STAGES

VOLUME 42 (3) **Dec 2021**

INSIDE THE ISSUE

ELHS BACK IN THE DAYS

5 years ago:
ELHS editor Lee Fuiman steps down as editor after 11 years. Audrey Geffen and Cindy van Damme take over the job as editors

20 years ago:
25th LFC held in Sandy Hook, New Jersey.

30 years ago:
15th LFC held at University of Southern California

35 years ago:
New record for newsletter: 36 pages!

40 years ago:
107 people from US and Canada attended 5th LFC at Louisiana State University

MESSAGE FROM THE EDITORS

Dear Early Life History Researchers and Enthusiasts,

We are happy to present you the latest edition of our STAGES newsletter with contributions and exciting research from around the world.

Unfortunately, we are also mourning the loss of three giants in the field who were influential members of this section and who are honoured in this edition.

We would like to thank all contributors to submit the great content and look already forward to the next one, scheduled for Spring 2022 with an submission deadline by Feb. 1st 2022.

Elections are coming up in the New Year! Please send your nominations for president and secretary to alison.deary@noaa.gov by December 31st 2021.

Simon and Peter

AFS ELHS SOCIAL MEDIA STATEMENT

The American Fisheries Society (AFS) Early Life History Section (ELHS) is a diverse group of researchers who span every continent on the globe. As such, social media is a great opportunity for our section's researchers to connect and engage with each other outside of our annual meeting.

The ELHS's Early Career Committee manages our social media platforms. Their goal is to feature and promote the great work (current and upcoming) that our members are doing. As our section continues to grow, we want to grow our social media presence, too. We need your help to do this!

If you, or anyone in your research group, has content that may be relevant to the AFS ELHS please email it to afs.elhs@gmail.com. Some examples would be photos of you in the field, newly published papers, a blurb about a recently funded grant, etc. This is a great opportunity for you to share your research to a broader audience and to connect with others studying the early life stages of fishes. When possible, include photos, videos, links to papers, and a caption (max 280 characters). Also provide the names of any accounts you would like us to tag. We will review these materials and if the content aligns well with our section we will post it to our Twitter and/or Facebook page.

If you post elsewhere, please consider using the #AFS_ELHS hashtag or tagging us (@AFS_ELHS on Twitter; @earlylifehistory on Facebook) in relevant content so we can better engage with you.

Finally, if there are any accounts that you feel are relevant to the AFS ELHS that we are not already following, please tag us.

Thank you, in advance, for engaging with us!

Kind regards,

The AFS ELHS Early Career Committee

NEWS FROM THE REGIONS

EUROPEAN REGION

SMALL PELAGIC FISH EGG PREDATION

Susana Garrido, Portuguese Institute for the Sea and Atmosphere (IPMA)

After the successful acclimatization of the European sardine (*Sardina pilchardus*) by the team of the Aquaculture Station in Olhão, Portugal (EPPO – IPMA), egg predation experiments included in project SARDINHA2020 and postponed due to the pandemic, finally took place this year, done by S. Garrido and P. Fonseca. Adults of sardine and chub mackerel were offered different concentrations of fish eggs and other prey types, at different temperatures, with the objective of estimating the daily ratio of eggs consumed by these pelagic species and their potential impact on egg mortality. Previous stomach content analysis of coastal pelagic fish revealed that sardines and chub mackerel are the main consumers of fish eggs. While sardine and anchovy eggs are easily identified, due to the large perivitelline space or ellipsoidal shape, other fish eggs, frequent and abundant in the stomachs, were not possible to identify by visual inspection. We have been collaborating with Ana Veríssimo of the Research Centre in Biodiversity and Genetic Resources in Portugal (CIBIO) to be able to identify the eggs, combining traditional Sanger sequencing of individual eggs with metabarcoding of multiple eggs on a per stomach basis using COI and 12S mitochondrial markers. The diversity of fish eggs in the stomachs is impressive, and includes species such as bogue, *Boops boops*, thinlip grey mullet, *Chelon ramada*, or the Axillary seabream, *Pagellus acarne*. This diversity varies spatially and according to the predator. We plan to finish these papers and submit to publication soon. The work is part of a large Portuguese project SARDINHA2020, financed by MAR2020, which aims at developing an Ecosystem approach to purse-seine fisheries management.

(Photos P. Fonseca).

Figure 1: Pedro Fonseca, AnaVerissimo, Susana Garrido

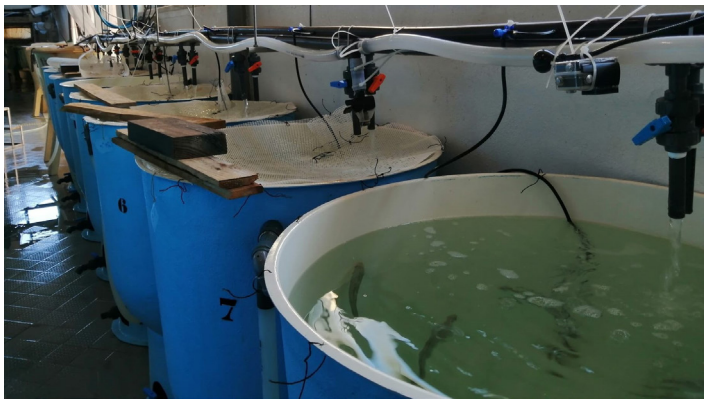


Figure 2: Egg Predation Experiments

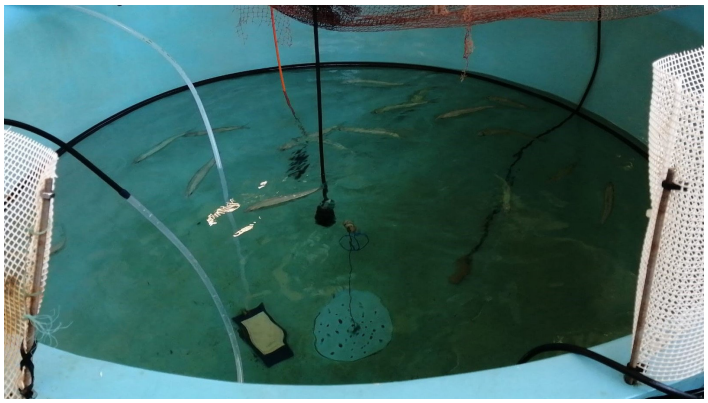


Figure 3: Egg Predation Experiments

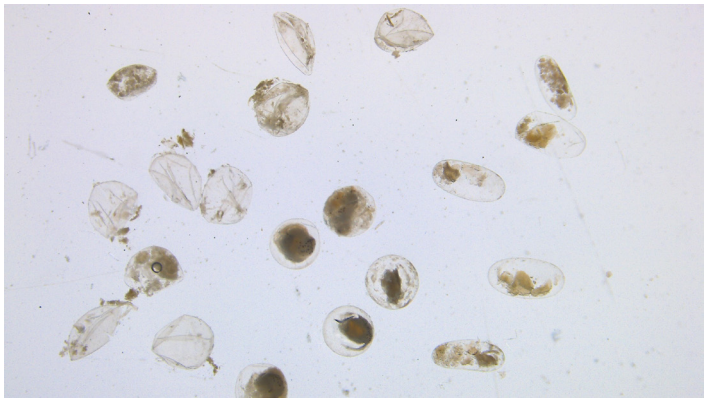


Figure 4: Fish Eggs in the Stomach

HIERARCHICAL ANALYSIS OF ONTOGENETIC TIME TO DESCRIBE HETEROCHRONY AND TAXONOMY OF DEVELOPMENTAL STAGES

Nalani Schnell, MUSÉUM NATIONAL D'HISTOIRE NATURELLE, Station Marine de Concarneau

Even though an accurate description of early life stages is available for a few teleostean species in form of embryonic or post-embryonic developmental tables, there is poor overlap between species-specific staging vocabularies beyond the taxonomic level of family Urho (2002). For instance, Peñáz (1983) showed that the development of anatomical characters during the "larval period" differs in Coregonidae, Thymallidae, Osmeridae and Salmonidae, three families belonging to the same order. The difficulty of a common staging vocabulary is therewith considerable among teleosts. The onset and the end of the "larval period" is still a matter of strong controversy, as convincingly exposed by Urho (2002). Criteria by which a teleostean "larva" is defined have never been consensual. What is a larva in non-amniotic vertebrates? The same conundrum befalls the concept of metamorphosis, because one of the landmarks for defining the end of the larval period is precisely the onset of metamorphosis (see Fuiman's (1998) ontogenetic index).

Heterochrony is often suggested but rarely measured. We developed an unified comparative method which consists of **phylogenetic hierarchization of ontogenetic time** to (i) design a unified frame of reference and nomenclature for **organizing developmental stages** for any set of species; and (ii) detect **heterochronies**. This method is not just a novel measurement of absolute developmental chronology and staging but a nominalistic way to hierarchize relative stages from a matrix of species comparisons of anatomical characters (or transcriptomes) present or absent at different degree-days of development. From fecundation to juveniles the ontogenetic time (measured in degree-days) is arbitrarily segmented in % (e.g. 25%, 50%, 75%, Figure 5). Each species (Sp1, Sp2…) at a given time is an OTU of a data matrix where each organ or anatomical trait of interest is a character coded "0" if absent at the corresponding time and "1" if present. A parsimony analysis produces a rooted non cyclic connected graph to hierarchize the ontogenetic time. As development is a cumulative process through time, the hierarchy provided by the most parsimonious (= the most consistent) tree is a time hierarchy. Therefore, it is logical to define the outgroup

(the root of the tree) at the boundary 0%: outgroups will be OTUs at 0% of their development (no traits). Potential loss of organs or traits during the development will appear as character reversals, which is classical in such analyses.

We published a parsimony analysis of 53 characters coded for four time-segments and four teleostean species: *Tinca tinca*, *Barbus barbus*, *Hucho hucho* and *Thymallus thymallus* results in two equi-parsimonious trees of length of 62 steps (strict consensus shown in Figure 6), with a consistency index of 0.85 and retention index of 0.96. Such high consistency values mean that the developmental time is a hierarchical time, in other words (1) the rise of organs is overall cumulative and (2) their timing is much similar between the four species. At 25% and 50% of their developmental time, *Hucho hucho* was late compared to *Thymallus thymallus*; grayling is late compared to *Tinca tinca*; tench is late compared to *Barbus barbus*. It is interesting that this trend is modified at 75% of the developing time, where *Tinca tinca* is late (white arrow in Figure 6): at that time segment, it does not yet exhibit characters 46, 49 and 52 in contrast to all other species (46 is the onset of lepidotrichia in dorsal fins, 49 is the onset of lepidotrichia in anal fin, 52 is the onset of lepidotrichia in pelvic fins). The presented method in our paper performs a phylogenetic segmentation of ontogenetic time, which can be correctly seen as depicting ontophylogenesis. Find out more in the published paper:

Lecointre, G., Schnell, N.K. & Teletchea, F. Hierarchical analysis of ontogenetic time to describe heterochrony and taxonomy of developmental stages. Sci Rep 10, 19732 (2020). https://doi.org/10.1038/s41598-020-76270-4

References:

Fuiman L.A. et al. (1998) Copeia 1998(3): 602-611;

Penaz M. (1983) Folia Zool. 32(4): 365-378;

Urho L. (2002) Folia Zool. 51(3): 161-186.

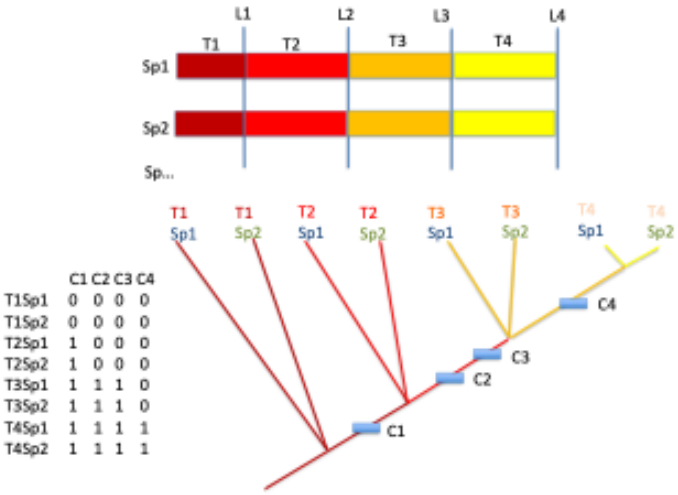


Figure 5. General methodological framework. Colored bars are developmental time for species 1 (Sp1) and species 2 (Sp2), and more species. L1, L2, etc. are arbitrary time landmarks measured as percentage of time (in degrees Celsius-days of development) of the full development from fecundation (0%) to the rise of lepidotrichia in pectoral fin rays (100%). Time segments T1, T2, etc. are defined between landmarks. The matrix at bottom left records presence and absences of various organs and traits as characters (columns: C1, C2, etc.) for each Operational Taxonomic Unit (line). After Lecointre et al., 2020.

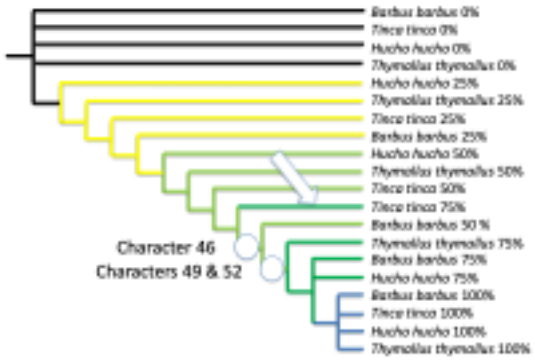


Figure 6. Strict consensus of two equi-parsimonious trees with the length of 62 steps, consistency index of 0.85 and retention index 0.96, obtained for the four species under the time frame 25–50–75%. Note that *Hucho* is late compared to *Thymallus*, *Thymallus* is late compared to *Tinca*, and *Tinca* is late compared to *Barbus*. The arrow shows heterochrony (see text); onsets of characters shown with circles are those detecting it. After Lecointre et al., 2020.

FROM SOUTH AFRICA

UPDATE ON SOUTH AFRICAN RESEARCH ON EARLY STAGE FISHES

Nadine A. Strydom,
Nelson Mandela University,
South Africa

Nelson Mandela University is the hub of early-stage fish research in South Africa. We have a small fish research group based in the Zoology Department under the leadership of Prof Nadine A. Strydom. Our work integrates early life history stages in ecological studies including larval and early juvenile stages. Much of our work in the past three years has focused on threats in fish nursery areas. This included estuarine and surf zone studies. The rising threat of Harmful Algal Blooms (HABs) in estuaries that receive excess nutrients from either sewage or agricultural sources is of major concern. MSc student Taryn Smit and PhD student Eugin Bornman adopted an integrated approach by not only studying fish larvae but also the entire planktonic realm to assess the knock-on effects in predators and prey of fish larvae too. Collaboration with Dr Catriona Clemmesen from GEOMAR, in Kiel Germany, has gone a long way to shed more light on body condition of fish larvae under HAB conditions using RNA:DNA ratios. We were able to show that poor recruitment results from periods of high HAB presence and despite spawning by adults of the estuarine herring *Gilchristella aestuaria* (Clupeidae), larvae struggle to survive to metamorphosis in our study estuary. The phytoplankton and zooplankton follow boom-bust cycles relative to HAB intensity. Eugin Bornman took this further and followed older juveniles and adult mugilids relative to HABs using acoustic telemetry.

We have also been advancing our understanding of cueing into estuaries from marine spawned fishes during the late larval and early juvenile stages. Postflexion larvae actively migrate toward their preferred habitats by being able identify odours or chemical cues in the water. This process is still largely unstudied worldwide. In South African estuaries, the estuarine-dependent Cape stumpnose (*Rhabdosargus holubi*) and freshwater mullet (*Pseudomyxus capensis*) are important species utilizing estuaries. Cape stumpnose larvae are known to be attracted to river water but the marine-spawning, freshwater mullet has not yet been researched in this way. We don't know the exact origin of these cues but we hypothesized from previous work that they may be related to vegetated habitats where the stumpnose juveniles live or terrestrial chemicals such as geosmin which are known cues to some eel species that migrate through estuaries. Geosmin is produced by bacteria in soil and drains into rivers during rain, it also appears in high concentration in beetroot to which it gives an earthy flavour. To help fill in some of these gaps, Postdoctoral student Yansivan Kisten developed a chamber to test the attraction of young fishes to potential chemical cues from different sources. He retested riverine and estuaries sources on both species to identify any developmental differences in attraction behavior. Preliminary results show strong attraction by newly settled stumpnose juveniles to riverine water cues but did not show the same for mullet larvae. This could mean that mullet may cue to physical changes such as salinity instead of chemical odours. We are still in the process of testing for geosmin (via beetroot) and vegetative habitats (via eelgrass). If freshwater flow for salinity or chemicals cues are important then we should allow enough water to flow to the sea via estuaries to enhance recruitment.

Figure 7. Sorting post-flexion larvae in the lab

Figure 8. Chamber developed by Yansivan Kisten to test the attraction of young fishes to potential chemical cues from different sources

Plastic pollution is ever-present in ocean water, yet the consumption of plastics in nursery areas is not well studied, especially in African countries. MSc student Steven McGregor completed research on the accidental ingestion of plastic particles in a surf zone nursery area by late stage larvae and early juveniles of Mugilidae. These fishes feed at the water surface in blooms of the surf diatom *Anaulus australis*, however, these accumulation areas pose a real risk to young fishes as they ingest microplastics while feeding, especially at the late larval stages. Work is ongoing on marine fish larvae occurring in the shelf waters of the south-east coast of South Africa.

Josephine Edward is completing her M.Sc. and this study is the largest survey of ichthyoplankton along the South Africa coast to date. Josephine hails from Namibia and will be taking her ichthyoplankton identification training back to her home country where she will apply her skills in her job in fisheries.

Collaboration on the second book of Kenyan Marine Fish Larvae, this time from offshore waters, is underway with Dr James Mwaluma from the Kenyan Marine and Fisheries Research Institute in Mombasa and other colleagues. Although COVID-19 has slowed down progress we hope to complete the book in 2022. One of the collaborators, Dr Shael Harris sadly passed away in early 2021 after a long illness and she will be sorely missed by the team. Keep a look out for the new book on Estuarine Fish and Fisheries to be published by Wiley Publishes in 2022 – there is a lot of ichthyoplankton and early juvenile research summarized in two chapters which I co-authored. This new book will be an asset to estuarine researchers and provides a comprehensive review on larval fish habitat selection, nursery areas, feeding recruitment dynamics from a global perspective.

Figure 9. Josephine Edwards in the field with two helpers

PACIFIC RIM REGION

THE INFLUENCE OF HABITAT ASSOCIATION ON SWIMMING PERFORMANCE IN MARINE TELEOST FISH LARVAE

Adam T. Downie[1], Jeffery M. Leis[2,3], Peter F. Cowman[1,4,5], Mark I. McCormick[1], and Jodie L. Rummer[1,6]*

*[1]Australia Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD, Australia; [2]Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia; [3]Ichthyology, Australian Museum Research Institute, Sydney, NSW, Australia; [4]Biodiversty and Geoscience Program, Museum of Tropical Queensland, Queensland Museum, Townsville, QLD, Australia; [5]Centre for Tropical Bioinformatics and Molecular Biology, James Cook University, Townsville, QLD, Australia; [6]College of Science and Engineering, James Cook University, Townsville, QLD, Australia; *adam.downie@my.jcu.edu.au*
Link to paper: DOI: 10.1111/faf.12580

Since the early 1900s, fish biologists have shared an interest in all aspects of fish swimming. These interests include physiological perspectives, such as energy supporting swimming (e.g., Brett, 1964; Rummer et al. 2016) and biomechanics of muscle movement (e.g., Johnston, 1999), behavioral studies focusing on daily movement patterns (e.g., Humston et al. 2004), social interactions (e.g., Oliveira, 2012) and predator-prey relationships (e.g., Olson, 1996), and large-scale ecological questions focusing on migration and dispersal (Mora & Sale, 2002). Therefore, it is clear that fish swimming is a multi-disciplinary area of research with practical applications on improving management and conservation practices. Indeed, while there is much diversity in how fishes swim, how fast fishes swim, and the ways in which fishes interact with their environment and other species, the uniting principal shared by all fishes is that the ability to swim can be traced back to early life history stages, specifically larvae (Downie et al. 2020).

Upon hatch, most fish larvae are poorly developed (e.g., lacking developed gills, muscles, and fins), and consequently have weak swimming capabilities (Downie et al. 2020). Until the early 1990s, it was generally assumed that all fish larvae, regardless of habitat and phylogeny, were in the context of dispersal, effectively passive particles that went with the flow of ocean currents until they transformed into juveniles (Roberts, 1997). In the

early 1990s evidence began to emerge that larval tropical reef fishes were capable of impressive swimming capabilities (speeds to 30-40cm s-1, Stobutzki & Bellwood 1994; and endurances of days, Fisher & Bellwood 2001) during their pelagic larval phase, kick-starting the next several decades of research investigating the capabilities of reef fish larvae and the implications such performance has on dispersal. Although tropical reef fishes were the focus due to their 'athletic' capabilities, recent evidence suggests that larval fishes from temperate reefs are also impressive swimmers (Leis et al. 2012). Could habitat be an important factor that has shaped larval fish swimming over evolutionary history?

This idea that habitat could have an influence on how fishes swim motivated us to develop several questions around the factors that may contribute to the magnitude of swimming capabilities of fish larvae living in distinct habitats (reef, pelagic, and non-reef demersal) across tropical and temperate latitudes. Specifically, we were interested in 1) how swimming performance changes with ontogeny across habitats, 2) differences in swimming performance among habitats across three performance measures (described below) of post-flexion larvae within a phylogenetic comparative framework, and 3) taking a case-study approach to compare swimming performance of tropical larval reef fishes to current speeds around Lizard Island, Australia. A systematic literature search provided swimming performance data from a range of methodological techniques (endurance –a laboratory measure of maximum distance traveled under constant velocity, Fisher & Bellwood 2001; in situ swimming – swimming speed under natural, undisturbed conditions in the ocean, Leis et al. 1996; and critical swimming speed or Ucrit –maximal aerobic swimming capability for short-term swimming in the laboratory). These were also related to morphology (developmental stage, length, body shape) data.

Overall, we found support that both tropical and temperate larval reef fishes are capable of the fastest swimming speeds, when compared to larval pelagic and non-reef demersal fishes. We found larval temperate reef fishes had the greatest increases in swimming speed with increasing size, possibly attributed to a phenomena known as counter-gradient variation, which shows that animals from temperate latitudes have increased growth but other physiological processes are compromised (Kingsolver & Huey, 2008). Larval tropical reef fishes have the fastest Ucrit speeds (and in situ speeds) across all body size ranges (Fig. 10A), but when compared among a common body size range (16-22 mm), their Ucrit values are similar to those of larval temperate reef fishes and larval tropical demersal fishes (Fig. 10B). Investigation of phylogenetic relationships shows that reef-associated groups have greater Ucrit swimming capabilities than either of the non-reef groupings. Of particular interest, temperate reef fishes have similar Ucrit capabilities as tropical pelagic and demersal fishes, despite swimming in 10°C cooler water. Body size and shape is likely a key contributor to this increased performance among reef fishes, especially tropical reef fishes, as they have more robust body morphologies (Fig. 11) and greater muscle and caudal fin area than fishes from other habitats. Being a fast swimmer has critical ecological benefits for a reef fish, as coastal reef currents, especially on shallow exposed coral reefs, are quite fast (>30 cm s-1; Johansen, 2014). Therefore, in order to successfully find and settle onto a reef, reef fish larvae likely need to grow larger to have these improved swimming capabilities.

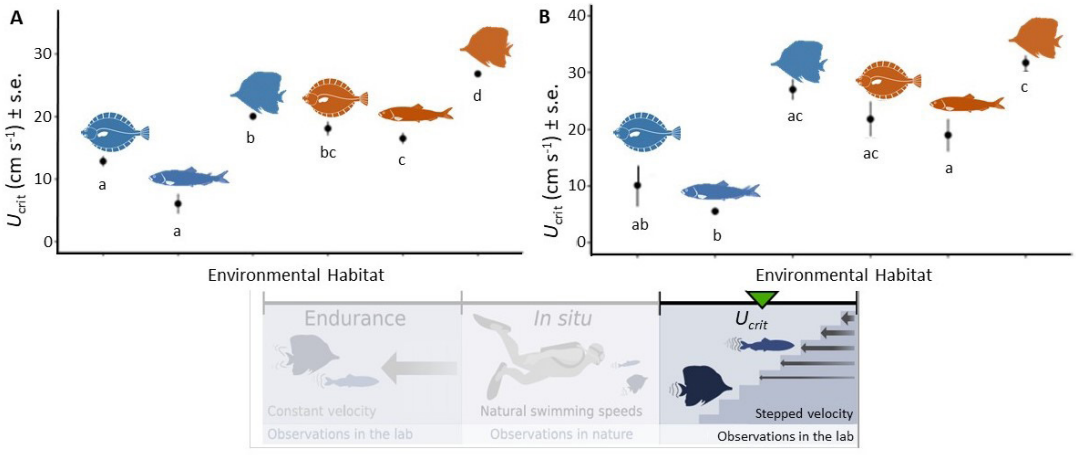


Fig. 10. Average critical swimming speed (mean Ucrit; cm/s; ± standard error, s.e.) of post-flexion-stage marine teleost larvae from six "Environmental Habitats," based on latitude (orange = tropical, blue = temperate) and habitat (herring symbol = pelagic, butterflyfish symbol = reef, flatfish symbol = demersal) (A) comparing swimming speeds of post-flexion larvae across all sizes and (B) comparing swimming speeds at a common size range (16–22 mm SL). Linear models included body length (standard length; mm) as a covariate, and different lowercase letters represent statistical differences between groups (α = 0.05)

At the end of their larval phase in the open ocean, tropical and temperate reef fishes need to locate a patchily distributed coastal reef habitat which is characterized by distinct changes in hydrodynamic conditions. This urgency to find a coastal reef habitat after a period of time in the open ocean may require such 'athletic' feats of performance that remaining in the pelagic environment or finding non-reef benthos do not require. While more research is warranted (i.e., sampling more non-percamorph fishes at tropical latitudes), our research provides valuable context as how and why fish larvae swim as well as they do, and suggests that accounting for habitat will be beneficial in the interpretation of future research. Further research will be critical to better understand and manage the recruitment patterns of fish larvae to coastal and pelagic environments, and help predict how anthropogenic stressors may impact larval fish swimming performance, and therefore health of their ecosystems in the future.

References

Downie, A. T., Illing, B., Faria, A. M., & Rummer, J. L. (2020). Swimming performance of marine fish larvae: review of a universal trait under ecological and environmental pressure. Reviews in Fish Biology and Fisheries, 30(1), 93-108.

Fisher, R., & Bellwood, D. (2001). Effects of feeding on the sustained swimming abilities of late-stage larval *Amphiprion melanopus*. Coral Reefs, 20(2), 151-154.

Humston, R., Olson, D. B., & Ault, J. S. (2004). Behavioral assumptions in models of fish movement and their influence on population dynamics. Transactions of the American Fisheries Society, 133(6), 1304-1328.

Johansen, J. L. (2014). Quantifying water flow within aquatic ecosystems using load cell sensors: a profile of currents experienced by coral reef organisms around Lizard Island, Great Barrier Reef, Australia. PLoS One, 9(1), e83240.

Johnston, I. A. (1999). Muscle development and growth: potential implications for flesh quality in fish. Aquaculture, 177(1-4), 99-115.

Leis, J. M., Sweatman, H. P., & Reader, S. E. (1996). What the pelagic stages of coral reef fishes are doing out in blue water: daytime field observations of larval behavioural capabilities. Marine and Freshwater Research, 47(2), 401-411.

Leis, J. M., Balma, P., Ricoux, R., & Galzin, R. (2012). Ontogeny of swimming ability in the European sea bass, *Dicentrarchus labrax* (L.) (Teleostei: Moronidae). Marine Biology Research, 8(3), 265-272.

Mora, C., & Sale, P. F. (2002). Are populations of coral reef fish open or closed?. Trends in Ecology & Evolution, 17(9), 422-428.

Oliveira, R. F. (2012). Social plasticity in fish: integrating mechanisms and function. Journal of Fish Biology, 81(7), 2127-2150.

Olson, M. H. (1996). Predator-prey interactions in size-structured fish communities: implications of prey growth. Oecologia, 108(4), 757-763.

Roberts, C. M. (1997). Connectivity and management of Caribbean coral reefs. Science, 278(5342), 1454-1457.

Rummer, J. L., Binning, S. A., Roche, D. G., & Johansen, J. L. (2016). Methods matter: considering locomotory mode and respirometry technique when estimating metabolic rates of fishes. Conservation Physiology, 4(1), cow008.

Stobutzki, I. C., & Bellwood, D. R. (1994). An analysis of the sustained swimming abilities of pre-and post-settlement coral reef fishes. Journal of Experimental Marine Biology and Ecology, 175(2), 275-286.

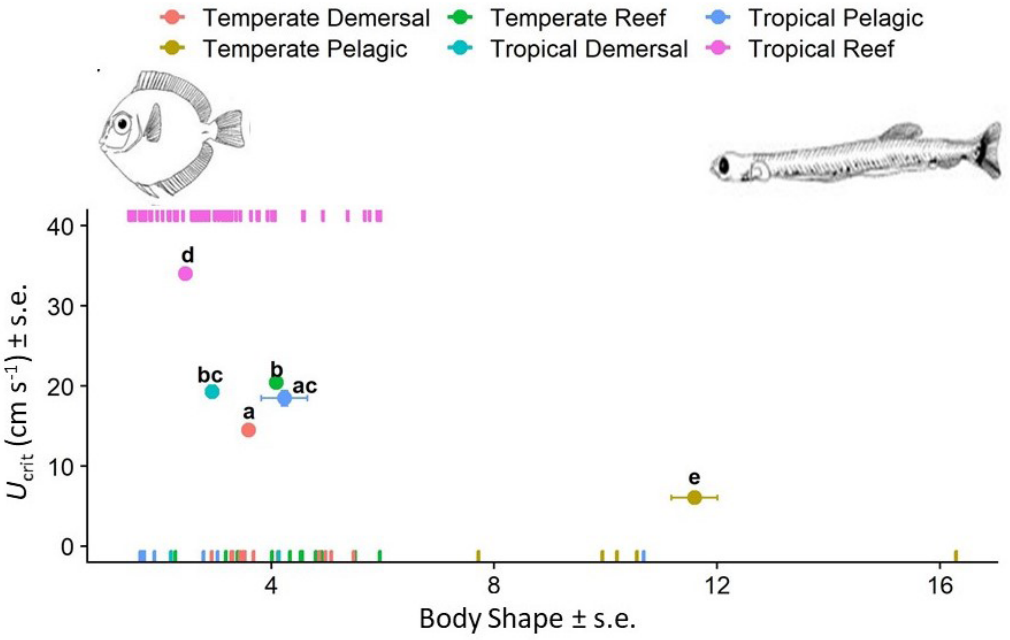


Fig. 11. Average critical swimming speed (mean Ucrit; cm/s ± standard error; s.e.) of post-flexion-stage marine teleost fishes from six "Environmental Habitats" (temperate demersal, temperate reef, temperate pelagic, tropical demersal, tropical reef, and tropical pelagic) versus body shape (ratio of body length to body width). Raw data (x-axis for tropical pelagic, tropical demersal, temperate reef, temperate demersal, and temperate pelagic habitats; tropical reef data placed above figure to mitigate cluttering of data points) show the spread of the body shapes per "Environmental Habitat". Fishes used in analyses were categorized into "Environmental Habitat" based on latitude (tropical or temperate) and habitat (reef, non-reef demersal, or pelagic). A representative example of the most robust body shape (surgeonfish Acanthuridae, left side of figure; body shape ratio [body length:body depth] = 1) and the most streamlined body shape (herring Clupeidae, right side of figure; body shape ratio [body length:body depth] = 16) are present on the figure to help visualize the shapes. Linear models were used to analyse data, and different lower-case letters represent statistical differences between groups ($\alpha = 0.05$)

NEW RECORD FOR EASTERN AUSTRALIA OF THE GEMPYLID *DIPLOSPINNUS MULTISTRIATUS* BASED ON LARVAL SPECIMENS

Tony Miskiewicz, Australian Museum, Sydney, Australia and School of Biological, Earth, and Environmental Sciences, University of New South Wales, tonymisk@yahoo.com

Prior to our last covid lockdown, I was working to register historical larval fish samples, currently stored in my garage, into the larval fish collection of the Australian Museum in Sydney. Interestingly, when I was trying to register 3 larvae of the gempylid *Diplospinnus multistriatus*, this species was not included in the Museum's data base, indicating no records of this species in the collection. The FAO Fisheries Synopsis No 125 (Nakamura and Parin 1993) shows a wide spread distribution for this species across the south-east Pacific, but not extending to eastern Australian waters. The Australian Faunal Directory website reports that the occurrence of *D. multistriatus* on the North-west shelf of Australia and the Lord Howe Rise and Norfolk Ridges in the South Pacific Ocean.

The larvae of *D. multistriatus* are very distinctive and have been previously described by various authors. The larvae are distinguished by their body morphology including a large head and eye, an elongate snout and early forming and elongate dorsal and pelvic fins.

Three specimens of *D. multistriatus* (Fig. 12) were collected in 1986 off the northern New South Wales coast by the NSW Fisheries vessel Kapala while conducting plankton surveys for the gempylid *Rexea solandri*, a commercially trawled species.

These larvae illustrate the value of historical specimens and the need to deposit samples in appropriate institutions such as museums where they are available for future research. Such specimens are useful as the basis for new distributional records of a species as well as providing baseline data for assessing changes in species distributions due to climate change.

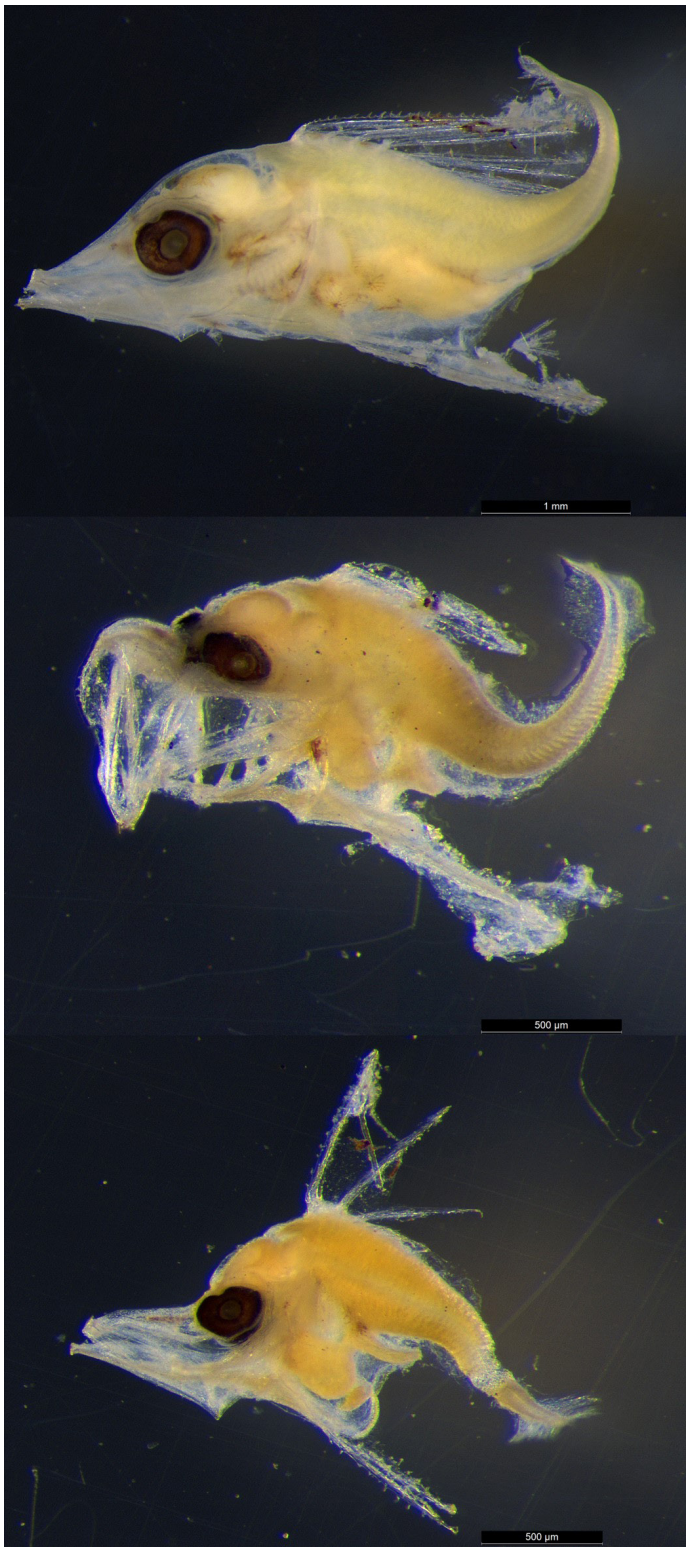


Fig. 12. Specimens of *Diplospinnus multistriatus* collected off northern New South Wales in 1986. Photographs were taken by Kerryn Parkinson from the Australian Museum.

Reference

Nakamura, I. and Parin, N. V. (1993) Snake mackerels and cutlassfishes of the world (Families Gempylidae and Trichiuridae). FAO Species Catalogue Vol. 15, FAO, Rome.

NEW PERSPECTIVES ON LEPTOCEPHALUS FEEDING ECOLOGY FROM THE WESTERN PACIFIC

Michael J. Miller, Graduate School of Agricultural and Life Sciences, The University of Tokyo, michael.miller@marine.fs.a.u-tokyo.ac.jp

The food source of leptocephali (larvae of eels, elopomorphs), remained mysterious because they were eventually found to feed on marine snow, which consists of amorphous materials with few obvious structures. A recent review paper overviewed the history of research on the food source of leptocephali in nature and in aquaculture of Japanese eel leptocephali mostly in Japan (Tsukamoto & Miller 2021).

A research study in the Philippine Sea of the western North Pacific (WNP) was also published recently (Watanabe et al. 2021), which helps to further clarify what can be learned about the natural diet of leptocephali using NGS analysis of DNA sequences in their gut contents. Many taxonomic groups were detected that were consistent with feeding on marine snow, but dinoflagellates were the dominant sequence-reads in Sept.-Nov. 2016. However, a similar study in the same region in Sept.-Oct. 2017 found that siphonophores were the dominant sequence-reads in the gut contents (Chow et al. 2019), as was found in the Sargasso Sea (see Miller et al. 2020 for an overview). Watanabe et al. (2021) reported that when dinoflagellates were the dominant DNA detections, there were 6 typhoons in the study area, but when siphonophores were dominant there were no typhoons in the study period, and this is consistent with reported effects of typhoons on productivity and plankton composition. DNA sequence content cannot be considered to be what the larvae gain nutrition from, but it reflects some origins of consumed marine snow, which was suggested to be variable in the same region of the WNP among years by the 2 recent studies.

Interestingly, the gut contents of a muraenid leptocephalus caught in winter 2013 (Fig. 13) just after a 30 km/hr storm passed over the area, showed red-colored gut contents, which seems consistent with dinoflagellates (e.g., red tide related taxa). The other unique aspect of the Watanabe et al. (2021) study was that it detected for the first time sequences of the Labyrinthulomycetes (e.g., thraustochytrid protists) in gut contents, which have recently been suggested to be present in leptocephalus gut contents (Miller et al. 2019), but they require special primers to detect all the taxa, even though they may be frequently present in marine snow (reviewed by Miller et al. 2020).

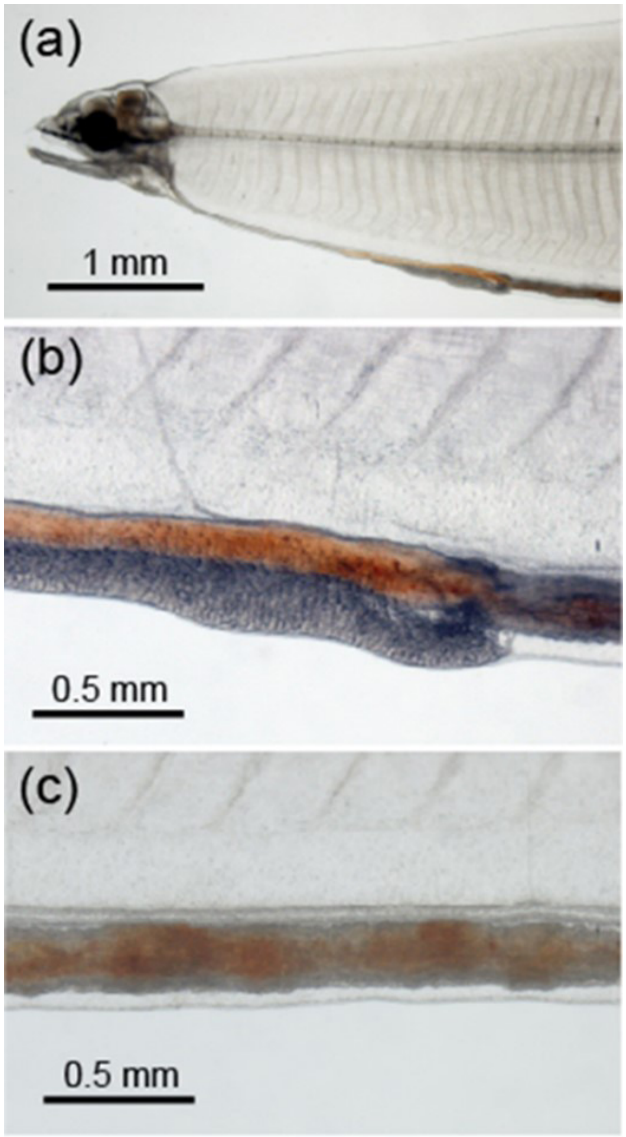


Fig. 13. Photographs of reddish gut contents of a 31 mm Muraenidae leptocephalus that was collected in the western North Pacific (5°N, 136°E) in January 2013. Modified from Tsukamoto and Miller (2021).

References

Chow S, Inaba N, Nagai S, Kurogi H, et al. (2019) Molecular diet analysis of Anguilliformes leptocephalus larvae collected in the western North Pacific. PLoS ONE 14(11):e0225610

Miller MJ, Marohn L, Wysujack K, et al. (2019) Morphology and gut contents of anguillid and marine eel larvae in the Sargasso Sea. Zoologischer Anzeiger 279:138–151

Miller MJ, Hanel R, Feunteun E, Tsukamoto K (2020) The food source of Sargasso Sea leptocephali. Mar Biol 167:57

Tsukamoto K, Miller M (2021) The mysterious feeding ecology of leptocephali: a unique strategy of consuming marine snow materials. Fish Sci 87:11–29

Watanabe, T, Nagai S, Kawakami Y, et al. (2021). 18S rRNA gene sequences of leptocephalus gut contents, particulate organic matter, and biological oceanographic conditions in the western North Pacific. Sci Rep 11:5488

RESEARCH PROJECT: EARLY LIFE BIOLOGY OF "MISCELLANEOUS" SPECIES IN THE OFFSHORE PELAGIC ZONES OF THE KUROSHIO CURRENT SYSTEM

Akinori Takasuka[1], Shigetaka Usui[1], Shijie Ma[1], Kazunari Higashiguchi[1], Mikio Watai[2], Jyunji Kinoshita[2], Mitsuo Nyuji[2], Chiyuki Sassa[2], Kiyotaka Hidaka[2], and Tohya Yasuda[2]*

*[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo; [2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency; *atakasuka@mail.ecc.u-tokyo.ac.jp*

Recently, Pelagic Fish Group II of the Fisheries Resources Institute, Japan Fisheries Research and Education Agency (FRA) and Fisheries Biology Laboratory of the Graduate School of Agricultural and Life Sciences, The University of Tokyo launched a collaboration project: Early life biology of "miscellaneous" species in the offshore pelagic zones in the Kuroshio Current system.

The field of Fisheries Biology, including Early Life Biology, has developed mainly through intensive studies on commercially important fish species. On the contrary, much less is known about early life biology (i.e., distribution, growth, feeding, survival, etc.) of non-commercial or commercially less important fish species. However, those species may play important roles in ecosystems if they dominate the fish communities. Further, possible interspecific interactions between those species and commercially important species would also be of great concern in understanding recruitment mechanisms of commercially important species.

The FRA has conducted extensive egg and larval surveys off the Pacific coast of Japan during February to March since 2003 (RV Wakatake-maru and Hokuho-maru). The surveys have covered broadly the potential spawning grounds of small pelagic fish from inshore to offshore waters across the Kuroshio Current. As a part of the surveys, a neuston net with a frame of 1.3 m width and 0.75 m height and with a mesh size of 0.45 mm was towed horizontally at the sea surface (Takasuka et al. 2019). The neuston net was developed and modified specifically for quantitative sampling of Pacific saury (*Cololabis saira*) larvae and juveniles. Hence, distribution, transport, and early growth variability have been examined for Pacific saury larvae and juveniles in previous studies (Takasuka et al. 2014, Oozeki et al. 2015, Takasuka et al. 2016). In addition, Myctophidae juveniles have been sorted for studies on their early life biology (Sassa & Takasuka 2019, 2020). The remaining contents of the samples have long been stored as ichthyoplankton sample collections in the storage.

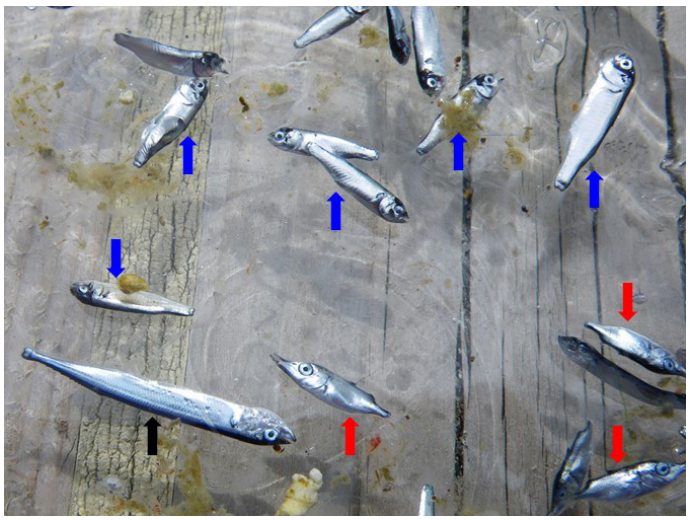
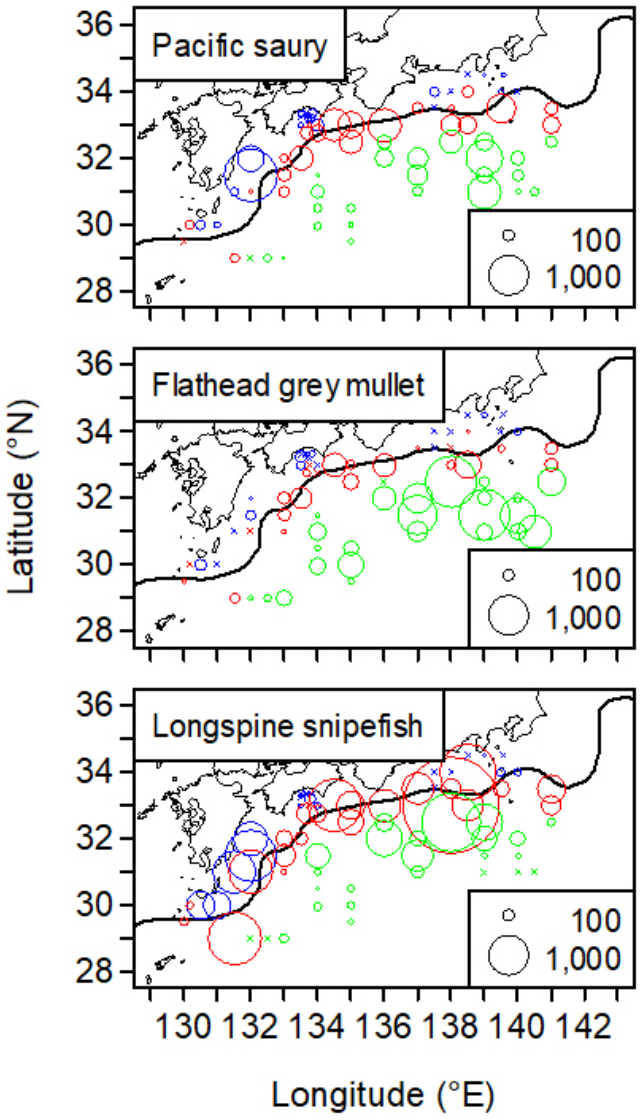


Fig. 14. Samples collected by a horizontal tow of a neuston net. Pacific saury (*Cololabis saira*) juvenile (black arrow), flathead mullet (*Mugil cephalus*) juveniles (blue arrows), and longspine snipefish (*Macroramphosus scolopax*) juveniles (red arrows) are major species in the tows during the daytime.

However, the ichthyoplankton samples by a neuston net during the daytime tended to be dominated by juveniles of two species: flathead mullet (*Mugil cephalus*) and longspine snipefish (*Macroramphosus scolopax*) (Fig. 14). These non-target species have long been regarded as "miscellaneous" species in the surveys. In fact, very few studies have been conducted for biology of these species in Japan. Our preliminary analysis showed that these juveniles were distributed broadly from inshore to offshore waters with substantial overlaps with Pacific saury larvae and juveniles (Fig. 15). This motivated us to launch the collaboration project. This project deals with various aspects of early life biology of the "miscellaneous" species in the offshore pelagic zones in the Kuroshio Current system: the time of the day of occurrence, spatial distribution, long-term fluctuations in abundance, transport/migration, feeding habits, and environmental effects on growth variability. Lastly, we intend to discuss trophic interactions and differences in survival strategies during the early life stages between Pacific saury and the "miscellaneous" species.

Fig. 15. Example of distributions of Pacific saury (*Cololabis saira*) larvae and juveniles, flathead mullet (*Mugil cephalus*) juveniles, and longspine snipefish (*Macroramphosus scolopax*) juveniles off the Pacific coast of Japan during February–March in 2013. Only the samples collected during the daytime (06:00–18:00) are shown. Density was calculated as the number of individuals per swept area (individuals per 104 m^2). Crosses indicate sampling stations without any individuals captured. Each station was classified into one of three area categories: the inshore side of the Kuroshio axis (light blue), the Kuroshio axis (red), and the offshore side of the Kuroshio axis (blue). The panel for Pacific saury was redrawn from Takasuka et al. (2016).



References

Oozeki, Y., Okunishi, T., Takasuka, A., and Ambe, D. (2015) Variability in transport processes of Pacific saury *Cololabis saira* larvae leading to their broad dispersal: Implications for their ecological role in the western North Pacific. Progress in Oceanography, 138: 448–458. https://doi.org/10.1016/j.pocean.2014.05.011

Sassa, C., Takasuka, A. (2019) Distribution of *Symbolophorus californiensis* (Teleostei: Myctophidae) in the Kuroshio region during late winter: Evidence of a southward spawning migration. Deep Sea Research Part I, 150: 103053. https://doi.org/10.1016/j.dsr.2019.05.013

Sassa, C., Takasuka, A. (2020) Distribution and feeding of *Myctophum orientale* juveniles (Teleostei: Myctophidae) on the onshore side of the Kuroshio off Japan. Deep Sea Research Part I, 162: 103318. https://doi.org/10.1016/j.dsr.2020.103318

Takasuka, A., Kuroda, H., Okunishi, T., Shimizu, Y., Hirota, Y., Kubota, H., Sakaji, H., Kimura, R., Ito, S., Oozeki, Y. (2014) Occurrence and density of Pacific saury *Cololabis saira* larvae and juveniles in relation to environmental factors during the winter spawning season in the Kuroshio Current system. Fisheries Oceanography, 23: 304–321. https://doi.org/10.1111/fog.12065

Takasuka, A., Nishikawa, K., Kuroda, H., Okunishi, T., Shimizu, Y., Sakaji, H., Ito, S., Tokai, T., Oozeki, Y. (2016) Growth variability of Pacific saury *Cololabis saira* larvae under contrasting environments across the Kuroshio axis: survival potential of minority versus majority. Fisheries Oceanography, 25: 390–406. https://doi.org/10.1111/fog.12160

Takasuka, A., Nyuji, M., Kuroda, H., Oozeki, Y. (2019) Variability of swept area by sea-surface tows of a neuston net: Balance of resistance, clogging, and over-inflow effects. Fisheries Research, 210: 175–180. https://doi.org/10.1016/j.fishres.2018.10.021

WESTERN REGION

IATTC MARKS THE 25th ANNIVERSARY OF SUSTAINED CAPTIVE SPAWNING OF YELLOWFIN TUNA AT THE ACHOTINES LABORATORY IN THE REPUBLIC OF PANAMA

Daniel Margulies, Vernon Scholey, Susana Cusatti and Yole Buchalla, Inter-American Tropical Tuna Commission, 8901 La Jolla Shores Drive, La Jolla, CA 92037 USA

The Inter-American Tropical Tuna Commission's (IATTC's) Early Life History (ELH) Group has conducted research on the early life history and biology of tropical tunas at the Achotines Laboratory in the Republic of Panama since 1986. In 1994, an expansion of the Laboratory's tank and seawater system, financially supported by the IATTC and the Overseas Fishery Cooperation Foundation (OFCF) of Japan, accommodated research studies of yellowfin tuna at the Laboratory. Spawning from a captive population of yellowfin tuna has taken place almost daily in the Laboratory's land-based tank since 1996. The near-daily spawning of yellowfin at the Achotines Laboratory represents the only sustained spawning of yellowfin in captivity in the world. In October 2021, the Laboratory reached a milestone of 25 years of sustained spawning of yellowfin.

Yellowfin spawn at the Achotines Laboratory in an in-ground concrete tank (17 m diameter x 6 m depth, 1,362 m3 volume). Their spawning and courtship behaviors, and the effects of physical factors on spawning and egg production, have been described (Margulies et al. 2007). Eggs and larvae collected from spawning events are used to conduct ecological experiments on early life stages and estimating effects of environmental factors on pre-recruit development, growth and survival. Effects on larval survival and growth from physical factors, including microturbulence, light intensity, water temperature, dissolved oxygen and ocean acidification, have been investigated (Margulies et al. 2016). Effects of prey concentration and quality on larval growth and survival have also been estimated. Pre-recruit research on yellowfin at the Achotines Laboratory has focused on growth and survival dynamics of larvae (first 3 weeks after hatching), but in recent years with improved rearing success, the research focus has expanded to the early-juvenile stages (1-6 months)(Fig 16).

The majority of the YFT research has been conducted by the ELH Group of the IATTC, but important investigations have also been conducted in collaboration with Japanese scientists, the University of Miami's Aquaculture Program, and other academic and nongovernmental researchers. The results of this research are summarized in a series of publications listed on the IATTC website (http://www.iattc.org/AchotinesLab/AchotinesPublicationsENG.htm).

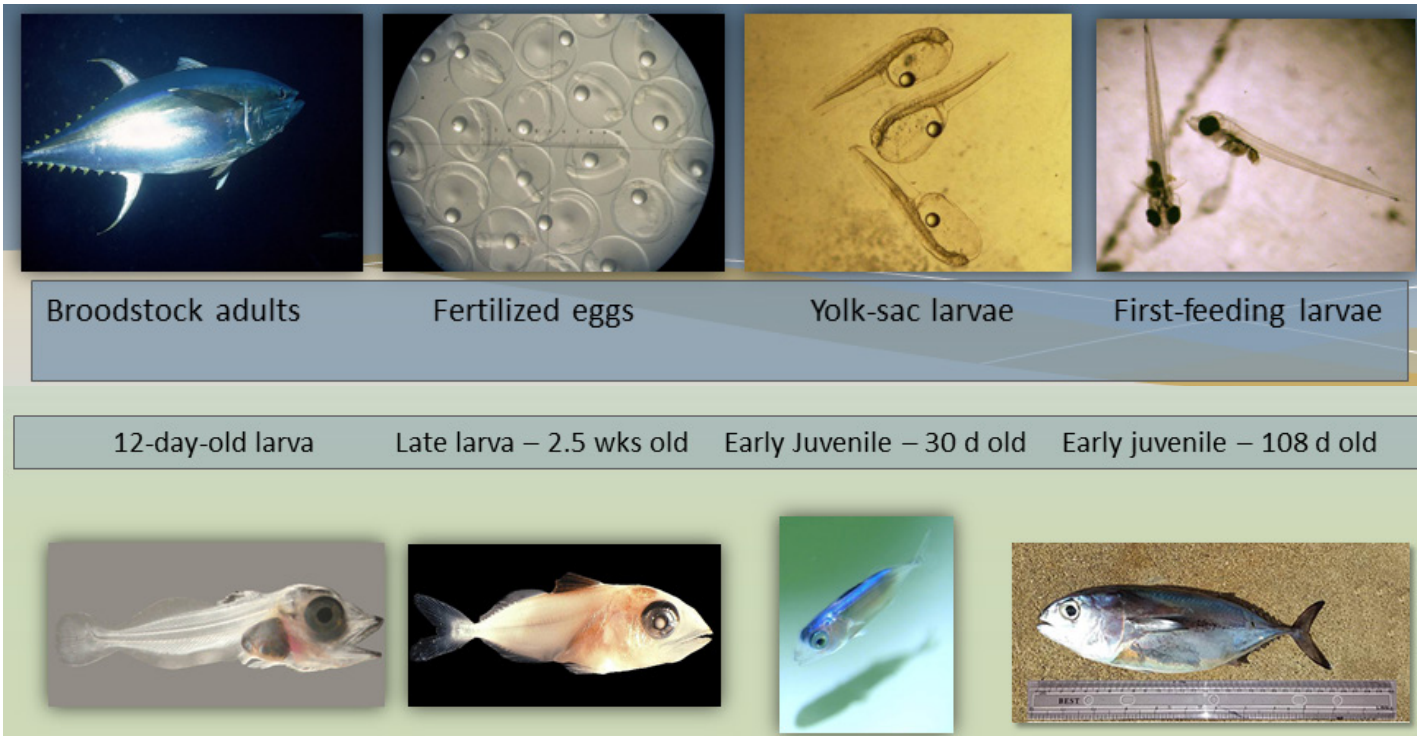


Fig. 16. Achotines Laboratory:Yellowfin Life Stages Studied

Growth rates have been estimated for all transformation and early-juvenile individuals reared at the Achotines Laboratory in land-based tanks or a sea cage over a 20 year period; the early-juveniles have ranged from 1.6 - 28.0 cm in length and up to 158 days old. Larval growth is exponential in length (0.2 – 0.4 mm/d linearized) and weight (20 – 40% SGR), and early-juvenile growth is exponential in weight (30 – 50% SGR) and non-linear in length (1.0 – 3.8 mm/d linearized). In 2015, in collaboration with Kindai University, the first transfer worldwide of yellowfin juveniles from land-based tanks to a sea cage was successfully completed at the Achotines Laboratory.

The studies of yellowfin growth and survival during the first 6 months have strong application to tuna ecology and aquaculture. Improved rearing success of early-juvenile yellowfin now provides opportunities to study density-dependence in juvenile growth, the release of tagged early-juveniles in coastal waters of the Panama Bight to provide rare information on pre-recruit movements and distribution, and support for the potential completion of full-life-cycle rearing of yellowfin.

Besides the current members of the ELH Group, important contributions to the yellowfin research program have been made by Robert Olson, Jenny Suter, Maria Stein, Enrique Mauser, Sharon Hunt, Jeanne Wexler and Akio Nakazawa, as well as the talented local staff of the Achotines Laboratory.

References:

Margulies, D., J.M. Suter, S.L. Hunt, R.J. Olson, V.P. Scholey, J.B. Wexler, and A. Nakazawa. 2007. Spawning and early development of captive yellowfin tuna, Thunnus albacares. Fish. Bull. 105: 249-265.

Margulies, D., V.P. Scholey, J.B. Wexler, and M.S. Stein. 2016. Research on the reproductive biology and early life history of yellowfin tuna Thunnus albacares in Panama. Pages 77-114 In: D. Benetti, G.J. Partridge, and A. Buentello (eds.), Advances in Tuna Aquaculture, Elsevier-Academic Press.

SEASONAL DISTRIBUTION AND GROWTH OF ARCTIC GADIDS IN THE US CHUKCHI SEA

Ali Deary, Cathleen Vestfals, Franz Mueter, Libby Logerwell, Esther Goldstein, Phyllis Stabeno, Seth Danielson, Russ Hopcroft, Janet Duffy-Anderson

The Arctic is an ecosystem shaped by ice and the species that live there have evolved life cycles tuned to seasonal sea ice dynamics. Ice has made the Arctic a difficult area to sample, constraining our field observations to the late summer when ice is at a minimum. Arctic ecosystems are particularly vulnerable to climate change and are experiencing warming at twice the global rate. The National Oceanic and Atmospheric Administration's Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI) program has been sampling the US Chukchi Sea consistently for over ten years in the late summer to learn about this Arctic ecosystem.

We were afforded the opportunity to complement our usual late summer sampling in 2017 with samples collected in the late spring during the inaugural year of the Arctic Integrated Ecosystem Research Program (Arctic IERP) funded by the North Pacific Research Board. The Arctic IERP brought together several university and federal sampling programs to study the processes that structure the US northern Bering Sea and Chukchi Sea. For the first time, we had two seasonal snapshots of the ichthyoplankton community from the Arctic, one collected in the late spring and a second in the late summer. This gave us the data we needed to assess the seasonal abundance, distribution, and growth of two ecologically important fish species in the US Arctic, Polar Cod (*Boreogadus saida*) and Saffron Cod (*Eleginus gracilis*). We then integrated our field observations with individual-based model output to examine the potential source-sink dynamics of individuals collected between these two seasonal snapshots.

The initial goal of this study was to generate baseline data for Polar Cod and Saffron Cod. However, 2017 was a warm year with an elevated sea surface temperature of +4°C relative to the historic average and the lowest recorded March sea ice minimum in the 39-year history of the time series (Timmermans et al. 2017; Perovich et al. 2017), suggesting our findings may not be representative of dynamics under "normal" conditions. Polar Cod and Saffron Cod larvae were centered in Kotzebue Sound in the late spring a few weeks after sea ice had receded. This suggests that sea ice is likely an important factor influencing hatching and that Kotzebue Sound may

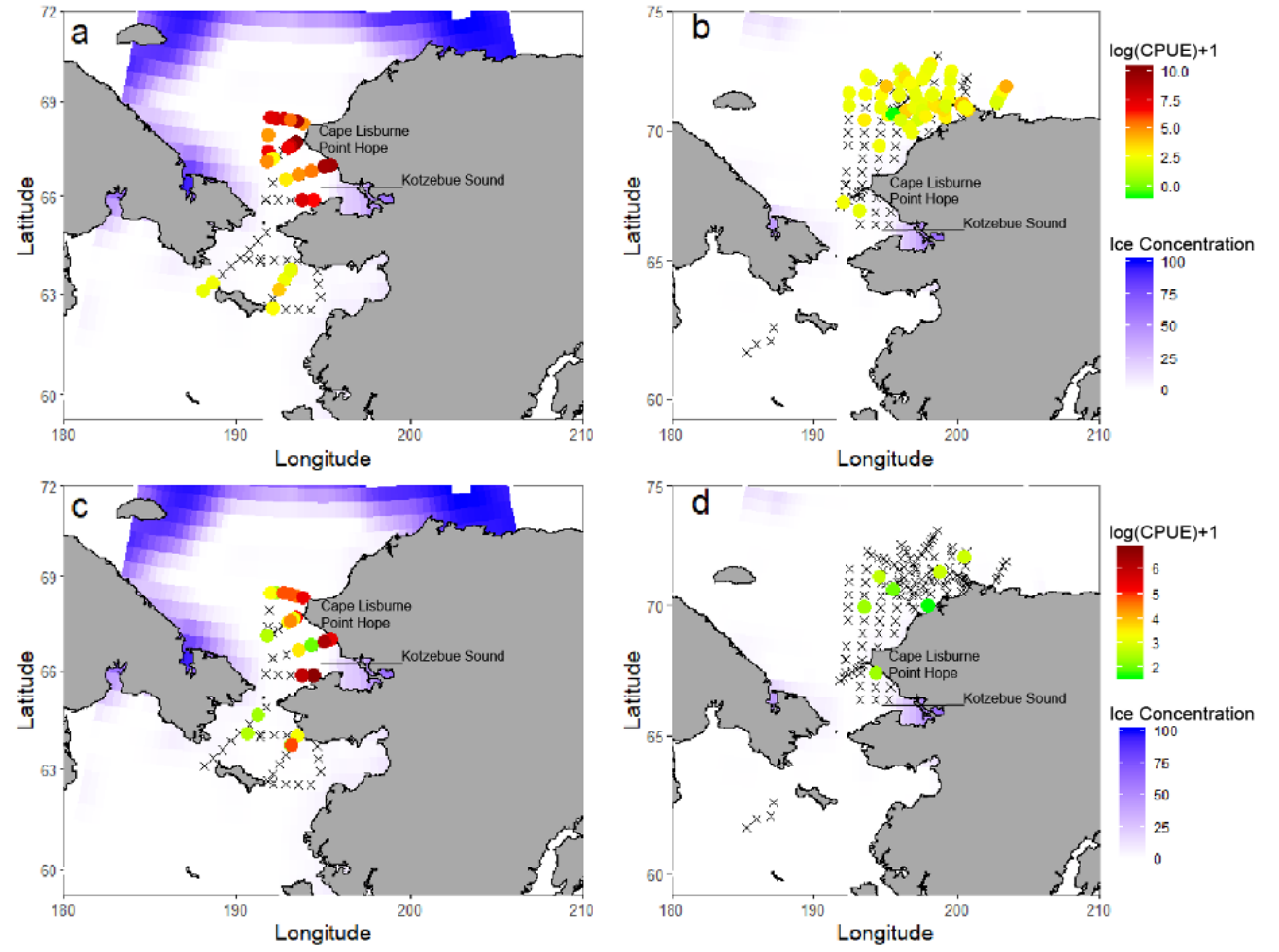


Figure 17. Distribution of Polar Cod (*Boreogadus saida*) (a, b) and Saffron Cod (*Eleginus gracilis*) (c, d) in late spring (left column) and late summer (right column) 2017 collected in the water column with the 60-cm bongo net. Catch data are reported as catch-per-unit-effort (CPUE) and log(CPUE)+1 to highlight variability at lower abundances. Ice concentration (% cover) is plotted in the background. Black X's denote sampled stations where Polar Cod and Saffron Cod were not caught. Note the different scales for CPUE between the species.

provide a nursery habitat for newly hatched individuals of both species. By late summer, Polar Cod juveniles were centered offshore in the northern Chukchi Sea whereas Saffron Cod were distributed nearshore around Cape Lisburne. Modeled drift trajectories and growth in spring for Polar Cod and Saffron Cod matched well with empirical observations, especially along the northern coastline of Kotzebue Sound and offshore of Point Hope/Cape Lisburne. Given the coherence between modeled and observed distributions, Kotzebue Sound is likely a source of gadid ELHS in the nearshore areas of the Chukchi Sea and offshore of Cape Lisburne/Point Hope, although it is not the likely source of Polar Cod in the northern Chukchi Sea in the late summer. This is the first study to examine seasonal distribution and abundance of Polar Cod and Saffron Cod and is the first study to estimate daily growth for larval Saffron Cod in the US Arctic.

Our full paper is available here:

Deary AL, Vestfals CD, Mueter FJ, Logerwell EA, Goldstein E, Stabeno P, Hopcroft RR, Duffy-Anderson JT (2021). Seasonal abundance, distribution, and growth of the early life stages of polar cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*) in the US Arctic. Polar Biol (2021). https://doi.org/10.1007/s00300-021-02940-2

References

Perovich D, Meier W, Tschudi M, Farrell S, Hendricks S, Gerland S, Haas C, Krumpen T, Polashenski C, Ricker R, Webster M (2017). Sea Ice [in Arctic Report Card 2017]. http://www.arctic.noaa.gov/Report-Card

Timmermans ML, Ladd C, Wood K (2017) Sea surface temperature [in Arctic Report Card 2017]. http://www.arctic.noaa.gov/Report-Card

NORTH CENTRAL REGION

APPLIED RESEARCH ON LARVICULTURE ENABLES THE COMMERCIALIZATION OF WALLEYE AQUACULTURE

Greg Fisher, Assistant Director/Research Programs Manager at The University of Wisconsin - Stevens Point Northern Aquaculture Demonstration Facility

For over 15 years, the University of Wisconsin-Stevens Point Northern Aquaculture Demonstration Facility (UWSP NADF) has experienced substantial success raising both walleye and hybrid walleye (saugeye) in indoor, intensive systems for research and demonstration of food-fish production. Building on previous research on intensive culture of walleye from Robert Summerfelt and Alan Johnson in Iowa, the facility is utilizing specialized larval rearing systems, optimized starter diets, enhanced husbandry, and indoor, land based, closed-loop production through recirculating aquaculture system technology (RAS), to assemble a systematic culture protocol that has advanced walleye food fish production to the point that a commercial walleye industry is emerging.

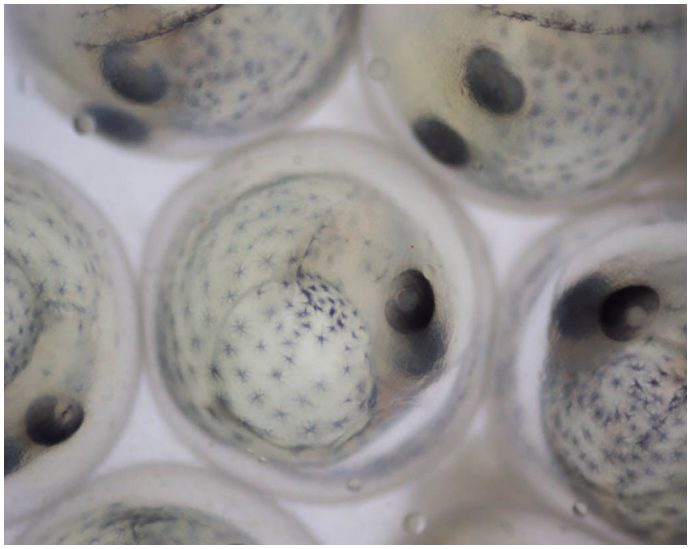


Fig. 18. Hard-eyed walleye eggs

The UWSP NADF has traditionally worked with partners, such as Wisconsin state hatcheries, to collect walleye eggs from wild broodstock. These eggs are disinfected and transferred into a bell jar incubation system at the facility. Upon hatch, walleye fry are collected, enumerated using a Jensorter larval counter and stocked into either indoor, intensive systems for food fish research or stocked into ponds and raised extensively for restocking efforts.

Fig. 19. UWSP NADF bell jar incubation system with collection insert tanks

Indoors, walleye fry are raised in the intensive systems for around 30 days, where they are fed a fish-meal rich, otohime larval feed from hatch. In this early larval developmental stage, walleye require specific environmental parameters for survival such as, highly turbid water using specific bentonite clay, 24-hour feeding with consistent dim overhead lighting, optimal water quality with temperatures of around 19-21°C, and an overhead sprayer to assist in gas bladder inflation. Careful attention to other details such as tank flow rates, velocities, mortalities and cannibalism, is crucial. One month post hatch walleye are then slowly converted to a commercial feed diet, and stocked into indoor semi-commercial RAS which utilize cornel-style dual drain tanks, mechanical and biological filtration, sterilization, oxygenation and further water quality monitoring and control. Prior facility research has demonstrated walleye growth potential in indoor systems, reaching an average of .45kg (1.0lb) in 12 months from egg to market size utilizing RAS at commercial density levels of 60-90kg/cubic meter.

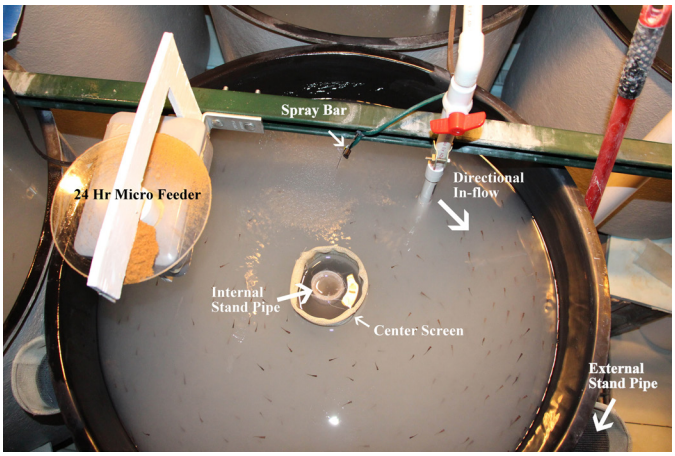


Fig. 20. Aerial view of larval walleye tank at UWSP NADF

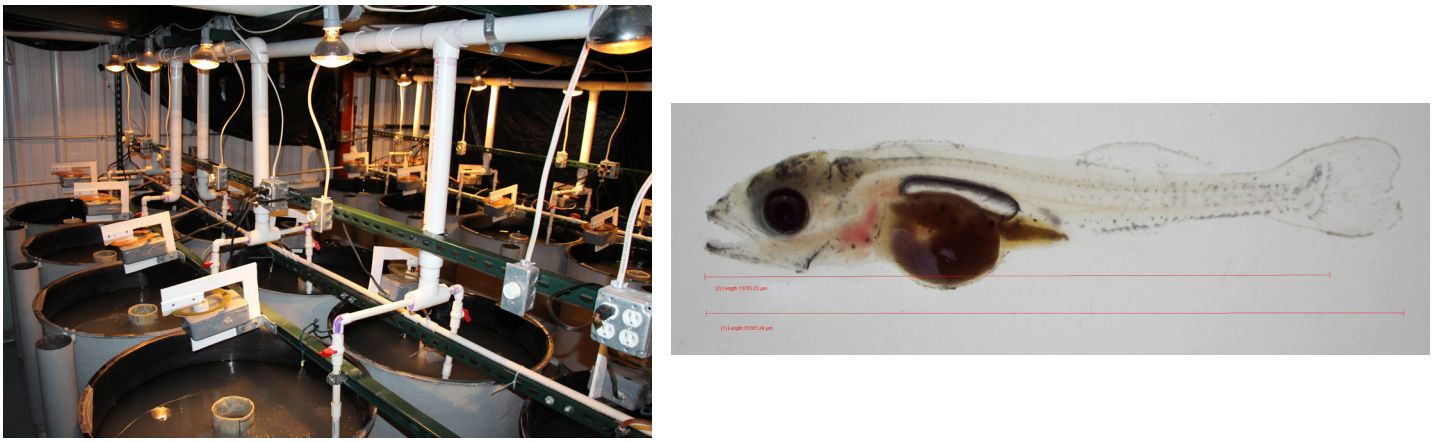


Fig. 21. UWSP NADF larval walleye room (left) for intensive production of walleye raised on commercial feed from hatch (right)

Not only is there demand for this market-size walleye, but also an additional market exists for pellet fed and intensively reared fingerlings, which are highly biosecure and can be utilized for stocking into other RAS or aquaponics facilities for grow-out.

There remains a limited number of bottlenecks for commercial walleye industry production, with one of the most important being a domesticated in-house broodstock reared in RAS, that can supply high quality eggs and fry for out-of-season commercial production. Building upon past and moving forward with recent research projects related to commercial walleye production with University of Wisconsin Sea Grant Institute (WISG) and the North Central Regional Aquaculture Center, the facility is very close to achieving the goal of a commercial, land based, regional walleye industry. The most recent walleye project, funded by WISG, "Commercial application of out-of-season spawning of walleye (*Sander vitreus*)", is succeeding in completing the full life cycle of walleye reproduction under intensive conditions within a land based, sustainable, recirculating aquaculture system and is providing the methodology for supplying suitable eggs and fingerlings to a growing commercial walleye industry.

UWSP NADF Assistant Director and Research Programs Manager, Greg Fischer explains "We are seeing more and more interest in rearing walleyes intensively for both food fish and for conservation stocking practices from a variety of state, federal, tribal and private agencies."

For further information on UWSP NADF research, demonstration, and deliverables, please visit aquaculture.uwsp.edu.

Fig. 22. Intensively reared walleye in RAS culture tank at UWSP NADF.

SOUTHERN REGION

CLOSE-KIN RECAPTURE STUDY ON WEST ATLANTIC BLUEFIN TUNA, THUNNUS THYNNUS

Trika Girard, NMFS, Southeast Fisheries Science Center, Miami, Florida, trika.gerard@noaa.gov

Globally, tunas are among the most valuable fish stocks, but are also inherently difficult to monitor and assess. Standardized larval surveys aim to measure relative spawning biomass of West Atlantic Bluefin tuna, *Thunnus thynnus* annually in the northern Gulf of Mexico (GoM). In a collaborative effort, The Early Life History Unit and the Sustainable Fisheries Division at NOAA's Southeast Fisheries Science Center (SEFSC) used Close-kin mark recapture to determine levels of sibship within and among larval aggregations of Bluefin tuna in the GoM. Close-kin mark recapture is a genetics-based technique capable of identifying individuals in the population based on the DNA profiles of their closely related family members, including parent-offspring and sibling genetic matches. Application of close-kin mark recapture to Atlantic bluefin tuna is expected to solve two major uncertainties: 1) identify the origin of fish caught by U.S. fisheries and 2) estimate the absolute abundance of Gulf of Mexico spawning stock annually. These two pieces of genetics-based information will allow SEFSC to monitor the trends in domestic stock production, as well as the contribution to catches of other stocks that migrate to U.S. fishing areas.

The research leveraged biological sampling for bluefin tuna in the West Atlantic to build a genetic database of DNA profiles. Sampling from known spawning grounds in the Mediterranean Sea and Gulf of Mexico provided genetic baselines for the stocks, from which we identified stock-identification markers. The larval collections also provided a method of marking actively spawning fish each year without ever handling the large, mature tuna. Simply put, each larval fish contains the genotypes of its mother and father, and therefore contains the genetic tag of two spawning fish in the Gulf of Mexico. Sampling adult fish from the fishery provided the recapture event, after the spawning fish migrated and mixed with the unmarked population. In our first pilot study evaluation, we identified two parent-offspring matches of fish that spawned in the Gulf of Mexico in May 2017 and were captured and sampled in Canada later in fall of 2017. Results also identified two half-sibling captures across years (2016 and 2017), translating to the recapture of two unique parents between 2016 and 2017. This pilot study provided the proof of concept that quantifying the unique number of spawners in the population based on larval catches is a possibility. The goal for the next phase of the project is to estimate the total abundance of the Gulf of Mexico spawning stock based on the ratios of genetically marked and unmarked fish in the 2016 to 2018 biological collections. The work is collaboratively conducted with partners from the Commonwealth Scientific and Industrial Research Organization, Virginia Institute of Marine Sciences, University of Maine, Canada Department of Fisheries and Oceans, and NOAA Fisheries.

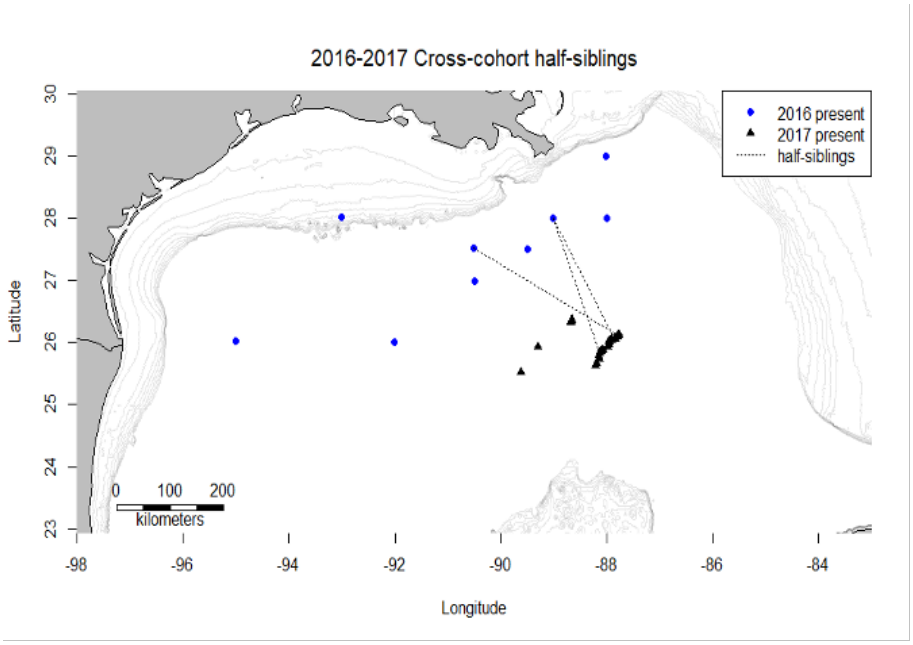


Figure 23. Stations with Atlantic bluefin tuna larvae selected for close kin mark recapture analyses are shown, the 2016 survey has blue symbols while the 2017 survey has black symbols. Half sibling pairs (HSP) across the two years sampled are indicated with dashed lines.

IN MEMORIAM

Remarkably and regrettably, two longtime members and contributors to the Early Life History Section passed away within a one-week period in August 2021. Edward J. Chesney, Jr. (Ed) and James H. Cowan, Jr. (Jim) both resided in Louisiana, USA, and conducted their professional work in academic institutions there over the past three decades. Many years ago, it was my good fortune to host each of them as postdoctoral scientists at the Chesapeake Biological Laboratory. I am saddened by the losses of these two excellent scientists and good friends. Ed and Jim had vastly different personalities, but each made important contributions to the science of early-life stages of fishes. As their careers evolved, they became productive in broad areas of fisheries ecology and management, and their contributions will have lasting impacts. In the mid-1980s to early-1990s, when Ed and Jim were resident in my laboratory, they were instrumental in shaping the success that we experienced in those years. Both went on to enrich their respective communities and institutions in the following decades. I was privileged to be a mentor to each early in their careers and to continue as friend and colleague in recent years. Below, I provide some brief tributes and notes on Ed and Jim and their respective careers.

Edward D. Houde, Professor Emeritus
Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science, Solomons, MD, USA

Ed Chesney

Ed was born and raised in the midwestern USA. He passed away on 9 August 2021 at age 70. After receiving his undergraduate degree from the University of Michigan, Ed worked as a research technician at the Woods Hole Oceanographic Laboratory and Skidaway Institute of Oceanography in the 1970s to early 1980s before obtaining his PhD at the University of Rhode Island in 1984. An excellent summary-tribute to Ed's life and research is available (Reeves et al. 2021). Ed's doctoral research was on marine polychaetes, including culture research and methodology. In the mid-1980s Ed took a postdoctoral scientist position in my laboratory where he developed culture methodologies for fish larvae, conducted experimental studies on larval-stage fishes, including research on effects of light on feeding, demonstrating, surprisingly, that larval-stage striped bass could feed and grow, albeit slowly, in the absence of light (Chesney 1989). Additionally, Ed undertook modeling research addressing early-life dynamics of striped bass. During that period, Ed also participated in a multidisciplinary program directed by Ken Tenore on the upwelling ecosystem off the Iberian peninsula where Ed initiated research with Spanish colleagues on sardine early-life ecology. At the Chesapeake Biological Lab, Ed successfully developed methods to spawn bay anchovy in the laboratory and engineered and built facilities to culture phytoplankton, copepods and rotifers to produce anchovies and provide foods for larval rearing experiments. Ed was a mentor to my graduate students and a teacher for my research technicians, which was critical because I was on assignment and away from CBL during a part of Ed's time in my lab. Ed brought the skills and advances he made at CBL to the Louisiana University Marine Consortium (LUMCON) where he pursued his career for 3+ decades.

At LUMCON, Ed pursued broad interests in fish ecology, with a substantial part of his efforts directed to early-life biology of Gulf of Mexico fishes. A part of his research was aimed at understanding foraging behavior and growth of fish larvae (Chesney 2008) which Ed pursued in laboratory experiments. He was expert in spawning and larval rearing, including developing methodology for propagation of marine fishes for aquaculture. Ed also made notable contributions to applications of fish otolith and hard-part chemistry in fisheries and oceanography (Chesney et al. 1998).

Over the years, Ed became increasingly engaged in collaborative research with colleagues on how stresses, especially toxicological stresses, including oil spills and hypoxia, affect early life stages of fishes (Chesney and Baltz 2001; Duffy et al. 2016). Ed also addressed broader interests in fishery productivity of the Gulf of Mexico and factors influencing sustainability of fishery resources (Chesney et al. 2000). With colleagues, he investigated effects of petroleum industry oil platforms in supporting fisheries productivity (e.g., Reeves et al. 2018), including reproduction and recruitment. Although LUMCON is primarily a research institution, Ed taught courses in fish ecology and coastal ocean science and he was a mentor to numerous graduate and undergraduate students.

I will remember Ed as a gentleman who willingly shared his knowledge and skills. He was unassuming but those who knew him were impressed with his broad command of marine ecology and, particularly, his breadth of knowledge of fish early-life and reproductive ecology.

References Cited

Chesney, E.J. 2008. Foraging behavior of bay anchovy larvae, Anchoa mitchilli. Journal of Experimental Marine Biology and Ecology 362, 117-124.

Chesney, E.J., Baltz, D.M. & Thomas, R.G. 2000. Louisiana estuarine and coastal fisheries and habitats: perspectives from a fish's eye view. Ecological Applications 10, 350-366.

Chesney, E.J. & Baltz, D.M. 2001. The effects of hypoxia on the northern Gulf of Mexico coastal ecosystem: a fisheries perspective. Coastal and Estuarine Studies, 321-354.

Chesney, E. J., McKee, B., Chan, L.-Heung & Blanchard, T. 1998. Chemistry of otoliths from Juvenile menhaden, Brevoortia patronus: Evaluating strontium, strontium:calcium and strontium isotope ratios as environmental indicators. Marine Ecology Progress Series 171, 261-273.

Duffy, T.A., Childress, W., Portier, R. & Chesney, E.J. 2016. Responses of bay anchovy (Anchoa mitchilli) larvae under lethal and sublethal scenarios of crude oil exposure.

Ecotoxicology and Environmental Safety 134, 264-272.

Reeves, D.B., Chesney, E.J., Munnelly, R.T. et al. 2018. Abundance and distribution of reef-associated fishes around small oil and gas platforms in the northern Gulf of Mexico's hypoxic zone. Estuaries and Coasts 41, 1835-1847.

Reeves, D., Munnelly, R., Riley, K. & Baltz, D.M. 2021. Edward J. Chesney 1950-2021. Gulf and Caribbean Research 32 (1). https://aquila.usm.edu/cgi/viewcontent.cgi?article=1640&context=gcr

DOI: https://doi.org/10.18785/gcr.3201.11

James H. Cowan, Jr.

Jim Cowan passed away at age 67 on 11 August 2021. Jim was a big man with big ideas and aspirations. His aspirations and many achievements impacted a broad spectrum of fisheries science and management. Jim's enthusiasm for research rubbed off on those who worked with him.

Jim received his PhD from Louisiana State University in 1985. He became a postdoctoral scientist with me at the Chesapeake Biological Laboratory in 1989 and conducted research on dynamics and production of fish early-life stages for three productive years. While at CBL, Jim's research included investigations of predation on early-life stages of fishes to understand how predation might control recruitment. His studies focused particularly on the role of jellyfishes preying on bay anchovy larvae in mesocosm and in modeling experiments (e.g., Cowan & Houde 1993; Cowan et al. 1997). With personal initiative, Jim expanded the scope of his postdoctoral research and sought out collaborations with Kenny Rose and others to develop individual-based models for bay anchovy and striped bass that provided new insights into early-life dynamics and recruitment potential (e.g., Cowan et al. 1993). In a collaboration with Lee Fuiman, Jim investigated the role of individual behavior and 'survival skills' of fish larvae as factors controlling recruitment (Fuiman & Cowan 2003).

Jim took a faculty appointment at the Dauphin Island Sea Lab, University of South Alabama, in the 1990s where he quickly became a prominent fishery scientist and educator. Jim maintained his strong interest in early-life studies and causes of recruitment variability (Cowan & Shaw 2002), including the role of density dependence as a regulator of abundance (Cowan et al. 2000) but his research expanded to include and encompass investigations addressing many pressing management issues affecting Gulf of Mexico fisheries. In 1996-98, Jim served as President of the Early Life History Section of AFS. In 2001, Jim joined the faculty as Professor in the Department of Ocean & Coastal Sciences at Louisiana State University where he continued to broaden his research portfolio. At LSU, Jim's teaching and mentoring gained prominence; he guided numerous graduate students to M.S. and PhD degrees. Teaching played a major role in Jim's professional activities, including his leadership in developing new programs in Fisheries Science at LSU. Throughout his career Jim maintained an enduring interest in the role of recruitment variability in controlling abundance of marine fish populations.

In the most recent two decades, Jim became prominent as an advisor to fisheries management agencies in the Gulf region and in developing fisheries and ocean policy at the regional and national levels in the USA. He served on numerous panels and committees dealing with fisheries policies. Prominent among issues facing Gulf fisheries during Jim's tenure at LSU was the need for knowledge on the ecology and dynamics of red snapper and also management of that species (Cowan et al. 2011). Jim took on a leadership role in red snapper research, especially the role of oil platforms in the Gulf of Mexico as habitat, and was active in developing policy and management advice for this controversial fishery (e.g., Cowan 2011). For readers interested in more details of Jim's career and his many awards and service activities, a nice account is provided in a Louisiana State University obituary (https://www.lsu.edu/cce/mediacenter/news/2021/08/16-cowanmemoriam.php).

References Cited

Cowan, J.H., Jr. 2011. Red snapper in the Gulf of Mexico and US South Atlantic: data, doubt and debate. Fisheries 36, 319-331.

Cowan, J.H., Grimes, C.B., Patterson, W.F. et al. 2011. Red snapper management in the Gulf of Mexico: science- or faith-based? Reviews in Fish Biology and Fisheries 21, 187-204.

Cowan, J.H., Jr. & Houde, E.D. 1993. Relative predation potentials of scyphomedusae, ctenophores and planktivorous fish on ichthyoplankton in Chesapeake Bay. Marine Ecology Progress Series 95, 55-65.

Cowan, J.H., Rose, K.A. & DeVries, D.R. 2000. Is density-dependent growth in young-of-the-year fishes a question of critical weight? Reviews in Fish Biology and Fisheries 10, 61-89.

Cowan, J.H., Jr, Rose, K.A. & Houde, E.D. 1997. Size-based foraging success and vulnerability to predation: selection of survivors in individual-based models of larval fish populations. In: R.C. Chambers & E.A. Trippel (Eds) Early Life History and Recruitment in Fish Populations. pp. 357–386. Chapman & Hall, London.

Cowan, J.H., Jr, Rose, K.A., Rutherford, E.S. et al. 1993. Individual based model of young-of-the-year striped bass population dynamics. II. Factors affecting recruitment in the Potomac River, Maryland. Transactions of the American Fisheries Society 122, 439-458.

Cowan, J.H. Jr & Shaw, R.F. 2002. Recruitment. In: L.A. Fuiman & R.G.Werner (Eds) Fishery Science: The Unique Contributions of Early Life Stages. pp. 88–111. Blackwell Science, Oxford.

Fuiman, L.A. & Cowan, J.H., Jr. 2003. Behavior and recruitment success in fish larvae: repeatability and covariation of survival skills. Ecology 84, 53-67.

H. Geoffrey Moser (1938-2021)

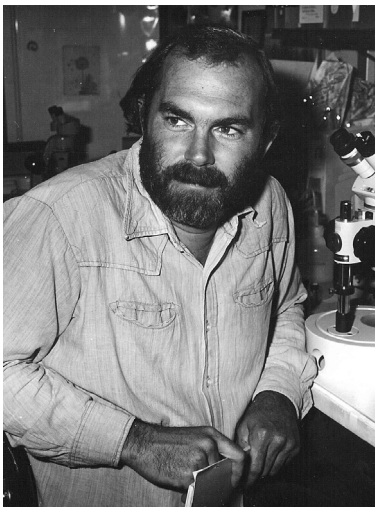


Figure 24. Geoff Moser in 1977 while co-teaching the larval-fish identification class with Elbert Ahlstrom at the NMFS SWFC, La Jolla.

by Eric J. Hilton[1] and Bruce Mundy[2]

Eric J. Hilton[1] and Bruce Mundy[2]

[1]Virginia Institute of Marine Science, William & Mary, Dept. of Fisheries Science, Gloucester Point, Virginia 23062, USA, Email: ehilton@vims.edu

[2]National Marine Fisheries Service, Pacific Islands Fisheries Science Center, 1845 Wasp Blvd., Honolulu, HI 96818, USA, Ocean Research Exploration, P.O. Box 23, Email: mundyichthyo@gmail.com

H. Geoffrey Moser (Figure 24), a founding member of the Early Life History Section, passed away at the age of 83 on September 30, 2021, in Bozeman, Montana, where he and his wife Pam had moved to after he retired from NOAA in 2002. Geoff, as he was known to friends and colleagues, was predeceased by his mother, Hazel, father, Howard, his older sister, Judith ("Judy") Booth, and his younger brother, Kris. Geoff is survived by his wife Pam and their daughter, Joscylen Donnelly, and son, David Moser, and their families.

Geoff was born in Philadelphia, Pennsylvania, on December 5, 1938. As a child, Geoff's family moved to Ridley Park, PA, and that is where he graduated from high school. He played clarinet in the marching band and tenor saxophone in the high-school dance band. He was also captain of his school's football team, which he led to an undefeated season in his senior year. Beyond sports and music, Geoff and his siblings were heavily influenced by their father's love of fishing and nature. Geoff, of course, ultimately pursued a career in larval fishes; his brother became a wildlife biologist and his sister an amateur naturalist and elementary school teacher.

Geoff graduated high school in 1955, and moved to Dartmouth College, where he majored in biology (Margulies, 2005). He became a research student in the lab of William Whitney Ballard (1906–1998), whose research centered on embryology, and included studies of *Lepisosteus*, *Polyodon*, *Amia*, and *Salmo*. Geoff graduated from Dartmouth in 1960, and became Ballard's teaching assistant. He began work on a Master's degree under Ballard on the development of the gill arches in the axolotl, although he did not complete that degree. Geoff had developed an interest in marine biology, which led him to the University of Southern California (USC), Los Angeles, to continue his graduate studies with Jay Savage, who at the time had funding for a project on the midwater fishes of the Southern California offshore basins. Geoff and Pam, who were married in 1961, moved to California later that year.

Savage's lab at the time included a number of others who would go on to have long and productive careers in ichthyology and herpetology, including John Paxton, Robert Lavenberg, William Bussing (1933–2014), Richard McGinnis, Arnold Kluge, David Wake (1936–2021), Marvalee Wake, and Roy McDiarmid. Many of these individuals became close, lifelong friends of Geoff's. It was Savage who also introduced Geoff to Elbert "Ahlie" Ahlstrom (1910–1979) at the Bureau of Fisheries Laboratory in nearby La Jolla, CA, an introduction that would change the course of Geoff's Ph.D. research as well as the rest of his career. Ahlstrom was director of the La Jolla California Current Resources Laboratory of the U.S. Fish and Wildlife Service Bureau of Commercial Fisheries (BCF) from 1959–1967. At the time, Geoff had become interested in bathylagids in the midwater samples that he was collecting with others in Savage's group, and thought that he would like to work on the family for his dissertation. As it turned out, Ahlstrom also was working on bathylagids, and had a manuscript already in preparation. Therefore, Geoff turned to working on Rockfishes, and completed his Ph.D. on the reproductive and developmental biology of the genus *Sebastes*. The reproduction and early development of Rockfishes and other viviparous teleosts remained a research interest throughout his career (e.g., Moser, 1967, 1996a; Moser et al., 1977; Washington et al., 1984; Butler et al., 2003). Geoff was the recipient of a patronym of a Rockfish, *Sebastes moseri* Eitner, Kimbrell, and Vetter, 1999.

Geoff was fortunate in the timing of his visit with Ahlstrom, as at the time, Ahlstrom was expanding the size of lab personnel to process samples from the California Cooperative Oceanic Fisheries Investigation (CalCOFI) surveys. As a graduate student, Geoff was hired by Ahlstrom as a technician in the CalCOFI program in 1962, initially working on adult fishes under Fred Berry. Geoff soon was switched by Ahlstrom to help with the

Figure 25. Geoff Moser (Right) with Elbert "Ahlie" Ahlstrom (Left) in 1972, taken for a San Diego newspaper article about the Wildlife Society recognition of Moser and Ahlstrom (1970).

identification of larval fishes from the surveys. Under the mentorship of Ahlstrom, Geoff set his career path to work on larval fishes as a fisheries biologist (Figure 25). A unique feature of the CalCOFI surveys under Ahlstrom's supervision was that all fishes in the samples were identified, regardless of their commercial importance. This circumstance provided Geoff with the opportunity to study and publish on not just a limited number of groups of larval fishes, but rather all fishes from the California Current ichthyofauna.

Ahlstrom stepped down as director of the BCF La Jolla lab after its move to a new fisheries building at Scripps Institution of Oceanography in 1964, so that he could spend more time on research than administration, and in 1967 led multi-vessel EASTROPAC cruises in the tropical eastern Pacific Ocean. The EASTROPAC samples increased the taxonomic scope of specimens available for Geoff and Ahlstrom's research. Among the EASTROPAC samples, the two found an unusual, small, slender sternoptychid species, which they described as *Ariaophos eastropas* Ahlstrom and Moser 1969. This was one of two new species for which Geoff was coauthor, the other being *Bythites hollisi* Cohen, Rosenblatt, and Moser 1990 (now *Thermichthys hollisi*).

Geoff traveled widely in his studies of larval fishes. From 1970-1971, he was awarded the Johannes Schmidt Stipendium for Oceanographers, which allowed him to move to Denmark for nearly a year to study the Dana collections at the Zoological Museum at the University of Denmark with Erik Bertelsen (1912–1993) and Jørgen Nielsen. He also conducted research at the British Museum (Natural History) in London with Norman B. "Freddy" Marshall (1915–1996), the Institute of Oceanographic Sciences on a Food and Agriculture Organization of the United Nations (FAO) in Wormley, England, and at the University of Kiel in Germany to work with Walter Nellen on his collection of larval fishes, and later to Hamburg to work briefly with Gerhard Krefft (1912–1993) on specimens at the Institut fur Seefischerei. This European research trip greatly expanded the scope of Geoff's research, particularly on myctophids, and allowed him to publish a great number of papers of larvae in that family (Moser and Ahlstrom, 1970, 1974, 1996; Moser et al., 1984a; Moser and Watson, 2006). Later in his career, Geoff traveled to Japan to work with Kouichi Kawaguchi (1940–2007) at the Ocean Research Institute (now part of the Atmosphere and Ocean Research Institute), University of Tokyo and to work with Kunio Amaoka in Hokkaido. Work with collections of oceanic fish larvae worldwide enabled Geoff to continue expanding the reach of his work on larval fishes.

Among his many notable accomplishments, Geoff was co-instructor for the six of the seven Ahlstrom larval fish identification courses that were held annually at the SWFC in the 1970s (Geoff was on his European sabbatical when the first course was taught in 1971). These courses were a catalyst for a great number of larval fish biologists to expand and hone their larval fish identification skills – many of the larval fish researchers active today can trace their skills through those of their mentors, and their mentor's mentors, to the Ahlstrom-Moser courses. As G. David Johnson recalls, "Geoff's passing is not only a personal loss for many of us, but a huge loss to science and particularly the special world of larval fishes. I was one of many who benefited from his and Ahlie's mentorship as a graduate student at Scripps - in fact it completely changed my research trajectory and played a critical role in eventually being hired at the Smithsonian, where I have now been for almost 40 years." Ahlstrom and Geoff also co-taught a larval-fish identification course at the Universidad Autónoma de Baja California School of Marine Science, Ensenada, Mexico, and after Ahlstrom passed away, Geoff taught two courses on larval-fish identification at the Centro Interdisciplinario de Ciencias Marinas in La Paz (Figure 26) and at Mazatlan, and at the Instituto Nacional de Pesca in Mexico City. These courses are undoubtedly one of the greatest legacies that Ahlie and Geoff gave to ichthyology[1].

When Ahlstrom died in August, 1979, the SWFC, and the field of larval fish taxonomy, lost one of its leaders. As John Paxton recalls, Ahlstrom's "unexpected passing must have been a shock to Geoff, who lost a mentor, coauthor, friend, and icon. While Geoff was not alone in this regard, as Ahlie had many coauthors and coworkers, he must have gone through a particularly hard time."

Figure 26. Geoff Moser (far left) in 1997 teaching a larval fish course at the Centro Interdisciplinario de Ciencias Marinas in La Paz, Mexico. Left to right: Geoff Moser (standing); Lourdes Guevara Rascado (in foreground, seated at microscope with back to camera); Martin Hernandez-Rivas (seated and partially obscured); Rogelio Gonzalez Armas (seated at microscope); René Funes-Rodríguez (standing); Bill Watson (seated at microscope).

At the request of Reuben Lasker, then head of the SWFC Coastal Resources Division, Geoff organize a symposium commemorating Ahlstrom's stature in the field of larval fishes. Geoff envisioned this symposium honoring his friend and colleague as the perfect opportunity to build upon an outline of a book on larval fishes that he and Ahlstrom had put together that would unite the larval fish biology and evolutionary biology of fishes, and emphasize the importance of the utility of early life history characters for understanding aspects of the systematic relationships of fishes. Geoff organized an editorial team that also included Daniel Cohen (1930–2016), Sally Richardson (1944–1986), Michael Fahay, Arthur Kendall, Jr., and William Richards, all of which were close friends of Geoff's. The symposium, which included 87 presentations by authors from 10 countries, was held August 15-18, 1983 at the University of California, San Diego, and was published by Allen Press as the first special publication of the American Society of Ichthyologists and Herpetologists (Moser et al., 1984b). Nalani Schnell remarks that the "Red Book," as it has come to be known, "is unparalleled and remains the best reference combining information not only on identification characters, development and relationships, as well as on larval sampling, storage, and different methods that can be employed with tiny specimens…In our larval fish course, the students hardly ever put it down."

Geoff and Ahlstrom had discussed developing a short identification guide for larval fishes for the CalCOFI region, but this was one of those projects for which there never seemed to be time. After Ahlstrom died, other pressures, including the editing of the Symposium volume, took precedence. When other regional offices produced identification guides for larval fishes for other regions (e.g., western North Atlantic, Fahay, 1983, 2007; northern North Pacific, Matarese et al., 1989), Geoff, together with William Watson, revived the idea for a CalCOFI guide. The resulting tome was published as part of the CalCOFI Atlas series by Allen Press in 1996 (Moser, 1996b) and is one of the most complete and useful works on larval fishes, extending far beyond the CalCOFI region. In addition to being editor of this book, Geoff was the sole author of 22 chapters (primarily those on the Stomiiformes and Myctophiformes) and coauthor of 24 others.

Although perhaps foremost in Geoff's research program was the identification of larval fishes and the importance of early life history stages to understanding the evolution and biology of fishes, he was also a fisheries biologist, with a responsibility to investigate the influence of the ecology and distribution of larval fishes on the recruitment of commercially-important species. Among his publications, he authored more than 40 data reports documenting and reporting on the distribution of larval fishes from the CalCOFI surveys as a way to make them publicly available and serve as a contribution to the conservation and management of the fisheries resources of the southwestern region of the US. Geoff's research also was fundamental to the development of the egg production method for stock assessment of species with pelagic eggs and well-defined spawning areas and seasons, such as many clupeiforms (Moser and Ahlstrom, 1985).

Over the course of his career, Geoff published over 200 papers and data reports on a wide variety of topics in the early life history of fishes, and he was honored with many professional awards throughout his career. In 1971 his paper on larval Myctophidae (Ahlstrom and Moser, 1970) was awarded the best paper in fish ecology and management by the Wildlife Society. In 1985, Geoff and the other editors of Ontogeny and Systematics were awarded the U.S. Department of Commerce Silver Medal for Distinguished Achievement and Geoff was awarded the NOAA Bronze Medal in 1996 for "superior federal service for a career of scientific excellence of lasting benefit to the nation" for publication of the CalCOFI atlas. Also, in 1996 Geoff was a member of the group of fisheries biologists to be awarded a NOAA Bronze Medal for "superior federal service, for planning and conducting a joint NMFS-Mexico-California survey method to estimate spawning biomass of Pacific sardines." He was co-author on a paper that won the best paper award in Fishery Bulletin in 2003 (Butler et

al., 2003). After his retirement, Geoff was awarded the first AFS ELHS's Elbert H. Ahlstrom Career Achievement Award and the Outstanding Career Achievement Award from the American Institute of Fishery Research Biologists, both in 2006. Throughout his career, Geoff was a good friend to many in the ELH and ichthyological world, and was freely giving of his time, good nature, and humbleness. Mike Fahay recalled that "Geoff was a good friend. More than that, he did an awful lot for me early on in my fish ontogeny career, including guiding me through the intricacies of NMFS bureaucracy. I couldn't have prepared my monograph on northwestern Atlantic fish development without Geoff's help early on." Bruce Mundy remembers that "I first talked with Geoff when I was looking for employment after graduate school. His encouragement is something that I treasure. I later visited him again when he asked me to go to La Jolla to assist with a MOCNESS that his group had acquired. Geoff also came to Honolulu at the invitation of George Boehlert, his friend from Scripps and my supervisor (Figure 27). We sailed together on an oceanographic sampling cruise. His enthusiasm for larval fishes, our shared interest, was a treat during that time."

Figure 27. Geoff Moser with some of the larval fish and micronekton group at the NMFS Honolulu Laboratory in 1986. From left to right, Geoff, Bruce Mundy, Alton Chung, Michael Seki, and George Boehlert.

Perhaps the most fitting sentiment to close this memorial are those that were expressed by Jeff Leis in learning of Geoff's passing: "Another giant in the field has left us, but he has left the field so much better than when he arrived. Geoff was a true gentleman, a wonderful friend and an innovative researcher. He was employed by a fisheries agency doing taxonomy and systematics – subjects that are typically not greatly appreciated by such organizations. But, his contributions were greatly appreciated by the La Jolla lab, where there was a great interdisciplinary team at the time (Geoff, Ahlie Ahlstrom, Paul Smith, John Hunter, Ruben Lasker, etc.). He demonstrated that a larval fish biologist need not be pigeon-holed in a narrow field of research, as is typically the case of 'big-fish' biologists, and that was an inspiration to me throughout my career." Bill Watson adds, "Aside from his numerous scientific accomplishments, Geoff was one of the best colleagues, supervisor and friend anyone could hope to have." Indeed, it was Geoff's enthusiasm, modesty, and generosity toward others that contributed to his success and influence as a mentor, program manager, and highly productive scientist.

The information in this obituary was based on a manuscript for the Historical Perspectives series in the journal Ichthyology & Herpetology (Mundy and Hilton, in press). Geoff Moser was interviewed in April, 2021 for that article by internet during the COVID-19 pandemic at his home in Bozeman, Montana, and through follow-up questions by email. Geoff supplied photographs and read and approved the final manuscript of that more detailed article, and was in communication about it up through the days immediately before his death. The reader is referred to that article for more details about the life and career of Geoff Moser and a more complete bibliography of his publications.

References

Ahlstrom, E. H., and H. G. Moser. 1969. A new gonostomatid fish from the tropical eastern Pacific. Copeia 1969:493–500.

Butler, J. L., L. D. Jacobson, J. T. Barnes, and H. G. Moser. 2003. Biology and population dynamics of cowcod (Sebastes levis) in the southern California bight. Fishery Bulletin 10:260–280.

Cohen D. M., R. H. Rosenblatt, and H. G. Moser. 1990. Biology and description of a bythitid fish from deep-sea thermal vents in the tropical eastern Pacific. Deep-Sea Research 37:267–283.

Eitner, B., C Kimbrell, and R. Vetter. 1999. Sebastes moseri (Scorpaeniformes: Scorpaenidae): A new rockfish from the Eastern North Pacific. Copeia 1999:85–92.

Fahay, M. P. 1983. A guide to the early stages of marine fishes occurring in the western North Atlantic Ocean, Cape Hatteras to the southern Scotian Shelf. Journal of Northwest Atlantic Fishery Science 4:415 p.

Fahay, M. P. 2007. Early stages of fishes in the western North Atlantic Ocean (Davis Strait, Southern Greenland and Flemish Cap to Cape Hatteras), Vol I and II. Northwest Atlantic Fisheries Organization. 1681 p.

Margulies, D. 2005, Geoff Moser retires. Stages, newsletter of the Early Life History Section of the American Fisheries Society. 26(3):7.

Matarese, A. C., A. W. Kendall, Jr., D. M. Blood, and B. M. Vinter. 1989. Laboratory Guide to Early Life History Stages of Northeast Pacific Fishes. NOAA Technical Report NMFS 80:652 p.

Moser, H. G. 1967. Reproduction and development of Sebastodes paucispinis and comparison with other rockfishes off southern California and Baja California. Copeia 1967:773–797.

Moser, H. G. 1996a. Scorpaenidae: Scorpionfishes, p. 733–795. In: The early stages of fishes in the California Current region. H. G. Moser (ed.). California Cooperative Oceanic Fisheries Investigations Atlas 33, Allen Press, Lawrence, Kansas.

Moser, H. G. (ed.) 1996b. The early stages of fishes in the California Current region. California Cooperative Oceanic Fisheries Investigations Atlas 33, Allen Press, Lawrence, Kansas.

Moser, H. G., and E. H. Ahlstrom. 1970. Development of lanternfishes (family Myctophidae) in the California Current. Part I. Species with narrow-eyed larvae. Bulletin of the Los Angeles County Museum of Natural History Science Number 7:145 p.

Moser, H. G., and E. H. Ahlstrom. 1974. Role of larval stages in systematic investigations of marine teleosts: The Myctophidae, a case study. Fishery Bulletin 72:391–413

Moser, H. G., and E. H. Ahlstrom. 1985. Staging anchovy eggs, p. 37–41. In: An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, Engraulis mordax). R. Lasker (ed.). U.S. Department of Commerce NOAA Technical Report NMFS 36.

Moser, H. G., and E. H. Ahlstrom. 1996. Myctophidae: Lanternfishes. p. 387–475. In: The early stages of fishes in the California Current region. H. G. Moser (ed.). California Cooperative Oceanic Fisheries Investigations Atlas 33, Allen Press, Lawrence, Kansas.

Moser, H. G., E. H. Ahlstrom, and J. R. Paxton. 1984a. Myctophidae: development, p. 218–239. In: Ontogeny and Systematics of Fishes. H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., and S. L. Richardson (eds.). American Society of Ichthyologists and Herpetologists Special Publication Number 1, Allen Press, Lawrence, Kansas.

Moser, H. G., E. H. Ahlstrom, and E. H. Sandknop. 1977. Guide to the identification of scorpionfish larvae (family Scorpaenidae) in the eastern Pacific with comparative notes on species of Sebastes and Helicolenus from other oceans. NOAA Technical Report NMFS Circular 402, 71 pp.

Moser, H. G., W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., and S. L. Richardson (eds.). 1984b. Ontogeny and Systematics of Fishes. American Society of Ichthyologists and Herpetologists Special Publication Number 1, Allen Press, Lawrence, Kansas.

Moser, H. G., and W. Watson. 2006. Chapters 39 and 40. Order Myctophiformes, Families Neoscopelidae and Myctophidae, p. 463–579. In: Early stages of Atlantic fishes. An Identification guide for the central western North Atlantic. W. J. Richards (ed.). Taylor and Francis CRC Press, Miami.

Mundy, B., and E.J. Hilton. In press. H. Geoffrey Moser. Larval fishes: Taxonomy, distribution, and fisheries biology. Ichthyology & Herpetology.

Washington, B. B., H. G. Moser, W. A. Laroche, and W. J. Richards, Jr. 1984. Scorpaeniformes: development, p. 405–428. In: Ontogeny and Systematics of Fishes. H. G. Moser, W. J. Richards, D. M. Cohen, M. P. Fahay, A. W. Kendall, Jr., and S. L. Richardson (eds.). American Society of Ichthyologists and Herpetologists Special Publication Number 1, Allen Press, Lawrence, Kansas.

LARVAE OF THE ISSUE

The Spotted tinselfish (*Xenolepidichthys dalgleishi*) belongs to the Grammicolepididae, a family that contains only three species. The species occurs in the Western and Eastern Atlantic, Indian Ocean, and the Western Pacific. The maximum size of Spotted tinselfish is about 150mm. Spotted tinselfishes are rare and there is not much known about them. They can be found on continental shelves in depth between between 100 – 900 meters.

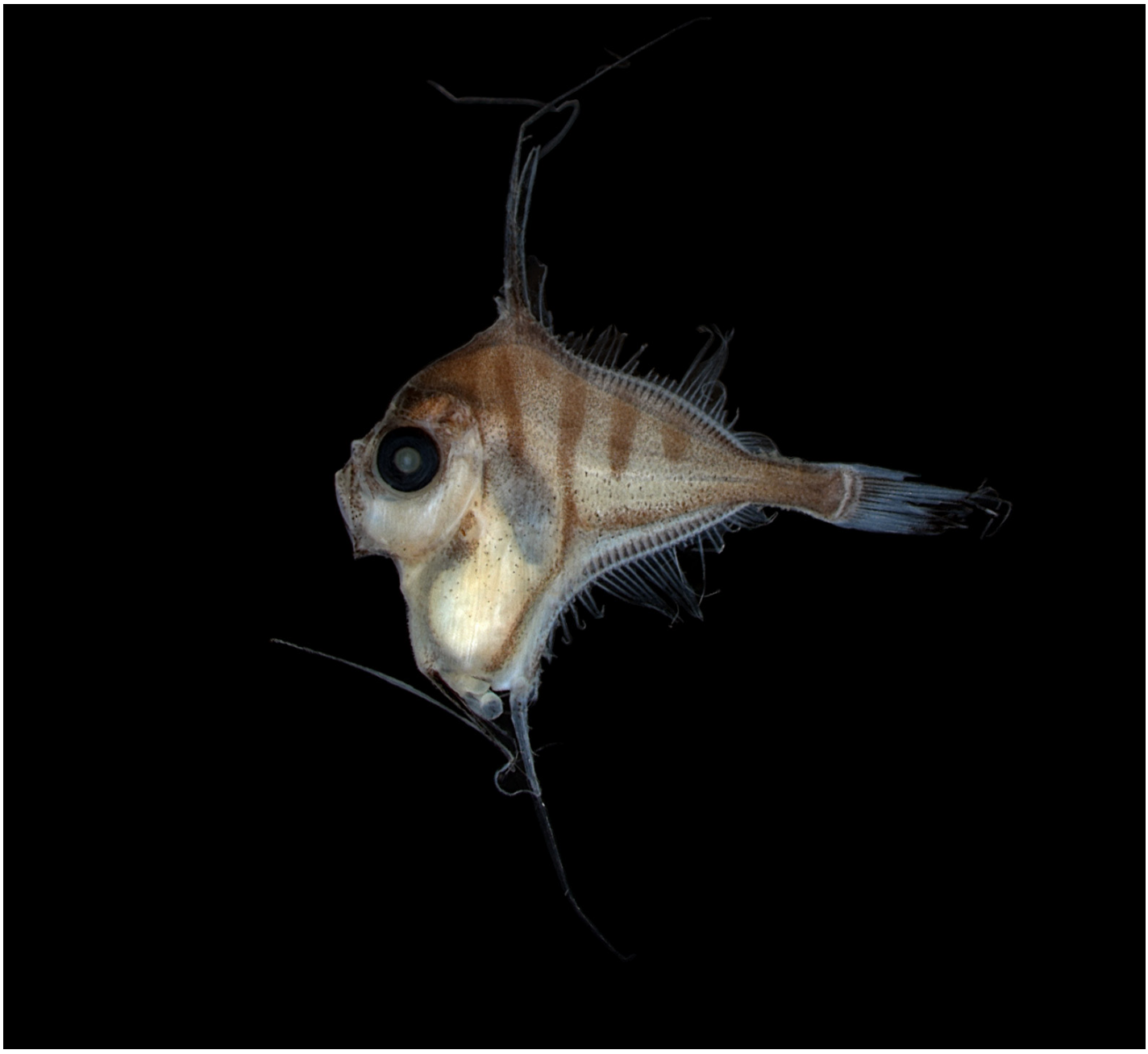


Figure 28: Spotted tinselfish (*Xenolepidichthys dalgleishi*), 9.9 mm SL

LARVAL FISH COLLECTION OF THE ISSUE

Nalani Schnell,
MUSÉUM NATIONAL D'HISTOIRE NATURELLE, Station Marine de Concarneau

The Muséum national d'Histoire naturelle (MNHN) in Paris is home to a large ichthyoplankton collection, comprising more than 16 000 lots. Most of these samples were collected offshore of French Polynesia in the Pacific Ocean, in the Indian Ocean, and the Antarctic during multiple expeditions carried out since 1966. Until recently these specimens have been stored in the Museum's collection unsorted, unidentified and fixed in formalin. Supported through internal funds, most of the collection has been transferred in ethanol in 2017 and invited experts as well as the participants of the 2018 international larval fish course have started to identify this vast and unique collection. However, the collection was lacking larval fish from the Eastern North Atlantic.

In 2016, Cindy van Damme from Wageningen Marine Research (WMR), IJmuiden, The Netherlands and I were both invited instructors for the larval fish workshop in Plymouth, England, where we discussed about identification, fixation and storage of larval fishes. It soon became obvious that our two institutes (the MNHN and WMR) treat collections differently. WMR provides independent scientific research and advice for an integrated sustainable protection, exploitation and spatial use of the sea and coastal zones. One specific project focuses on collecting monthly data on the spatio - temporal distribution of fish eggs and larvae on the Dutch Continental Shelf (NCP) in the southern North Sea. The English Channel and the south-western North Sea are important spawning areas for many fish species and the prevailing currents transport eggs and larvae from these areas towards the NCP.
Once ichthyoplankton samples have been analyzed at WMR, they are kept for about five years before they are discarded, due to storage space constraints. This is contrary to the strategy and policy we employ in museums like the MNHN. Cindy and I both agreed that the samples, fixed and preserved in formalin, are in good condition and quite valuable as they come from monthly ichthyoplankton samples. Such a collection is a big asset for any larval fish collection, but especially for the one at the MNHN, as we did not have any larval fish samples from European waters nor access to a research vessel to undertake ichthyoplankton sampling. Thanks to Cindy and WMR, the MNHN had the unique opportunity to receive about 60 boxes of glass vials with larval fishes from their year-round survey in 2010-2011 (Figure 29), including 73 different species in different developmental stages. Once the samples arrived at the MNHN, the collection was transferred to ethanol and added to the existing larval fish collection. It now also serves as teaching material for the international larval fish course. If you are interested to see this collection with specimen from different oceans, then sign up for our next year's course: https://sites.google.com/view/larval-fish-course/home!

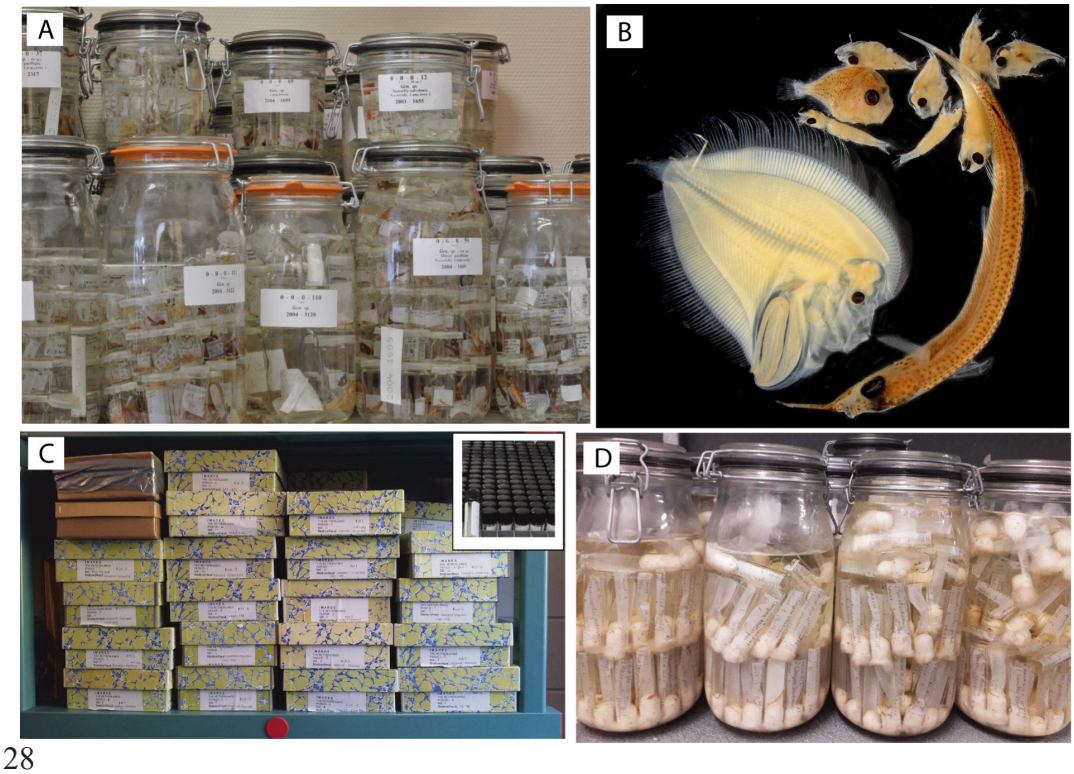


Figure 29: A) Existing larval fish collection from the Pacific and Indian Ocean. B) Unsorted sample from this collection. C) WMR collection from the southern North Sea. D) WMR collection transferred to ethanol and included in the MNHN larval fish collection.


Early Life History Section
American Fisheries Society
ROCK THE VOTE 2022!
Send your nominations for President and Secretary to alison.deary@noaa.gov by **December 31st**.

Larval Fish Course

19th September - 30th September 2022,
Concarneau, France

MUSÉUM NAT HIST NATURELLE
STATION MARINE CONCARNEAU

We offer an international lecture and laboratory course at the marine station in Concarneau, France, based on samples from the Eastern North Atlantic and Pacific Ocean.

We provide:

1) **Labs on larval fish identification (~50 fish families)**
2) **Lectures on key identification features, systematics and ecology**
3) **Lectures on sampling and preservation methods**

Lectures and labs will be delivered by:
Catriona Clemmesen (GEOMAR, Germany),
Cindy Van Damme (Wageningen Marine Research, Netherlands),
Peter Konstantinidis (Oregon State University, USA),
Cyril Gallut (UPMC, France), and
Nalani Schnell (MNHN, France).

GEOMAR Helmholtz Centre for Ocean Research Kiel
WAGENINGEN UNIVERSITY & RESEARCH
Oregon State University
SORBONNE UNIVERSITÉ

Places limited to 15 participants, course registration fee 850 € per person

For further information and registration please visit
https://sites.google.com/view/larval-fish-course/
or contact Nalani Schnell
nalani.schnell@mnhn.fr

Marine Station in Concarneau, France - http://concarneau.mnhn.fr

NEWSLETTER PRODUCTION TEAM

Newsletter Editor
Peter Konstantinidis
Oregon State University
Dept. of Fisheries & Wildlife
Corvallis, Oregon
peter.konstantinidis@oregonstate.edu

Simon Geist
Texas A&M University Corpus Christi
Dept. of Life Sciences
Corpus Christi, TX
simon.geist@tamucc.edu

Social Media
Contact Dominique Robert
for any news for the section homepage
earlylifehistory.fisheries.org
dominique_robert@uqar.ca

Northeast Region
Katey Marancik
NMFS, Northeast Fisheries Science Center
Narraganset, Rhode Island
katey.marancik@noaa.gov

Western Region
Daniel Margulies
Inter-American Tropical Tuna Commission
La Jolla, California
dmargulies@iattc.org

Southern Region
Trika Gerard
NMFS, Southeast Fisheries Science Center
Miami, Florida
trika.gerard@noaa.gov

European Region
Catriona Clemmesen
GEOMAR, University of Kiel
Kiel, Germany
cclemmesen@geomar.de

North Central Region
Ed Roseman
USGS Great Lakes Science Center
Ann Arbor, Michigan