## NRAC ANNUAL PROGRESS REPORT

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| **Project Title** | Improving Hatchery Techniques of Lumpfish (*Cyclopterus lumpus*) for Use as a Cleaner Fish to Control Sea Lice in Atlantic Salmon and Steelhead Trout Net Pens |
| **Reporting Period** | 9/1/2020 – 6/30/2021 |
| **Author (Chair)** | Elizabeth Fairchild |
| **Key Word** | lumpfish, nutrition, larviculture, strip spawning, egg incubation, sea lice mitigation, cleaner fish, salmonids |
| **Funding Level** | Total funds allocated for this project to date. *Year One: FY 2020, $ 100,000* *Year Two: FY 2021, $ 100,000* |
| **Participants** | List participating personnel and respective institutions/agency/business; include outreach representative. Indicate funded participants with an asterisk. \*Dr. Elizabeth A. Fairchild: Project Coordinator & lead PIAssociate Research Professor, Department of Biological Sciences, University of New Hampshire, Durham, NH 03824; ph: 603-862-4475; fax: 603-862-3784; elizabeth.fairchild@unh.eduDr. Brian Peterson: co-PICenter Director, USDA ARS National Cold Water Marine Aquaculture Center25 Salmon Farm Rd., Franklin, ME 04634(207) 422-2713; Fax: N/A; brian.peterson@ars.usda.edu\*Dr. Michael Pietrak: co-PIResearch Associate, USDA ARS National Cold Water Marine Aquaculture Center, 25 Salmon Farm Rd, Franklin, ME 04364; Ph: (207) 812-0605; Fax: N/A; michael.pietrak@ars.usda.edu\*Dr. Gary Burr: co-PIResearch Physiologist, USDA ARS National Cold Water Marine Aquaculture Center, Franklin, USDA ARS National Cold Water Marine Aquaculture Center, 25 Salmon Farm Rd, Franklin, ME 04364; Ph: (207) 422-2716; Fax: N/A; gary.burr@ars.usda.edu\*Dr. Michael Chambers: co-PI and lead outreach coordinatorAquaculture Specialist, NH Sea Grant & Cooperative Extension, University of New Hampshire, Durham, NH 03824; ph: 603-862-3394; michael.chambers@unh.edu Dr. Keng Pee Ang: Cooperating non-funded industry partnerVice President of Research, Cooke Aquaculture, 40 Wellington Row, St. John, New Brunswick, Canada E2L 3H3; ph: 506-456-6600; keng.pee.ang@cookeaqua.com**Note:** Dr. Keng Pee Ang has retired from Cooke Aquaculture during this reporting period and was replaced on this project by his successor, Andrew Swanson. In addition, we added another funded NH outreach member to the team, Arron Jones.Dr. Andrew Swanson: Cooperating non-funded industry partnerVice President of Research, Cooke Aquaculture, 40 Wellington Row, St. John, New Brunswick, Canada E2L 3H3; ph: 506-456-6600; andrew.swanson@cookeaqua.com\*Arron Jones: Outreach coordinatorAquaculture Program Manager, NH Sea Grant, University of New Hampshire, Durham, NH 03824; arron.jones@unh.edu |
| **Project Objectives** | **Objective 1:** Optimizing lumpfish hatchery techniques for early life history stages. *Ho 1: Declumping the naturally, sticky lumpfish eggs will increase survival and hatching.**Ho 2: Eliminating live feed for newly-hatched lumpfish larvae will not affect their growth and survival*.**Objective 2:** Optimizing lumpfish larval and juvenile nutrition parameters through protein to energy studies to identify protein and fat levels that improve growth and survival.*Ho 3: Varying protein and fat levels will affect the growth and survival of larval lumpfish.**Ho 4: Varying protein and fat levels will affect the growth and survival of juvenile lumpfish.***Objective 3:** Conveying research findings to stakeholders by developing lumpfish husbandry guides and standard operating procedures and holding workshops.  |
| **Anticipated Benefits** | The overall goal of this project is to address existing lumpfish culture gaps at the hatchery, provide rearing protocols and guidelines that enable the development of a Northeast lumpfish hatchery, and provide the salmon and steelhead trout industries with feasible techniques so that sea lice mitigation is less costly and more sustainable. |
| **Project Progress** | **Objective 1:** Optimizing lumpfish hatchery techniques for early life history stages. *Ho 1: Declumping the naturally, sticky lumpfish eggs will increase survival and hatching.*No new updates on this objective during this reporting period.*Ho 2: Eliminating live feed for newly-hatched lumpfish larvae will not affect their growth and survival.*NCWMAC trial: The first feeding study was completed during this reporting period at the NCWMAC to examine the effects of starting newly-hatched lumpfish on live feed (enriched *Artemia*) compared to starting them directly on commercial micro-diets. The fish hatched on Aug. 25th and 26th, 2020. They were divided into 12 tanks on Aug. 26th with 650-700 newly hatched fish per tank. Six of the tanks were fed live feed and weaned onto micro-diets by Sept. 30, 2020. The remaining 6 tanks were only being fed micro-diets. In addition, to the diet study, 3 tanks from each diet treatment (6 tanks total) had a false bottom to facilitate cleaning the tanks, while the remaining 3 tanks per diet treatment had a solid bottom like traditional tanks. Time spent feeding both feed types and cleaning both tank types was recorded. The study was completed at the end of October 2020. Survival to the end of the trial was better in fish fed micro-diets and in fish that were reared in the false bottom tanks. Fish that were fed on *Artemia* did grow slightly larger than those fed on the micro-diets. These differences were primarily explained by the time and frequency of cleaning required. When trying to siphon the tanks, larval lumpfish do not move out of the way and often get siphoned up as well, causing stress, possible damage, and loss of some normal healthy fish. Two strategies tried to minimize loss were using screens on the end of the siphon and siphoning into a screen to try and catch live fish so they can be put back into the tank. While somewhat successful, neither was 100% effective. The use of false bottom tanks greatly reduced the frequency of cleaning required compared to using traditional flat bottom tanks. This likely resulted in the higher survival in the false bottom tanks. Overall, either going straight to *Artemia* or use of micro-diets are both feasible ways for rearing larval lumpfish. When using traditional flat bottom tanks, use of *Artemia* is preferred given the slightly reduced cleaning time compared to only feeding micro-diets. **Objective 2:** Optimizing lumpfish larval and juvenile nutrition parameters through protein to energy studies to identify protein and fat levels that improve growth and survival.*Ho 3: Varying protein and fat levels will affect the growth and survival of larval lumpfish.*This study was conducted by UNH in Year 1 (fall 2019). No further updates occurred during this reporting period.*Ho 4: Varying protein and fat levels will affect the growth and survival of juvenile lumpfish.*This study was conducted at both UNH and the USDA NCWMAC during 2020-21. Based on the insight we had with the larval diet experiment, it was recommended that we focus on higher protein diets, so we eliminated the 40% and 45% protein experimental diets. Instead, we added two commercially available and higher protein diets to the study. Diets for the study were manufactured by the USFWS and shipped to the USDA NCWMAC. They were then spilt in half and half was sent to UNH for running trials. The diets (protein/lipid) tested are as follows:* Diet 1: 50/15
* Diet 2: 55/10
* Diet 3: 50/20
* Diet 4: 55/20
* Diet 5: 55/15
* Diet 6: 50/10
* Diet 7 (Biotrout): 47/24
* Diet 8 (Europa): 55/15

We included Diet 8, as a control, as it is the main commercial juvenile lumpfish diet available and what the fish had been fed prior to the start of the experiment. Diet 7 was included to understand what the effects to lumpfish will be post-stocking into salmonid farms if the lumpfish eat the salmonid diet (instead of a lumpfish diet or sea lice). UNH trial: Two juvenile diet trials were conducted for 10 weeks each at UNH. A flow-through system was used to evaluate 8 experimental diets in quadruplicate using 10L tanks in trial 1, and 5 experimental diets in triplicate trial 2 (see tables below).

|  |  |  |
| --- | --- | --- |
| **Parameter**  | **Trial 1** | **Trial 2** |
| Testing Period  | 5/18/20 – 7/ 27/20 | 3/27/21 – 5/12/21 |
| Initial Fish Size (g) | 9 | 8 |
| Number of Diet Treatments | 8 | 5 |
| Temperature Range (°C) | 8-19 | 4-11 |
| Salinity Range (ppt) | 33-36 | 27-33 |
| Number of Fish per Tank | 15 | 10 |

|  |  |  |  |
| --- | --- | --- | --- |
| **Diet** | **Protein/Lipid Conc. (%)** | **Trial 1** | **Trial 2** |
| 1 | 50/15 | X |  |
| 2 | 55/10 | X | X |
| 3 | 50/20 | X | X |
| 4 | 55/20 | X | X |
| 5 | 55/15 | X | X |
| 6 | 50/10 | X |  |
| 7 | 47/24 (BioTrout) | X |  |
| 8 | 55/15 (Skretting Europa) | X | X |

Fish were hand fed the 2.0 mm experimental diets 5 x daily (800, 1000, 1200, 1400, 1700) at 3% body weight, and the amount of feed fed/day was recorded. Temperature and salinity were monitored daily. All fish were sampled (g) bimonthly. A subsample of fish at week 0 and at the end, week 10, were euthanized and frozen for proximate composition analysis. All data were analyzed using Excel 2019 and JMP Pro 15. One-way repeated measures ANOVAs and Tukey’s tests were used to compare the mean percent growth and mean mortality between the treatments biweekly and overall for each trial. One-way ANOVAs were used to compare the mean FCR, SGR, and weight gain between the treatments. Overall percent growth was calculated by comparing the original fish mean weights to the final fish mean weights: ((Final Weight – Original Weight)/ Original Weight) x 100%).In Trial 1, fish fed Diet 7 (Biotrout) had significantly slower growth than any of the other fish throughout the study and had the least amount of weight gain by week 10. Final mean fish weights/treatment ranged from 40.8 to 75.9 g.  When the BioTrout diet was excluded from analyses, diets with higher protein concentrations (55/15 and 55/20) resulted in significantly higher overall growth at the end of experimentation than the other treatments (p < 0.0001), and fish fed Diet 5 (55/15) were significantly larger than fish fed Diet 8 (55/15). This difference was also evident in the weight gain and SGR metrics. The experimental 55/15 diet resulted in significantly higher weight gain (p = 0.0039) and SGR (p = 0.0228) than the Skretting Europa diet. This is somewhat surprising since Diet 8 (Europa) has the same protein:lipid mix as Diet 5, indicating that some of the other ingredients are affecting the outcome. Overall percent growth was highest in fish fed Diet 5 (667%) and lowest in fish fed Diet 7 (394%). There were no significant differences between the treatments in terms of FCR. Survival remained at 100% throughout the entire 10-week study with the exception of one mortality early on in a Diet 4 replicate.In Trial 2, survival was not impacted by diets; no fish died during the experiment. Omitting poorer performing diets evaluated in Trial 1 led to less differentiation in the results. Fish in all diet treatments had similar growth rates throughout the study. There were no significant differences in weight gain or SGR between the treatments, and there were no significant differences in FCR either. However, overall mean percent growth was lowest in fish fed the diet with the lowest lipid concentration (55/10) compared to fish fed the 55/20 and Skretting Europa diets (p = 0.0251). Proximate composition analysis has not occurred yet and some data analysis is still ongoing as this forms a portion of graduate student Nathaniel Spada’s Master’s thesis research. NCWMAC trial: Lumpfish from UNH were transported to the USDA to conduct the juvenile diet trial once the USDA new lumpfish facilities were established. The trial was conducted for 8 weeks from June 12 to Aug. 7, 2020. The study was conducted in 24 16-L tanks initially stocked with 20 fish weighing 15 g (±2.9 g). Diets were randomly assigned to tanks in triplicate and fed twice a day to satiation. Fish were individually weighed, and the weight of feed fed per tank was recorded biweekly. At week 6, five fish were removed from each tank after weighing to reduce tank densities below 40 kg/m3. A subsample of fish at week 0 and at the end, week 8, were euthanized and frozen for proximate composition analysis.Proximate composition and data analysis are still ongoing. Fish grew more than 300% (323%-396%) over the course of the study, except for those on the BioTrout diet (277%). This result is similar to what was seen at UNH where the commercial salmon diet, BioTrout, was by far the lowest performing diet. Unlike UNH, the commercial Europa control diet was the best performing diet (396%) and the experimental diet (diet 5) with the same protein:lipid (55:15) mix was the second best performing diet with 387% growth. Generally, the diets containing higher protein levels had slightly greater growth compared to the lower protein diets but this still has to be analyzed.Ongoing work: For both juvenile diet experiments, feed samples and fish tissue samples are being analyzed for proximate composition using methods published in Burr et al. (2020)[[1]](#footnote-1). This analysis has been delayed while the USDA purchased a new updated protein analyzer. This is scheduled to be installed on July 21, 2021. These samples will be the first run through the new equipment. Average fish weight gain (average final tank weight- average initial tank weight), protein retention efficiency (PRE: fish protein gained/feed protein intake\*100), feed conversion ratio (FCR: weight gain (g)/weight of food (g)), and specific growth rates (SGR: (ln(final weight)-ln(initial weight))/days cultured) are being calculated for each two-week period, and the data analyzed so that results between the two studies can be compared. **Objective 3:** Conveying research findings to stakeholders by developing lumpfish husbandry guides and standard operating procedures and holding workshops. Covid-19 has disrupted many of the plans to present at meetings, and host workshops or sessions to help promote knowledge and the use of lumpfish. In particular, the pandemic has postponed the industry workshops initially planned for Spring 2020; we hope to be able to have those in Spring 2021. Additionally, the Northeast Aquaculture Conference & Exposition (NACE) has been postponed from Jan. 2021 until Jan. 2022, and a cleanerfish session was being planned. It will still be held when the meeting is hosted again, but just after the grant is finished. Another cleanerfish session was planned for Aquaculture America 2021, but cancelled since UNH still prohibited non-essential travel at the time of the conference planning plus the US-Canada border remains closed and many speakers would not have been able to attend. A cleanerfish session will be planned for Aquaculture America 2022 instead. In addition, farm tours at the UNH steelhead trout farm were not permitted during this reporting period due to restricted access during Covid-19. When they do resume, a lumpfish/cleanerfish module will be in place for outreach leaders and visitors alike.We have managed, however, to conduct quite a bit of outreach and did help to organize and present in a cleanerfish session at Aquaculture American 2020 in Feb. 2020. Further, we have taken advantage of many opportunities to promote this research via other outreach outlets including radio interviews, press releases, trade magazine articles, and online newsletters. Several seminars about this research topic have been presented at UNH to undergraduate and graduate students. These details are listed below under Accomplishments.Work on the standard operating procedures (SOP) has been initiated with tentative agreements to publish it online via the UNH Innovation Office. Content development has been started.  |
| **Accomplishments:** |
| **Outreach Overview** | Many of our outreach activities we plan to do are covered by Objective 3 (above) in that we will develop lumpfish husbandry guides and SOPs, as well as hold workshops with salmonid farmers, and ultimately publish fact sheets and peer-reviewed articles. In addition, once we are back to normal operations (post-COVID), we will be able to resume in-person outreach activities, including hosting tours of the UNH IMTA farm and at the NCWMAC to showcase this research project. The project is featured on the UNH School of Marine Science and Ocean Engineering’s website at <https://marine.unh.edu/resource/lumpfish-research>.We have managed to inform the public and aquaculture stakeholders (scientists, industry) about the importance of this research through several internet avenues including:* “Liking lumpfish: grad student’s research goes viral.” In UNH Today. Written by Jody Record (3/15/2021). <https://www.unh.edu/unhtoday/2021/03/liking-lumpfish>
* One of Dr. Fairchild’s graduate students, Nate Spada, regularly posts on social media outlets about the lumpfish research conducted at UNH. With over 1.6 million TikTok followers, Nate has been able to educate a wide array and number of people about lumpfish, general finfish culture, and cleanerfish use. For more information, please see @spadaniel44.
* "Instagram Takeover" by Nate Spada for the UNH Graduate School Instagram Page. This consisted of posting videos on their story talking about the tasks we do at the UNH Coastal Marine Laboratory and overall lumpfish information. The videos showed how lumpfish were cared for daily, the experiments conducted with the lumpfish, and general information about lumpfish as cleanerfish. (4/3/2021).
* Profile: @unhgraduateschool
* Profile URL: [https://instagram.com/unhgraduateschool?igshid=3wc2anym0xb2](https://nam12.safelinks.protection.outlook.com/?url=https%3A%2F%2Finstagram.com%2Funhgraduateschool%3Figshid%3D3wc2anym0xb2&data=04%7C01%7CElizabeth.Fairchild%40unh.edu%7Cbf9f7fe1db5147e9238708d8fa976e54%7Cd6241893512d46dc8d2bbe47e25f5666%7C0%7C0%7C637534875577515755%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=q4jrfX6nGHrLd%2BgTpGPBGSLcpEYVqjLF3BhTN86N7IY%3D&reserved=0)

In addition, this lumpfish research has been featured in the following public and university educational events:* Guest lecture in UNH Introductory Marine, Estuarine, and Freshwater Biology (MEFB 401) class – 40 students (all freshman); 10/7/20
* Guest lecture in UNH Introductory Zoology (ZOOL 401) class – approx.25 students (majority freshman); 10/26/20
* Live Zoom meeting with Seacoast Science Center (Rye, NH) High School Fellows. Discussed career paths, future education, research at UNH, and the lumpfish project; 12/5/20.
* “Lumpfish are more than just a funny looking fish.” Portsmouth Herald article by Ellen Goethel with UNH lumpfish research mentioned. (6/30/21).
 |
| **Targeted Audiences** | Our target audiences have included students (K-12, undergraduate, and graduate) to educate them about sustainable aquaculture and developments in domestic seafood production. By working with university students, we are training the next crop of marine scientists. We also have targeted other scientists and academics along with aquaculture industry members to work together towards solving limitations in domestic salmonid farming. We have targeted the international cleanerfish community so that we receive relevant guidance from those who already have initiated cleanerfish hatcheries and use in salmonid farms in their home countries. We also continue to communicate with state regulators about this research and need to utilize cleanerfish in finfish aquaculture farms within state waters so that a permitting pathway can be created to allow salmonid farmers to stock lumpfish in their farms. |
| **Outputs:** | The funding and research of this project has spurred the creation of the US Lumpfish Consortium by the PIs. This informal group consists of researchers from UNH, USDA, UMaine, Cooke Aquaculture (both US and Canadian groups), Kennebec River Biosciences, and Memorial University of Newfoundland. The group is open to any persons or groups interested in promoting research on the culture and use of lumpfish in US aquaculture. To date the consortium members have submitted research proposals to Sea Grant (1), NOAA Saltonstall-Kennedy Program (1), NRAC (1 new proposal in 2020; 3 pre-proposals submitted in 2021), Maine Technology Institute (1), USDA NIFA NH AES (1), and USDA AFRI (1). These efforts have resulted in at least two of these proposals being funded:1) “Sustainable US Cleanerfish Production: Developing a Lumpfish Broodstock Program,” funded by NOAA S-K Program to UNH for $296,337; 1/1/2021-12/31/2022; lead PI Elizabeth Fairchild). 2) “Developing strategies to minimize sea lice infestation in cage cultured steelhead trout and advancing lumpfish aquaculture,” funded by USDA NIFA NH AES to UNH for approx. $70,000; 9/1/2019-8/31/2021; lead PI Elizabeth Fairchild). NH AES also is funding one UNH Master’s student on a GRA who is focusing on cleanerfish use in steelhead trout cages.Lumpfish produced at UNH: Approximately 30,000 juvenilesLumpfish supplied to others:* Portland Children’s Museum, Portland, ME: 15 for educational purposes
* Gulf of Maine Research Institute, Portland, ME: 10 for educational purposes
* Seacoast Science Center, Rye, NH: 15 for educational purposes
 |
| **Outcomes/Impacts:** | Although we are still in the midst of our research project, we already are having an impact. * Through our first round of hatchery studies, we are gaining a better understanding of lumpfish culture techniques and nutritional requirements.
* Through the creation of the US Lumpfish Consortium, community connectivity has been strengthened between research organizations/academia and aquaculture industries.
* Lumpfish production at US research facilities (mainly UNH and UME CCAR) is increasing.
* Development of a captive reared broodstock program at the USDA and CCAR to support industry and public research efforts,
* Initiation of permitting process for the first commercial US lumpfish hatchery.
 |
| **Impacts Summary** | Provide short statements (2-3 sentences) about each of the following:(pre-established fields for Researchers to complete short statement answers)1. **Relevance:** Issue – what was the problem?

The US has the potential to increase domestic aquaculture finfish production by utilizing cleanerfish as a way to combat sea lice infestation in salmonid sea cages.1. **Response:** What was done?

While we are still working on this research project, we have raised (and are still raising) lumpfish. We have worked with commercial fishermen to try to establish a wild-caught lumpfish broodstock. We have examined experimental diets to learn more about the nutritional needs of young lumpfish. We have experimented with multiple husbandry systems and techniques between facilities to gain experience. We have formed collaborations and organized talks about cleanerfish to educate the public and our stakeholders about cleanerfish use and why it could be beneficial if used in the US.1. **Results:**  How did your work make a difference **(change in knowledge, actions, or conditions)** to the target audiences?

This project has not been completed yet but as a result of the research to date, lumpfish production in US research facilities has increased and there is a greater understanding in the US about cleanerfish use in fish farms. We have expanded the interest by researchers, across a range of disciplines, in lumpfish culture and increased the number of proposals being submitted and secured. The first commercial US lumpfish hatchery currenlty is in permitting review.1. **Recap:** One- sentence summary

There is industry interest in using lumpfish as a cleanerfish in US salmonid farms and we have shown that small-scale hatchery production of lumpfish is feasible in university facilities.  |
| **Publications** | **Symposium Paper:**Pietrak, M.R., and Peterson, B.C. Genetic and other innovative strategies to reduce sea lice. Theme-based Special Session of the Council of North Atlantic Salmon Conservation Organization (NASCO), Virtual Meeting May 27, 2021. (invited paper)**Oral Presentations:**Fairchild, E. A. 2020. US Lumpfish Consortium: promoting cleanerfish in salmonid farming. AFS Atlantic International Chapter October meeting, October, 24, 2020; live Zoom presentation.Doherty, M. 2021. Aquaculture of the lumpfish, *Cyclopterus lumpus*, and implementation as a cleanerfish. University of New Hampshire Marine Docents Seminar Series, March 2, 2021; live Zoom presentation.Doherty, M. 2021. UNH Grad School: lumpfish research, aquaculture, and a career in marine science. Troy Howard Middle School career day talk, March 26, 2021; live Zoom presentation and Q&A.Doherty, M. 2021. Marine Bio Spotlight: Lumpfish research and my path as a marine biologist. Gulf of Maine Research Institute Scientist to go program, April 8, 2021; live Zoom presentation and Q&A.Doherty. M. 2021. An analysis of sea lice in an experimental NH aquaculture station, and the use of lumpfish as a lice mitigation strategy. UNH Graduate Research Conference, April 19, 2021. <https://media-gallery.unh.edu/media_submission/500/> Doherty, M. 2021. Parasitic sea lice populations in an experimental salmonid aquaculture system in NH waters and using lumpfish as a possible solution. UNH School of Marine Science and Ocean Engineering Graduate Research Symposium, May 5, 2021; live Zoom presentation.Fairchild, E. A. 2021. Increasing domestic aquaculture production with environmentally friendly technology: promoting cleanerfish in salmonid farming. Biology Department Spring Seminar Series, College of Charleston, March 8, 2021; live Zoom presentation. (invited speaker)Spada, N. 2021. Quantifying the impacts on growth in juvenile cultured lumpfish: nutritional and density dependent conditions. UNH Graduate Research Conference, April 19, 2021. <https://media-gallery.unh.edu/media_submission/513/> Spada, N. 2021. Nutritional and density dependent effects on the growth of juvenile culture lumpfish.UNH School of Marine Science and Ocean Engineering Graduate Research Symposium, May 5, 2021; live Zoom presentation.Pietrak, M.R., and Peterson, B.C. 2021. Genetic and other innovative strategies to reduce sea lice. Theme-based Special Session of the Council of North Atlantic Salmon Conservation Organization (NASCO), Virtual Meeting May 27, 2021. (invited speaker) |
| **Students/Participant** | Shelly Lancaster:* University of New Hampshire; B.S. in Natural Resources
* New undergraduate student
* No capstone or thesis related to this project
* Anticipated date of graduation: 5/2022

Nathaniel Spada:* University of New Hampshire; M.S. in Biological Sciences: Marine Biology
* Continuing MS student
* Optimization of Larval and Juvenile Lumpfish Culture
* Anticipated Date of Graduation: 1/2022

Mary Kate Munley:* University of New Hampshire; B.S. in Marine, Estuarine & Freshwater Biology
* Undergraduate student
* No capstone or thesis related to this project
* Graduation date: 5/2021

Andrew Shapiro:* University of New Hampshire; B.S. in Marine, Estuarine & Freshwater Biology
* Undergraduate student
* No capstone or thesis related to this project
* Graduation date: 5/2021

Alexander Gross:* University of New Hampshire; B.S. in Marine, Estuarine & Freshwater Biology
* Undergraduate student
* No capstone or thesis related to this project
* Graduation date: 5/2021

Michael Doherty: * University of New Hampshire; M.S. in Biological Sciences: Marine Biology
* Continuing MS student
* Interactions and behaviors of lumpfish, *Cyclopterus lumpus,* and steelhead trout, *Oncorhynchus mykiss*, and sea lice prevalence in experimental open water aquaculture cages
* Anticipated date of graduation: 9/2021

Alex Lora* University of Maine; BS Marine Science with Aquaculture concentration
* Continuing student
* No capstone or thesis related to this project
* Anticipated Date of Graduation: Spring 2022

Marissa Burr* Delaware Valley University; BS Environmental Biology
* Continuing student
* No capstone or thesis related to this project
* Anticipated Date of Graduation: Spring 2023

Bayley Bryant* University of Maine; BS Marine Science
* Intern (recent graduate)
* Graduation date: Spring 2020
 |
| **Partnerships** | * Dr. Gibson Gaylord (USFWS Fish Nutritionist): reviewed experimental diet formulations and manufactured the diets for the juvenile feeding study
* Jason Frost (USDA ARS Biological Science Technician): reviewed experimental diet formulations and manufactured diets for the larval feeding study
* Danny Boyce (Memorial University of Newfoundland, Aquaculture Facilities Manager): provided advice and guidance on the culture of lumpfish and provided lumpfish eggs in 2019 and 2020
* Geoffrey McBriarty (Cooke Aquaculture Lumpfish Production Coordinator): provided advice and guidance on lumpfish care and husbandry
* Frank Lank (Cooke Aquaculture USA): assisted with efforts to collect wild lumpfish from Atlantic salmon net pens in Maine
* Mike Brown (Cooke Aquaculture USA): assisted with efforts to collect wild lumpfish from Atlantic salmon net pens in Maine
* Steve Eddy, Melissa Malmstedt, Ben Reed (University of Maine Center for Cooperative Aquaculture Research Director and Technicians): collected wild young of the year lumpfish in Maine for grow-out to sexual maturity (i.e., future broodstock) and also growing out UNH reared lumpfish
* Greg Lambert (Cooke Aquaculture USA): provided advice and guidance on timing of lumpfish hatchery operations and logistics to coincide with needs at the Atlantic salmon farms in Maine
 |
| **Partner**      | **Specific Type**  | **Level** | **Nature of Partnership** |

1. Burr, G, Peterson, B, Pietrak, M, Sealey, W, Block, S, Bowzer, J. Effect of PROPLEX DY and PROPLEX T on growth performance of Atlantic salmon smolts. *Aquac Res*. 2020; 00: 1– 9. <https://doi.org/10.1111/are.14814> [↑](#footnote-ref-1)