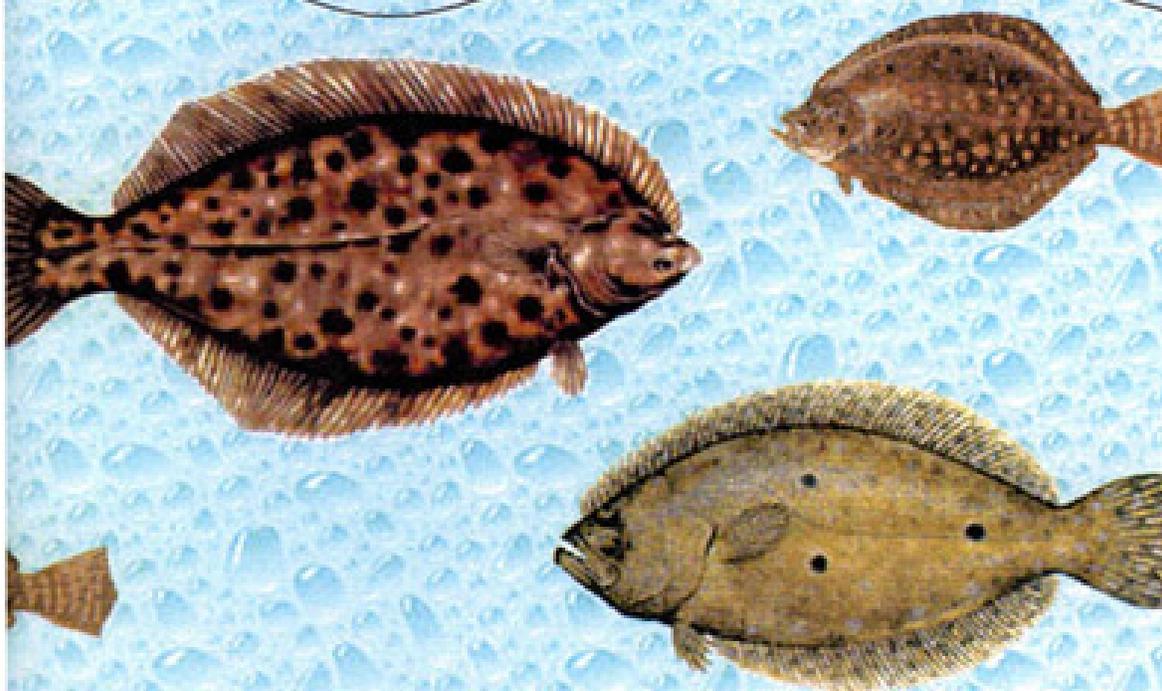

Flatfish Biology Conference



December 5-6, 2000
Mystic, Connecticut

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Flatfish Biology Workshop

December 5-6, 2000, Mystic, Connecticut

by Conference Steering Committee: Anthony Calabrese (Chair)¹,
Jay Burnett², Donald Danila³, Penelope Howell⁴, Ambrose Jearld²,
Jeremy King⁵, Renee Mercaldo-Allen¹, and Chris Powell⁶

¹ National Marine Fisheries Service, Milford CT 06460-6490

² National Marine Fisheries Service, Woods Hole MA 02543

³ Northeast Utilities Environmental Laboratory, Waterford CT 06385

⁴ Connecticut Department of Marine Environmental Protection, Old Lyme CT 06385

⁵ Massachusetts Division of Marine Fisheries, Pocasset MA 02563

⁶ Rhode Island Division of Environmental Management, Wickford RI

Seventh in a series of Flatfish Biology Conferences



U.S. DEPARTMENT OF COMMERCE
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Southern New England Chapter of the
American Fisheries Society

Flatfish Biology Workshop

December 5-6, 2000, Best Western Sovereign Hotel, Mystic, Connecticut

Oral Presentations

Tuesday, December 5th

8:00 a.m. **Registration/Coffee, Danish and Muffins**

8:45 a.m. Welcome and Introduction
Anthony Calabrese, Chair
National Marine Fisheries Service
Milford Laboratory
Milford, CT

John Boreman, Director
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA

Session I

Penny Howell, Chair

Connecticut Department of Environmental Protection
Fisheries Division, Old Lyme, CT

9:00 a.m. Beyond Winter Flounder: A Global Perspective of Species Diversity in the Flatfish (Order Pleuroneciformes)

Thomas Munroe
National Marine Fisheries Service, National Systematics Laboratory, Washington, DC

9:20 a.m. Melanophore Receptor Diversity as a Component of Flatfish Patterning Physiology

Derek Burton, Dennis Mayo, and Joanne Vokey
Memorial University of Newfoundland, Department of Biology, St. John's, Newfoundland, Canada

9:40 a.m. Pigmentation Development in Hatchery-reared Summer Flounder

Jessica Bolker
University of New Hampshire, Department of Zoology, Durham, NH

10:00 a.m. Patterns of Reproduction in Flatfish: Frequency, Up-regulation and Down-regulation

Margaret Burton
Memorial University of Newfoundland, Department of Biology, St. John's, Newfoundland, Canada

10:20 a.m. **Coffee/Danish/Muffins**

Session II

Don Danila, Chair

Northeast Utilities Environmental Laboratory
Waterford, CT

- 10:50 a.m.** Experimental Analysis of Geographic and Seasonal Differences in Spawning Time on Growth, Development, and Survival of Larval Summer Flounder, *Paralichthys dentatus*
Chris Chambers and David Witting
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ
- 11:10 a.m.** Timing of Feeding Transition and Individual Consumption Rates Affect Growth of Summer Flounder (*Paralichthys dentatus*) Larvae
Markus Koelbl and David Bengtson
University of Rhode Island, Department of Fisheries, Animal and Veterinary Sciences, Kingston, RI
- 11:30 a.m.** Energetics of Growth Differences in Cultured Summer Flounder, *Paralichthys dentatus*: Prey Consumption and Absorption Efficiency by Newly-settled Juveniles
Tessa Simlick¹, Robin Katersky^{1,2}, and David Bengtson¹
¹University of Rhode Island, Department of Fisheries, Animal and Veterinary Sciences, Kingston, RI, and ²National Marine Fisheries Service, Milford Laboratory, Milford, CT
- 11:50 a.m.** The Oxygen Consumption, Ammonia Excretion and Scope for Growth of Newly Settled Summer Flounder, *Paralichthys dentatus*
Robin Katersky^{1,2}, Tessa Simlick², and David Bengtson²
¹National Marine Fisheries Service, Milford Laboratory, Milford, CT, and ²University of Rhode Island, Department of Fisheries, Animal and Veterinary Sciences, Kingston, RI
- 12:10 p.m.** **Hosted Buffet Lunch**

Session III

Ambrose Jearld, Chair

National Marine Fisheries Service
Woods Hole, MA

- 1:10 p.m.** Correlations among Stage-specific Abundances of Larval and Juvenile Winter Flounder near Millstone Point, CT and their Relation to Year-class Strength
Donald Danila¹, Ernest Lorda¹, and J. Dale Miller^{1,2}
¹Northeast Utilities Environmental Laboratory, Waterford, CT and ²Normandeau Associates, Plymouth, MA
- 1:30 p.m.** Distribution, Life History, and Identification of Southern U. S. *Paralichthys* with Implications for Management
Bruce Thompson and Andrew Fischer
Louisiana State University, Coastal Fisheries Institute, Baton Rouge, LA
- 1:50 p.m.** Abundance, Density and Life Frequency of Juvenile English Sole in Pacific Coast Estuaries from 1998-2000
Christopher Rooper and Donald Gunderson
University of Washington, School of Fisheries, Seattle, WA

2:10 p.m. The Distribution and Abundance of Juvenile American Plaice, *Hippolossoides platessoides*, in the Southwestern Gulf of Maine, New Hampshire
Augustine Mungkaje and W. Huntting Howell
University of New Hampshire, Zoology Department, Durham, NH

2:30 p.m. Plasticity in Size, Age and Development of at Settlement Individually Reared Winter Flounder (*Pseudopleuronectes americanus*) Larvae
Marc Gravel and Joseph Brown
Memorial University of Newfoundland, Ocean Sciences Centre, St. John's, Newfoundland, Canada

2:50 p.m. Refreshment Break

Session IV

Chris Powell, Chair

Rhode Island Division of Environmental Management
Wickford, RI

3:20 p.m. Temperature Effects on Embryonic Developmental Rates, Size at Hatching, and Survival of Yolk-sac Larvae of Summer Flounder, *Paralichthys dentatus*
Peter Berrien, John Sibunka, and Chris Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

3:40 p.m. Metamorphosis in Summer Flounder: Manipulation of Thyroid Status to Modify Growth, Development and Settling Behavior
Steven Gavlik and Jennifer Specker
University of Rhode Island, Graduate School of Oceanography, Narragansett, RI

4:00 p.m. Ontogenetic Transitions During the First Year of Life in Two Cohorts of Windowpane Flounder, *Scophthalmus aquosus*
Melissa Newman and Ken Able
Rutgers University Marine Field Station, Tuckerton, NJ

4:20 p.m. Gonadotropin-releasing Hormone Affects Sperm Production of Atlantic Halibut, *Hippoglossus hippoglossus*
Debbie Martin-Robichaud¹ and J. Powell²
¹Fisheries and Oceans, Biological Station, St. Andrews, New Brunswick, Canada, and ²Syndel International, Inc., Vancouver, British Columbia, Canada

4:40 p.m. Larval Winter Flounder Stock Identification using Microelements: First-year Analysis (2000) and Preliminary Results
Saul Saila¹, Ernest Lorda², Bradley Moran¹, and Donald Danila²
¹University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, and ²Northeast Utilities Environmental Laboratory, Waterford, CT

5:00 p.m. Poster set-up

6:00 p.m. Hosted Mixer and Poster Session

Wednesday, December 6th

7:45 a.m. Registration/Coffee, Danish and Muffins

Session V

Jeremy King, Chair

Massachusetts Division of Marine Fisheries
Pocasset, MA

8:20 a.m. Winter Flounder, *Pseudopleuronectes americanus*, Stock Enhancement in New Hampshire: Evaluating Release Locations

Elizabeth Fairchild and W. Huntting Howell

University of New Hampshire, Zoology Department, Durham, NH

8:40 a.m. Effects of Scallop Dredging on a Recently Settled Continental Shelf Flatfish: Disturbance or Status Quo?

Mark Sullivan¹, Robert Cowan¹, Kenneth Able², and Michael Fahay³

¹Rosenstiel School of Marine and Atmospheric Science, Division of Marine Biology and Fisheries, Miami, FL., ²Rutgers University, Marine Field Station, Tuckerton, NJ, and ³National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

9:00 a.m. Dynamic Habitat in a Temperate Estuary and Spatio-temporal Variation in the Growth of an Early Juvenile Flatfish

John Manderson¹, Beth Phelan¹, Carol Meise¹, Linda Stehlik¹, Allen Bejda¹, Jeff Pessuti¹, Linda Arlen¹, Andrew Draxler¹, and Allan Stoner²

¹National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and ²National Marine Fisheries Service, Hatfield Marine Sciences Laboratory, Newport, OR

9:20 a.m. Recruitment of Summer Flounder Larvae to Chesapeake Bay: Larval Flux at an Inlet

Harvey Walsh¹, Jonathan Hare¹, Simon Thorrold², Arnoldo Valle-Levinson³, Chris Reiss³, and Cynthia Jones³

¹NOAA, National Ocean Service, Center for Coastal Fisheries and Habitat Research, Beaufort Laboratory, Beaufort, NC, ²Old Dominion University, Department of Biological Science, Norfolk, VA, and ³Old Dominion University, Ocean, Earth, and Atmospheric Sciences, Norfolk, VA

9:40 a.m. Use of A Rhode Island Salt Pond by Juvenile Winter Flounder, *Pseudopleuronectes americanus*

Maureen Koprowski, Chris Orphanides, Marnita Chintala, Giancarlo Cicchetti, and Lesa Meng
U.S. Environmental Protection Agency, Office of Research and Development, Atlantic Ecology Division, Narragansett, RI

10:00 a.m. Coffee/Danish/Muffins

Session VI

Jay Burnett, Chair

National Marine Fisheries Service
Woods Hole, MA

10:20 a.m. Experimental Evaluation of Ontogenetic Diet Transitions in Summer Flounder, *Paralichthys dentatus*, Using Stable Isotopes as Diet Tracers

David Witting¹, Keith Bosley², Christopher Chambers¹, and Sam Wainright³

¹National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, ²National Marine Fisheries Service, Hatfield Marine Sciences Laboratory, Newport, OR, and ³U. S. Coast Guard Academy, Department of Science, Academic Division, New London, CT

- 10:40 a.m.** Restriction Endonuclease Characters of Flatfish Ribosomal DNA may Help Resolve their Phylogeny
Z. M. G. Sarwar, Jahangir¹, Ronald Eckhardt², and Pradip Kar²
¹Wabash College, Department of Biology, Crawfordsville, IN, and ²Brooklyn College of the City University of New York, Department of Biology, Brooklyn, NY
- 11:00 a.m.** An Examination of Winter Flounder (*Pseudopleuronectes americanus*) Larvae Genetic Stock Structure in Long Island Sound
Joseph Crivello¹, J. Dale Miller^{2,3}, Donald Danila², Milan Keser², Ernest Lorda², and Saul Saila⁴
¹University of Connecticut, Department of Physiology and Neurobiology, Storrs, CT, ²Northeast Utilities Environmental Laboratory, Waterford, CT, ³Normandeau Associates, Plymouth, MA, and ⁴University of Rhode Island, Graduate School of Oceanography, Narragansett, RI
- 11:20 a.m.** The Role of Carbonic Anhydrase in Renal Sulfate Secretion by Winter Flounder (*Pseudopleuronectes americanus*)
Larry Renfro^{1,2}, Thomas Maren², Eric Swensen², David Miller², and Alice Villalobos²
¹University of Connecticut, Department of Physiology and Neurobiology, Storrs, CT, and ²Mount Desert Island Biological Laboratory, Salisbury Cove, ME
- 11:40 a.m.** The Effects of Hypoxia on Growth and Hematology of Juvenile Summer and Winter Flounder
Kevin Stierhoff and Timothy Targett
 University of Delaware, College of Marine Studies, Lewes, DE
- 12:00 p.m.** **Hosted Buffet Lunch**

Session VII

Renee Mercaldo-Allen, Chair
 National Marine Fisheries Service
 Milford, CT

- 1:10 p.m.** Foraging in Juvenile Summer and Southern Flounder: Effects of Light, Turbidity and Prey Type
Ursula Howson^{1,2} and Timothy Targett²
¹National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and ²University of Delaware, College of Marine Studies, Lewes, DE
- 1:30 p.m.** An Experimental Analysis of Size-specific Predator-prey Interactions between Juveniles of Summer Flounder, *Paralichthys dentatus*, and Winter Flounder, *Pseudopleuronectes americanus*
Chris Chambers and David Witting
 National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ
- 1:50 p.m.** Response of YOY Winter Flounder to Sediment Biogeochemicals
Andrew Draxler¹ and Jessica Siclare²
¹National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and ²Saint Joseph's University, Philadelphia, PA
- 2:10 p.m.** Field and Laboratory Observations on Feeding Behavior of Newly Settled Winter Flounder, *Pseudopleuronectes americanus*
Patricia Shaheen¹, Linda Stehlik², Carol Meise², Allan Stoner³, John Manderson², and Danielle Adams²
¹Rutgers University, Institute of Marine and Coastal Sciences, New Brunswick, NJ, ²National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and ³National Marine Fisheries Service, Hatfield Marine Sciences Laboratory, Newport, OR

- 2:30 p.m.** GIS Mapping of Winter Flounder (*Pseudopleuronectes americanus*) Data for Rhode Island Waters, an Effort to Identify Essential Fish Habitat (EFH)
Wilfrid Rodriguez¹, Peter August¹, and Chris Powell²
¹University of Rhode Island, Environmental Data Center, Kingston, RI and ²Rhode Island Division of Fish and Wildlife, Marine Fisheries, Wickford, RI
- 2:50 p.m.** Wrap-up
- 3:00 p.m.** Adjourn

Poster Session

Tuesday, December 5th, 6:00 p.m.

Comparison between Two Methodologies for Batch-marking Adult Winter Flounder: Preliminary Results

Donald Danila

Northeast Utilities Environmental Laboratory, Waterford, CT

A Family of Pleurocidin-like Antimicrobial Peptides from Winter Flounder

Jeffery Gallant and Susan Douglass

Institute for Marine Biosciences, Halifax, Nova Scotia

Spatial Distribution of Flounder Collected in Channel and Shoal Habitats of the New York and New Jersey Harbor Estuary as Related to Sediment Characteristics

Teresa Nelson¹, John Duschang¹, and Jenine Gallo²

¹LMS Engineers LLP, Pearl River, NY, and ²U. S. Army Corps of Engineers-NY District New York, NY

Increase in Numbers of Smallmouth Flounder, *Etropus microstomus*, in the Ichthyoplankton of Narragansett Bay and Mount Hope Bay, RI

Grace Klein-MacPhee¹, Michael Scherer², Richard Satchwill³, Aimee Keller¹, and Carol Vasconcelas³

¹University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, ²Marine Research, Falmouth, MA, and ³Rhode Island Department of Environmental Management, Coastal Fisheries Laboratory, Wakefield, RI

GIS Mapping of Winter Flounder (*Pseudopleuronectes americanus*) Data for Rhode Island Waters, an Effort to Identify Essential Fish Habitat (EFH)

Wilfrid Rodriguez¹, Peter August¹, and Chris Powell²

¹University of Rhode Island, Environmental Data Center, Kingston, RI, and ²Rhode Island Division of Fish and Wildlife, Marine Fisheries, Wickford, RI

Density-dependent Changes in Area of Habitat Occupied by Georges Bank Yellowtail Flounder (*Limanda ferruginea*)

Travis Shepherd and Matthew K. Litvak

University of New Brunswick, Saint John, New Brunswick, Canada

Abstracts

Oral Presentations

Beyond Winter Flounder: A Global Perspective of Species Diversity in the Flatfish (Order Pleuronectiformes)

Thomas A. Munroe

*National Marine Fisheries Service, National Systematics Laboratory
National Museum of Natural History
Washington, DC 20560*

More than 690 species of flatfish are currently recognized worldwide; with species distributed from northern polar seas to southern boreal seas. Most commercially important flatfish occur in northern oceans, however, the greatest diversity of flatfish species (ca. 466 species, 68%+ of total diversity) is in tropical shallow waters. Systematic knowledge for most commercially important flatfishes in northern waters is well known, however, for most other flatfishes this is not the case. For the Pleuronectidae (60 species, 9% of total diversity) and Scophthalmidae (8 species) and tropical families with low diversity, such as the Psettodidae (2 species) and Citharidae (6 species), we have a good working knowledge of species-level diversity. New species are still being described in Paralichthyidae (94 species, 14% of total diversity) and Rhombosoleidae, although rates of new descriptions for these families suggest we are also approaching a good understanding regarding taxonomy of these species. For Cynoglossidae (142 species, 21% of species diversity), Bothidae (138 species, 20% of total diversity), Soleidae (139 species, 20% of total diversity) and Achiridae (ca. 35 species, 5% of diversity), many new species have been described recently and more work is needed to properly assess species diversity in these families. From a global perspective, north temperate and polar species number about 115 (ca. 17% of total diversity), with few new species being discovered in these areas. Flatfish diversity in southern temperate and subantarctic waters is low (only 4% of diversity), and the majority of species were described in the past 50 years. Freshwater flatfishes (only 2% of total diversity) are relatively rare, but undescribed species, especially in South America, continue to be discovered. New species are still being discovered at a relatively high rate in tropic waters. The majority of flatfishes are 30 cm or less in adult size. Most new species described in the last 50 years are 20 cm or less in length, suggesting that probably no large-sized species of flatfishes remain to be discovered. Present estimates are that ca. 36% of flatfish species occur in neritic and shallow water habitats, 272 species (39% of total diversity) inhabit inner continental shelf habitats; 153 species (22%) live on the outer shelf and upper slope; and 18 species (3%) occur only on the continental slope. The greatest levels of flatfish diversity occur on the inner continental shelf and in neritic habitats in 100 m or less. Nearly 24 % of the total known species have or will be described from 1951 to the present. That 24% of the total known species of flatfishes has been described only within the past 50 years indicates that we are not yet close to knowing the total diversity of species in the Pleuronectiformes.

Melanophore Receptor Diversity as a Component of Flatfish Patterning Physiology

Derek Burton, Dennis Mayo, and Joanne E. Vokey

*Memorial University of Newfoundland
Ocean Sciences Centre and Department of Biology
St. John's, Newfoundland, Canada A1B 3X9*

Winter flounder (*Pseudopleuronectes americanus*) can display a chromatophore pattern with white spots, dark bands, and general background as major components. Melanophores from these major pattern components show variable responses to background changes and to stress, and they are predominantly under adrenergic neural control. *In vitro* experiments with catecholamines and their antagonists, as well as with melanophore stimulating hormone (MSH) and melanophore concentrating hormone (MCH), can demonstrate pattern-related differences in melanosome aggregative and dispersive responsiveness. Such experiments indicate that α_1 - and α_2 - adrenoceptors, and also MCH receptors, mediate melanosome aggregation and that β_1 - and β_2 - adrenoceptors, as well as MSH receptors, are involved in melanosome dispersion. These results demonstrate that melanophore receptor diversity is an important facet of flatfish patterning physiology facilitating subtle gradations in balance between those which are antagonistic and synergistic in their effect.

Pigmentation Development in Hatchery-reared Summer Flounder

Jessica A. Bolker

*University of New Hampshire
Department of Zoology
208 Rudman Hall, 46 College Road
Durham, NH 03824*

Malpigmentation is a common problem in hatchery-reared flatfishes, and diminishes both their market value and their suitability for stock enhancement. Although much progress has been made in preventing malpigmentation through supplementation of larval diets, the fundamental causes of pigmentation problems and the mechanisms of pigmentation development, remain obscure. I examined the appearance and distribution of pigment cells in summer flounder (*Paralichthys dentatus*) larvae from hatching through metamorphosis, using a variety of microscopical techniques. Melanophores and xanthophores appear early in development, and reflective iridophores differentiate later. After metamorphosis, the blind side of normal fish is populated almost exclusively by iridophores; these cells are present on the ocular side as well, but largely masked by melanophores. Abnormally-pigmented light patches on the ocular side of postmetamorphic juveniles closely resemble normal blind-side skin, and dark areas on the blind side appear much like normal ocular-side skin. This pattern suggests that some forms of malpigmentation may be due to spatially inappropriate activation of normal developmental processes.

Patterns of Reproduction in Flatfish: Frequency, Up-regulation, and Down-regulation

Margaret P. M. Burton

*Memorial University of Newfoundland
Ocean Sciences Centre and Department of Biology
St. John's, Newfoundland, Canada A1B 3X9*

Initial studies on winter flounder, *Pseudopleuronectes (Pleuronectes) americanus*, showed that this flatfish, off Newfoundland, had a very short spawning time for individual females unlike other locally occurring pleuronectids such as yellowtail, *Limanda ferruginea (Pleuronectes ferruginea)*, or American plaice, *Hippoglossoides platessoides*, which are batch or serial spawners, and which have the possibility of up-regulation by very late recruitment of oocytes after spawning has begun. If this is a widespread option for “group synchronous” batch-spawners, then the idea of determinacy for fecundity studies prior to spawning may need some adjustment. Studies on winter flounder indicated that wild fish, both males and females, were subject to spawning omission, itself probably related to the long winter fast off Newfoundland, and it is still not clear how widespread this type of irregular spawning pattern may be; it is more difficult to recognize in batch-spawning fish with a lengthy spawning season. However, records indicate such spawning omission for halibut (at high levels) and for American plaice off Newfoundland. Recent studies on groundfish, including flatfish, off Newfoundland have shown some populations with high levels of atresia during late vitellogenesis, producing a large amount of down-regulation, perhaps even two years of reproductive omission, in females. It is not known why this is occurring or whether it is a new phenomenon; it does not seem to have been reported before for flatfish, except in the Barents Sea for *Reinhardtius hippoglossoides*, in connection with temperature changes, and in the Western English Channel for *Pleuronectes platessa*, in an area previously contaminated by the oil-spill from the Amoco Cadiz.

Experimental Analysis of Geographic and Seasonal Differences in Spawning Time on Growth, Development and Survival of Larval Summer Flounder, *Paralichthys dentatus*

R. Christopher Chambers and David A. Witting

*National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732*

Summer flounder, *Paralichthys dentatus*, is a widely distributed paralychtyid of subtropical and temperate waters of the U. S. Atlantic Coast. Egg frequencies in ichthyoplankton collections suggest that spawning occurs from southern Georges Bank to North Carolina in the autumn, initiating earlier in the north than the south. Eggs and larvae are abundant in waters of southern New England and the New York Bight. In contrast, young juvenile summer flounder are infrequent in these northern areas relative to their abundance in the bays of the Carolinas and Virginia. It may be surmised that eggs and larvae spawned in northern areas are largely lost to recruitment because of cooler water temperatures there. This experimental study was designed to elucidate the effects of autumn through spring water temperatures on summer flounder larvae. Using a 2²- factorial design, we evaluated the effects of early versus late spawning times and northern versus southern water temperature regimes on the growth, development and survival of summer flounder larvae. In addition, we challenged larvae of various sizes (6 to 10 mm TL) to cooler temperatures typical of inner shelf conditions in winter as larvae might encounter while migrating shoreward. We also challenged late-staged, transitional larvae (12 to 14 mm TL) to temperatures typical of bays and estuaries in winter as these larvae might experience during ingress. Larvae that experienced temperatures intended to simulate spawning at southerly latitudes, and larvae reared at temperatures mimicking a spawning origin in early autumn at northerly latitudes, reached the developmental stages associated with ingress before cool winter temperatures prevented further development. Larvae with the shortest initial season of growth (*i.e.*, products of northerly spawning in late autumn) failed to reach ingress stages until temperatures warmed in spring, but by this time these larvae were significantly larger-at-stage than were members of cohorts that ingressed before winter. We discuss these results, along with those on inner-shelf and ingress challenges, in the context of a temperature-based habitat map for the early life history stages of summer flounder.

Timing of Feeding Transition and Individual Consumption Rates Affect Growth of Summer Flounder (*Paralichthys dentatus*) Larvae

Markus Koelbl and David A. Bengtson

University of Rhode Island
Department of Fisheries, Animal and Veterinary Science
Kingston, RI 02881

Minimizing inter-individual variation in the growth and size of cultured fish is necessary for the synchronization of fish to a target size, reducing competitive interactions and cannibalism, reducing food wastage, and improving production efficiency. We investigated the causes of size variation in larval summer flounder that magnifies around 20-25 days after hatch (DAH), several days after the larvae make the transition from rotifers to *Artemia* nauplii. Specifically, we conducted two experiments to determine whether the time of transition to *Artemia* and consumption rates of *Artemia* by individual larvae may contribute to varying growth rates. In the first experiment we examined size differences between larvae that could ingest *Artemia* vs. those who could not on days 12, 13, 14, and 15 DAH and grew replicate batches of each group to 30 DAH to determine if day of feeding transition was related to size at 30 DAH. In the second experiment, we monitored daily *Artemia* consumption rates of individual larvae that made the rotifer- *Artemia* transition at 12 vs 13 vs 14 DAH and related that to size at 26 DAH. The first experiment showed that the larva's ability to transition from rotifers to *Artemia* is size-dependent, but also that larvae making the transition at 13 DAH grew significantly larger than their siblings making the transition at 12 or 15 DAH. The second experiment showed a high degree of variability in inter-individual consumption patterns. Larval size at 26 DAH correlated well with food consumption by individuals, with consumption explaining 72-93% of the variance in fish size. No significant differences were found in the food consumption-fish size relationship for larvae that made the rotifer- *Artemia* transition on 12 vs 13 vs 14 DAH. ANOVA showed that ability to ingest *Artemia* at 12 DAH did not provide a consumption advantage over larvae that started eating *Artemia* a day or two later. An examination of the correlations between fish size at 26 DAH and cumulative food consumption through days 17, 20, or 23, showed a greatly increased correlation between day 17 and 20. Based on the results of both experiments, we conclude that there is no growth advantage for fish that can feed on *Artemia* earlier than their siblings (although there may be an advantage for the transition on 13 DAH). The second experiment showed that there is a critical period between 17 and 20 DAH when the larva's consumption rates begin to determine whether it will be a fast-or-slow-growing larva.

Energetics of Growth Differences in Cultured Summer Flounder, *Paralichthys dentatus*: Prey Consumption and Absorption Efficiency by Newly-settled Juveniles

Tessa L. Simlick¹, Robin S. Katersky^{1,2}, and David A. Bengtson²

¹*University of Rhode Island, Department of Fisheries, Animal and Veterinary Science
Kingston, RI 02881*

²*National Marine Fisheries Service, Milford Laboratory
212 Rogers Avenue, Milford, CT 06460*

Since fast growth is a desired quality in hatchery-raised fish, it is of interest to the aquaculturalist to study the bioenergetic causes of intraspecific differences in growth rate. We have examined the differences in consumption and absorption efficiency of fast-growing vs slow-growing newly-settled juvenile summer flounder, *Paralichthys dentatus*. In particular, we investigated five cohorts of juveniles derived from individual male x individual female crosses. Consumption and absorption efficiency were measured in order to determine partly the “scope for growth” for newly-settled summer flounder. Size differences appear within a cohort in the mid- to late-larval stages, such that the fastest-growing fish settle first and the slowest growing fish settle last. Upon settling, fish were graded into three tanks: grade 1 (fast-growing fish), grade 2 (medium-growing fish), and grade 3 (slow-growing fish). Food consumption rate, absorption efficiency, and specific growth rate data were collected to compare rates for: (1) fish of different sizes (15, 20, 25, and 30 mm) within a cohort, (2) fast-growing (grade 1) and slow-growing (grade 3) fish within a cohort, and (3) fish from different sets of parents. Fish were removed from the stock tank, measured by image analysis, and placed randomly into 2-L bowls (n=5 fish per bowl). The consumption rate was measured by the difference between the initial ration given to the fish and the remaining uneaten nauplii after the 24-hr feeding experiment. Absorption efficiency was determined by calculating the difference between the amount of energy ingested and the energy egested as fecal matter. Energy (in joules) was measured indirectly through a wet oxidation process. Fecal material (from each of the replicated tanks) was collected onto a preweighed glass fiber filter after a 24-hr feeding trial and subjected to a strong oxidizing agent (potassium dichromate) which was then titrated in order to determine the oxygen consumed in the experiment (= energy consumed). Food consumption rates, absorption efficiencies, and specific growth rates did not differ between fast- and slow-growing fish at 15 mm; however, significant differences did become apparent at larger sizes, although they were not continuous over the size range and among all cohorts. Food consumption rates decreased on a weight-specific basis, with increasing size, in each of the five cohorts. Significant differences between food consumption rate, absorption efficiencies and specific growth rate were observed among fish from different sets of parents.

The Oxygen Consumption, Ammonia Excretion and Scope for Growth of Newly-settled Summer Flounder, *Paralichthys dentatus*

Robin S. Katersky^{1,2}, Tessa L. Simlick¹, and David A. Bengtson¹

¹University of Rhode Island, Department of Fisheries, Animal and Veterinary Science
Kingston, RI 02881

²National Marine Fisheries Service, Milford Laboratory
212 Rogers Avenue, Milford CT 06460

The time of metamorphosis in summer flounder larvae from within a single cohort and between cohorts is variable due to large differences in the growth rates of individual fish. Differences in fish size leave the slower-growing fish more susceptible to cannibalism and stress. In laboratory experiments metamorphosed fish were graded into three tanks: grade 1 (fast-growing fish), grade 2 (medium-growing fish), and grade 3 (slow-growing fish). Oxygen consumption and ammonia excretion data were collected to compare rates between 1) fish of different sizes (15, 20, 25, and 30 mm), 2) fast-growing (grade 1) vs. slow-growing (grade 3) fish within a single cohort, and 3) cohorts with different sets of parents. The results showed a significant difference in O₂ consumption between fish of different sizes; however, there was no significant difference between fast- and slow- growing fish from within or between cohorts. The peak SDA (specific dynamic action) was ~2 times the baseline rate of O₂ consumption. There was also a significant difference in ammonia excretion for fish of different sizes and between fast- and slow-growing fish at some sizes (30 mm, cohort 2; 15 mm, cohort 3). Post-prandial ammonia excretion rates were 3.61 and 5.20 times the endogenous rates for grade 1 and grade 3 fish, respectively, and accounted for ~3% of the ingested energy. These results have been incorporated with concurrent research on the food consumption and the absorption efficiency to create an energy budget for newly-settled summer flounder using the Scope for Growth index.

Correlations among Stage-specific Abundances of Larval and Juvenile Winter Flounder near Millstone Point, CT and their Relation to Year-class Strength

Donald J. Danila¹, Ernst Lorda¹, and J. Dale Miller^{1,2}

*¹Northeast Utilities Environmental Laboratory
PO Box 128
Waterford, CT 06385*

*²Normandeau Associates
34 Maine St, Ste. 203
Plymouth, MA 02630*

Monitoring studies of winter flounder have been conducted in the vicinity of Millstone Point in eastern Long Island Sound since 1976. Various indices of abundance were determined: adults spawning in the Niantic River during late winter-early spring and resulting female egg production, larvae of four developmental stages in the Niantic River and Bay from late winter through late spring, demersal age-0 juveniles in the Niantic River and Bay during summer, age-0 fish in late fall and early winter that were found throughout the study area, and age-1 juveniles present in the River and Bay concurrently with the adult spawner survey. Strongest correlations among these winter flounder abundance indices were found to occur between consecutive life stages. An exception has been a lack of correlation between a fall-winter age-0 index and succeeding age-1 indices. In fact, some persistent negative correlations have been found between age-1 abundance and several measures of adult abundance, perhaps indicating processes operating after winter flounder become age-1 that result in fewer recruits from more abundant year-classes of juveniles. In some years, events occurring during one or more of the early life history stages have led to the formation of either a relatively strong or weak year-class. Similar trends in abundance of early life history stages have been observed in some other areas of southern New England, suggesting that in many years processes occurring throughout the region likely govern the survival of winter flounder eggs, larvae or juveniles.

Distribution, Life History, and Identification of Southern U. S. *Paralichthys* with Implications for Management

Bruce A. Thompson and Andrew J. Fischer

Louisiana State University
Coastal Fisheries Institute
Wetland Resources Building
Baton Rouge, LA 70803

Although the three species of *Paralichthys* (*albigutta*, *lethostigma*, *squamilentus*) found in the northern Gulf of Mexico have been known for well over 100 years, there has been continued confusion over their specific distinctiveness and identification, and thus a lack of understanding of their life histories. The life histories of these three *Paralichthys* are “variations on a theme”, with spawning offshore in the Gulf of Mexico during winter; larvae and young then move towards shore. *Paralichthys squamilentus* uses barrier island beaches as nurseries between December and May, with larger individuals migrating to deeper offshore waters for the remainder of their life. Present studies suggest this is a smaller species and does not exhibit as extreme sexual dimorphism as *P. lethostigma*. *Paralichthys lethostigma* primarily uses inland marshes as nurseries, with mature individuals migrating offshore to spawn, but commonly returning to estuarine waters over its life span. *Paralichthys albigutta* is now considered to be virtually absent from Louisiana waters; many museum species of young and juvenile *P. albigutta* are being misidentified *P. squamilentus*. Meristics, morphometrics, and coloration distinguish the three species, and based on an analysis of these characters suggest that *albigutta* and *lethostigma* are closely related with *squamilentus* sister to this pair. Management plans for these species must include different strategies for habitat protection and harvest restrictions.

Abundance, Density, and Length Frequency of Juvenile English Sole in Pacific Coast Estuaries from 1998-2000

Christopher N. Roper and Donald R. Gunderson

*University of Washington
School of Fisheries
Box 355020
Seattle, WA 98195*

Fishes with pelagic egg and larval stages are typically susceptible to dramatic fluctuations in population abundance and many have demonstrated strong correlation between physical variables and recruitment. English sole have extended pelagic egg and larval stages before settlement and movement to juvenile habitat in estuaries. The objective of this study was to examine trends in juvenile sole abundance, density, and length of frequency patterns in four nursery estuaries along the Oregon and Washington coasts. Trawl surveys were conducted in June and August of 1983-1988 and 1998-2000 in Grays Harbor, 1985-1988 and 1998-2000 in Willapa Bay and in Coos Bay and Yaquina Bay from 1998-2000. In 1998-2000 English sole abundance was lowest in Yaquina Bay and highest in Willapa Bay, and was related to the area of the estuary. In some years there were two pulses of recruitment to the estuaries shown by the bimodal length distribution indicating differences in time of settlement. Patterns in abundance, density, and length of juveniles in the estuaries may reflect inter-annual and inter-regional differences in egg and larval transport, development and growth rates due to increased water temperatures, or estuarine conditions during El Nino.

**The Distribution and Abundance of Juvenile American Plaice,
Hippoglossoides platessoides, in the Southwestern Gulf of Maine,
New Hampshire**

Augustine J. Mungkaje and W. Huntting Howell

*University of New Hampshire
Department of Zoology
Spaulding Life Sciences Building, 38 College Road
Durham, NH 03824*

As part of a study investigating the ecological impacts of shrimp trawling on juveniles of four species of benthic fish, two sites were sampled in the southwestern Gulf of Maine during the summer and winter of 1998 and 1999. One of the sites is within a regular shrimp-trawling ground, while the other is separated from it by a distance of 1.19 km and is designated as the “no trawl” site. Analysis of these samples indicated that of the four species sampled American plaice, *Hippoglossoides platessoides*, was predominant in the samples both spatially and temporally. It was more abundant at the site where shrimp trawling is known to occur than at the site where trawling is absent. Furthermore, *H. platessoides* was more abundant at the two sites in summer than in the winter.

This distribution and abundance pattern was correlated with trawling activity and a number of environmental variables (sediment organic content, sediment particle-size composition, macroinvertebrate abundance, and microtopography) to determine possible relationships. Most of these variables were found to vary naturally between the two sites, masking any impact of trawling. Hence, the diet and size-composition of *H. platessoides* were also analyzed to provide further insight into any relationships between its abundance patterns and the selected variables, especially from the perspective of assessing the relative potential of the two sites as nursery and refuge habitats to juveniles of this species.

**Plasticity in Size, Age and Development at Settlement
of Individually Reared Winter Flounder
(*Pseudopleuronectes americanus*) Larvae**

Marc. E. Gravel and Joseph A. Brown

*Memorial University of Newfoundland
Ocean Sciences Centre
St. John's, Newfoundland, Canada A1C 5S7*

Metamorphosis in insects and amphibians is often accompanied by a niche shift, *e.g.*, an aquatic mosquito larva to a terrestrial adult. Studies examining differences in growth rates in insect and amphibian larvae suggest these taxa express a degree of plasticity in the timing of metamorphosis which allows an organism to metamorphose (*i.e.*, shift niches) at an optimal size and time that will maximize its fitness. Flatfish exhibit life history traits similar to insects and amphibians; they undergo a niche shift from pelagic larvae to benthic juveniles while experiencing a change in morphology. Thus, it is conceivable that the same environmental pressures selecting for phenotypic plasticity in insects and amphibians (resource availability, predation, abiotic factors, etc.) may have the same impact on larval flatfish enabling them to quicken or delay their settlement and/or development in order to maximize their fitness. In this study we examined how developmental stages (flexion and eye migration) coincided with the timing of settlement and how these factors varied between individuals with different growth rates. Individuals were reared in 4-L flow-through tubs in a temperature-controlled (10°C) tank, and individuals were checked daily for eye migration progress and video images were taken (nondestructively) every 2-4 days to collect sizes and flexion data. Preliminary results indicate that although differences in growth rates produced high variation in larval size at, and time of, settlement, there was less variation in stage of development at settlement. This suggests that settlement and development may be independent of somatic growth (size), but the timing of settlement is dependent on development.

Temperature Effects on Embryonic Developmental Rates, Size at Hatching and Survival of Yolk-sac Larvae of Summer Flounder, *Paralichthys dentatus*

Peter L. Berrien, John D. Sibunka, and R. Christopher Chambers

*National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
Highlands, NJ 07732*

Summer flounder, *Paralichthys dentatus*, has a geographically broad and protracted spawning season. Because spawning occurs from waters of southern Georges Bank to North Carolina, continues through the autumn, and progresses from northerly to southerly areas, eggs are likely to experience a wide range of thermal conditions. The objective of this study was to quantify the effects of water temperature on the rate of embryonic development and the size and condition of larvae at hatching. Eggs obtained from broodstock were allocated to 1 of 10 constant temperatures (8.0 to 24.25°C) immediately after fertilization. Eggs were sampled every 4 hours until hatching to provide accurate, temperature-dependent ages from fertilization to expression of each of 6 developmental characters that can be scored on field-collected eggs. At hatching, larvae were videotaped live and/or preserved for purposes of size and yolk content determination. A subset of larvae was maintained to evaluate the effect of temperature on resilience of yolk-sac larvae to starvation. No eggs hatched at temperatures < 10.0 °C. Median ages to developmental events varied inversely and curvilinearly with temperature. Median ages at hatching ranged from 39 hr at 24.3 °C to 178 hr at 11.5 °C. Sizes at hatching were greatest at the cooler temperatures that produced viable larvae. Yolk-sac sizes at hatching varied inversely with the lengths of larvae at hatching. Survival to hatching was maximal at intermediate temperatures. The resilience of yolk-sac larvae to starvation varied inversely with temperature but was affected little by the temperature that these larvae experience as embryos. It is our intention to apply laboratory-based estimates of the temperature-dependent expression of embryonic features to eggs from ichthyoplankton collections. This application should support improved estimates of egg production and mortality rates in nature.

Metamorphosis in Summer Flounder: Manipulation of Thyroid Status to Modify Growth, Development, and Settling Behavior

Steven Gavlik and Jennifer L. Specker

*University of Rhode Island
Graduate School of Oceanography
218 South Ferry Road, Box 200
Narragansett, RI 02882*

In the aquaculture of summer flounder (*Paralichthys dentatus*), high variability in growth rate (GR), development rate (DR) and settling behavior during metamorphosis leads to increased labor through the grading out of settled juveniles and to mortality through cannibalism. Our goal was to evaluate manipulation of thyroid status as a means to modify GR, DR and settling behavior of metamorphosing summer flounder. Premetamorphic flounder were treated with an exogenous thiourea (TU, 30 ppt, an inhibitor of thyroxine (T4) synthesis). Following removal of TU, metamorphosing flounder were exposed to either exogenous T4 (T4-Na salt, 100 ppb, dissolved in 1 ml of DMSO) or 1 ml of DMSO only. A control (no TU, then DMSO only, when appropriate) was used for comparison. Settling in the control was prolonged, with the > 60% (< 20% to >80%) settlement interval occurring over 9 d. TU inhibited settling over 16 days (d) of treatment. Discontinuation of TU treatment induced rapid settling after a 2-d delay, with the >60% interval reduced to 5 d. Addition of T4 further accelerated settling, resulting in a 1-d delay and reduction of the >60 % interval to 3 d. Settling rate was affected by treatment, with the TU-T4 treatment-settling rate significantly greater than the control. Additionally, both TU and TU-T4 treatments significantly increased length at settling in comparison to the control. GR and DR were calculated from length and developmental stage data collected before and after TU treatment and after T4 treatment. Eight days after completion of TU treatment, both GR and DR were significantly lower than rates in the control. In contrast, TU followed by T4 treatment resulted in GR and DR that were not significantly different than the control. Percent survival was unaffected by TU treatment. A priority for aquaculture is the reduction of both the labor associated with size grading, and the mortality due to cannibalism in the high stocking density, non-food limiting rearing environment. Our results suggest that manipulation of thyroid status to synchronize settling behavior and modify settling rates should reduce the effort associated with grading out settled juveniles. In addition, synchronization of settlement, combined with the ability to alter GR and DR, may potentially limit the exposure of pelagic larvae to cannibalistic attacks from newly-settled juveniles.

Ontogenetic Transitions During the First Year of Life in Two Cohorts of Windowpane, *Scophthalmus aquosus*

Melissa J. Neuman and Kenneth W. Able

*Rutgers University Marine Field Station
800 c/o 132 Great Bay Blvd
Tuckerton, NJ 08087*

Ontogenetic transitions in habitat, morphology, and otolith microstructure were examined in young-of-the-year (YOY) windowpane, *Scophthalmus aquosus* (Mitchill), an abundant flatfish in the Middle Atlantic Bight. The goal of this research was to identify and examine transitions that occur during early life and determine how these events might affect subsequent patterns of growth and survival of YOY windowpane. Differential habitat utilization between spring- and fall-spawned cohorts was evident, whereby spring-spawned fish were collected in estuarine, inlet, and ocean habitats while fall-spawned were collected primarily in the ocean. Densities of spring-spawned windowpane captured with planktonic gears (~ 2-20 mm standard length, SL) peaked in May in all habitats (estuary, inlet, and ocean, 10.3, 67.9 and 39.3 per 1000 m³, respectively) and declined significantly by July. A second peak of planktonic windowpane occurred in October, when fall-spawned (~ 2-10 mm SL) reached densities of approximately 13 per 1000 m³ in the ocean. Spring-spawned windowpane appeared in demersal gears initially in the inlet and ocean in May (~6-13 mm SL), but the first demersally-captured windowpane did not appear in the estuary until June and at ~24-32 mm SL. Settled, fall-spawned windowpane appeared in the inlet and ocean in October, with a peak in abundance occurring in the ocean in December. Various morphological characters were developed incompletely in larvae (4.0-8.0 mm SL), but most of these were well developed in juveniles (>35.0 mm SL). A transitional phase of development occurred between 8.0-27.0 mm SL, during which time 50% of the characters examined were developed incompletely. This developmental transition occurred in fish that were similar in size to field-captured windowpanes that had recently settled to demersal habitats. Examination of otolith microstructure in field-captured windowpane, belonging to both cohorts (n=31, 6-35 mm SL and n=22, 7-33 mm SL, respectively) revealed that the formation of accessory growth primordia coincides with a transitional settlement period, and the completion of eye migration (~8-20 mm SL). Back-calculated growth rate estimates for spring-spawned windowpane were significantly faster than those for fall-spawned windowpane and these differences could produce differential rates of survival for the two cohorts during the first year of life.

Gonadotropin-releasing Hormone Affects Sperm Production of Atlantic Halibut (*Hippoglossus hippoglossus*)

D. J. Martin-Robichaud¹ and J. Powell²

¹*Fisheries and Oceans Biological Station
531 Brandy Cove Road
St. Andrews, New Brunswick, Canada E5B 2L9*

²*Syndel International Inc.
92111 Shaughnessy Street
Vancouver, British Columbia, Canada V6P 6R5*

Under simulated natural photoperiod, Atlantic halibut (*Hippoglossus hippoglossus*) ovulate between January and May depending on temperature and individual variability. However, spermiation commences about 1-2 months prior to female ovulation. This asynchronous production of milt and eggs frequently results in reduced sperm production and higher spermatocrit levels later in the spawning season, while some females may produce viable oocytes. Poor quality milt at this time adversely affects fertilization and, thus, production capabilities. Gonadotropin-releasing hormone (GnRH) has been used on cultured fish to stimulate or enhance spermiation. In this study, spermatocrit levels of Atlantic halibut were measured throughout the reproductive season. When spermatocrit exceeded 80%, eight males were injected with a slow-release GnRH analogue (D-Arg⁶-Pro⁹-NEt salmon GnRH; Ovaplant®; 150 g; sGnRH_a). Control fish were implanted with placebo implants (no sGnRH_a). After two weeks half of the males that received an initial implant received another implant. After a single injection of an implant, spermatocrit levels decreased from 90% to 60% in one week. However, in fish receiving one initial implant, spermatocrit again increased to 90% within 30 d. When fish received an additional implant 2 weeks after the first, spermatocrit never exceeded 70%. Fertility of milt from males treated with sGnRH_a was not significantly different from those of control fish.

Larval Winter Flounder Stock Identification Using Microelements: First-year (2000) Analysis and Preliminary Results

Saul B. Saila¹, Ernest Lorda², Bradley Moran¹, and Donald Danila²

*¹University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882*

*²Northeast Utilities Environmental Laboratory
Waterford, CT 06385*

Inductively-coupled mass spectrometry was utilized to obtain measurements of the quantities of a suite of 30 elements from whole winter flounder (*Pseudopleuronectes americanus*) larvae. The training set consisted of 46 second-stage larvae taken from three separate spawning areas namely, the Niantic River, Connecticut River, and the Thames River, with 13, 17, and 16 individuals, respectively. Preliminary feature selection methods reduced the number of elements substantially, and later discriminant analysis procedures provided further refinements. Classification accuracy by discriminant analysis was good with only a few (2-3) misclassifications in the entire training set. However, a neural network classifier provided even better classification results, providing a classification accuracy of about 98 percent. The neural network was then applied to 53 entrainment samples of winter flounder larvae from the Millstone Nuclear Power Station. Only two larvae were classified as being of Niantic River origin with the majority being classified as Thames River fish. We conclude the method is very promising and suggest larger samples to more accurately and precisely determine power plant effects.

Winter Flounder, *Pseudopleuronectes americanus*, Stock Enhancement in New Hampshire: Evaluating Release Locations

Elizabeth A. Fairchild and W. Huntting Howell

*University of New Hampshire
Zoology Department
Durham, NH 03824*

The feasibility of winter flounder stock enhancement is being investigated in New Hampshire. Of particular interest is the development of optimal release strategies, including optimal release size, season, and site. To determine an optimal release site, three areas were selected in the Great Bay Estuary based on substrate type, bathymetry, and food availability.

During the summer of 1999, an experiment was conducted in which caged, cultured winter flounder were monitored at each of the three sites. Growth, survival, and temperature were measured weekly. In addition, substrate composition and food availability were determined from core samples. The results from the cage study indicate that the two sites in the upper estuary may be more optimal for released flounder than the one site at the mouth of the estuary. Although there was no difference in survival between the fish at the three sites, the fish grew significantly faster at the upper estuary sites where the water temperature was generally warmer. These sites had more prey available to the flounder and contained less gravel than the site at the mouth of the estuary.

Trawling was conducted and core samples were collected from these three sites over a two-year period. Data compiled from these efforts corroborate the enclosure experiment. These data and results from the summer pilot release will be presented as well.

The Effects of Scallop Dredging on a Recently-settled Continental Shelf Flatfish: Disturbance or Status Quo?

Mark C. Sullivan¹, Robert K. Cowen¹, Kenneth W. Able², and Michael P. Fahay³

¹*Rosenstiel School of Marine and Atmospheric Science
Division of Marine Biology and Fisheries
4600 Rickenbacker Causeway
Miami, FL 33149*

²*Rutgers University Marine Field Station
Institute of Marine and Coastal Sciences
800 c/o 132 Great Bay Blvd
Tuckerton, NJ 08087*

³*National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
Highlands, NJ 07732*

Impacts of mobile bottom fishing gear on demersal fisheries have received increased attention in the scientific, trade, and popular press. However, previous findings do not necessarily extend to all environments, life stages, and/or gear types. The juvenile stage is one life stage that may be particularly sensitive to disturbance as it generally lasts longer than the larval stage and involves a complex transition from a three-dimensional, pelagic environment to a two-dimensional, benthic one. We examine the impact of scallop dredging on a recently-settled continental shelf fish in the context of a storm-dominated continental shelf system (the New York Bight). Open ocean experimental manipulations at three depths (45, 67, 88 m) using replicated control/treatment effects (BACI design) were used to investigate the immediate and longer-term impacts of a dredging event on recently-settled juvenile yellowtail flounder (*Limanda ferruginea*) and their benthic nursery habitat. Submersible surveys were used to examine temporal changes in *Limanda* abundance and habitat composition, while future work will address aspects of growth (otolith microstructure) as well as distribution of benthic infauna. Using concomitant buoy data (NOAA buoy #44025, Long Island), we also examined the physical regime of the region as it relates to critical groundfish settlement windows. Finally, natural and anthropogenic disturbances are discussed in the context of the New York Bight as a whole.

Dynamic Habitat in a Temperate Estuary and Spatio-temporal Variation in the Growth of an Early Juvenile Flatfish

John P. Manderson¹, Beth A. Phelan¹, Carol Meise¹, Linda L. Stehlik¹, Allen J. Bejda¹, Jeff Pessutti¹, Linda Arlen¹, Andrew Draxler¹, and Allan W. Stoner²

¹National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

²National Marine Fisheries Service
Hatfield Marine Sciences Laboratory
Newport, OR 97365

The effects of spatial and temporal habitat variation on early juvenile winter flounder (*Pseudopleuronectes americanus*, Walbaum; 10-30 mm standard length (SL)) growth was examined using field enclosure techniques in a temperate Northwest Atlantic estuary. Enclosures (N=5; 3 fish enclosure⁻¹) were deployed at each of 12 fixed stations established along gradients of temperature, salinity, and sediment organic content in the Navesink River-Sandy Hook Bay estuarine system, New Jersey. Three 12-day runs of the experiment were performed over 40 consecutive days in late May through June, 1999.

The spatial pattern of flounder growth rates (Range = 0-0.9 mm SL d⁻¹ enclosure⁻¹) varied in time. Initial fish size was not a significant source of growth variation and the dynamic growth pattern was related to habitat variation. Generalized additive modeling indicated that growth was highest at relatively cool temperatures (< 22°C), low salinities (<24ppt) and high prey densities (>0.6 individuals cm⁻²). Analysis in trends in partial growth related to each parameter suggested that temperature and salinity gradients were responsible for growth variation at coarse spatial scales, while variation at fine spatial scales was related to prey availability and unmeasured factors (*i.e.*, residual growth). However, the relative strengths of influence of temperature and salinity on coarse-scale growth patterns changed over time. During the first run of the experiment, temperatures were cool (< 22°C) throughout the estuary and growth was highest in the river at locations where optimal prey densities and salinities intersected within the estuary. During later runs, however, the three habitat parameters were out of phase in space as a result of spatial variation in spring warming. Average growth rates declined and the region of highest relative growth shifted downstream to the bay where temperatures were optimal but salinities and prey availability were suboptimal. Thus, the dynamic growth patterns we observed appeared to be related to the effects of multiple and nested habitat parameters that promoted rapid growth during periods when optimal conditions for the parameters intersected within estuary, but this spatial synergy of optimal conditions was transitory.

Current strategies of marine habitat conservation typically involve the preservation of areas defined by relatively stable fine-scale habitat features easily identified by human observers. Our study suggests that habitat suitability for growth of a commercially important fish is defined by a suite of spatially and temporally variable habitat parameters and as a result the location and suitability of nursery habitat can change rapidly in time.

Recruitment of Summer Flounder Larvae to Chesapeake Bay: Larval Flux at an Inlet

**Harvey J. Walsh¹, Jonathan A. Hare¹, Simon R. Thorrold², Arnaldo Valle-Levinson³, Chris S. Reiss²,
and Cynthia M. Jones²**

¹*NOAA, National Ocean Service
Center for Coastal Fisheries and Habitat Research
Beaufort Laboratory
101 Pivers Island Road
Beaufort, NC 28516*

²*Old Dominion University
Department of Biological Science
Norfolk, VA 23529*

³*Old Dominion University
Ocean, Earth, and Atmospheric Sciences
Norfolk, VA 23529*

Ichthyoplankton samples were collected continuously from the mouth of Chesapeake Bay for 56 hours during mid November 1999. Nets were fished near the surface, middle and bottom of the water column and changed hourly. Tidal velocity and direction were monitored continuously using an Acoustic Doppler Current Profiler (ADCP) and temperature, salinity, and depth were sampled with a CTD every half hour. Summer flounder larvae were removed from samples, counted, measured, and staged. Temperature and salinity plots indicated three water masses during sampling. During strong northwest winds at the beginning of sampling, warm water was blown out of the bay on an ebb-tide dominated cycle. This was followed by a cold-water mass during an ebb and flood tidal cycle. The final 40 hours consisted of several tidal cycles of higher salinity water. Summer flounder larvae were collected over the entire sampling interval and were more abundant in the higher salinity water mass. Stages of larvae ranged from pre-eye migration and late flexion (stages E and F) to complete eye migration and post flexion (stage I). Larvae apparently were higher in the water column during flood tides, but other patterns are being evaluated. Concentration of larvae and current velocity were combined to calculate larval flux. Early-stage larvae spend more time in the water column during ebb tides; their upchannel flux is lower than later stage larvae.

**Use of a Rhode Island Salt Pond by Juvenile Winter Flounder,
*Pseudopleuronectes americanus***

Maureen Koprowski, Chris Orphanides, Marnita Chintala, Giancarlo Cicchetti, and Lesa Meng

*U.S. Environmental Protection Agency
Office of Research and Development, Atlantic Ecology Division
27 Tarzwell Drive
Narragansett, RI 02882*

We used a 1.75-m² drop-ring sampler in June and July of 2000 to quantify populations of juvenile flatfishes and other small nekton in Ninigret Pond, Rhode Island. The drop sampler was deployed in approximately 1 m of water from a boom mounted on the bow of a small boat. Abundance of juvenile winter flounder (15-95 mm) was 3.9 ± 0.8 (SE) inds/m² in seagrass habitat. Abundance was somewhat higher in non-vegetated habitat, though direct comparisons between habitats are difficult because of possible gear bias.

This non-vegetated habitat consisted of either macroalgae or bare sand/mud. Our results point to the importance of all these habitat types as valuable nurseries for flatfishes in Ninigret Pond. We suggest that similar habitats in other coastal areas may likewise be very important. We also report on high abundances of other fishes, crabs and shrimps in both seagrass and non-vegetated/macroalgal habitats in Ninigret Pond.

Experimental Evaluation of Ontogenetic Diet Transitions in Summer Flounder, *Paralichthys dentatus*, Using Stable Isotopes as Diet Tracers

David A. Witting¹, Keith L. Bosley², R. Christopher Chambers¹,
and Sam Wainright³

¹National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

²National Marine Fisheries Service, Hatfield Marine Sciences Laboratory
2030 S. Marine Science Drive, Newport, OR 97365

³U. S. Coast Guard Academy
Department of Science, Academic Division
27 Mohegan Avenue, New London, CT 06320

Summer flounder, *Paralichthys dentatus*, is a rapidly growing flatfish that increases in length by nearly 100-fold during its first year of life. A series of diet shifts including transitions in trophic status (e.g., planktivory to piscivory) as well as in diet source (e.g., habitat shifts) occurs during this period. The diet source and trophic status of a consumer can be deduced from the proportion of stable isotopes of both carbon and nitrogen. The rate at which the isotopic signal from a new diet is reflected in the tissue of a consumer (i.e., isotopic turnover) is a function of both growth and metabolic rate. It is therefore likely that temperature and ontogenetic state affect turnover rate. Our experiments were designed to determine the effect of temperature and ontogenetic state on the rate of isotopic turnover for summer flounder. We examined three ontogenetic diet transitions: 1) endogenous (yolk) nutrition to exogenous (zooplankton) feeding, 2) zooplankton type 1 (rotifers) to type 2 (*Artemia*) and 3) zooplanktivory to piscivory. Each of these experiments was conducted at two temperatures (13 and 18°C) using two related families of summer flounder as replicates. First feeding was monitored by destructively sampling larvae at 8 time-points from hatching to 16 days after first feeding. The transition between two types of zooplankton was initiated by moving 40 rotifer-fed summer flounder larvae (6-7 mm TL) into a rearing container where only *Artemia* nauplii were offered as food. These *Artemia*-fed larvae were sampled destructively at 9 time-points from 0 to 32 days after the change in diet. The zooplanktivory to piscivory transition started with individually contained summer flounder (37.4, 3.9 mm TL, 0.61, 0.15 g wet weight) that were offered 3 to 6 juvenile winter flounder per day and destructively sampled from 0 to 32 days after the change in diet. Summer flounder in each of the three experiments displayed a clear shift in isotopic signals. Turnover was slower at cooler temperatures. First feeding resulted in the most rapid turnover rate and piscivory the slowest. The relative contribution of growth and cellular rebuilding to isotopic turnover as well as the observed shift in isotopic signal during a trophic shift will be discussed.

Restriction Endonuclease Characters of Flatfish Ribosomal DNA May Help Resolve their Phylogeny

Z. M. G. Sarwar. Jahangir¹, Ronald Eckhardt², and Pradip Kar²

¹Wabash College
Department of Biology
Crawfordsville, IN 47933

²Brooklyn College of the City University of New York
Department of Biology
2900 Bedford Avenue
Brooklyn, NY 11210

Pleuronectiformes comprise a specialized assemblage of flatfishes which first appeared about 50 million years ago. There are about 570 flatfish species, representing 123 genera grouped into 11 families. One of the synapomorphic characters of the pleuronectiform fishes is the bilateral asymmetry of their eyes in juveniles and adults. Their current phylogeny based on morphology is in question due to homoplasy and convergence of many of these characters. However, molecular diversity of their genes may provide additional information to aid in resolving their phylogeny. The present study characterizes the rDNA of two flounders, summer flounder (*Paralichthys dentatus*) and winter flounder (*Pseudopleuronectes americanus*), and a sole, hogchoker (*Trinectes maculatus*) using restriction endonucleases (RE).

Nuclear DNA was extracted from each species and was digested with *Bam*HI, *Eco*RI, *Hind*III, *Pst*I and *Pvu*II individually and in combinations. The DNA fragments were separated by agarose gel electrophoresis, transferred to a nylon membrane following the Southern transfer technique and hybridized with digoxigenin-labeled *Xenopus laevis* rDNA (pXlr101A). The hybrids were immunoreacted with anti-digoxigenin alkaline phosphates conjugate, that was detected using Lumi-Phos 350 and recorded on Kodak XAR X-ray film. Sizes of the rDNA RE fragments were determined graphically in order to construct a RE map for each species. Using parsimony analysis, the rDNA data alone supported winter flounder to be closer to summer flounder than hogchoker, while 23 of their well accepted apomorphic morphological characters could not resolve this relationship.

An Examination of Winter Flounder (*Pseudopleuronectes americanus*) Larvae Genetic Stock Structure in Long Island Sound

Joseph F. Crivello¹, J. Dale Miller^{2,3}, Donald Danila², Milan Keser², Ernest Lorda², and Saul B. Saila⁴

¹University of Connecticut
Department of Physiology and Neurobiology
Storrs, CT 06269

²Northeast Utilities Environmental Laboratory
Waterford, CT 06385

³Normandeau Associates
34 Main Street, Ste. 203
Plymouth, MA 02360

⁴University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882

Winter flounder larvae (*Pseudopleuronectes americanus*) populations isolated from adjacent geographical areas in Long Island Sound (LIS) and larvae entrained by the Millstone Nuclear Power Plant were examined for genetic differences with microsatellite markers (from Dr. Susan Douglas, Institute for Marine Biosciences, Halifax, Nova Scotia). Larvae (stages 1 and 2) were isolated in March 2000 from the Niantic River (NR) stations (A & B at 3 m of depth), the Thames River (TR, due west of the Submarine Base at 12-m depth) and from Plum Bank (PB, about 2.5 miles west of the river mouth, at the bottom) with 202- and 333- μ m mesh nets. Four hundred twenty-three larvae were collected from these reference populations (135, 135, and 444, respectively). Three hundred sixty larvae (stage 2 through 4) entrained at the power plant were collected during April, May and June 2000. Genomic DNA was isolated from each larva and microsatellite markers were amplified in a standard PCR reaction mixture with one of three primer sets (hHiD34a & b or hHiI29a & b or hHiJ24a & b). Microsatellite products were analyzed by high-resolution PAGE (polyacrylamide gel electrophoresis). Microsatellite product sizes were determined by comparison to size markers. Primer hHiD34a & b gave 5 products between 200-325 bp, primer hHiI29 a & b gave 9 products between 80-225 bp and primer hHiJ24a & b gave 19 products between 100-188 bp.

The initial analysis examined the genetic differences between the 3 source populations by calculation of F_{ST} and genetic differences. The 2 most separate geographical populations, PB and TR, had a very significant genetic differentiation ($F_{ST} = 0.436$). There was also a large genetic differentiation between the NR and TR populations ($F_{ST} = 0.0384$). The NR and PB populations were more genetically related ($F_{ST} = 0.0158$). Entrained larvae were then compared to each reference population to determine their most likely source geographical location. Data were analyzed by SPAM (Software Program for Analyzing Genetic Mixtures). During the month of April, 3% of the entrained larvae were from the NR, 55% from the TR, 39% from PB, and 3% from an unknown area. In May, less than 1% of the entrained larvae were from the NR or PB areas and 98% were from the TR. In June, 10% of the larvae were from the NR and PB areas, 78% from the TR, and 1% from an unknown area. These results are in agreement with the identification of entrained larva source locations by elemental analysis (data not shown).

The Role of Carbonic Anhydrase in Renal Sulfate Secretion by Winter Flounder (*Pseudopleuronectes americanus*)*

J. Larry Renfro^{1,2}, Thomas H. Maren², Eric R. Swenson², David S. Miller², and Alice R. Villalobos^{1,2}

¹University of Connecticut, Department of Physiology and Neurobiology
Storrs, CT 06269

²Mount Desert Island Biological Laboratory, Salisbury Cove, ME 04672

Winter flounder plasma sulfate is stable at about 0.6 mM and is regulated by the kidneys through tubular secretion. This process is vital for excretion of the large inorganic sulfate load gained from ingestion of seawater. Transport studies on isolated flounder renal tubule basolateral (BLM) and brush-border membrane (BBM) vesicles revealed that sulfate entry, interstitium-to-cell, across the BLM is in exchange for OH⁻, whereas the exit, cell-to-lumen, at the BBM is in exchange for HCO₃⁻. Carbonic anhydrase (CA) apparently enhances this process through dehydroxylation of HCO₃⁻ (*Am. J. Physiol.* 276: F288-F294, 1999). Teleosts that tolerate varying salinities obviously have the capability to regulate renal excretion. Cortisol has been implicated in the adaptation of teleosts to seawater; indeed, it was termed the “seawater adapting” hormone (*Am Zool.* 15:937-948, 1975). Renfro (*Am. J. Physiol.* 257: R511-R516, 1988) showed that adaptation of seawater winter flounder to 10% seawater (SO₄-free) resulted in sulfate clearance ratios less than one and decreased BBM HCO₃⁻ SO₄²⁻ exchange. Clearance ratios greater than one and enhanced BBM HCO₃⁻ SO₄²⁻ exchange in these animals were restored by daily injections of the long-lived cortisol analogue, dexamethasone (60 μg/100 g bd. wt.), for 5 days. This profound effect of glucocorticoid on renal sulfate secretion, together with the recent observation that renal sulfate secretion was CA dependent, prompted examination of the influence of cortisol on Ca-dependent renal sulfate secretion. Flounder renal epithelial cells were isolated as previously described (*Am. J. Physiol.* 251: F424-F432, 1986) and plated to confluence on native rat tail collagen. Unidirectional ³⁵SO₄²⁻ fluxes were determined for 14-day old cultures mounted in Ussing chambers. Net secretion rates were calculated from unidirectional fluxes. Control tissues had complete tissue culture medium with 5 g/ml hydrocortisone (cortisol). Removal of cortisol 5 days prior to flux determination caused a significant 20% reduction in net secretion. Methazolamide (100 μM), a specific CA inhibitor, reduced net secretion to about 43% in both control and no-added-cortisol tissues. The methazolamide-insensitive component of flux was unaffected by cortisol removal. These treatments had no significant effect on the transepithelial electrical properties of the tissues. We conclude that cortisol controls the methazolamide-sensitive component of renal sulfate secretion possibly through renal CA functional activity.

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The Effects of Hypoxia on Growth and Hematology of Juvenile Summer and Winter Flounder

Kevin L. Stierhoff and Timothy E. Targett

University of Delaware, Graduate College of Marine Studies, Lewes, DE 19958

The objectives of this research were to determine the effects of static and diel-cycling hypoxia on growth rate and hematocrit (HCT) of young-of-the-year summer flounder (*Paralichthys dentatus*) and winter flounder (*Pseudopleuronectes americanus*). Fish (40-80 mm TL) of both species were exposed to four static levels of hypoxia (7.0, 5.0, 3.5, and either 2.0 or 2.5 mg/l O₂) and one diel-cycling treatment (7.0-2.5 mg/l O₂). Experiments were conducted at two temperatures (20 and 25°C) in 25 ppt salinity seawater. Fish were fed *ad libitum* on live spionid polychaetes (*Marenzelleria virens*). Fish (N = 9 per treatment) were measured (0.1 mm) and weighed (± 1.0 mg) on days 0, 7, and 14 of each experiment. Daily specific growth rate (SGR = % body weight/d) was determined separately for consecutive one-week periods. Blood for HCT determinations was taken from a subsample of fish from each treatment condition on days 0 and 7 (N=5 each) and from all fish in the growth rate experiment on day 14 (N =9 per treatment).

Summer flounder at 20°C showed no significant decrease in SGR between 7.0 and 5.0 mg/l O₂. However, SGR decreased by 45% between 5.0 mg/l O₂ (SGR = 9.08% bw/d) and 2.0 mg/l O₂ (SGR = 4.9% bw/d). There appeared to be no detrimental effect of diel-cycling oxygen levels on SGR in summer flounder at 20°C.

Winter flounder at 20°C also showed no significant decrease in SGR between 7.0 and 5.0 mg/l O₂. However, SGR decreased by 65% between 5.0 mg/l O₂ (SGR = 4.35% bw/d) and 2.5 mg/l O₂ (SGR = 1.46% bw/d). Diel-cycling oxygen levels resulted in SGR values intermediate between those at 7.0 and 2.5 mg/l O₂ in winter flounder at 20°C. No increase in SGR was apparent in week 2, compared to week 1, suggesting no acclimation response in growth rate over this time scale.

Although there was a similar decrease in absolute SGR with decreasing oxygen levels in summer and winter flounder, the proportional decrease was much greater for winter flounder, due to their slower growth rate. Juvenile summer flounder appear to be less impacted by diel-cycling oxygen levels than are juvenile winter flounder. Potential HCT differences across oxygen level treatments, and between weeks 1 and 2, will be discussed for both species.

Foraging in Juvenile Summer and Southern Flounder: Effects of Light, Turbidity and Prey Type

Ursala A. Howson^{1,2} and Timothy E. Targett²

¹National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

²University of Delaware
Graduate College of Marine Studies
700 Pilottown Road, Lewes, DE 19958

The ranges of two paralicthid flounders, summer flounder (*Paralichthys dentatus*) and southern flounder (*Paralichthys lethostigma*), overlap in the South Atlantic Bight from North Carolina to Florida. Juvenile summer flounder typically feed in euryhaline habitat within the estuary and are exposed to fluctuating levels of turbidity. Juvenile southern flounder inhabit oligohaline regions of the upper estuary and forage in high-turbidity habitat. Previous field studies have indicated that juvenile summer flounder feed primarily on benthic invertebrates, while southern flounder consume epibenthic/pelagic prey. It is unclear whether these differences in prey consumption are the result of differences in foraging modes between the two species, artifacts of prey density or location, or differences in visual capabilities in turbid estuarine habitats.

Turbidity impacts foraging by decreasing reactive distance between predator and prey and may thus impact growth and survival of estuarine fishes. Particulates in the water column decrease light levels by absorbing light and reduce visibility by scattering light. To separate the effects of absorption (reduction in light intensity) with those of scattering (reduction in visibility), foraging rates of summer and southern flounder were determined in clear water (1 NTU) at five light levels (2×10^{14} to 6×10^{11} quanta $\text{sec}^{-1} \text{cm}^{-2}$) and in darkness. Foraging rates were also compared across four turbidity levels (1, 11, 20 and 40 NTU) at 6×10^{12} quanta $\text{sec}^{-1} \text{cm}^{-2}$. The effects of light intensity and turbidity on prey preference were also examined by conducting separate trials with two different prey types (mysid shrimp as epibenthic/pelagic prey, polychaetes as benthic prey). To examine the effects of turbidity on locomotory behavior, activity of summer and southern flounder (food withheld for > 12 hr) was assessed at 1, 10, 20, and 40 NTU.

An Experimental Analysis of Size-specific Predator-prey Interactions between Juveniles of Summer Flounder, *Paralichthys dentatus*, and Winter Flounder, *Pseudopleuronectes americanus*

R. Christopher Chambers and David A. Witting

*National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732*

The outcome of an encounter between a predator and its prey often depends on the sizes of the interacting individuals. This size dependency is more likely to be expressed in species that grow through a wide range of body sizes. Knowledge of the growth rates of the potentially interacting species, as well as the timing of their spatial and temporal overlap, is especially important for life periods during which rapid growth is exhibited. During their early juvenile period, summer flounder (*Paralichthys dentatus*) and winter flounder (*Pseudopleuronectes americanus*) are a good candidate pair for the analysis of such size- and growth-based predator-prey interactions. Juveniles of these two flatfishes overlap spatially in inshore waters from Southern New England through New Jersey. The ingress and settlement of summer flounder typically precedes the settlement of winter flounder. Summer flounder become piscivorous at small sizes (25 mm TL) and grow rapidly as spring temperatures increase. In this experimental study we used recently-settled juvenile summer and winter flounder in order to evaluate 1) the size combinations at which winter flounder were at risk to summer flounder, 2) the magnitude of risk as a function of relative body sizes of the two species, and 3) the attack rates, satiation levels, and the handling times of summer flounder when encountering winter flounder that fall within the range of vulnerable sizes. Regarding critical size combinations of the two species, we show that the boundary separating the region resulting in predation from that in which winter flounder is invulnerable to predation is linear, is tightly related to summer flounder mouth gape, and is accurately represented by a proportionality constant, *i.e.*, winter flounder is at risk to predation if summer flounder TL is > 2.2 winter flounder TL. We also show that the function relating the number of winter flounder consumed versus the number offered is a decelerating ('Type II') functional response with a calculated attack rate and handling time of 0.5 and 1.2 hr, respectively, which vary with the specific size combination of prey and predator. Lastly, we provide estimates of temperature-dependent growth for juveniles of both species and suggest how these parameters could drive the outcome of predator-prey interactions at the population level.

Response of YOY Winter Flounder to Sediment Biogeochemicals

A. F. J. Draxler¹ and Jessica A. Siclare²

¹National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

²Saint Joseph's University
5600 City Avenue
Philadelphia, PA 19131

The location of juvenile winter flounder (*Pseudopleuronectes americanus*) habitat at the estuarine sediment-water interface subjects these fish to an environment characterized by precipitous biogeochemical gradients. Changes in habitat quality variables (dissolved oxygen, sulfide, nitrite, ammonium, etc.) of macrobiotic behavioral significance can occur on scales as small as millimeters and hours. Even in high energy areas of the Hudson-Raritan Estuary with coarse sandy substrates, oxygen disappears in the upper millimeters of the sediment, and water column oxygen concentrations have been observed to decrease from 250 μM to less than 30 μM over a few days. Bedja *et al.* (1992) have shown that such periodic reductions of oxygen concentrations (to 60 μM) reduce growth rates of young-of-the-year (YOY) winter flounder. To simulate exposure to biogeochemicals at the seabed, wild-caught YOY winter flounder were held in a sand-bottom, vertical-flow tank in which half the sediment area was perfused with manipulated seawater. Temperature was maintained between 19.4 to 21.5°C over the course of 26 experiments and temporal biogeochemical gradients and fish locations were recorded. The winter flounder responded to declining O_2 at approximately 100 μM (3.2 mg/L) by moving to more oxygenated water. Sulfide treatment produced a more complex response, apparently requiring concentrations in excess of 15-20 μM sulfide and a steep rate of increase for initiation of movements. In exploratory trials with nitrite (50 μM) and ammonium (100 μM) we found no clear response though the fish appeared to be in distress.

Field and Laboratory Observations on Feeding Behavior of Newly-settled Winter Flounder, *Pseudopleuronectes americanus*

Patricia A. Shaheen¹, Linda L. Stehlik², Carol J. Meise², Allan W. Stoner³,
John P. Manderson², and Danielle L. Adams²

¹Rutgers University
Institute of Marine and Coastal Sciences
71 Dudley Road, New Brunswick, NJ 08903

²National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

³National Marine Fisheries Service
Hatfield Marine Sciences Laboratory
2030 S. Marine Science Drive, Newport, OR 97365

Field and laboratory investigations were conducted to examine feeding by newly-settled winter flounder, *Pseudopleuronectes americanus*, on two co-occurring calanoid copepods, *Eurytemora affinis* and *Acartia hudsonica*, in the Navesink River estuary, NJ. During the spring, these prey are present when winter flounder initiate their demersal lifestyle. Epibenthic zooplankton were collected concurrently with winter flounder in May 1998 and 1999. Although both calanoid species were in the estuary during the two-year survey, *E. affinis* was consumed nearly to the exclusion of *A. hudsonica* by newly settled winter flounder. Annually, *E. affinis* and *A. hudsonica* had similar size distributions in field collections, indicating that species choice was not size selective. However, when preying on *E. affinis*, winter flounder preferred the larger-sized organisms. In single-species laboratory experiments, *E. affinis* and *A. hudsonica* were consumed equally by newly-settled winter flounder (19-23 mm TL), but there were more strikes made toward *E. affinis*. Despite the lower catch efficiency, *E. affinis* was selected over *A. hudsonica* when the prey species were offered together in equal numbers. The selection for *E. affinis* over *A. hudsonica* by newly-settled winter flounder may be the result of behavioral or morphological differences in the prey species.

GIS Mapping of Winter Flounder (*Pseudopleuronectes americanus*) Data for Rhode Island Waters, an Effort to Identify Essential Fish Habitat (EFH)

Wilfrid Rodriguez¹, Peter August¹, and J. Christopher Powell²

*¹University of Rhode Island
Environmental Data Center
Kingston, RI 02881*

*²Rhode Island Division of Fish and Wildlife
Marine Fisheries
Wickford, RI 02852*

Geographical Information Systems (GIS) can be used to optimize sampling, explain the spatial distribution of coastal fish populations, identify Essential Fish Habitat (EFH), and to assist decision makers in ecological impact assessment of non-point source pollution, oil spills, and natural disturbances of fisheries resources. The objective of this project was to develop the first geo-spatial databases and coverages of sampling stations and winter flounder populations from data collected by the Rhode Island Department of Environmental Management, Division of Fish and Wildlife during 1979 through 1999, in Narragansett Bay, Rhode Island Sound, and Block Island Sound. The resulting geo-spatial coverages will serve as the basis for further spatio-temporal analysis of winter flounder spawning and nursery habitat, adult habitat, migratory routes, and help define Essential Fish Habitat (EFH) for this species in Rhode Island waters. This effort was a pilot study to evaluate the feasibility of using this methodology for future assessment of other important finfish and shellfish species. Future studies will integrate marine habitat and land use information for a more comprehensive ecological assessment of Rhode Island fisheries.

Abstracts

Poster Presentations

Comparison Between Two Methodologies for Batch-marking Adult Winter Flounder: Preliminary Results

Donald J. Danila

*Northeast Utilities Environmental Laboratory
PO Box 128
Waterford, CT 06385*

Spawning adult winter flounder have been collected in the Niantic River since 1977 as part of long-term monitoring studies for assessment of impact of Millstone Nuclear Power Station. Before release, healthy fish larger than 15 cm (1977-82) or 20 cm (1983 and thereafter) were freeze-branded in a specific location with a number or letter made by a brass brand cooled in liquid nitrogen. Marks and brand location were varied in a manner such that the year of marking was apparent for recaptured fish. These mark-recapture data are used with the Jolly-Seber model to estimate population size. Throughout most of the study, some fish were captured having an apparent freeze brand, but the specific mark was indistinguishable. Thus, some information was being lost. Since this study began, more technologically advanced techniques have been developed to batch-mark fish. In both 1999 and 2000, a second mark was applied to freeze-branded winter flounder using fluorescent-pigmented particles injected into the dorsal fin with New West Technologies Biometrix System 1000 Micro-Ject™ or SuperMicro-Ject™ portable injectors. Color and fin position of the photonic mark were unique by year. The efficacy of this marking system versus freeze branding was examined by noting the presence or absence of each mark following the recapture of these fish within the year or one year later for 1999 fish. Difficulties were encountered in marking fish in 1999 using the less powerful Micro-Ject™ injector, but these were overcome in 2000 by using a stronger spring in this injector. Nevertheless, larger (ca. >35 cm) flounder were more difficult to mark than smaller fish with both injectors. Preliminary results indicated that nearly all recaptured fish retained the freeze brand (at least up to 1 year). Although most of the fish recaptured within a few weeks of marking had a photonic mark, only a fraction of them had retained fluorescent pigment after one year. Results may have been influenced to some degree by an inability to use UV light in the field to examine for photonic marks, despite constructing a special viewing box for that purpose.

A Family of Pleurocidin-like Antimicrobial Peptides from Winter Flounder

Jeffery W. Gallant and Susan E. Douglas

*Institute for Marine Biosciences
1411 Oxford Street, Halifax, Nova Scotia, Canada B3H 3Z1*

Low molecular weight antimicrobial peptides are an important component of the innate immune system in animals, yet they have not been examined widely in fish. We report genomic sequences encoding pleurocidin-like antimicrobial peptides from the winter flounder, *Pseudopleuronectes americanus* (Walbaum), as well as reverse transcription-PCR products from skin and intestine-two mucosal surfaces that form the first defensive barrier to microcrobies. Alignment of the predicted polypeptide sequences shows a conserved hydrophobic signal peptide of 22 amino acids followed by approximately 25 amino acids that are able to form an amphipathic α -helix, followed by a conserved acidic portion. Southern hybridization analysis indicates that related peptides are encoded in the genomes of other flatfish species. Northern and RT-PCR analyses of RNA show that two of the pleurocidin genes are expressed predominantly in the skin whereas two other genes are expressed mainly in the intestine. RT-PCR assays of total RNA from winter flounder larvae of different ages indicate that the pleurocidin gene is first expressed at 13 days post-hatch and provide the first evidence of developmental expression of antimicrobial peptides in fish.

Spatial Distribution of Flounder Collected in Channel and Shoal Habitats of the New York and New Jersey Harbor Estuary as Related to Sediment Characteristics

Teresa A. Nelson¹, John H. Duschang¹, and Jenine Gallo²

*¹Lawler, Matusky and Skelly Engineers LLP
One Blue Hill Plaza, Pearl River, NY 10965*

*²U. S. Army Corps of Engineers-New York District
CENAN-PL-EA
26 Federal Plaza, New York, NY 10278*

The New York and New Jersey Harbor estuary provides spawning, nursery and foraging habitats for several commercially and recreationally important flatfish species. As part of a study related to deepening Harbor navigation channels, shoal and channel habitats in the New York and New Jersey Harbor estuary were sampled during a year-long monitoring program. One objective of the sampling program was to determine the spatial and seasonal distribution of flatfish in the Harbor. Fish were collected using a 9-m bottom trawl at twenty stations ranging in water depth from 9 to 51 ft (MLW). Species distribution and relative abundance was compared to bottom-sediment characteristics at each sampling station. Bottom-sediment varied from hard sand to smooth sand, with some stations exhibiting a combination of sediment types.

Winter flounder (*Pseudopleuronectes americanus*), smallmouth flounder (*Etropus microstomus*), windowpane flounder (*Scophthalmus aquosus*), fourspot flounder (*Paralichthys oblongus*), and summer flounder (*Paralichthys dentatus*) were collected at both shoal and channel stations; however, their spatial distribution varied between stations and among Harbor sampling areas. Species distribution varied with bottom-sediment characteristics. Winter flounder dominated most catches, but was predominant over smooth mud habitat. Windowpane flounder was the dominant species collected over hard sand. Stations with mixed sediment characteristics provided the greatest variety of species. Additional information on bottom sediment characteristics and flatfish distribution would aid in determining habitat preference in estuarine areas.

Increase in Numbers of Smallmouth Flounder, *Etropus microstomus*, in the Ichthyoplankton of Narragansett Bay and Mount Hope Bay, Rhode Island

Grace Klein-MacPhee¹, Michael Scherer², Richard Satchwill³, Aimee Keller¹, and Carol Vasconcelas³

¹*University of Rhode Island
Graduate School of Oceanography
Narragansett Bay Campus, Narragansett, RI 02882*

²*Marine Research
141 Falmouth Heights Road, Falmouth, MA 02540*

³*Rhode Island Department of Environmental Management
Division of Fish and Wildlife, Marine Fisheries
Coastal Fisheries Laboratory
Wakefield, RI 02879*

The smallmouth flounder is a small flatfish found in nearshore waters and estuaries ranging from Cape Cod to Cape Hatteras. The center of distribution appears to be the Chesapeake Bight where they are one of the most numerous flatfish species collected in the ichthyoplankton. The eggs and larvae are fairly common off southern New England and Cape Cod but are rare in Narragansett and Mount Hope Bay. Impingement data from the Braden Point Power Plant in Mount Hope Bay, Massachusetts shows an increasing upward trend in smallmouth flounder numbers since 1985. Previous ichthyoplankton surveys in Narragansett Bay collected few smallmouth flounder, but a recent survey begun in June 2000 collected relatively large numbers of eggs. Sampling conducted in 1972-1973 showed no smallmouth flounder, but the eggs were not described until 1980. To date, in the 2000 ichthyoplankton collection, the eggs comprise 6% of the ichthyoplankton and are ranked 4th in abundance. Water temperatures have been rising in Narragansett and Mount Hope Bays and it will be interesting to see if this increase in the smallmouth flounder will be a permanent long-term trend.

GIS Mapping of Winter Flounder (*Pseudopleuronectes americanus*) Data for Rhode Island Waters, an Effort to Identify Essential Fish Habitat (EFH)

Wilfrid Rodriguez¹, Peter August¹, and J. Christopher Powell²

¹*University of Rhode Island
Environmental Data Center, Kingston, RI 02881*

²*Rhode Island Division of Fish and Wildlife, Marine Fisheries
Wickford, RI 02852*

Geographical Information systems (GIS) can be used to optimize sampling, explain the spatial distribution of coastal fish populations, identify Essential fish Habitat (EFH), and to assist decision makers in ecological impact assessment of non-point source pollution, oil spills, and natural disturbances of fisheries resources. The objective of this project was to develop the first geo-spatial databases and coverages of sampling stations and winter flounder populations from data collected by the Rhode Island Department of Environmental Management, Division of Fish and Wildlife during 1979 through 1999, in Narragansett Bay, Rhode Island Sound, and Block Island Sound. The resulting geo-spatial coverages will serve as the basis for further spatio-temporal analysis of winter flounder spawning and nursery habitat, adult habitat, migratory routes, and help define Essential Fish Habitat (EFH) for this species in Rhode Island waters. This effort was a pilot study to evaluate the feasibility of using this methodology for future assessments of other important finfish and shellfish species. Future studies will integrate marine habitat and land use information for a more comprehensive ecological assessment of Rhode Island fisheries.

Density-dependent Changes in Area of Habitat Occupied by Georges Bank Yellowtail Flounder (*Limanda ferruginea*)

Travis Shepherd and Matthew K. Litvak

*University of New Brunswick
Saint John, New Brunswick, Canada E2L 4L5*

We examined density-dependent changes in habitat-usage patterns through the relationship between abundance and the area of habitat occupied by George's Bank yellowtail flounder (*Limanda ferruginea*). Canadian Georges Bank spring groundfish survey data from the Department of Fisheries and Oceans (1986-2000) were used to estimate density and the area of habitat occupied. Annual densities were estimated on a fixed-square grid (0.1° longitude x 0.1° latitude) by interpolating (kriging) between known survey values. Annual global densities were estimated from the mean of the grid estimates. Area of occupied habitat was estimated by contouring the grid estimates to a minimum patch density threshold (the minimum yellowtail density which defines occupancy) and calculating the area within that contour. A range of values for minimum patch density was used (*e.g.*, 1 fish, 5 fish, 10 fish, etc.) in order to examine density-dependent aspects in the rate of change of occupied habitat area. Increases in area of occupied habitat were related closely to increases in global density. The nature of this relationship was dependent on minimum patch density; *i.e.*, exponential for low patch density thresholds and asymptotic for high thresholds. These results have implications for the spatial definition of the Georges Bank stock, transboundary management issues, and the possibility for systematic changes in catchability.

