were the first baited camera deployments at low latitudes in the deep Eastern Atlantic Ocean. Analysis of the photographic data showed that the lowest number of fish at bait was observed in the Madeira Abyssal Plain and that the grenadier *Coryphaenoides (Nematonurus) armatus* was the dominant species attracted to bait at all study sites except off the Angolan Coast, where the dominant fish observed were deep-sea eels. Primary productivity is suggested to dictate the distribution of these deep demersal fish assemblages. Fish tracking data for the grenadier *C. armatus*, the morid *Antimora rostrata* and the ophidiid *Barathrites iris*, were obtained from different depths at the Porcupine Seabight and Cape Verde Terrace stations. The first swimming speed data ever obtained for the latter species are presented.

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FISHES WITH RED LIGHTS: DIFFERENT STRUCTURES, DIFFERENT MECHANISMS.

Three genera of deep-sea fish have been reliably reported to emit red bioluminescence. Most stomiiform fishes have a postorbital photophore which emits blue light but species of *Malacosteus*, *Aristostomias* (family Malacosteidae) and *Pachystomias* (family Melanostomiidae) additionally have large red light-emitting suborbital photophores. *Pachystomias* also has a small red-emitting preorbital photophore. We have examined the anatomy of the red-emitting photophores, made video recordings of the emissions of live specimens and measured the *in vivo* fluorescence and reflectance characteristics of the photophores.

The anatomy and fluorescence of the suborbital photophores of *Pachystomias* and *Aristostomias* are very similar and differ markedly from that of *Malacosteus*. In the last genus the flashes from the red photophore are longer than those of the blue postorbital photophore and the spectral characteristics of the emitted light derive from the emission of an internal fluor modified by an overlying filter. *Aristostomias* and *Pachystomias* lack any spectral filtering and the emission must derive from the internal fluor alone. The anatomy of the photophores suggests that *Aristostomias* is more closely related to *Pachystomias* than to *Malacosteus* and that red emission has evolved at least twice in these fishes.

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WHY DO FEMALE VESTIMENTIFERANS STORE SPERM?

Vestimentiferans are dioecious tubeworms that live around deep-sea hydrothermal vents and cold seeps. As adults they have no mouth, gut, or anus, and depend on sulphur-oxidizing bacterial endosymbionts for nutriment. Although species of Vestimentifera vary widely in size and may be found in widely separated geographic regions, the reproductive biology of this taxon is very conservative. Much is known about reproductive anatomy and the morphology of gonads and gametes, but the most fundamental mechanisms of reproduction, including fertilization, synchrony and development remain poorly understood. Apparent spawning events have been observed in *Riftia pachypila*. However it is not known if the spawn consists of unfertilized oocytes, zygotes, developing embryos, bundles of sperm, or free sperm. In *Ridgeia piscesae*, sperm bundles have been found attached to the vestimentum and within the oviduct, strongly suggesting sperm transfer followed by internal fertilization. Morphological criteria of modified sperm in *Riftia pachyptila* suggest that this species has some form of direct sperm transfer or internal fertilization. However, *in situ* experiments demonstrated that fertilization of *Riftia pachyptila* eggs occurs after release from the adults. Our electronic and light microscopy examination of gonads of *Lamellibrachia* sp., *Seepiophila jonesi*, *Riftia pachyptila*, and *Ridgeia piscesae* revealed mature spermatocytes in the most posterior region of the oviduct. The wall of this region of the oviduct is formed of prominent ridges and it seems to act as a spermatheca. The presence of glycogen within sperm suggests a need to prolong sperm metabolism and may provide a morphological clue that can be correlated with sperm transfer or sperm storage mechanism. Supported by NSF Grant OCE-0243688 (C.M. Young).

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A COMPARATIVE TRIAL OF MACROBENTHOS SAMPLERS – THE BOX-CORER VERSUS THE MEGACORER.

During a recent, BP-commissioned, environmental survey of the deep-water oil province off Angola, a comparative trial of macrobenthos samplers was carried out. Three gear types were tested: the standard deep-sea macrobenthos sampler; an USNEL Mk2 box corer; a Bowers & Connelly Megacorer (an hydraulically damped multiple corer); and a new multi-box corer. At each of 10 stations, one sample was collected with each of the gear types. All 30 samples were collected during the same cruise and all were handled and processed in a consistent manner. Comparison of macrobenthos density estimates (individuals per m^2) between the three samplers show dramatic and statistically significant differences. The box corers lose over 50% of specimens. Statistically significant variations are also apparent in some diversity measures between the gears, being most evident in species richness indices (as compared with dominance indices). Assessments of numbers of species and numbers of individuals show little variation between gears until the area sampled (or density) is considered, when the differences become clear. The relative loss of specimens by the box corers is not uniform for each species, leading to variations in the apparent diversity and composition of the macrobenthos. This variation in species composition between gear types is statistically significant when assessed by standard multivariate techniques.

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APEC FISHERIES WORKING GROUP AND DEEP-SEA FISHERIES

The Asia Pacific Economic Cooperation (APEC) Fisheries Working Group is a co-sponsor of the International Conference on Governance of Deep-Sea Fisheries being held in Queensland, New Zealand December 1-5, 2003. As a member of the steering committee, the United States has sought to bring together developing countries from the Asia-Pacific region to increase awareness of deep-sea ecosystems. Our current knowledge of deep-sea resources is limited; however, technological advances make their exploitation economically viable for many countries. For this reason, it is necessary to encourage sustainable use of these resources to ensure their long-term success. Fish associated with seamounts and submarine ridges are of particular concern to managers because they are characterized as long lived with highly variable recruitment, making them particularly vulnerable to overfishing and incidental damage by fishing techniques. The conclusions and recommendations put forth at the Deep Sea Biology Symposium will be important for furthering our knowledge of these fragile ecosystems and providing input for the New Zealand Conference. In addition, knowledge gained will contribute to a regional Deep Water Fish and Fisheries Network to aid in the development and implementation of environmentally sustainable fisheries practices. I will discuss the short and long-term alternatives to close the governance gap in order to maintain these unique ecosystems.

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REPRODUCTIVE ISOLATION AMONG MORPHOTYPES OF THE ATLANTIC SEASTAR SPECIES *ZOROASTER FULGENS* (ASTEROIDEA: ECHINODERMATA).

Zoroaster fulgens is a slope-dwelling seastar species that is distributed throughout the Atlantic Ocean. Studies into the population structure and systematics of marine animals have increasingly found that species with a reported cosmopolitan distribution are, in fact, collections of closely related cryptic or sibling species. In the Porcupine Seabight (PSB), three morphotypes of *Z. fulgens* can be found that have a distribution that is stratified by depth. This study investigates the genetic divergence between these morphotypes using sections of the COI and 16S regions of the mitochondrial genome. Bathymetrically-separated morphotypes of *Zoroaster fulgens* are reproductively isolated over distances of ~1km while gene-flow occurs among morphotypes, along isobaths, over distances of ~900km. Reproductive isolation on the continental slope may have occurred as a result of selection exerted by gradients of depth-correlated physical factors, such as pressure and temperature. However, allopatric speciation with subsequent range expansion may also explain the observed patterns of genetic divergence. Further investigation of radiation within this group may provide important information on the evolution of slope species. Taxonomic revision of the genus is required.

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DEEPSEA BIOLOGY, FOOD FOR THOUGHT? SEASONAL AND REPRODUCTIONAL ASPECTS OF FOOD AVAILABLITY IN DEEPSEA HOLOTHURIANS

Most animals living on the deep-sea floor rely upon organic matter falling from the sea surface for their food. The flux of this material in many areas occurs in distinct seasonal cycles. In summer months the detritus may form temporal oases in an otherwise deep-sea desert. The organic matter contains many essential biomarkers, including chlorophyll and carotenoid pigments, fatty acids and sterols. Using these compounds it has been possible to examine the biochemical selection of food in 14 species of holothurian from 800 to 4885m in the NE Atlantic. A seasonal pattern was observed in the fatty acids and pigments ingested by the holothurians. In summer months the species showed greater differences in the biochemistry of the detritus ingested. In winter months there was greater overlap between species. In terms of body tissues, each species had a different lipid chemistry and pigment composition indicating a requirement for different compounds. Many of the compounds ingested by holothurians are used with little or no modification and therefore at little metabolic cost. This is an important consideration within food-limited environments, such as the deep sea. Potentially, changes in the biochemistry of detritus deposited on the seabed can have dramatic effects on the dynamics of the benthic fauna.

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USING BIOLOGY TO INFORM GEOCHEMISTRY: ANALYSIS OF BURROW CONTENTS FROM TWO SITES IN THE BATHYAL N.E. ATLANTIC

Large burrows were studied in boxcores from two bathyal NE Atlantic sites, and contents analysed to determine their effects on sediment geochemical profiles. At 1100 m depth, burrow openings up to 3 cm diameter occurred at a density of 5 m^{-2}. Burrows descending vertically for 12-18 cm, then running horizontally for up to 35 cm were provisionally attributed to echiurans, although no occupants were found. A burrow found after the spring phytoplankton bloom contained a green slurry, for which microscopic evidence,excess ^{210}Pb and organic C content all indicated a phytodetrital origin. Subsurface faecal pellet masses derived from recent surface deposit-feeding were also found. At 1920 m depth, no large burrow openings occurred in five boxcores. Subsurface galleries at 15-26 cm depth were traced horizontally for up to 30 cm, but contained no occupants or distinguishable filling. Faecal pellet masses, possibly deposited by enteropneusts, were found in three boxcores at 13-17 cm depth. Excess ^{210}Pb content indicated that the pellets resulted from selective surface deposit-feeding, and may account for subsurface peaks in excess ^{210}Pb profiles. 'Caching' of phytodetritus and faecal deposition are two mechanisms for the rapid, deep burial of relatively fresh organic matter, which may potentially enter the paleoceanographic record. Similar bioturbation modes appear to operate at both sites despite the dissimilarity of ^{210}Pb profiles, emphasizing the need for integration of biological and geochemical data to characterise sediment mixing regimes in the deep sea.

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DISTRIBUTIONAL PATTERN OF DEEP-SEA MACROFAUNA IN THE INDIAN OCEAN

Deep-sea macrofaunal communities have been evaluated for their composition, distribution, abundance and biomass from different areas of the Indian Ocean during oceanographic expeditions on board 5 research vessels between 1982 and 2001. The locations vary from mid-oceanic ridges to deep abyssal plains ranging from 2000-6000m depths having a variety of sediment types. Macrofauna comprised of 24 major groups belonging to 15 phyla and was dominated by Polychaeta and Crustacea. The faunal density varied from 30-1430 ind.m^{-2} (mean=376.39 ± 345.97 SD; n=56) and the biomass varied from 0.11 to 12.75g. wet wt. m^{-2} (mean: 1.02 ± 1.85 SD; n=56). The results indicate that faunal density is negatively correlated with water depth (Y=-0.204x+1204.5;r=-0.601;n=56;p<0.001). Exponential increases in benthic standing stock from east to west region (y = 2.3328x2 - 328.8x + 11640;r= 0.712;n=56;p<0.001;n=56) suggest a positive co-relation with the mid-ocean ridge environment. Vertical profile of the macrofauna within the sediment column, showed presence of benthic organisms such as nematodes and polychaetes down to a sediment depth of 35cms. However, ³ 60% of the fauna was found to live in the top 2cms with about 80% in the top 0-5cms of deep-sea sediment, suggesting deep-sea macrofauna is concentrated in the top semi-liquid layer. A consolidated database of macrofauna from the Indian Ocean is one of the projected activities for the future.

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BENTHO-PELAGIC FISH BEHAVIOURAL RESPONSES TO AUTONOMOUS LANDER PLATFORMS

Modern micro-processors and sensor systems enable relatively sophisticated biological studies in the deep using autonomous lander vehicles placed on the sea floor. Many of these experiments however depend on the ability to attract study fauna into the field of view of camera systems or into experimental chambers using bait or chemical attractants. Many species of fish do not show any behavioural attraction to bait and thus are excluded from study. It is usually assumed that the behaviour of animals in the vicinity of benthic platforms is representative of normal behaviour on or above the sea floor. Observations from both simultaneous sonar and baited camera systems in a Norwegian fjord showed megafauna avoidance behaviour. However, observations from the FRESP and SPRINT landers in the NE Atlantic have shown that *Coryphaenoides armatus* exhibit three-dimensional tactile exploratory behaviour, systematically investigating the structural members of the lander vehicle. These observations suggest that behavioural responses around submerged structures in the deep sea are species specific. Such behaviour calls into question the effects that long-term (6-month) lander platforms may have on local fish behaviour as well as problems of creating an artificial reef effect over extended periods of time.

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OOPHAGUS LIFESTYLE IN A BIVALVE ASSOCIATED WITH COLD-SEEP TUBE WORMS

The large bivalve, *Acesta bullisi*, lives attached to the anterior tube opening of the long-lived siboglinid tubeworm *Lamellibrachia luymesi*, where it surrounds the plume of the worm with its shell and mantle, holding the aperture of the tubeworm inside its inhalant cavity. The nature of this unusual association has been a matter of speculation ever since it was first discovered. The simplest explanation is that these bivalves perch high on tubeworm bushes to increase filter-feeding efficiency. This, however, does not explain why their shells are modified in shape to surround the end of the worm and the same height advantage could be obtained by simply attaching to the tube with byssus threads. We postulate that *A. bullisi* is oophagous, making its living at least in part by preying upon the lipid-rich eggs of the host tubeworms. The modified shell surrounds not only the tube, but the gonopores, so that gametes can be filtered efficiently as they are released. Specialized mechanisms for predation on newly spawned eggs are unknown anywhere else in the animal kingdom.

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SURFACE-BENTHIC COUPLING AND THE STRUCTURING OF DEEP-SEA COMMUNITIES

Because no primary production occurs in typical deep-sea soft-sediment habitats, most benthic communities are dependent on organic input from surface waters. Understanding how surface-benthic coupling affects community structure remains one of the fundamental problems in deep-sea ecology. Using SeaWiFS satellite data, we compared estimated surface production to abundance, biomass, and species diversity of benthic communities in the northwest Atlantic. The primary goal was to investigate the spatial and temporal scales that best predict these features of community structure. Nutrient input at depth was estimated using the Pace algorithm, which accounts for the strong influence exerted by depth in modulating the flux of organic material. Surface production was averaged over areas ranging from 54 km^2 to 1998 km^2. All scales showed essentially the same trend. While abundance and biomass are positively correlated with yearly average Pace-transformed surface production ($p < .0001$), this input proved a poor predictor of species diversity for all taxa examined. Results may suggest that organic input has an indirect effect on diversity mediated through its relationship with abundance.

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EYELESSNESS AMONG THE GNATHIIDAE (CRUSTACEA, ISOPODA)

Eyelessness occurs frequently among deep-sea crustaceans, and has mainly been related to the absence of light in deeper waters. Eyelessness occurs also among the gnathiid isopods (Crustacea). These are remarkable benthic isopods, which live as adults in harems on the bottom, in coral rubble or in cavities. The larvae are, however, external parasites on fish. The occurrence of larvae in the water column seems to differ between day and night, so absence of eyes may have implications upon their use of the water column. Although most of the species live at shallow coral reefs, the family has several deep-sea members.

Data were extracted from the literature on the presence/absence of eyes on gnathiids and their depth ranges. When the whole family was considered, eyelessness was absent in shallow waters (< 100 m), but increased with depth to about 64 % at the depth range of 900-1000 m. At depths below 1400 m more than 75% of the species were blind. The pattern of eyelessness with depth differed between the genera of the Gnathiidae. Eyelessness was further common within certain genera (*Bathygnathia*; 11 blind species out of 13; *Monodgnathia*, all four known species blind), but rare with the large genera *Gnathia* (4 blind of 73 species, 5.5 %) and *Caecognathia* (6 blind of 42 species, 14.3 %). This indicates that eyelessness may have occurred at different evolutionary times within the gnathiids and for some genera (*Bathygnathia* and *Monodgnathia*) may not reflect light patterns with depths.

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PHYSICAL TIME SIGNALS IN THE DEEP SEA, AND THE BEHAVIOURAL AND PHYSIOLOGICAL RESPONSE OF THE FISH COMMUNITY

The lives of shallow water temperate fish are dominated by rhythmic cycles of growth, reproduction and activity. Despite the absence in the deep sea of the major zeitgebers that entrain these cycles, seasonal patterns are also apparent in the lifecycles of some grenadier species. The Deep Ocean Benthic Observer (DOBO) lander is designed to investigate the possible role of ocean currents as time signals in the deep sea. The DOBO is a titanium lander capable of long term (6 month) deployments and equipped with a stills camera, acoustic doppler current profiler, FSI current meter and bait system. It has undergone two consecutive six-month deployments at 2500m depth in the Porcupine Seabight, NE Atlantic. These experiments were designed to investigate the species and size composition of fish attracted to a bait, and to identify physical time signals in the deep sea and possible biological responses to them. Time series analysis of the 12 month data set indicates a clear semidiurnal tidal signal in current velocity and direction, and possible longer term signals.

The lander has since been refitted with a multiple bait release system and deployed at 4000m depth on the Porcupine Abyssal Plain. A solution of amino acids, formulated to mimic a fish bait, is pumped into a sponge and creates an odour plume in the water column every 14 days. This design side-steps the complicating influence of a deteriorating large bait when investigating changes in the frequency, behaviour, size and number of fish visitors to the bait.

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CHEMICAL CONSTRAINTS IN THE *ALVINELLA POMPEJANA* ENVIRONMENT: NEW INSIGHTS

Alvinella pompejana is one of the most peculiar metazoan of the deep-sea hydrothermal vent ecosystem. This EPR alvinellid species which colonize the wall of active vent smokers, is expected to deal with extreme thermal and chemical conditions in its habitat. In addition to its high temperature, the fluid surrounding *Alvinella pompejana* colonies was shown to display the highest sulfide levels encountered for Pacific vent alvinellids. Sulfide toxicity is thus potentially a major constraining factor in this habitat. This would be particularly the case for *A. pompejana* colonies associated with iron-depleted vents where high level of toxic free-H_2S can be expected. The sulfide exposure levels which are truly experienced by the worms however remain enigmatic. Mineralogical gradients that were evidenced at the tube interface indicate that different chemical conditions should be expected for the inner and outer environments with respect to sulfide minerals. One possible explanation to this difference is a substantially reduced sulfide level inside tubes, as the result of detoxification processes. These additional clues to the Pompeii worm enigma will be discussed in the light of new data sets obtained during the PHARE 2002 cruise on the EPR 13°N.

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METAZOAN RESPONSE TO SULFIDE STRESS AT PACIFIC METHANE SEEPS: DISTRIBUTION, COMMUNITY STRUCTURE, NUTRITION, AND RECRUITMENT

High sulfide concentrations are characteristic of methane seep sediments worldwide. Off California and Oregon (500-600 m), bacterial-mat covered sediments exhibit maximum sulfide concentrations of 10-25 mM; clam-inhabited sediments have lower concentrations (1-8 mM). Fine-scale vertical profiling of oxygen in sediments using microelectrodes combined with quantification of macrofauna in the same cores reveal that most animals in seep sediments avoid sulfide concentrations over 1mM. Vesicomyid bivalves and dorvilleid polychaetes are the exceptions; their greatest densities occur at 1-5 mM. High sulfide concentrations at Pacific seeps appear to have promoted the evolution of a complex of dorvilleid polychaetes. Up to 17 dorvilleid species have been found in clambed and bacterial mat- covered sediments; 10 of these species are in the genus *Ophryotrocha*. Distribution studies, gut content observations and stable isotope measurements suggest that dorvilleid species are partitioning the seep environment through differential sulfide tolerance and diet. Most macroinfauna present in seep sediments are heterotrophic. Utilization of chemosynthetically fixed carbon by macroinfauna off N. California appears to be greater in vesicomyid beds, where clam pumping enhances oxygen/sulfide interfaces, than in bacterial mats. The opposite is true on the Oregon margin, where animals in microbial mat-covered sediments have very light carbon isotopic signatures. Colonization experiments were conducted off California to examine the influence of sulfide and the proximity to seep sediments on recruitment. Nerillid polychaetes were attracted to defaunated sediments with sulfide added to a lower layer, whereas tanaids and echinoderms exhibited sulfide avoidance. Annelids (oligochaetes, *Mediomastis* and dorvilleid polychaetes) exhibited preference for seep patches, independent of sulfide additions.

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SPECIES-LEVEL PHYLOGENIES IN THE GONIASTERIDAE (ASTEROIDEA; ECHINODERMATA): PATTERNS OF EVOLUTION IN DEEP-SEA STARFISH

The Goniasteridae is a diverse and phylogenetically important family of asteroids within the order Valvatida, one of three major superorders of post-Paleozoic starfish. Most goniasterids occupy deeper-water, continental shelf habitats and, for starfish, possess a fairly good fossil record that dates back to the Jurassic. Goniasterid ecology is poorly known; however, studies suggest that they occupy important ecological roles in both shallow and deep-water ecosystems.

A genus-level phylogeny of the Goniasteridae provides insight into higher level relationships, basal diversification, and broad macroevolutionary patterns. However, species-level phylogenies are more appropriate for displaying finer-scale biogeographic and bathymetric shifts associated with speciation events.

Phylogenetic analyses of several goniasterid genera, were developed at the generic level. Species-level phylogenies based on morphological data, were developed for several genera, including but not limited to *Anthenoides*, *Calliaster*, and *Paragonaster*. Diverse evolutionary events within the Goniasteridae have been documented including examples of "onshore-offshore" evolutionary migration (as outlined by Jablonski and Bottjer, 1991), heterchrony, and vicariance biogeography in the Central Pacific.

Some taxa, such as *Plinthaster* and *Peltaster* show very conservative evolution demonstrating very few morphological differences between species even over a very broad geographic distribution. This pattern can be contrasted with species within the genus *Calliaster*, which show remarkably diverse species, i.e., autapomorphies are common, within a relatively constrained geographic region (Indian Ocean + South-Central Pacific).

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DECAPOD CRUSTACEANS FROM HYDROTHERMAL VENTS AND COLD SEEPS: AN UPDATE

Approximately 50 species of decapod crustaceans have been reported from hydrothermal vents and cold seeps to date. Species can be grouped into endemics (known only from vent or seep sites and presumably restricted to them) and vagrants (deep sea opportunistic species occasionally found in the vicinity of such sites but not restricted to them). All endemic shrimp are now considered members of either the family Mirocarididae Vereshchaka, 1997 (containing only the genus Mirocaris) or the family Alvinocaridae Christoffersen, 1986 (all other vent shrimp genera), rather than the family Bresiliidae. Fifteen vent-endemic shrimp species are currently recognized; several more species are in various stages of being described. Vagrant shrimp species include members of the families Oplophoridae and Hippolytidae. Endemic crabs are all members of the family Bythograeidae, which includes five genera: Bythograea, Cyanograea, Segonzacia, Austinograea, and Allograea Vagrant crab species in the families Majidae, Homolidae, Geryonidae, and Portunidae are also known. Vent-associated members of the family Galatheidae (squat lobsters) (genera Munida, Munidopsis, and Uroptychus) are likely all vagrants rather than endemics, as are the two known lithodid species. At least one nephropid and one axiid (both undescribed) are also known. Unresolved taxonomic problems, some of which are presently under study by traditional morphological methods and/or studies employing comparative allozymes as well as mtDNA and 16S rDNA, are summarized.

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A NEW HYPOTHESIS FOR BATHYMETRIC SIZE CLINES IN THE DEEP SEA

One of the most intriguing aspects of deep-sea life is the apparent miniaturization of body size in many taxa. Quantification of size-depth relationships reveals a variety of trends. Some of this variation reflects the differences in measurements, methods, locality, and taxonomic resolution. I present a detailed analysis of bathymetric size clines for prosobranch gastropods along the Gay Head-Bermuda Transect that suggests to a new hypothesis for body size in the deep-sea that may account for contradictory results of earlier studies. The association between body size and depth appears to be a consequence of the relationship between depth and input of production. Size increases with decreased input; supported by theory showing increased per unit mass efficiency for larger organisms. Once a low production threshold is reached, size decreases because minimum viable population size and large body size cannot both be maintained. This threshold coincides with the transition from the lower bathyal zone to the abyssal plain indicating a major biogeographic shift. A similar relationship between size and input of primary production is seen in published datasets from a variety of taxa. The range of published trends between depth and size may depend on how nutrient input varies with depth at a regional level.

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BIOZONATION ON DEEP-WATER CARBONATE MOUNDS AND ASSOCIATED HARDGROUNDS ALONG THE WESTERN MARGIN OF LITTLE BAHAMA BANK, WITH NOTES ON OTHER DEEP BAHAMIAN BANK-MARGIN ASSEMBLAGES

Carbonate mounds found in a broad band from about 300 to 700 m along the western margin of Little Bahama Bank exhibit consistent faunal zonations characterized by assemblages of attached, suspension-feeding invertebrates dominated by octocorals, sponges, crinoids, ophiuroids, and stylasterid and scleractinian corals. Hard-substrate zonation appears chiefly dependent on depth (and associated parameters, e.g., temperature) and current flow. Elongated lithoherms (Neumann et al. 1977, Messing et al. 1990) in 500-700 m with up to 50 m vertical relief support up to three distinct faunal zones: ahermatypic branching scleractinians (chiefly *Lophelia pertusa*) upcurrent, an arborescent zoanthid (*Gerardia* sp.) on the crest, and stalked crinoids and octocorals on flanks and downcurrent end. Surrounding low-relief hardgrounds support many of the same taxa as flanks, but accompanied by additional taxa absent from mounds (e.g., the fan sponge, *Phakellia ventilabrum*). Hardground faunal transitions may be gradual or abrupt. Mounds in 300-400 m with up to 30 m vertical relief reveal dense assemblages on shallower upcurrent slopes and flanks, and an almost complete lack of macrofauna on steep downcurrent slopes. Macrofauna includes stalked crinoids on upcurrent slopes and crest, octocorals on flanks, and branching ahermatypic corals and basketstars at and near the crest. Within-group taxonomic composition may vary between slopes and crest or between up- and downslope flanks. In 500-600 m on the southwestern bank margin, mounds distinct from lithoherms and with up to 40 m vertical relief support a dense assemblage dominated by lithistid sponges and ophiacanthid ophiuroids; limited local biozonation here may be associated with a weaker flow regime. Depth-related sequences of assemblages along the Bahama Platform margin away from the Florida Current (NW Providence Channel, Turks & Caicos Is.) exhibit lower densities than those under its direct influence. Analyses of skeletal components in coarse sediment fractions (>2 mm) reveal significant abrasion and reflect local habitat variations. The combination of abrupt, small-scale biozonation and abraded sediment grains can therefore not automatically be considered as evidence of a shallow-water environment when interpreting fossil assemblages.

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WINDOWS TO THE DEEP: EXPLORATIONS OF THE BLAKE RIDGE METHANE HYDRATE RESERVOIR

In July, the vessel Atlantis will embark on an exploration cruise to two unexplored methane hydrate sites: the Cape Fear Diapir and the Blake Ridge Depression. Ranging in depth from 2580 to 2800 meters, these sites are located along the Atlantic's Blake Ridge. The Blake Ridge Diapir, explored with ODP in 1995 and Alvin in 2001, will also be revisited. Well-established chemosynthetic communities have been documented at this site; prevalent features include mussel beds, clam beds, and tubeworms. Evidence of active venting at Cape Fear Diapir and Blake Ridge Depression suggests that these sites may also support biology. Indications of active methane emission at the Cape Fear Diapir include well-developed pock marks, the presence of authigenic carbonate, complicated sulfate profiles, and drilling results from ODP leg 164. The extreme sliding and slumping of the Cape Fear Diapir may have exposed of methane-bearing sediments and permitted gas release into surrounding waters. Such gas escape is suspected at the Blake Ridge Depression because the seafloor in this area is highly disturbed and marked by fault lines. Bottom-stimulating reflector data also supports this hypothesis, revealing complex gas and fluid flow patterns at the site.Samples of biology, mud, and rock will be taken from each site, as will a profile of the seafloor and sub-bottom characteristics. Sediment will be characterized in terms of grain size, and sulfide, methane, and organic content. These geological and biological features will be integrated in a map of biology with respect to these seafloor features.

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BENTHIC RESPONSE TO SEASONAL PHYTODETRITUS DEPOSITION ON THE WEST ANTARCTIC PENINSULA SHELF

Seasonal deposition of phytodetritus on the WAP shelf following the retreat of winter sea-ice likely constitutes a major benthic food source, and should profoundly influence the ecology of shelf benthos. We hypothesize that much of the POM produced during the summer bloom is deposited rapidly on the sea floor, and is subducted into the sediments by activities of the benthos. Microbial activity is limited by low temperatures, and phytodetritus degrades slowly, representing a persistent "food bank" for detritivores. We conducted a seasonal study of the flux and fate of phytodetritus, and it's impact on benthic community dynamics, at three stations in a transect crossing the WAP shelf. Chloropigment concentrations in surface sediments and sediment traps verify the occurrence of highly seasonal deposition events. However, sediment inventories of chloropigments and hydrolyzable amino acids remain relatively constant year-round, showing little seasonal variation below the top 1cm. Despite relatively high microbial biomass relative to other deep-sea settings, the supply of labile organic material in the sediments is not depleted, even during lean winter months. Our data indicate the presence of a persistent sediment "food bank", which could support benthic detritivores year-round.

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BIOGEOGRAPHY OF THE DEEP-SEA FISH FAUNA OFF NEW ENGLAND

The deepwater fish fauna off New England is one of the best-known faunas around the world. A new checklist provides substantial information on the distribution for each of the 590 species found in the area. An analysis of this data provides evidence for a biogeographic boundary that occurs in deep water off New England. Half of the species (296 spp.) terminate their range off New England. Most (85%) of the species terminating their range in New England are part of the tropical/subtropical fauna typically found further south. The provincial boundary is not clearly demarcated because of differences in the area of turnover for pelagic vs. benthic species. Deeper dwelling species (bathypelagic or continental rise/abyssal) show the same patterns of turnover as 'shallower' deepwater species (mesopelagic or slope). A small proportion of the overall deepwater fish fauna (2%) is anomalous, because these 13 species are more typically found in the eastern Atlantic or southern Atlantic. These have possibly migrated into New England waters via the Mid Atlantic Ridge/Corner Rise Seamounts/New England Seamount chain.

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EARLY AND RECENT HISTORY OF DEEP SEA MICROBIOLOGY

The early history of the microbiology of the deep sea lies in the publications of Certes (1884) and Regnard (1884, 1985). The latter participated in the Talisman Expedition (1882-1884) and definitely established that bacteria do exist at 6,000m. However the data set are scant, not even the temperatures were recorded.

This presentation will deal only with the microbiology of the deep sea. It should be realized that there were many studies on hydrostatic pressure as it relates to non deep sea bacteria. Research probably lagged due to funding since there were no ONR, NSF, NIH etc. Although there was much discussion of the affect of pressure as it relates to the microbiology of the deep sea, instrumentation was being developed. Some of this early data will be discussed in relation to its impact on the actual programs dealing with the microbiology of the deep sea.

The actual study of deep sea microbiology began with the Mid-Pacific Expedition of 1950. Unfortunately, Mills does not even discuss this expedition in his book since its real mission was mainly geophysical. However, microbiology did play a great role since it was a precursor for the Galathea Expedition. Methodology was tested and perfected. During the Galathea Expedition, barophiles were discovered but research did not progress because we could not obtain pure cultures. The basic reason was probably the room temperature used when trying to obtain pure cultures.

The existence of barophiles was not accepted by many microbiologists until Schwartz, Yayanos and Colwell obtained them from the Aleutian Trench about 20 years later. Further research was done on the hydrostatic pressure effect on the physiology and biochemistry of marine bacteria, and I was informed by the editors of Limnology and Oceanography not to submit any more manuscripts. As a result, most of the data from my laboratory were published in microbiological journals.

Currently there is much data coming out on deep sea microbiology. However, extrapolating results back to the *in situ* environment must be done with care – mainly because the deep sea contains very little organic matter.

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DISTRIBUTION AND FEEDING OF MUNNOPSID ISOPODS IN THE DEEP WATER COLUMN OF THE GULF OF CALIFORNIA, MEXICO

Using the *ROV Tiburon*, three genera of munnopsid isopods (Asellota) were observed in high abundances below the oxygen minimum layer in the Gulf of California, March 2003. The high abundances revealed previously unrecorded feeding and intraspecific behaviors and provided insight into how these unusual animals fit into their environment. Work in the Gulf also allowed collection and examination of several species not yet collected from Monterey Bay. Vertical distributions and interactions with the benthos are discussed for each Gulf of California species. Species belonging to *Munnopsis, Paramunnopsis* and *Munneurycope* were identified from Gulf collections. Members of *Acanthamunnopsis*, the most abundant midwater genus in and around Monterey Bay, were not found in Gulf of California waters. Net hauls made between Gulf of California and Monterey Bay determined the distribution of shallow living (0-300m) *Acanthamunnopsis* along that coast.

Munneurycope were observed feeding on collapsed and sunken larvacean houses. They were attracted to a food fall experiment, where they fed continuously. These observations coupled with laboratory experiments, suggest that *Munneurycope* feed opportunistically and are non-selective scavengers. They consumed all non-living food items presented, including: various crustaceans, fish, gelatinous zooplankton, and discarded larvacean houses. In contrast, *Munnopsis* foraged selectively on the sea floor, avoided the food fall, and did not feed in captivity. Feeding observations are discussed in relation to jaw morphology and the asellote literature. Intraspecific aggression was recorded between *Munnopsis* individuals.

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TIME-SERIES MONITORING OF DEEP-WATER ENVIRONMENTS

Benthic populations in coastal seas have traditionally been used for monitoring impacts of offshore oil and gas exploration against a baseline knowledge of the environment. However, comparable studies in the deep-sea are rare.

A bathymetric transect ranging in depth from 150-1000m has been sampled three times from 1996 to 2000, north-west of Scotland. The transect is situated in an area where localised contamination by drilling muds and deep-sea trawling have been detected. To detect these anthropogenic perturbations it is important that they are recognisable against changes in the natural background environment. The combined results of the transect with those of associated survey work will provide a general overview of benthic ecology in the region.

Results from the three years appear to correspond well; abundance increased to a depth of 800m before decreasing whereas biomass peaked at a depth of *c.*650-800m. The suite of diversity indices suggests that a maximum occurs at intermediate bathyal depths. Faunal composition varies between years, but the dominant species are similar, e.g. *Spiophanes kroyeri* and *Paramphinome jeffreysii*. At present, natural environmental variables, in particular water temperature; appear to have the greatest influence over the macrobenthic polychaete fauna.

Time-series observations will considerably improve our resolution of change and its underlying cause. Ultimately only an understanding of responses at the level of individual organisms and populations will provide sufficient predictive power in environmental assessment to best minimise potential impacts. Work such as that undertaken along the transect must continue to be repeated if information on temporal variability is to be provided.

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SPATIAL VARIABILITY OF THE CHEMOSYNTHETIC FAUNA, CHEMICAL ENVIRONMENT AND MICROBIAL COMMUNITIES ON A GIANT POCKMARK IN THE GULF OF GUINEA

A giant pockmark colonised by dense cold seep communities has been discovered along the Congo-Angola margin by the ROV Victor 6000. A video study using GIS and image mosaicking was made to quantitatively map the distribution of the chemosynthetic communities. Water and sediment samples were taken at selected sites to describe the chemical environment and the microbial communities. Several types of fauna aggregates, either dominated by mytilid and vesicomyid bivalves, or vestimentiferans are distributed on the 900m in diameter active area. The site is characterised by a most active central part in a depression with abundant carbonate concretions where high-density clusters of mussels and vestimentiferans dominate. On the contrary the external areas show large fields of dead and live vesicomyids, with a lower mean density. Methane concentrations in subjacent water decrease from mytilids to vestimentiferans and to vesicomyids. Differences were also evidenced between young and adult vestimentiferans and according to the bivalve density in clusters. Microbial communities include aggregates of both methane-oxidising archae and sulfate- reducing bacteria. Their concentrations and vertical distribution vary according to the dominant symbiotic megafauna species. Isotopic analyses of host tissues ($d^{13}C$) are in the range of nutrition via symbiosis using methane for mussels and sulfide for vesicomyids and vestimentiferans. Symbionts have been identified by phylogenetic analyses. Small-scale spatial distribution showed a succession from soft reduced sediment with vesicomyids, to large size concretions with vestimentiferans. Mytilids are distributed along a higher range of substrate conditions. This spatial distribution may reflect a temporal pattern of succession of both substrate and fauna. The distribution and densities of other megafauna species in the different types of aggregates will be also discussed.

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REPRODUCTIVE PATTERNS IN *ALVINELLA POMPEJANA* (POLYCHAETA: ALVINELLIDAE) COLONIES FROM 9°N AND 13°N/ EPR HYDROTHERMAL VENTS

Hydrothermal vent chimney walls offer a mosaic of environmental conditions in terms of temperature, chemical composition and hydrodynamics, that are changing at short spatial scale (of the order of the dm), and that strongly contrasts with the stable surrounding deep sea floor. Mineral precipitation due to the mixing between hydrothermal fluid and seawater constantly modifies chimney wall topography and local environmental conditions. Here we investigated reproductive processes of the Alvinellid polychaete *Alvinella pompejana*, that builds tubes and forms colonies on the walls of chimneys of the East Pacific Rise. Individuals of this species might have to cope with extreme conditions, but behavior of escaping might be not negligible in their adaptation to the environment. They thus migrate along the chimney walls which induces constant process of rearrangement of the colonies. We thus expected that if synchronism in reproduction might occur, it would be more likely detected between individuals exposed to similar environment inhabiting a same patch. We used artificial colonization devices (TRAC : Titanium Ring for Alvinellid Colonization) that mimic a newly formed chimney wall surface to investigate Alvinella colonization, and to analyze reproduction of individuals belonging to the same colony. Devices were deployed on Alvinellid colonies for short (less than 1 month) and long (3-5 months) term *in situ* exposition before recovery. Animals that had migrated on the device were analyzed and reproductive characteristics of females were compared in order to find out whether synchronism could be detected, and if migration had an influence on reproductive processes.

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NEW BIOLOGICAL MICROBIAL MODELS FROM DEEP-SEA HYDROTHERMAL VENTS

A rather large number of microbiologists has been involved in microbiology of deep-sea hydrothermal vents and numerous novel species from various metabolic types and phylogenetic lineages have been isolated and described during the last decades. Among these organisms, Thermococcales were frequently reported and particularly the first barothermophile *Thermococcus barophilus*, and *Thermococcus gammatolerans* which resists to ionizing radiations almost similarly to the well known model *Deinococcus radiodurans*.

The first deep-sea Thermococcales, *Pyrococcus abyssi,* has been isolated from a deep-sea hydrothermal vent in the North Fiji Basin in 1993. This novel species appeared rapidly as a performing archaeal model for physiology (responses to hydrostatic pressure, starvation and ionizing radiations), enzymology and biotechnology (thermostable enzymes including alkaline phosphatase, alcohol dehydrogenase and DNA polymerases I and II have been fully characterized). The structural and functional conservation of some proteins involved in DNA replication between Thermococcales and human (e.g. PCNA, RF-C and RP-A) raised a considerable interest in elucidating the DNA replication machinary in *Pyrococcus*. In addition, the type strain GE5, harbours a cryptic plasmid (3,5kb), the first reported for Thermococcales. This genetic element has been used for research on DNA topology at high temperatures, but mostly for the design of a shuttle vector (*E.coli*/*Pyrococcus*) and a transformation system for *Pyrococcus abyssi*. More recently, another strain belonging to the same species was found to harbour a DNA virus (named PAV1). *Pyrococcus abyssi*, whose genome has been fully sequenced and annotated represents probably one of the best example of the richness of extreme environments and particularly deep-sea hydrothermal vents for novel biological models.

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A SOURCE-SINK HYPOTHESIS FOR ABYSSAL BIODIVERSITY

Since the discovery of surprisingly high macrofaunal biodiversity in deep-sea soft sediment habitats, the central question in deep-sea ecology has been: How can so many ecologically similar species coexist in such a uniform low-energy environment? Numerous equilibrial and nonequilibrial theories that invoke a wide range of biotic and abiotic mechanisms have been advanced to explain this seeming contradiction. Current alternative explanations are based on inferences made about geographic variation in a-diversity, primarily in samples taken at bathyal depths (200-4000m) along continental margins. Here we examine depth ranges of mollusks across both bathyal and abyssal (>4000m) regions of the western and eastern North Atlantic. The abyssal fauna is shown mainly to represent sparsely occupied range extensions for a subset of bathyal species with high dispersal ability. We propose the hypothesis that the continental margins and abyssal plains constitute a source-sink system in which many abyssal populations experience a chronic Allee Effect, and are maintained by immigration from the adjacent bathyal zone. Since the great abyssal plains represent the largest marine ecosystem, this new and fundamentally different perspective has very significant implications for the genesis and maintenance of species diversity, and for estimating the magnitude of global marine biodiversity. The source-sink hypothesis is falsifiable and can be tested by documenting biogeographic ranges, gradients of standing stock, reproductive patterns and genetic population structure.

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GENETIC STRUCTURE OF *LOPHELIA PERTUSA* POPULATIONS IN THE NE ATLANTIC.

Genetic studies were undertaken in the Atlantic Coral Ecosystems Study (ACES) to answer questions related to the taxonomy, reproduction and dispersal capacity of the cold-water reef-forming coral *Lophelia pertusa*. Molecular phylogenetic analyses targeting the rRNA encoding nuclear (ITS1&2) and mitochondrial 16S regions showed that different morphotypes of coral in the NE Atlantic were conspecific. However, genetic distances between European and Brazilian specimens *of Lophelia pertusa* were extremely high indicating that these populations had been isolated for a long time and may even be different species. 10 microsatellite loci were isolated for *Lophelia pertusa* and along with rRNA encoding sequences (ITS1 & 2) were used to analyse the population structure along the European margin. Potential clones were assigned through the use of the microsatellite markers. Genetic variation was found to be markedly different between sites. This may reflect sampling bias but particularly low genetic variation in the Darwin Mounds site may be attributable to the distribution of corals in this area or even trawling impacts. Overall, it was found that fjord populations of *Lophelia* were genetically distinct from populations on the open continental margin. This probably reflects reproductive isolation of these populations because of the hydrographic and topographic structure of fjords. Open margin populations showed sufficient levels of gene-flow to maintain genetic cohesion of populations over long periods of time. However, significant genetic differentiation was detected between populations. Further analysis of the genetic population structure of NE Atlantic *Lophelia pertusa* is currently being undertaken.

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BIODIVERSITY OF THE MACROINVERTEBRATE ASSEMBLAGES OF THE KERMADEC VOLCANIC ARC SEAMOUNTS: AN OPPORTUNITY TO ANSWER LONG-ASKED QUESTIONS

Seamounts are prominent and widely distributed features of the New Zealand marine environment, and also the focus of important commercial fisheries and some exploratory mineral mining. Scientists in New Zealand are involved in a number of integrated programmes to study the physical and biological processes of seamounts. Since 1998 seamount biodiversity has received particular attention. Most recently, sampling has been undertaken of submarine volcanoes associated with the Kermadec volcanic arc, a >1000 km sector of the convergent Pacific-Australian plate boundary. Twelve of these linearly arranged seamounts (between 30° – 37°S), five of which have active hydrothermal vents, were sampled in 2001/02. Sampling consisted of multi-beam swath mapping, camera and video survey, and towed rock dredges and epibenthic sleds to recover substrate and associated biotic assemblages. Data from this study that describes the macroinvertebrate assemblage composition, and the age, origin and geochemical characteristics of the seabed, allows for some of the persistent questions in seamount ecology to be addressed. In particular, do seamounts provide stepping-stones for dispersal of biota?, to what degree has isolation on seamounts led to speciation? and what affect does the geologic history of a seamount have on the composition of its biota? The preliminary results of this study, for three vent-possessing seamounts ~50 km apart (that extend to water depths of 3500m), will be presented with respect to these questions.

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STRUCTURE AND FUNCTION OF BENTHIC COMMUNITIES IN THE DEEP GULF OF MEXICO

The Deep Gulf of Mexico Benthos (DGoMB) program is investigating the community structure and dynamics of sea-floor ecosystems of the deep Gulf of Mexico. Diversity, recurrent groups (zonation, for example, with depth), biomass and abundance, and mean size within functional size categories across a broad suite of locations are being used to test the underlying premise is that deep-sea communities are all food limited. Critical but limited community fluxes in the food web are being measured at a six sites at water depths of up to 3.6 km.

Preliminary results suggest that diversities in the macrofauna conform to the unimodal pattern observed in other ocean basins, but the mid-depth maximum is somewhat shallower (1.5 km) than that observed elsewhere. Densities of megafauna are significantly lower than those across similar depth intervals in other basins where quantitative photographic surveys have been made. Methane seeps affect normal mud-dwelling assemblages, but only in the immediate vicinity of an active seep. The gigantic Mississippi Trough adjacent to the outflow of the Mississippi River is characterized by the highest abundance and biomass values across all size groups, from the bacteria up through the fishes. Surprisingly however the macro-infauna is dominated by amphipods, rather than the expected polychaetes and nematodes, even though the sampling sites are in close proximity (ca. 5 km) to several producing oil platforms.

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VARIATION IN DEEP-SEA EPIBENTHIC MEGAFAUNA DISTRIBUTION AND ABUNDANCE, AND PARTICLE FLUX IN THE NE PACIFIC

The distribution and abundance of dominant epibenthic megafauna was estimated using line-transect photography from forty-eight camera sled and otter trawl tows conducted from 1989 to 2002 as part of the PULSE deep-sea time series study in the NE Pacific. These image data were evaluated using a Canadian grid system and the computer program DISTANCE, which is based on line-transect theory. Otter trawl collections were used in part as a voucher collection to identify species present in the photography. Particle flux to 50 meters above bottom (4050m water depth) was also measured during the same period and included measurements of the quantity and quality of the material. The distribution of specific epibenthic megafauna species vary from aggregated to random on scales from meters to hundreds of meters respectively. The overall abundance and diversity have varied significantly from seasonal to inter-annual time scales. There are also significant relationships between megafauna abundance and particle flux, suggesting the influence of climate variations on inter-annual time scales. Factors that may be controlling the distribution and abundance of the observed populations are discussed. Long time series studies such as this are just beginning to provide new insights into the dynamics of the deep-sea benthos.

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PHYLOGENY AND HISTORICAL BIOGEOGRAPHY OF THE TRIACANTHODIDAE (TETRAODONTIFORMES, TELEOSTEI), WITH COMMENTS ON THE ROLE OF ISLAND ARCS SYSTEMS AND PLEISTOCENE SEA LEVEL CHANGES IN CAUSING THE PRESENT-DAY DISTRIBUTION OF THIS CLADE

The Triacanthodidae are a deep-sea family of the Tetraodontiformes,a fish clade broadly distributed in tropical shallow-waters worldwide. Because of their basal phylogenetic position within the Tetraodontiformes, the Triacanthodidae have long been thought to indicate that the Tetraodontiformes were originally a clade of deep-sea fishes that had radiated in shallow-waters after the K/T extinction. During my presentation I will illustrate how new phylogenetic hypotheses indicate that the Tetraodontiformes were an originally shallow-water group, and that the deep-sea distribution of the Triacanthodidae represents a secondary invasion of a new habitat. Furthermore, the disjunct distribution of many species of Triacanthodidae, with populations present on the Eastern African coast and the Indonesian Region or Western Pacific Ocean, but absent in the Central Indian Ocean, can probably be explained by the movement of some groups of island arcs systems and with the sea-level changes that took place during the Pleistocene. These phenomena, long thought to be important for the interpretation of the biogeography of coral reef organisms, likely had a major impact also on deep-sea benthic groups.

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MOSAIC COMMUNITY DYNAMICS ON JUAN DE FUCA RIDGE SULFIDE EDIFICES: REFINING A MODEL OF COMMUNITY SUCCESSION

A model of community succession developed by Sarrazin et al. (1-2) proposed that a series of faunal assemblages form mosaic communities on hydrothermal edifices at northeast Pacific spreading ridges. This presentation further develops the succession model by incorporating preliminary analyses of substratum characteristics, temperature time series and biochemical analysis of potential particulate food within different faunal assemblages. Data indicate a trend of decreasing subsratum porosity from earlier-successional assemblages through to later-successional stages (3), with little variation of mean temperature. We interpret this to indicate that early-stage vent communities are primarily influenced by fluid diffusing through the substratum, while lateral inputs from adjacent sources are more important to later-successionnal assemblages. Particulate debris showed a higher organic content and lower nutritional quality within later-occurring faunal assemblages, suggesting that suspension- and deposit-feeders will exploit a more 'detrital' food supply as succession proceeds and communities age. The accumulation and utilisation of organic detritus within vent ecosystems has received little attention, as food web studies have focused on primary productivity and it's direct utilisation by invertebrate grazers and animal hosts of symbionts.The expanded model now includes a decrease in substratum porosity and stabilisation of the habitat as the driving abiotic processes while biotic factors (diversification of particulate food resources and trophic complexity) are now considered separately and given greater prominence. An improved understanding of the importance of biological interactions in relation to the physico-chemical driving forces awaits further study of vent community ecology.

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LIVING ON THE (ICE-) EDGE: FIRST RESULTS FROM INTER-ANNUAL AND SEASONAL STUDIES AT AN ARCTIC DEEP-SEA BENTHIC STATION.

One of the largest white spots in the scientific investigations of marine Arctic ecosystems is the question: How do benthic animals survive the long and dark Arctic winter, dominated by an entirely collapsed primary production? Recent studies of central Arctic deep-sea regions have already shown, that benthic populations are generally well adapted on that kind of food scarceness. During this year's expedition with the German research icebreaker POLARSTERN we had the golden opportunity to investigate Arctic deep-sea populations in late winter/ early springtime. These investigations were performed in an area which was already established in 1999 as a long-term research field. The area is located about 150 km west of Svålbard, which consists of sampling sites along a depth transect between 1000 and 5500m and an experimental area at 2500m depth. Up to now we collected a dataset of annual investigations exclusively performed during the summer months. The results presented in this paper cover especially investigations concerning the smallest benthic biota. They arise from various biochemical analysis concerning food availability, bacterial-activity and organisms biomasses as well as from investigations of the meiobenthic community. The now performed complementary winter-studies enhance the dataset by important insights about typical winter conditions. Additionally we realized in situ experiments concerning the capabilities of pulsed phytodetritus-sedimentation for structuring the community of smallest benthic biota. These experiments will be finished in June by help of the ROV "VICTOR 6000" and first preliminary results will be obtained immediately during the cruise.

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ELEMENTS OF RICHNESS AND ENDEMISM IN SPONGE ASSEMBLAGES ON SEAMOUNTS

Seamounts are frequently likened to 'oases' of prolific productivity and biomass. Such localised enrichment of benthic communities may be accompanied by elevated levels of biodiversity. Yet, biological richness of seamounts may be of a spatially tightly delineated nature caused by restricted range sizes of many component species. In this study we report on bathymetric and geographic patterns of biological richness in the sponge fauna of South Pacific seamounts along the Norfolk Ridge (New Caledonia), including elements of species turnover and range sizes. Sponge assemblages were sampled from 10 seamounts over a depth range of 236-583m using a combination of beam trawling and dredging. A total of 114 species (belonging to 40 families and 17 orders) was recorded, but local species richness varied widely from 6 to 47 per seamount. The majority of species had highly compressed range sizes, with 69% of recorded species being restricted to a single site; thus, 'spot endemics' were clearly the dominant geographic distribution class amongst this sponge fauna. Species turnover (beta diversity) was high and independent of spatial scale: geographically closest seamounts ('nearest neighbours') did on average not share more species than more distant localities. While geographic distance *per se* is a poor predictor of faunal similarities, depth appears to be a main driver in shaping patterns of richness and turnover: (1) species replacement rates increases with increasing depth separation of sites irrespective of their geographic distance, (2) biological richness declines with depth across several taxonomic levels (species, genera, families), and (3) compressed range sizes appear more prevalent in shallower occurring taxa while deeper-living sponges are geographically distributed more widely. While parallels exist between the seamounts' mosaic of sponge diversity and endemism and equally patchy distribution patterns and compressed range sizes found in some shallower settings, the isolation of seamount habitats would suggest perhaps stronger roles of localised processes in shaping their assemblages. In turn, this would emphasise the notion of seamount communities' 'uniqueness' and high 'vulnerability'.

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OBSERVATIONS OF HARD SUBSTRATE AND EPIBENTHIC MEGAFAUNA AT AN UPPER SLOPE SITE IN THE GULF OF MEXICO

In July 2002, over 60 km of 150 kHz side-scan sonar data and video were acquired by the USN submarine NR-1 in and around a submarine canyon and adjacent topographic highs. The area is located approximately 63 km east of the Mississippi River delta in 300 to 500 m of water. Preliminary viewing of the video and draft versions of side-scan sonographs clearly document at least two extensive rock complexes associated with the topographic highs, as well as the occurrence of mainly small to moderate size, low-relief outcrops/formations along the eastern side and rim of the canyon. This hard substrate is most likely authigenic carbonate; precipitated in conjunction with biogeochemical activity associated with hydrocarbon and related fluid seepage. It appears that the dominant epibenthic organism, both in terms of numbers and biomass, is a large unidentified sea anemone which occurs throughout the site often in dense aggregates. Other megafauna that have tentatively been identified from the videos include *Lophelia pertusa* and *Callogorgia* sp. as well as one or two species of antipatharians. These organisms appear to have most successfully colonized the higher relief features. No evidence of current or past chemosynthetic communities has been observed.

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GENETIC STRUCTURE OF NASCENT BIOLOGICAL COMMUNITIES AT GALÁPAGOS RIFT VENT FIELDS

In May-June 2002, two major vent fields with markedly different community structures were discovered near 86° 13'W (Rosebud) and 89° 37'W (Calyfield). Alvin dives were initially conducted to extend the time-series data at some of the earliest discovered vent sites (e.g., Rose Garden, 1979). Four Alvin dives to the Rose Garden (RG) area (86°W) revealed: 1) a notable absence of the 14 seafloor markers and ~7 stacks of Alvin dive weights that were observed during the last visit in 1990; 2) relatively recent lava flows; and 3) relatively young (small/juvenile) species assemblages. The well-developed vent faunal communities documented 13 years ago at RG have been apparently buried by eruptive lava flows.

Within 200 meters of RG, the Rosebud vent site (2470m), supports communities presently in the early stages of their development in fluids exhibiting some of the highest temperatures (23°C) and H_2S concentrations (>0.55 mmol per L) observed on the Galápagos Rift. Photomosaics of the 70 x 50 m vent field reveal 4 major venting areas that contain *Riftia pachyptila* (majority less than 6 cm in length), linear rows of bathymodiolid mussels (average ~1cm in length), and adjacent carpets of amphianthid anemones (ca. 50 per square meter). Vesicomyid clams (<3 cm length) were observed along cracks in the central sheet flow.

Calyfield, (60m x 60m; 1679m), was discovered to be dominated by the Vesicomyid clam *Calyptogena magnifica*. Photomosaics constructed revealed the distribution of large clams (ca. 18-32cm) in the flow contacts between pillow lavas, along with interspersed clumps of bathymodiolid mussels (individuals >10 fold larger than those found at Rosebud), sparse vestimentiferan tubeworms, numerous amphipod swarms, and large patches of a grey encrusting sponge (*Demospongiae* sp., endemic to Calyfield).

Based on time-series analysis of biological community structure on the East Pacific Rise, the age of the Rosebud communities is likely not more than 2 years old, and the post-eruptive pattern of colonization is unlike those previously documented. To examine the relationship of Rosebud colonists to established assemblages on the EPR, we compared *R. pachyptila* genomic fingerprints (Amplified Fragment Length Polymorphisms; ALFPs) from Rosebud, Guaymas Basin, 21°N, 9°N, and 17°S on the EPR. Analysis of 630 polymorphic AFLP loci reveal low levels of genetic diversity among the Rosebud colonists, and significant levels of genetic differentiation between the well-defined clades of populations from 21°N, 9°N, and 17°S on the EPR. The resulting genetic structure suggests larval dispersal mechanisms that maintain cohort fidelity during transport in this species.

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RICH AND COMPLEX DEEP-SEA ECOSYSTEMS ON THE EQUATORIAL AFRICAN MARGIN: GENERAL OBJECTIVES AND RESULTS OF THE BIOZAIRE ENVIRONMENTAL PROGRAM.

The deep sea environment of the African equatorial margin was almost unknown before the recent petroleum exploration. Ifremer and TotalFinaElf initiated an integrated program with a long term strategy, which aims to analyze, at local and regional scales, the influence of environmental factors on benthic communities on 6 selected sites ranging from 400 to 4000 m depth. The objectives were 1) to obtain the species composition with the contribution of taxonomists 2) to evaluate variability of the community structure together with physical and chemical characteristics at the water-sediment interface, including trophic resources (pelagic/terrigeneous input) 3) to characterize communities associated with pockmarks and methane rich fluids. 4) to undertake long term *in situ* experiments for colonization studies. Several cruises, onboard Ifremer Research Vessels between 2000 and 2003 allowed to undertake long term moorings, sampling of sediment and fauna with USNEL and multiple corers, and controlled operations with the ROV Victor. We discovered deep coral mounds, gas hydrate outcrops and bubbles of gas rising in a large cold seep field, exceptional rich chemosynthesis based communities and a great variability in the colonization of pockmarks. The occurrence of large populations of species associated with symbiotic bacteria demonstrates the existence of active pockmarks. The presence near the Zaïre canyon of isolated living organisms, indicators of reduced environment, suggests diffusive and long term influence of the arrival and transformation of rich organic matter driven by the channel. Moreover, a turbiditic event observed in the channel had consequences relatively far from the canyon in terms of input of organic matter, and in turn on the benthic community.

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DISTRIBUTION OF ZOOPLANKTON AND NEKTON ABOVE HYDROTHERMAL VENTS ON THE JUAN DE FUCA AND EXPLORER RIDGES

A rising cloud of warm water enriched with chemical and mineral species advects particulates upward from productive benthic communities and disperses laterally from hydrothermal vents. Mid-depth and deep-sea plankton aggregate above the neutrally buoyant plume, feeding on largely benthic-derived resources. My study focuses on the area between the seafloor and the neutrally buoyant plume: the composition and the distribution of zooplankton and nekton with respect to hydrothermal outflow.

The remotely operated vehicle JASON flew a 0.5 x 3 km grid at 20 m above bottom over vent fields and non-vent areas on the Endeavour Segment. My primary source of information for organism distribution was visual: high resolution video distinguished animals by form and motion. A simultaneous net tow complemented visual information. Environmental and navigational data collected every 3 seconds in conjunction with video data allow distributions of organisms to be linked with physical water characteristics. Additional net tows were taken over vent and non-vent areas on the Endeavour Segment, Axial Seamount and Explorer Ridge.

Zooplankton, gelatinous plankton, fish and shrimp were all less abundant over large vent fields. Distribution of zooplankton (primarily calanoid and cyclopoid copepods; e.g. *Neocalanus, Oncaea, Oithona sp.*) is distinctive: gaps in abundance spatially coincide with increases in temperature and turbidity (indicative of high vent outflow). Different species of zooplankton characterize different vent fields: cyclopoids dominate at smoker vents while calanoids are relatively more abundant at diffuse sites. Macrourid fish, scavengers, appear to cue to vents using temperature anomalies; their distribution within vent fields appears to be influenced high salinity.

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FOOD BANKS ON THE DEEP ANTARCTIC SHELF: THE IMPACT AND FATE OF SUMMER BLOOM MATERIAL AT THE SEAFLOOR

The Antarctic shelf is deep (~550 m), cold (1°C), and harbors many "deep-sea" taxa (e.g., *Scotoplanes* and *Peniagone*). It also experiences extraordinary seasonal variability in primary production and particle flux to the seafloor, providing a global end-member to explore the range of deep-sea community responses to seasonal phytodetrital pulses.

We hypothesize that much of the summer production on the Antarctic shelf deposits rapidly onto the seafloor where it degrades slowly due to low temperatures. The deposited phytodetritus may represent a persistent "food bank" for detritivores, selecting for non-planktotrophic larvae. If the food bank degrades slowly, much of the evolved CO_2 may reenter the water column under winter sea-ice, facilitating its loss into circumpolar deepwater.

To test these hypotheses, we used sediment traps, core sampling, radiochemical profiles, and bottom photography to evaluate temporal variability in the flux and inventory of bloom detritus, and benthic biological responses, on the Antarctic shelf in Nov 99 (pre-bloom), Mar 00 (post-bloom), Jun 00 (beginning of sea ice), Oct 00 (end of winter ice) and Feb 01 (shortly post bloom). We find intense seasonality in the flux of POC and chl-*a* to the seafloor. In contrast, seafloor inventories of chl-a, microbial biomass, and macrofauna are high and relatively constant at all sampling times. These results suggest that there is indeed a persistent "food bank" for detritivores in Antarctic shelf sediments, providing substantial food resources throughout the year. This food bank may influence the selection of life histories in Antarctic benthos, and may facilitate the global carbon pump.

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CLIMATE CHANGE AND BENTHIC BOUNDARY LAYER PROCESSES AT 4,100 M DEPTH IN THE NE PACIFIC: A 13-YR TIME-SERIES STUDY

A long time-series station was established 200 km west of the central California coast at 4100 m depth (Sta. M) in June 1989 and monitored through September 2002. Sequencing sediment trap collections at 50 m above bottom were analyzed for particulate organic carbon (POC) and nitrogen (PN) as a measure of food supply, entering the benthic boundary layer (BBL). A free vehicle grab respirometer was deployed on seasonal cruises to measure sediment community oxygen consumption (SCOC), an estimate of food consumed by the benthic community. POC and PN fluxes significantly declined from 1989 through 1996 then increased substantially from 1998 through 2002. SCOC, varied seasonally in concert with seasonal fluctuations in particulate matter fluxes but remained relatively consistent from year to year. POC flux:SCOC declined from unity in 1989 to 0.1 in 1996 only to return to unity in 1998. There are significant correlations between POC fluxes and climatic indices including the Bakun Upwelling Index, Pacific Decadal Oscillation and Northern Oscillation Index. Sea surface temperature and photosynthetic rates derived from satellite data were used in a pelagic food web model to estimate export production from the euphotic zone. Export production from the euphotic zone surrounding Sta. M was significantly correlated with POC fluxes at 4050m. Strong climatic links exist between surface ocean processes and abyssal BBL processes.

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REGULATION OF DEEP, COLD OCEAN, BENTHIC INFAUNA BY SURFACE PROCESSES

The deep muddy bottoms of the Newfoundland coast depend on surface waters to provide organic matter and transport of propagules, yet these surface waters are extremely variable seasonally and spatially. We set out to test whether this variability could help to explain patterns in benthic macrofaunal communities in individual bays. Box coring at six sites in Trinity Bay (depth 160-300 m) indicated that our initial expectation of higher densities of organisms and reduced diversity in areas with upwelling and high sedimentary carbon and phaeopigments was found to be an oversimplification. Although distinct faunal communities were observed at several of the sites, along with variation in total densities and diversity, differences cannot be attributed to any single variable such as geographic locale, organic input, or sediment grain size. It is likely that the combination of these variables helps to delimit distributions of macrofauna in the deep bays of Newfoundland. We will contrast these results with similar data collected in other major deep embayments around the island to provide a regional interpretation of bentho-pelagic linking for cold ocean environments.

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GRADIENTS IN ACTIVITY AND BIOMASS OF THE SMALL-SIZED BENTHIC BIOTA AROUND THE HÅKON MOSBY MUD VOLCANO, SW BARENTS SEA SLOPE

The Håkon Mosby Mud Volcano (HMMV) is an active mud oozing gas seep located at 1250 m water depth within a slide scar on the SW Barents Sea slope. HMMV has a 1-km-diameter circular shape and a relief of 8-10 m. It displays a central zone of 200 m in diameter with methane-containing non-stratified, highly reduced sediments; this zone represents the thermal "eye" of the volcano. Beyond that zone, sediments containing non-associated methane are replaced by gas hydrate-containing ones. Large areas in the southern-central part of the volcano are densely covered by bacterial mats. The outer zone consists of sediments that are oxidized from the surface; small pogonophorans with symbiotic methanotrophic bacteria dominate the macrofauna community inhabiting these areas. HMMV represents an area of extreme physical and chemical gradients, which should have a severe impact on the associated sediment-inhabiting community.

RV "Polarstern" expedition ARK XVIII/1 in summer 2002 gave the opportunity to carry out an extensive sampling program to assess the activity and biomass of the small-sized benthic biota (bacteria - meiofauna). A total of 11 stations, covering the different key areas within the crater (see above) and control sites outside the moat were sampled using a multiple corer. Subsamples were analyzed for various biogenic compounds to estimate the flux of organic matter to the seafloor, benthic activities (e.g. bacterial exo-enzymatic activity) and the total biomass of the smallest sediment-inhabiting organisms. Direct investigations on bacterial numbers and biomasses, as well as meiofauna densities and composition completed our investigations at HMMV.

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MEIOBENTHIC RESPONSE TO THE PULSED DEPOSITION OF PHYTODETRITUS – AN IN SITU EXPERIMENT IN THE PORCUPINE ABYSSAL PLAIN

Phytodetritus represents the major food source for abyssal benthic communities. In various oceanic regions parts of the annual organic carbon load is deposited in pulses within a few days. Attempts to decipher the benthic response to such pulsed sedimentation events of organic carbon are constrained by the unpredictability of these events and logistic limitations. Embedded within the integrative German deep-sea project BIGSET we studied the meiobenthic response to phytodetritus deposition in 11 in situ experiments about 4850 m deep at the Porcupine Abyssal Plain, NE-Atlantic. The phytodetritus pulse was simulated by injecting $^{13}C/^{15}N$ labeled freeze dried diatoms (*Thalassiosira rotula*) into chambers of benthic landers. Meiofaunal carbon uptake down to a sediment depth of 5 cm was followed during experiments of 2.5, 8, and 23 days duration. Meiobenthic response to carbon deposition was immediate. Within 2.5 days injected carbon was accessed in the sediment surface. After 8 and 23 days nematodes colonising in deeper sediment layers also showed increased specific $^{13}C/^{15}N$ uptake rates. Overall uptake of the labeled carbon source by nematodes was up to 592 times higher (367.6 µg $^{13}Cm^{-2}23d^{-1}$) than by copepods, although these organisms constitute 56-63 % of the meiofaunal biomass. In contrast to previous findings meiofaunal response to freshly deposited organic carbon is very fast and extends deep into the sediment.

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SEAMOUNTS AND SUBMARINE CANYONS: THE KNOWN, THE UNKNOWN, THE UNKNOWABLE, AND FUTURE STEPS

Seamounts and submarine canyons are both topographically-isolated seafloor features that are known to support unusual biological communities with respect to high levels of endemism, elevated biomass, unexpected biogeographic affinities (including range extensions), and/or altered species diversity compared to surrounding habitats. Both habitats are also the focus of commercial fisheries and consequently of management and conservation efforts. This talk reports on the outcome of a Census of Marine Life workshop recently held to summarize what is known about these habitats globally and to identify priority research needs. It will summarize the unique community and biogeographic features and how they vary spatially, highlight gaps in current sampling, and outline plans for a future, coordinated, international research effort.

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FATTY ACIDS AND STABLE ISOTOPES: A NEW APPROACH TO THE TROPHIC ECOLOGY OF THE DEEP-SEA ICHTHYOFAUNA

Despite the importance of fish in the trophic ecology of the deep-sea as predators, scavengers and in the dispersal of large food falls, relationships between fish species and their prey remain largely undescribed and little is known about their role in benthopelagic food webs.

Previous studies on diets of deep-sea fish have relied on conventional stomach content analysis. However trawl feeding and regurgitation of prey, resulting from hydrostatic decompression, have largely compromised such studies. Fatty acids remain relatively unchanged as they pass from prey to predator while stable isotope ratios tend to change up food webs. As such, fatty acids and stable isotopes have the potential to be used as trophic markers.

Fatty acid and stable isotope analyses were applied to quantitatively investigate the trophic ecology of five species within the two dominant families of deep-sea fish (Macrouridae and Moridae) at the Porcupine Abyssal Slope and Plain (NE Atlantic). Both fish and a variety of potential prey species were sampled so as to determine the fatty acid and stable isotope signatures.

Preliminary fatty acid data show significant differences between fish species, indicating species relying on different food sources. Within species, changes in fatty acid profiles were found with increasing body size and between bathymetric zones. Results will be used to assess the importance of seasonality and scavenging on trophic relationships within these fish communities.

This combination of fatty acid and stable isotope analysis has not previously been applied to deep-sea ichthyofauna. These results offer the prospect of a significant advance in understanding the role of fish in benthopelagic food webs of the deep sea allowing a greater understanding of fundamental processes in this environment.

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WHO IS EATING MOST OF THE ZOOPLANKTON IN THE OCEANIC GULF OF MEXICO? THE IMPACT OF MESOPELAGIC FISHES

Deep-sea pelagic fishes are the most abundant vertebrates on Earth, yet their role in the overall economy of the sea is poorly known. Low latitude oligotrophic regimes, typified by the eastern Gulf of Mexico, constitute most of the world ocean and consequently support the largest global ecosystems. Thus, we have little information on the trophic role of most of Earth's vertebrates. To address this, the diets of an entire midwater fish assemblage (164 species, constituting > 99% of assemblage numbers) were analyzed to assess feeding guilds and predation impact. Zooplanktivory was the dominant feeding mode (80% of prey biomass taken), followed by piscivory. However, the entire fish assemblage predation impact on zooplankton was only 5-10% of daily production. This points to critical limitations in our understanding of how tropical-subtropical regimes, the largest of global ecosystems, function and which taxonomic groups are the most important zooplanktivores. Regarding the latter, the obvious candidate is other zooplankton, including large gelatinous predators.

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PROTECTION OF HIGH SEA AREAS - STATUS REPORT

Between 2001 and 2003, three workshops have been held to discuss the protection of certain species and communities in deep-water regions. A fourth workshop will be conducted towards the end of this year. Scientists, non-governmental organizations and a few governments are the driving power behind this development. Lawyers and legal officers always delivering essential contributions.

Protected areas have been established in Exclusive Economic Zones under national laws, but the United Nations Law of the Sea (UNCLOS) does not provide the legal basis for conservation measures on the high seas, i. e. beyond national jurisdiction. However, where deep-sea mining is concerned, UNCLOS has entrusted the International Seabed Authority with the responsibility for safeguarding the environment. This should result in an undisturbed seafloor network to conserve biodiversity, interrupted by isolated mining blocks. For support of such a concept, scientists are requested to study species distributions on scales of kilometers. This approach should be applicable also to other human impacts on the deep seafloor.

Discussions aim at regional regulations, particularly to overcome the intensive overfishing of deep-water fish stocks, and at ammendments to UNCLOS through the United Nations Consultative Informal Process (CIP). High seas protected areas have been proposed particularly by non-governmental organizations.

Scientists should be aware that intrusion into the deep sea by various societal activities may severely disturb the research work they conduct in the interest of human society. Conflicting interests may develop between stakeholders, and scientists should realize that they are among the stakeholders. The establishment of Unique Science Priority Areas (USPAs) to safeguard scientific activities in the deep sea would also provide certain protection to species diversity and communities.

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CONSEQUENCES FOR THE DEEP-SEA FAUNA OF INJECTION OF LIQUID CARBON DIOXIDE: PRELIMINARY RESULTS

Instead of releasing carbon dioxide from power plants into the atmosphere, where it would contribute to global warming, the waste CO_2 could be collected, liquefied, and injected into the deep ocean. At the pressures and temperatures below ~2600 m, liquid CO_2 is negatively buoyant and thus would stay in place and slowly dissolve into the overlying water. Some of the environmental consequences of CO_2 injection are clear; a lake of CO_2 on the seabed would smother the animals directly beneath it. We are studying the far-field effects. We have begun with a small-scale experiment in which we injected 20 liters of liquid CO_2 into each of three open-topped, 10-cm-tall cylinders on the seafloor that were arranged in a triangular array (10 m apart) at 3200 m off Monterey, CA. After 30 days, we took core samples within the triangular treatment area and in an area 40 m away. CO_2 was not present on the sediment surface in either area, but the pore water of treatment cores was ~0.75 pH unit more acidic than that of control cores. (A decrease in pH indicates increased concentration of CO_2.) We report the condition of harpacticoid copepods from the treatment and the control cores in terms of mortality, energy reserves, and reproductive potential.

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BENTHIC COMMUNITY STRUCTURE IN THE DEEP HYPERSALINE ANOXIC BASINS OF THE EASTERN MEDITERRANEAN SEA

Recently, five deep hypersaline anoxic basins (DHAB) were discovered in the Mediterranean Sea (below the depth of 3000 m), namely the Bannock, Urania, Discovery, Atalante and Tyro basins. They represent unique deep-sea environments originating from the dissolution of buried salt deposits (evaporites), that are the remains of hypersaline waters of the Miocene period (5.5 M.y. before present). DHABs are characterised by a total salinity above 30%, absence of light, elevated pressure, methane and hydrogen-sulphide concentrations, variable pH values, a unique geochemical composition, high organic content and are sharply separated by the overlying normal sea water.

Very little is known about the biological characteristics of the sediments of DHABs. One of the principal goals of the project was to characterize the diversity and taxonomic composition of the meiobenthic communities inhabiting the different basins in relation to the prevailing environmental conditions. To do so, sediment samples were collected from all DHABs both within and outside the influence of the brine.

Nematodes and foraminifera dominate the meiobenthos outside the brine area. Low meiofaunal densities supported by low values of chloroplastic pigments and mineralization rates are indicative of the typical oligotrophic environment of the deep Eastern Mediterranean Sea.

Within the brines, sediment chemistry and community structure differ considerably. High quantities of organic matter, enhanced mineralization rates and surprisingly high meiofaunal densities were recorded. Nematodes, benthic foraminifera (fam. Allogromiidae), bivalves and gastropods dominate the meiofaunal community. These taxa are known to harbour prokaryotic symbionts and thrive in organically enriched – oxygen depleted habitats.

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GAMETOGENIC PERIODICITY IN THE GENUS *BATHYMODIOLUS*

The bivalve genus *Bathymodiolus* is the most speciose and widespread of invertebrate genera found at cold hydrothermal vents and cold seeps. Species of this genus are found at vents in the eastern and western Pacific, the Mid Atlantic and the Indian Ocean, and at cold seeps in the Gulf of Mexico, the Barbados accretionary prism, the eastern margins of the Pacific and off Japan. From the MAR there is evidence of seasonal recruitment to the population of *Bathymodiolus*, unlike the population structure in the Pacific. We have examined a time-series of samples of *Bathymodiolus thermophilus* from 9°N on the EPR and *B. childressi* from the Brine Pool on the Louisiana slope. At 9°N, comparison of gametogenic development between samples of *B. thermophilus* from spring and late autumn do not suggest any gametogenic periodicity. Conversely, in *B. childressi* from the Brine Pool, there is evidence of a distinct seasonal gametogenic periodicity with a potential spawning period from December to early March. As all the evidence suggests a planktotrophic larval stage, we believe the controlling factor in gametogenic periodicity is the temporal periodicity in the availability of organic matter from surface-derived primary production. Supported by NSF Grant OCE-0243688 (C.M. Young).

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HIGH NEMATODE SPECIES DIVERSITY IN THE DEEP SEA: CORRELATIONS AND CAUSES FOR DIVERSIFICATION WITHIN GENERA?

The controversy on how diverse nematode communities are in the deep sea from basin scales to global scale is despite the slowly growing number of species data still alive because of the lack of taxonomic work that would allow us to compare species distribution patterns over larger areas. We know at this stage that at local scales (within cores of 10 tot 25 cm^2) the number of genera (50 to 70) equals the number of species of the most diverse habitats in shallow waters. However whereas the dominant genera of shallow water communities are only exceptionally represented by maximum 3 to 5 species (for instance *Microlaimus*) within one spot, the within-genera diversification in the deep-sea is showing extreme proportions of up to 40 species per dominant genus within one area of a few square km's at different locations of the world. Records of up to 15 to 20 closely related species living together at a few square cm's are available for *Monhystera, Acantholaimus* and *Halalaimus* to name a few. Recent observations of relatively low turnover within basins (Lambshead and Boucher, 2003) are indeed confirmed by our observations showing that many species are distributed over relatively wide bathymetric and geographical ranges. Global distribution patterns and thus integrated biodiversity estimates are however hardly known because of the lack of published morphological data. Species lists, numbering different forms do help to estimate biodiversity within one study area but are a waste for more integrated spatial or temporal analyses. However the few data available suggest that the high diversification took place within each basin separately. The questions that remain unanswered concern the processes that are responsible for this high species richness: 1. What allows so many closely related species to live together? 2. Which processes have driven this assumed repeated high diversification for the same dominant genera at different ocean basins. It is illustrated that the diversification for different genera is associated with different environmental gradients including sediment, oxygen and bathymetry. The potential importance of micro-evolutionary processes such as adaptive radiation and local adaptation are discussed.

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TYPICAL SHALLOW WATER COPEPODA HARPACTICOIDA IN THE ATLANTIC DEEP SEA

The members of the meiobenthic harpacticoid family Paramesochridae are typically small interstitial animals, cylindrical in shape, inhabiting sandy beach ground water, the intertidal and shallow waters. Recently some new species have been recorded from the deep sea but the genus *Kliopsyllus* with its 28 species seemed to be restricted to shallow areas. Two international scientific cruises (DIVA and ANDEEP) to the Angola basin and the Scotia Arc as well as the northern Weddell-Sea now contributed three new species to the genus, which is even more astonishing as they form the majority of all Paramesochrid species at the sampled sites. Additionally, not only species diversity is dominated by *Kliopsyllus* but individual number as well.

A short introduction to the new *Kliopsyllus*-species and their taxonomic peculiarities will be given, followed by the discussion of links between atlantic and Antarctic deep sea Paramesochrids and their possible ways of distribution.

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THE BIGGEST BABY OCTOPUS IN THE WORLD: HATCHLINGS OF *GRANELEDONE*

Two reproductive patterns unify coleoid cephalopods, fairly large yolky eggs and a general semelparous life history strategy. Small (2-4 mm long) eggs of shallow-water benthic octopuses hatch into planktonic young; large (up to 17 mm long) eggs of shallow-water octopuses hatch into miniature benthic adults. Although deep-sea octopuses are diverse, the eggs of all four octopod egg clutches reported collected from depths of 784 m to 1106 fm (2057 m) since 1885 are 21 and 31 mm long. Here 40 mm long eggs of a brooding octopus of *Graneledone boreopacifica* collected from 1650 m on the Gorda Escarpment are reported with 28 hatchlings that are roughly 55 mm in total length. Gonadal development of the hatchlings is comparable to that typical of 3.5 month old shallow-water octopuses. The 51 extraordinarily large eggs in the clutch document a phenomenal investment of energy in each individual egg rather than in producing more smaller eggs, a strategy congeneric octopuses collected from shallower, comparable and greater depths follow. Their semelparous life history strategy may pre-adapt cephalopods to the deep sea, where deferred reproduction and the production of large young may maximize fitness due to food-limitation and habitat stability. The large size of these eggs and their extremely mature hatchlings suggest that the Gorda Escarpment is special, or perhaps that this species is special in experimenting with an evolutionary extreme level of energy investment per offspring. We report here characters of these hatchlings, the world's biggest baby octopuses.

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A NEW LOOK AT EVOLUTIONARY PATHWAYS AND THE AGE OF DEEP-SEA HYDROTHERMAL VENT TAXA

The view that deep-sea hydrothermal vent taxa represent phylogenetically ancient lineages is not consistent with current molecular phylogenetic analyses of the dominant vent taxa. Although fossil evidence suggests that most of these taxa appeared during the Mesozoic or earlier, current molecular evidence suggests that the crown-taxa may have diversified more recently during the Cenozoic. In an attempt to rectify these disparate views, I examine some assumptions, and some of the perils and pitfalls of paleontological versus molecular approaches to assessing the evolutionary age and patterns of diversification of animal taxa. Current phylogenetic evidence makes it apparent that any consideration of the evolution of vent-endemic taxa must simultaneously consider their cold-seep and hydrothermal seamount relatives. Species from cold-seeps and sometimes seamounts occupy basal positions in many clades that include vent-endemic crown-taxa. Also, a broad-scale pattern of evolution from shallower to deeper environments appears to exist, although evolution is not orthogenic. Degrees of specialization versus generalization with regard to habitat and depth are reversible. These patterns appear to be consistent with the hypothesis that deep-sea environments were subjected to broad-scale extinction events during the late Mesozoic and early Cenozoic. Thus, the crown-taxa that dominate modern hydrothermal vents appear to have radiated, or re-radiated, from stem-ancestors that survived in shallower seep habitats or on hydrothermal seamounts.

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THE REPRODUCTIVE ECOLOGY OF TWO DEEP-WATER REEF BUILDING CORALS IN THE NE ATLANTIC OCEAN

Two of the deep-water reef building scleractinians found within the NE Atlantic are *Lophelia pertusa* (Linné, 1758) and *Madrepora oculata*, Linné, 1758. These two species are commonly found together in reefs and mounds throughout European waters. Deep-water reefs have been shown to provide an important habitat for many invertebrate and vertebrate species. These reefs are used as habitats for feeding, protection and reproduction. Many commercial species of fish have also been found around *L. pertusa*. With pelagic fish stocks falling, many fishermen have moved to deeper waters. Deep-water trawling has been shown to have a detrimental effect on corals, damaging the fragile habitat.

The reproductive ecologies of *L. pertusa* and *M. oculata* from the Thérèsa Mound (Porcupine Seabight) and the Darwin Mounds (NE Rockall Trough) was investigated using histological techniques.

Both *L. pertusa* and *M. oculata* were found to have seasonality of gamete production, though *M. oculata* is thought to be periodic rather than truly seasonal. Oocytes and spermacysts first appear in August and spawning is inferred to occur around January/ February. It is hypothesised that both may produce a lecithotrophic larvae.

Samples from the Darwin Mounds were all found to be non-reproductive. The constant disturbance from trawling in this area may have lead to colonies being broken to a size below that required for reproduction. With this site soon to become a Marine Protected Area, this raises interesting questions as to this corals ability to recover from the constant damage.

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PATTERNS OF MEGABENTHIC COMMUNITY STRUCTURE AND ACTIVITY IN RELATION TO OXYGEN MINIMA ON THE OMAN CONTINENTAL SLOPE, NW ARABIAN SEA

The continental slope of the Oman margin is characterised by large canyon systems, variable sediment facies and the presence of an extensive oxygen minimum zone (OMZ). The Oman OMZ begins at a depth of approximately 50m and extends through the water column to a depth of approximately 1300m. It is characterized by oxygen concentrations of $<0.5 ml\ L^{-1}$ throughout this depth range, but at 500-700m depth, in the heart of the OMZ, values $<0.1 ml\ L^{-1}$ were recorded. We present observational and quantitative data on megafauna from a seven-station transect down the Oman slope. The high productivity in the surface waters promotes the persistence of the OMZ and shapes the depositional environment on the seafloor. Environmental conditions for the benthos change rapidly over a few hundred metres, both vertically in depth and horizontally in distance from the shore. Using a combination of video imaging, coring and trawling, benthic communities were found to be very specific to a certain depth, oxygen concentration and sedimentary environment. Even in the heart of the OMZ some species were abundant although both species and functional diversity were low. Levels of activity, measured in terms of visible bioturbation, were compared along the depth transect and are discussed in relation to oxygen minima and the sediment character of each locality.

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BENTHIC ISOPOD DIVERSITY IN THE GULF OF MEXICO

During May-June 2000, box corer transects were collected from north central Gulf of Mexico by the R/V *Gyre*. These samples yielded more than 100 species of Isopod crustaceans. This diversity is higher than observed off New England at 2100m, although no species was found over the total depth range of the samples (approximately 2800m). Some species were highly patchy (underdispersed), with some samples dominated by single species, such as a species of Macrostylidae. Although these data show the well-known mid-depth peak in species richness centered around 1500m, individuals and species in a sample were highly correlated, and depth range sizes of species show a clear mode at mid depths. This survey added more than 20 species to the Gulf of Mexico isopod fauna mentioned in a Pequenaut (1990) study. Some species are known from the North Atlantic, but most are undescribed taxa. Of the 14 families observed, only the most diverse and numerous Desmosomatidae were found at all sites. The Macrostylidae were next most numerous but represented by few species.

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THE FATE OF ORGANIC CARBON SETTLING AT THE DEEP-SEA FLOOR: AN EXPERIMENTAL APPROACH

The deep-ocean floor is one of the major marine reservoirs in the global carbon cycle and the transfer of carbon through the ocean plays a key role in controlling atmospheric CO_2 concentrations. For logistic as well as financial reasons, however, in situ measurements of deep-ocean fluxes can only be performed at a few spots. Although a close benthic-pelagic coupling as well as temporal changes in benthic carbon turnover are evident in many areas of the deep-sea, it still remains difficult to pinpoint the steering factors triggering the benthic response and predict its speed and amplitude from POC flux measurements. The descriptive approaches to this question have so far been hampered by logistic difficulties and the unpredictability of seasonal sedimentation events. These difficulties can be overcome by in-situ experimental approaches. Food pulses consisting of ^{13}C-labeled diatoms were simulated in benthic chambers, the stable isotopes served as tracers in order to follow the POC-transport into the sediment as well as uptake, incorporation and remineralization of the algal material by the different functional benthic groups of organisms.

Experiments at abyssal depth (4800 m) in the NE Atlantic revealed an instantaneous increase in activity that was maintained for at least 3 weeks. In both continental slope and deep-sea sediments, macrofauna turned out to be of great importance for initial carbon processing. The entrainment of label into the sediment and the incorporation into bacterial biomarkers was fast at the continental slope, but a considerable time lag was recorded at abyssal depths, pointing to a pronounced difference in the response pattern of slope and abyssal plain benthic communities to a food pulse. In addition, the benthic response to such a pulse is clearly modulated by both the quality and the quantity of settling organic material.

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THE DANISH *DANA* EXPEDITIONS: PURPOSE AND ACCOMPLISHMENTS

The year 2003 marks the 75th anniversary of the outset of the circumnavigation 1928-30 of the *Dana*, the culmination of 25 years of previous oceanic research directed by Johannes Schmidt, fishery biologist and later professor of the Carlsberg Laboratory.

The starting event of the whole enterprise happened in 1904 when Schmidt and colleagues on board the Danish fishery research vessel *Thor* captured at the Faroe Islands the very first *Leptocephalus brevirostris,* the larva of the European eel (*Anguilla anguilla),* collected in the Atlantic outside the Mediterranean. Schmidt's hunting for the then completely unknown breeding place of the eel was subsequently initiated on the *Thor.*

In order to prove whether or not the eel did breed in the Mediterranean he undertook there what is still the most comprehensive pelagic investigation of that sea, first during the winter 1908-09 and then during the summer 1910: the *Thor* Expedition. Not a single small eel larva was found, but the effort resulted in the *Thor Report* of nine volumes. From 1911 to 1915 Schmidt persuaded captains of Danish commercial ships to collect larvae for him in the North Atlantic. The larvae were of increasingly smaller size towards the west. In 1913 he also hired and sent the schooner *Margrethe* to the West Indies; here she was wrecked, but the rich larva collections were saved.

After World War I the four-masted schooner *Dana* of the Danish East Asiatic Company was used in 1920 for collecting intensely in the Sargasso Sea, but a serious leak interrupted the work for one decisive month. When returning next spring, thousands of larvae of the European and American eel were again captured, and large numbers of eel-like fish eggs were hatched, but none were babies of the elusive *Anguilla.*

Later in 1921 Schmidt came back on the new, just acquired and well equipped fishery research vessel, a former British minesweeper of 360 tons, which was also named *Dana.* After ten months of intensive investigation with collection of eel larvae down to 5-6 mm in length, Schmidt could in late 1922 crown his achievement when publishing the results under great attention worldwide.

The following years Schmidt revised the systematics of Indo-Pacific *Anguilla* species based on material in museums as part of his plans for an investigation of their life history during a circumnavigation. This should at the same time provide the first really comprehensive comparisons between the pelagic faunas of the three oceans down to 2000-3000 m.

"The Carlsberg Foundation's Oceanographical Expedition Round the World 1928-30" began in June and got off to a flying start in the Gulf of Panama. The first *Anguilla* larvae were caught just east of Tahiti. After the Cook Islands, Samoa, Fiji, New Caledonia and New Zealand, raging hurricanes off eastern Australia and later south of Japan unfortunately prevented a search for eel larvae there. By far the best results were obtained in the waters west of Sumatra, where the greatest diversity of freshwater eels was found. In the northern Indian Ocean a range, later baptized the Carlsberg Ridge, was located, and after a two-month detour into the Mediterranean, *Dana* returned in late June 1930 after covering 5000 nautical miles.

Meticulous sampling for more than two years with mainly 1 1/2 3 m ring nets at different depth levels (mainly 4-6 nets per haul) had yielded a total of 3700 net samples. Initial and targeted sorting during 40 years (!) into 300-400 animal groups, corresponding to the framework of individual publications, resulted in more than 1/2 million samples.

Results have primarily been published in the *Dana Report* 1932-91, covering 7450 large quarto pages and with 91, mainly monographic, contributions. None bears Schmidt's name. He died in 1933, only 56 years old.

The overwhelming richness of the collections may be exemplified as follows: A study of more than 25,000 eels and elvers reduced the number of species to only 16, spawning places were documented on the basis of 1500 *Anguilla* larvae (only 2 known previously!), and another nine papers cover other eel-like families; the development of 140 juvenile and 7000 larval Notosudidae or wary fishes (30 known previously) could be supplemented with adults collected with midwater trawls by later expeditions; a study of 19,500 larvae and adults of Paralepididae or barracudinas resulted in 32 species, 24 being new; the knowledge of the fascinating ceratioid angler fishes was revolutionized after the study of 2400 *Dana* larvae and 500 adult females, many with parasitic males; the new order Miripinnati was erected for two families, one with a single specimen of a strange "hairy" fish, the other with 3 species; until 1920 only 13 specimens of the small deep-sea squid *Spirula* with its air-filled spiral shell were known, but the study of almost 100 Atlantic and another 100 Indo-Pacific specimens revealed its life history; access to 635 *Dana* samples of the heteropod gastropods reduced the number of species from 107 to 22 "by using the pruning knife severely"; similarly, a study of 35,000 oxycephalid amphipods reduced the number of species by two thirds to only 18; on the other hand, the study of 255 very spiny larvae of the eryonid deep-sea lobsters increased the number of species from 7 to 32; five papers of 1250 pages in all cover the myodocopid ostracods (with the seven most common species comprising from 21,000 to 460,000 specimens!).

Somehow it is a paradox that the enormous richness of *Dana* collections has been their greatest weakness. In several cases it has been impossible to find specialists willing to study the perhaps tens of thousands of individuals of various groups, although they are well sorted. A recent monograph on the oceanic shrimp genus *Sergia,* published in the *Galathea Report* and with other sergestids still under study, shows that *Dana* collections are available for study.

The *Dana* Expeditions undoubtedly represent the greatest contribution ever made to the exploration of oceanic animal life. Moreover, the expenses of the many cruises, the continuous sorting, the publication, etc. were all covered by the Carlsberg Foundation, certainly being the largest and most significant grant that has ever been made in any country by a private fund for scientific exploration.

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UNUSUAL ORGANIC OSMOLYTES IN ABYSSAL AND HYDROTHERMAL-VENT ANIMALS: ADAPTATIONS TO HYDROSTATIC PRESSURE AND SULFIDE METABOLISM?

Shallow marine invertebrates use compatible organic osmolytes, e.g., taurine and glycine. Shallow elasmobranchs use the protein-destabilizer urea and the protein-stabilizer trimethylamine oxide (TMAO) at a 2:1 ratio. Most shallow teleosts have low organic osmolyte contents. Our studies show deep-sea animals have different compositions. Previous work showed that TMAO, 70 mmol/kg or less in shallow teleosts, increases with depth in muscles of several teleost families. Pacific grenadiers (*Coryphaenoides armatus* and congeners) from 2.9 km were found to contain 170-180 mmol/kg TMAO in muscles. We now report that Atlantic grenadiers (*C. armatus*) from 4.8 km contain 261 mmol/kg (SD=12, n=5), fitting a linear depth trend. Similarly, deep elasmobranchs have less urea and more TMAO (1:2 ratio at 2.9 km) than shallow relatives. We also found that 150-250 mM TMAO counteracts effects of hydrostatic pressure. For inhibition at 200-1000 atm, TMAO (but not glycine) protected ligand binding of lactate dehydrogenase (LDH) and pyruvate kinase, stability of LDH, polymerization of F-actin, and growth of yeast. Animals from hydrothermal vents and cold seeps have no TMAO, but contain other unusual osmolytes. Vestimentiferans have high levels of an unsolved N-methyl solute, hypotaurine and thiotaurine. The latter is highest in symbiont-bearing tissues in seep clams and vent vestimentiferans,and limpets, but is also found in vent snails with no symbionts. The amount of thiotaurine decreases in the laboratory in vent snails and limpets kept without sulfide. Thiotaurine and hypotaurine show no depth correlations and probably function in sulfide metabolism of symbionts and/or detoxification of sulfide.

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MODIFIED CONCEPT OF FAUNAL ZONATION SUGGESTED FROM THE HORIZONTAL AND VERTICAL TREND OF ZONATION OF DEEP-SEA DEMERSAL FISH AROUND JAPAN

To understand the gradient-controlled distribution is one of the principal interests in the community ecology. The depth-related faunal change is usually termed zonation. The causes of this pattern remain one of the most difficult and elusive problems faced by deep-sea ecologist.

Data analysis was performed by means of a clustering technique, Morisita-Horn index and non-combinatorial method, and an ordination technique, detrended correspondence analysis (DCA). Then the correlation between the main gradients (DCA axes) and environmental variable was tested by the randomization test for Spearman's rho correlation. The similarity level of 0.15 was used as reference points for identifying communities. Cluster analysis indicated three geographical areas; Japan Sea, North Pacific Ocean and Philippine Sea. Though the North Pacific Ocean and Philippine Sea have several typical faunal zonation deeper than 200 m, Japan Sea showed no faunal zonation and has a uniform faunal composition. Correlation of DCA axes with environmental variables showed that temperature and salinity explain main faunal groupings.

The concept of zonation has apparently been accepted among various taxonomy groups since 1970s. In this study, we found the horizontal and vertical faunal zonations of deep-sea demersal fish around Japan coincide well with the regional hydrography, and then the concept of zonation of deep-sea demersal fish was modified according to our observations. The modified concept of zonation was as follows: 1) The boundary of faunal zones should be like the boundary of water mass. 2) The width of faunal zones changes variably within a geographic area. 3) In the shallow water, there is geographical displacement of zonation boundaries. 4) The submergence on the community level of demersal fish could be happened. 5) The community structure of demersal fish coincided with the regional hydrography. 6) Water mass plays a more important role than topography in regulating faunal distributions.

ABSTRACTS OF POSTER PRESENTATIONS

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GIANT PROTOZOA FROM THE ARABIAN SEA

Gromiids (phylum Cercozoa, order Filosea, genus *Gromia*) are large benthic protozoa with organic tests that occur in intertidal and sublittoral habitats. They are closely related to the foraminifera. The Precambrian ancestors of the foraminifera may have been gromiid-like protozoa. In 1994 the first deep-sea gromiid was discovered at bathyal depths on the Oman margin. This species was identified as a gromiid on the basis of its wall structure and subsequently described as *Gromia sphaerica*. Since then, a variety of undescribed gromiid-like protozoa have been found at other localities on the Oman and Pakistan margins. They range in size from a few millimetres to a few centimetres and include elongate carrot-shaped, sausage-shaped and grape-shaped forms. Spherical and grape-like forms predominate on the Oman margin while elongate forms are more common on the Pakistan margin. The gromiids were mainly found below the OMZ where oxygen levels were >0.5 ml/l and the organic carbon content of the sediment still relatively high. On the Oman margin they occurred in the depth range 1000-1800 m; on the Pakistan margin they were abundant in trawl samples from 1800-1900 m. A series of studies, addressing the morphological and molecular taxonomy, ecology and ultrastructure, has been initiated in order to address the biology of these important and spectacular deep-sea protozoa and to confirm that they are, indeed, gromiids.

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BRAZILIAN DEEP-WATER SKENEIMORPH GASTROPODS FROM BACIA DE CAMPOS, RIO DE JANEIRO STATE, BRAZIL

The major oil producing areas explored by Petrobras (Brazilian Petroleum Co.) are at the northern coast of Rio de Janeiro State (about 22°S), at depths ranging from hundreds to around two thousand meters. In this context, Petrobras is carrying out a large project of environmental characterization of the whole area in Bacia de Campos ("Projeto de Caracterização Ambiental da Bacia de Campos"), as a demand from Brazilian Environmental Agencies. Several samples were collected using box-core at depths varing between 900 and 2000m. The sediment was washed through a 300μm sieve and sorted under a stereomicroscope. We have found more than 120 nominal benthic molluscan taxa, many of them remaining identified at generic level only. Among them, for the first time, the following are reported for the Brazilian coast: *Adeuomphalus* cf. *ammoniformis* (Seguenza, 1876), *Adeuomphalus* sp. 1, *Adeuomphalus* ? n. sp., *Eudaronia* aff. *jaffaensis* Vergo, 1909, *Palazzia ausonia* (Palazzia, 1988), *Palazzia planorbis* (Dall, 1927), *Moelleriopsis* cf. *watsoni* (Tryon, 1888), *Moelleriopsis* sp. 1, *Moelleriopsis* sp. 2, *Skenea* sp., *Anekes* spp. and *Retigyra* sp. Our findings on the Brazilian continental margin also have shown high biodiversity as for other deep-sea areas of the world. Although the high proportion of taxa lack a complete identification to species level, only recently more material has been collected from the virtually unknown South Atlantic deep-sea, including the Brazilian slope. Despite difficulties of working with such minute gastropods and/or a very limited sampling effort, our results have indicated so far that we are dealing with a high endemism yet to be properly studied and described.

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***ESCARPIA SOUTHWARDAE* A NEW SPECIES OF VESTIMENTIFERAN TUBEWORM FROM WEST-AFRICAN COLD SEEPS**

A new species of vestimentiferan tubeworm (Annelida, Siboglinidae, Vestimentifera), belonging to the genus *Escarpia*, is described from Southeast Atlantic cold seep communities, on the African passive margin. The African tubeworms are morphologically close to *Escarpia laminata*, but differ by the lack of pinnules on both the distal and basal branchial filaments. At a molecular level, their DNA sequences encoding for the Cytochrome Oxidase subunit I (COI) belong to the Escarpiid clade. Among the collected individuals some morphological characters differ, such as the presence or absence of an axial rod on the obturaculum and the shape of the posteroventral margin of the vestimentum. However, the COI DNA sequences of these morphotypes are not significantly different, leading to conclude that they correspond to intra-specific variations. The absence of branchial pinnules was previously known from Moniliferan (Pogonophoran) only. For the mouth- and gut-less Vestimentiferan species, branchial pinnules represent an anatomical feature which enhances gas and nutriments uptake. In *E. southwardae*, the flat shape of the branchial filaments and a sub-cuticular capillary loop allow a low diffusion distance, which may compensate for the lack of pinnules. Biometrical measurements lead us to hypothesize a discontinuous recruitment for this species.

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HEMOCYANIN, CRYPTOCYANIN AND PHENOLOXIDASE IN DEEP SEA (*BATHYNOMUS GIGANTEUS*) AND INTERTIDAL (*CIROLANA HARFORDI*) ISOPODS

The cirolanid isopods, *Bathynomus giganteus* and *Cirolana harfordi,* belong to the same family, but reside in very different habitats, the deep sea and the lower intertidal. Moreover, *B. giganteus* is purportedly an evolutionarily ancient isopod and thus may be a predecessor to *C. harfordi.* It has been suggested that structures of the closely related proteins, hemocyanin and cryptocyanin, could be used to distinguish phylogenetic relationships in the Ecdysozoa. Hemocyanin is a copper-containing, extracellular blood protein that combines reversibly with oxygen. Cryptocyanin is a copper-free hexameric protein similar in sequence and structure to hemocyanin that is involved in molting. This study compares the structure of these proteins in *C. harfordi* and *B. giganteus.* One- and two- hexameric hemocyanins are present in both isopods by non-denaturing pH 7.4 PAGE in the presence of Ca^{2+}. This contrasts with published reports of an exclusively hexameric hemocyanin in *B. giganteus.* SDS-PAGE indicates at least two polypeptides with molecular masses between 73 and 83 kDa in each species, similar to hemocyanin subunits of other isopods. Western Blots identify a cryptocyanin-like protein in both isopods. These preliminary studies are the first to demonstrate the presence of cryptocyanin in the Peracarida. Hemocyanins of both isopods have phenoloxidase activity, and there is apparently no other phenoloxidase in the hemolymph, consistent with Pless et al. (ABB 409:402-410, 2003). This pattern is similar to chelicerate hemolymph but differs from that of other crustaceans, where both hemocyanin and a hemocyte phenoloxidase show enzymatic activity. Supported by NSF 9984202 (NBT) and NSF Grant OCE-0243688 (C.M. Young).

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EMBRYOLOGY AND LARVAL ECOLOGY OF THE COLD-SEEP MUSSEL *BATHYMODIOLUS CHILDRESSI*

The cold-seep mussel *Bathymodiolus childressi* is highly abundant at the Gulf of Mexico seeps and its ecology and physiology have been well studied. However, little is known of its reproductive ecology, particularly with respect to understanding *B. childressi* embryology and larval ecology. We induced spawning via serotonin injection to adult *B. childressi* maintained in the lab. Induction of spawning was successful beginning in December and continuing through the following March. Laboratory cultures maintained at 7-8° C developed at an average rate of one division per 4-9 hours through the 32-cell stage. Larvae hatched by 36 to 48 hours and the larval shell began to form at day 12. Cultures have been successfully maintained in the laboratory for up to two weeks, indicating a potential planktonic life of at least 12 days. Bivalve larvae were found in the water column at depths no shallower than 500 m, 7.5° C, in December and March. Descriptions of the larval shell of *B. childressi* match these found in the plankton and the timing matches the spawning season of *B. childressi.* Moreover, temperature tolerance experiments with recently hatched larvae show high survival at a wide range of temperatures (from 5-20° C), indicating that temperature does not limit migration to at least 500 m. Supported by NSF Grant OCE-0243688 (C.M. Young).

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LANDERS FOR DEEP SEA RESEARCH

Autonomous landers provide an economical means of accessing the deep sea environment for research and are particularly advantageous for any experiments requiring a sea floor duration in excess of 8 hours. Technical information is provided on new lander designs for studies of deep sea animals. In particular: The FRESP, deep water in situ respirometry lander is capable of trapping, filming and measuring the oxygen consumption of trapped animals over a 2 to 3 day period. The FRESP has worked successfully at depths to 4800m; The SPRINT, deep water lander is capable of attracting animals to a bait in view of a high speed camera, then stimulating them to generate a startle response. This system has been used successfully in both the Atlantic and Mediterranean oceans in animal swimming speed experiments to 4800m depth; The ISIT deep water lander, records images of bioluminescent events both in profile through the water column, and on the sea bed using a high sensitivity Intensified Silicon Intensified Target (ISIT) camera. Images are taken with and without artificial illumination. The ISIT lander has been successfully deployed to 4800m; The DOBO deep-water lander is deployed for long duration's (> 6months) to investigate the role of time signals on the deep sea megafaunal community. The latest evolution of this lander houses a periodic bait release which releases an amino acid solution at 2 week intervals in view of a stills camera to stimulate the local community. Environmental monitoring in the form of an ADCP, current meter and CTD are also included.

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PATTERNS OF BENTHIC MEGAFAUNA DIVERSITY AND BIOMASS IN THE OTAGO SUBMARINE CANYON COMPLEX, SOUTH-EASTERN NEW ZEALAND

The benthic ecology of New Zealand's continental slope is very poorly known, despite this zone's status as New Zealand's main fisheries resource. Off the south-eastern province of Otago, South Island, the slope is incised by a series of submarine canyons that are overlain by productive Subtropical Front waters. The area is also notable for its constricted shelf, shallow shelf-break (115 m depth) and the close proximity of canyon heads to land (10-15 km).

In this physical and biological setting bottom photography, augmented by grab and dredge sampling, was used to quantify and map megafaunal biodiversity and biomass. Data gathered using a random-stratified sampling design (with strata incorporating depth and bottom topography, replicated in four adjacent canyons) can be used to test for megafauna assemblage structure, and to investigate megafauna assemblage patchiness at scales ranging from tens of centimetres to tens of kilometres.

Data on seafloor topography (obtained via multibeam acoustic technology), sediments and hydraulic regime are also being collected and, along with photographically derived information, will be used to create a benthic habitat/biotope map using a Geographic Information System. The resulting habitat/biotope map and image database will have applications for the environmental management of the continental slope in this region.

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RESTING STAGES IN DEEP SEA SEDIMENTS: POTENTIAL FOR BENTHIC PELAGIC COUPLING?

It has long been established that many organisms produce resting stages which, although originating in the pelagic zone, settle in the sediments of the benthos. These resting stages can remain alive for many years, constituting a 'seed bank'. Other meroplanktonic or merobenthic organisms move actively between the benthos and the pelagic, without undergoing a life-form shift, in response to environmental cues and thereby form a shorter-term repository of benthic organisms. Evidence exists, for a range of aquatic habitats, that pelagic populations develop via inoculation from these benthic sources following either mechanical re-suspension (e.g. wind-mixing, storms, wave action or upwelling currents) or active processes such as hatching, excysting or migration. However, no viable resting stages have been collected from waters a depths greater than 1180 m. Here we examine the extent and importance of resting stages in deep sea sediments from the Porcupine Abyssal Plain, NE Atlantic (4810m) and confirm the presence of cysts in high abundances at these depths.

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PHYSIOLOGICAL RESPONSE OF THE COLD SEEP MUSSEL, *BATHYMODIOLUS CHILDRESSI*, TO THERMAL STRESS

In response to an external stress such as temperature, almost all organisms will increase heat-shock protein synthesis in an effort to save existing protein pools from irreversible damage. However, the loss of an inducible heat-shock response has been observed in a few cold water adapted organisms such as Antarctic notothenioid fish and a freshwater hydroid. Deep water methane seep organisms reside in a relatively cool habitat with minimal temperature variation, where the potential for the loss of an inducible heat-shock response is plausible. We examined the physiological response of the cold seep mussel, *Bathymodiolus childressi*, to thermal stress by measuring (1) heat-shock protein expression in the 70 kDa size class (hsp70) and (2) mortality rates. Using an immunochemical assay specific to heat-shock proteins in the 70 kDa size class, no obvious inducible heat-hock expression patterns were observed for *B. childressi* exposed to temperatures ranging from 5 °C to 25 °C for a six hour period. When *B. childressi* was exposed to temperatures lower than 20 °C for six hours, no mortality occurred. However, when exposed to either 25 °C or 30 °C for a six hour period, *B. childressi* mortality increased to 30 percent or 90 percent, respectively. Based on these preliminary findings, further experimentation, possibly examining total protein synthesis via metabolic labeling, is still necessary to determine whether *B. childressi* has an inducible heat-shock response. Supported by NSF Grant OCE-0243688.

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DISTRIBUTION AND ABUNDANCE OF MACROBENTHOS IN THE CANADA BASIN, HIGH ARCTIC – PRELIMINARY RESULTS

In high latitudes, the amount of sinking food particles rather than the low water temperature *per se* is restraining growth and survival of Arctic benthic organisms. Due to the ice cover, few benthic samples in the North American high Arctic are from water deeper than 200 m until now. One of the objectives of a 4-week ice breaker expedition in August 2002 was to identify habitats, species composition, distribution, abundance and biomass of macrofauna in the Canada Basin using ROV *in situ* imaging in conjunction with box core samples. Eleven box cores were collected at 6 stations ranging from 625 m to 3250 m depth from Amundsen Gulf to Northwind Ridge. 9.2 hours of video were recorded along with 853 still images. All materials are currently being analyzed. Preliminary data from photographic materials indicate that the most abundant epifauna comprised fish, crustaceans (amphipods, isopods, decapods), ophiuroids, polychaetes, and anemones. Where hard bottom was present (western basin) it was occupied by cnidarians, polychaetes, ascidians and crinoids. Preliminary analysis of the box core samples indicates low macro-infauna abundances and biomass, comparable to other Arctic deep-sea areas. In terms of abundance, the dominant macro-infauna taxa were polychaetes, crustaceans (tanaids, cumaceans, isopods, amphipods), and bivalves. So far, noteworthy differences between the western and eastern basin include a higher energy environment on the western slope (more rocks, less lebensspuren, coarser sediment) along with more suspension feeders while the eastern basin was characterized by finer sediments, persisting lebensspuren and relatively more deposit/ opportunistic feeders.

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DO ANTIPATHARIANS BELONG IN THE SUBCLASS CERIANTIPATHARIA?: INFERRING PHYLOGENY FROM MITOCHONDRIAL GENE ORDER OF A DEEP-SEA BLACK CORAL

Black corals (Order Antipatharia) are a poorly studied group and their phylogenetic position within the class Anthozoa remains a subject of debate. There are two competing hypotheses on the classification of anthozoans. One hypothesis divides the nine anthozoan orders among two subclasses: Octocorallia and Hexacorallia. The alternate hypothesis removes two hexacorallian orders, Antipatharia and Ceriantharia (tube anemones), to a third subclass, Ceriantipatharia. Recent molecular data, based on 16S and 18S rDNA sequences, suggest that antipatharians and cerianthids are highly divergent groups and should not be classified together. In this study we have sequenced the complete mitochondrial genome of an undescribed antipatharian (likely a new genus and species; D. Opresko, pers. comm.) collected from 640 meters on Fieberling Guyot (NE Pacific). The antipatharian mitochondrial genome (18,429 ntp) consists of the typical 13 energy pathway proteins and 2 ribosomal RNA genes, but only 2 transfer RNA genes. Gene arrangement is most similar to the sea anemone *Metridium senile* (a hexacoral), with the exception of a sequence of three genes (COII-ND4-ND6) and the presence of only one group I intron (*M. senile* has two introns), which is found within the NADH dehydrogenase subunit 5 (ND5) gene and consists of the only copies of the ND1 and ND3 genes. No novel genes were found in the genome.

We will compare the gene order to that of the five published anthozoan mitochondrial genomes to determine phylogenetic relationships. We are currently determining the mitochondrial gene order of the cerianthid *Ceriantheopsis americanus*.

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EXPLORING DAVIDSON SEAMOUNT: BIOLOGICAL CHARACTERIZATION AND PROTECTION

The Davidson Seamount is an impressive geologic feature located 120 km southwest of Monterey, California. This inactive volcano is roughly 2,300 m tall and 40 km long, yet its summit is far below the ocean surface (1,300 m). In May 2002, a diverse group of scientists led by the Monterey Bay National Marine Sanctuary embarked on an exploration to more fully characterize the Davidson Seamount. Using the research vessel *Western Flyer* and ROV *Tiburon*, we completed 6 full-day dives and recorded 90 hours of video from all depths of the seamount. Meanwhile, at the surface, a team counted seabirds and marine mammals. We collected 104 rock samples, 21 sediment cores, 123 biological samples, and 3 trash items. The crest of Davidson Seamount had the highest diversity of species, including large gorgonian corals and sponges. While detailed analyses are still in progress, it is clear that these assemblages of species are arranged in previously undiscovered large, contiguous patches, and are susceptible to physical disturbance. The number of new species is unknown, but with the samples collected and associated digital video, there is a potential to describe several. At least 4 rare fishes were observed and many invertebrates have yet to be identified. Our work is helping resource managers make a decision regarding inclusion of the Davidson Seamount into the Monterey Bay National Marine Sanctuary boundary to conserve and protect the species and habitats there.

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CHEMICAL ENVIRONMENT OF CHEMOSYNTHETIC COMMUNITIES FROM TWO DISTINCT COLD SEEP SITES (GULF OF GUINEA)

Chemical measurements were realized within faunal communities colonizing two distinct cold seep sites during a series of French oceanographic cruises in 2001 (Biozaire 1 and 2). The first site, named REGAB and locatedat 3200m depth off Congo, extended over an area of up to 480 000 m². It was characterized by a mosaic of faunal assemblages constituted by vesicomyid clams, vestimentiferan bushes and mussel beds. In the second site (GUINESS), located at 600 m depth off Gabon, only two zones were explored. They were colonized by vesicomyid clams and bacterial aggregates.

Fluids were collected in the environment close to the organisms with the ROV Victor using a multisampling system (P.E.P.) Preliminary analyses of physico-chemical parameters (temperature, methane, dissolved oxygen, sulphides, pH, and isotopic methane) were realized. On REGAB, methane values vary from a factor 1 to 5000 while on GUINESS high temporal variations were observed between the two cruises at differents sites. Methane values from about 10 to 1000 µl/l were measured near invertebrate species on REGAB, reaching a peak in vestimentiferan and mytilid clusters. Isotopic measurements indicate biogenic production of methane.

Push cores were used to collect sediments underneath different faunal assemblages. Sediment analyses were realized (% carbon organic, total hydrocarbons, P.A.H.). Surface sediments were characterized by high organic carbon concentrations (2.5-4.2%) reaching a maximum near bivalve and vestimentiferan clusters. No variation of organic matter concentrations was observed within the sediments until a depth of approximately 30 cm. Low levels of P.A.H. and the presence of perylene were observed. A characterization of microbial communities was also carried out on sediment samples.

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SEQUENCING, LOCALIZATION AND EXPRESSION OF GLOBIN GENES IN THE VESTIMENTIFERAN *RIDGEIA PISCESAE*

The basis for the broad range of phenotypic diversity displayed by the Juan de Fuca Ridge vestimentiferan tubeworm *Ridgeia piscesae* remains a mystery. Genetic studies examining single genes and allozymes revealed no significant differentiation between the phenotypes. An amplified fragment length polymorphism (AFLP) survey of 677 anonymous genomic DNA markers confirmed these findings. The presence of distinct *Ridgeia* phenotypes in microhabitats where temperature and chemistry differ leads us to hypothesize that the local environment induces phenotypic differentiation by causing differences in gene expression. We chose hemoglobin, a carrier of environmental oxygen and sulfide, as a candidate molecule for studies in gene expression, molecular evolution, and population genetics of two of the most extreme *R. piscesae* phenotypes. Hemoglobin's role in directly linking the animal to its environment, as well as preliminary findings which show phenotype-specific differences in its structure and function, lead us to believe that this molecule will aid our understanding of environmental effects on development and evolution in this species. Current studies will examine DNA sequences of the genes encoding the four different globin chain types to detect morph-specific variation. The globin genes will be localized using in situ hybridization of globin-specific probes to chromosome preparations to help understand how the regulation of these genes might occur. RT-PCR studies will determine if morph-specific differences exist in the levels of expression of the different globin chain subunits.

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ACID-BASE RESPONSES TO HYPERCAPNIA IN HYDROTHERMAL VENT CRUSTACEANS

The high CO_2 content of vent fluid has certainly driven specific adaptations to hypercapnic exposure in hydrothermal vent endemic species. As a first step in identifying these adaptations, we are looking at the hemolymph acid-base disturbances induced by an hypercapnic exposure of crustaceans. In littoral species, such as the shore crab Carcinus maenas, the initial repiratory acidosis is only partly compensated by a rise in blood bicarbonate, a retrun to initial status is only achieved after a recovery period under normocapnia. The same type of response is observed in a bathyal crab, *Chaceon affinis*, a species often seen around shallow vents on the mid-atlantic ridge. In contrast, in the shrimp *Rimicaris exoculata*, the initial respiratory acidosis is less pronounced with large interindividual variations, but most importantly, blood CO_2 partial pressure always stays low, and even lower than the water Pco2 imposed by the experimental protocol. A similar response is observed in the crab *Segonzacia mesatlantica*. Hemolymph composition and buffer capacity do not explain these observations and mechanism allowing CO2 excretion against the pressure gradient may be needed. This study was funded in part by the European Union within the VENTOX program (EVK3-CT1999-00003).

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THE MID-SLOPE DEMERSAL FISH COMMUNITY OFF EASTERN BRAZILIAN COAST

The deep demersal ichthyofauna from soundings of 200-2,200 m off Brazilian continental slope between 11°- 22°S was studied from 48 otter-trawl hauls taken in June-July, 2000 during cruise BAHIA-2 of the French R/V *Thalassa* (IFREMER). The collection comprised 9,101 specimens (1,316 kg) representing 20 orders, 69 families and some 225 species. New records for Brazilian waters included 84 species, 3 families and 1 order. The most speciose families were Macrouridae (22), Ophidiidae (17), Alepocephalidae (17) and Synaphobranchidae (17), which accounted for 50 % of biomass estimated at different depths. Acropomatidae (5) and Steindachneriidae (1) were numerically dominant. Three main demersal species assemblages were identified by means of an ordination technique, Correspondence Analysis (CA). Canonical Correspondence Analysis (CCA) showed that water temperature, depth and latitude explained the main groupings ($P<0,05$). There appeared to be quite a good correlation between the permanent thermocline zone from 200 to about 1,000 m and the occurrence of the upper-slope fauna. The lower-slope assemblage coincided with the beginning of the aphotic zone and also with cold isocline (2-3°C), mainly under influence of Antartic Intermediate Water (AIW). Overall mean biomass (161,2 kg/ km^2) and yields (29,2 kg/haul) were low and comparable to those found at abyssal depths in the North Atlantic. The slope fish communities off Brazil and Suriname showed the strongest affinity at species level, what conforms to proximity and development of ocean basins. Secondly, the presence of elements from tropical eastern Atlantic (South Africa) and tropical Indian (Maldives) ichthyofaunas represents a pattern which appears consistent with the circulation of AIW in the south western Atlantic.

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INTERACTIONS OF BENTHIC COMMUNITIES AND SEDIMENT GEOCHEMISTRY ACROSS THE PAKISTAN MARGIN (ARABIAN SEA) OXYGEN MINIMUM ZONE

Benthic organisms strongly influence sediment biogeochemistry but processes remain poorly quantified. We are conducting parallel assessments of benthic communities and sediment geochemistry, combined with rate determinations for microbial processes and sediment accumulation and mixing, during monsoon and inter-monsoon periods at sites across the oxygen minimum zone on the Pakistan margin (Arabian Sea). The roles of benthic communities in particle mixing, organic matter cycling and benthic fluxes are being addressed with shipboard and *in situ* incubation experiments. Preliminary biological results indicate negligible macrofauna (> 300 µm) within the OMZ core [300-700 m, O_2 = 0.09-0.15 ml/l], where sediments were fully laminated and calcareous foraminiferans dominant. Microelectrode profiling and incubations indicated clear differences in O_2 penetration and consumption rates across the OMZ. Visual inspection of 2- and 5-day experiments revealed rapid ingestion of ^{13}C labeled algae by *Uvigerina* and *Cassidulina* (epifaunal foraminiferans). Uptake was focused at the sediment surface with no vertical mixing, although infaunal *Globobulimina* ingested some tracer. The lower portion of the OMZ, where O_2 increases from 0.15 to 0.3 ml/l (800-1100 m), exhibited sharp gradients in macrofaunal communities and bioturbation. Low-diversity assemblages of larger organisms, several exhibiting evidence of ^{13}C phytodetritus ingestion or chemosynthetic symbionts, occurred at 800-950 m. Foraminiferal communities changed more gradually, some species spanning substantial depth ranges (e.g. 950-1200 m). Macrofauna were sparse but deep burrowers occurred and sediments were fully bioturbated at the lower OMZ boundary (1200 m) and below the OMZ (1850 m) where large epifaunal agglutinated foraminiferans (e.g. komokiaceans, *Rhizammina*) were dominant.

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CARBONIC ANHYDRASE LOCALISATION IN THE GILLS OF TWO HYDROTHERMAL VENT CRUSTACEANS, *BYTHOGRAEA THERMYDRON* AND *RIMICARIS EXOCULATA*

Considering the high CO_2 content of vent fluid, and the physiological response of hydrothermal vent crustaceans following exposure to hypercapnia (see poster by Chausson et al.), it seemed important to look for the existence and localization of the enzyme carbonic anhydrase (CA) in the gills of these species. Two species were investigated: the crab *Bythograea thermydron (Bt)*, from the East Pacific Rise vent sites at 13°N, and the shrimp *Rimicaris exoculata (Re)*, from the Mid-Atlantic Ridge at Rainbow site. On total soluble protein extracts from the gills of both species, we used western blot with a cytosolic-Chick-CA antibody to reveal the existence of a reactive band at 25 kDa in *Bt* and *Re*. Using the same antibody, it was possible to localize cytosolic CA on cross section of the gills by immunohistology. In *Bt*, immunoreactive CA-containing cells were more abundant in posterior versus anterior gills, and different but specific epithelial cell types were marked in the shaft and the lamellae. In *Re* immunoreactive CA-containing cells could be found in large numbers both in the shaft and lamellae. Labelling is absent from pillar cells, although we could not discriminate between the different epithelial cell types. This study was funded in part by the European Union within the VENTOX program (EVK3-CT1999-00003).

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DEVELOPMENT OF A HYPERBARIC TRAP-RESPIROMETER FOR THE CAPTURE AND MAINTENANCE OF LIVE DEEP-SEA ORGANISMS

The capture and maintenance of live deep-sea fishes is difficult due to the rapid decompression and expansion of the gas-filled bladders of some species upon ascent to the surface, and potentially to the intolerance of many species to surface pressure (1 atm). Overcoming these problems would enable an enormous diversity of studies concerning the biology and physiology of deep-sea animals. We are constructing a pressurized trap-aquarium to capture fishes and other large organisms at depths to 4000 meters and bring them to the surface under pressure. The system consists of a stainless steel pressure cylinder (1.2 m long, 30 cm ID) that is deployed as a free vehicle. After the organism is captured at depth a pressure-retaining door is sealed and the trap is brought to the surface. Upon recovery and transfer of the system to the laboratory, high-pressure pumps maintain a flow of seawater and a pressure accumulator and regulator system controls pressure within the trap. Internal instrumentation includes a circulating pump, oxygen optode, and low light camera. Experiments are planned to investigate metabolic rates and the pressure tolerances of the captured animals.

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GROWTH AND PRODUCTION OF THE BATHYAL BRITTLE STAR *OPHIOCTEN GRACILIS* ALONG THE SCOTTISH CONTIINENTAL MARGIN

The small deep-water brittle star *Ophiocten gracilis* occurs in enormous numbers along the continental margin of the northern NE Atlantic. Its high fecundity with ophiopluteus larvae dispersed well beyond the continental slope significantly affects POC flux measured in sediment traps. I provide estimates of secondary somatic production calculated from population age structure and individual growth estimated from skeletal growth marks and from size frequencies incorporated into a demographic model. Using fitted size/mass relationship the fitted growth models provided estimates of the ratio of somatic production/biomass, P/B, in the range of 0.39 – 0.48. A narrower but otherwise similar range in estimated P/B ratio (0.48-0.49) was obtained in a parallel approach using the Mass-Specific Growth Rate Method (MSGRM) where the same size/mass relationship was applied to the observed frequencies and growth parameters fitted to growth banding. Using previously obtained data on the population density, a standing crop of 4.8 g wet weight (˜ 0.58 mg AFDW) m^{-2}, provides annual wet weight production in the range of 1.9 – 2.4 g (˜ 0.23 - 0.29 mg AFDW) m^{-2} in the population between ca 700-1 000 m. Somewhat greater production estimates (P/B = 0.73-0.98) were obtained from MSGRM by pooling the samples. Even the lower estimates are easily comparable to production estimates from boreal brittle stars in shallow water.

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UNUSUAL SCALING OF METABOLIC ENZYMES IN WHITE MUSCLE OF THE EEL *SYNAPHOBRANCHUS KAUPI*

The Northern Cutthroat Eel, *Synaphobranchus kaupi* (Johnson 1862) is characterised by an enormous depth range (235-3200 m) spanning the transition from well-lit surface waters to the darkness of the lower continental slope. In this study, we analysed the activities of key metabolic enzymes of the glycolysis (pyruvate kinase, PK ; lactate dehydrogenase, LDH) and citric acid cycle (malate dehydrogenase, MDH ; citrate synthase, CS) in white muscle of specimens (9-390 g body weight) caught in the Porcupine Seabight (NE Atlantic). All assays were carried out at 4°C. Average enzyme activities were high (PK : 3.15 U/g ww ; LDH : 139.90 U/g ww ; MDH : 18.64 U/g ww; CS 0.60 U/g ww) for a deep-sea species. Negative scaling relationships [Activity= Body Weight $(^{-b})$] were found for both aerobic and anaerobic metabolism enzymes. This is opposite to what is observed in other fish species where LDH activity per unit mass of white muscle increases with body size in order to counteract the allometric effects of body size on the relationship between body mass and muscle cross-sectional area. This suggests that large individuals have a low capacity for burst-swimming, contradicting feeding ecology data indicating that the diet of *S. kaupi* contains an increasing proportion of fish and other motile animals as the fish grows. The possible explanations of this paradox will be discussed. This work was supported by grants from the Fonds National de la Recherche Scientifique (Belgium) and by UK NERC Grant N° GR3/12789. We thank the Captain and Crewmembers of RRS Discovery.

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BIODIVERSITY OF DEEP-SEA ASELLOTE ISOPOD CRUSTACEA IN HISTORICAL AND EVOLUTIONARY PERSPECTIVES

The presence of asellote isopod crustacea as a dominant component of the benthic macrofauna was discovered during the Challenger expedition (1872 – '76). Nevertheless, this global cruise failed to establish the high species diversity of asellote isopods in the deep-sea because the collecting devices were not suitable to take representative and quantitative samples of infauna. The results of the *Galathea* expedition (1952 – 54) revealed that asellote isopods are found as significant part of the benthos in major trenches in the hadal zones. However, the most recent Gay Head - Bermuda transact study from Woods Hole and Beaufort - Bermuda transact study (discussed in this paper) established the high species diversity of asellote isopods in the deep-sea, as in several other regional deep-sea studies in different oceans. Minute asellote isopods of the family Haploniscidae (1 to 2 mm), 103 species known thus far, contains no species below 1000 m, 67 % of species over the slope, 13 % from continental rise, 13 % from abyssal plains and 7 % in hadal depths in the trenches. The deep-sea family Desmosomatidae in the Northwest Atlantic clearly pointed out latitudinal gradients in species distribution. The robust (1 to 3 cm) and benthopelagic asellote isopods of the family Munnopsididae revealed evolutionary patterns, associated with deep-sea currents both from the Arctic and the Antarctic . The recent deep-sea colonizers of the family Dendrotionidae showed co-evolution with deep-sea sponges. The ornamental asellote deep-sea isopods of the family Mesosignidae indicated both allopatric and sympatric speciation on either side of the Isthmus of Panama since its formation 3 million years ago. This paper is a manuscript for publication in '*Deep-Sea Research*'.

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SPATIAL AND TEMPORAL VARIABILITY IN *RIFTIA PACHYPTILA* COMMUNITIES AT 9°N (EAST PACIFIC RISE)

In the dense aggregations of *Riftia pachyptila* that occur in the diffuse-flow habitat of the East Pacific Rise, there is a high relative abundance of endemic heterotrophic species. A combination of abiotic and biotic factors regulates the structure of this hydrothermal vent community (Childress and Fisher 1992, Mullineaux et al. 2000, Micheli et al. 2002). As part of our goal to model the flow of energy and matter at the ecosystem level, we collected eight aggregations of *R. pachyptila* and all of the associated fauna with a quantitative sampling device operated from the DSV *Alvin*. In order to test the spatial and temporal variability in *R. pachyptila* communities, we sampled at two discrete sites in December 2001 and December 2002. High free sulfide concentrations characterize the diffuse flow at Tica (9°50.447'N 104°17.493'W, 2500 m), whereas the diffuse flow at Riftia Fields contains high concentrations of iron and much lower concentrations of free sulfide. In the ephemeral and patchy habitat created by hydrothermal vents, we hypothesize a significant difference in the species composition of the *R. pachyptila* community with respect to space and time.

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CHITINASE ACTIVITY OF FISHES WITH VARYING DEPTH DISTRIBUTIONS

This study investigated a possible energetic adaptation in deep-sea fishes, specifically an increased ability to digest and absorb chitin when compared with shallower living species. High chitinase activities were measured in stomachs and stomach contents, while lower but still significant activities were measured in intestinal tissues and contents, in both deep and shallow living fishes. The measurement of high chitinase activity in tissue samples from empty gastrointestinal tracts supports the conclusion that chitinases are endogenous, constitutive enzymes in fishes and not inducible enzymes of bacterial origin. The finding of chitobiase limitation in myctophid species is supported by their feeding pattern and by a morphological adaptation which facilitates rapid gastric evacuation. At the current stage of this project no apparent depth-related trend in chitinolytic activity has been found. However, lack of chitobiase limitation in most of the sampled fishes is interesting because it reflects chitinolysis beyond the step needed for exoskeleton breakdown to the production of an absorbable nutritive monomer. This conflicts with the accepted belief that shallow living fish do not utilize chitin for food.

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COMPOSITION, ABUNDANCE AND DIVERSITY OF THE MEIOBENTHIC ASSEMBLAGE OF THE ABYSSAL ANTARCTIC

Previous studies on composition, abundance and spatial distribution of antarctic deep-sea meiobenthic assemblages only contributed data on depths no more than 2000m. The international ANDEEP project (ANtarctic Benthic DEEP-sea Biodiversity), carried out during RV Polarstern cruise 61, now revealed sediment samples from 7 stations between 2274 and 5194m depth from the Scotia Arc and the Weddell Sea. Two to three replicate MUC deployments per station yielded altogether 166 sediment cores. After meiofauna extraction, specimens were sorted for major taxa and counted. Further taxonomic work will take place focussing on benthic copepods in detail. Nematodes were determined to be the dominant group at all stations. Together with copepods they comprise approximately 90 – 95 % of overall meiobenthic abundance. Besides nematodes other groups of the nemathelminthes like rotifers, kinorhynchs, and gastrotrichs were found in very low densities. A pronounced reduction of meiofaunal abundance at the deepest stations (5191 and 5194m) in comparison with the shallower stations around 2300m has been observed. These first data on abundance and diversity of major meiofauna taxa in abyssal Antarctic waters are compared with literature data from other deep sea sites.

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FORAMINIFERAL COMMUNITIES INHABITING THE ABYSSAL EASTERN MEDITERRANEAN SEA

In order to study the distribution of benthic foraminiferal communities in relation to the prevailing sedimentary environmental parameters, samples were collected from different areas at the abyssal zone of the Eastern Mediterranean Sea, in depths ranging from 2700 to 4617m. Samples were collected during METEOR cruises 25/1 (June 93) & 40/3 (Dec. 97-Jan. 98), MATER TransMed cruise (June 1999) and ADIOS cruises (April & October 2001). Within the meiobenthos community (>32μm), stained foraminifera represented the second most abundant group after nematodes, constituting 16-54% of the total. In most cases, standing stock of foraminifera was very low, ranging from 3 - 15 ind $10cm^{-2}$ at the upper 6cm of the sediment, indicating the oligotrophic conditions characterising the sediments at abyssal depths. However, surprisingly high abundance was recorded at the Hellenic Trench (4617m, 81 ind $10cm^{-2}$ at the upper 4cm), possibly related to the downslope fluxes of fresh organic matter. The foraminiferal community consisted of both hard-shelled (agglutinated/calcareous) and soft-shelled species, the latter of which constituted a significant part of the total assemblage (up to 90% at many cases). At the Hellenic Trench where high foraminiferal density was recorded, the assemblage is dominated by the species *Articulina tubulosa*, which is also commonly described as a major component of the foraminiferal assemblages of the deep eastern Mediterranean basin at depths >2500m.

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EXTREME SALINITY TOLERANCE OF *METHANOARICIA DENDROBRANCHIATA* Blake (POLYCHAETA: ORBINIIDAE)

The orbiniid polychaete *Methanoaricia dendrobranchiata* Blake is found abundantly as individuals or in clumps at a unique deep-sea brine pool in the Gulf of Mexico. This species may experience temporary spikes in salinity due to its proximity to a hypersaline environment. Therefore, we investigated the salinity tolerance of *M. dendrobranchiata*. Individual and clumps of five worms were exposed to salinities ranging from ambient (35 ppt) to 85 ppt. Survivorship was assessed after 15 hours. An additional experiment measured weight change before and after exposure to hypersaline conditions. Individual worms and worms in clumps survived in 75 ppt but died at 85 ppt, indicating that clumping behavior is unlikely to ameliorate salinity stress. A direct relationship was observed between weight loss and duration in hypersaline water, suggesting water loss as a response to heightened salinity. Based on these results, we hypothesize that *M. dendrobranchiata* could withstand brief exposures to high salinities caused by disturbances mixing ambient and brine seawater. Supported by NSF Grant OCE-0243688 (C.M. Young).

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DEEP-SEA TAXONOMIC RESEARCH – AMPHIPODA AND THE OIL AND GAS INDUSTRY

Deep-sea environments are likely to harbour high levels of natural biodiversity, and although there is a large (and growing) body of evidence both for and against this hypothesis, the deep sea remains relatively unexplored. This has meant that, despite more than a century of study, knowledge of the deep-sea benthos is still limited. This information, although very exciting for those who study the deep ocean, constitutes a problem for BP and the oil and gas industry more generally. Until improvements are made in the taxonomy of the deep-sea fauna, species diversity estimates (used in Environmental Impact Assessments) may not be wholly reliable. Two three-year postdoctoral posts in the fields of deep-sea invertebrate taxonomy and biodiversity have been funded by BP and are hosted at the Texas A & M University (USA) and the Southampton Oceanography Centre (UK). The amphipod genus *Valettiopsis* Holmes, 1908, which comprised four species has been revised with the addition of three new species. A revision of the family Scopelocheiridae (Amphipoda: Lysianassoidea) is in preparation and studies are underway on genera in the Lysianassoidea and Oedicerotidae.

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BENTHIC COMMUNITY STRUCTURE AND BIOTURBATION ALONG A CONTINENTAL MARGIN TRANSECT FROM NORWAY TO SVALBARD

This poster presents preliminary results of benthic sampling carried out in July 2002 from the RRS *James Clark Ross* as part of the Scottish Association for Marine Science core research programme *Marine Environmental Change in Northern Seas: Natural and Anthropogenic Influences*. Benthic faunal samples and seabed photographs were taken at four stations along the Norwegian and Barents Seas continental margins from the Voring Plateau (68°N) to the Yermak Plateau (81°N) north-west of the Svalbard archipelago, at depths of 900-1400 m. Patterns in total infaunal numbers and biomass, taxonomic and fucntional community composition, and occurrence of Lebensspuren and other evidence of burrowing megafauna are interpreted in relation to contrasts in the source and quantity of organic input to the benthos along the latitudinal transect.

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FEEDING ON THE BOTTOM AT THE TOP OF THE WORLD

The trophic structure of the benthic community of the deep Canadian Basin in the Arctic was investigated. We used stable isotope analysis to elucidate how closely linked deep-sea benthos is to the pelagic and ice-associated production. $d^{15}N$ ratios are indicative of relative trophic relationships with a stepwise enrichment between trophic levels (TL) of about 4‰. Mean $d^{15}N$ isotopic values for water column POM was 5.1‰. Benthic animals ranged from 10.2‰ to 17.7‰ in their $d^{15}N$ isotopic values with most of the organisms falling into the second and third TL with respect to the POM values. This suggests that little fresh phytodetritus is reaching the seafloor. The benthic community consists mainly of deposit feeders consuming refractory material, e.g. many polychaetes, and of scavengers, predators or omnivores. In contrast to the benthic system, distinctive herbivores (TL1) and 1st order predators (TL2) were present at the sea ice and the upper water column, with $d^{15}N$ values between 5-7‰ and 10-13‰, respectively. Few pelagic/ice organisms fell within the third TL suggesting that the link between the pelagic/sea ice and the benthic system is through sinking of grazers and their products (e.g. fecal pellets, molts, dead animals) to the seafloor rather than through direct input of algal material to the benthos.

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MEGABENTHIC ECOLOGY OF THE DEEP FAROE-SHETLAND CHANNEL: A PHOTOGRAPHIC STUDY

The megabenthic ecology of the cold water (<0 degree C) area of the Faroe-Shetland Channel was investigated using the SOC WASP (Wide Angle Seabed Photography) towed camera platform. A series of ten photo transects, on the channel axis, between the Wyville Thomson Ridge and the Norwegian Sea were studied. Photographic transects allowed quantitative benthic biodiversity data to be obtained from this understudied yet commercially important area for oil and gas exploration. The sedimentary characteristics of the seabed change dramatically from a region of ice rafted boulders and gravel in the south west of the channel to fine sediments more typical of the deep sea in the north east. Despite the relatively low species richness, faunal composition varied with depth and sediment type. Standing stock of megabenthos decreased towards the northwest of the channel. The results of this study are used to assess the utility of towed camera sleds as a method for obtaining ecological information. Some initial comparisons are made with seabed photography carried out from remotely operated vehicles operated in support of the oil industry activities in the region.

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EYELESSNESS AMONG THE GNATHIIDAE (CRUSTACEA, ISOPODA).

Eyelessness occurs frequently among deep-sea crustaceans, and has mainly been related to the absence of light in deeper waters. Eyelessness occurs also among the gnathiid isopods (Crustacea). These are remarkable benthic isopods, which live as adults in harems on the bottom, in coral rubble or in cavities. The larvae are, however, external parasites on fish. The occurrence of larvae in the water column seems to differ between day and night, so absence of eyes may have implications upon their use of the water column. Although most of the species live at shallow coral reefs, the family has several deep-sea members.

Data were extracted from the literature on the presence/absence of eyes on gnathiids and their depth ranges. When the whole family was considered, eyelessness was absent in shallow waters (< 100 m), but increased with depth to about 64 % at the depth range of 900-1000 m. At depths below 1400 m more than 75% of the species were blind. The pattern of eyelessness with depth differed between the genera of the Gnathiidae. Eyelessness was further common within certain genera (*Bathygnathia*; 11 blind species out of 13; *Monodgnathia*, all four known species blind), but rare with the large genera *Gnathia* (4 blind of 73 species, 5.5 %) and *Caecognathia* (6 blind of 42 species, 14.3 %). This indicates that eyelessness may have occurred at different evolutionary times within the gnathiids and for some genera (*Bathygnathia* and *Monodgnathia*) may not reflect light patterns with depths.

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BENTHIC DISTRIBUTION PATTERNS AND TURNOVER PROCESSES IN AN ARCTIC DEEP-SEA CHANNEL SYSTEM

In contrast to former beliefs it is commonly accepted that the deep-sea floor comprises a well-structured habitat for a diverse fauna. Objectives of the biological and biochemical investigations within the frame of the interdisciplinary project ARKTIEF-II were to assess large-scale distribution patterns of benthic organisms in and around a 200 km long channel system in the vicinity of the eastern Greenland continental margin and the adjacent deep Greenland Sea, and to estimate benthic processes in this area and their relevance for the Arctic Ocean ecosystem. Spatial patterns in the distribution of composition, activity and biomass of benthic organisms are thought to allow to estimate the frequency and intensity of particle-loaded near-bottom currents within the channels as well as to evaluate the quality of suspended matter. Field studies in the summer seasons of 2000 to 2002 revealed no indications of intensive recent transport processes within an „active" channel system. Abundance and composition of epibenthic megafauna assemblages show a gradient from the slope foot to the central Greenland Basin. These findings are in accordance with a decrease in food availablility from the slope area to the deep sea, despite a contrasting trend in bacterial activities. On the other hand, the distribution patterns of specific megafauna species across the channel profile indicate a pattern of small-scale habitats in the channel vicinity which are characterised by the availability of food and substrates for sessile fauna.

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DOES BENTHIC-PELAGIC COUPLING EXIST IN A EUTROPHIC DEEP-SEA ENVIRONMENT?: RESULTS FROM "THE PROJECT SAGAMI"

Very high accumulations of both organic and inorganic materials have been recorded from such marginal seas along arc-trench systems, where tectonic processes are very active. High primary production occurs in marginal seas, since nutrients for phytoplankton are supplied from the adjacent land in every season. Therefore, we expected to observe carbon cycling and sediment particle transport processes different from those in the open oceans in Sagami Bay, having eutrophic, deep-sea environment with steep bottom topography. Most previous studies of sedimentary processes have been performed over tectonically calm, nearly flat bottoms in open oceanic environments. We collected data from ocean color observation satellites, surface water samples, hydrographic casts accompanied by a turbidity profiler, sediment trap moorings and multiple-corer samplings at a permanent station in the central part of Sagami Bay during 1997 and 1998.

We succeeded in documenting dynamic sedimentary processes in detail from the ocean surface through the water column to the seafloor. We observed distinct spring blooms, even though mass fluxes deposited in sediment traps did not show distinct signals of spring blooms because of the influence of resuspended materials. Dense clouds of suspended particles were observed only in the spring in the near-bottom nepheloid layer. A phytodetrital layer started to form on the sediment surface about two weeks after the start of the spring bloom. Several species of protozoan meiobenthos increased in densities after phytodetritus deposition. "Benthic-pelagic coupling" was certainly observed, even in this marginal sea environment with undulating bottom topography.

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AN INDIVIDUAL-BASED MODEL APPROACH TO THE CHARACTERIZATION OF MACROBENTHIC COMMUNITY DYNAMICS

In deep-sea regions characterized by stable conditions and low diversity of benthic habitat, the spatial and temporal structure of the macrobenthic community is likely to be highly dependant on biotic interactions — both with other biota and the available supply of resources. The potential to understand population and community dynamics through their emergent patterns make these regions compelling milieus in which to focus research. However, the remoteness and geographic size of the deep-sea benthos, coupled with low population densities and characteristically slow rates of succession, all conspire to make thorough sampling and detailed study extremely difficult. Numerical modeling may represent one potentially useful approach in overcoming some of these difficulties. With this purpose, I created a spatially-explicit, size-structured, multi-generational, individual-based model (IBM) to explore the emergent characteristics of deep-sea macrobenthic communities. In this paper, I present several IBM experiments, including work on inter and intra-specific competition, the ecological significance of demography, evolution and natural selection, and population and community level processes under conditions of severe resource limitation.

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DIRECT MEASUREMENT OF ~DECADAL-SCALE POPULATION CHANGES FOR A DEEP-SEA SESSILE BENTHIC COMMUNITY

Demographic rates (birth and mortality rates) of marine organisms are usually estimated from changes in population abundance over time, and are very rarely based on direct measures of individual survival. We have measured the survival rates of 6 species of deep-sea sessile invertebrates over the past nine years by monitoring directly the recruitment and survival of individuals along a permanent transect in 950 m depth on the continental slope in Monterey Bay, California. Since 1994, we have been following the survival of more than 700 individuals of benthic megafauna, including the mushroom anemone (*Anthomastus ritteri,* N=199), the armored sea cucumber (*Psolus squamatus,* N=480), a fan coral (Gorgonacea sp. A, N=17), two anemones (*Stomphia* sp. A, N= 57; *Corallimorphus pilatus,* N=12), and the articulate brachiopod, *Laqueus californianus* (N=18). Rates of recruitment were low (0 to 0.03 $\%y^{-1}$) and rates of survival varied among species, but were uniformly high (92.9, 99.7, 100, 100, 100, and 100 $\%y^{-1}$ for *A. ritteri*, *P. squamatus*, Gorgonacea sp. A, *C. pilatus*, and *L. californianus*, respectively). Direct measures such as these, combined with estimates of size and age, allow accurate measurements of age-specific rates of growth and mortality.

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ECOLOGY OF THE GREENLAND SHARK, *SOMNIOSUS MICROCEPHALUS* (BLOCH AND SCHNEIDER, 1801)

The Greenland shark (*Somniosus microcephalus*) is the only large elasmobranch that routinely inhabits Arctic seas and species of the genus *Somniosus* are known to occur in deep-waters of the Arctic and the Atlantic Ocean. Although there is little information on this unique species, recent evidence suggests it may play an important but unrecognized role in the marine ecosystem of the Arctic. The species has in the past been fished intensively, suggesting that the population size of the species has been large in the past. With a maximum size well over 6 meters, this deepwater benthic species may play a substantial role, at least in the Arctic. New information is presented in particular on the feeding ecology of the species and on the levels of contamination in tissue of the Greenland shark.

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EVOLUTION AND DIVERSIFICATION OF DEEP-SEA GONIASTERID STARFISHES: PHYLOGENY, PALEONTOLOGY AND MACROEVOLUTION

Phylogenetic analysis is the most powerful tool for understanding bathymetric and spatial migrations (i.e., onshore-offshore) patterns within the marine realm. Goniasterids occupy an ideal phylogenetic position in which to address questions regarding global scale environmental/paleoenvironmental and biogeographic shifts. Phylogenetic location is ancestral to several frequently encountered and ecologically significant starfish groups found throughout all of the world's ocean basins. Goniasterids are predominantly deep-sea taxa, occupying abyssal and continental shelf environments.

A phylogenetic analysis of the Goniasteridae developed from 80 taxa and 80+ morphological characters was performed, recovering a tree topology that shows several recurring, relatively well-supported clades. The phylogeny shows *Pseudarchaster* and the related *Paragonaster* as taxa relatively basal to several derived clades, including the shallow-water tropical Oreasteridae and Ophidiasteridae as sister taxa to a clade containing the deep-water genus *Anthenoides*. Broad phylogenetic results suggest multiple incursions of goniasterid genera into the Atlantic Ocean Basin. Phylogenetic results from species level studies of goniasterid genera containing Atlantic members support "invasions" into the Atlantic Ocean Basin via different routes, including the Indian Ocean and through the Panamanian seaway.

The tree recovered by the complete analysis is tested by and compatible with known occurrence of goniasterid starfish in the fossil record. Isolated goniasterid ossicles can be quite common in certain localities. For example, Cenozoic deposits from Florida and the Tropical Atlantic region include extensive goniasterid remains, implying a shallow water fauna that was present in this region until the late Pleistocene. All of the Goniasteridae found in this region are deep-water inhabitants.

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NEW DEEP-WATER GONIASTERID STARFISH FROM HAWAII AND THE SOUTH-CENTRAL PACIFIC

Biodiveristy of the deep Indo-Pacific Ocean region remains poorly understood despite ongoing trawl sampling and increased submersible studies over the last 20 years. Descriptions of new megafaunal echinoderms now are few not because the fauna is well-known but rather because of declining numbers of systematists trained to evaluate and describe newly available material. Expertise is diminishing while misconception seems to grow about what remains to be learned. Several undescribed genera and species of south-central Pacific goniasterid starfish are illustrated here. Most new taxa collected range in size from moderate (~15 cm in diamter) to large (~30 cm in diamter), dispelling any notion that only small and cryptic species remain to be described. The new taxa suggest biodiversity at present is incompletely understood. New generic concepts will be supported by phylogenetic analysis. This approach will provide objective comparison with existing concepts, and it will allow analysis of events in the evolutionary history of the group, e.g. shifts in ecology (water depth, substrate preference) and biogeography associated with morphological change and phylogenetic events. The new taxa will be largely based on extensive collections from Hawaii, Palau, New Caledonia, and other regions in the south-central Pacific. Taxa shown here were collected primarily by the Museum National d'Histoire Naturelle in Paris, the Bishop Museum in Honolulu, and the Western Australian Museum. Additional specimens and *in situ* images were provided by the Hawaiian Research Laboatory (HURL) in Honolulu, HI and the Coral Reef Research Foundation in Koror, Palau.

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***EPISTOMINELLA EXIGUA* AND *ALABAMINELLA WEDDELLENSIS* (PROTISTA, FORAMINIFERA): TWO ABYSSAL "PHYTODETRITUS SPECIES" WITH CONTRASTING ECOLOGICAL CHARACTERISTICS.**

Long time-series samples (1989 to 2002), from an abyssal site (4840 m water depth) in the northeast Atlantic Ocean (Porcupine Abyssal Plain, 49°N 16° 30'W) were examined in order to investigate temporal trends in two calcareous foraminiferal species, *Epistominella exigua* and *Alabaminella weddellensis*. Previous studies have shown that these species are closely associated with phytodetrital deposits. In general terms both showed a similar pattern of abundance in relation to the presence of phytodetritus in the PAP time series. However, our results also reveal significant differences. 1) *Epistominella exigua* was more abundant (17% of the entire foraminiferal fauna) when fresh phytodetritus was clearly present on the seafloor (pre-1996 samples). 2) *Alabaminella weddellensis* became more important (up to 20%), and *E. exigua* declined correspondingly, in later samples in which phytodetritus was virtually absent. The switch from dominance by *A. weddellensis* to dominance by *E. exigua* occurred in March 1997. A few previous studies spanning large geographical regions have suggested that *A. weddellensis* is more abundant in higher productivity areas than *E. exigua*. Our time-series observations at a single site demonstrate that the two species also respond differently across temporal gradients. However, the trend is the opposite to one suggested by the geographical studies, i.e. *A. weddellensis* is more abundant in the absence of phytodetritus than in its presence. We hope to continue this time series study in order to clarify the ecological requirements of these two species, both of which are important for reconstructing palaeoproductivity as well as in modern ecological studies.

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GADIFORMES (TELEOSTEI: OSTEICHTHYES) COLLECTED BY THE FRENCH R/V THALASSA ON THE BRAZILIAN CONTINENTAL SLOPE BETWEEN 11° AND 22°S

Information on gadiforms from Brazilian waters is scarce, mainly due to undersampling over slope waters. The studied material was obtained by the French R/V *Thalassa* off Brazil between 11° and 22° S in depths from 200 to 2,200 m. Bottom and mid-water trawlings yielded more than 720 gadiform specimens of about 190 lots, a collection which has been deposited at the Museu Nacional, in Rio de Janeiro. Thirty species included in 6 different families of Gadiformes were identified. Bregmacerotidae: (1) *Bregmaceros atlanticus*; Gadidae: (2) *Urophycis cirrata*, and (3) *U. brasiliensis*; Macrouridae: (4) *Gadomus capensis*, (5) *G. arcuatus*, (6) *Caelorinchus caribbaeus*, (7) *C. occa*, (8), *C. caelorhinchus carminatus*, (9) *C. marinii*, (10) *Cetonurus globiceps*, (11) *Corypahenoides* sp., (12) *C.* cf. *thelostomus*, (13) *Hymenocephalus aterrimus*, (14) *H. billsamorum*, (15) *Malacocephalus laevis*, (16) *M. occidentalis*, (17) *M. okamurai*, (18) *Nezumia atlantica*, (19) *N. suilla*, (20) *Sphagemacrurus grenadae*, (21) *Trachonurus* cf. *sulcatus*, (22) *Ventrifossa macropogon*, (23) *V. mucocephalus*, (24) *Squalogadus modificatus*; Merlucciidae: (25) *Merluccius hubbsi;* Steindachneridae: (26) *Steindachneria argentea*; and Moridae: (27) *Antimora rostrata*, (28) *Gadella imberbis*, (29) *Halargyreus johnsoni*, (30) *Laemonema goodebeanorum*. Of these, one (12) is closely similar to a species known only from Hawaii, and comparative studies may reveal it represents a yet undescribed form. In decreasing order of importance, the most abundant species were 7, 16, 25, 26. Biogeographically, the region has species in common with the western North Atlantic (1, 5, 6, 7, 10, 13, 17, 18, 19, 20, 21, 22, 23, 26, 30), with off Argentina and Uruguay (2, 3, 9, 14, 16) and with the eastern South Atlantic (4, 12). Such distribution pattern suggests that the fauna of the continental slope off central Brazil has more affinities with that of the western North Atlantic.

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A NEW SYNAPHOBRANCHID EEL (ANGUILLIFORMES: SYNAPHOBRANCHIDAE), WITH COMMENTS ON OTHER SOUTH WESTERN ATLANTIC SPECIES

Synaphobranchid eels are important components of the demersal deep-sea fish fauna of continental slopes and rises of both temperate and tropical regions. The family contains 30 valid species included in 11 genera of 3 subfamilies. We examined 160 specimens of 56 lots collected by the French R/V *Thalassa* while surveying the fishery resources of the Brazilian continental slope between the states of Bahia (11°S) and Rio de Janeiro (22° S). The specimens were deposited in the ichthyological collection of the Museu Nacional, in Rio de Janeiro. Nine forms were recognized: *Simenchelys parasitica* Gill (1879), *Iliophys brunneus* Gilbert (1892), *I. blachei* Saldanha & Merret (1982), *Synaphobranchus* sp., *S. affinis* Günther (1877), *S. oregoni* Castle (1970), *S. brevidorsalis* Günther (1877), and *Diastobranchus* sp. All such species had been previously recorded from Brazilian waters, except for the two new species. *Synaphobranchus* sp. is easily distinguished from its congeners by the absence of scales in the head (vs. head scaled in other species) and its black to brown body with a deep blue belly (vs. body entirely black or brown in other species). The presence of *S. affinis*, *I blachei* and *A. phrix* in our samples represents their first record in the western South Atlantic. In other hand, *S. kaupii* was mentioned to occur in the area of study, but none specimens was identified.

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STALK GROWTH RATES OF ISOCRINIDAE (ECHINODERMATA: CRINOIDEA): A SUMMARY OF A DECADE OF *IN SITU* EXPERIMENTS

From 1991 to 1998, we collected stalked crinoids belonging to the family Isocrinidae along the western margin of the Little Bahama Bank using the submersible Johnson Sea Link. Specimens were measured, tagged with color-coded cable ties, returned to the sea floor either to the site at which they were collected or to different habitats or depths, and recovered several months to a year later. Values are extrapolated mean annual rates except where noted. *Neocrinus decorus*, the most abundant species on low-relief hardgrounds in ~275-520 m (study sites: 404-430 m), grew 10.1±0.7 cm y^{-1} (n=5) between August and April and 14.2±2.3 cm y^{-1} (n=7) between February and October, suggesting possible seasonality. Study site temperatures ranged from about 12 to 17°C. A single small specimen recorded 14.6 cm y^{-1} during the former period. Another specimen apparently autotomized all its arms after deployment; it was recovered after 8 months with regenerating arms 3.0-3.3 cm long while its stalk grew at a rate of only 1.5 cm y^{-1}, strongly suggesting a significant reallocation of resources to permit regrowth of feeding appendages. *Endoxocrinus muelleri*, often abundant on raised topography (e.g., boulders, ridges, mounds) between ~300 and 520 m, grew significantly more slowly: 2.4±0.5 cm y^{-1} (n=20). As part of a series of experiments examining environmental control of morphology, *E. muelleri* was transplanted beyond its local depth range to the habitat at which deeper-dwelling *E. prionodes* occurs (572 m). *E. muelleri* grew at 0.6±0.4 cm y^{-1} (n=6) here, significantly more slowly than in 404 m and also more slowly than *E. prionodes* (2.1±0.6 cm y^{-1}; n=4), supporting the hypothesis that these two morphs represent distinct species. Although growth rates for *E. muelleri* and *N. decorus* do not differ significantly between adjacent high and low energy habitats at the same depth, both exhibit significantly shorter stalk lengths and crown elevations on raised topography apparently subject to stronger flow. All specimens transplanted from low- to high-energy habitats had shorter stalks at the end of the study, as expected. Although most specimens replaced in the same habitat from which they were collected also had a net stalk loss (perhaps due to treatment-associated trauma), two of three *E. parrae* and one of three *N. decorus* transplanted from high- to low-energy habitats grew longer stalks. Because undisturbed isocrinids likely maintain relatively constant stalk lengths by sloughing terminal columnals at the same rate at which new columnals develop (except for changes with growth to maturation), these data reinforce the idea that confamilial taxa may contribute skeletal components to sediments at very different rates, and that flow regime may modify crinoid morphology.

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STRUCTURE AND DIVERSITY OF MICROBIAL COMMUNITIES AT METHANE SEEP SITE (GULF OF GUINEA)

During the French oceanographic cruise Biozaire 2 (November 2001) in the Gulf of Guinea a methane seep, lately discovered by the geologists of Ifremer (DRO/GM), has been investigated. Sampling of animals and sediments have been done with a Remote Operated Vehicule (Victor 6000). Sediment cores have been taken on bacterial mat and close to animals known as organisms depending on chemoautotrophic nutrition (Bivalvia Mytilidae and Vesicomyidae, Vestimentifera). Measurements of physico-chemical parameters (temperature, methane, dissolved oxygen, sulfides and pH) have been carried out. In sediments, microbial aggregations of methane-oxidising archae (ANME2) and sulfate-reducing bacteria (Desulfosarcinales) have been observed using fluorescent *in situ* hybridisation (FISH). These aggregates are known to be involved in the anaerobic oxidation of methane (AOM).

This study compares the number and the distribution of microbial aggregates in sediments for different places of the methane seep (close to mussels, close to clams, close to vestimentifera and beneath a microbial mat). The results are interpreted in relation with methane concentrations. Diversity of archeal communities is established in sediments close to mussels and close to bacterial mat by 16S rDNA. Bacterial symbionts in mussels, clams and vestimentifera have been identified by 16S rDNA. The presence of both methanotrophic and thioautotrophic symbionts in mussel gills, and only thioautotrophic symbiont in clam gills and vestimentifera trophosoma is discussed in function of methane concentrations and distribution of microbial aggregates involved in AOM.

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BENTHIC FORAMINIFERAL UPTAKE OF ORGANIC CARBON MEASURED BY *IN SITU* EXPERIMENTS USING ^{13}C LABELED ALGAE IN SAGAMI BAY, NW PACIFIC

The deep-sea benthic community is thought to be an important component controlling the carbon budget of the ocean system. However, its role in the deep-sea carbon cycle is poorly known due to limited understanding of the deep-sea benthic ecology. We investigated the feeding ecology of deep-sea benthic foraminifera and evaluated their roles in carbon cycling at the seafloor by measuring their uptake rates of organic carbon. *In situ* experiments were carried out with the manned submersible "SHINKAI 2000" in November 2001 and April 2002. Algae labeled with ^{13}C were supplied into culturing devices, and were kept on the seafloor for several days and then recovered. Both foraminifera and metazoan meiofaunal species from the sediment surface down to 5 cm depth within sediment were analyzed both for $d^{13}C$ and TOC. Our results indicate the following: labeled algae were mixed 4 to 5 cm deep in the sediment within 2 to 4 days of incubation. Distinct increases of $d^{13}C$ values in foraminiferal cytoplasm were found after 2 days incubation both in November and April. Even individuals that lived 4 to 5 cm deep in the sediment assimilated labeled carbon within 2 days. Shallow infaunal species showed rapid and large assimilation of labeled carbon in comparison to intermediate and deep infaunal species. Benthic foraminifera assimilated 10.1mgC m^{-2} of labeled carbon in April within 2 days incubation, whereas metazoan meiofauna assimilated only 2.3mgC m^{-2}. Deep-sea benthic foraminifera therefore play an important role in short-term carbon cycle processes at the sediment-water interface.

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***TIBIA DELICATULA* (NEWILL, 1881), A VERY ABUNDANT GASTROPOD IN THE OXYGEN MINIMUM ZONE OF THE OMAN MARGIN**

In December 2002, RRS *Charles Darwin* carried out a survey of the Oman margin, including its Oxygen Minimum Zone (OMZ) between 400 and 700 m depth. Molluscs are generally rare in OMZs, but at 500 m (O_2 < 0.4 mg/l) the gastropod *Tibia delicatula* (Nevill) was present in large numbers. This species has been reported previously in the OMZ of the northern Indian Ocean, but generally at shallower depths. Basic aspects of its ecology and biology remain unknown. Population size structure and some aspects of reproduction are described. Several hypotheses are discussed to explain the observed pattern of size-distribution. The population was represented by a few adults and many juveniles. Size, measured as total length, varied between 10 mm and 73 mm. Most of the population (67%) was in the 10-23 mm size class. There was a unimodal size structure with evidence of a marked recruitment of juveniles. All specimens had a penis and sperm groove. None of the specimens in the small size classes (size < 49 mm; $n = 33$) had mature gonads. Of the large specimens (size class 62-75 mm; $n = 7$), only 3 had developed gonads and all of these were female. The gonad wall consists of a reticular tissue which might be used for nutrients storage or as an irrigation system. Only vitellogenic oocytes were present. In two females most of the oocytes (> 95%) measured between 50 and 150 µm, whereas in the third female 82% of the oocytes measured between 150 and 250µm.

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FEEDING HABITS OF GREENLAND HALIBUT, KAMCHATKA FLOUNDER, AND PACIFIC HALIBUT IN THE RUSSIAN WATERS OF THE NORTHWESTERN PACIFIC

Greenland halibut *Reinhardtius hippoglossoides matsuurae*, Kamchatka flounder *Atheresthes evermanni*, and Pacific halibut *Hippoglossus stenolepis* are very important targets of groundfish fishery in the North Pacific continental slope waters. Feeding habits of these predators in the western Bering Sea were investigated long ago and previously published data from the Kuril-Kamchatka area contained only frequency of occurrence of dietary components in stomachs. Present paper is based on stomach contents of Greenland halibut, Kamchatka flounder, and Pacific halibut sampled in the western Bering Sea (168° E - 178° W) and Pacific waters off the northern Kuril Islands and southeastern Kamchatka (47°55′ - 51°40′ N) during 1997. The paper considers diet compositions of three halibut species, dietary differences depending on length and sex of predators, regional and depth-depended dietary distinctions of all three halibut species within two study areas. Dietary similarities between various size groups of species considered within each study area are analyzed.

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WHAT DO WE KNOW ABOUT SKILFISH *ERILEPIS ZONIFER* (ANOPLOPOMATIDAE)?

Skilfish is a rather rare representative of the sablefish family, inhabiting the North Pacific from Japan and California to the Aleutians. This species does not support a commercial fishery. Its biology is generally poorly studied. Published data contain mostly capture depths and localities, fish lengths, and occasionally some morphological peculiarities.

Skilfish nomenclature and morphology, new data on distribution and biology, and aquarium observations are considered. Morphological analysis of skilfish from waters off Japan, the Kuril Islands, the United States and Canada did not reveal any considerable distinctions between Asian and American individuals that did not support the hypothesis of an amphipacific distribution. With increasing body length, the predorsal length, head length and maxillar length increased, while the length of the first dorsal fin base, pelvic fin and pectoral fin demostrated decreases that are associated with the transition from a pelagic to a benthic life pattern.

Small fry of skilfish inhabit surface-drifting seaweed in coastal areas. With increasing length, skilfish become more widely distributed in the high seas, and are often caught by surface gill nets. Adults inhabit near-bottom layers and are caught over continental slopes and seamounts at depths up to 1030m. Pelagic juveniles are usually <40 cm, though they occasionally attain 60 cm. Transition from pelagic to benthic life pattern occurs by the length of 60 cm (only a single bottom-trawl-caught skilfish was 45 cm). Juveniles inhabit pelagic regions within the temperature range of 8.4-13.2C (average 10.2C) while adults are caught over the bottom at 0.9-3.45C (average 2.7C).

The relationship between body length and weight of skilfish is provided. Data on reproduction are almost lacking. Only red squid, Berryteuthis magister and octopi were found in stomachs of skilfish caught in the Kuril Island waters. On the basis of aquarium observations, some skilfish behavior patterns in captivity are considered.

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FEEDING ECOLOGY OF HYDROTHERMAL VENT LIMPETS OF THE GENUS, *LEPETODRILUS*

Limpets of the vent-specific genus *Lepetodrilus* are wide spread. Species have been found at the majority vents so far described. Four species were studied, from the East Pacific Rise, Galapagos Rift and the Mid Atlantic Ridge. Lipid compositions and distributions were analysed to assess long and short-term changes in diet and ecology. The overall condition of the limpets, together with oxygen isotope values, was used to estimate micro-ecological effects. HUFAs (Highly unsaturated fatty acids) were found to be abundant and reflected trophic status. The behavioural and mechanical processes of feeding were investigated in *Lepetodrilus atlanticus* by analysis of videos of the animals taken at the vents and in aquaria.

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cDNA MICROARRAYS REVEAL DIFFERENTIAL GENE EXPRESSION IN THE DEEP-SEA EURYTHERMAL POLYCHAETE, *ALVINELLA POMPEJANA*

Alvinella pompejana is thought to be one of the most eurythermal eukaryotes known, and lives in an environment of high temperature, high hydrogen sulfide concentration, low oxygen and high pressure. These worms spend much of their time in tubes built on deep sea vents, which perhaps creates a steep gradient of environmental conditions between the posterior end of the worm, nearest to where the worm tube abuts the vent, and the anterior end of the worm, which is exposed to the ambient temperature of the surrounding seawater. We hypothesize that there are differences in gene expression between the anterior and posterior of the worm due to this environmental gradient. We have constructed microarrays of more than 5000 cDNAs and our preliminary results suggest that there is differential transcript abundance in the anterior versus the posterior of the worm. Interestingly, we found high levels of Heat Shock Protein 90 and other chaperone proteins in the posterior. This suggests that the posterior of *Alvinella pompejana* does experience high temperatures. We are characterizing genes of unknown function that are differently regulated, which may represent new stress-response genes.

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AGGREGATION DYNAMICS OF ARCTIC DEEP-SEA SCAVENGERS AT LARGE FOOD FALLS: TEMPORAL ATTRACTION, CONSUMPTION RATE AND POPULATION STRUCTURE

Several studies with baited time-lapse cameras and traps have discovered a large motile scavenging fauna attracted to carrion in the deep-sea all over the world. One of the most striking pattern is the formation of animal aggregation. Comparing the bait-attending fauna of different areas within the North Atlantic, Mediterranean Sea and the Pacific, the scavenger communities have been found to differ in terms of species composition and numbers of individuals attracted. Here we present data obtained by using a free falling lander equipped with a time-lapse camera, current meter and trap. Six experiments were carried out in the Arctic Ocean for investigating scavengers community, its spatial temporal distribution and its composition (species, sex-ratio, length-frequency distribution) at about 2500m water depth, in the Fram Strait, the deepest connection between the Atlantic Ocean and the Arctic Ocean. Scavenging community of the deep Arctic Ocean was found to quickly discover and consume bait as has been reported from other deep-sea areas and was almost dominated by the main bait consumers *Eurythenes gryllus* (Lichtenstein, 1822) and *Tmetonyx norbiensis* (Oleröd, 1987), while bait consumption of other scavengers was not remarkably. We counted extraordinary many individuals of *E. gryllus* on our pictures exceeding numbers of individuals counted by others not only more than 13 fold but appeared up to 20 times faster as in other experiments. The maximum numbers of individuals were very unequal and we recorded differences in the temporal arrival of individuals that we can differentiated between two types of feeding aggregation – reasons are up to now topics of investigations.

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DEEP SEA BIOLOGY CRUISES TO THE PORCUPINE SEA-BIGHT, NE ATLANTIC OCEAN 2000-2002

Over a period of three years 5 cruises of the *RRS Discovery* visited the Porcupine Sea-Bight, D250, September 2000, D252 April 2001, D 255 August 2001, D260 March 2002 D266 September-October 2002. Biological sampling was carried out at depths from 750m to 4000m and excursions were made out to the Porcupine Abyssal Plain at 4800m during cruises D250 and D266. This sampling scheme allowed investigation of temporal and seasonal change with samples from spring summer and autumn.

The single OTSB trawl was deployed on a single warp 52 times and 7866 fish of 99 species were captured. On board weighing and measuring of each specimen allowed extensive investigations population size structure and condition factor. Tissue sampling supported studies on genetics, biochemistry and comparative anatomy. Invertebrate samples were also collected. Observations were made using landers equipped with cameras, AUDOS, FRESP, SPRINT and ROBIO. Bioluminescence was investigated using the ISIT lander. Long term experiments were serviced that were left on the sea floor between cruises including BATHYSNAP, DOBO, sediment trap moorings and ANIMATE multi -sensor moorings.

With participation from the Southampton Oceanography Centre and other institutions this sampling effort supported a wide range of research projects. The film, video, tissue and data archives will provide research output for years to come.

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ACTIVE DEEP-SEA FAUNA OF THE BASINS OF THE EASTERN MEDITERRANEAN SEA

The basins of the eastern Mediterranean are unusual with a temperature of over 14°C in the abyss compared with <4°C in most of the world's oceans. The marine fauna of the Mediterranean is thought to have originated largely from the Atlantic Ocean within the last 5 million years following the Pleiocene normalisation event and ingress of waters from the west. The deep basins themselves have only become oxygenated and hence colonisable within the last 6000 years. Down to a depth of 2500m several species of shark are present, the six-gilled shark, *Hexanchus griseus,* the Blackmouth catshark, *Galeus melastomus* and velvet belly *Etmopterus spinax*. Below 2500m there is only one species of fish, the macrourid *Chalinura mediterranea.* Similarly amongst the crustaceans, the crabs, *Geryon longipes* occurs down to 2000m depth, and *Chaceon mediterraneus* down to 3800m but only one species, the shrimp *Acanthephyra eximia* is found at the bottom of the deep basins. Interestingly *Acanthephyra* has been observed in warm water around hydrothermal vents on the Mid-Atlantic ridge, possibly pre-adapting the species for warm deep-sea conditions in the Mediterranean. The ecosystem of the abyssal floor of the Eastern Mediterranean basins is therefore simple, with one mobile crustacean, one fish and one species of polychaete worm *Myriochele fragilis*. Remarkably this species of worm is best known from the Arctic Ocean. Studies on activity and metabolism of these species will be described

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ESONET- EUROPEAN SEA FLOOR OBSERVATORY NETWORK

The ESONET aim is a network of sea floor observatories around the European Ocean Margin from the Arctic Ocean to the Black Sea for strategic long term monitoring as part of the European GMES (Global Monitoring for Environment and Security). ESONET will have capability in geophysics, geotechnics, chemistry, biochemistry, oceanography, biology and fisheries. Both long-term data collection and alarm capability in the event of hazards (e.g. earthquakes) will be considered. The aim is progressive development of ESONET beginning with networks in key areas where there is industrial sea floor infrastructure, scientific/conservation significance (e.g. coral mounds) or sites suitable for technology trials (e.g. deep water close to land). Technologically, work will progress from existing autonomous long-term stations to development of hard-wired networked capability with real time data acquisition. ESONET will be multidisciplinary providing data on various time scales from real time to decadal time scale archiving according to requirements of different user communities.

Initially 9 key areas have been identified for implementation of ESONET long term stations. A mobile observatory system is also proposed to allow responsive deployment in case of disasters such as large ship wrecks or sub sea slides. ESONET will provide opportunities for long-term studies in deep-sea biology at contrasting locations around the European Margin and is expected to begin operation by 2008. European Commission Concerted Action *EVK3-CT-2002-80008*

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IMPACT OF SMALL-SCALE SEDIMENT STRUCTURES ON THE VARIABILITY OF BACTERIAL DYNAMIC PATTERNS IN ARCTIC DEEP-SEA SEDIMENTS

Accounting for a topographic and nutritional heterogeneity, macrofaunal organisms inhabiting Arctic deep-sea sediments continuously restructure the upper sediment layer by creating feeding tracks, faeces, burrows and mounds. The present study focuses on a comparative investigation of different small-scale biogenic sediment structures in the context of local enhancement of bacterial communities. Among structures like tracks and faeces, 50-70% of the samples were characterised by higher protein synthesis rate, whereas 20-30% showed higher DNA synthesis rate compared to undisturbed sediment samples (simultaneous ^{3}H-thymidine and ^{14}C-leucine incorporation measurements). The relatively small percentage of structures characterized by a local enhancement of bacterial activity could be explained by the lack of information on the longevity of tracks and faeces.In contrast thereto, microenvironments of small epibenthic sponges have been observed to support an exceeding bacterial activity in relation to control sediments. With cell abundances up to 4 times higher than in control sediments (mean= $5{,}33 \times 10^{8}$ cells g^{-1}), sponges are supposed to create a specific microclimate in their sedimentary environment. This may be attributed to a small-scale deposition of organic matter and/or excretion products in an active or a passive way, deriving from characteristic current regimes around bottom-near obstacles.

The potential importance of spatial heterogeneity and connectivity in controlling competition, and thus diversity, could not be confirmed in this study. Although sponges have been shown to create high productive patches in deep-sea sediments, the bacterial community composition did not differ significantly compared to sediments without biogenic structuring.

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ChEss: BIOGEOGRAPHY OF DEEP-WATER CHEMOSYNTHETIEC ECOSYSTEMS FOR THE CENSUS OF MARINE LIFE

ChEss is one of the seven pilot projects within the Census of Marine Life initiative. The aim of ChEss is to determine the biogeography of deep-water chemosynthetically-driven ecosystems and to understand the processes driving them. The main objectives are to assess and explain the global diversity, distribution and abundance of species from chemosynthetic systems including hydrothermal vents, cold seeps, whale falls, sunken wood and oxygen minimum zones. ChEss will follow two approaches: 1- development of a web-based relational database for all species from deep-water chemosynthetic systems is being developed, 2- development of a long-term field programme for the discovery and exploration of new vent and seep sites. The global mid-ocean ridge system where vents occur extends for ~60000 km and continental margins where cold seeps occur cover vast regions of seafloor. It is therefore unlikely that all regions with potential sites would be examined in detail. The ChEss programme proposes to select a limited number of target areas where specific scientific questions on biogeographic issues will be answered. The key areas endorsed by ChEss comprise two combined regions and several specific regions. The combined regions have a variety of chemosynthetic systems related by their geography, hydrography, history and/or biology. The specific locations reflect institutional or national interests in areas endorsed by ChEss. ChEss has an international steering committee, which will ensure coordination of the programme, collaboration between participants and promote ship-time applications at national level.

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LONG-TERM CHANGE IN ABYSSAL ECOSYSTEMS – THE "*AMPERIMA* EVENT" REVISITED

In 1996 a radical change in the density of megafauna in the NE Atlantic was detected. The change was apparent over a very large area of the Porcupine Abyssal Plain. Statistically significant increases were apparent in the abundance of several taxa, most notably the holothurian *Amperima rosea*. Prior to 1996 this holothurian had only been recorded at low densities (apart from one sample taken in 1911) of no more than three individuals per hectare, but post-1996 it increased to 6000 individuals per hectare. Sampling undertaken in October 2002 indicates that the density of *Amperima* is still very high, and changes in other taxa, such as ophiuroids, pycnogonids, tunicates and actiniarians, are also notable. The rate at which the megafauna rework the sediment surface has also increased dramatically: pre-1996, the time to rework 100% of the sediment surface was estimated from time-lapse photographs at over two years, in 1997 the 100% reworking time had reduced to six weeks. This high rate of *Amperima* activity prevents phytodetritus accumulating at the seabed and presumably alters the food available to other fauna. In a food-limited environment, intense competition for key resources essential for reproductive processes, such as carotenoids and poly-unsaturated fatty acids, may be the dominant control on the ecology of the system and provide an explanation for the radical change in benthic populations associated with the "*Amperima* Event".

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LOW TEMPERATURE HOT WATER ENGINE – ELECTRICAL POWER GENERATION PROJECT

This paper presents the development of an operating mechanical model of a Low Temperature Hot Water Engine that generates 1/2 horsepower of electrical power driven by hot water from a household hot water heater at 120 degrees Fahrenheit. This operating mechanical model demonstrates the inexpensive potential of energy from very low temperature sources such as the ocean. This paper compares the greatest low temperature technologies where low temperature energy is available such as Ocean Thermal Energy Conversion, Deep Ocean Geothermal Vents, Solar and Waste Heat. Ocean Sciences have always recognized the potential for power generation from the inherent energy contained through wave action and ocean thermal systems. Man has taken advantage of the currents set up by ocean thermal systems since the beginning of time. More recently man has extracted electrical power from ocean temperature differences with systems known as Ocean Thermal Energy Conversion (OTEC). Most US experiments in recent years have taken place in Hawaii at the Natural Energy Laboratory of Hawaii Authority (NELHA) at Keahole Point on the island of Hawaii. The Low Temperature Engine presented in this paper uses the Organic Rankine Cycle to produce the electricity from low temperature water. This cycle uses a refrigerant fluid to extract the energy from the water and transfer this energy to electrical power. This cycle is easily explained so the reader can identify opportunities for producing power in this fashion. The unique approach of this engine, as compared to the typical Low Temperature Power Cycle, is the ability to produce power, up to 50 KW, at remarkably inexpensive costs and with relatively no resulting polluting emissions. The reason for this potential breakthrough in reduced costs of this engine is the ability to use "off-the-shelf" readily available already manufactured components. A 50 KW power source could be very valuable for Ocean Scientists working in remote locations and for developing countries that have a need for localized power generation. The thermal energy source could come from come from sources such as waste energy from ocean thermal, geothermal, solar or the exhaust stacks of diesel engines. The rising world population and improvement of living standards are leading to a higher demand for cleaner energy, regardless of decreasing traditional fossil energy sources such as coal or crude oil. A complete bibliography on Low Temperature Power Cycles including Ocean Thermal Energy Conversion is included in the paper. The working model will be demonstrated at the conference.

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BIOLUMINESCENCE FROM THE ARM TIPS OF THE BATHYPELAGIC CEPHALOPOD *VAMPYROTEUTHIS INFERNALIS*

The archaic, deep-sea cephalopod *Vampyroteuthis infernalis* occurs in dark, oxygen-poor waters below 600 m off Monterey, California. Living specimens, collected gently with a remotely operated vehicle and quickly transported to our laboratory ashore have revealed two, hitherto undescribed means of bioluminescent expression. In the first, light is produced by organs located at the tips of all eight arms. In the second, a viscous fluid containing microscopic luminous particles is released from the arm tips to form a glowing cloud around the animal. Both modes of light production are apparently linked to anti-predation strategies. Use of the tip-lights is readily educed by threat stimuli, while fluid expulsion has a much higher triggering threshold. This paper presents information on the structure and operation of the arm-tip light organs, the character of the luminous cloud, and how their light output is incorporated into behavioral patterns.

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OLFACTORY, GUSTATORY AND TACTILE SEARCHING BEHAVIOUR BY THE DEEP-SEA GRENADIER FISH *CORYPHAENOIDES ARMATUS.*

The grenadier *Coryphaenoides armatus* inhabits the world's ocean basins at depths greater than 2000m and is an active bentho-pelagic predator and scavenger. It has well-developed eyes; presumably used for detection of bioluminescence emitted by other organisms in the absence of downwelling light. *In situ* studies have shown that while these animals have functional eyes, they appear to ignore artificial lights and continue feeding behaviour while illuminated. On the basis of video observations and studies of brain anatomy, *C. armatus* are thought to be predominantly olfactory foragers. New histological data suggest an important tactile or gustatory sensory role for the barbels of this species. Detailed motion analysis studies of foraging in *C. armatus* were undertaken using baited cameras deployed to the seafloor in the North-East Atlantic. *Coryphaenoides armatus* exhibited two types of swimming: horizontal swimming and head down swimming. We hypothesise that slower head down swimming is used to forage directly on the seafloor compared to faster horizontal swimming without seafloor contact. Once in contact with the lander *C. armatus* was shown to circle the lander poles both in vertical and horizontal planes, in an apparent attempt to decipher these new additions to its environment. Motion analysis appeared to show that contact between the barbel and the lander poles and sea floor allowed *C. armatus* to navigate when close to the bait and to determine the detailed structure of objects protruding from the sea floor. This suggests that although olfaction and rheotaxis may allow *C. armatus* to locate the general area of food-falls a sense of touch focussed in the barbel may allow the fish to produce a 3D sensory model of its surroundings and maximise the effectiveness close-range foraging.

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DIFFERENCES IN REPRODUCTIVE ACTIVITY AMONG DEEP-SEA BENTHIC COPEPOD SPECIES

Temporal changes in abundance and reproductive activity of deep-sea benthic copepod species were investigated for nine abundant species that composed about 50 % of total individuals at a bathyal site (depth 1430 m) in Sagami Bay, central Japan, based on time series data for two years (from December 1996 to August 1998).

Density of adults of these species fluctuated temporally (4.7 - 32 individuals per 10 cm^2 in all), but did not show seasonal trend. Strong evidence for competitive relationship among species could not be detected: there was no significant negative correlation in abundance between any pair of the species.

The percentage of ovigerous females per total adult females of *Schizopera* sp. 1 was different significantly among months. Furthermore, adult sex ratio of the species appeared to fluctuate temporally. These suggest temporal change in reproductive activity and synchronized growth of *Schizopera* sp. 1. There was no temporal trend, however, in any parameter for the other species. Mean egg number of *Schizopera* sp.1 was 3.7, which was as same as or lower than the values of the other species (2.7 - 15). Although differences in egg number did not explain those in reproductive patterns among species, their egg numbers seem to be smaller than those of congenerous species previously reported from the shallow water, suggesting adaptation for the food-limited environments.

Diversity and species compositions of the copepod communities were similar through the years, which would be explained by the rareness of seasonal reproduction among abundant species at the bathyal Sagami Bay site.

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SIZE, PLATE DEVELOPMENT, AND DISTRIBUTION IN THE EPIBIOTIC BARNACLE, *OCTOLASMIS AYMONINI GERYONOPHILA*

Many species of barnacle have adapted to an epibiotic lifestyle, choosing to settle on the hard surfaces of other living animals rather than rock or wood. In doing so, these animals have become specially modified in morphology and possibly in life history for coping with the activities of their hosts. Voris and Jeffries (1997) documented interspecific patterns in the morphology of the capitular plates that strongly corresponded to the host microhabitat (i.e. exposed or protected) in which members of the lepadomorph genus *Octolasmis* could be found. The deep-sea barnacle *Octolasmis aymonini geryonophila* can be found on both exposed and protected areas of the giant isopod *Bathynomus giganteus*. These obligate epibionts were collected from *B. giganteus* in the Gulf of Mexico and size, distribution on the host, and the percent coverage of the capitular plates were analyzed. The calcification of plates showed no correlation with the location of residence. However, sizes and distributions of the barnacles along the host were significantly different. This may be attributed to stress factors associated with location and the need to allocate energy to different functions, such as growth and reproduction. Supported by NSF Grant OCE-0243688 (C.M. Young).

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ECOPHYSIOLOGY OF *MEGANYCTIPHANES NORVEGICA;* SOME RECENT ADVANCES

Meganyctiphanes norvegica is the largest of the krill species (Euphausiacea) in the Northern Hemisphere. It is restricted to the North Atlantic but has a wide latitudinal and longitudinal distribution meaning that it experiences very different environmental conditions. Thus, it has been of interest to investigate the adaptability of this krill species to varying physical/chemical factors and how its reproductive strategy and moulting activity may be affected. Many of the investigations have been made with a fjord population on the Swedish west coast. This is a summary of some investigations jointly carried out with the European researchers listed below[1-4].

The diel vertical migration of this species is not triggered by some internal factor but of extremely low changes in light intensities as was found during a solar eclipse[1]. The species may experience waters with low oxygen content, but it has a poor anaerobic capacity[2]. *M. norvegica* can tolerate low oxygen levels for short periods only if the water is relatively cold (about 6-8°C) which lowers the metabolic rate (Q_{10} >2)[3]. Changes in environmental factors (PO2, temperature, salinity and food availability) influences the concentration of the respiratory pigment haemocyanin in *M. norvegica* already over the course of a few hours at normal ambient temperature (6-8°C), which is much shorter than in other investigated crustaceans. With increasing temperature this effect isexacerbated. Hc may be used as an energy source even when oxygen levels decrease[4].

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ABUNDANCE OF A SARGASSUM-DWELLING GASTROPOD, *LITIOPA MELANOSTOMA*, IN DEEP-SEA SEDIMENT CORES REPRESENTING THE LAST 35,000 YEARS

During the last two decades much has been learned about paleoclimatology by examining proxy variables and composition of foraminiferans collected in deep-sea sediment cores. Very little is known about other taxa found in cores. Here we show that larval shells of *Litiopa melanostoma*, a gastropod that lives exclusively on Sargassum, occur in relatively large numbers in two sediment cores taken from the Sargasso Sea at depths between 2100 m and 2300 m. Other than pelagic pteropod and heteropod gastropods, *L. melanostoma* was the only abundant metazoan. Occasional benthic bivalves and gastropods were found. Larval shells of *L. melanostoma* were not present until after the Last Glacial Maximum (LGM). They first appeared at the beginning of the deglacial period (~17 ka) and then fluctuated in abundance on millennial time scales until the present. Oxygen isotope ratios of the larval shells mirrored those of pelagic foraminiferans. Ratios were heavier near the LGM and during the Younger Dryas cold episode (~12 ka), and lightest during the present interglacial period.

The absence of *L. melanostoma* larvae during the LGM may be the result of colder sea surface temperatures causing the Sargassum, a warm-water alga, to shift to more southern latitudes. Variation in abundance during the postglacial period is more difficult to interpret. It may represent surface conditions affecting the success of larval production or dispersal patterns, or variation in corrosive conditions influencing preservation on the sea floor. The non-foraminiferan component of deep-sea sediment cores may provide valuable information to reconstruct past climate conditions.

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DIEL CHANGE IN OCCURRENCE FOR SOME DEEP-SEA DEMERSAL FISHES IN SOUTHWEST JAPAN

In order to examine the diel change in occurrence for four deep-sea demersal fishes, *Congriscus megastomus*, *Hymenocephalus lethonemus*, *Nezumia condylura* and *Ventrifossa garmani*, nine bottom trawl hauls were carried out through 22 hours at one station of 500 m deep in southwest Japan. Salinity and temperature were recorded as environmental factors at the all hauls. *C. megastomus* was the most abundant at the last haul before sunset, and decreased during night hauls. After sunrise, its occurrence increased again. The appearance of the other three macrourids was showed the opposite pattern to that of *C. megastomus*; they were more abundant during night than daytime and their peak in occurrences was at the second haul after sunset. The changes in species occurrence were found to correlate with temperature and salinity in three macrourids, but not in *C. megastomus*. These suggested that occurrence of the four abundant species in this study area seemed to change distribution daily, but in a different way among species. The occurrence patterns in these four species would be reflected by the difference of food items between *C. megastomus* and the other three macrourids. This would be helped to make them inhabit same area for reducing the effect of competition. The considerable effects of temperature and salinity on the occurrence of the three macrourids indicate the structural change in water mass would be important in considering their distributions.

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SELECTIVE FEEDING OF BENTHIC FORAMINIFERA ON PHYTODETRITUS FROM A LATE SUMMER BLOOM ON THE WESTERN ANTARCTIC PENINSULA SHELF

We used fatty acid biomarkers to examine the responses of selected abundant foraminiferal species to the seasonal deposition of fresh phytoplankton-derived organic matter at a 560-m deep sampling site on the Western Antarctic Peninsula Shelf (65°10'S, 64°46'W, FOODBANCS site A). Fatty acids of known origin can be used as biomarkers for marine micro-organisms, i.e. they can indicate what the studied organism has been feeding on. Of particular interest in our study are Polyunsaturated Fatty Acids (PUFAs), which are only produced in high amounts in planktonic marine ecosystems by photosynthetic organisms such as diatoms and flagellates, and can serve as bioindicators for the quality and freshness of organic matter deposited on the seafloor. After a depositional event following a phytoplankton bloom, the fatty acid profiles of the calcareous species *Globocassidulina subglobosa* (Brady 1884) and *Quinqueloculina seminula (Brady 1881)* and the agglutinated *Thurammina albicans* (Brady 1884) were compared to that of the surrounding phytodetritus. While all three species demonstrated selective feeding behaviour, only *Globocassidulina crassa* showed a significant increase in PUFAs derived from phytodetrital food source. This indicates that in areas with a pulsed food input, such as parts of the Antarctic and Arctic as well as many deep-sea areas, abundant and common species like *G. subglobosa* have a potentially very important and complex role in the decomposition of freshly deposited phytodetritus and the cycling of organic matter on the seafloor.

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EMBRYOLOGY AND OBSERVATIONS OF EGG CAPSULE DISTRIBUTION OF *BATHYNERITA NATICOIDEA*

Bathynerita naticoidea (Gastropoda: Neritacea) is the most abundant gastropod found at cold seeps in the Gulf of Mexico at depths of 500-1000m. Adult *B. naticoidea* and egg capsules were collected in October, 2002 and February, 2003, from three sites, Brine Pool NR1 (27°43'24"N; 91°16'30"W), Bush Hill, and Green Canyon . Lecithotrophic embryonic and larval development occurs within capsules laid on the dominant seep mussel, *Bathymodiolus childressii.* Early embryological development follows the typical spiral cleavage of gastropod development. Cleavage is unequal; a large polar lobe is present during the first cell division. Complete development of this species takes at least four months within capsule at ambient temperature. Spatial distribution of egg capsules between discreet zones within the mussel bed at the Brine Pool differed significantly. The outer zone is characterized by relatively low oxygen and methane concentration, and high hydrogen sulfide concentration. Significantly greater numbers of egg capsules were laid in the outer zone compared to the inner zone (46.4 and 19.3, respectively). These results suggest that *B. naticoidea* can detect minute differences in water chemistry and select sites to place egg capsules to facilitate survival of developing embryos. Supported by NSF Grant OCE-0243688 (C.M. Young).

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ACCESS TO MBARI'S DEEP-SEA VIDEO ANNOTATION DATA: 14 YEARS OF OBSERVATION

The Monterey Bay Aquarium Research Institute uses high-resolution video equipment to record over 300 remotely operated vehicle (ROV) dives per year. Over the past fourteen years, 14,000 videotapes have been archived and managed as a centralized institutional resource. This video library contains footage of the biological, chemical, geological, and physical aspects of the Monterey Bay submarine canyon and other areas including the Pacific Northwest, Northern California, Hawaii, and the Gulf of California. MBARI has developed a software and hardware system, Video Annotation and Reference System (VARS), to facilitate the creation, storage, and retrieval of video annotations based on ROV dive tapes. The VARS components reference a knowledge database of over 3,000 biological, geological and technical terms. This hierarchical information allows for consistent and rapid classification, description, and complex querying of objects observed on video.

The 10,000 hours of catalogued and stored video have proven to be a valuable resource for scientists and collaborating researchers when determining descriptive and quantitative attributes of the ocean environment. The use of over 900,000 annotation records and related ancillary data aids in the descriptions of new organisms and unique geological features, and in the documentation of deep-sea exploration and experimentation. Recognizing the tremendous intellectual value of the extensive collection of the video captured by ROVs, the institute continues to develop applications for internal and external user access to this video database. A computer station will be available to demonstrate what information is available and how it can be accessed.

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THE DEEP WATER FAUNA OF THE GALAPAGOS ARCHIPELAGO

The Galapágos Islands have long been of interest to biologists and geologists alike. The deeper waters surrounding the archipélago have had little biological attention thus far. The three main currents into the Galapágos (Humbolt, Californian and Southern Equatorial Current) create diverse marine environments. In the shallow water, these three currents create different habitats, and so a different faunal diversity can be found between islands. It is as yet unknown whether this pattern extends to the deep-water fauna.

This poster looks at three research cruises to the area, two led by scientists from the Harbor Branch Oceanographic Institution in 1986 and 1995, and one in 2001 by scientists from the Woods Hole Oceanographic Institution. These three cruises represent the only known extensive collections of deep-water (500m – 3520m) fauna from around the islands. 205 species were collected in total, with the Cnidaria and Echinodermata being the major phyla.

Exposed basalts and boulders were the dominant habitat and many coral biomes were also found around eight of the islands. These are mainly composed of *Madrepora oculata* and antipatharians. Attracting a variety of fauna, these corals create important habitats for many commercial species.

These unique collections have shown the Galapágos fauna to be diverse. Though the specimens collected do not conclusively show a deep-water provincial pattern, they do begin to show evolutionary pathways. The importance of knowing the deep-water fauna comes at a time when an extension of fisheries to these areas is being considered. By understanding the deep-water ecosystem, potential impacts of this decision can be properly assessed.

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LABORATORY-REARED LARVAE OF THE HYDROTHERMAL VENT-ENDEMIC BARNACLE *NEOVERRUCA* SP.

For vent-endemic sessile organisms, planktonic larval stage is the most plausible opportunity to migrate from one vent field to another. Neoverrucid barnacles are widely distributed and abundant in the hydrothermal vent fields throughout the North Western Pacific, providing opportunities to consider of dispersal of vent-endemic animals. As the first step of detailed study on their dispersal, we reared the larvae of *Neoverruca* sp. sampled from a hydrothermal vent field on the Dai-Yon Yonaguni Knoll, the Okinawa Trough. The larvae of *Neoverruca* sp. were released from the parent at the first naupliar instar, whereas non-vent deep-sea barnacles were generally considered to grow up to the cyprid in the mantle cavity of the parent. Released naupliar larvae were reared with filtered seawater at 4? under atmospheric pressure. Neither naupliar nor cyprid eyes were observed, therefore, phototaxis was not observed. The larvae were lecithotrophy and absent of gnathobase throughout larval stages. The larvae took 55 days on average to grow up to the fifth naupliar instar. All of nauplii had survived through these naupliar instars. The subsequent sixth instar nauplii took another 50 days before metamorphosis to cyprid larvae. The intermolt period is unusually long as a single naupliar instar and the most of larvae seem to be failed to develop cyprid adductor and thoracic limb muscles during this period. Current study shows that the larvae of *Neoverruca* sp. have the longest planktonic period among barnacles under laboratory condition, therefore, they may successfully disperse one vent field to another.

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ECOSYSTEM CHANGE AT ABYSSAL DEPTHS – A LINK TO CLIMATIC MODULATION OF ORGANIC MATTER FLUXES?

Organic matter derived from primary production and other biological processes in surface waters provides a major food source for deep-sea organisms. In many areas this downward flux of organic matter is seasonal affecting the reproduction and growth of abyssal organisms. However, longer-term temporal variations have now been detected. Recently, a marked, long-term change in the abundance and composition of the invertebrate megafauna has been observed over an extensive area of the abyssal NE Atlantic. Here we demonstrate that the faunal change is driven by a change in flux from surface primary production as determined from chlorophyll and carotenoid pigment biomarker data. We show that deep-sea benthic deposit feeders partition detritus in subtle ways. Particle selection is related to pigments, and hence to the original phytoplankton source of the detritus. We have traced these pigments within the organisms to gonad tissue highlighting their impact on reproductive processes. Variability in the detritus source alters the composition of the food available to the benthic community and hence, may influence its structure through recruitment success. This suggests that climate-influenced cycles in the upper ocean have the capacity to generate ecosystem change in the deep sea through modulation of organic matter fluxes from the sea surface.

[1]Wishner[1], K.F., H. Sigurdsson[1], S. Carey[1], D.C. Smith[1], A. Staroscik[1], J.B. Shepherd[2], W.D. Wilson[3], and S. Lundin[1]
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BIOLOGY OF HYDROTHERMAL VENTS ON KICK'EM JENNY VOLCANO IN THE CARIBBEAN

The crater of Kick'em Jenny Volcano in the Caribbean contains a hydrothermal vent system. The volcano and surrounding region were investigated as part of the NOAA Ocean Exploration program in March 2003 using an ROV for *in situ* photography and sampling. Caridean shrimp (with eyes) were the most prominent vent megafauna and occurred in high numbers on the edges of fissures and nearby sediment surface. Polychaete worms were found in mud mats on the seafloor near some of the vents and also in cracks in rocks collected from vent areas. Orange and white bacterial mats covered extensive areas. These are the first shallow vents found in the Caribbean. Analyses of the collections are just beginning, but it is clear that there are major faunistic differences between this area and other Atlantic vents and seeps.

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EXPLORING DEEP-SEA FISH DIVERSITY AROUND TAIWAN

The deep-sea fish fauna around Taiwan was investigated from the samples collected by the R/V 'Ocean Researcher I' under the three years project (August 2002 - July 2004) of National Science Council. For the limitation of wire length, the depths shallower than 3570 m were surveyed during 6 cruise by otter trawl, beam trawl of 3 m span, dredge of 1 m span and IKMT. Totally twenty-one otter trawl stations, twenty-three beam trawl stations, seven dredge stations and eight IKMT stations were established during the first two years.

Two new species (Diceratiidae, and Oneirodidae), five possible new species (Gigantactinidae, two in Oneirodidae, and two in Macrouridae) and eighty-six new records of Taiwan were added to the Taiwan fish fauna from the samples of these surveys. These new records include three species in Rajidae, two in Dalatiidae, Scyliorhinidae, three in Nettastomatidae, Muraenesocidae, three in Congridae, two in Synaphobranchidae, Serrivomeridae, seven in Sternoptychidae, Neoscopelidae, Microstomatidae, four in Gonostomatidae, six in Stomiidae, Phosichthyidae, four in Alepocephalidae, two in Melamphaidae, Ceratiidae, Himantolophidae, Linophrynidae, Melanocetidae, two in Oneirodidae, Ipnopidae, Halosauridae, twenty in Macrouridae, Moridae, eight in Ophidiidae, two in Bythitidae, Trachichthyidae, Diretmidae, Sebastidae, Ereuniidae and Zoarcidae. These data also filled the gaps in worldwide knowledge of the deep-sea fish fauna between Japan and Philippines.

The quantitative data of all collections as well as the specimen photos of almost all species were digitalized and pictured in the web-accessable GIS database - Fauna and Distribution Database of Deep Sea Organism of Taiwan (http://webgis.sinica.edu.tw/seafish/viewer.htm) for public access. The database was also connected with FishDatabase of Taiwan (http://fishdb.sinica.edu.tw/) to complement fish database around Taiwan.

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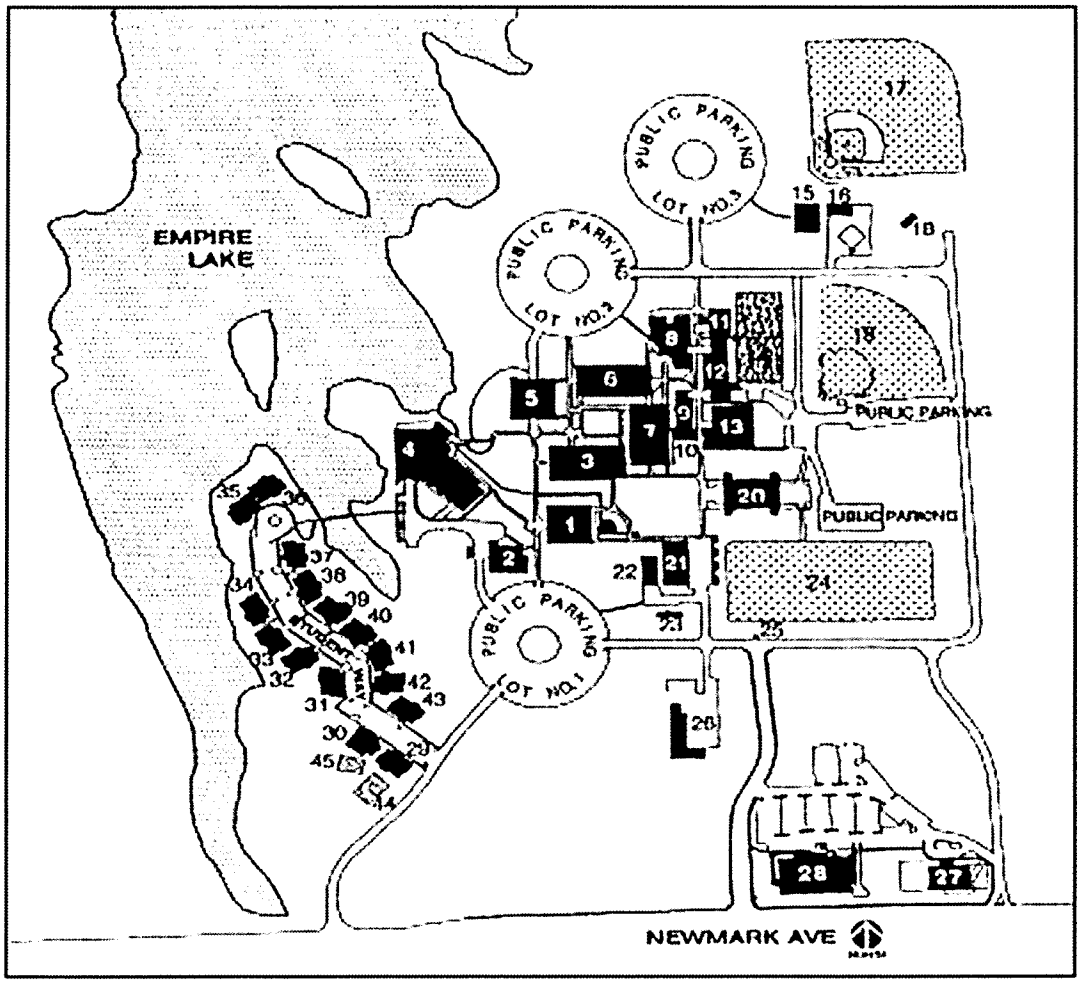
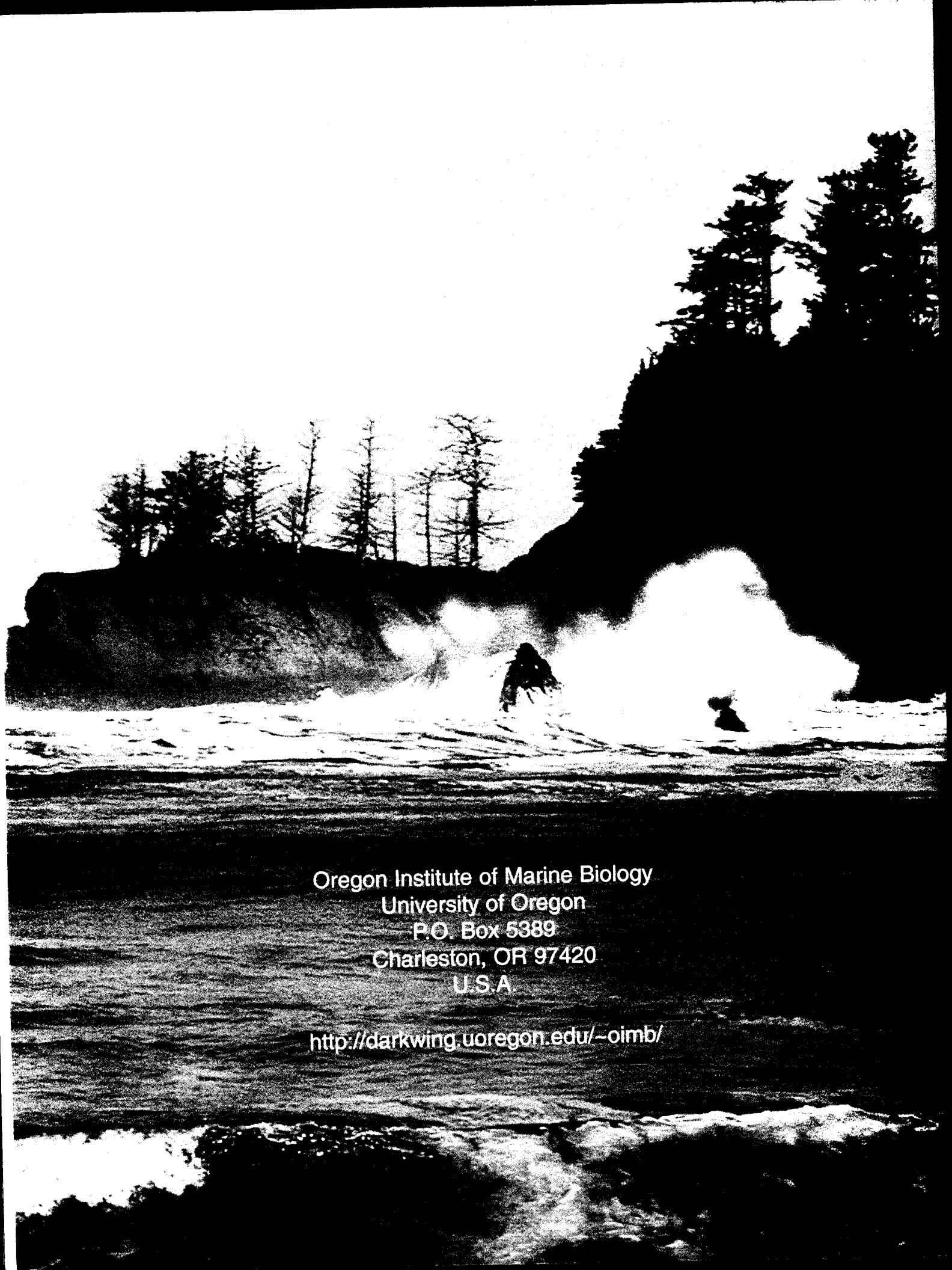
Map of SWOCC Campus



1. Dellwood Hall
2. Stensland
3. Randolph Hall
4. Empire Hall/Perf Arts Center
5. Tioga Hall
6. Sitkum Hall
7. Coaledo Hall
8. Eden Hall
9. Lampa Hall
10. B-2
11. Sunset Hall
12. Sumner Hall
13. Fairview Hall
14. Tennis Courts
15. Field House
16. Fire Science
17. Baseball Field
18. Fire Tower
19. Softball Field
20. Prosper Hall
21. Umpqua Hall
22. B-3 Storage
23. Offices
24. Soccer Field
25. Guard Shack
26. Maintenance
27. Child care
28. Newmark Center
29. North Head
30. Lighthouse Depot
31. St George Reef
32. Cape Blanco
33. Coquille River
34. Cape Arago
35. Umpqua River
36. Heceta Head
37. Yaquina Head
38. Cape Meares
39. Tillamook Rock
40. Point Adams
41. Desdemona Sands
42. Warrior Rock
43. Willamette River
44. Volleyball court
45. Basketball Court



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