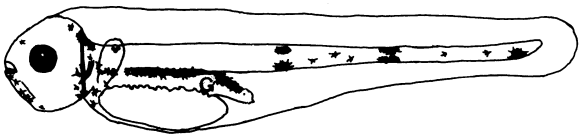
STAGES



Newsletter of the AFS Early Life History Section

Volume 19, Number 2 Sept. 1998

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Abstract Deadlines:

AFS: Jan 15
to be held Aug 29 - Sept 2 in Charlotte, North Carolina

23rd Larval Fish Conference - Feb 1
to be held April 6- 10 at the NMFS/NOAA lab in Beaufort, NC to celebrate the 100th centenary of the Beaufort Lab. See page 3 for more details

PRESIDENT'S MESSAGE

The 22nd Annual Larval Fish Conference, held at the University of Michigan, Ann Arbor, 9-13 July 1998, was both intimate and highly interactive. The Early Life History Section thanks Ed Rutherford and his local committee for their work. There were about 75 registrants, with 51 presentations including 22 student presentations and invited presentations in four theme sessions: Great Lakes Early Life History, Advances in Otolith Microchemistry Techniques, Larval Fish Feeding Ecology, and Modeling Predator-Prey Relationships in Early Life History. Dr. James A. Rice offered the Plenary Address: "Evolution and application of the process-oriented approach to recruitment dynamics in fishes. "

The Sally Richardson Award for best student paper was awarded to Sharon Herzka for her presentation of a paper, co-authored by Joan and Scott Holt, entitled "Determination of stable isotope turnover rates for red drum larvae and potential applications to habitat and recruitment studies". Honorable mention was awarded to: Elizabeth North for her presentation, with Ed Houde, of "Potentials for transport and predator-prey interactions in bay anchovy (*Anchoa mitchilli*) eggs and larval stages"; Brian Kennedy, with R. Harrington, C.L. Folt, J.D. Blum, and C.P. Chamberlain, for "Tracing the tributary origins and movements of anadromous Atlantic salmon (*Salmo salar*) through the use of stable isotopes"; and Stephen Swearer, with J.A. Harlan, J.E. Caselle, D.W. Lea, and R.R. Warner, for "Island wakes and environmental markers: using otolith elemental fingerprinting in studies of larval dispersal and recruitment of coral reef fishes." The number, and indeed the quality, of student presentations is seemingly ever increasing, a condition that steepens the competition and augments the prestige of the Sally Richardson Award.

The installation of new officers was executed at the Business Meeting of the Larval Fish Conference. With this passing of the baton, came a two year agenda for the Early Life History Section.

Masthead

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Principal among agenda items are the implementation of new Standing Rules for the Section, which detail the recently approved By Laws. These Standing Rules simply provide a clear *modus operandi* for our organization. A secondary item is the fostering of membership. Affiliate membership has increased over recent years, while Sectional membership has steadily declined. This tells us something about our composition.

Perhaps with this transition of officers and recognition of the need to encourage membership, it is appropriate to think about what we are, in the sense of a professional organization, and what are the benefits of membership. I was somewhat taken aback in a recent conversation with a respected colleague, when he referred, with apparent disparagement, to the study of the early life histories as the "larval fish movement." The implication, I supposed at the time, was that the Early Life History Section was something of a cult, that, a body of people with an excessive dedication to some intellectual fad. Are we? Is it not reasonable to question periodically just who we are as an organization and where we are going?

We are all scientists or resource managers who predicate decisions on scientifically acquired information. As scientists, we try to describe nature empirically and to understand how it works. Most would agree that the development of fishes, owing in part to their almost overwhelming diversity, is incompletely described. This alone verifies the study of early life histories as a legitimate intellectual pursuit. From a management or conservation point of view, the thought that variation in the numbers of fish that survive through their early life accounts for variation in overall population size remains a valid supposition and hence forms the recruitment problem.

Tom Miller, our Newsletter Editor, once argued, very convincingly I think, for the multi- disciplinary nature of our interests and work (*STAGES* 17(1), May 1996). The ELHS comprises fisheries biologist, fisheries oceanographers, limnologists, fish biologists, marine and aquatic ecologists, aquaculturists, and ichthyologists. Many wear several hats. The last of these, ichthyologists, is not the least. While some ichthyologists would assert that ichthyology is exclusively restricted to the study of fish phylogeny, with the skills of taxonomy a requisite, ichthyology is really the study of fishes, all aspects of their biology, including their evolution. We study the biology of young fishes --- embryos, larvae, and juveniles --- their morphology, physiology, ecology, and adaptations. As an organized group, a renegade Section of AFS perhaps, and an unaffiliated out-group of ASIH, we are the

(Continued on page 4)

Larval Fish Conference - 1999

NOAA's Beaufort Laboratory

6-11 April 1999

The 23rd Annual Larval Fish Conference will be held at NOAA's Beaufort Laboratory in Beaufort, North Carolina to help celebrate the lab's 100th birthday. The meeting will open with a Welcome Mixer on the evening of April 6th. Scientific presentations will start on the morning of the 7th with a special session in tribute to John Blaxter's contribution to the study of fish early life history. The remainder of the meeting will be a single session from the 8th to 10th. Given the single session format, there are a limited number of oral presentation slots, which will go on a first come first serve basis. There will also have a dedicated poster session with some special incentives for strong attendance.

Abstract Submission Deadline is 1 February 1999

Please follow the format on the sample abstract. Abstracts can be submitted via the Conference's Hompage: http://www.bea.nmfs.gov/lfc/. Mail, email and FAX submissions will also be accepted:. In these cases abstracts should be submitted to:

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NOAA Beaufort Laboratory
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phone: (252) 728-8732
FAX: (252) 728-8784
Jon.Hare@noaa.gov

Registration Deadline is 1 February 1999

Registration Forms can be submitted via the Homepage http://www.bea.nmfs.gov/lfc/ . Mail and FAX submissions will also be accepted. In these cases, please submit registration material to Jon Hare (see above).

Registration fees can be paid by check or money order. Sorry no credit cards. Fees must be paid by 1 February 1999 unless special arrangements are made with Jon Hare. Checks or money orders should be made out to **LFC-99**.

For further information please see the conference's webpage or contact Jon Hare

(Continued from page 2)
single group of ichthyologists with this common interest.

So what of the benefits. We meet annually to share this common interest at our centerpiece function, The Annual Larval Fish Conference, and hence we accomplish a means of communication among those of like ilk. We seek to encourage and recognize student research by awarding the Sally Richardson award for best student presentation at these conferences. We further encourage student participation by offering travel grants for these meetings, when we can. We offer the means of further communication with are Newsletter and Webpage, now very well organized and produced.

All of this, as a whole, is not trivial, since through communication we learn. We learn who is doing what, where, when, and how; and perhaps most importantly in a pragmatic sense, with what support. The benefit then is that we can better serve science as its practitioners. I ask all present members to encourage membership among our students and colleagues.

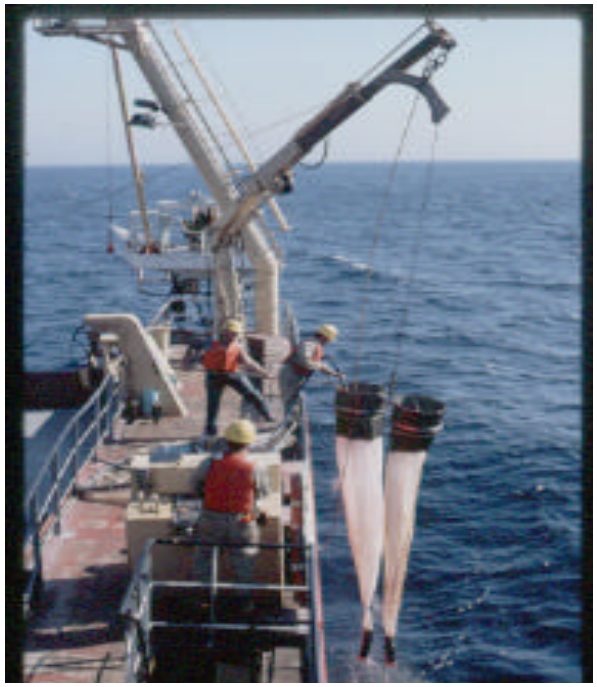
NEWS FROM THE REGIONS

Northeast Region — Ben Letcher, S. O. Conte Anadromous Fish Research Center, 1 Migratory Way, P. O. Box 796, Turner Falls, MA 01376. (Phone: (413) 863-8995 ext 34, Email: bletcher@external.umass.edu).

Fish Ecology Lab, Queen's University, Kingston, Ontario, Canada

The unifying theme of work in Bill Leggett's lab continues to be the identification and quantification of the various biotic and abiotic factors that regulate interannual variability in the growth and survival of ELH stages.

On the marine side of things, recent research efforts have included field-work in coastal Newfoundland as well as on the Scotian Shelf. John Dower (who has since left the lab to start a faculty position at UBC in Vancouver) has been collaborating with Pierre Pepin (Fisheries & Oceans, Newfoundland) since 1995 through a series of cruises in Newfoundland to examine various aspects of the relationship between turbulence and larval fish feeding success. Most of the research has focused on larvae of the radiated shanny, *Ulvaria subbifurcata*. An initial cruise in 1995 consisted of a 23-day time series that examined the turbulence/feeding relationship at a single site on Conception Bay, Newfoundland. This study showed that increased turbulence affected not only the *amount* but also the *type* of food ingested by larval shannies, with the larvae apparently switching to larger prey under increased turbulence. In 1997 we adopted a Lagrangian approach to examine spatial variability in the turbulence/feeding relationship by sampling larval fish and their prey for periods of 3-5 days while following drogued drifter buoys. Sampling was conducted in each of three large bays of differing hydrographic characteristics. In addition to examining larval feeding success we used otoliths to estimate larval growth rates in the three bays. Simultaneous physical measurements included data on hydrographic structure, currents and turbulent mixing. Preliminary results suggest significant between-bay differences in larval growth rates. Whether this is related to between-bay differences in turbulence and mixing remains to be seen. We hope to present our results at the ASLO Aquatic Sciences Meeting in Santa Fe in February and at the upcoming Larval Fish Meeting in Beaufort in April.



Ichthyoplankon sampling on Conception Bay

We recently completed a third field season in coastal Newfoundland, again on Conception Bay. The goal of this year's cruise was to examine how spatial patterns in larval feeding and growth are generated in areas without any abrupt changes in hydrographic structure. To do this, we sampled repeatedly along the main axis of the bay over a period of three weeks. By day we collected ichthyoplankton and zooplankton samples to examine along-bay trends in feeding success in response to the offshore gradient in mixing intensity. We also used a Self-Contained Autonomous Micro-Profiler (SCAMP) to collect turbulence profiles along the transect. By night, we conducted a series of Acoustic Doppler Current Profiler (ADCP) transects to calculate fluxes between the two sections of the bay, and between the head of the bay and the shelf. We will use this information to determine whether observed patterns in growth and condition are due to real gradients in response to physical forcing or due to advective transport of ichthyoplankton between the two sections of Conception Bay. Of course, we have to deal with the 1997 data first!

During 1997-98 the lab also collaborated in two GLOBEC Canada cruises with members of the Oceanography Department at Dalhousie University. This work paralleled our Newfoundland research and examined spatial and temporal patterns of feeding and growth around fronts on Western Bank on the Scotian Shelf. Analyses of data form these cruises are still in progress. However, with Western Bank representing a more strongly mixed system than the well-stratified bays that we've been studying in Newfoundland we hope it will provide a means of comparing the role of turbulence in larval feeding ecology across a range of hydrographic regimes.

Matthew Sclafani, a doctoral student in the lab, is currently working for the New York State Department of Environmental Conservation as the Peconic Estuary Program Coordinator. Matthew is completing his thesis and plans to submit it by the first quarter of 1999. For his Ph.D. Matthew examined larval cod (*Gadus morhua* L.) nutritional condition indices, placing an emphasis on larval buoyancy/density methods (density= g cm^{-3}). Larval buoyancy has been proposed as a simple method to assess the nutritional condition of cod larvae, where starved individuals are less dense than well-nourished larvae. Matthew demonstrated that loss of osmotic control (i.e. osmotic breach and failure) significantly changed the density of starved larvae, including those with yolk reserves. Specifically, osmotic breach and failure increased the density of larvae, which could ultimately confound interpretation of feeding effects on buoyancy. We developed a method to separate nutritional and osmotic effects on larval density. Matthew also developed a conceptual model of larval density that included starvation, feeding and osmotic effects. This study examined nutritional effects on larval density while controlling for osmotic effects and demonstrated that osmotic effects confounded feeding effects. We were able to separate the confounded effects with stratified sampling and calibrated the larval cod density model for use as a nutritional condition assay.Matthew also found a strong, positive linear relationship between initial larval density and subsequent mortality. This work represents the first clear link between a larval

condition index and probability of survival, which is an ultimate goal of condition indices. Matthew is currently comparing the larval density assay with other commonly employed nutritional condition indices for cod larvae. This work will determine how buoyancy measures perform relative to other condition indices and will identify other useful condition measures for use in the laboratory and field.

In the freshwater world, Jim Garvey (who has since started a faculty position at Kansas State in Manhattan, Kansas) and Tom Herra are examining growth and size-dependent survival of early stages of *Lepomis sp.* in Lake Opinicon (Queen's University Biological Station). This study involves both laboratory and field-based work. Specifically, they are testing the null hypothesis that mortality does not differ in magnitude between the larval and juvenile stages and that recruitment is regulated by the same factors in both stages. If the null hypothesis is rejected, one alternative hypothesis is that most mortality occurs in the larval stage, another one that cohort strength is set in the juvenile stage. In addition to determining relative mortality throughout the first year (by comparing hatch dates of fish from visual nest surveys, larval tows, and juvenile trawls), growth rates of individuals hatched at different times are being back-calculated to determine if growth rate and survival are related. Jim and Tom are also exploring the question of how two species with nearly identical life histories coexist, given the same resources. This work is part of a larger study to determine whether these fishes are resource-limited during the larval stage and, thus, compete directly with each other. Given the rather patchy distribution of larvae and zooplankton in the lake, the responses are being explored at two spatial scales: site-specific and whole-lake.

Also in the freshwater realm, M.Sc. student Steve Chong is testing the "Species Range Hypothesis" using yellow perch. This past summer, Steve sampled 19 yellow perch populations across their latitudinal range within the province of Ontario. Using otolith-age interpretations, the age structure of each population is being reconstructed and used to estimate the relative year-class strengths present. A measure of the variability in year-class strength of each population will also be calculated for comparison among the populations sampled.

Two new postdocs also joined our lab recently: Peter Grønkjær and Alexander Bochdansky will combine field and laboratory studies in order to investigate how observed feeding rates translate into variability in growth rates in larval marine fish. Cruises to Conception Bay in Newfoundland in July/August and a GLOBEC cruise to the Western Bank off Nova Scotia in October have been used to sample ichthyoplankton and their prey. Laboratory-based growth and consumption experiments will start next spring. Peter will focus on maternal effects on the development of the phenotype. Silver hake (*Merluccius bilinearis*) larvae sampled on the Western Bank are being used to test how strongly feeding, nutritional condition and growth are correlated. Lack of correlation could indicate that maternal effects or genetic control over growth is influencing the growth patterns. In order to investigate these factors, Peter and Tom Herra are analyzing otolith growth during the egg and yolk-sac stages. Peter uses microelectrodes to measure oxygen uptake of individual eggs and larvae in the laboratory in order to establish the relationship between otolith hatch-check size, larval size and metabolic rate during the early formation of the otoliths. Alexander will investigate the extent of food-limited growth for silver hake and the radiated shanny (*Ulvaria subbifurcata*) larvae by comparing growth and feeding in individual organisms. He will perform enclosure experiments with larval shanny to establish gross growth efficiencies at various consumption levels and compare them to energy and material conversion efficiencies of larval cohorts in the field. Central to this topic is the allometric scaling of consumption, growth, protein retention efficiencies and respiration during early ontogeny. Emphasis is put on individuals in order to identify whether there exist consistently better-feeding, faster-growing individuals.

For more information please contact:
Dr. Bill Leggett
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Location http://www.eos.ubc.ca/afs_early

DIRECTORY

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Welcome to the

EARLY LIFE HISTORY SECTION (ELHS)

Of the American Fisheries Society

Welcome to our new home page! The purpose of these pages is to provide a rapid means to disseminate information to ELHS members and anyone looking for information about the ELHS section. As such, these pages will complement Stages, our official newsletter

We are currently testing an online version of Stages. Follow the ELHS Newsletter link in the Directory on the left of the screen

Although still under construction, we hope you will find these pages informative in their present form. If you encounter any problem in viewing this page, please let me know (include the size and resolution of the monitor in your message).

Some of the items currently under consideration for inclusion in these pages are a searchable (and updateable) membership list, downloadable (pdf) versions of older issues of Stages, and an archive of larval fish images and drawings. If you have any comments on these or other elements of these pages, or if you have an ELHS web-page you would like to see linked under the "Other Links" section, please email me.

John Dower
ELHS Webmaster

Visit to new ELHS Homepage!!
The site contains full details of meetings, a membership directory and back issues of Stages!!!

Northcentral Region. David Culver, Department of Zoology, The Ohio State University, 1735 Neil Ave, Columbus, OH 43210-1220. (Phone (614) 292 6995, E-mail: culver.3@osu.edu)

A Focus on Yellow Perch

For several years there has been concerns over the status of yellow perch populations in Lake Michigan. In the early 1990's catch rates in the commercial fisheries in Wisconsin, Indiana, and Illinois all declined markedly. In 1997 all three states closed the commercial fishery and drastically cut recreational bag limits. What caused the declines that forced these actions?

Abundance's of yellow perch in Lake Michigan have fluctuated historically. However, the current declines are the most severe. Over the past 7 years few perch has survived to reach maturity. It seems that something is reducing larval survival and recruitment. Adding to the effects of the year class failures, the size selective nature of the commercial fishery that operated until recently has caused a bias in the sex ratio of the remaining adults so that the spawning stock may now be limited.

To address these concerns the management agencies and academic institutions that border Lake Michigan asked the Yellow Perch Task Force of the Great Lakes Fishery Commission to develop a multi-agency research initiative to elucidate factors possibly responsible for the decline. Management agencies have increased fishery-independent monitoring to provide baseline data. The academic research response has been to develop a series of coordinated Sea Grant projects involving scientists from Wisconsin, Michigan, Illinois, Indiana, Maryland and North Carolina. The coordination between the different groups is a central feature of the research. Individual groups can only sample a limited geographic area at the temporal resolution required. However, by coordinating sampling protocols and then combining results from separate areas around the lake, the group will be able to draw inferences about the mechanisms potentially contributing to year class strength in perch on a lake wide basis. In this article we summarize the focus of some of the projects.

Wisconsin Sea Grant funded two collaborative projects to work on yellow perch in Green Bay and in Lake Michigan. Fred Binkowski, (WATER Institute, University of Wisconsin – Milwaukee), Brian Belonger (WDNR), Jim Rice (North Carolina State Univ) and Tom Miller (Chesapeake Biological Lab) are PI's on the projects. Brian Belonger (WDNR) has been monitoring perch spawning in the southern end of Green Bay for almost 20 years. He has a unique time series of spawning and larval surveys conducted around Little Tail Point. Importantly, the perch population in Green Bay does not seem to be showing the same declines as that in Lake Michigan. Consequently, the Green Bay project provides an important comparison for results from Lake Michigan. The projects involve both field and lab components.

In the field, identical sampling programs sought to follow 4 d birthdate cohorts throughout the summer, from the larval to the juvenile stage. Sampling

was conducted using neuston nets, Miller high speed samplers and beach seines. Larval samples were immediately frozen for subsequent age and condition analysis. Juvenile samples were preserved for age analysis. Samples of the food base were also taken for diet information. Field samples are currently being processed. However, even from the limited data available it is clear that while larvae were abundant in Green Bay, they were extremely rare in samples from Lake Michigan.

In the laboratory, experiments focused on determining the potential role of maternal effects on larval survival and growth. Half-sib groups from 10 different females were produced by artificially fertilizing the eggs of females collected from gill nets set in Lake Michigan. Research aimed to answer two questions: Are there maternal effects, and for how long can they be detected. A replicated experiment in which half sib groups were either fed or starved was used to address both questions. The fed group were followed for 30 days following hatching, to a size at which they would switch from the pelagic to a benthic mode. Larvae were sampled every 2 d from the tanks to assess growth and condition. Results are currently being analyzed. The data collected in the laboratory will be used to explain patterns observed in the field collections.

Michigan Sea Grant funded Dave Jude (Univ. Michigan), Scott McNaught (Michigan Central University) and Mary Bremigan (Univ. Michigan) to conduct work in the Lake. Dave Jude's efforts focus on larval collections in the Grand Haven area. These collections extend a time series of similar collections that Dave has been making for several years now. Similar to the results of the Wisconsin group Jude found few larval perch in his samples. Scott McNaught conducted similarly sampling efforts along the northern shore of the Lake and at several inland lakes. He is currently analyzing results. Mary Bremigan's interests lie in the dietary patterns in perch. She has received zooplankton samples from Green Bay and Lake Michigan. The results from these samples will be compared with gut content information from those larvae collected in both sites to see if dietary differences exist.

Indiana Sea Grant funded John Jansen to conduct field sampling in the southern basin of Lake Michigan. His project was closely coordinated with efforts in Michigan and Wisconsin.

Finally, John Dettmers (Illinois Natural History Survey) also conducted sampling in Lake Michigan north of Chicago. These collections extend a time series of samples that INHS has collected for several years. John's interests focus on the interaction between perch and their food supply. As with all other sampling INHS efforts were coordinated with those in WI, MI and IN.

If you want to know more about any of these projects, please contact the individual PI's

If you have any information on ELH research being conducted in the Northcentral region, please contact David Culver, or Tom Miller so that we can show case research from this region in future issues.

Affiliate Members!

We have completed a project to update our database of full and affiliate members to make contacting section members more efficient. This list will allow us to contact voting members at election time and to send out reminder notices to affiliate members in a more timely and efficient manner. Until now, we have had a policy of sending out copies of Stages to all affiliate members in good standing as of December 1995. Now all affiliate members will be receiving dues reminder notices as their membership expires. We ask that you please submit your dues to Kathy Lang, the section treasurer. Kathy is continuing to find ways to ease payment for our foreign affiliates, until that time, checks and money orders only please. If we do not hear from you we will stop sending the newsletter!

PERSPECTIVES

This Perspectives essay is based on the keynote address at the 22rd Larval Fish Conference in Ann Arbor, MI., delivered by Dr. Jim Rice. Jim is a professor in the Department of Zoology at North Carolina State University. Jim has been at the forefront of efforts to assess whether the few fish that survive to recruitment possess a unique suite of traits or are simply lucky. His doctoral work on recruitment in bloater (*Coregonus hoyi*) in Lake Michigan was one of the first studies to use this approach. Over the past few years Jim has been applying this approach as a part of a multi-disciplinary project investigating the early life history of menhaden (*Brevoortia tyrannus*) within the South Atlantic Bight Recruitment Experiment (SABRE). The SABRE project brings together physical oceanographers, and ecologists to determine when in the life history of menhaden year class is set, and which mechanisms may be responsible. Jim's other research interests include the role of size-based interactions in aquatic predator prey systems, and the impact of low oxygen conditions on estuarine fish communities.

Evolution of the Process-Oriented Approach to Recruitment Dynamics in Fishes

The meeting theme for our 1998 Larval Fish Conference prompted two questions in my mind: "What exactly is a 'recruitment process?' and "How is it that recruitment processes have become such a central focus in our field?" I would like to share my own perspective on the evolution of our approach to fish recruitment questions, and then share a few ideas about the most useful future contributions of the process-oriented approach to our understanding of larval fish ecology and recruitment dynamics.

Recruitment variability is a very old problem; today it's one of the most prominent issues in early life history studies, but historically most efforts to understand recruitment variability focused on big fish. Although Hjort (1914) proposed the critical period concept 75 yrs ago, in the old days most available information was limited to data from commercial fisheries and sampling adult fish. The classic approach was stock-recruit, mainly because it was most feasible with the data at hand.

Although theory and common sense tell us that at some level there has to be a linkage between spawning stock and abundance of recruits, the fact is, such a relationship is often weak or undetectable in field data. This uncertainty may simply reflect our inability to measure these parameters adequately (Walters and Ludwig 1981). However, about 30-40 yrs ago there seemed to be a growing consensus that understanding recruitment variability would require knowledge of the processes that modify survival between spawning and recruitment.

It was at this stage that the baton was passed to those of us interested in the ecology of larval fishes; the big-fish biologists said "Hey, most of the mortality occurs when fish are little, so YOU figure it out!" As a result, tremendous effort was focused on trying to identify the key source(s) of larval mortality and when and how they act, with the notion that if we could account for the causes of mortality, we'd understand what controls year class strength. This research taught us a great deal about sources of mortality, but the magnitude of uncertainty in abundance, and consequently in mortality estimates, was far too great to adequately discriminate causes of variation in survival.

One of the most important contributions to emerge from this

effort was the development of lab-rearing techniques for larvae and their food (Blaxter 1995). To understand how the processes affecting larval survival work, we needed to do experiments, and we couldn't do experiments without larvae. These tools allowed tremendous growth in our knowledge of the fundamental ecology of larval fishes. At this stage our approaches in both the field and the lab tended to be species-specific, and tended to treat hypotheses individually: what's important for my species - predation, or starvation, or transport, or what?

As this information accumulated, there were three fairly dramatic philosophical shifts in approach. The first was a shift from species-specific analyses to recognition of general relationships that unify patterns across species, exemplified by the Miller et al. (1988) synthesis of body size effects on recruitment mechanisms. This paper showed that many differences among species can be accounted for in large part by differences in size at hatching.

The second change was a shift from focus on individual, alternative hypotheses to multiple, interacting hypotheses as it became increasingly clear that processes affecting survival do not act independently. For example, starvation is one extreme of a growth rate continuum; growth rate dictates stage duration and body size affects predation mortality, and so on. General frameworks linking these interacting processes began to emerge, integrating the dynamics of biological processes such as feeding, growth, and vulnerability to starvation and predation with effects of abiotic factors like temperature and transport dynamics. Note that these interactions aren't system-specific. If we compare recruitment dynamics in freshwater and marine systems, as Ed Houde (1994) has done so well, we do see some general differences in the relative importance of different processes in different systems. But I contend that the underlying rules of the game remain the same; the same processes can produce very different outcomes depending on the characteristics of the environment and the particular species.

The third change was a shift from a population level approach to the level of individual animals. The mechanisms that govern survival, and ultimately evolution, operate at the level of the individual. If individuals don't vary much, then predictions based on the average larvae may be fine. But when individuals vary in some important way, the population result may depend heavily on a small minority of atypical individuals.

Two technological developments really precipitated this focus on individuals. The first was otolith analysis. It's hard to imagine our field before daily otolith increment analysis, but application of this technique is really only about 20 years old. The ability to extract information from individual fish larvae allowed development of the "characteristics of survivors" approach; instead of asking what accounts for all the mortality, we can ask what's different about survivors, and let that help us narrow the list of important mechanisms governing survival.

The second key technological advance was development of the personal computer. Again, it's hard to imagine our field without microcomputers, but we've also only had them around for about 20 years. Advances in computer speed and memory have made possible the development and application of individual-based simulation models, which have become one of our most powerful tools for exploring the consequences of the interacting processes affecting larval fish survival.

So, in just a few decades our approach to recruitment dynamics has shifted dramatically from a stock-recruit approach at the population level focused on adults, to a process-oriented approach at the individual level focused on early life history stages. These are what we have come to call recruitment

processes - basically any process that affects how many little fish will grow up to be big fish. The conceptual and analytical frameworks emerging from this effort apply across taxa and systems, and can often provide powerful insights regarding the contribution of various processes in governing survival of fishes. They are especially useful in evaluating the potential importance of a particular mechanism, while taking into account the influence of other interacting effects and the variability that naturally occurs in the real world. By using an individual-based, process-oriented approach we are able to combine information from different sources in ways that allow us to address questions about recruitment dynamics we couldn't otherwise tackle.

There is no question our knowledge of larval and juvenile fish ecology and the factors that affect survival has come a long way. Despite this progress the fact remains that except in rare cases we still lack reliable predictive relationships for year class strength. So how should we proceed? The default strategy is to simply keep trying harder and hope that clarity will emerge. But I would argue that if that approach was going to yield definitive answers, it would have done so by now. Even if our current models of how the world works are correct, practical limits on our ability to collect the data necessary to apply them, and the uncertainty of those requisite data estimates, may preclude better predictive resolution.

Alternatively, instead of saying "In order to deal with recruitment variability we have to be able to predict it," maybe it's time to turn that problem around and begin asking "How can we best cope with recruitment variability given that we can't fully predict it?" That switch in perspective leads to a different set of questions. Up to this point the process-oriented approach to recruitment dynamics has been focused primarily on asking: What are the key mechanisms affecting survival and year class strength? When do they act? How do they interact? This approach will continue to help us clarify these issues, but I suggest that its utility will be greatly enhanced if we also begin to ask what it can tell us about the nature of uncertainty and limits on predictability of recruitment: How much variability is inherent in the key process(es) affecting year class strength? How do practical limitations on data collection contribute to uncertainty in predictions? What inferences can we draw from our work that will help managers cope with uncertainty in practical terms?

Ironically, the same analyses that show that a particular process may have significant effects on interannual variation in survival may also demonstrate that we are unlikely to be able to quantify these effects in the field. In such cases it may be more useful to focus on the magnitude and consequences of uncertainty than on trying to predict specific effects on survival. I think the process-oriented approach to recruitment dynamics can offer some valuable insights concerning these questions, and I encourage you to consider how you might address them in your own work.

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MEETING REVIEW

22nd Annual Larval Fish Conference

Ann Arbor, MI
9-13 July 1998

Early Life Dynamics of Fishes.

This session focused on processes that occur and interact over a range of spatial and temporal scales to produce the patterns and trends in growth and abundance that we typically observe in cohorts of larval fish. Within this general theme was an invited session on ELH dynamics in fishes of the Great Lakes, and a contributed and poster sessions.

Roseman et al. delivered the first talk in the invited session. They discussed effects of storms on walleye egg survival in Western Lake Erie. Storm events, associated with cold temperatures, are known to affect walleye recruitment. Roseman estimated that in April 1998, most of the walleye egg production deposited on shallow water reefs was lost during a major storm, which limited subsequent larval and juvenile abundance and potential recruitment.

Jude presented an analysis of historic field studies to test hypotheses about the recent recruitment failure of yellow perch in Lake Michigan. Historically, abundance's of alewife, the major predator of yellow perch larvae, varied inversely with yellow perch abundances. Jude suggests that the present decline in yellow perch recruitment is not caused by alewife predation because alewife densities have remained constant during this period.

Dean Fitzgerald presented an analysis of size distributions of fall YOY and spring yearling yellow perch populations around the Great Lakes to determine the relationship between lake size and overwinter survival. The smallest yellow perch which survived was independent of lake size.

Effects of habitat on early life dynamics and community composition characterized the next few talks. Woldt and Rutherford contrasted dynamics of steelhead production in 2 Lake Michigan tributaries. Both rivers have similar watershed characteristics, but one is dammed, and has stressfully high summer temperatures in the steelhead nursery area. The major effects of temperature on steelhead parr dynamics were on survival and ontogeny of production, but not growth. Although egg and early fry production was much higher in the dammed tributary, late-stage young-of-the-year (YOY) and smolt production was higher in the stable, coldwater tributary due to higher parr survival. Results suggested manipulation of tailwater temperatures by dam operators potentially could increase parr survival and smolt production.

Newcomb presented additional evidence for temperature limitations on growth, survival and production rates of steelhead in Lake Michigan tributaries. The relative contribution of parr production in small, thermally-stable tributaries greatly exceeded the production in larger, thermally-unstable mainstem habitats.

Mitro and Zale characterized movement of rainbow trout parr among habitat types in the Snake River, Colorado. Eagan characterized the species composition and diversity of the larval fish assemblages in 3 Northern Lake Huron embayments.

Auer submitted an abstract on larval lake sturgeon drift in the Sturgeon River, Michigan.

Contributed Session

Friday's contributed paper session was composed of presentations on age and growth histories of larvae immigrating into coastal estuaries, a laboratory study of larval feeding, modeling and

field studies of spatial and temporal distributions of larvae, and models of larval recruitment and predation mechanisms.

Wasaff et al. related age and growth patterns of larval spot migrating through North Carolina inlets to identify origin of the offshore stocks. Their results suggested one stock contributed to both inlets.

Cheshire and Rice presented data on growth histories of Atlantic menhaden larvae immigrating through North Carolina inlets to characterize offshore events which may influence variability in survival. They found individuals immigrating from the same cohort arrived at the inlets at different ages, with high variation in growth rates. The results suggested larvae had experienced different transport paths and/or environments of prey and predators.

Harding reported a laboratory feeding study of 3 species of fish larvae inhabiting oyster reefs in Chesapeake Bay. She examined effects of larval age, density and prey density on feeding selectivity by naked goby, striped blennies, and feather blennies. Predator age and prey species concentration affected selectivity. All species examined showed preference for bivalve veligers, which may influence settlement patterns.

The next 3 talks examined hypotheses to explain spatial or temporal distributions of fish larvae. Sale and Danilowicz examined temporal settlement patterns of reef fishes using an individual-based model (IBM). Inputs were variation in spawning times, larval mortality rates and stage durations. The simulations were comparable in most cases to observed settlement patterns.

Reiss et al. described spatial distributions of larval fish in the Northwest Atlantic in relation to water mass structure and circulation of density-driven surface currents. Surface current circulation was estimated using a "simple" method known as the dynamic height method. Spatial distributions, sizes and abundances of many species of larvae were explained by advection and retention determined by the density-driven flow.

North and Houde examined distributions of bay anchovy eggs and larvae in Chesapeake Bay in relation to physical and biological factors. Larvae showed finite distributions within the water column relative to their zooplankton prey and gelatinous predators. Ontogenetic development of vertical migration behavior, combined with short-term variation in hydrographic conditions, potentially may influence larval transport, spatial distributions, and co-occurrence with prey and predators.

The final 3 papers used IBM simulations to examined recruitment dynamics and size-selective mortality in larval fishes. Wang et al. examined stable ocean and match-mismatch hypotheses to explain recruitment variability in northern anchovy. Simulations suggested that the scale of recruitment variability, mechanisms of recruitment, and stage at which recruitment is determined all varied with population size. Paradis et al. used an IBM to examine components of vulnerability (susceptibility, encounter) which may generate size-selective mortality of fish larvae. In a second paper, she compared observed size frequency distributions of larvae in Conception Bay, Newfoundland to distributions predicted by IBM simulations. Model results suggested mortality rates of larvae increased with size.

Poster Session

Three posters were submitted. Steingraeber et al. described evidence for paddlefish spawning in the Chippewa and Wisconsin Rivers. Peck et al. described an energy budget and discussed its implications for life history strategies of the inland silverside in a Rhode Island estuary. Swank et al. reported on the use of otolith trace element composition to discriminate stocks of steelhead in Lake Michigan.

Ed Rutherford

Otolith Chemistry Symposium

Although studies of otolith chemistry date back more than 20 years, the approach has only recently generated widespread interest among fish ecologists. This symposium was designed to highlight some of the most recent and exciting applications of the technique, and drew speakers from Australia, Canada, Sweden and the United States.

A good deal of the renewed interest in otolith chemistry can be attributed to developments in analytical methodologies, and particularly to the commercial production of inductively coupled plasma mass spectrometry (ICP-MS) instrumentation. Over half of the talks in the symposium were based on ICP-MS data, which probably reflects both the popularity of the technique and the bias of the symposium organizer. As with any analytical technique, however, the data reported in otolith studies is determined by the quality of the sample preparation, and the skill of the analyst. Two papers addressed this problem directly. Lyn Beary, of the National Institute of Standards and Technology, reported preliminary work by NIST and co-authors at Old Dominion University to develop techniques for accurate characterization of first row transition elements in otoliths. They outlined a number of potential pitfalls, and highlighted the need for a reference material to ensure data quality among labs. Steve Shuttleworth and Simon Thorrold also noted a number of problems with conventional ICP-MS, and how at least some of these problems may be overcome with new generation ICP-MS instrumentation that feature a high resolution sector field, rather than a quadrupole, mass analyser. They also showed that the sector field ICP-MS instruments couple well with laser ablation systems to allow high resolution spatial analysis of sectioned otoliths. Graham Forrester and co-authors addressed the reliability of chemical signatures in otoliths from a practical, rather than analytical, perspective. They examined inter-annual and inter-specific stability of these signatures from estuarine-dependent juvenile fish along the coast of California. Significant variability, both between years and among species collected at the same site, underscored the need for a better understanding of the factors determining otolith composition.

Although we clearly have much to learn about the factors determining trace element signatures in otoliths, applications of the technique are already providing useful insights into recurring problems in fish ecology. Karin Limburg used Sr/Ca ratios in the core region of otoliths from adult American shad to determine if juvenile survivorship was influenced by the timing of juvenile outmigration from natal rivers during the first growing season. She found that returning adults were not a random sample of egressing juveniles, and suggested that differential predation rates on early and late-egressing cohorts may play a role in determining which juveniles survive and subsequently return to natal rivers to spawn. Steve Campana presented an example of the use of otolith elemental fingerprinting applied to fisheries management of Atlantic cod in the Gulf of St. Lawrence and on the Scotian Shelf. Whole otolith assays of adult cod while stocks were separated during summer months were used to parameterize a maximum likelihood function for determining stock association of fish collected during annual fall migrations and subsequent over-wintering on the Scotian Shelf. Stephen Swearer and co-authors presented perhaps the most ambitious application in a study of the potential for self-recruitment of larval bluehead wrasse to reefs around St. Croix. Larval growth rate, age at settlement, and otolith chemistry of new recruits were combined with settlement surveys and physical oceanographic measurements to argue that a significant proportion of the recruits to the island were spawned locally. They also suggested that high recruitment occurred during periods favorable for physical retention of larvae. In what became a recurring theme during the symposium, Bronwyn Gillanders and Mike Kingsford hypothesized that otolith chemistry may be useful for determining the contribution of differ-

ent juvenile nursery areas to adult stocks on the continental shelf off New South Wales, Australia. Although they did find differences in otolith chemistry among estuaries, they also noted significant variability among sites within estuaries which may complicate this approach. Will Patterson and co-authors also found good evidence that trace element signatures in otoliths of juvenile red snapper may be specific to regional nursery areas around the northern Gulf of Mexico. Classification accuracy for juveniles collected from Texas, Louisiana and Alabama/Mississippi were better than 90%, clearly suggesting that this technique was worth pursuing in this heavily-exploited species. The final two papers in this section dealt with salmon restoration projects on the east and west coast of the United States. Peter Weber and Lynn Ingram presented preliminary data on the trace element and strontium isotope chemistry of the Sacramento and San Joaquin River systems. Further work is underway to determine if these differences are reflected in chinook salmon otoliths which will, in turn, allow fish from different runs to be separated based on these chemical signatures. Brian Kennedy and co-authors also utilized variable strontium isotope ratios of tributaries, this time in the Connecticut River, to distinguish among juvenile Atlantic salmon using vertebrae and otoliths. Stable nitrogen values in tissues of the juvenile salmon also varied among tributaries, presumably reflecting agricultural levels in the different watersheds. Together, these tracers allowed accurate discrimination of juvenile salmon over remarkably small spatial scales.

The final two papers in the symposium made use of the excellent preservation of otoliths at archaeological sites. John Kalish gave some fascinating insights into the human prehistory of the Willandra Lakes, Australia. Otoliths of golden perch are a major component of recovered faunal remains from campfire sites, and the chemistry of these otoliths may provide unique records of environmental change at the lakes over the last 40,000 years. Bill Patterson described a computer controlled micromilling apparatus that he is using to extract stable carbon and oxygen records in adult freshwater drum otoliths from archaelogical sites around the Great Lakes. High-resolution sampling of otolith carbonate revealed temperature records based on oxygen isotopes from Lake Erie at almost daily time intervals. These data are being used to reconstruct climatic variability in the continental United States over the last millenium.

In summary, it was clear from the talks that otolith chemistry research is expanding rapidly, and is already proving to be a powerful tool in fish ecology and paleo-climatology. It was also apparent that although some stable isotopes appear to be deposited in equilibrium with the ambient environment, this may not be the case for trace elements. More work, probably under laboratory conditions, is sorely needed. Nonetheless, I think that the success of the symposium was evident when our esteemed section president, a skeptic of some renown, approached me after the symposium and suggested that 'maybe there **is** something in all this otolith chemistry hype, after all'.

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Sally Leonard Richardson Best Student Paper Award

The award for the best student presentation this year went to Sharon Herzka for a paper co-authored with Joan and Scott Holt on "Determination of stable isotope turnover rates for red drum larvae and potential applications to habitat and recruitment studies." The paper was presented in the Otolith Chemistry symposium. Sharon is pictured on the left receiving the award from section president Jeff Govoni. For a background to the award, please see p. 18.

Determination of stable isotope turnover rates for red drum larvae and potential applications to habitat and recruitment studies.

Sharon Z. Herzka, G. J. Holt and S. A. Holt. University of Texas at Austin, Marine Science Institute, 750 Channelview Drive, Port Aransas, TX 78373. (Iguanas@utmsi.utexas.edu)

Stable isotopes have been used to examine food web carbon sources, trophic links and migration patterns. Many marine fish exhibit abrupt habitat and/or dietary shifts during early life. Because rapidly growing animals quickly reflect the isotopic signature of a new diet, stable isotopes may be useful as tracers of recent habitat change, including recruitment to nursery areas. Settlement may be traced as larvae go from a pelagic habitat based on planktonic food sources to a demersal habitat based on benthic primary producers. Utilizing stable isotopes as tracers requires information on turnover rates and evaluation of the potential effects of ontogenetic development on fractionation. We determined turnover rates for carbon and nitrogen by switching laboratory-reared red drum (*Sciaenops ocellatus*) larvae of various sizes from an initial diet of known isotopic composition. The extent of fractionation as a function of age and size was determined by raising fish on an isotopically constant diet. These data will be utilized in conjunction with published growth rates for natural populations to estimate how quickly red drum larvae should reflect a shift in the isotopic composition of their diet during the transition from the plankton to nursery areas.

Previous recipients

1998 Sharon Herzka (UT Austin)
1997 Jennifer Caselle-Reinhardt (Univ of California - Santa Barbara)
1996 Jay Rooker (UT Austin)
1995 F. Javier Gago and Ilona Stobutzki (Joint award)

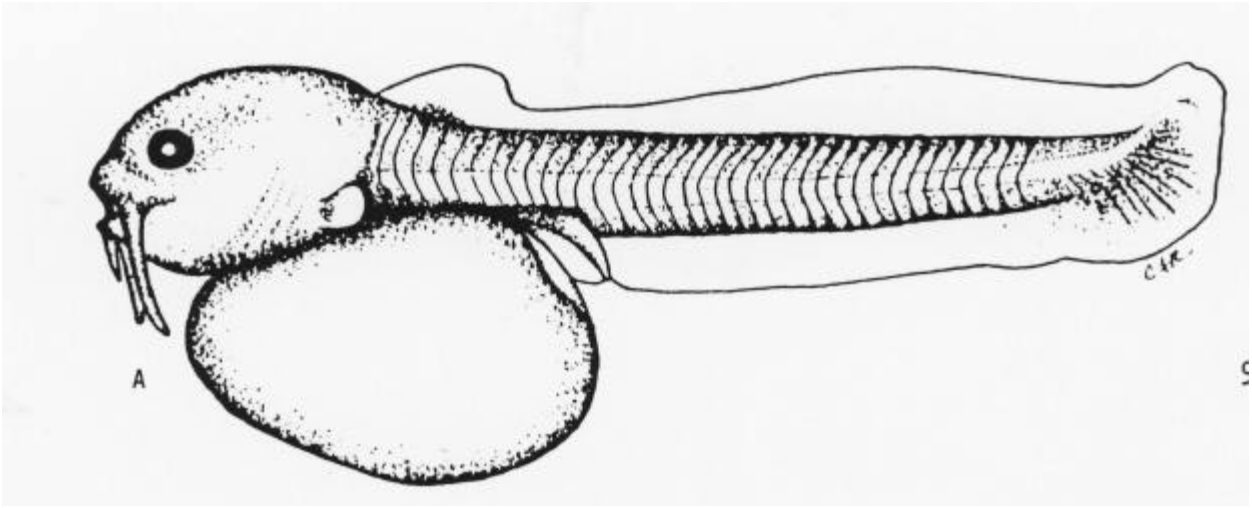
Background to the Sally L. Richardson Award

Sally Leonard Richardson was a dedicated and formidable woman, and a resourceful student of the ontogeny of fishes, principally the study of larval fish form and its application to the understanding of fish phylogeny. Sally died on route to the 1986 Larval Fish Conference in Miami.

Sally obtained her Ph.D. from the Virginia Institute of Marine Sciences in 1971 for her work on the early life history of bothids. From there, Sally's career took her to Oregon, Mississippi and Massachusetts, where she continued her work on the systematics and distribution of fishes. Although Sally's early papers were extremely descriptive, her work grew to include an increasingly more prominent phylogenetic aspect. In fact the paper she was due to present in Miami combined larval descriptions with classical systematics.

So bereaved by her passing was one of her friends and colleagues, that this anonymous benefactor appropriated personal funds to establish a 'best paper' award in her memory. Thus, the inaugural Sally Leonard Richardson Award was made in Miami in 1986. A committee was established in the Spring of 1988 to consider the long term future of the Sally Richardson award. The committee recommended that the Richardson Award should become a student award, that is should not be restricted by citizenship, nor by membership in the Section or its parent society; and that the local committee of each Larval Fish Conference appoint judges and execute the competition. In addition, this committee developed judging criteria for their National Meeting Awards. The status of the award was reassessed in 1997 by an *ad hoc* committee. In consultation with the original benefactor the committee recommended that the Richardson Award should "remain a student award because Sally was so involved in stimulating students," (the words of the benefactor). The committee also recommended that the endowment be increased to become self-supporting, and hopefully increased in the future. Currently, the award is accompanied by a handsome plaque, a check for $150 and, at the request of the originating benefactor, a reprint of Sally's obituary report published in Copeia.

Simply stated the Sally Richardson Award is the most prestigious award the section can bestow.



Ictalurus nebosus

Larval Fish Feeding Ecology

The final day of the conference focused on the issues pertaining to the feeding ecology of larval fish. Fourteen talks were delivered on topics that ranged from the early life history of swordfish (Govoni et al.) to whether there are natural athletes in the larval fish world (Fuiman and Cowan).

The session started with a modeling paper by Miller, Dower and Juanes in which they suggested selective feeding by larval fish can result largely from physical constraints rather than by needing to invoke behavioural mechanisms. Miller et al's model predicted selectivity curves similar to those observed in lab and field experiments in the complete absence of any behavioural algorithm. In the paper immediately following, Cox demonstrated elegantly that behaviour was responsible for, or at least could modify selectivity in the Australian greenback flounder (*Rhombosolea tapirina*). The juxtaposition of these two papers was not lost on the audience or on the presenters. Broughton then presented evidence of interannual differences in selectivity of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) on George's Bank.

The next three talks in the morning session, presented by Claramunt and Wahl, Goodrich et al. and Smith and Wahl, focused on the link between habitat and feeding ecology in riverine systems. The first two talks examined the link between habitat, particularly near shore and backwater habitat on plankton dynamics. Smith and Wahl looked at the role of the timing and amplitude of the spring flood in determining year class strength of fishes in rivers. Smith and Wahl cleared demonstrated that for their rivers, the pattern and nature of the spring flood was responsible for a significant amount of the variability in fish recruitment.

The next group of talks were part of a session on individual based effects in fish ecology organised by Jim Cowan. In the first paper, Sue Sogard presented some results of her work on the fast growing sablefish (*Anoplopoma fimbria*). As adults these fish live at cold temperatures at great depth in the eastern North Pacific. Consequently, most of the important growth dynamics in these fish occurs in the juvenile phase. Sue's experiments clearly showed the plasticity of growth in this species. Fuiman and Cowan then presented a pair of talks on their NSF-funded work on patterns of covariation in feeding and predator avoidance performance in larval fishes. Fuiman, with exemplary use of PowerPoint, described the nature of the suite (Olympiad) of tests to which they subject individual fish. By performing the suite of traits on the same individuals, Fuiman and Cowan are able to determine whether some fish possess above average abilities across the board, or whether good performance in some arenas is gained at the cost of lower performance in other areas. Do surviving larvae all come from Lake Wobegon?

Grace Kelin MacPhee et al. considered vulnerability to predation of larval cod from an individual point of view. Their experiments in the MEERL tanks used an unusual predator, a pelagic hydroid *Cytia gracilis*. Surprisingly, their results indicated that this predator has the potential to significantly impact larval abundance, particularly for extremely young individuals.

The final session of the conference included three talks that encompassed a wide range of spatial scales. Berkely and Bobko presented the results of their work on age-related differences in spawning time and its potential impact on recruitment in black rockfish (*Sebastes melanops*). The final two papers moved the focus to the east coast. Curran et al. examined whether vertical migration behaviour observed in winter flounder (*Pseudopleuronectes americanus*) caused larvae to be retained within nursery habitats in New Jersey estuaries. Finally Govoni et al. examined field collections of swordfish larvae to infer the existence of a probable spawning area off of the southeast US.

Tom Miller

DATES TO REMEMBER

Dec 1-2, 1998	Flatfish Biology Workshop	Mystic, CT
Feb 1 - 5, 1999	American Society of Limnology and Oceanography Annual Meeting	Santa Fe, NM
April 6-10, 1999	22nd Annual Larval Fish Conference	Beaufort, NC
June 24-30, 1999	79th Annual Meeting of the American Society of Ichthyologists and Herpetologists	University Park, PA
August 29 - Sept 2, 1999	American Fisheries Society Meeting	Charlotte, NC

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