NOAA FISHERIES

Southwest Fisheries Science Center

Status of *Seriola* Aquaculture in the United States of America

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翻訳・解説　荒井　大介
尾崎　照遵

Introduction

- Will present information about *Seriola* aquaculture in the U.S.
  - Information gained through:

    - Work on various *Seriola*-related projects at NOAA Fisheries, Southwest Fisheries Science Center

    - Seriola Workshop: 2016, 2018, 2020

Consumption of Seriola in the United States

Sushi/sashimi/nigiri

- *Seriola* (Hamachi) is served in most, if not all, sushi restaurants.
    - Some sushi restaurants will also serve Hamachi collars.

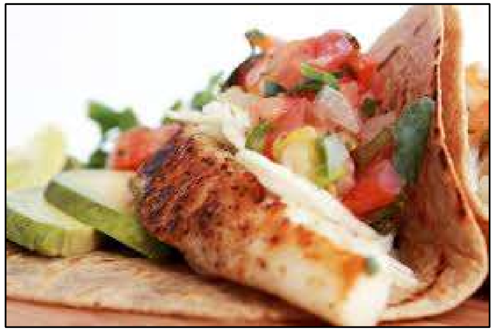
- Thousands of sushi restaurants in U.S.A. (almost 300 in Los Angeles alone); market size of $20 billion USD in 2020.
- In all 50 states, but unequally distributed (most along western and eastern coasts).

Consumption of Seriola in the United States

Ceviche
(Southwest and Southeast US)

Poke
(Hawaii, West and East Coast, gaining in popularity across U.S.)

Tacos
(Southwest and Southeast US)



Grilled/seared fillets
(In some seafood restaurants)

Appeal of Seriola aquaculture in U.S.

- Higher-end product for domestic markets
- Fast-growing species with proven success in culture methods
- Three native species throughout the southern coastal U.S.

  Seriola dorsalis (California);
  Seriola rivoliana (Hawaii, Gulf of Mexico, Atlantic Coast);
  Seriola dumerili (Gulf of Mexico, Atlantic Coast).


Photo from Blue Ocean Mariculture


Photo from Blue Ocean Mariculture

Commercial, pilot, and potential Seriola Operations in U.S.

Ocean-based Seriola aquaculture in U.S.A.

Photo from Blue Ocean Mariculture

Blue Ocean Mariculture (Kona, Hawaii): *Seriola rivoliana*

- Only company commercially producing *Seriola* in U.S.
- Producing 'Hawaiian kanpachi'
- Scaling up from ~800 metric tons to ~2400 metric tons

Photo from Blue Ocean Mariculture

Photo from Blue Ocean Mariculture

Photo from Blue Ocean Mariculture

Ocean-based Seriola aquaculture in U.S.A.

Pacific Ocean Aquafarms (Southern California): *S. dorsalis*

- In process of obtaining permits
- Aiming to scale up from 1,000 mt to 5,000 mt (may include other finfish).
- Collaboration between Hubbs-SeaWorld Research Institute and Pacific6 (investment company).

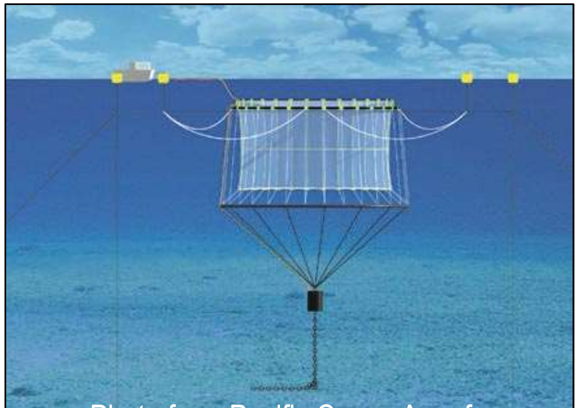


Photo from Pacific Ocean Aquafarms

Photo from HSWRI

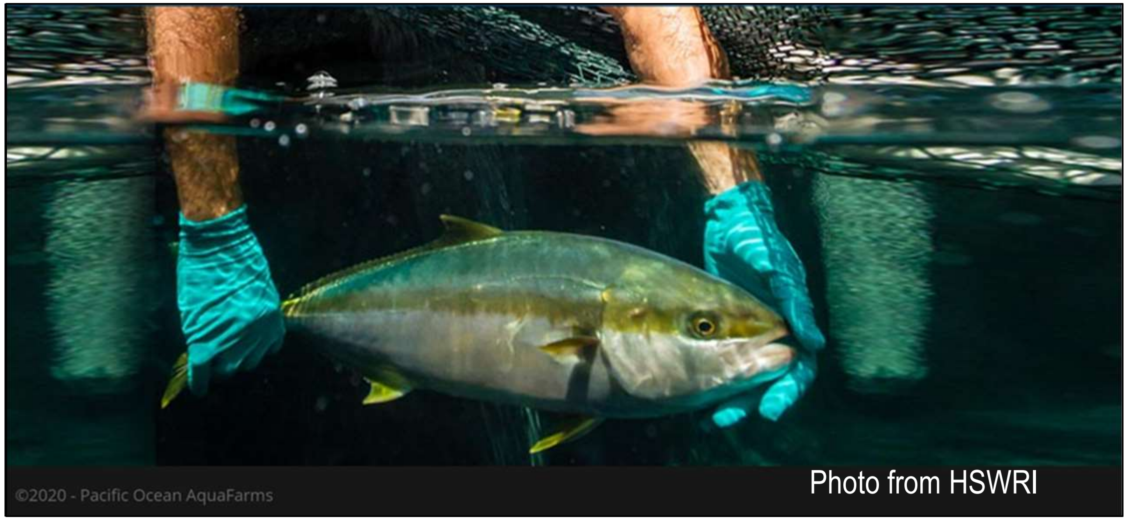


Photo from HSWRI

Ocean-based Seriola aquaculture in U.S.A.

Manna Fish Farms (Gulf of Mexico - Florida): *S. rivoliana*

- In process of obtaining permits
- May initially focus on other species, but *S. rivoliana* expected to be included on permit.
- 120 acre site, scaling up from 2 to 18 submersible cages.

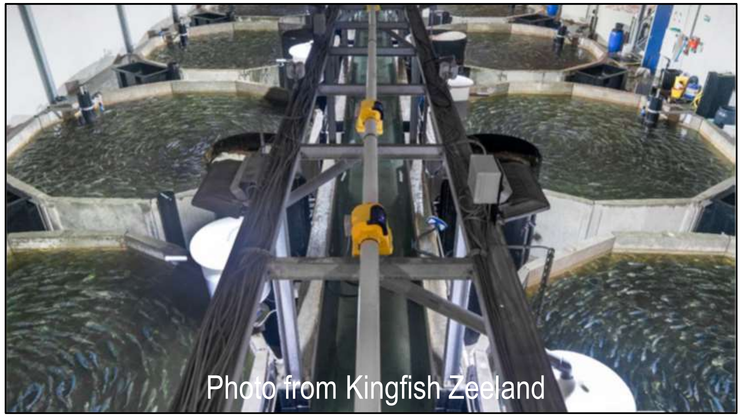
Ocean Era (Gulf of Mexico - Florida): *S. rivoliana*

- Experimental Velella projects
- Unclear as to how these projects will progress.


Photo from Ocean Era


Photo from Ocean Era

RAS-based Seriola aquaculture in U.S.A.



King Fish Maine (Maine): *S. lalandi*

- In process of obtaining permits; permitting close to allowing construction of RAS site.
- It is believed that they will use Kingfish Zeeland *S. lalandi* broodstock for this production facility.
- Gradually scaling up to 6,000-8,000 mt of production.

Nordic Aquafarms (Maine & Northern California): *Seriola(?)*

- Two large RAS sites in the process of permitting.
- Although *Seriola* was considered, they are currently only working to obtain permits for salmonid species.

Challenges to Seriola aquaculture in U.S.A.

Primary challenges for U.S. producers

- Production issues and costs
- Consumer market
- Permitting and site selection


Photo from Blue Ocean Mariculture


Photo from Ocean Era


Photo from Blue Ocean Mariculture


Photo from HSWRI

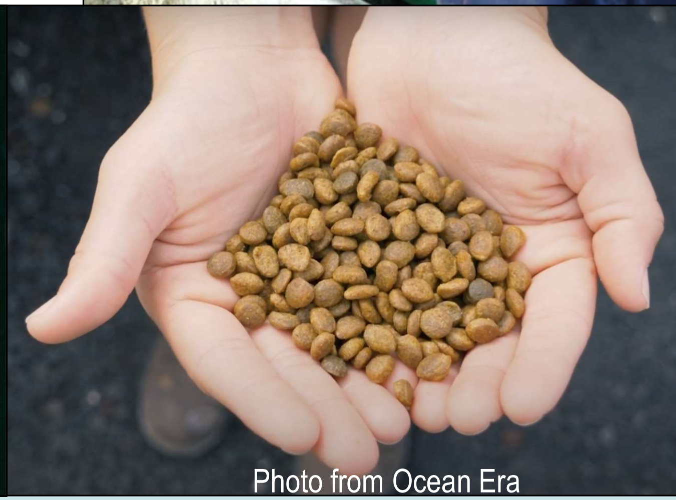


Photo from Ocean Era

Challenges of Seriola aquaculture in U.S.A.

Production issues and costs:

- Disease management – skin fluke (*Neobenedenia girellae*), Cryptocaryon, Epithellocystis
- Improved/faster growth, particularly under less ideal water temperatures in ocean pens.
- Feed cost reduction (e.g., improved FCR, or alternative feeds that are less expensive and more sustainable).
- Technology associated issues (e.g., accommodating oxygen demands, feeding and grading system improvements).

Photo from Blue Ocean Mariculture

Photo from Blue Ocean Mariculture

Challenges of Seriola aquaculture in U.S.A.

Production issues and costs:

- Interest in using **selective breeding** (improve disease resistance, growth, 'soy tolerance', etc.)

Photo from Ocean Era, LLC. - Soy diet feed results: larger kampachi (right) on a soy based diet, the smaller kampachi (left) on a commercial control diet.

Shrimp – average genetic gain of 8.7% per generation

(Gjedrem & Rye 2016)

Atlantic Salmon – 113% increased growth rate over wild population (5 generations; 20 years)

(Gjedrem 2016)

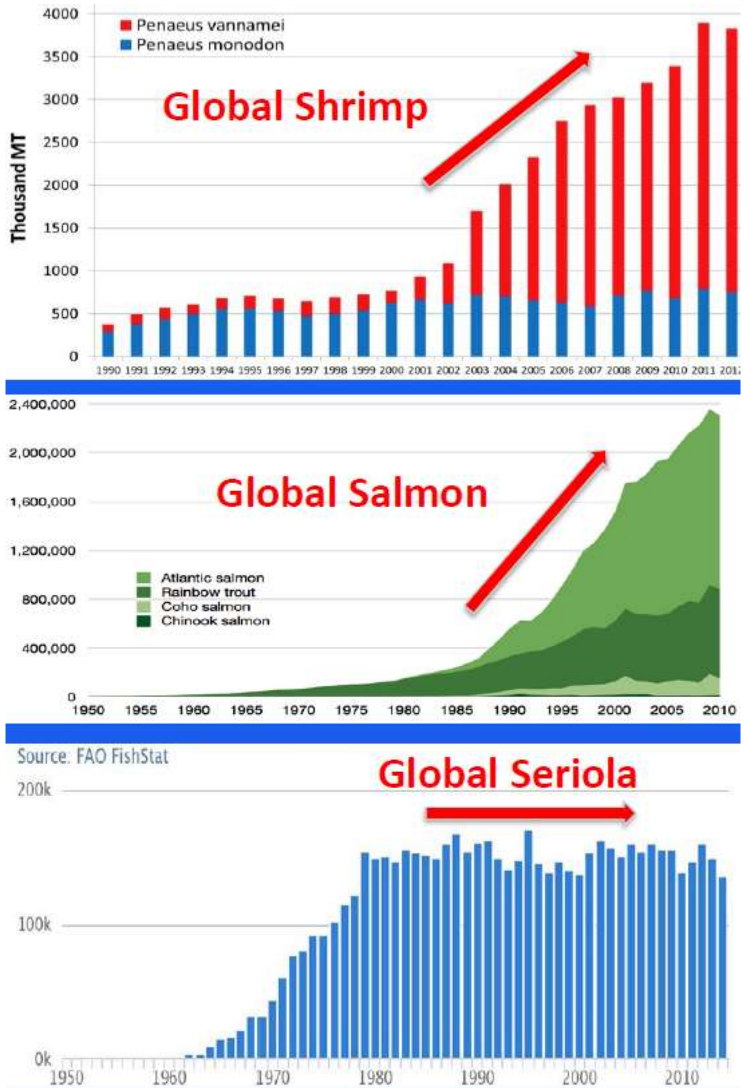


Figure from Neil Sims' 2020 Seriola Workshop Presentation

Challenges of Seriola aquaculture in U.S.A.

Consumer market:

- Most *Seriola* products end up in higher-end seafood or sushi restaurants -> Targets a relatively small number of consumers.
- To support increasing *Seriola* culture, market (consumer) familiarity needs to improve (in terms of eating and cooking Seriola).
- There is also limited traction for selling *Seriola* fillets in retail (grocery stores).
  - Partly due to lack of market familiarity
  - Partly due to a need for consistent supply to retail chains; this is a conundrum where retail outlets need a consistent supply to be willing to sell *Seriola,* but producers need a consistent sale outlet to be willing to produce more.


Photo from Blue Ocean Mariculture


Photo from Ocean Era

Challenges of Seriola aquaculture in U.S.A.

Permitting:

- Has been an ***incredibly*** tedious and complicated process.
- Diagram of who and what is involved in permitting and regulating offshore aquaculture in California.

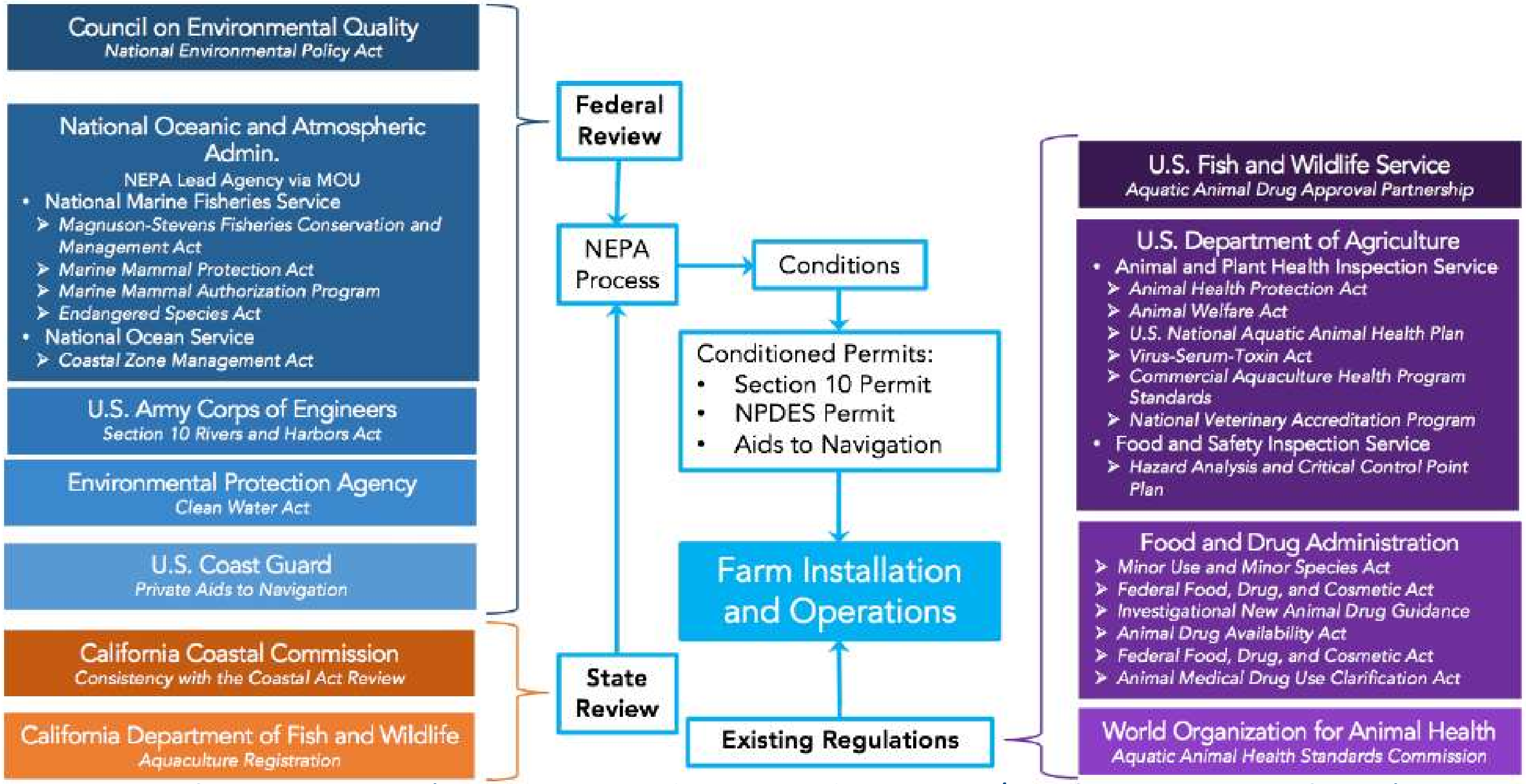


Figure from Don Kent (Hubbs-SeaWorld Research Institute/Pacific Ocean Aquafarms)

Includes federal and state agencies for permitting and regulations.

Challenges of Seriola aquaculture in U.S.A.

- Permitting is most complicated for offshore operations, but still challenging for RAS farms.

salmonbusiness.com/nordic-aquafarms-state-permits-approved/

Erik Heim. PHOTO Stian Olsen

Nordic Aquafarms' state permits approved

News by **editorial staff** - 20 November 2020

But USD 400 million project still needs federal permits and to resolve intertidal dispute.

In a press release, land-based salmon farmer Nordic Aquafarms writes that authorities have unanimously to approve its state permits, a process which has taken 18 months.

18 months to receive state permits, but still need federal permits, and need to resolve legal case against them.

Still need other permits BEFORE they can receive another permit.

Sequential portions of permitting (rather than concurrent); makes process longer.

ellsworthamerican.com/maine-news/waterfront/kingfish-maines-first-permit-application-accepted/

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Kingfish Maine wants to build a $110 million recirculating aquaculture facility on this site on Chandler Bay. KINGFISH CO. PHOTO

Kingfish Maine's first permit application accepted

October 26, 2020 on News, Waterfront

By Stephen Rappaport

JONESPORT — The Dutch company that wants to build a huge land-based aquaculture facility on the shore of Chandler Bay has moved one step closer to achieving its goal.

Submission of the submerged lands lease application is just the first step in a long process the company faces before it can receive the necessary Maine Pollutant Discharge Elimination System (MPDES) permit from the Maine Department of Environmental Protection.

The MPDES permit process reviews the company's plans for eliminating pollutants such as liquid and solid fish waste and unconsumed feed from the water the facility would discharge into Chandler Bay.

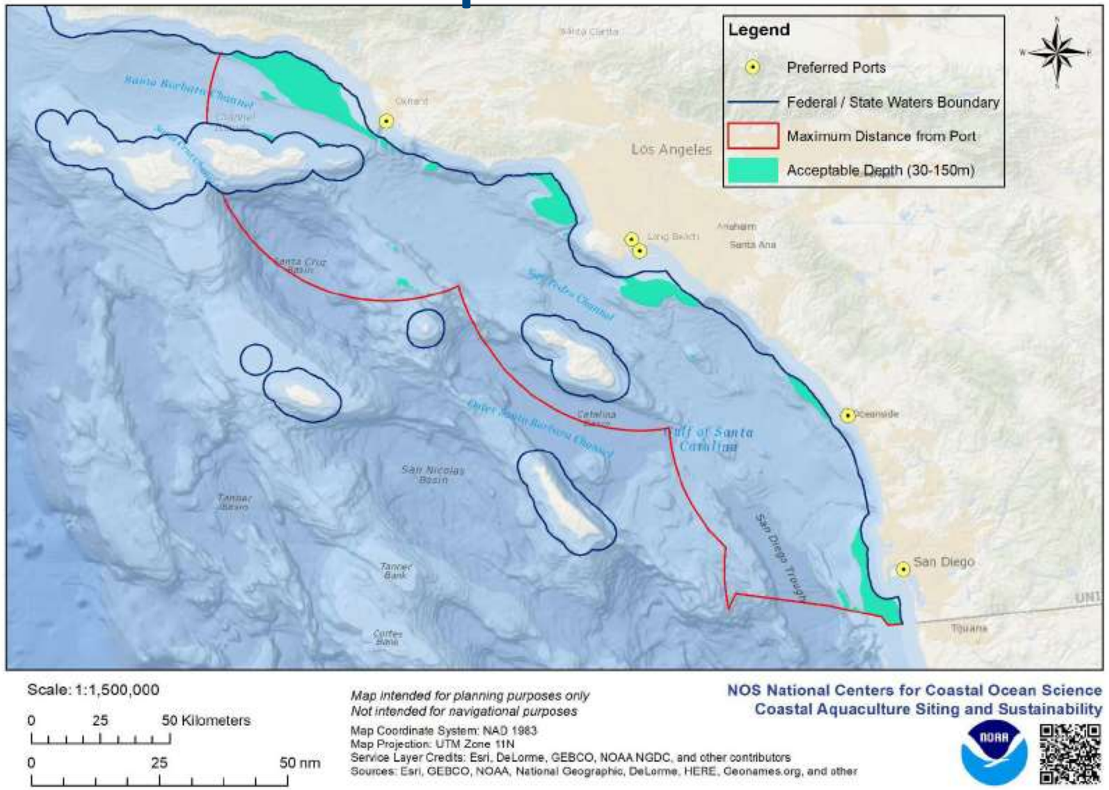
In addition to the submerged lands lease, Kingfish also will need several other permits including a Site Location and Development Act (SLOTA) permit and a Natural Resources Protection Act (NRPA) permit before it can receive the MPDES permit.

Challenges of Seriola aquaculture in U.S.A.

Site selection/spatial planning: this process finds farmable sites, and all permitting is tied to the location.

- Also a complicated process; depends on planned region for the operation.
- As an example – spatial planning process from Don Kent for the Pacific Ocean Aquafarms site in S. California.
- Start with basic farm parameters: preferred ports, max distance from port, physical characteristics (depth, currents, etc.) , and federal/state water boundaries.

Farm parameters



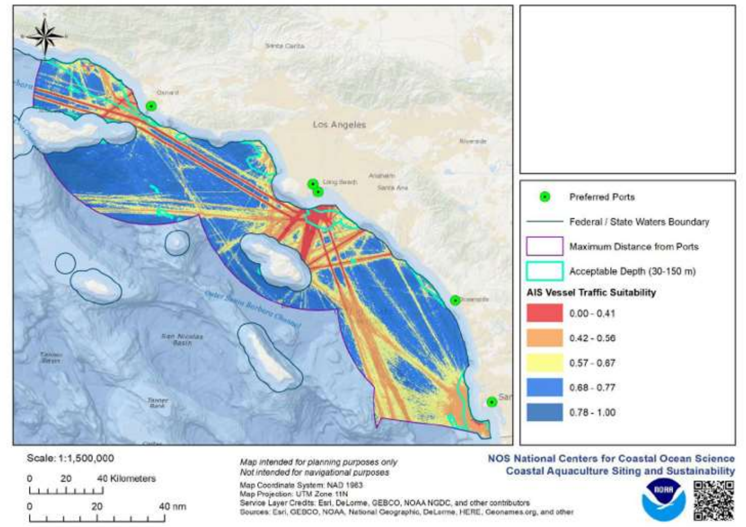
(Figure courtesy of Don Kent, HSWRI/POA)

Challenges of *Seriola* aquaculture in U.S.A.

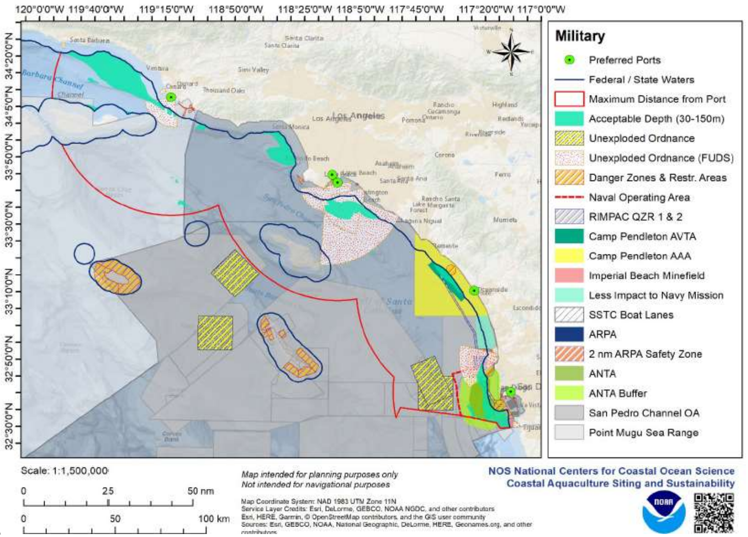
Site selection/spatial planning:

- Then layer on user and natural resource conflicts (e.g., vessel traffic, military, commercial and recreational fishing, protected habitats).

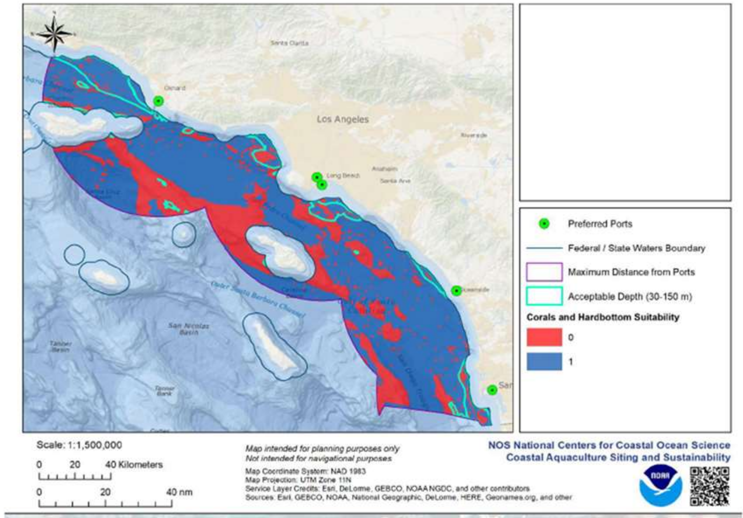
Navigation: AIS Vessel Count



Military



Deep sea corals and hard bottom



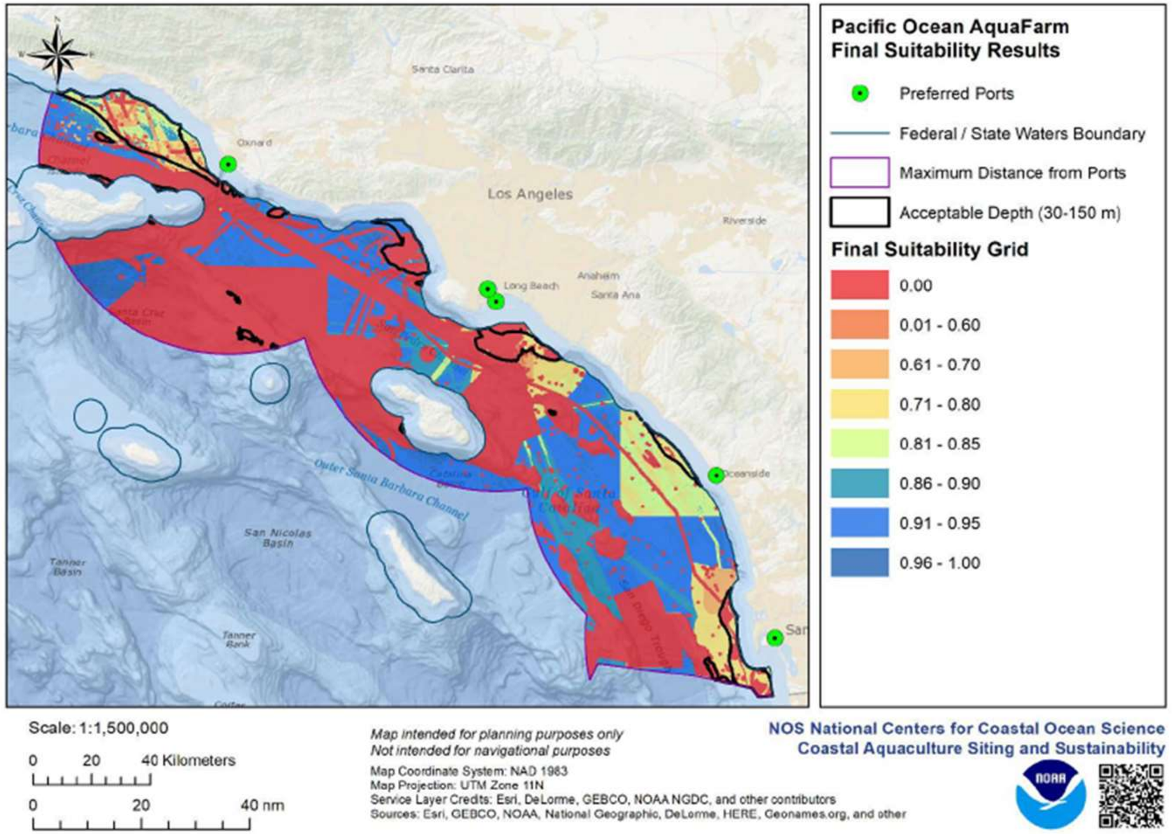
(Figures courtesy of Don Kent, HSWRI/POA)

Challenges of Seriola aquaculture in U.S.A.

Site selection/spatial planning:

- In some circumstances, end up with few options for farm placement.
- Every region will have different considerations, and availability of suitable farm sites will vary accordingly.

Final Suitability Results for Pacific Ocean Aquafarms



(Figure courtesy of Don Kent, HSWRI/POA)

Executive Order on Promoting American Seafood Competitiveness and Economic Growth – May 2020

Executive Order focuses on:

- Regulatory reform to maximize commercial fishing
- Seafood Trade
- The expansion of sustainable U.S. seafood production through more efficient and transparent aquaculture permitting

↓

Primary benefit is the development of Aquaculture Opportunity Areas (AOAs)


Photo from Blue Ocean Mariculture


Photo from Blue Ocean Mariculture

Aquaculture Opportunity Areas (AOAs)

- Uses best available science to find appropriate spaces for offshore aquaculture while minimizing interactions with other users (e.g., shipping, military, fishing).

- Individual farms will still need to acquire all permits to operate.

BUT the background siting and environmental analysis will already be done within the aquaculture opportunity areas.

↓

Helps to expedite the permitting process to some extent.

Aquaculture Opportunity Areas (AOAs)

- A total of 10 AOAs will be identified (I.D.) over 5 years (2 per year)

- Will have an additional 2 years to complete the 'Programmatic Environmental Impact Statements' (PEIS) for each set of AOAs

- **Southern California** and **Gulf of Mexico** have been selected as the first AOAs.

Year 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7
I.D. 2 AOAs*	Complete PEIS* for each AOA					
	I.D. 2 AOAs	Complete PEIS for each AOA				
		I.D. 2 AOAs	Complete PEIS for each AOA			
			I.D. 2 AOAs	Complete PEIS for each AOA		
				I.D. 2 AOAs	Complete PEIS for each AOA	

*AOAs = Aquaculture Opportunity Areas
PEIS = Programmatic Environmental Impact Statements

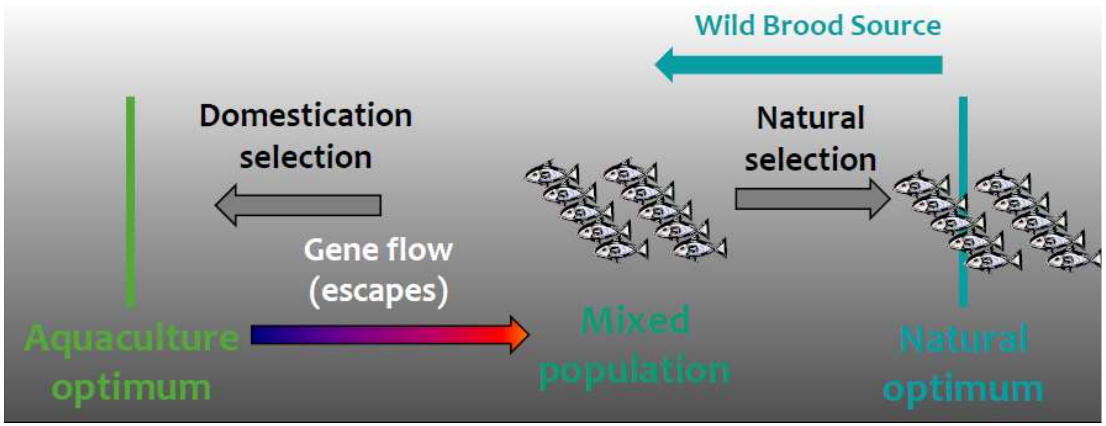
U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

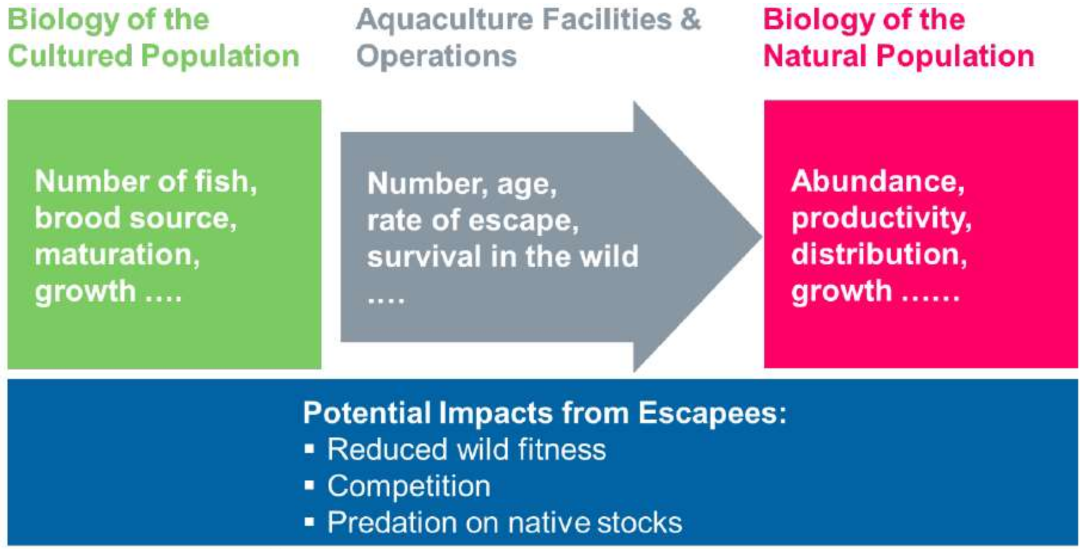
    - Based on already available spatial analysis data and current industry interest.

Efforts at the NOAA Fisheries, Southwest Fisheries Science Center (SWFSC; La Jolla, CA) to advance Seriola aquaculture

Modeling the fitness impact of escapes from aquaculture:

- ***Offshore Mariculture Escapes Genetics Assessment (OMEGA) Model*** – Excel-based program to simulate the fitness impact of escapes from marine aquaculture programs
- NOAA Fisheries is exploring using this tool in the offshore aquaculture permitting and regulation processes



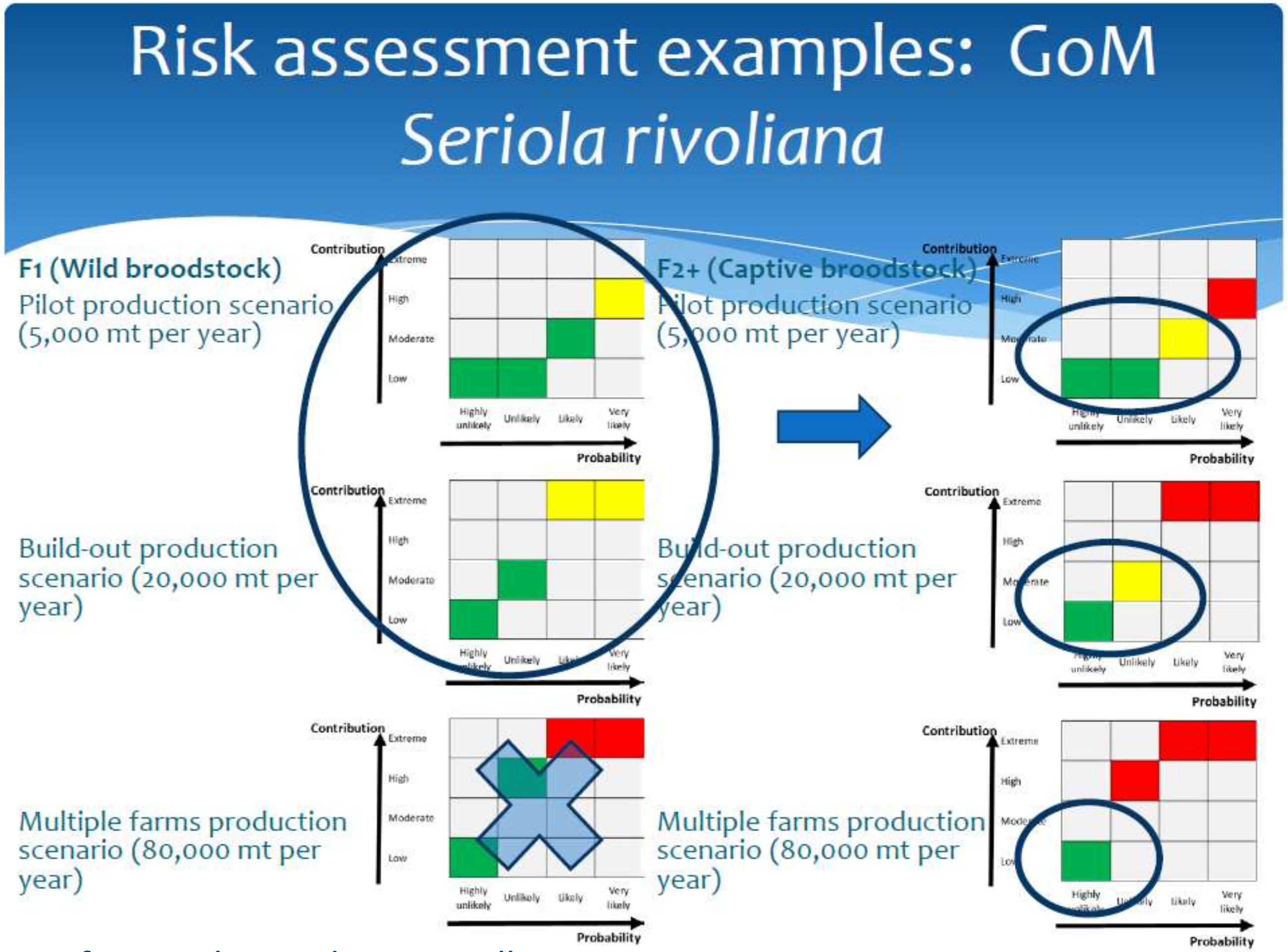


Figures courtesy of Greg Blair and Jason Volk, ICF

Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

Modeling the fitness impact of escapes from aquaculture:

- Use OMEGA to conduct risk assessment modeling specific to a farm operation and for a particular species.
- E.g., a risk assessment conducted on *S. rivoliana* in the Gulf of Mexico for a possible farm site.



Key to Impact Conclusions

(red)	Severe, relative fitness < 0.80
(yellow)	Moderate, relative fitness >0.80 & < 0.98
(green)	No impact or minor, relative fitness >0.98
(grey)	Not modeled

Figures courtesy of Greg Blair and Jason Volk, ICF

Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

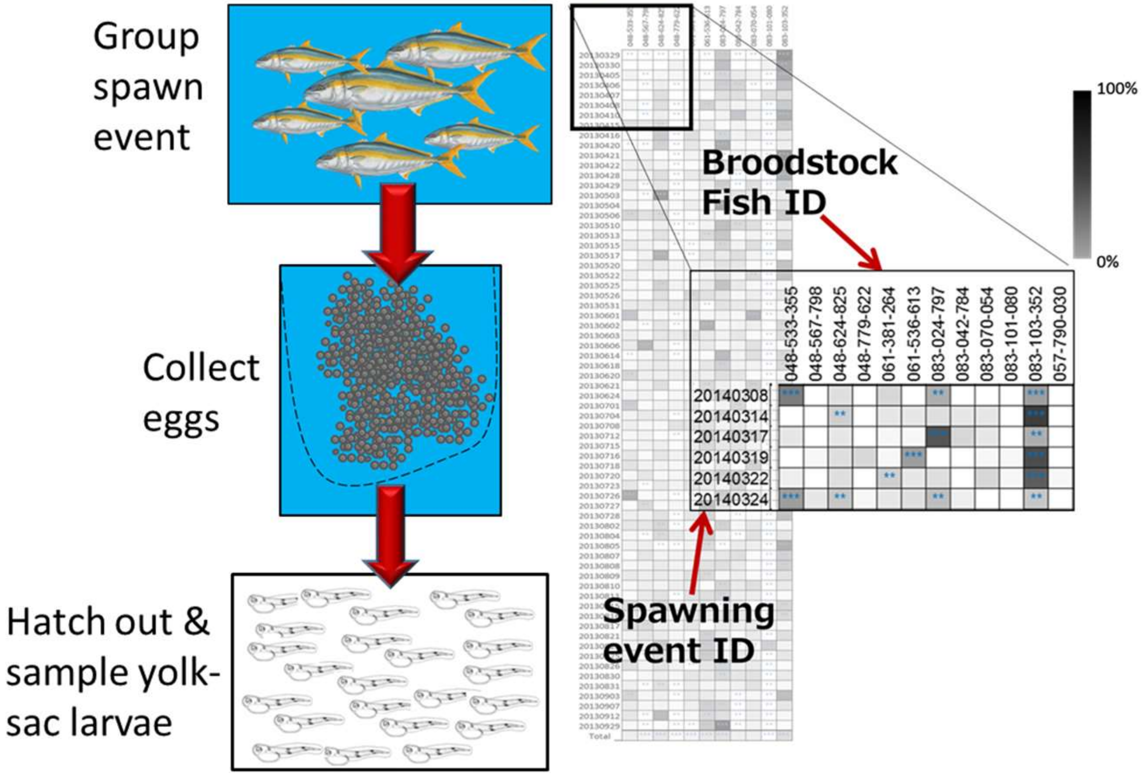
Genetic/genomic resource development:

- Critical to breeding/culture improvements.

Technologically difficult and expensive to develop.

NOAA Fisheries/Office of Aquaculture investment helps the developing industry get over that hurdle

Genetic parentage analyses to investigate spawning dynamics



Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

Building genomic resources:

S. dorsalis genome assembly

- 180x coverage of 685 Mb genome
- ~93% of genome covered


Photo: Hubbs-SeaWorld Research Institute

Species	Common Name	Genome size	Number of scaffolds	N50 scaffold length	Longest scaffold	Percent BUSCO groups captured
S. dorsalis	California Yellowtail	685 Mb	**4,439**	**1,492,000**	8,096,577	94%
S. rivoliana	Almaco Jack	620 Mb	**1,485**	**9,509,606**	25,273,714	96%

S. rivoliana genome assembly

- 296x coverage of 620 Mb genome
- ~96.5% of genome covered

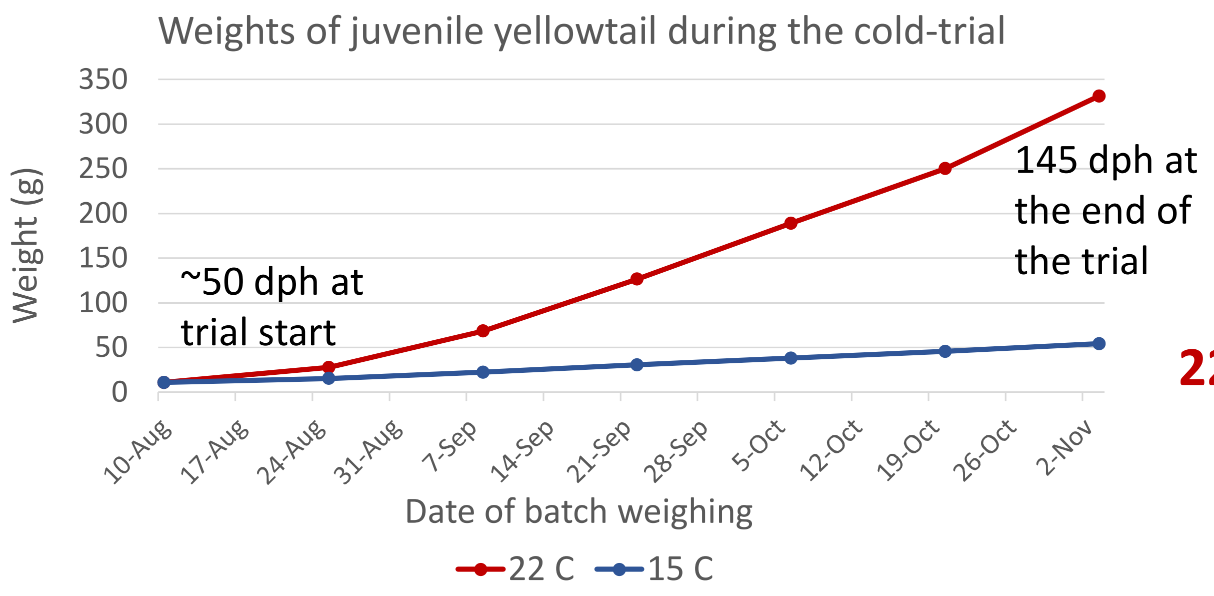
Photo: Blue Ocean Mariculture

Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

Identify trait-associated markers:

ID genomic regions associated with better growth in cold water temperatures:

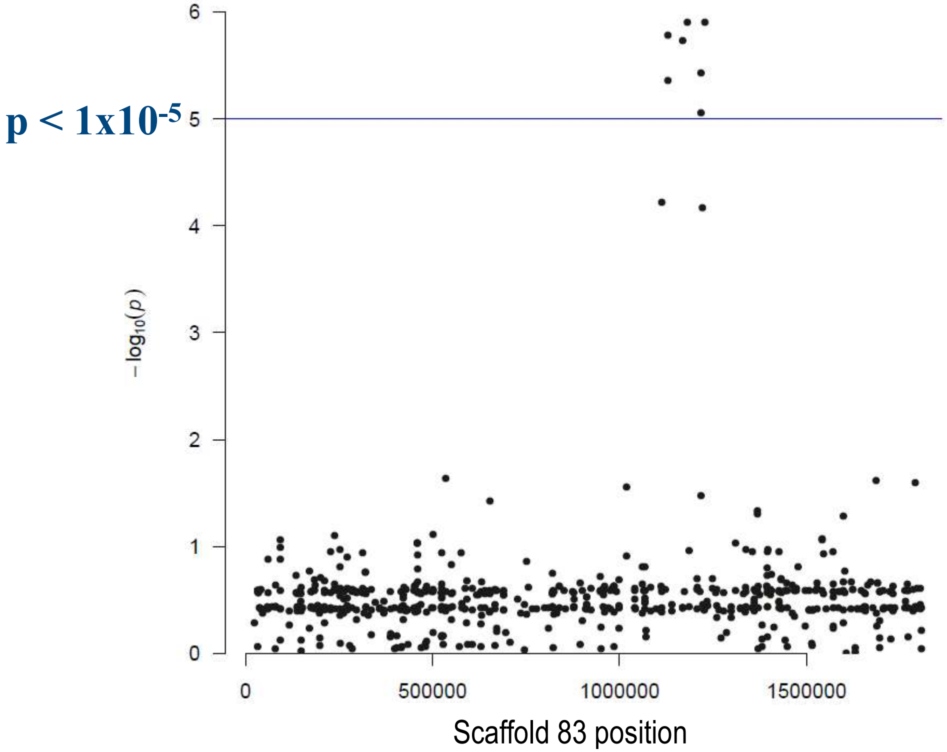
- In collaboration with: HSWRI and ISU



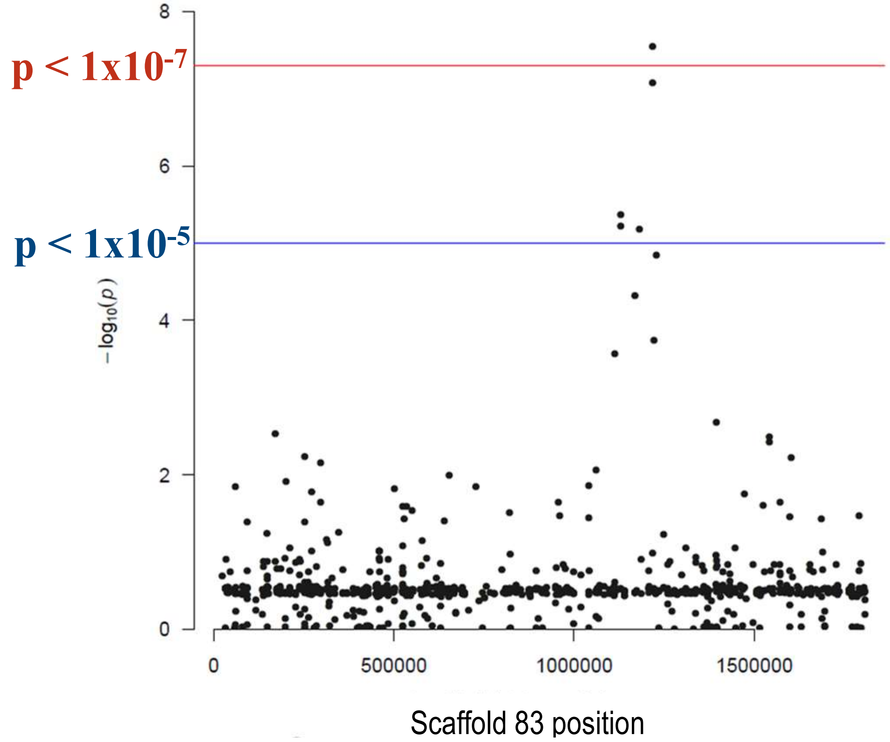
Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

Identify trait-associated markers:

- GWAS analyses identified regions significantly associated with growth:



Fish from 15 °C trial



Fish from both temperatures

Efforts at the NOAA Fisheries, SWFSC to advance Seriola aquaculture

Use physiological tools to assess and optimize *S. dorsalis* aquaculture:

1. Fitness comparison between aquaculture-reared and wild-caught yellowtail

2. Using fitness metrics to examine aquaculture-reared yellowtail lacking a properly developed gas bladder (a common hatchery abnormality)

Endurance testing using a treadmill

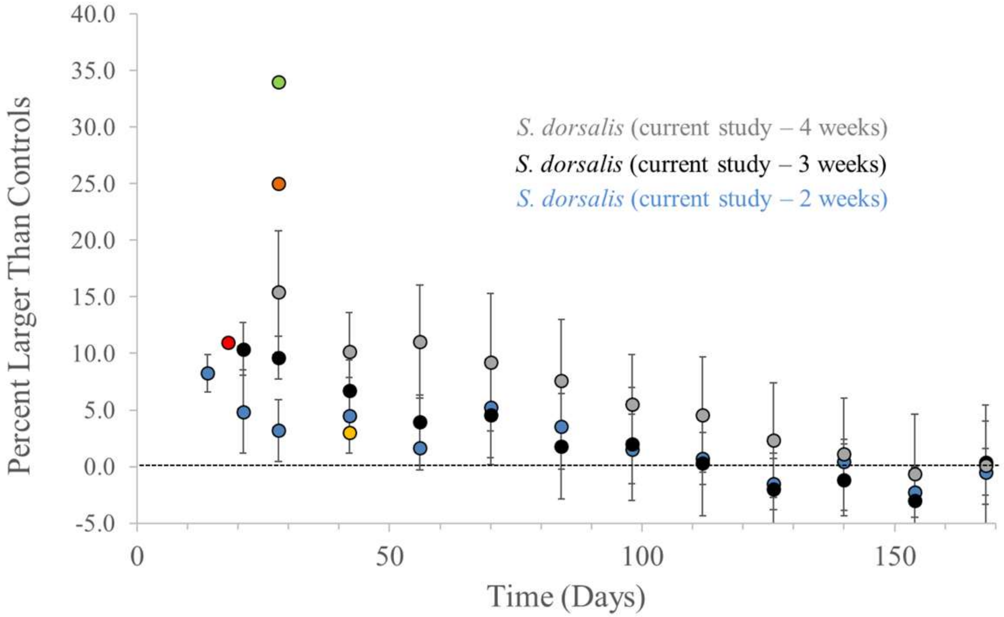
Used to determine fitness metrics

- Critical swimming speeds
- Metabolic rate

Figures and photos courtesy of Nick Wegner, NOAA

Use physiological tools to assess and optimize *S. dorsalis* aquaculture:

3. Enhancing fish fitness and growth through exercise



Figures and photos courtesy of Nick Wegner, NOAA

Acknowledgements

- Todd Madsen (Blue Ocean Mariculture), Neil Sims (Ocean Era, LLC), Don Kent (POA/HSWRI), Diane Windham (NOAA; AOAs), Greg Blair and Jason Volk (ICF; OMEGA), Andrew Severin (ISU; genomics), Nick Wegner (NOAA; exercise physiology) – for figures, photos, and information for this presentation.


Thank You!