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31 March – 2 April 2009

El Rompido (Huelva), Spain



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International Council for
the Exploration of the Sea

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Contents

Executive summary	1
1 Opening of the meeting.....	2
2 Discuss and evaluate new results concerning physical/biological interactions (ToR a)	2
3 Complete the publication of the Manual of Recommended Practices for Modelling Physical/Biological Interactions in Fish Early-Life History (ToR b).....	4
4 Prepare for the ASC theme session on “Death in the Sea,” the Workshop on Mortality (WKMOR) and evaluate advances on modelling fish early life stages (ToR c).....	5
5 Prepare for the ASC Theme Session on “Combining models of the full life cycle of fish with lower trophic models: integration and prediction” and continue to evaluate proposed approaches for coupling regional models of NPZD-type biogeochemistry with higher trophic levels (ToR d).....	5
6 Demonstrate potential effects of climate change on the lower trophic levels of marine ecosystems (ToR e)	5
7 Develop a statement of requirements for monitoring data to be useful for development and validation of models of physical/biological interactions and review the state of microinstrumentation available for use in monitoring (ToR f)	6
8 Meet with the Working Group on Modelling Harmful Algal Bloom Dynamics (WGHABD) and develop projects of mutual interest (ToR g)	7
9 Other business.....	8
10 Final business.....	12
Annex 1: List of participants.....	13
Annex 2: Agenda.....	14
Annex 3: WGPBI Terms of Reference for the 2009 meeting.....	15
Annex 4: Action Items 2008/2009	16
Annex 5: WGPBI terms of reference for the 2010 meeting	17
Annex 6: Action items for 2009/2010	21
Annex 7: Supporting information for Terms of Reference and action items.....	22
Annex 8: Past and future WGPBI activities.....	26

Annex 9: Recommendations	29
Annex 10: Theme session proposals for ICES ASC 2010	30
Annex 11: Abstracts for presentations at the WGPBI meeting	32
Annex 12: Agenda for the joint WGHABD/WGPBI meeting.....	36
Annex 13: Report from the joint WGHABD/WGPBI meeting.....	39
Annex 14: Proceedings of the ICES/PICES Early Career Scientists Conference (ICES JMS)	41

Executive summary

- The 'Manual of Recommended Practices for Modelling Physical-Biological Interactions in Fish Early Life History' is now in press with the ICES Cooperative Research Reports.
- A Workshop on Mortality (WKMOR) will be held in Aberdeen, Scotland on 22–24 March 2010.
- WGPBI is supporting a book project on 'Individual-based modelling of organisms within aquatic ecosystems: coupling biology with hydrodynamics' by Sarah Hinckley, Albert Hermann, and Bernard Megrey.
- WGPBI has developed a statement of requirements for monitoring data to be useful for development and validation of models of physicalbiological interactions.

1 Opening of the meeting

The 2009 meeting of the Working Group on Modelling Physical Biological Interactions was held in Punta Umbria, Spain, from 31 March to 2 April 2009. The meeting was attended by 21 scientists (Annex 1). The agenda (Annex 2) was adopted. The terms of reference for the meeting are given in Annex 3. The meeting included a joint day on 1 April 2009, with the Working Group on Harmful Algal Bloom Dynamics (WG HABD).

The working group thanks Luz Mamán (Spain) for the local arrangements.

2 Discuss and evaluate new results concerning physical/biological interactions (ToR a)

There were 8 talks in this session:

- Chad Gilbert: Sustainability of Scallops on Georges Bank (presented by Charles Hannah)
- Jonathan Beecham: Linking a Biogeochemical Model (GOTM) with an ecosystem model (EwE): Challenges, Opportunities and Approaches.
- Marc Hufnagl & Myron Peck: Biophysical individual-based modelling of North Sea herring: Exploring Bottom-up controls on larval survival and growth
- Tom Osborn: Particle Image Velocimetry in the Bottom Boundary Layer
- Rubao Ji: Life history traits and spatio-temporal distributional patterns of copepod populations in the Gulf of Maine
- Marta Moyano: Larval fish dynamics in the Canaries-African Coastal Transition Zone
- Susa Niiranen: Incorporating environmental forcing into Baltic food web study
- Elizabeth North: Larval TRANSport Lagrangian (LTRANS) model update.

Abstracts are given in Annex 11.

C. Hannah reported, on behalf of Gilbert and co-authors, on the role of larval transport for the connectivity of scallops beds on Georges Bank, and in turn how the dynamics of individual scallop beds determine the overall population dynamics on Georges Bank. The study combines 2-D particle tracking, the physical environment and bed-structured population dynamics, with the aim of assessing the sustainability of the population under management strategies.

E. North reported that she and Zachary Schlag released the Larval Transport Lagrangian model (LTRANS) as open source code in September, 2008. LTRANS is an off-line 3-D particle-tracking model that runs with the stored predictions of the Regional Ocean Modelling System (ROMS), a 3D hydrodynamic model. LTRANS was built to simulate oyster larvae but can easily be adapted to simulate passive particles and other planktonic organisms. LTRANS is written in Fortran 90 and includes a 4th order Runge-Kutta scheme for particle advection, a random displacement model for vertical turbulent particle motion. Reflective boundary conditions, larval behaviour, and settlement routines are also included. The web site contains the code, the open source license, a 146-page User's Guide, example input files, and visualization scripts (see <http://northweb.hpl.umces.edu/LTRANS.htm>). An application of LTRANS to

oyster larvae transport was published by North *et al.* (2008 MEPS 359: 99–115). North and Schlag are currently adapting LTRANS to run within the Chesapeake Bay Forecasting System and to assist with oyster restoration site selection. In addition, an upcoming field program is designed to validate the oyster larval behaviours in LTRANS using the Larval Identification and Hydrographic Data Telemetry (LIHDAT) designed by Scott Gallagher and colleagues at WHOI. This system shines polarized light on bivalve larvae shells and uses the species-specific birefringent patterns to identify bivalve larvae; see the TRANSPORT program

<http://northweb.hpl.umces.edu/TRANSPORT/home.htm>

Osborn reported on measurements with a Particle Image Velocimetry (PIV) system in the bottom boundary layer of the coastal ocean. The measurements identify a log layer in the very near-bottom region, also in presence of a wave boundary layer. The log layer showed constant dissipation rather than constant stress.

Beecham reported on progress towards end-to-end models, following an approach of linking models that each apply at different trophic levels. In particular, an Ecopath with Ecosim (EwE) foodweb model was linked with a General Ocean Turbulence Model (GOTM) of ocean biogeochemistry. A key software engineering issue which has received particular attention is to synchronize the time-stepping in each model. A future step in this direction is to exchange information on functional groups; for example zooplankton growth depends primarily on biogeochemistry so may be computed in GOTM, whereas zooplankton mortality depends on predators that are modelled in EwE.

Marc Hufnagl and Myron Peck reported on a physiologically-based growth model parameterised for the feeding and growth of larval herring in the North Sea. Novel aspects of the model included interactions between temperature and muscle developmental characteristics known to exist in that and other species. Calibration of the model was performed using a variety of published laboratory and field studies reporting rates of growth and/or feeding. Biophysical simulations will compare model estimates derived from three different North Sea hydrodynamic models (ECOSMO, NORWECOM and HAMSOM). Key issues were discussed including the generation of model-derived prey fields. Specifically, current NPZD models underestimate zooplankton biomass (and hence potential prey fields for autumn or winter-spawning larval fish) limiting the utility of a coupled model approach (NPZD-IBM) to investigate trophic coupling in December–February in the North Sea.

Niiranen reported on a Ecopath with Ecosim (EwE) model of the food web in the open Baltic Proper. The model represents cod, herring, sprat and three groups of zooplankton biomasses. The external forcing on population dynamics is fishery pressure, temperature and salinity. The objective of the model is to enable decision support at ecosystem level, targeting management challenges such as eutrophication and sustainable fisheries, in particular at centurial time scale and related to climate change. Future steps include a software coupling between the foodweb model and a biogeochemical model, allowing both bottom-up and top-down effects.

Moyano reported on the importance of mesoscale structures for larval fish between the Canaries and the African Coast. Relevant structures are wakes and eddies downstream of the Canaries, as well as upwelling filaments. The details of these structures determine if larvae, originating near the African coast, return to that region, reach the Canaries, or are lost offshore. Changes in the larval community composition near the Eastern Canaries were observed during the arrival of filaments. The study highlights

the relationship between mesoscale oceanographic processes and the larval fish community.

Ji reported on a study of the effect of life history traits on the distribution in space and time of marine copepods in the Gulf of Maine. The traits considered were the generation time and its temperature dependence, as well as the role of egg-carrying and resting eggs. The study employed a coupled biological-physical model and found that the shorter generation time of *Pseudocalanus* spp. at cold temperatures, together with their egg-carrying strategy, allows an earlier population development compared to *Centropages* spp. Another result from the study is the importance of resting eggs for the *C. hamatus* population in the area. Observed distributions are a result of patterns in the egg production, growth rates, and mortality rates, but also of transport with ocean currents.

3 Complete the publication of the Manual of Recommended Practices for Modelling Physical/Biological Interactions in Fish Early-Life History (ToR b)

The ICES Cooperative Research Report entitled “Manual of recommended practices for modelling physical/biological interactions during fish early life” will be published in April 2009 as CRR number 295. Editors are Elizabeth North (USA), Alejandro Gallego (UK), and Pierre Petitgas (France). The 27 authors are: Bjørn Ådlandsvik, Joachim Bartsch, David Brickman, Howard I. Browman, Karen Edwards, Øyvind Fiksen, Alejandro Gallego, Albert J. Hermann, Sarah Hinckley, Ed Houde, Martin Huret, Jean-Olivier Irisson, Geneviève Lacroix, Jeffrey M. Leis, Paul McCloaghrie, Bernard A. Megrey, Thomas Miller, Johan van der Molen, Christian Mullon, Elizabeth North, Carolina Parada, Claire B. Paris, Pierre Pepin, Pierre Petitgas, Kenneth Rose, Uffe H. Thygesen, and Cisco Werner. The editors thank the ICES editors, especially Bill Anthony, for their hard work and help on this project. A pdf version of the manual will be published on the ICES web site:

<http://www.ices.dk/products/cooperative.asp> and will be accessible from the WKAMF web site:

<http://northweb.hpl.umces.edu/wkamf/home.htm>

The Manual focuses on 3D biophysical Lagrangian models which are coupled to 3D hydrodynamic models and assign biological attributes to particles (e.g., behaviour, pelagic stage duration, growth, mortality). These individual-based models have been used to understand how physical and biological processes interact to influence the dispersal, survival, and population connectivity of organisms with planktonic life stages. The MRP objectives are to summarize appropriate methods for modelling physical/biological interactions during the early-life of fish, recommend modelling techniques in the context of specific applications, and identify knowledge gaps. The manual provides a reference for early career modellers who are interested in applying coupled biological and three-dimensional circulation models to determine the survival and transit of fish eggs, larvae, and juveniles from spawning to nursery areas and to provide updates for current practitioners on latest techniques and areas in need of further research. Major knowledge gaps that were identified were related to: validation and sensitivity methods, model complexity, physics, energetics, mortality, and behaviour and cues. Mortality will be the focus of the WGPBI Workshop on “Understanding and quantifying mortality in fish early life stages: experiments, observations and models” which will be held in Aberdeen UK, on 22–24 March 2010.

4 Prepare for the ASC theme session on “Death in the Sea,” the Workshop on Mortality (WKMOR) and evaluate advances on modeling fish early life stages (ToR c)

The Theme Session “Death in the sea: Mortality in the zooplankton and early life stages of marine fish (estimates, processes and outcomes)”, convened by Alejandro Gallego (UK), Edward D. Houde (USA), and Elizabeth W. North (USA), was finally accepted for the ICES ASC 2009. The theme session is an integral part of the preparations for the Workshop on Mortality (WKMOR).

The Workshop on Mortality (WKMOR) will be held in Aberdeen, Scotland, on 22–24 March 2010. The workshop will bring together state-of-the-art knowledge about mortality, a process which is critical for the understanding of recruitment in marine fish. The workshop goal is to develop recommended practices for quantifying mortality in the field (e.g. accounting for advection/diffusion effects) and for constructing process-based forecasting tools that quantitatively link spawning stock biomass/egg production and post-juvenile stages. This workshop will foster information exchange between international organizations such as ICES and PICES.

The preparations for the workshop are well underway. A shortlist of potential venues within the city have been identified and visited by the local organiser and a decision on the final venue for the workshop will be taken in the immediate future. The relevant administrative structures have been put in place locally to host the event.

5 Prepare for the ASC Theme Session on “Combining models of the full life cycle of fish with lower trophic models: integration and prediction” and continue to evaluate proposed approaches for coupling regional models of NPZD-type biogeochemistry with higher trophic levels (ToR d)

The theme session was included on the list of proposed sessions for ASC 2010 based upon last year’s PBI report. It will be convened by Pierre Petitgas (France), Myron A. Peck (Germany), Bernard Megrey (USA), Kenneth Rose (USA).

The synopsis of the session is found in Annex 10. The text is an updated version and will be presented to the ICES Science Committee at the meeting in May by Petitgas.

6 Demonstrate potential effects of climate change on the lower trophic levels of marine ecosystems (ToR e)

This Term of Reference concerns the downscaling of climate change scenarios using regional ecosystem models, and follows work being conducted in the EU projects RECLAIM and ENSEMBLE as well as other projects. The aim of the work is provide quantitative estimates of future shelf seas primary production and associated variables, by running relevant models with forcing from climate scenarios. This allows prediction of e.g. the individual and combined effects of changes in Atlantic inflows, sea ice, temperature, and stratification on primary production. Implications for zooplankton production are also estimated. One application is to determine the effect of climate scenarios on the timing of the phytoplankton/zooplankton production cycles. At the time of the 2009 WGPBI meeting, this work was still ongoing. Highlights from relevant project reports will be discussed at the 2010 WGPBI meeting.

7 Develop a statement of requirements for monitoring data to be useful for development and validation of models of physical/biological interactions and review the state of microinstrumentation available for use in monitoring (ToR f)

The following is the WGPBI statement of requirements for monitoring data to be useful for development and validation of models of physical/biological interactions. This includes information about the very new technology of digital holography which will be an important tool over the next decade.

Modelling physical/biological interactions requires the best possible simulations of the physical environment. Therefore monitoring must make the observations required for the physical models. In addition the flux of nutrients and materials between the different oceanographic domains must be measured as inputs to the models (e.g. between the deep ocean and the shelf; between the land and the ocean; and between the surface ocean and the benthos). In particular the time varying flux of nutrients from the rivers must be monitored and better estimates of the time varying flux of nutrients and organisms (e.g. *Calanus* species) from the deep ocean to the shelf are required for most shelf regions.

Routine, large-scale surveys (monitoring) of phytoplankton and zooplankton are useful for assessing the skill of regional models at reproducing seasonal cycles, interannual variability and large-scale gradients. The combination of biological and physical data can be analyzed using spatial analysis techniques such as 'self organizing maps' (Allen *et al.* 2007) to establish whether the model is reproducing the observed relationships between the variables.

Large-scale surveys are useful for demonstrating that a set of model solutions are plausible. However they do not discriminate between plausible models nor do they provide the information to develop the next generation of models. Zooplankton, which provides the link between the primary production (phytoplankton) and higher trophic levels (e.g. fish), will be an important modelling activity over the next decade and validation data will be required. Many important zooplankton species produce more than one generation in their annual cycle. Validating the number of generations produced is a useful test of a coupled ecosystem model. This would require (typically) weekly sampling at several locations in order to capture whether the model is correctly simulating the number of generations produced. In addition many important zooplankton species go through a series of stages as part of their life cycle and the different stages are the food source for different organisms. The abundances of the different stages at (typically) weekly resolution would also be extremely useful.

For zooplankton, visual systems such as video and holographic systems offer the opportunity to observe zooplankton in their natural environment. New digital holographic techniques allow high resolution imaging of a three dimensional volume of water without the need for film and can be used to create holographic movies. The development of video and holographic systems continues as does the software for automated species identification and analysis. Using these systems one can identify zooplankton species, measure distances between organisms, estimate the parameters describing zooplankton movement and observe the details of predator prey interactions. These instruments will provide the basis for understanding the interactions between individual organisms in the ocean which will be the basis for the next generation of zooplankton and larval fish models.

These systems have the potential when incorporated into environmental moorings to assess and ground truth the seasonal development of populations and the resultant species interactions for the identification of key processes in situ for the further development of ecosystem and IBM modelling activities. A coordinated effort to support the routine use of these instruments and the systematic archiving of the enormous amount of output could provide the databases required for the development of individual based models.

Lagrangian measurements (e.g. drifters) are required for validating individual-based models (e.g. or larval fish). However research is required in order to identify what types of routine monitoring might be useful for this application.

The data archive should include:

- modern meta-data standards,
- published data formats,
- documented quality control procedures,
- a data dictionary defining the data items and the units of measure;
- a searchable data base of meta-data to aid the process of data discovery.

In addition,

- each data value should be geo-referenced and time stamped in order to make it easier to implement
- searches for all data in a specified space-time region should be possible.

This would make it possible to bring different data sets together. The following would be very useful:

- the data should be freely available via the web;
- a process for automated downloading of data rather than requiring point and click access.
- monitoring programs should publish annual reports describing the time series collected and putting the current year's results in context with previous years.
- A web portal or mechanism to help the researchers identify additional data sources such as local atmospheric monitoring stations and stream gauges.

References:

Allen, J.I., P.J. Somerfield and F.J. Gilbert. 2007. Quantifying uncertainty in high-resolution coupled hydrodynamic-ecosystem models. *Journal of Marine Systems* 64: 3–14.

8 Meet with the Working Group on Modelling Harmful Algal Bloom Dynamics (WGHABD) and develop projects of mutual interest (ToR g)

WGPBI and WGHABD met on 1 April 2009. The agenda for the joint day, as well as abstracts for the presentations in the WGPBI session, is included in Annex 12. A detailed report from the joint day is included in Annex 13.

The joint day was deemed a success, in particular due to inspired discussion in break-out groups following presentations. It was mutually agreed to propose a joint theme session for ICES ASC 2010, convened by WGPBI member Geneviève Lacroix (Belgium) and WGHABD member Donald Anderson (USA); c.f. the recommendations in Annex 9 and a synopsis of the proposed session in Annex 10. It was also mutually agreed to propose a joint meeting between the two groups in 2011, which should

stretch over more than one day and include more time for discussions. WGPBI has generated a Term of Reference for the 2010 meeting to follow up on this. Discussions are also underway on the feasibility of adding WGOOFE to the 2011 meeting.

9 Other business

Book Project

Sarah Hinckley presented the proposal by Hinckley, Megrey and Hermann to write a book entitled 'Methods for spatially explicit individual based modelling of marine organisms: coupling of biology with hydrodynamics.' She reviewed the proposed content and chapters, and asked for names of potential authors. The group was very enthusiastic about the project and encouraged her to continue. The book has been adopted as a WGPBI project. North, Gallego, Petitgas and Hannah have offered to serve on the advisory book. A description of the book project is in Annex 7.

The state of WGPBI

Charles Hannah reviewed the history of WGPBI and presented his thoughts of the future. The record of attendance at WGPBI meetings is shown below and the major achievements of WGPBI are listed in Annex 8. An important activity of WGPBI is the one or two theme sessions that are co-sponsored at the ASC every year. These sessions are generally well attended and have a large number of young scientists (students and postdocs) as speakers.

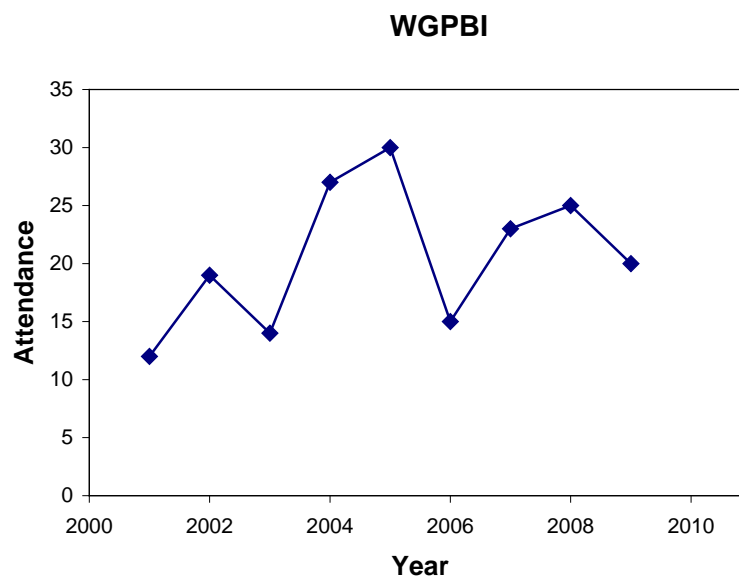


Figure 1. Attendance at WGPBI meetings.

The last re-examination of WGPBI was at the Barcelona meeting in 2004. The outcome of that meeting has guided the WG activities for the last 5 years. At the Barcelona meeting two subgroups were formed: Larval Fish subgroup, Numerical Experimentation subgroup.

The Larval Fish subgroup has been very successful and has generated the following output:

- WKAMF (2006)
- Manual of Best Practice (2009, in press)

- WKMOR (2010)
- Hinckley, Megrey, and Hermann. Methods for spatially-explicit individual-based modelling of marine organisms: coupling of biology with hydrodynamics. Book project discussed at the 2009 meeting.

The Numerical Experimentation subgroup limped along for about 2 years and then faded away. Its primary accomplishment was to encourage the introduction of biological modules into GOTM (General Ocean Turbulence Model): an open source 1-d ocean model that contains all the common vertical mixing schemes.

Other activities have a long standing within the group and continue at a low level, these include:

- Pierre Petitgas has tried to create interest in using 3d models and PBI tools to characterize environmental variability and its links to fish recruitment.
- Mike St. John has tried to keep an interest in phytoplankton modelling but we were never successful in attracting phytoplankton people who might generate new ideas for improving the models.
- We have had some activity with size and state based models.

A potentially important event for WGPBI has been the gradual loss of the 3d ocean modellers. Possible factors are:

- The European program MERSEA and its successor MyOcean which are focussed on delivery of operational products from ocean models. The MyOcean kick-off meeting was at the same time as the 2009 WGPBI meeting.
- Our decision to encourage the creation of an ICES WG on Operational Ocean Products rather than include that in WGPBI activities.

Both of these groups create more meetings and make it difficult for people to attend WGPBI.

Dr. Hannah reminded the group that:

1) WGPBI exists only as long as the members are willing to work together to make it exist and

2) the flavour of the group will be determined by those who show up and contribute. The larval fish group has taken this to heart and done an excellent job to ensure that WGPBI will continue to exist. He suggested that as WGPBI moves forward it needs:

- a second active theme or subgroup to provide some balance to the group;
- to attract a new group of 3d modellers because 3d circulation models are central to everything WGPBI does.

Given the new ToRs several activities have the potential to provide a second large theme: HABs, end to end modelling, and using 3d models and PBI tools to characterize environmental variability and its links to fish recruitment.

ICES/PICES Early Career Scientists Conference

Elizabeth North reported that the collection of 10 papers from the ICES/PICES Early Career Scientists Conference have been published in the ICES Journal of Marine Science. Titles and further details are in Annex 14.

The Virtual Ecology Workbench (VEW)

Dr. John Woods is writing a monograph on Virtual Plankton Ecology (VPE) with Dr Silvana Vallerga of CNR (Italian National Research Council). This will involve a set of new numerical experiments to illustrate what VPE can contribute to biological oceanography. Physical/biological interactions lie at the heart of VPE and are handled rather well by the individual-based modelling of the Lagrangian Ensemble meta-model used in VPE.

Dr. Woods has chosen the unusual procedure of beta testing each chapter of the monograph as it is completed. This will be done by putting on the web one chapter per month with an invitation to readers to send him comments by e-mail. The first chapter should be on the web in early April - hopefully in time for the WGPBI meeting. The website is <http://www.virtualecology.org>

Members of WGPBI are invited to read and comment on the chapters. Those who comment will of course be acknowledged in the book when it is published in hard copy.

The Virtual Ecology Workbench VEW3.3 is operational at a growing number of institutes and universities around the world. It has been adopted by the UK National Oceanography Centre for a joint project with the Southampton University Institute of Complex Systems. It has also completed two seasons at Bermuda (BIOS) under Mike Lomas, who has been leading a team to use the VEW to simulate BATS.

Our software engineers are now completing a major streamlining of the VEW software. That will result in VEW4 to be released early next year. Trials with the prototype suggest VEW4 will run 10 times faster than VEW3, and use much less memory. That will open the door to running on a PC projects that hitherto have needed a massively parallel machine.

Temperature and phytoplankton growth

The relationship between temperature and phytoplankton growth is an outstanding issue in the modelling of phytoplankton bloom dynamics and the incorporation of carbon and hence for WGPBI. Early work by Eppley (1972) provided a major synthesis of the area when he compiled laboratory data on growth rates as a function of temperature. A new review of maximum specific growth rates (μ_{\max}) by Bissinger *et al.* (2008) has provided an update to the Eppley (1972) relationship. The new work considers 1500 experiments compared to 162 used by Eppley (1972). The new and old relationships are:

$$\text{New:} \quad \mu_{\max} = 0.81 e^{0.0631T} \text{ d}^{-1}$$

$$\text{Eppley (1972)} \quad \mu_{\max} = 0.59 e^{0.0633T} \text{ d}^{-1}$$

The rate of increase of μ_{\max} with temperature is the same ($Q_{10} = 1.88$) but the revised μ_{\max} is about 30% larger at any specific temperature. Bissinger *et al.* (2008) also note that the data do not support an exponential increase in μ_{\max} for temperatures greater than 29°C.

The use of the new relationship instead of the Eppley curve in an NPZ model to prescribe temperature-dependent growth rates for the phytoplankton resulted in a 30% increase in primary production.

Ongoing work by the authors will address the shape of the maximum envelope especially at high temperatures and will explore the links with the metabolic theory of ecology (Brown *et al.* 2004; Allen *et al.* 2005). The authors note that a Q_{10} value of 1.88 is somewhat higher than predicted by the metabolic theory of ecology, which gives a Q_{10} value of between 1.62 (for 0–10°C) and 1.52 (for 20–30°C), derived from a predicted activation energy of 0.32 eV for rates controlled by photosynthesis.

The Eppley (1972) growth rates and the revisions by Bissinger *et al.* (2008) are expressed in terms of ‘cell doublings’ whereas the majority of models that employ the Eppley curve use it in relation to the amount of carbon (or nitrogen) fixed. This involves an implicit assumption that cell size and carbon (or nitrogen) content is independent of temperature. In contradiction there is the general rule that cell size decreases as temperature increases (e.g. Montagnes and Franklin 2001) and there is the experimental result of Goldman and Ryther (1976) that the generation of particulate organic carbon was maximized for temperatures less than the temperature that maximized cell doubling. At the WGPBI meeting in 2008, St. John reported on a study that reviewed the literature for laboratory experiments examining the relationship between doubling rate, cell volume, cell carbon content and temperature. Preliminary analysis found a suggestion that the rate of carbon fixation is roughly independent of temperature. The analysis and the manuscript are still in progress.

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WG Microbial Ecology

Charles Hannah told the group that Bill Li (Canada) is trying to create a new WG to replace WGPE. It is called WG on Microbial Ecology. He asked for names of people who might be interested in participating. He will distribute the email from Bill Li to the group.

Report on WKAMF web site

Co-Chairs of WGPBI's 2006 “Workshop on Modelling Physical/Biological Interactions During the Early Life of Fish” (WKAMF) declared victory. With the publication of the Manual of Recommended Practices as an ICES CRR in April 2009, all planned activities are complete. All products of the workshop are served to the research and management community on the WKAMF web page:

(<http://northweb.hpl.umces.edu/wkamf/home.htm>). This page includes links to the original workshop web page, the workshop program, the workshop report, the report of the follow-up WKAMF Collaborators meeting, and links to the MEPS Theme Section and Manual of Recommended Practices.

10 Final business

Election of new Co-Chairs

Elizabeth North (USA) and Uffe Thygesen (Denmark) were nominated to serve as Co-Chairs starting in 2010.

The next meeting

The next meeting will be held in Aberdeen on 25/26 March, 2010, immediately after WKMOR. Alejandro Gallego will be the host.

Closing

The Co-Chairs thanked everyone for the talks and discussion.

The WG extends warm thanks to Luz Mamán who handled the local arrangements, to Beatriz Reguera for coordination and communication during arrangements, to WGHABD for inviting us to Punta Umbria, and to the Fisheries Directorate under the Ministry of Agriculture and Fisheries in the Andalusian Autonomous Government for sponsoring lunch and the lovely dinner.

Annex 1: List of participants

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Annex 2: Agenda

Tuesday March 31:

09.00-09.15 Welcome, etc.

09.15-12.30 Presentation of new results, with discussion.

13.00-14.30 Lunch

14.30-15.30 Presentations and discussion re. Terms of Reference

15.30-16.00 Next steps for WGPBI

16.00-17.00 Preparation of joint day

Wednesday April 1: Joint day with WGHABD

09.00-13.00 WGHABD session: Presentations and discussion

13.00-14.00 Lunch

14.00-18.00 WGPBI session, with discussion

18.00-18.30 Plenary discussion & Conclusion

Evening:

20.15: Departure for dinner by bus

22.45: Return from dinner by bus

Thursday April 2:

09.00-09.15 Evaluation of Joint Day between WGPBI and WGHABD

09.15-13.00 Presentations and discussion re. Terms of Reference

13.00-14.00 Lunch

14.00-15.00 Management of the WG

15.00: Close the meeting

Annex 3: WGPBI Terms of Reference for the 2009 meeting

The **Working Group on Modelling Physical Biological Interactions** [WGPBI] (Co-Chairs: Charles Hannah, Canada, and Uffe Thygesen, Denmark) will meet in El Rompido (Huelva) Spain from 31 March to 2 April 2009 to:

- a) Discuss and evaluate new results concerning physical-biological interactions;
- b) Complete the publication of the Manual of Recommended Practices for Modelling Physical-Biological Interactions in Fish Early-Life History;
- c) Prepare for the ASC theme session on “Death in the Sea,” the Workshop on Mortality (WKMOR) and evaluate advances on modelling fish early life stages;
- d) Prepare for the ASC Theme Session on “Combining models of the full life cycle of fish with lower trophic models: integration and prediction” and continue to evaluate proposed approaches for coupling regional models of NPZD-type biogeochemistry with higher trophic levels;
- e) Demonstrate potential effects of climate change on the lower trophic levels of marine ecosystems;
- f) Develop a statement of requirements for monitoring data to be useful for development and validation of models of physical-biological interactions and review the state of micro-instrumentation available for use in monitoring;
- g) Meet with the Working Group on Modelling Harmful Algal Bloom Dynamics (WGHABD) and develop projects of mutual interest.

WGPBI will report by 30 April 2009 to the attention of the SCICOM.

Annex 4: Action Items 2008/2009

- Item 1: Joint meeting with WGHABD. Plan joint day. Hannah, Lacroix, and others, plus WGHABD. Dates set. Completed.
- Item 2: Complete the review of maximum phytoplankton growth rates and primary production as function of temperature and write a short paper during 2007, perhaps for publication in the 'Horizons' section of the Journal of Plankton Research. St. John and Hannah. Paper not yet written. Item is completed with material presented in this report.
- Item 3: At 2009 meeting consider the following two ToRs for 2010: 1) Continue to investigate (pre)operational applications of PBI models with special focus on the availability of its products; 2) Review, by using recent inventories, the access to operationally produced data that may be used for the development and validation of PBI models. Hans Dahlin and EurOceans have this well covered for the physical models and they are keeping track of PBI models. Decision made not to do these things. Replaced with other list making activities.
- Item 4: The work of WKIMS should be carried on. Consider Petitgas proposal for a workshop in 2010 on fish habitat. Petitgas.
- Item 5: WKAMF: Complete publication of Manual of Best Practices. North Gallego Petitgas. The manual is 'In Press'.
- Item 6: Demonstrate potential effects of climate change on the lower trophic levels of marine ecosystems. The core is an IMR project (Skogen, Svendsen) to down scale climate change scenarios using their ecosystem model. The authors did not attend the meeting and the item has been removed from the activities.
- Item 7: Develop a statement of requirements for monitoring data to be useful for development and validation of models of physical/biological interactions. (which quantities, archived, accessible). What do we need in design of system? Proposed by Dahlin. Completed by Hanna for the 2009 report.
- Item 8: Document how PBI tools can be useful in estimating fish habitats potentials and survival windows and their variation in the context of climate change. On that basis propose operational products of potential interest for fisheries ecology users. Petitgas to coordinate. This activity has been replaced by several specific items in the new ToRs.
- Item 9: Review proposed approaches for coupling higher trophic levels with NPZD models (St. John E2E, plus, Moll). Replaced by list of end-to-end programs and progress updates and such from the EU program MEECE.
- Item 10: Start search for new co-chair to replace Hannah after 2009 meeting. North is the new co-chair.
- Item 11: Encourage Hinkley, Megrey, and Hermann on their book with the working title "Methods for spatially-explicit individual-based modelling of marine organisms: coupling of biology with hydrodynamics." The book is moving forward.
- Item 12: Prepare for WKMOR in 2010. Gallego, North, Petitpas. The preparations are on schedule.

Annex 5: WGPBI terms of reference for the 2010 meeting

The **Working Group on Modelling Physical Biological Interactions** [WGPBI] (Chairs: U.H. Thygesen, Denmark, and E. North, USA) will meet in Aberdeen, Scotland, UK on 25–26 March 2010 to:

- a) Discuss and evaluate new results concerning physical/biological interactions;
- b) Review and assess the results of WKMOR and plan publications and other follow on activities;
- c) Publish a review of the physiological attributes of early life stages of marine fish species relevant for projecting climate-impacts using coupled hydrodynamic bio-physical models;
- d) Report on recent advances in models and observations of physical and biological processes at scales below the Rossby radius;
- e) Report on developments in linking physical models, biogeochemistry models, and higher trophic level models, and disseminate information on common meta-data standards needed for linking these models;
- f) Assess progress on the book “Individual-based modelling of organisms within aquatic ecosystems: coupling biology with hydrodynamics”;
- g) Prepare for ASC Theme sessions on ‘Combining models of the full life cycle of fish with lower trophic models: integration and prediction’ and ‘Physics and biology in modelling HABs: validation and application to forecasting and climate change’;
- h) Prepare for Workshop on Mapping Potential Fish Habitat using Physical/ Biological Models convened by Petitgas and Peck.
- i) Prepare for joint meeting with WGHABD in 2011.

WGPBI will report by 30 April 2010, to the attention of SCICOM.

Supporting Information

Priority:	<p>The WG should be given high priority, since it is concerned with the evaluation and development of the modelling tools used to increase the understanding of the interaction between the living resources in the sea and its ambient physical and abiotic environment. This understanding is essential to the successful development of predictive capability of the state and evolution of the ecosystem for issues such as harmful algal blooms, eutrophication, marine protected areas, fish recruitment, and global change. This contributes directly to fulfilling the vision of ICES, “to improve the scientific capacity to give advice on the human impact on, and impacted by, marine ecosystems.”</p> <p>The work of WGPBI contributes to ICES Strategic Goal #3: “ICES should lead the development of methods and tools needed in support of operational ecosystem observation services in order to improve the understanding of climate change and impacts to our ocean and marine ecosystems.”</p>
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Scientific justification	<p>a) Providing a forum for the presentation and discussion of new results is an important component of the Group's mandate.</p> <p>b) The larval fish subgroup identified mortality as the top priority topic; it is critical for the understanding of recruitment in marine fish. To address this issue the Workshop on Mortality (WKMOR) will be held in Aberdeen, Scotland, on 22–24 March 2010. The workshop goal is to develop recommended practices for quantifying mortality in the field (e.g. accounting for advection/diffusion effects) and for constructing process-based forecasting tools that quantitatively link spawning stock biomass/egg production and post-juvenile stages. This workshop will foster information exchange between international organizations such as ICES and PICES. Papers from the Workshop will be published in a theme section of a journal. Research Themes: Operational Ecosystem Modelling and Life History.</p> <p>c) Ocean temperatures are expected to increase with global warming and the physiology of marine fish is sensitive to temperature changes. A comprehensive review of the physiological parameters required to create mechanistic foraging and growth subroutines for marine fish early life stages is needed to: 1) identify gaps in knowledge and highlight research needs to funding agencies; 2) calculate confidence limits to model-derived estimates of changes in vital rates (e.g., growth, survival); and 3) search for (and possible reveal) common physiological traits allowing generic models to be created and projections made concerning climate impacts on the potential habitats of a broader range of fish species. Research Themes: Climate Change Predictions and Coastal Habitat.</p> <p>d) Understanding and describing the interactions between physics and HABs requires understanding physical processes on scales smaller than oceanographers commonly work. A review of recent advances in models and observations of physical and biological processes at scales below the Rossby radius (layers (1 m) in the vertical and 1–10 km in the horizontal) would be very useful as part of the next joint meeting with WGHABD.</p> <p>e) The next frontier in modelling physical biological interactions involves linking together physical models, biogeochemistry models, and higher trophic level models. This substantial technical challenge is central to the EU project MEECE (Marine Ecosystem Evolution in a Changing Environment). The development and wide spread acceptance of common metadata standards will be crucial for making this work. Research theme: Operational Ecosystem Modelling.</p>
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- f) WGPBI supports Sarah Hinckley (WGPBI member) and co-authors Bern Megrey and Al Hermann in their proposal to write a book tentatively titled “Methods for spatially-explicit individual-based modeling of marine organisms: coupling of biology with hydrodynamics.” A high level of sophistication has been achieved with these types of models, however, there is little information available on how to determine if they are appropriate for a given problem, how to use them to address theoretical or applied problems, how to construct them, and how to test, validate and analyze them. They propose to remedy this deficiency. The book was inspired by the WKAMF Manual of Recommended Practices. Research themes: Life History and Operational Ecosystem Modelling.
- g) Successful theme sessions at the ASC is considered an important output of the group. In 2010, the proposed theme session on ‘Combining models of the full life cycle of fish with lower trophic models: integration and prediction’ targets the important issue of coupling fish with their environment. The proposed session on “Physics and biology in modeling harmful algal blooms (HABs): validation and application for forecasting and climate change” targets HABs, a great concern because of their toxicity and/or the damage they cause to ecosystems and coastal resources. Key challenges are: (i) understanding the physiological/biological/environmental factors that regulate HABs, (ii) forecasting HAB events and (iii) assessing the impact of climate change on HABs (occurrence/frequency/magnitude). This theme session will bring together modellers and experimentalists to review modeling studies, laboratory and experimental research, field studies and remote sensing investigations that advance our ability to understand the underlying physical/biological interactions that control HABs, to improve HAB model validation, to forecast HAB events, and to assess effect of climate change. Research Themes: Operational Ecosystem Modelling and Climate Change Predictions.
- h) The Workshop on Mapping Potential Fish Habitat using Physical/Biological Models will build on the successful Workshop on Indices of Mesoscale Structures (WKIMS). It will incorporate the ongoing activities of WGOOFE (Working Group on Operational Oceanographic Products for Fisheries and Environment, Mark Dickey-Collas and Morten Skogen) and be a joint workshop. One theme will be the use of outputs from hydrodynamic / NPZD hindcasts to force fish models (directly) or to build environmental indices that can be used as co-variables for analyzing fish-environment relationships (distribution of stocks, vital rates of individuals, etc.). The workshop will utilize the knowledge gained in the review proposed in ToR c). Research Themes: Life History and Coastal Habitat.
- i) Provisional ideas for a two day joint meeting include presentations in the morning and discussions in the afternoon with the first day focusing on small scale physical processes (think layers (1 m) in the vertical and 1–10 km in the horizontal) and the second day focusing on modeling, HABs and climate change. WGOOFE may also be interested in participating. Research Themes: Operational Ecosystem Modelling, Life History, Climate Change Predictions and Coastal Habitat.

Resource requirements:	None
Participants:	The WG is normally attended by some 20–30 members and guests. The Working Group benefits from the participation of those outside of the modelling community. Observational and experimental scientists with an interest in physical/biological interactions are encouraged to attend.
Secretariat facilities:	None.
Financial:	No financial implications.

Linkages to advisory committees:	ACFM, ACE
Linkages to other committees or groups:	ICES-IOC Working Group on Harmful Algal Bloom Dynamics, WGRP, BSRP, WGLESP, WGZE, LRC
Linkages to other organizations:	The work of this group is closely aligned with similar work in GEOHAB (IOC/SCOR), GLOBEC (IOC/SCOR), IMBER and PICES.

Annex 6: Action items for 2009/2010

- 1) Produce a report reviewing prey fields likely experienced by zooplanktivorous life stages of marine fish species with recommendations on how best to derive model-based prey fields (including small- and mesoscale spatial attributes). Peck, Ji and others
- 2) Compile list of programs engaged in end-to-end (E2E) type modelling, starting with Petitgas's list. Beecham, Peck and others.
- 3) Report on Galway GEOHAB meeting (June 2009). Ruiz.
- 4) Organize a joint meeting with WGHABD in 2011. There will be a two day overlap. Possible themes: Day 1 small-scale interactions; Day 2: climate change. Osborn, North, Thygesen.
- 5) Organize a workshop on Mapping Potential Fish Habitat using Physical/Biological Models. This should be joint with WGOOFE. Petitgas, Peck, and possibly Ji.
- 6) Review and assess the results of WKMOR and plan publications and other follow on activities. Gallego, North
- 7) Publish a review of the physiological attributes of early life stages of marine fish species relevant for projecting climate-impacts using coupled hydrodynamic biophysical models. Peck
- 8) Report on recent advances in models and observations of physical and biological processes at scales below the Rossby radius. Organize an event in 2011, probably as part of joint meeting with WGHABD. Osborn and North
- 9) Report on developments in linking physical models, biogeochemistry models, and higher trophic level models, and disseminate information on common metadata standards needed for linking these models. Beecham
- 10) Prepare for ASC Theme session on 'Combining models of the full life cycle of fish with lower trophic models: integration and prediction.' Petitgas, Peck
- 11) Assess progress on the book "Individual-based modelling of organisms within aquatic ecosystems: coupling biology with hydrodynamics" and find co-authors for the chapters. Hinckley.
- 12) Prepare for ASC theme session on 'Physics and biology in modelling HABs: validation and application to forecasting and climate change. Lacroix
- 13) Coordinate MEECE meeting in spring 2011 with WGPBI meeting probably joint with WGHAB. Make the meetings back to back. Beecham
- 14) Prepare for the ASC Theme session on 'Operational Oceanography for Fisheries and Environmental Applications' with convenors: H. Sagen, C. Hannah.

Annex 7: Supporting information for Terms of Reference and action items

ToR c), Action item 1): Publish a review of the physiological attributes of early life stages of marine fish species relevant for projecting climate-impacts using coupled hydrodynamic biophysical models.

Peck *et al.*

Individual-based models (IBMs) offer a tool to estimate the effects of variability in environmental factors on fish vital rates. IBMs differ in the complexity of their biological components depending upon the research objectives. For example, larval growth rate has been calculated using simple, empirical functions that include one or more important independent variables such as larval age, food concentration and/or temperature. Although this “holistic” approach provides spatiotemporal estimates of variability in growth rates that are particularly useful for some purposes (i.e., in drift modelling studies), climate-driven mechanisms influencing growth variability are ignored. More advanced IBMs include subroutines depicting the underlying processes of energy gain via foraging and energy loss via metabolism. This added biological complexity provides the possibility to investigate the impact of changes in specific biotic and abiotic factors such as temperature, advection, turbulence, light level and the size and availability of prey on larval fish vital rates. Model growth estimates are often particularly sensitive to the parameter estimates employed within these physiological subroutines.

These physiologically-based IBMs have been coupled to hydrodynamic, particle tracking and NPZD models in hindcasts to project climate-driven changes in suitable habitats for marine fish early life stages. At the forefront of current efforts, this suite of models can be used to project future climate impacts based on ensemble averaging of physical forcing resulting from regionally-downscaled global climate models (GCMs). A comprehensive review of the physiological parameters required to create mechanistic foraging and growth subroutines for marine fish early life stages is currently needed to:

- a) identify gaps in knowledge and highlight research needs to funding agencies
- b) calculate confidence limits to model-derived estimates of changes in vital rates (e.g., growth, survival) and
- c) search for (and possibly reveal) common physiological traits allowing the generic models to be created and projection made concerning climate impacts on the potential habitats of a broader range of fish species.

The review should include estimates of the impacts of both intrinsic and extrinsic (environmental) variables on a suite of parameters associated with egg and yolk sac larval development and/or growth and the feeding (e.g., gut evacuation rates, gut size, mouth gap, maximum prey size, swimming speed, reaction distance to prey, capture success of prey, prey handling time, assimilation efficiency) and metabolic losses (rates of respiration at different levels of activity, specific dynamic action, activity multipliers) of exogenously feeding larvae. It should also identify ways to reduce model complexity without loss of biological realism.

ToR f), action item 11). A book proposal “Individual-based modelling of organisms within aquatic ecosystems: coupling biology with hydrodynamics”

Hinckley, S., A.J. Hermann, B.A. Megrey

WGPBI Advisory Board: Elizabeth North, Charles Hannah, Alejandro Gallego, Pierre Petitgas

Synopsis

Since the early 1990's, a new method of modelling planktonic marine organisms such as fish and zooplankton, has been developed. These models, that combine individual-based models (IBMs) of organism biology and 3D hydrodynamics models, are a noteworthy departure from earlier models. These coupled biophysical IBMs portray the movement of individuals or cohorts through the water, and focus our attention on how physics (currents or temperature, for example) interacts with biology in a way that takes account of spatial differences in the history of individuals, and how they interact, move, grow and die. Applications of these models have enabled advances in the fields of marine biology, fisheries oceanography and biological oceanography, in areas such as population structure and connectivity, recruitment, habitat suitability, foraging ecology and marine reserve design.

A high level of sophistication has been achieved with these models, however, there is little information available on how to determine if they are appropriate for a given problem, how to use them to address theoretical or applied problems, how to construct them, and how to test, validate and analyze them. We propose to remedy this deficiency. Our book will address the development and use of these models through application of the scientific method: first, by definition of the problem, development of hypotheses, and development of conceptual models to organize our thinking and make critical decisions about the scope and elements of the model. Then we will discuss the development and implementation, and testing, calibration and sensitivity analysis of the model, its application in the form of model experiments, hindcasts or forecasts, and model output analysis and visualization. We will include case studies in each chapter to reinforce the major points. A DVD with examples of code and exercises will provide students or researchers with practice in writing and working with code. The DVD will also include examples of movies of model output, and 3D immersive visualization.

This book is intended to educate marine researchers about this exciting, cutting-edge modelling technique, which has already shown its value to marine science and holds promise of more extensive contributions. The book will contain multiple perspectives, and will cover organisms of different types with a variety of life histories, from fish to shellfish to crustaceans, zooplankton and phytoplankton. Modellers from the international scientific community will contribute. The book is intended to be useful to three types of readers: scientists (especially early-career scientists) who have a problem they think might need this kind of approach, modellers, and students (graduate or postdoctoral) studying or using modelling of marine and aquatic systems.

Terms of Reference

The working group will

- Act as an advisory panel providing scientific and technical advice on the proposal to write a book on biophysical individual based models.

- Provide lists of qualified experts in the field that could serve as lead or co-authors for different chapters.
- Act as an editorial board providing technical advice on content matter proposed for inclusion in the book as well as the process of publication of the book..

Plan for 2009/2010

The authors (Hinckley, Megrey and Hermann) will confer with the Working Group to assemble a list of potential contributors and gain their commitment to participate. The book proposal will then be submitted to Blackwell Scientific in the spring of 2009. If accepted, a timeline will be established by consensus with all the authors and writing will begin. If not accepted by Blackwell, another publisher will be sought.

The Working Group members will support the authors in this process by suggesting and acting (in some cases) as contributors and expert reviewers. An advisory committee composed of members of WGPBI (Charles Hannah, Alejandro Gallegas, Elizabeth North and Pierre Petitgas) will oversee progress of the book.

Relation to ICES Science Plan

Coupled biophysical IBMs models have the potential (or are already in use) to directly address the following areas of the 2009–2013 Science Plan:

Climate change processes and predictions of impacts: Coupled biophysical IBMs are important tools to further our understanding of individual and population responses to changes in climate through changes in ocean physics, for example, currents, temperature, salinity, or oxygen content. Downscaling of climate change future scenarios, such as those developed by IPCC, to regional levels can be used to drive these models to generate predictions of the effects of climate change.

Fish life history information in support of EAM: As these models are inherently spatial, examination and prediction of spatial organizations of fish populations including distributions of species, connectivity of populations through transport of larval or other early life stages, and the coupling of scales from individual organism processes to regional scales can be accomplished. There is potential for their use in the prediction of recruitment, through inclusion of biological and physical mechanisms processes thought or known to be important. These models can incorporate complex fish behaviours and movements, and can include variability in all processes which may be of consequence for populations.

Introduced and invasive species: Biophysical IBMs are presently being used to investigate the spread of introduced and invasive species under different climate change scenarios.

Development of options for sustainable use of ecosystems: Coupled biophysical models have the potential for use as operational models, for example, through forecasts of recruitment trends as a function of oceanographic variables, and as spatial planning tools to assist ecosystems managers via prediction of spatial patterns in populations due to changes in the environment. They may be used for marine spatial planning, including the effectiveness of management practices such as MPA's (by planning placement and size), and spatial extent and distribution of management areas.

Furthering the dissemination of knowledge about the development and use of these coupled biophysical IBMs via this comprehensive volume, will be a significant contribution to marine science. It addresses ICES goals of global research collaboration, (as contributors to the book will be from many areas of the world), and the transfer of knowledge, information and technologies.

ToR e) Report on developments in linking physical models, biogeochemistry models, and higher trophic level models, and disseminate information on common metadata standards needed for linking these models

The EU FP7 Meece project is focussing on linking Biogeochemical lower trophic level models with models suitable for ecosystem-based management of fisheries with both top-down and bottom-up drivers. Increasingly we will be making use of existing models of parts of the system joined together, rather than creating a complete model de novo. It has become apparent that there are a potentially large number of combinations of high and low level models. It is also apparent that the way that data and model components are specified in many of these models varies. Examples include different units of mineral concentrations (g per cubic metre versus molar units) and different definitions of functional groups such as division of Zooplankton. At a recent Meece meeting it was proposed that there should be a repository of metadata (possibly in xml format) formally describing model outputs and input requirements for a variety of models. It would be a good idea to extend this formal specification beyond the models of Meece participants to involve those people working in a broader range of projects. ICES and specifically WGPBI would be a good body to be involved in the collation and dissemination of this information (for example by maintaining and publicising a web repository of metadata).

Annex 8: Past and future WGPBI activities

YEAR	EVENT
2004	<p>Workshop on ‘Future Directions for Modelling Physical Biological Interactions.’, chairs Peters and Hannah (Barcelona, March 2004).</p> <p>WGPBI meeting (Barcelona, March 2004).</p> <p>Theme Session at ICES ASC on Physical/Biological Interactions: Experiments, Models and Observations (September 2004, Vigo Spain).</p> <p>WG web page is located at www.icm.csic.es/bio/projects/wgpbi/wgpbi.htm and maintained by Cesc Peters.</p>
2005	<p>Theme Session at ICES ASC on ‘Connecting Physical/Biological Interactions to Recruitment Variability, Ecosystem Dynamics, and the Management of Exploited Stocks’ with convenors North, St. John, and Gallego. Joint with WGRP.</p> <p>First meeting the Numerical Experimentation Subgroup (Hamburg, 6 April 2005).</p> <p>First meeting of the Larval Fish Group (Hamburg, 6 April 2005).</p> <p>WGPBI meeting (Hamburg, April 2005).</p> <p>Draft review of nutrient load reduction experiments. See Section 5 of 2005 Report.</p> <p>Report on the interannual variability comparison is now published as Skogen, M.D. and Moll, A., 2005. Importance of ocean circulation in ecological modelling: An example from the North Sea. <i>Journal of Marine Systems</i>, 57(3-4):289-300.</p>
2006	<p>Workshop on ‘Advancements in modelling physical/biological interactions in the early-life history of fish: recommended practices and future directions larval fish modelling.’ 3–5 April 2006 in Nantes France. Co-Chairs: A. Gallego, E. North, P. Petitgas.</p> <p>WGPBI meeting 6–7 April 2006 in Nantes France.</p> <p>Database on effects of turbulence on planktonic organisms. F. Peters. What is current status?</p> <p>Peters, F., and C.G. Hannah (editors). 2006. Special Issue on Future Directions in Modelling Physical/Biological Interactions. <i>J. Marine Systems. Journal of Marine Systems</i>. Volume 61, Issues 3-4, Pages 115-274 (July 2006).</p> <p>Theme Session at the ICES ASC on ‘Harmful Algae Bloom Dynamics; Validation of model predictions (possibilities and limitations) and status on coupled physical/biological process knowledge’. Joint with WGHABD. Co-convenor T. Stipa</p> <p>Theme session at ICES ASC on ‘Operational Oceanography’ (joint with PICES). Co-convenor: G. Han.</p> <p>Workshop on ‘Indices of Meso-scale Structures in ICES waters’, 22–24 Feb, 2006 in Nantes France. Joint with ICES SGRESP (Study Group on Regional Scale Ecology of Small Pelagics). Co-chair: C. Schrum</p> <p>Synthesis of progress on zooplankton modelling in German GLOBEC. T. Neumann and A. Moll</p> <p>Radach, G. and Moll, A., 2006. Review of three-dimensional ecological modelling related to the North Sea shelf system - Part 2: Model validation and data needs. <i>Oceanography and Marine Biology; an Annual Review</i>, Vol. 44:in press.</p> <p>WGPBI “Inventory of Operational and Preoperational Models” at http://northweb.hpl.umces.edu/WGPBI/WGPBI_links.htm.</p> <p>WKAMF Participants Web Page at http://northweb.hpl.umces.edu/wkamf/home.htm</p>

YEAR	EVENT
2007	<p>WGPBI Meeting. Bergen Norway 25–28 March 2007.</p> <p>Gallego, North, Petitgas (editors) Special section of Marine Ecology Progress Series devoted to papers from the Advancements in modelling physical/biological interactions in the early-life history of fish: recommended practices and future directions larval fish modelling.</p> <p>Hannah, C.G. 2007. Future directions in modelling physical/biological interactions. Marine Ecology Progress Series. 347: 301–306. Summarizing main themes from 5 years of deliberations of SGBPI and WGPBI.</p> <p>First draft of Recommended Practices for Modelling Physical/Biological Interactions in Fish Early-Life History. Gallego, North, Petitgas (editors).</p> <p>Workshop on ‘Parameterizing Trophic Interactions in Ecosystem Models.’ 20–24 March 2007, Cadiz Spain. Organized as part of EurOceans. Mike St. John</p> <p>Theme Session at ASC on ‘Integrating observations and models to improve predictions of ecosystem response to physical variability.’ Convened by Elizabeth North, Penny Holliday and Sarah Hughes. Joint with WGOH</p> <p>Theme Session at ASC on ‘Linking oceanographic physical features with biological production and fish habitat potentials’ Conveners: Pierre Petitgas, Corinna Schrum, and Charles Hannah</p>
2008	<p>Meeting of Larval Fish subgroup to consider activities flowing from WKAMF. Sete, France, 30 March 2008.</p> <p>WGPBI meeting, 31 March to 3 April 2008, Sete, France. One day joint session with WGZE</p> <p>Manual of Recommended Practices for Modelling Physical/Biological Interactions in Fish Early-Life History is complete. A resolution will be written for publication in ICES Cooperative Research Reports. North, Gallego, Petitgas.</p> <p>Theme Session at ASC on ‘Coupled Physical and Biological Models: Development and Validation.’ Co-convened by Han and Moll. Joint with XXX</p> <p>Theme Session at ASC on ‘Size is almost everything! Size and trait based processes and models in ecosystems and management’. Co-convened by Ken Haste Andersen. Joint with XXX</p>
2009	<p>WGPBI meeting 31 March – 2 April 2009, Huelva, Spain. Joint with WGHABD.</p> <p>Theme Session for 2009 Death in the sea - Mortality in the zooplankton and early-life stages of marine fish (estimates, processes and outcomes): Convenors: A. Gallego, E. North, E. Houde</p> <p>Theme Session for 2009: Beyond geolocation: Inferring and explaining the behaviour of tagged fish: Co-convenor: U. Thygesen</p> <p>Gallego, North, Petitgas. 2009. Manual of Recommended Practices for Modelling Physical-Biological Interactions in Fish Early-Life History. ICES Cooperative Research Reports. Get details</p> <p>Elizabeth North, Plenary speaker at ASC. What can science tell us that fishermen don’t already know?</p> <p>Release of Larval TRANSport Lagrangian model (LTRANS) an open source code with a User's Guide. LTRANS is a 3D off-line particle-tracking model that runs with the stored predictions of the Regional Ocean Modeling System (ROMS). More information, LTRANS code, and associated tools can be found at: http://northweb.hpl.umces.edu/LTRANS.htm.</p> <p>Hannah, C.G., A. Vezina, M. St. John. The case for marine ecosystem models of intermediate complexity. Progress in Oceanography. In press September 19, 2008.</p> <p>Proceedings from the ICES/PICES Early Career Scientists Conference have been published in the ICES Journal of Marine Science, vol 66, 2009.</p>

YEAR	EVENT
2010	<p>WGPBI meeting 25–26 March 2010, Aberdeen.</p> <p>Workshop on ‘Understanding, quantifying and predicting mortality in fish early-life stages: experiments, observations and models’ (WKMOR) 22–24 March, 2010. Aberdeen. Gallego, North, Houde.</p> <p>Hinkley, Megrey, and Hermann. Methods for spatially-explicit individual-based modeling of marine organisms: coupling of biology with hydrodynamics. Draft of book.</p> <p>Proposed theme sessions for ICES ASC 2010:</p> <ol style="list-style-type: none"> 1. Community level analysis and models. Convened by Ken H. Andersen (Denmark), Julia Blanchard (UK) 2. Combining spatially-explicit models of lower and upper trophic levels: integration and prediction in the context of global change. Convened by Pierre Petitgas (France), Myron A. Peck (Germany) Bernard Merge (USA), Kenneth Rose (USA) 3. Physics and biology in modelling harmful algal blooms (HABs): validation and application for forecasting and climate change. Convened by Donald M. Anderson (USA), Geneviève Lacroix (Belgium)

Annex 9: Recommendations

Recommendation	For follow up by:
1. WGPBI nominates Uffe Thygesen (Denmark) and Elizabeth North (USA) as Co-Chairs starting in 2010.	Science Committee
2. Theme session for ICES ASC 2010: Physics and biology in modeling harmful algal blooms (HABs): validation and application for forecasting and climate change. Convened by Donald M. Anderson (USA), Geneviève Lacroix (Belgium)	Science Committee
3. Theme session for ICES ASC 2010: Community level analysis and models. Convened by Ken H. Andersen (Denmark), Julia Blanchard (UK)	Science Committee
4. Theme session for ASC 2010: Combining spatially-explicit models of lower and upper trophic levels: integration and prediction in the context of global change. Convened by Pierre Petitgas (France), Myron A. Peck (Germany) Bernard Merge (USA), Kenneth Rose (USA)	Science Committee
5. Theme session for ASC 2010: Operational oceanography for fisheries and environmental applications. Conveners: Charles Hannah (Canada), Helge Sagen (Norway), Barbara Berx (UK).	Science Committee
6. WGPBI proposes that an ICES ASC theme session on Model Validation should be developed jointly with WGOOFE.	WGPBI and WGOOFE
7. Joint meeting between WGPBI and WGHABD in 2011. WGOOFE may also be interested in participating.	WGPBI, WGHABD, WGOOFE
8. The Statement of Requirements for monitoring data to be useful for development and validation of models of physical-biological interactions has been completed.	WGOOFE and EuroGOOS

Annex 10: Theme session proposals for ICES ASC 2010

Combining spatially-explicit models of lower and upper trophic levels: integration and prediction in the context of global change

Conveners: Pierre Petitgas (France), Myron A. Peck (Germany) Bernard Megrey (USA), Kenneth Rose (USA)

Mechanistic tools are necessary to increase predictability of changes in fish distribution and productivity under global change scenarios and for fishery management and/or restoration plans. Climate-driven processes can act on all life stages of marine fish species to impact life cycle closure and recruitment strength. For example, the ability to project changes in the spatiotemporal extent of habitats suitable for high rates of survival and growth as well as those enabling connectivity among life stages is essential for estimating the potential impacts of climate variability on fish stocks. One approach has been to utilize biophysical NPZD (nutrient, phytoplankton, zooplankton detritus) models to generate climate-forced variability in prey fields and link these to bioenergetics, displacement and/or feeding models of planktivorous fish at individual and population levels. Ongoing challenges in linking spatially-explicit lower and upper trophic level models include tradeoffs between the needs for biological realism and model simplicity.

In this session, presentations are welcome that focus on:

- methodological advancements (e.g. simulation platforms, novel life cycle modelling, trophic coupling strategies)
- mature applications of linked models projecting spatially-explicit trophodynamic climate impacts
- demonstrative use of models and approach in applied fisheries cases

Physics and biology in modelling harmful algal blooms (HABs): validation and application for forecasting and climate change

Conveners: Donald M. Anderson (USA), Geneviève Lacroix (Belgium)

Harmful Algal Blooms (HABs) are of great concern because of their toxicity and/or the damage they cause to ecosystems and coastal resources. Toxic HAB events in aquaculture can have adverse effects on economy (fish or shellfish mortality) and public health (human disease, mortality) and high-biomass, non-toxic blooms can affect water quality and tourism. Aquaculture and tourism are mainly located in coastal zones that can be affected by eutrophication, sometimes cited as a cause of HABs. Amongst the challenges related to HABs we can cite the need to: (i) understand the physiological/biological/environmental factors that regulate HABs and in particular the underlying physical/biological interactions that are the most important, (ii) forecast HAB events and (iii) assess the impact of climate change on HABs (occurrence/frequency/magnitude). Models, providing that they are carefully validated and adapted to the situation (region/species), are necessary tools for forecasting, assessing the impact of future scenarios and for process studies. The development of HAB models requires interdisciplinary (biological, chemical, and physical) research. Strong interaction between modellers and experimentalists is crucial and data availability essential. Recognizing the rapid progress in HAB modelling in recent years, we invite contributions of modelling studies, laboratory and experimental research, field stud-

ies and remote sensing investigations that advance our ability to understand underlying physical/biological interactions that control HABs, to improve HAB model validation, to forecast HAB events, or to assess effect of climate change.

Donald M. Anderson, Woods Hole Oceanographic Institution, USA, e-mail: dander-son@whoi.edu

Geneviève Lacroix, Management Unit of the North Sea Mathematical Models, Royal Belgian Institute of Natural Sciences, BE, e-mail: G.Lacroix@mumm.ac.be

Community level analyses and models

Conveners: Ken Haste Andersen (Denmark) and Julia Blanchard (UK).

In recent years there has been an increase in focus on changes taking place in an ecosystem as a whole as a response to fishing, climate change or other types of anthropogenic forcing. These perturbations of one part of the system can lead to system-wide effects, like trophic cascades, changes in stability and regime shifts. Recent progress in size- and trait-based models of marine ecosystem and new initiatives into developing multi-species simulation models for specific ecosystems lends hope to throw light on the mechanisms behind system-wide changes. This session will bring together analysis of community-wide patterns and processes with ecosystem models to form a synthesis of our current understand of the dynamics of the marine ecosystem as a whole.

Operational Oceanography for Fisheries and Environmental Applications

Conveners: Charles Hannah (Canada), Helge Sagen (Norway), Barbara Berx (UK).

Note: A convener to replace Hannah must be found.

Annex 11: Abstracts for presentations at the WGPBI meeting

Sustainability of scallops on Georges Bank: The role of larval transport

Chad S. Gilbert, Wendy C. Gentleman, Catherine L. Johnson, Claudio DiBacco, James M. Pringle & C Chen

Sea scallops (*Placopecten magellanicus*) on Georges Bank are important both ecologically and as commercial fisheries. The population is comprised of 3 distinct scallop beds, which are connected via transport of planktonic larvae spawned in the spring and fall. In order to develop sustainable management strategies, we need to quantify how the different beds and spawning times contribute to larval recruitment and how these recruitment patterns affect population dynamics.

Here, we calculate larval drift and retention using a 3D particle-tracking model, which couples seasonal currents, larval swimming, turbulent dispersion and larval development. Bed connectivity is quantified, and then analyzed using a novel Markov-chain approach. Sensitivity to variation in adult distribution, temperature-dependent growth, reproduction and mortality is assessed and the implications for management of the population are discussed.

Larval TRANSport Lagrangian (LTRANS) model update

North, E. W.

E. North reported that she and Zachary Schlag, developers of the Larval Transport Lagrangian model (LTRANS), released the model as open source code in September, 2008. LTRANS is an off-line particle-tracking model that runs with the stored predictions of the Regional Ocean Modelling System (ROMS), a 3D hydrodynamic model. Although LTRANS was built to simulate oyster larvae, it can easily be adapted to simulate passive particles and other planktonic organisms. LTRANS is written in Fortran 90 and is designed to track the trajectories of particles in three dimensions. It includes a 4th order Runge-Kutta scheme for particle advection and a random displacement model for vertical turbulent particle motion. Reflective boundary conditions, larval behaviour, and settlement routines are also included. The web site contains the code, the open source license, a 146-page User's Guide, example input files, and visualization scripts (see <http://northweb.hpl.umces.edu/LTRANS.htm>, Figure 1). The peer-reviewed paper that describes an application of LTRANS to oyster larvae transport was published last year (North *et al.*, 2008 MEPS 359: 99-115). North and Schlag are currently adapting LTRANS to run within the Chesapeake Bay Forecasting System and to assist with oyster restoration site selection. In addition, an upcoming field program is designed to validate the oyster larval behaviours in LTRANS using the Larval Identification and Hydrographic Data Telemetry (LIHDAT) designed by Scott Gallagher and colleagues at WHOI. This system shines polarized light on bivalve larvae shells and uses the species-specific birefringent patterns to identify bivalve larvae (see TRANSPORT program

<http://northweb.hpl.umces.edu/TRANSPORT/home.htm>).

Wave Boundary Layer measurements with Particle Image Velocimetry

Tom Osborn

Measurements with a Particle Image Velocimetry (PIV) system in the bottom boundary layer of the coastal ocean show the transition from the log layer to the wave boundary layer. Contrary to previous results, where the log layer was not seen in the presence of waves, it was found because the measurements were sufficiently close to the bottom. The layer showed constant dissipation, indicating that the stress increased with elevation and that the log layer was not a constant stress layer.

Linking a Biogeochemical Model (GOTM) with an ecosystem model (EwE): Opportunities, Challenges and Solutions

Dr. Jonathan Beecham, Cefas Lowestoft Laboratory, U.K.

In order to understand how bottom up drivers (from physics to plankton) might affect marine communities (zooplankton to fish), it has been possible to link Ecopath with Ecosim (EwE) version 6 with the General Ocean Turbulence Model (GOTM), which is a physical model that may have biological components (e.g. the BFM model) for incorporating the dynamics of plankton. The connection between the two models has been conducted at the level of the user interface, which means that the functions for file management; data entry and graphical display can be used in the normal way for entering the data in the combined model. The model coupler for EwE v6 uses the Visual Studio net plug-in mechanism, so that the core EwE code does not have to be altered. The coupler plug-in includes an embedded Python interpreter, which is able to launch the scripts and libraries for the front end to GOTM. The two model are able to use the coupler to exchange information on the time-steps of the two models and synchronise the thread of the models. In the future they will exchange information on functional groups, so that, for example zooplankton production can be determined in GOTM and consumption in EwE.

Incorporating environmental forcing into Baltic food web study

Susa Niiranen, Thorsten Blenckner, Maciej T. Tomczak and Olle Hjerne

A time dynamic food web model has been developed for the open Baltic Proper (ICES subdivisions 25–29) using the Ecopath with Ecosim (EwE) software. Currently this model has been fitted to annual biomasses and catches of cod (*Gadus morhua*), herring (*Clupea harengus membras*) and sprat (*Sprattus sprattus*) as well as three groups of zooplankton biomasses for the time period 1974–2006. External forcing such as fishery pressure, temperature and salinity are used to drive selected functional groups of the model. The future aim is to incorporate the food web model into the Baltic NEST decision support system (DSS, <http://nest.su.se/nest/>) as well as to apply it in the Baltic Bonus-project ECOSUPPORT (Advanced modelling tool for scenarios of the Baltic Sea ECOSystem to SUPPORT decision making, <http://www.baltex-research.eu/ecosupport/index.html>). The NEST DSS is a tool to explore and synthesize ecosystem information, evaluate the effects of eutrophication and fishery as well as to calculate costs of different management options in the Baltic Sea area and it is freely downloadable from nest.su.se/nest. The goal of ECOSUPPORT is to produce policy-relevant information on combined future (present-2100) impacts of climate change as well as industrial and agricultural practices on the Baltic Sea ecosystem. An approach of multi-model ensemble simulations is an integral part of the project and the types of models used include regional climate, marine biogeochemical as well as

foodweb and multi-species models. Within this project coupling between different types of models is aimed at and the goal is to also couple the EwE food web model with a biogeochemical model so that a proper two-way feedback is enabled between the two. Currently, phytoplankton is seen as an appropriate link between the two types of models, but other suggestions are welcomed from the WGPBI members present in the meeting. GOTM and consumption in EwE.

Climate-driven changes in the recruitment of North Sea herring: Bottom-up control on the survival of early life stages identified using a biophysical individual-based model

Marc Hufnagl, Myron A. Peck, Mark Dickey-Collas, Richard Nash, Thomas Pohlmann

North Sea herring (*Clupea harengus*) has experienced extremely poor recruitment in recent years despite having high spawning stock biomass and relatively low fishing mortality. Field survey data suggest that poor year classes stem from processes acting during the first months of life, when cohorts of larvae passively drift eastward across the North Sea from western spawning grounds during the boreal winter. We investigated how intra- and inter-annual changes in climate-driven bottom-up processes might impact early larval growth and survival by developing a coupled 3-d individual-based, biophysical model for Atlantic herring larvae in this region. Physiologically-based foraging and growth subroutines allowed us to examine the impact of key abiotic (e.g. water currents, temperature, light, turbulence) and biotic (prey size and prey concentration) factors on the feeding, growth and survival of young larvae. Model foraging and growth estimates were validated using a variety of field and laboratory studies previously conducted on larval herring and a sensitivity analysis of model parameters was performed. Model simulations employed extensive (>35 yr) time series data on larval herring abundance and distribution and projected large inter-annual differences in prey concentrations required for the survival and growth of this species in this region. In many years, climate-driven changes in average winter water temperature and zooplankton phenology were predicted to markedly influence the survival of the youngest larvae originating from selected spawning grounds. Although projecting future trends remains challenging, climate-driven changes in bottom-up processes should be taken into account for the effective management of North Sea herring.

Larval fish dynamics in the Canaries-African Coastal Transition Zone

Marta Moyano, J.M. Rodríguez, S. Hernández-León

During this talk, we synthesise relevant information on the ichthyoplankton assemblage of the Canaries-African Coastal Transition Zone (C-ACTZ). This CTZ shows the singularity that the Canary Archipelago interrupts the main flow of the Canary Current and Trade Winds, introducing large mesoscale variability, in the form of island warm wakes and cyclonic and anticyclonic eddies downstream of the islands. Besides, upwelling filaments stretch towards the archipelago from the African coastal upwelling, transporting phytoplankton, zooplankton and, fish larvae. They also interact with eddies shed from the islands to exchange water properties and biogenic material. All these mesoscale features influence the composition, structure, abundance and distribution of the larval fish community (LFC) of the region. The Canary Current (CC) and eddies shed from the islands drag larvae of island neritic fish species into the oceanic region and participate, along warm wakes, in the horizontal distribution of fish larvae. Upwelling and upwelling filaments transport larvae of African neritic species into the oceanic region. These larvae dominate the LFC and

account for the relatively high average larval fish abundance found in the C-ACTZ during the summer upwelling season. Filaments originated in the region of Cape Juby-Cape Bojador are entrained around a quasi-permanent cyclonic eddy, trapped between Gran Canaria and the African coast, forming a system through which most of the African neritic larvae may return to the African shelf. However, sometimes this eddy may quickly drift offshore, with little hope of survival for the transported larvae. A third case was observed in which these larvae reached the easternmost islands of the Canary archipelago. Changes in the larval community composition of those islands were observed during these filament arrivals. Overall, this study highlights the strong relationship between mesoscale oceanographic processes and the LFC in the C-ACTZ.

Life history traits and spatio-temporal distributional patterns of copepod populations in the Gulf of Maine

Rubao Ji, Biology Department, Woods Hole Oceanographic Institution

Life history traits play a significant role in determining the spatiotemporal distributional patterns of marine zooplankton, but biological-physical mechanisms controlling the population dynamics need to be further examined. In this study, we used a coupled biological-physical model to examine the processes controlling the observed distributional patterns of three representative copepod populations in the Gulf of Maine-Georges Bank region including *Pseudocalanus* spp., *Centropages typicus*, and *Centropages hamatus*. The model reveals that the shorter generation time of *Pseudocalanus* spp. at cold temperatures, together with their egg-carrying strategy, allows an earlier population development compared to *Centropages* spp.. The model further reveals that predation mortality plays an important role in the decline of *Pseudocalanus* spp. in the warm season; and that the resting egg strategy is crucial for the persistence of *C. hamatus* population in the Gulf of Maine-Georges Bank region. Analyses of observational data and model results suggest that temperature- and food-dependent egg-production and development rates, temporally and spatially varying mortality rate, as well as physical transport are important contributors to the formation of characteristic distributional patterns for the copepod populations in the system.

Annex 12: Agenda for the joint WGHABD/WGPBI meeting

Wednesday April 1:

09:00 - 11:30 WGHABD presentations

11:30 - 13:00 Discussion

13:00 - 14:00 Lunch

14:00 - 16:30 WGPBI presentations

14:00 - 14:15 Charles Hannah: Overview of WGPBI

14:15 - 14:55 Andy Visser: Small scale physical/biological interactions

14:55 - 15:25 Tom Osborn: Holographic imaging of plankton

15:25 - 15:45 Manolo Ruiz: Modelling oceanographic conditions on the western Iberian shelf during autumn HABs

15:45 - 16:05 Geneviève Lacroix: Spatial and interannual variability of primary production (Phaeocystis vs. diatoms) in the Southern North Sea

16:05 - 16:30 Coffee

16:30 - 16:50 Elizabeth North: Overview and application of recommended practices for modelling physical/biological interactions during the early life of fish

16:50-18:00 Discussion in 3 breakout groups

18:00- 18:30 Plenary session: Discussion and Conclusion

Evening: Joint WGHABD and WGPBI Dinner, by invitation from the Fisheries

Directorate. Ministry of Agriculture and Fisheries from the Andalusian Autonomous Government.

20:15 Departure by bus

20:30 Dinner

22:45 Return by bus

ABSTRACTS FOR WGPBI TALKS

Small wet and rational

Andy Visser

Plankton are small, inhabit a fluid environment, and while they may not be "thinking" creature, they are endowed by natural selection with behavioural algorithms that are open to rational interpretation. It is at the individual scale that the immediate impact of the fluid environment is manifest, impacting fundamental life processes. It is also the individual scale at which natural selection is active -- attributes that lend individuals greater success in meeting the challenges of survival and reproduction will have a greater expression in succeeding generations. This is true also for behav-

ioral algorithms. It is my contention that by bringing behavioural and evolutionary ecology together at the individual level, many of aspects of planktonic interactions can be given a mechanistic understanding. That is, if we can deduce the rules that shape behaviour, then we have extra information through which behavioural changes can be predicted. Zooplankton have rational behaviour, that has meaning only for the individual, but has implications across communities, populations and ecosystems.

Discussion of Digital, Microscopic Holography

Tom Osborn

Development of a digital, microscopic, holographic system (Sheng *et al.*, 2006 and 2007) enable imaging of a volume 0.8x0.8x3.0 mm with a spatial resolution of 0.975 μm in directions parallel to the imaging plane and 2 μm in depth direction. The sample rate is limited by the camera and data acquisition system, 2000 frames / sec for the camera. With this system it is possible to track many particles at once, both predators and prey in order to develop good statistics on the inter-particle distances as well as discerning behaviour.

The system will be described and new results showing variation among different strains of the same species will be described.

Modelling oceanographic conditions on the western Iberian shelf during autumn HABs

Manuel Ruiz Villarreal

North-West Iberian waters are frequently affected by dinoflagellate HABs during the autumn transition to downwelling-favorable winds. Different hypothesis have been put forward to explain the development of these HABs: germination of resting cists, latitudinal progress in microplankton succession and along-shore northwards transport. Numerical simulations of the oceanographic conditions during the intense HAB outbreak occurred in autumn 2005 allow us to shed light on the influence of oceanographic conditions on the propagation of HAB. The results indicate the presence of stratification and northwards advection on the shelf, and strong variability of shelf circulation in response to wind events and variations of the shape and depth on the shelf. During this period, the sequence of detection of toxic species indicates a northward propagation. Across-shore transport during downwelling episodes is associated to toxin detection in coastal monitoring stations. Comparison of mean modelled shelf circulation with the chronology of proliferation of toxic cells could support the hypothesis of the along-shore transport on the shelf.

Spatial and interannual variability of primary production (Phaeocystis vs. diatoms) in the Southern North Sea

Geneviève Lacroix

Primary production in the Southern North Sea (SNS) shows spatial heterogeneity due to the varying contribution of rivers (nutrient-enriched) and of Atlantic waters. The interannual variability of river loads is driven by anthropogenic pressure and meteorological conditions (precipitation) whereas the influx of Atlantic waters is governed by climate variability which can be related to the North Atlantic Oscillation (NAO). In this study a 3D biogeochemical model is used to study the relative impact of natural (climatic) variability and river loads on the primary production in the SNS. The MIRO&CO model has been implemented for the region between 48.5°N-4°W and

52.5°N-5°E by using actual river loads, SST and meteorological forcing (1993–2006). The sensitivity to natural variability is assessed considering different meteorological years but fixed river loads (for two situations, wet/dry). The sensitivity to river loads is estimated by constraining MIROC with constant meteorological conditions (for two contrasted NAO) and different river inputs. Primary production results are analysed in terms of the respective contribution of diatoms and Phaeocystis, the latter being considered as undesirable for the area. Impact of primary production variability on higher trophic levels will also be assessed.

Update on the ICES Cooperative Research Report “Manual of recommended practices for modelling physical/biological interactions during fish early life”

Elizabeth North

Two major products of the 2006 WGPBI Workshop on “Workshop on advancements in modelling physical/biological interactions in fish early-life history: recommended practices and future directions” (WKAMF) are a theme section in MEPS (2007, vol. 347) and the ICES Cooperative Research Report entitled “Manual of recommended practices for modelling physical/biological interactions during fish early life” which will be published in April 2009 (CRR number 295). Editors are Elizabeth North (USA), Alejandro Gallego (UK), and Pierre Petitgas (France).

The Manual focuses on 3D biophysical Lagrangian models which are coupled to 3D hydrodynamic models and assign biological attributes to particles (e.g., behaviour, pelagic stage duration, growth, mortality). These individual-based models have been used to understand how physical and biological processes interact to influence the dispersal, survival, and population connectivity of organisms with planktonic life stages. The MRP objectives are to summarize appropriate methods for modelling physical/biological interactions during the early-life of fish, recommend modelling techniques in the context of specific applications, and identify knowledge gaps. The manual provides a reference for early career modellers who are interested in applying coupled biological and three-dimensional circulation models to determine the survival and transit of fish eggs, larvae, and juveniles from spawning to nursery areas and to provide updates for current practitioners on latest techniques and areas in need of further research. Major knowledge gaps that were identified were related to: validation and sensitivity methods, model complexity, physics, energetics, mortality, and behaviour and cues. Mortality will be the focus of the WGPBI Workshop on “Understanding and quantifying mortality in fish early life stages: experiments, observations and models” which will be held in Aberdeen UK, on 22–24 March 2010.

Strengths and weaknesses of 3D individual-based models as applied to harmful algal blooms were discussed. Positive aspects included the ability to simulate thin layers and filamentous structures, track individual behaviours, change behaviours easily, and convert patches of particles to concentrations. Negative aspects included computational costs of running an appropriate number of particles, and the fact that the underlying numerics are not as well established as Eulerian models and systematic validation standards do not exist.

Annex 13: Report from the joint WGHABD/WGPBI meeting

After presentations, the combined group was split into three groups for discussions, using the three questions:

- what are the key processes needed for modelling HABs?
- what key life stages history should be represented?
- what drives or determines toxicity, e.g. how does toxicity relate to fitness?

The breakout sessions were followed by reports from the breakout sessions and a plenary discussion.

Key points from plenary discussion and breakout group reports:

- HABs are defined by nuisance value to humans and they are not necessarily toxic. Some HABs are bloom species and effect is simply caused by biomass (cover beach, clog nets, bad smell, etc.) whereas some exist in relatively low abundance and the effect is caused by toxicity.
- The properties of HABs need to be species and site specific. Nevertheless it should be possible to define HAB functional types which share common features but differ in the details. In other words we ought to be able to define which features of a particular HAB are generic and which are species and site specific.
- Currently, most models address just the biomass of HAB species. However toxicity in terms of seafood safety also depends on the toxicity levels of the HAB cells and the processes that transport the cells (and the toxins) up the food chain. Modelling of cell toxicity is an open field. Also, the vertical transport of the cells by sedimentation, e.g. in marine snow, is understudied.
- There is still a need for improved understanding and modelling of the processes that initiate and terminate the blooms for the bloom species and the onset of toxicity for the toxic species.
- The role of cell-to-cell communication, chemical cues and behaviour needs attention.
- There are physical processes that affect harmful algae in ways that deserve further work: Mixing and stratification, small-scale eddies, transport in the benthic boundary layer and in the near-shore, e.g. the surf zone.
- In terms of life histories of harmful algae, the triggering factors that inducing life stages shifts are unclear for many species, as are major control factors for each life stage. Finally, the phenotypic variability within the population during the various life stages, and its effects, are unclear.
- There is a need for systematic model validation and techniques for the use of available data to improve the simulations (data assimilation and parameter estimation).
- There is need for studies of processes on a large scale by multidisciplinary teams. Such projects should be associated to pre-existing hydrodynamical models and built on a conceptual model for one given species.
- It is essential that lab experiments be validated in situ by identifying all life stages.
- There are always concerns about spatial scale: For example is necessary to model filaments? Does density dependence matter, and if so, at which spatial scale must density be modelled? How do we model inter-particle distance in the cases where that is an important quantity? For model validation, is a point measurement useful? As usual the answer to the last question depends on spatial and temporal decorrelation scales.

- Several of the HAB applications presented were shelf oriented and the primary issue is whether the cells get advected to the coast where they interact with humans. So the key issues are identifying the initial location of the cells and the quality of the advective fields provided by the hydrodynamic model. In these cases useful results can be obtained and practical advice given to managers without sophisticated modelling of the biological processes.
- In small embayments the biological processes may overwhelm the physical ones and spatially explicit physical fields may not be required; a flushing time scale may suffice to present the effects of horizontal advection. The calculation of the flushing time scale may be nontrivial.
- Light: if light levels are important to the HAB process then sophisticated light models are available to calculate light attenuation are available. This calculation may require models or observations of phytoplankton and CDOM (coloured, dissolved organic matter). The relevant atmospheric forcing is often available from numerical weather prediction models (ECMWF, NECP).
- Climate change: Estimation of impact of climate change on HAB magnitude and frequency of occurrence is problematic. One needs to be able to link the HAB processes closely to the physics and biogeochemistry. This will be easier for in cases where temperature and stratification are the dominant factors in controlling the HAB.

Actions:

The participants felt that the time for the small group discussions (40 minutes) was too short: the discussions were just starting to get interesting. A future joint meeting should ensure that much more time is devoted to small group discussions (perhaps 3 hours).

Participants enjoyed the discussion enough that a second joint meeting has been proposed for 2011. This will be pursued.

A second joint meeting in 2010 was rejected because WGPBI already occupied by WKMOR.

A theme session for the 2010 ASC will be proposed by Don Anderson (WGHABD) and Geneviève Lacroix (WGPBI). The details are in Annex 8.

Annex 14: Proceedings of the ICES/PICES Early Career Scientists Conference (ICES JMS)

ICES/PICES Early Career Scientists Conference papers published in *ICES Journal of Marine Science*. The ICES/PICES Conference for Early Career Scientists was held in Baltimore, Maryland, U.S.A. on 26–29 June 2007. Elizabeth North and Franz Mueter served as guest editors for a group of papers submitted by early career scientists. The following introduction and nine papers were recently published in ICES JMS (2009, vol.66)

1. Elizabeth W. North and Franz J. Mueter. Marine science with global vision: creating a place for early career scientists. An introduction to selected articles from the 2007 Early Career Scientists Conference
2. Alan F. Koropitan, Motoyoshi Ikeda, Ario Damar, and Yasuhiro Yamanaka. Influences of physical processes on the ecosystem of Jakarta Bay: a coupled physical–ecosystem model experiment
3. Olav A. Ormseth and Brenda L. Norcross. Causes and consequences of life-history variation in North American stocks of Pacific cod
4. Eva Jakob, Reinhold Hanel, Sven Klimpel, and Karsten Zumholz. Salinity dependence of parasite infestation in the European eel *Anguilla anguilla* in northern Germany
5. Yan Jiao, Christopher Hayes, and Enric Cortés. Hierarchical Bayesian approach for population dynamics modelling of fish complexes without species-specific data
6. Dawit Yemane, Yunne-Jai Shin, and John G. Field. Exploring the effect of Marine Protected Areas on the dynamics of fish communities in the southern Benguela: an individual-based modelling approach
7. Tomas Didrikas and Sture Hansson. Effects of light intensity on activity and pelagic dispersion of fish: studies with a seabed-mounted echosounder
8. Sarah E. Dudas, Brian A. Grantham, Anthony R. Kirincich, Bruce A. Menge, Jane Lubchenco, and John A. Barth. Current reversals as determinants of intertidal recruitment on the central Oregon coast
9. Paul A. de Bruyn, Coleen L. Moloney, and Michael H. Schleyer. Application of age-structured production models to assess oyster *Striostrea margaritacea* populations managed by rotational harvesting in KwaZulu-Natal, South Africa
10. Guimei Liu and Fei Chai. Seasonal and interannual variability of primary and export production in the South China Sea: a three-dimensional physical–biogeochemical model study