NRAC 2021 Pre-Proposal
Title Page

Project Title: ***Tautog (Tautoga onitis) early life stage optimization in aquaculture systems: spawning, culture density, and diet through metamorphosis***

Project Duration (months)**: 24**

Total Funding Requested from NRAC: $185,000

States with Participants in Project (circle / list):

MA RI NJ

Project Coordinator (Lead Principal Investigator)
(name/position/institution/address/phone/fax/email):

Daniel Ward, PhD, Ward Aquafarms, LLC, 51 North Falmouth Highway, North Falmouth, MA 02556; Ph: 603-505-0865; FAX: none dan@wardaquafarms.com

Principal Investigator(s) (name/position/institution/address/phone/fax/email):

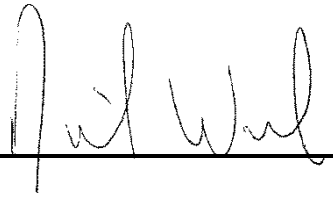
Joshua Reitsma, Marine Program Specialist: Cape Cod Cooperative Extension & Woods Hole Sea Grant, Deeds and Probate Building, 3195 Main Street, PO Box 367, Barnstable, MA 02630, Ph: 508-375-6950, Email: jreitsma@barnstablecounty.org

Michael Coute, University of Massachusetts Dartmouth 706 S Rodney French Boulevard, New Bedford, MA 02744 Ph: 774-487-1993; Email: mtcoute@gmail.com

Beth Phelan, PhD, Laboratory Director and Fisheries Ecology Branch Chief, Howard Marine Sciences Laboratory, Northeast Fisheries Science Center, NMFS, NOAA, 74 Magruder Road Highlands, N.J. 07732 Ph: 732-872-3079; Email: beth.phelan@noaa.gov

Cooperating, Non-funded Participant(s) (name/position/institution/address/phone/fax/email):

Rhode Island Fishermen's Alliance, P.O. Box 337, East Greenwich, RI 02818, Phone: (401) 742-4486

Project Coordinator's **Signature:**  **Date: 7/17/20**

1.0 WHY:

In the northeastern United States, aside from salmonids, finfish aquaculture expansion has been slow for many decades, and marine finfish research and development, has not translated into a commercial industry. Numerous species have been thoroughly investigated, such as black sea bass, summer flounder, cobia, Atlantic cod, among others, with research into many aspects of culture methods. However, there is at least one primary issue with raising each one of those species commercially; from Atlantic cod taking too long to grow to market size, to cobia costing too much to keep warm, to summer flounder frequently getting disease, and black sea bass being abundant in the wild and driving down market price. There is good reason there is not more marine finfish aquaculture in the northeastern US, and it all comes down to economics, and if the species raised can be cultured at a high density, with low disease, at temperate water temperatures; and critically, if the market demands the product and there is not an abundant supply available. While many species fit the biological requirements; if there is not a high market demand, and low supply availability, there will not be a commercial opportunity. Black sea bass are a viable aquaculture species from a biological perspective, but they are abundant in the wild, with current boat price in Woods Hole, Massachusetts at $1.25 per pound (July 10, 2020), which would be below the cost of production of even juvenile fish in an aquaculture setting.

Tautog (*Tautoga onitis*) is a marine wrasse native to western Atlantic communities, and extends from Nova Scotia to South Carolina, with the highest abundances noted from south of Cape Cod to the Delaware Capes (Bigelow and Schroeder 1953). Tautog exhibit strong site fidelity, low daily movement rates, and seasonal migrations, which naturally make this species vulnerable to robust fishing activity, and particularly difficult to rebuild impacted stocks (Olla et al., 1974). From the most recent stock assessment produced by the Atlantic States Marine Fisheries Commission, (ASMFC) tautog have been identified as a species that is recreationally and commercially overfished, and overfishing is occurring in 3 of the 4 distinct management areas (ASMFC 2017). Regional markets have supported recreational and commercial fishing of tautog for over a century. Tautog is a highly sought after food fish, prized throughout its range for its firm white fillet, which commands a premium on both the processed, fish market ($15-$22 retail) and on the live market ($11 per pound live).

Due to its life history characteristics, fish market potential, and fishing pressures, tautog have been identified as an ideal candidate for marine aquaculture (Perry et al., 1998). Laboratory studies of tautog conducted by the NOAA laboratory in Milford, CT have shown that adults can be conditioned to induce natural spawning, and success has been noted in multiple locations in Rhode Island and Connecticut (Perry et al., 1998). NOAA identified key issues in tautog early life history with transitioning from natural diets of artemia and rotifers to pellet diets. A nutritional component may be contributing to low growth rates in juvenile tautog, however, other components of food and feeding behavior may also be factors. Growth rates in laboratory studies have been shown to be significantly lower than in the wild, and authors have acknowledged a potential missing component in the commercial feed (Perry et al., 2001).

An ongoing collaboration between Ward Aquafarms and the University of Massachusetts Dartmouth has been looking into farming tautog, and investigating growout using wild-caught juveniles. It was hypothesized that slow growth rates determined from otolith samples of wild tautog, were due to resource competition and site fidelity through variable environmental conditions in southern New

England waters. Over the past year a trial was conducted comparing growth rates of juvenile (5 g) tautog fed one of three diets: a natural diet consisting of green crab (*Carcinus maenas*), a commercial marine finfish pellet (Ziegler Bros, PA), or a 50:50 ratio of the two diets. The natural diet, and the hybrid diets were very successful in demonstrating a fast growth rate in recirculating systems, as long as feed is sufficient, and water temperature is maintained at 20 C. Juvenile tautog in the natural diet treatment achieved growth rates as high as 0.77 mm/day, and growing from 7 grams to 400 grams in just 9 months. In order to effectively assess commercial viability, research into early life history is essential to close the loop, and address the early life stage history issues addressed by the NOAA Milford laboratory researchers. A year-round supply of high-quality, juveniles would boost regional economies, and could relieve fishing pressures.

2.0 WHAT:

The goal of this project is to identify the early life history requirements that will improve the overall commercial success in culturing tautog: 1) spawning and collection of eggs and rearing to larval size 2) transitioning larval tautog from diets of rotifers, and artemia to commercial grade pellets 3) comparing stocking densities to achieve the optimal survival and yield 4) assess commercial viability of tautog aquaculture.

Specific objectives:

1. Acquire tautog broodstock from local fishermen collaborators and condition these animals to induce natural spawning behavior.
2. Collect eggs from spawning fish and rear them in closed, recirculating aquaculture systems with different diets and at different stocking densities.
3. Assess growth rates and survival of the different stocking densities and diets.
4. Community outreach to regional farmers, managers, and professionals interested in farming tautog.

3.0 WHERE:

Broodstock conditioning and spawning will occur at the NOAA laboratory in Sandy Hook, NJ, while all the post-metamorphosis work will occur in Massachusetts (Ward Aquafarms, LLC, North Falmouth, MA), the source of broodstock will be secured from commercial fisherman due to a partnership with the Rhode Island Commercial Fishermen's Alliance based out of Pt. Judith, Rhode Island. The outreach coordinator is based out of Barnstable, MA (Joshua Reitsma, Cape Cod Cooperative Extension, Barnstable MA). The early life history specialists are from the National Oceanic and Atmospheric Administration and are based out of the Sandy Hook laboratory in Sandy Hook, NJ, and have previous experience with larval finfish early life history and conditioning. Due to Zoom video conferencing and flexible travel arrangements, the distance between project partners is not foreseen to be an issue. The methodology for early life history tautog farming will be transferable to the community for greater chances for future innovation, commercial success, and therefore greater farmer income.

4.0 WHO:

Dr. Daniel Ward is the owner of several aquaculture farms on Cape Cod in Massachusetts, (www.wardaquafarms.com), where they produce oysters, bay scallops, quahogs and sugar kelp. They currently have millions of shellfish growing on their sites. Dr. Ward is the lead PI on a current USDA NE SARE-funded project investigating the growout potential of tautog in

conjunction with UMASS Dartmouth. Dr. Ward will be overseeing all aspects of this project, and he will be in regular contact with the collaborators on project progress.

Joshua Reitsma has worked as a Marine Specialist for Cape Cod Cooperative Extension on many aquaculture projects. He has partnered with Ward Aquafarms in the past of research projects that benefit the industry, and is well connected to bring the results of the proposed project to the widest audience possible.

Michael Coute has been involved in research with tautog aquaculture as a MSc student at the University of Massachusetts Dartmouth. He has experience with system maintenance and design with finfish, shellfish, algae, and live feeds.

Beth Phelan has been a research fishery biologist at the Howard Marine Sciences Lab at Sandy Hook since 1984 and a supervisor since 2007. She has conducted field and laboratory research that focuses on a number of species from the Mid-Atlantic (summer and winter flounder, bluefish, striped bass, black sea bass, tautog, skate, goosefish, and American lobster).

5.0 HOW:

1. Condition adult tautog to become broodstock and naturally induce spawning in order to have an ample supply of larval stage tautog.

Methodology for this process will build upon previous research conducted by Olla & Samet 1977 and Perry et al., 2008, where tautog were documented spawning eggs each day for several months. Tautog are reliant on temperature cues to undergo courtship and spawning behavior, and through proper conditioning will produce viable eggs.

2. Collect eggs from spawning fish and rear them in closed, recirculating aquaculture systems with different diets and at different stocking densities.

In previous studies concerning larval tautog in recirculating aquaculture systems, the use of green water was not utilized to its full potential. By using algae enriched water, this mimics conditions that tautog larvae are adapted to under wild conditions and allows them to locate their prey more effectively. Artemia and rotifers will be cultured in high densities at Ward Aquafarms and fed to the fish as part of an enriched or nonenriched diet as they transition to pellet food. These fish will be held at various densities in order to discover the optimal density for larvae in aquaculture systems.

3. Assess growth rates and survival of the different stocking densities and treatment diets.

Effect of stocking density will be evaluated for three distinct size classes prior to metamorphosis in sequential 15-day trials. Additionally, post-metamorphosis, stocking densities will be evaluated for three sequential size classes as well.

4. Community outreach and presentations to convey information to industry professionals, managers, and interested stakeholders

Outreach locally, regionally, online, and at conferences (hopefully!).

6.0 WHEN:

September 2021: Acquiring brookstock tautog, system design, and larval fish production
September 2022: Larval rearing of tautog on 5 different diets, with 5 different stocking densities, comparing growth rates and survival

7.0 BUDGET SUMMARY:

NRAC will not pay for indirect costs (overhead), student tuition remission, and capital costs. These may not be included as a component of matching funds. Matching funds or cost sharing funds are not required but if included should be shown on the budget sheet. (Budget totals on the pre-proposal will be expected to be the same as on the full proposal if a full proposal is requested).

Funds Requested

	Funds Requested from NRAC	Matching Funds
Salaries and Wages		
A. Principal Investigators	80000	
B. Research Assoc./Postdoctorates	40000	
C. Graduate/Prebaccalaureate Students		
D. Other Professionals (not consultants)	5000	
Fringe Benefits	5000	
Non-expendable Equipment		
Materials and Supplies	35000	
Travel	5000	
Publication Costs/Page Charges		
Other Direct Costs		
Lab Analyses		
Consultant Services	15000	
Subcontracting		
Phone/Fax/Photocopy/Postage		
TOTALS	**185000**	

(Enter these values on the title/signature page)

BIOGRAPHICAL SKETCH

Daniel P. Ward, PhD
51 North Falmouth Highway, North Falmouth, MA 02556
Cell Phone: 603-505-0865 Email: dan@wardaquafarms.com

Education

University of Rhode Island, 2014	**Ph.D., Environmental Science and Biology**
University of New Hampshire, 2010	**M.S., Zoology**
University of Rhode Island, 2005	**B.S., Coastal and Marine Management**

Business milestones

Nantucket Sound Bay Scallop Company, LLC;	**Harwich, MA (Partner: Jeff Lang)**
January 2020	Purchase of Barlow's Boatyard (Bourne, MA)
December 2019	Start of company to farm bay scallops
Atlantic Aquaculture Technologies, LLC;	**North Falmouth, MA (Partner: Mark Tepper)**
October 2019	Start construction on first MAP system (Rowley, MA)
June 2019	Start of company to commercialize the MAP system
Ward Aquafarms, LLC;	**North Falmouth, MA**
November 2019	East Falmouth, MA *First farming-as-a-service farm*
November 2019	East Falmouth, MA *Commercial flip-bag farm*
June 2019	West Wareham, MA *First commercial shellfish hatchery*
May 2019	Dennis, MA *Municipal nutrient reduction shellfish farming project*
December 2018	West Wareham, MA *Commercial marina and Mercury Dealership*
December 2018	Orleans, MA C*ommercial shellfish nursery site, Lonnie's Pond*
April 2015	North Falmouth, MA *7.4 acre expansion (10 acres subtidal lease)*
March 2014	North Falmouth, MA *Nursery lease in Fiddlers Cove Marina*
April 2011	North Falmouth, MA *First 2.6 acre subtidal growout lease*

Relevant employment

Ward Aquafarms Hatchery;	**West Wareham, MA**
June 2019 - Present	*Owner/operator commercial shellfish hatchery*
Wareham Marina;	**West Wareham, MA**
December 2018 - Present	*Owner/operator commercial marina and Mercury Dealership*
Ward Aquafarms, LLC;	**Orleans, MA**
December 2018 - Present	*Owner/operator commercial shellfish nursery site, Lonnie's Pond*
Ward Aquafarms, LLC;	**North Falmouth, MA**
April 2011 - Present	*Owner/operator commercial oyster farm, Megansett Harbor*
Woods Hole Oceanographic Institution;	**Woods Hole, MA**
February 2018 – June 2018	*Guest investigator; Dept. of Applied Ocean Physics & Engineering*

Recent Publications

Julie M. Rose; J. Stephen Gosnell; Suzanne Bricker; Mark J Brush; Allison Colden; Lora Harris; Erik Karplus; Alix Laferriere; Nathaniel H. Merrill; Tammy B. Murphy; Joshua Reitsma; Johnny Shockley; Kurt Stephenson;

Seth Theuerkauf; **Daniel Ward**; Robinson W. Fulweiler, Ph.D.**.** 2020. Opportunities and challenges of including oyster-mediated denitrification in nitrogen management plans. Estuaries and Coasts. *In press.*

Tobi H and **Ward D.** 2019. Nursery and grow-out strategy optimization in bay scallop (Argopecten irradians) aquaculture. North American Journal of Aquaculture. Vol. 81 (2): 130-139.

Ward D., Bengtson D., Lee C., Gomez-Chiarri M. 2016. Incorporation of soybean products in summer flounder (Paralichthys dentatus) feeds: Effects on growth and survival to bacterial challenge. Aquaculture. 452 (395-401).

Ward D., Fore M., Howell W.H., and Watson W. 2012. The influence of stocking density on the swimming behavior of adult Atlantic cod, *Gadus morhua*, in a near shore net-pen. Journal of the World Aquaculture Society. 43 (5): 621-634.

Ward D., Morison F., Morrissey E., Jenks K., and Watson W. 2011. Evidence that potential fish predators elicit the production of carapace vibrations by the American lobster. Journal of Experimental Biology. 214 (16): 2641-2648.

Walker, A., **Ward D**., Duclos K., and Peters M. 2010. Surface disinfection and removal of adhesiveness from rainbow smelt eggs. North American Journal of Aquaculture 72:158–163.

Selected Presentations

Ward D. Lonnie's Pond, Orleans, MA. 2019 Overview and 2020 Plan. Orleans Shellfish Committee. February 11, 2020. Town Hall, Orleans, MA. Oral.

Ward D. Design of Electromechanical Robotic Systems - Design Challenge. 2.017 Design Class. February 4, 2020. MIT. Cambridge, MA. Oral.

Ward D. Offshore Fish Farming. ERC Planning Meeting. Offshore Aquaculture & Fisheries. December 12, 2019. MIT Sea Grant. Cambridge, MA. Oral.

Ward D. Bay scallop (Argopecten irradians) aquaculture and harmful algae mitigation strategies. Cape Cod Cooperative Extension. Basics of Shellfish Farming Course. March 28, 2019. Barnstable, MA. Oral.

Recent Competitive Funding

Town of Bourne, MA; Funded June 2020
"Town shellfish aquaculture propagation enhancements: Year 4"
NOAA, Small Business Innovation Research; Funded April 2020
"Connected shellfish grading system and integrated data management platform"
NOAA, Saltonstall-Kennedy Two-Year Research Contract; Funded June 2019
"Reducing risk for shellfish farmers through real-time, automated, harmful algal bloom monitoring and mitigation"
Town of Bourne, MA; Funded June 2019
"Town shellfish aquaculture propagation enhancements: Year 3"
Town of Dennis, MA; Funded May 2019
"Shellfish aquaculture nitrogen reduction demonstration project"

Associations

World Aquaculture Society, National Shellfish Association, Massachusetts Aquaculture Association, East Coast Shellfish Growers Association, URI Graduate Assistants Union, Falmouth Shellfish Cooperative, Massachusetts Community College Council, Cape Cod Cooperative Extension Research Farm Network, UMASS Grey Meat Research Network, Shellfish Advisory Board (Falmouth, MA): 2018-Present, New Jersey Sea Grant Program Review Panel (Highlands, NJ): 2017, Massachusetts Institute of Technology Sea Grant Program Review Panel (Cambridge, MA): 2017-Present

USDA Northeast Regional Aquaculture Center (Baltimore, MD): Co-Chair Industry Advisory Committee. 2017-Present.

USDA SBIR Aquaculture Review Panel (Washington, DC): 2015

Manuscript reviewer for: Aquaculture, Aquaculture Research, North American Journal of Aquaculture

Michael Coute
Graduate Research Assistant
University of Massachusetts Dartmouth
706 S Rodney French Boulevard
New Bedford, MA 02744
Phone: 774-487-1993
Email: mtcoute@gmail.com

Education

B.S. Marine Safety & Environmental Protection, Massachusetts Maritime Academy 2017

Positions:

Graduate Research Assistant/ MSc Student -University of Massachusetts Dartmouth
(August 2019- Present)

Aquaculture Specialist- Dana Farber Cancer Institute
(August 2018- August 2019)

Aquaculture Technician – Ward Aquafarms
(Seasonal May 2015- January 2018)

Laboratory Supervisor/ Aquaculture Teaching Assistant – Massachusetts Maritime Academy
(September 2016-June 2017)

Joshua Reitsma

Marine Program Specialist
Cape Cod Cooperative Extension Phone: 508-375-6950
& Woods Hole Sea Grant Fax: 508-362-4923
Deeds and Probate Building Email: jreitsma@barnstablecounty.org
3195 Main Street
PO Box 367
Barnstable, MA 02630

Education

B.S. Environmental Science, Unity College, 2002.
M.S. Fisheries, Animal and Veterinary Science, University of Rhode Island, 2008.

Positions

Marine Program Specialist – marine aquaculture and fisheries, June 2009 - present
Cape Cod Cooperative Extension & Woods Hole Sea Grant, Barnstable, MA
Hatchery Manager – marine aquaculture facility, June 2007- June 2009
Mid-Atlantic Aquatic Technology, Quinby, VA
Graduate Research Assistant – aquaculture, January 2004 – June 2007
University of Rhode Island, Kingston, RI
Fisheries Interviewer – large pelagics survey, August – October 2004
Quantech, Narragansett, RI
Biological Science Technician – fish health, May – December 2003
United States Fish and Wildlife Service, Anderson, CA
Resource Assistant – technician, November 2002 – May 2003
Connecticut Department of Environmental Protection, Riverton, CT

Scientific and Professional Organizations

World Aquaculture Society
American Fisheries Society
Massachusetts Aquaculture Association
Massachusetts Shellfish Officers Association
National Shellfisheries Association

Select Publications

Archer, A., Reitsma, J., and D. Murphy. 2014. A Comparison of Bottom and Floating Gear for Growing American Oysters (*Crassostrea virginica*) in Southeastern Massachusetts. Marine Extension Bulletin of Woods Hole Sea Grant.

Reitsma, J., Murphy, D., and A. Archer. 2014. Shellfish Nitrogen Content from Coastal Waters of Southeastern Massachusetts. A Technical Report.

Murphy, D. and J. Reitsma. 2013. Investigating Potential for Razor Clams (*Ensis directus*) to Augment Farm Profitability: A Case Study in Massachusetts, U.S.A. Proceedings of Aquaculture 2013, Feb. 21-25, Nashville, TN.

Magowan, K., Reitsma, J., Murphy, D. (2012). The Use of Dual-Frequency Identification Sonar (DIDSON) to Monitor Adult River Herring in a Small Stream. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 4:651–659.