RESEARCH/PD ANNUAL REPORT - PROGRESS REPORT

2015 annual report - progress
Graham Young
Development and commercial transfer of technologies to improve the hatching success and production of juvenile black cod (sablefish), Anoplopoma fimbria
R/SFA/N-2
Submitted On: 04/21/2016 11:12:14 AM

METRICS & MEASURES

Metric/Measure	Value	Note
Acres of coastal habitat	0	
Fishermen and seafood industry personnel	0	Impacts will be documented once tribes commence growout of project-generated fingerlins
Communities - economic and environmental development	0	
Stakeholders - sustainable approaches	0	
Informal education programs	0	
Stakeholders who receive information	10500	Most of the outreach activities will start at the end of year 2 but we have already begun to work with native tribes in the area to describe the project that we are conducting and how that will involve tribes in the future. Two individuals, Tiffany Royal and Betty Oppenheimer, who do reporting for native tribes in the Puget Sound region came to Manchester to discuss the NOAA project on sablefish and Tiffany Royal subsequently wrote an article on it: http://nwifc.org/w/wp-content/uploads/downloads/2016/04/Spring-2016-Magazine-1.pdf (online version: http://nwtreatytribes.org/jamestown-sklallam-noaa-partner-black-cod-broodstock-program/) for the Northwest Treaty Tribes News. This begins an outreach effort to involve more tribes in the Puget Sound region in sablefish culture. Northwest Treaty Tribes article viewed by 10,500.
Volunteer hours	0	
P-12 students reached	0	
P-12 educators	0	

REQUESTED INFORMATION

Publications

DMSP Increases Survival of Larval Sablefish (Anoplopoma fimbria)
Publication Type: Peer-reviewed: Journals (incl. articles), Books, Proceedings, and Other Documents

Publication Year: 2016 in press
Publication Authors:
Publisher Info:
Notes:
Related URLs:
Keywords:
Publication URLs:
Abstract: Since dimethylsulfoniopropionate (DMSP) is exuded by phytoplankton upon grazing by zooplankton, high DMSP concentrations indicate the presence of abundant zooplankton prey Previous studies have shown that some planktivorous fishes and birds aggregate or alter locomotory behavior in response to this chemical cue, which is likely adaptive because it helps them locate prey. These behavioral responses have been demonstrated in juveniles and adults, but no studies have tested for effects on larval fish. Larvae suffer from high mortality rates, largely due to starvation. While larvae are generally thought to be visual predators, they actually have poor vision and cryptic prey. Thus, larval fish should benefit from a chemical cue that provides information on prey abundance. We reared larval sablefish (Anoplopoma fimbria) for one week and supplemented feedings with varying concentrations of DMSP to test the hypothesis that DMSP affects larval survival. Ecologically relevant DMSP concentrations increased larval survival by up to 100%, which has implications for production in aquaculture and recruitment in nature. These results provide a new tool for increasing larval production in aquaculture and also suggest that larvae may use DMSP as an olfactory cue. In nature, through DMSP, phytoplankton may affect larval survival and ultimately recruitment.
Citation: J.S.F. Lee, R.S. Poretsky, M.A. Cook, J. Reyes-Tomassini, B.A. Berejikian, F.W. Goetz. 2016. DMSP Increases Survival of Larval Sablefish (Anoplopoma fimbria). J Chem. Eco (in press).
Citation for Coverpage:
SG can post PDF online?:
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Students Supported

No **Students Supported** information reported

Narratives

Technology transfer of research to commercial scale production of sablefish
Uploaded File: WA_SG_Progress_Report_final.docx

Partners This Period

Jamestown Point Whitney Venture, LLC
Types: Industry/Business
Scale: LOCAL
Notes:

NOAA Manchester
Types: Government
Scale: FEDERAL or NATIONAL
Notes:

NOAA Newport Research Station
Types: Government
Scale: FEDERAL or NATIONAL
Notes:

Jamestown S'Klallam Tribe
Types: Government
Scale: Tribal

Notes:

AquaTechnics, Inc.
Types: Industry/Business
Scale: FEDERAL or NATIONAL
Notes:

STANDARD QUESTIONS

Impacts and Accomplishments

(1)

Type	accomplishment
Title	Washington Sea Grant researchers investigate ways to achieve cost-effective, commercial-scale production of highly prized sablefish
Relevance	Sablefish, or black cod, are highly valued by consumers worldwide for their rich and delicate texture. Native to the West Coast, sablefish support a lucrative fishery in the Pacific Northwest. Culturing sablefish would provide economic benefits, but disease, poor-quality eggs and larvae and costly production processes have stymied efforts to produce sablefish at commercial scale.
Response	Washington Sea Grant researchers investigated potential solutions to the obstacles that prevent sablefish from becoming commercially viable. They developed and tested new protocols for producing better eggs and increasing larval production. In an effort to speed growth rates, they selected only females for rearing, reared the larvae at warmer temperatures, and investigated the use of DMSP, a chemical produced by plankton, the larvae's favorite food. To reduce feeding costs, they substituted clay for expensive plankton. They also developed new technologies for protecting juveniles against disease.
Results	These innovations succeeded in producing sablefish larvae at commercial scale (batches of 10,000), speeding their development, reducing larval mortality by 97 percent and lowering feeding costs. Hormone injections raised fertilization rates and lowered spawning time. Introducing various levels of DMSP speeded larval growth by up to 100 percent. Researchers successfully used a vaccine to protect sablefish against Aeromonas salmonicida, a common sablefish disease, and determined that clay could replace costly algae as feed.
Recap	Washington Sea Grant researchers investigated ways to improve productivity and reduce the cost of growing sablefish, which could yield a commercially profitable product for industry.

Comments	
Primary Focus Area	Sustainable Fisheries and Aquaculture
Secondary Focus Areas	
Goals	
Partners	AquaTechnics, Inc. Jamestown Point Whitney Venture, LLC Jamestown S'Klallam Tribe Northwest Fisheries Science Center, Manchester Research Station (DOC, NOAA, NMFS) Northwest Fisheries Science Center, Newport Research Station (DOC, NOAA, NMFS)
PI Draft	

Tools, Technologies, Information Services / Sea Grant Products

(1)

Description	Commercial-scale production method for black cod (sablefish) incorporating higher temperatures, alternative feeding strategies and all female stocks.
Developed (in the reporting period)?	Yes
Used (in the reporting period)?	Yes
Used for EBM?	No
ELWD product?	No
Number of managers	0
Description/Names of managers	
Reported in previous year?	

(2)

Description	Improved spawning protocols for black cod (sablefish).
Developed (in the reporting period)?	Yes
Used (in the reporting period)?	Yes
Used for EBM?	No
ELWD product?	No
Number of managers	0
Description/Names of managers	
Reported in previous year?	

(3)

Description	A. salmonicida vaccine for black cod (sablefish).
Developed (in the reporting period)?	Yes
Used (in the reporting period)?	Yes
Used for EBM?	No
ELWD product?	No
Number of managers	0
Description/Names of managers	
Reported in previous year?	

Economic Impacts

No **Economic Impacts** information reported

Community Hazard Resilience

No **Community Hazard Resilience** information reported

Meetings, Workshops, Presentations

No **Meetings, Workshops, Presentations** information reported

Leveraged Funds

No **Leveraged Funds** information reported

PI: Graham Young
Title: Development and commercial transfer of technologies to improve the hatching success and production of juvenile black cod (sablefish), *Anoplopoma fimbria*

The research objectives of this grant focused generally on two areas: 1) The transfer of existing research results to commercial-scale production of sablefish, and 2) New research on ways to increase larval production and to protect juvenile sablefish against disease.

Objective 1: Transfer of current research results to the commercial-scale production of sablefish fingerlings: To decrease commercial production time from larvae to fingerlings and to shorten the time to harvest we will incorporate techniques to a) rear larvae at higher temperatures; b) omit/contract live feeding phases; and c) produce all female stocks.

NOAA and University of Washington researchers have been conducting research on sablefish that specifically addresses the length of the larval rearing period through temperature manipulation, decreased dependence on live feeds by early weaning to microparticulate diets, and decreasing the time to market by producing all female stocks. However, the results of those studies need to be transferred to commercial-scale production in order to impact the industry. This technology transfer was major objective of the current NOAA grant. In 2015, we produced >20,000 feed acclimated sablefish larvae in commercial scale tanks (8ft dia.) contributed by our industry collaborators, Jamestown Point Whitney Venture, LLC (previously Troutlodge Marine) (figure 1). These larvae were all females, produced by fertilization of normal XX females with neomale (XX) milt. In addition, we used an elevated rearing temperature of 15^{o}C to increase the rate of development and compress the larval phase. Both of these elements were specific objectives of the technology transfer portion of the NOAA grant. In the current year (2016), we will attempt to further compress the larval period by omitting the *Artemia* feeding phase and acclimating larvae directly from rotifers to artificial feeds. The transfer of these technologies to commercial-scale production will greatly decrease the cost of larval production and will increase the growth of juveniles in growout since females grow faster than males.

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From the 2015 production, we selected 10,000 all female sablefish juveniles that are currently being grown-out to commercial harvest with the help of Jamestown Point Whitney Venture, LLC in Viking net pens (figure 2) at the Manchester Research Station. We anticipate an additional 10,000 all

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female sablefish juveniles will come from this year's production and will be grown in a second net pen starting in November, 2016. The commercial-scale production from the NOAA National Sea Grant leveraged a Saltonstall Kennedy grant application (*Pilot-scale net pen growout of sablefish ("black cod") by the Jamestown S'Klallam tribe*) that will directly involve the Jamestown S'Klallam tribe taking over the growout portion of the sablefish in the netpens. Proceeds from the sale of these fish will be reinvested to fund the purchase of more fingerlings by Puget Sound tribes to establish independent netpen growout of sablefish.

Objective 2: Conduct new research to: a) develop methods to increase fertilization success and to increase the production of viable embryos and larvae; and b) develop and test immersion vaccination protocols to shorten the juvenile to grow-out phase.

Table 1: Effects of a preinjection of GnRH at 5 ug/kg on sablefish spawning induced by a 50 ug/kg implant

	implant-only	pre-injected
total egg volume (in pulse)	1703.5	2190.0
total egg & fluid volume (in pulse)	1836.0	2383.2
egg volume (per spawn)	389.4	382.4
egg & fluid volume (per spawn)	419.7	416.1
fert % (weighted by volume of eggs)	57.9	74.5
symmetry (weighted by volume of eggs)	63.8	65.0
fert % (un-weighted)	61.3	73.4
symmetry (un-weighted)	62.6	66.0
Days until first spawn	20.5	18.3
number of fish in treatment	8.0	11.0
# of spawns	4.4	5.7

While sablefish are highly fecund, a limiting factor in producing larvae is still egg quality. Experiments were conducted this past year to optimize the hormone treatments used to initiate spawning in female sablefish. This treatment can have a significant effect on the viability of the eggs and thus fertilization and subsequent larval production. Normally females are implanted with a slow release pellet of gonadotropin releasing hormone (GnRH). We found that a primer injection of GnRH at a 10 fold lower concentration increased the fertilization success and decreased the time to spawning compared with the implant alone (Table 1). We also found that an implant dose of 25 ug/kg was better than the traditional 50 ug/kg dose. Experiments are being conducted this year to further refine the hormonal treatment to increase egg quality parameters including fertilization rate and egg cell symmetry.

A problem with sablefish culture is the loss of fish during grow-out due to furunculosis, caused by *Aeromonas salmonicida*. The most common clinical sign associated with furunculosis include raised circular boil-like lesions filled with pus on the skin. In other cases, the disease will go unnoticed, with no outward clinical signs. Internally, however, the fish will have hemorrhage of the viscera and disruption of osmoregulatory processes. Diseased fish will darken in color and stop feeding shortly before mortality occurs. In most cases, the occurrence of clinical disease will follow a seasonal pattern, with the most severe symptoms presenting in mid-late summer, at water temperatures ranging from 14 – 20 °C. Since grow-out of sablefish in the Pacific Northwest occurs in net pens in the presence of *A. salmonicida*, rising environmental water temperatures due to ocean coastal dynamics and global climate change can be expected to increase the incidence of disease in net pen operations. The *A. salmonicida* infecting sablefish is "atypical" and, therefore, different from the "typical" strains infecting salmonids. Thus, vaccines for salmonids are not effective in protecting sablefish.

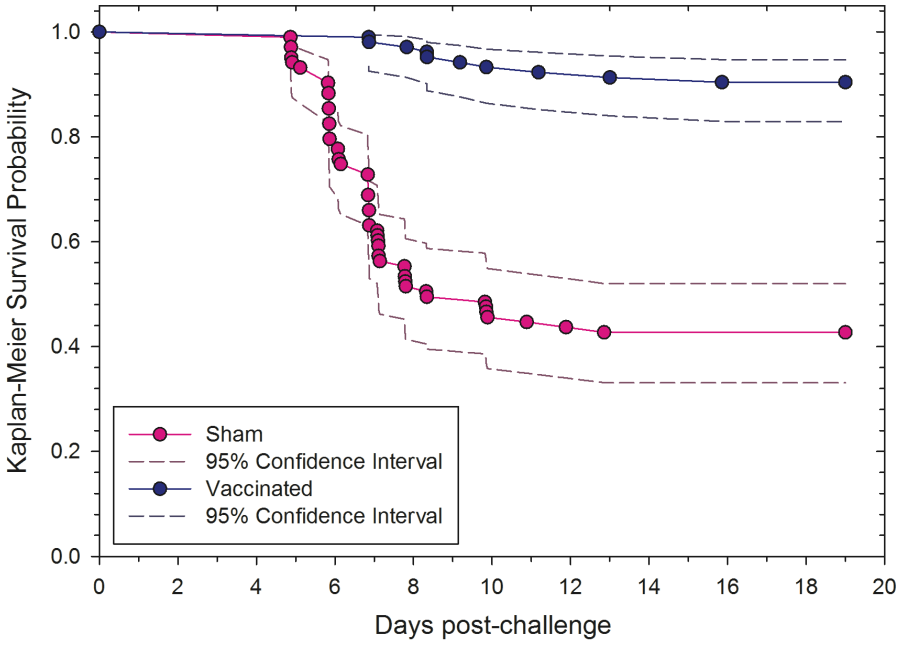

Figure 3. Survival of vaccine-injected and sham-injected juvenile sablefish exposed to atypical *Aeromonas salmonicida* at 8.4*105 cfu/ml. Survival curves are significantly different at p<0.0001 with the vaccinated cohort having a relative percent survival of 83%.

In the current grant we investigated the use of a vaccine directed specifically against strains of *A. salmonicida* that we found infecting sablefish in our net pens. We did this using injection and immersion treatment routes. Immersion vaccination is preferred for sablefish since it can be used on smaller fish and, thus, does not impede the movement of juveniles to growout net pens. Injections require large fish that must be retained for a longer period of time on land before moving to netpens increasing costs.

Our research, performed at NOAA's Newport Research Station (Newport, OR), determined that an oil emulsion vaccine containing formalin-killed whole bacteria induced a protective state when injected in 20-50g juvenile sablefish. The vaccinated sablefish had 90% survival when challenged with an atypical *A. salmonicida* concentration that resulted in 57% mortality in the sham (unvaccinated) controls (Figure 1). The atypical *A. salmonicida* bacteria used in the vaccine and the disease challenge had been isolated from clinically diseased sablefish at NOAA's Manchester Research Station. By contrast, formalin-killed whole bacteria used in an immersion vaccine was not protective for sablefish when it was administered when they were either 1-2g or 5-10g. Further research must be conducted to try and enhance the movement of *A. salmonicida* antigens into the fish in order to develop a successful immersion vaccine protocol.