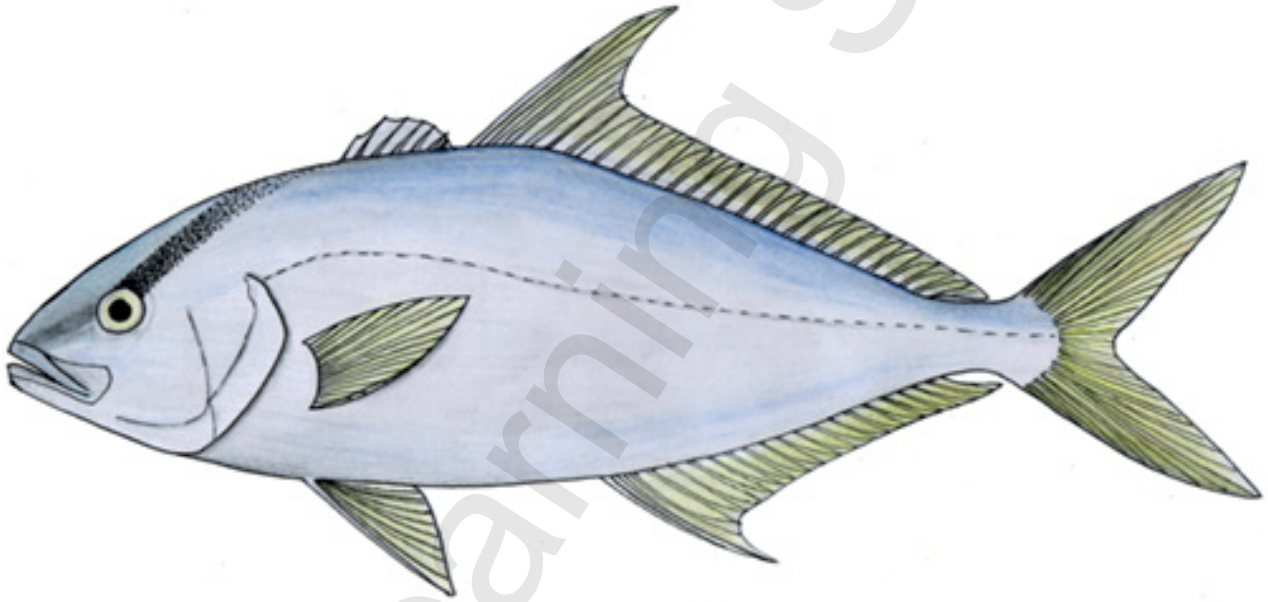
TEACHER RESOURCE

Mariculture and Fish Harvesting at
Natural Energy Laboratory of Hawaii Authority

Kona, Hawaii



Community Industry: **Kona Kampachi Mariculture**

Performance Learning Task Grades 11-12

PURPOSE OF PERFORMANCE LEARNING TASK (PLT)

Please read through the entire resource document before administering the PLT. There are links to videos throughout the PLT – for a seamless administration, ensure that videos are loaded before beginning PLT.

This PLT is a multi-step project. Its goal is to promote STEM learning and develop research-, argument-, and solution-design skills that are relevant to developing a deeper understanding of the mariculture industry in Kona, in order to foster community partnership and develop career-readiness skills.

The PLT begins by introducing students to the problem of overfishing and sustainable seafood. It then presents one potential solution to this problem, in the form of mariculture, which is the practice of farming fish, crustaceans, aquatic plants, algae, and other sea life in nets in the open ocean. The PLT then introduces students to the practices and products of the kampachi mariculture industry, located in Kona, in the NELHA science camp. The industry is a new and innovative one that needs help with its education and outreach to the general public. The performance task modules ask students to research and develop an educational outreach program for Kona's Kampachi industry, which they will present at the end of the project.

The accompanying ubrics have been developed to help you assess your students as they move through the stages of the PLT. Due to the nature of the PLT, students will be assessed using two sets of standards: The Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS).

Print or share an electronic copy of the Student Log with each student.

PERFORMANCE LEARNING TASK - ASSESSMENT MAP

Scaffolding Modules Formative Instruction and Learning Standards		Performance Task Modules Assessment Modules and Learning Standards	
Scaffolding Module I – Intro to Mariculture ▪ Students learn about the problem of overfishing and the massive loss of marine life through two videos and engage in a classroom discussion. ▪ Students learn about the practice of farming fish to combat loss of marine life, including the benefits and the pitfalls of the practice. ▪ Students analyze data and answer questions.	**Scaffolding Module I** **Engage in collaborative discussion** ▪ SL11-12.1 (CCSS) SL11-12.2 (CCSS) **Learn about overfishing and sustainable fishing options** ▪ HS-ETS1-1 (NGSS) ▪ HS-ETS1-3 (NGSS) **Analyze data and answer questions.** ▪ HS-LS2-2 (NGSS) ▪ HS-LS2-6 (NGSS) ▪ RST11-12.1 (CCSS) ▪ RST11-12.7 (CCSS)	**PT Module I – Research** ▪ Students conduct independent research on mariculture, sustainable seafood, and the processes at Kona Kampachi Mariculture	**Module I** **Conduct research** ▪ RST11-12.2 (CCSS) ▪ RST11-12.6 (CCSS) ▪ HS-ETS1-1 (NGSS)
		PT Module II – Argument ▪ Students formulate an argumentative position supporting Kona Kampachi and conduct further research on that topic.	**Module II** **Formulate an argument** ▪ WHST11-12.7 (CCSS) ▪ WHST11-12.1 (CCSS) ▪ HS-ETS1-3 (NGSS)
Scaffolding Module II - Intro to Kona Kampachi ▪ Students are introduced to Kona Kampachi Mariculture and engage in a classroom discussion. ▪ Students review Kona Kampachi packet and answer questions, including filling in the definitions of relevant science vocabulary words.	**Scaffolding II** **Engage in collaborative discussion** ▪ SL11-12.1 (CCSS) ▪ SL11-12.2 (CCSS) **Review packet and answer questions** ▪ HS-LS2-6 (NGSS) ▪ HS-LS2-7 (NGSS) ▪ HS-ETS1-3 (NGSS) ▪ HS-ETS1-2 (NGSS) ▪ RST11-12.1 (CCSS) ▪ RST11-12.9 (CCSS)	**PT Module III – Development** ▪ Students design and develop content for an educational outreach program about Kona Kampachi Mariculture	**Module III** **Designs and develop informational program** ▪ WHST11-12.2 (CCSS) ▪ RST11-12.7 (CCSS) ▪ RST11-12.9 (CCSS)
		PT Module IV - Present ▪ Students present their educational outreach program.	**Module IV** **Present informational program** ▪ SL11-12.4 (CCSS) ▪ SL11-12.5 (CCSS)

Key for Standards

SL: Speaking and Listening

RST: Reading Science and Technology

WHST: Writing for History, Science, and Technology

ETS: Engineering, Technology, and Applied Sciences

LS: Life Science

STANDARDS IN SCAFFOLDING MODULES:

Common Core State Standards (CCSS):

SL11-12.1: Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
SL11-12.2: Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
RST11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
RST11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
RST11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Next Generation Science Standards (NGSS):

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
HS-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
HS-LS2-6: Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
HS-LS2-7: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

PERFORMANCE LEARNING TASK AND FINAL PRODUCT

Scenario

Your students have been hired by Kona county to build an educational outreach program that promotes understanding and support for the Kampachi mariculture industry, located in the Natural Energy Laboratory of Hawaii Authority (NELHA) science camp in Kona, Hawaii. The industry aims to provide consumers with fresh fish that are raised in environmentally sustainable ways. The county wants to spread awareness of this unique Kona product and the associated practices in order to gain support for the industry from the general public. For this performance learning task (PLT), students should highlight the benefits and strengths of the Kampachi industry as well as identify the challenges and critiques directed at the current practices and products. They can then suggest solutions to these issues and/or develop a strategy for responding to critics.

For more information on NELHA, visit their website: http://nelha.hawaii.gov

Definitions

Aquaculture: the cultivation of aquatic animals or plants for food

Mariculture: a form of aquaculture that farms aquatic life in the open ocean, or enclosed parts of the open ocean

Questions/Topics of Focus

- What are the benefits and challenges of mariculture innovations?
- How does this industry benefit Kona? How does Kona contribute to this industry?
- How can I educate the public about Kona-based mariculture?
- What are the most effective ways to help educate a large group of people about an important local issue?

Final Product

Students will prepare a presentation on their findings and proposed solutions to help address the critiques and challenges associated with the mariculture industry in Kona. Their proposal will include a multi-media or social media component designed to help educate others about mariculture.

You may share the rubric with students before they begin the PLT.

SCAFFOLDING MODULE I – INTRODUCTION TO MARICULTURE

Guiding Questions for classroom discussion: *What is sustainable seafood and why do we need to harvest fish sustainably?*

Have a brief classroom discussion to introduce students to the concept of sustainable seafood.

DISCUSSION POINTS FOR INSTRUCTOR:

- Ensure students are familiar with the term sustainability.
- Billions of people all over the world rely on fish for protein.
- In order to meet this demand, fishing practices are causing the worlds oceans, rivers, and seas to be depleted of their wild fish.
- This poses a threat to the ecosystems as well as to the fishing industry and the people who rely on it for sustenance and income.

Show this video excerpt from *Planet Ocean* about the global problem of overfishing to your students: https://www.youtube.com/watch?v=-V4D77N3bZc

Next, introduce some less harmful alternatives.

DISCUSSION POINTS FOR INSTRUCTOR:

- There are sustainable alternatives to these harmful fishing practices.
- Some people are practicing better fishing practices and some people are figuring how to raise fish sustainably in fish farms.
- Fish farming is called aquaculture. Some aquaculture processes are more sustainable than others.
- Aquaculture that takes place in open nets in the ocean is called Mariculture.
- Mariculture is defined as the cultivation of marine organisms in their natural environment.

Show this video from Prevention Magazine about Sustainable Seafood (background 0:00 - 1:52), how to eat sustainably and an introduction to Seafood Watch rating system (1:52 - 2:42)
https://www.youtube.com/watch?v=6ps0truARKs

Have students discuss these questions on page 3 of their Student Logs in pairs or small groups, then discuss with the entire class:

1. What are some of the problems impacting the global wild fish populations?

Possible Responses:

- *New technologies, like the deep sea trawl, probes, and radar*
- *Big factory boats instead of small fishing businesses that use smaller boats*
- *By-catch: Nets and trawls take all kinds of fish and reject the ones they can't sell, wasting fish and other sea life*

2. What are some possible issues created by fish farms?

Possible Responses:

- *Fish farms can pollute the ocean with waste.*
- *Farmed fish are often genetically different from wild fish.*
- *If a farmed fish escapes, it can upset the natural ecosystem by changing the genetics of the system when they mate with wild fish.*

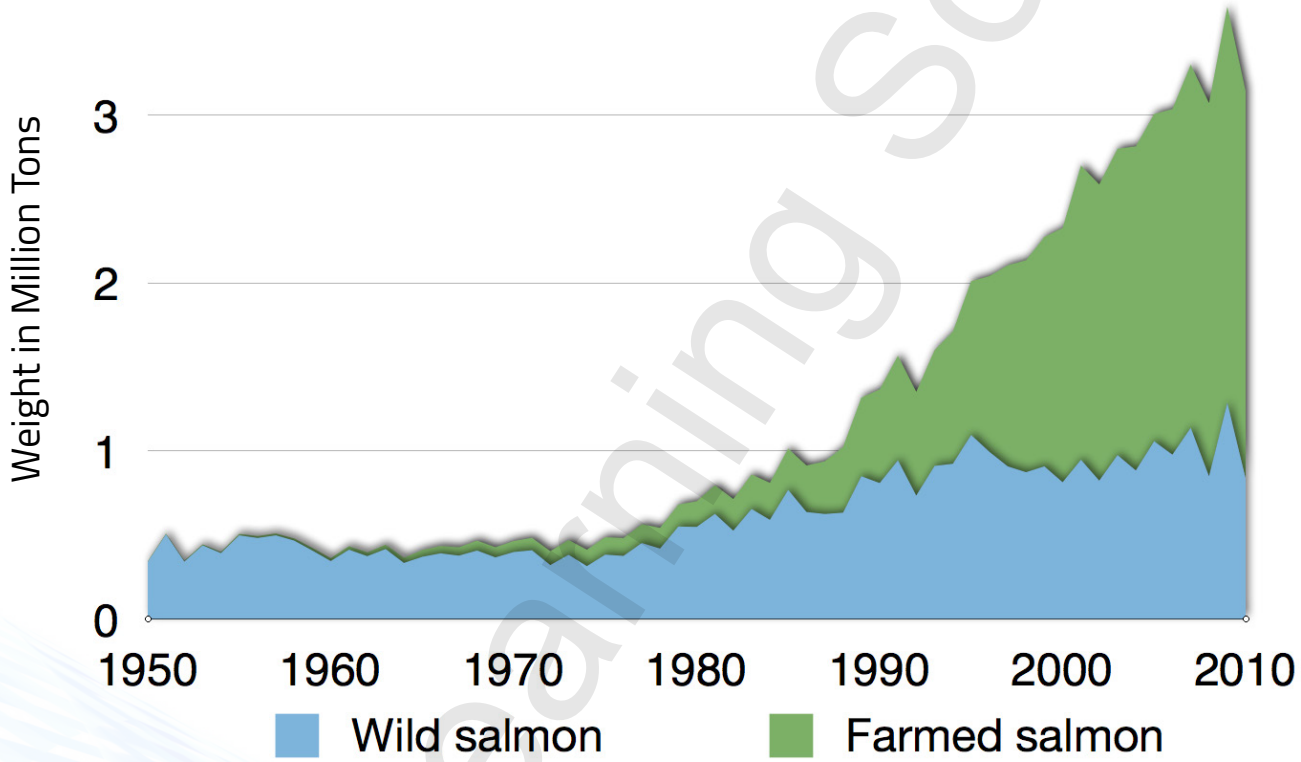
3. What are some solutions to these problems addressed in the videos?

Possible Reponses:

- *More sustainable fishing practices like hook-and-line, harpooning, and some traps minimize by-catch*
- *Sustainable fish farms that effectively keep their populations separate from wild populations and are careful about feed and pollutants.*

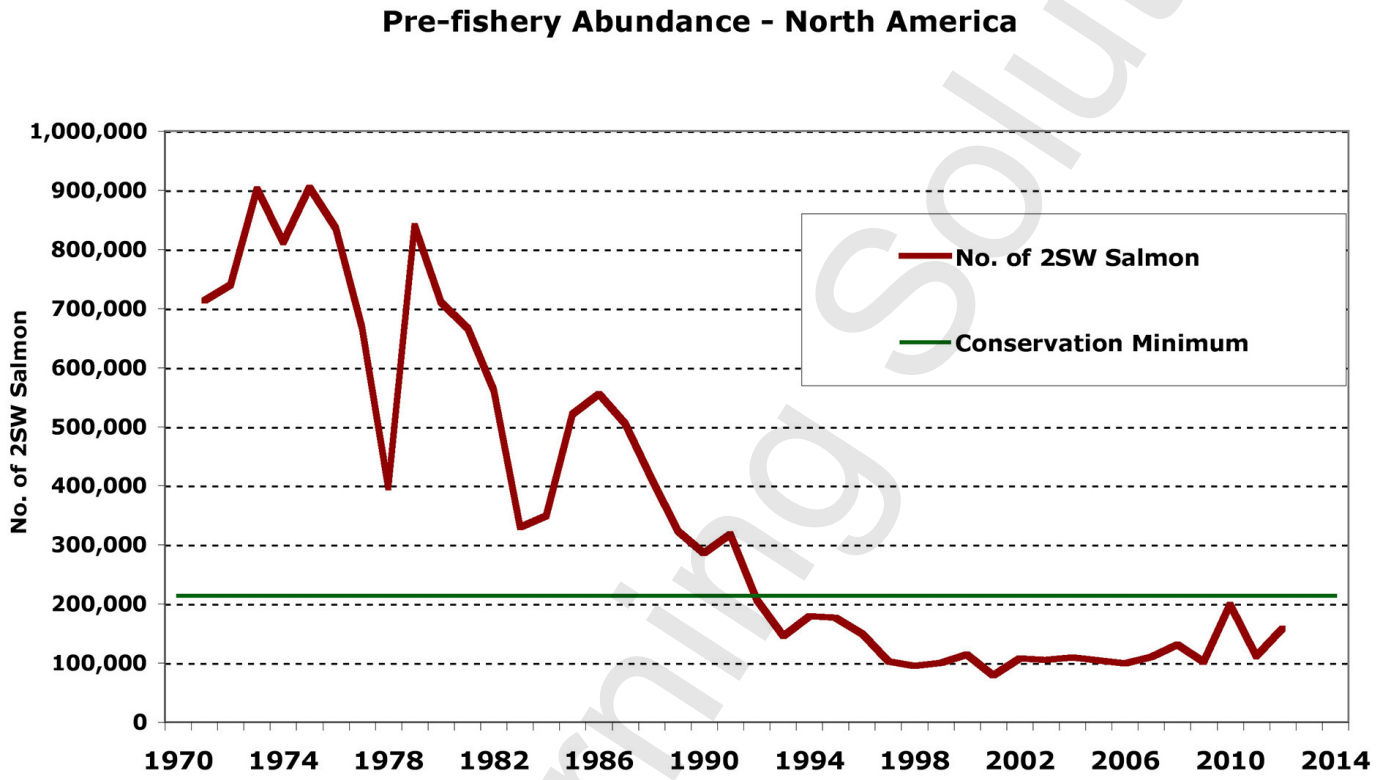
Next, introduce students to the two graphs **(FIGURE 1 and FIGURE 2)** on pages 4 and 5 of their Student Logs and have them answer the questions that follow. Remind students that these graphs can help them identify trends, but they should remember the rule that "correlation does not equal causation." (For example, just because farmed and wild-caught fish production increased does not mean that fish farming caused the increase in wild-caught fish.)

FIGURE 1: The amounts of wild and farmed salmon produced by the fishing industry from 1950 to 2010.



Source: http://www.fao.org/ and https://en.wikipedia.org/wiki/File:Time_series_for_global_production_of_all_salmon.png

FIGURE 2: wild populations of Atlantic salmon across North America from 1970 to 2014. 2SW Salmon refers to adult salmon that have lived through two winters at sea (hence, 2SeaWinters). The Conservation Minimum is the fewest number of salmon necessary for the population to continue to survive.



source: http://www.asf.ca/migrating-atlantic-salmon-face-a-triple-challenge-from-unsu.html

Have students respond to the questions on page 6 of the Student Log, then discuss their answers with the class:

1. Based on **FIGURE 1,** what conclusions can you make about the fishing industry?

Possible Responses:

- *There has been an increase in fish production by both wild and farmed sectors.*
- *Fish farming has created or responded to more demand for fish production.*

2. Based on **FIGURE 2**, how would you describe the general trend of wild salmon populations?

Possible Response:

- *There is a general decline among fish populations, even though they have fluctuated over the years.*
- *In most recent years, there appears to be a slight increase in some fish populations.*
-

3. Using the information in both charts, how could the relationship between fisheries and wild populations of salmon best be described? What additional questions would you need to answer to determine a cause and effect relationship between fisheries and salmon populations?

Possible responses:

- *Hypothesis: As fish-farming increases, the total wild population will also increase.*
- *Questions: Are people consuming more fish over time? Why do the populations of some sub-regions fluctuate more than others?*

Examples of Fish Farming

Guiding Questions: *What are the qualities of a sustainable aquaculture facility? What are the failures of some aquaculture facilities? How has the Kona mariculture industry learned from shortcomings of other existing aquaculture facilities?*

Introduce the three different reports of salmon farmed in Marine Net Farms from Seafood Watch, the organization that students learned about in the previous video.

Review this key of Criterion used in the reports before asking students to analyze the charts.

FIGURE 3: KEY for understanding Criterion in Seafood Watch Recommendation Charts

Data	The amount of data quality and availability for assessing and understanding the impacts of an aquaculture production facility. A higher number represents more data.
Effluent	The amount of waste produced and discharged per unit of production. A higher number represents less waste.
Habitat	The degree to which the environment provided for the fish maintains the functionality of ecologically valuable habitats. A higher number is a more functional habitat.
Chemicals	The degree to which the type, frequency of use, total use, or discharge of chemicals affect non-target organisms. A higher number represents lower risk.
Feed	The sustainability, the global impact, and the net nutritional gains or losses from the farming operation. A higher number represents sustainable and healthy feed.
Escapes	The frequency of escapes and degree to which they affect wild species or other ecosystem-level impacts. A higher number represents lower impact.
Disease	The degree to which the aquaculture practices prevent population-level impacts to wild species through the amplification and retransmission of pathogens or parasites. A higher number represents lower impact.
Source	The degree to which the aquaculture practices avoid impacting wild populations by using eggs, larvae, or juvenile fish produced from farm-raised broodstocks. A high number represents a low impact.
Wildlife Mortalities	The degree to which aquaculture populations pose substantial risk to wildlife or predator populations that may interact with farm sites. A score of zero represents no impact. A negative score represents an impact, which is deducted from the overall score.
Introduced Species Escape	The risk of introducing of unintended species into a wild ecosystem. A score of zero represents no risk. A negative score represents an impact, which is deducted from the overall score.

Have students review the Final Recommendation charts in **FIGURES 4-7** to identify some of the key factors in establishing good sustainable aquaculture practices. Summaries and data pulled from these three sources are included in Student Log.

FIGURE 4: Best Choice **-** New Zealand Chinook Salmon
http://www.seafoodwatch.org/-/m/sfw/pdf/reports/s/mba_seafoodwatch_chinook_salmon_newzealand_report.pdf

Final seafood recommendation - Marine Farms

Criterion	Score (0-10)	Rank	Critical?
C1 Data	9.20	GREEN	
C2 Effluent	8.00	GREEN	NO
C3 Habitat	7.73	GREEN	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	4.96	YELLOW	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	
C9X Wildlife Mortalities	-6.00	YELLOW	NO
C10X Introduced Species Escape	-0.80	GREEN	
Total	**61.06**		
final score	**7.63**		

Final Score	7.63
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO
Final Rank	GREEN

Scoring note - scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

The final numercial score for marine farming of chinook salmon in new zealand is 7.63 of 10. With no red criterion, the final Seafood Watch recommendation is a green “Best Choice.”

FIGURE 5: Good Alternative - Maine Farmed Salmon
http://www.seafoodwatch.org/-/m/sfw/pdf/reports/s/mba_seafoodwatch_farmed_atlantic_salmon_maine_atl_canada_report.pdf

Final Seafood Recommendation

Stat of maine, US

Criterion	Score (0-10)	Rank	Critical?
C1 Data	7.50	GREEN	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	5.72	YELLOW	NO
C4 Chemicals	1.00	RED	NO
C5 Feed	6.59	YELLOW	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife Mortalities	-5.00	YELLOW	NO
C10X Introduced Species Escape	-0.20	GREEN	
Total	**38.60**		
final score	**4.83**		

OVERALL RANKING

Final Score	4.83
Initial rank	YELLOW
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO

Final Rank
YELLOW

Scoring note - scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact. Color ranks: Red = 0 to 3.33, Yellow = 3.34 to 6.66, Green = 6.66 to 10. Criteria 9X and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects very poor performance. Two or more Red criteria trigger a Red final result.

Summary
The final numerical score for Atlantic salmon (Salmo salar) produced in marine net pens in the state of Maine, United States (US) is 4.83 out of 10, which is in the Yellow range, and with only one Red criterion (chemicals), the final ranking is Yellow and a recommendation of Good Alternative.

FIGURE 6: Avoid - Norwegian Farmed Salmon
http://www.seafoodwatch.org/-/m/sfw/pdf/reports/s/mba_seafoodwatch_farmednorwaysalmon_report.pdf

Final Seafood Recommendation

Criterion	Score	Rank	Critical?
C1 Data	7.50	GREEN	NO
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	6.27	YELLOW	NO
C4 Chemicals	2.00	RED	NO
C5 Feed	4.86	YELLOW	NO
C6 Escapes	1.00	RED	yes
C7 Disease	1.00	RED	NO
C8X Source	-0.00	GREEN	NO
C9X Wildlife Mortalities	-4.00	YELLOW	NO
C10X Introduced Species Escape	-4.00	YELLOW	
Total	**18.63**		
final score (0.10)	**2.66**		

OVERALL RANKING

Final Score	2.66
Initial rank	**RED**
Red criteria	3
Interim rank	**RED**
Critical Criteria?	YES

Final Rank
RED

Scoring note - scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operation have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of-10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary
The final numerical score for Atlantic salmon farmed in net pens in Norway is 2.66 out of 10, and with three Red-ranked criteria (Chemical Use, Escapes, and Disease), one of which is a critical conservation concern, the final ranking is Red and a recommendation of "Avoid."

Have students answer the questions on page 11 of their Student Logs in pairs or small groups, then discuss as a class:

1. What are some patterns in sustainable aquaculture?

Possible Response:

- *"Data" and "Source" are green in all three charts. Sustainably sourced aquaculture seems like a more widespread practice, based on these charts.*

2. In which areas could the more sustainable seafood options still improve?

Possible Response:

- *The "Best Choice" option rated yellow in "Feed" and "Wildlife Mortalities." The "Good Alternative" rated red in "Chemicals." These may be areas where the sustainable options could still improve.*

3. What are some of the issues associated with harmful fish farming practices?

Possible Response:

- *The use of chemicals, escapes of genetically altered fish, and disease seem to be the biggest issues associated with harmful fishing practices, based on these charts.*

4. What business or economic reasons do you think might motivate fish farmers to use those harmful practices?

Possible Response

- *The use of chemicals or non-sustainable feed may be cheaper than purchasing sustainable alternatives. Regulating genetic alteration and escapes may require more infrastructure and money.*

5. What information is ***not*** included in these charts that might explain why certain salmon farms are more sustainable than others?

Possible Response:

- *Information that would help explain why some farms are more sustainable than others would be location, size of facilities, and wholesale cost of fish.*

SCAFFOLDING MODULE II – INTRODUCTION TO HAWAIIAN KAMPACHI

Introduce your students to Hawaiian Kampachi

DISCUSSION POINTS FOR INSTRUCTOR:

- Hawaiian Kampachi is a locally farmed fish, also known as Alamo Jack or Amberjack
- A few companies in Kona farm this fish
- We are going to learn about their processes and the choices they have made in building their business

Text in Student Log:

Hawaiian Kampachi, which is the same species as *Almaco Jack* or *amberjack*, receives a "Good Alternative" rating from Seafood Watch, the organization that you learned about in the video. The full report from Seafood Watch is linked here. Review the Final Recommendation chart to see how Hawaiian Kampachi measures up. The full report is available for your reference as you research and create your final product: http://www.seafoodwatch.org/-/m/sfw/pdf/reports/a/mba_seafoodwatch_almacojackreport.pdf

FIGURE 7: Almaco Jack Report

Final Seafood Recommendation

Almaco jack *(seriola rivoliana)*
United States of America, specifically Hawaii
Submersible marine net pens

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.56	YELLOW	
C2 Effluent	7.00	GREEN	NO
C3 Habitat	7.87	GREEN	NO
C4 Chemicals	6.00	YELLOW	NO
C5 Feed	2.89	RED	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	9.00	GREEN	
C9X Wildlife Mortalities	-2.00	GREEN	NO
C10X Introduced Species Escape	0.00	GREEN	
Total	**46.32**		
final score	**5.79**		

OVERALL RANKING

Final Score	5.79
Initial rank	YELLOW
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO
FINAL RANK	GOOD ALTERNATIVE

Scoring note - scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

Summary

The final numerical score for farmed Almaco jack (alson known as amberjack or Hawaiian kampachi) farmed in submersible net pens in the United States is 5.79, which is in the yellow range, and with only one red criterion (feed), the overall ranking is Yellow - Good Alternative.

Students answer the questions on page 13 in Student Logs:

1. Based on this chart from Seafood Watch, what are the areas where Hawaiian Kampachi excels?
   Effluent, Habitat, Source, Wildlife Mortalities, and Introduced Species Escapes

2. Where does it seem to face challenges in sustainability?
   Feed in red. Data, Chemicals, Escapes, and Disease in yellow.

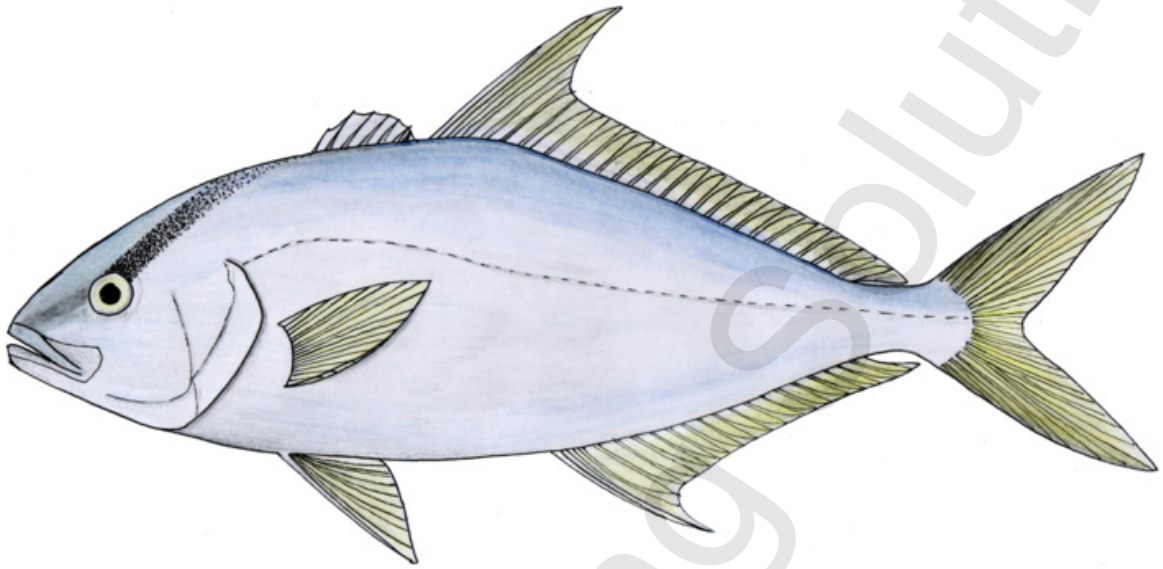
Keep these in mind as you read on about the Kampachi industry in Kona

Kona Mariculture

Next, introduce students to the Kona Mariculture Introductory Packet, found in their student logs beginning on page 14, and have them complete Glossary Words and Research Questions after moving through the packet together as a class.

INTRODUCTORY PACKET FOR MARICULTURE CONSULTANT

Kona Kampachi – Ocean-Raised Fish



NELHA (Natural Energy Laboratory of Hawaii Authority) is an ocean-based Science and Technology Camp located on the shoreline of Kona, Hawaii. From NELHA's website:

NELHA's mission is to develop and diversify the Hawaii economy by providing resources and facilities for energy and ocean-related research, education, and commercial activities in an environmentally sound and culturally sensitive manner.

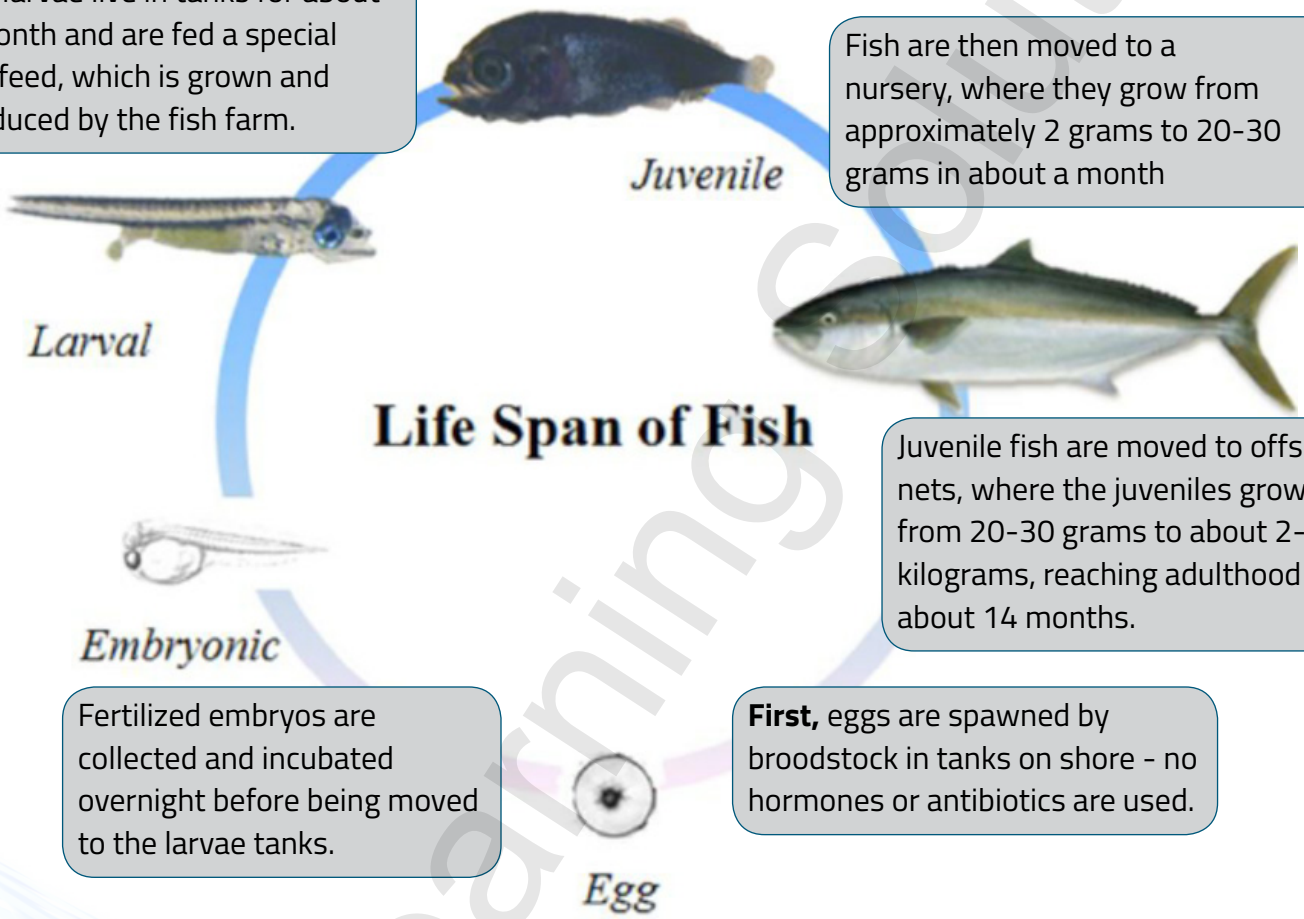
The State of Hawaii has invested over $100 million since 1974 to create HOST Park, a unique outdoor demonstration site for emerging renewable and ocean based technologies. **Three sets of pipelines deliver deep sea water from up to 3,000 feet depth as well as pristine sea surface water.** Solar insolation is among the highest for coastal areas in the United States. The innovative green economic development park is administered by NELHA, a State of Hawaii agency administratively attached to DBEDT. After three decades, NELHA is well on track to fulfilling its mission as an engine for economic development.

The Kona Kampachi industry takes advantage of the deep sea water being pumped in from far offshore, a unique advantage of NELHA's location. It is one of the only aquaculture industries in the United States practicing open ocean mariculture.

The Fish – Kampachi, from egg to adult

Life Cycle

The larvae live in tanks for about a month and are fed a special live feed, which is grown and produced by the fish farm.



Fish are then moved to a nursery, where they grow from approximately 2 grams to 20-30 grams in about a month

Juvenile fish are moved to offshore nets, where the juveniles grow from 20-30 grams to about 2-3 kilograms, reaching adulthood in about 14 months.

Fertilized embryos are collected and incubated overnight before being moved to the larvae tanks.

First, eggs are spawned by broodstock in tanks on shore - no hormones or antibiotics are used.

from www.researchgate.net

At the Lab: Breeding and Genetics

The Kampachi aquaculture process begins with a *broodstock*, or a group of mature fish used to breed the larger population. The parent fish are wild amberjack caught from the ocean. Kampachi mariculture facilities have a strict limit on the number of fish per year that they can remove from the wild. This limit minimizes damage to the natural ecosystem. **They also have a strict policy against breeding any "second generation" fish – fish born at their facilities – all parent fish were once wild.** This ensures that no *genetically modified* fish return to the wild gene pool, in the case of an escaped fish.

The broodstock are kept in tanks on land where they *spawn* eggs. These fish spawn on their own, as they would in the wild, so no hormones are used to induce the release of eggs. Once eggs are fertilized, they are collected and incubated at the mariculture facilities, where they are fed a *microorganism* grown on-site until they hatch into *larvae*. Once the eggs hatch, the larvae are cultured for about a month, during which time they grow larger. Once they reach a certain size, the fish are transferred to a nursery, and eventually to offshore cages.

image from http://prangerent.com/aquaculture/

In the Nets: Feeding and Harvesting

The offshore cages are designed so **the fish have all the same nutrients, light, and temperature conditions as fish living in the wild.** Scientists and staff perform daily dives to rid the cages of parasites, collect data, and perform other maintenance. Fish are fed by mariculture staff or feed pump, depending on the facility. Most Kampachi facilities import feed from U.S. based agriculture companies. Divers harvest fish from the cages twice per week. Fish are harvested before they reach sexual maturity, to prevent them from breeding. The harvested Kampachi fish is sold to distributors and restaurants in Hawaii and across the world, reaching menus from Japan to New York.

image from https://www.innovasea.com

The Economics of Mariculture

Beyond environmental sustainability, one of the major benefits of mariculture performed in offshore nets is cost savings. Typically fish are farmed in tanks on land, requiring water and nutrients to be pumped in continuously throughout the day and night. Offshore netting negates the need for this heavy volume of water, while also providing some of the natural nutrients found in the deep sea that are costly to replicate on shore.

Some facilities develop their own feed for the larval stage of fish development, offsetting another often costly component of aquaculture. The older fish are fed a feed that is purchased from a large company based in the mainland, because there is currently no comparablealternative produced in Hawaii.

Mariculture facilities are also able to increase profits by increasing the number of eggs that grow into adult fish. In the wild approximately 1% of fish eggs live to adulthood – in most mariculture settings approximately 5% of eggs survive. At Kona Kampachi facilities, between 5-15% of eggs can survive, increasing the total number of fish that can be harvested once they reach adulthood. And while the eggs start off as tiny specks only visible under a microscope, this is nothing to scoff at – Kampachi can sell for $20 to $50 per pound. If a million eggs are spawned every day, imagine the economic possibilities.

image from http://departureportland.com/blog/kampachi-at-departure/

From the Open Sea to your Plate: Health Benefits of Kanpachi

Of course, none of these innovations matter if the consumer does not benefit from them. Fortunately for Kampachi mariculture companies, Kampachi is considered one of the healthiest, most delicious fishes to consume. By growing the larvae in tanks on land and then using the deep sea water for the offshore nets, Kampachi are able to avoid the kind of *heavy metals* so often found in wild fish. From Fortune Magazine:

> *It's not genetically engineered in any way, just well bred. It's sashimi-grade and sustainably farmed without hormones or prophylactic antibiotics. It's richer in omega-3 than just about anything else in the ocean and has no detectable mercury. It melts on your tongue, holds up on the grill, and is so rich in oils that it'll fry in a pan without butter.*

The chart below shows some nutritional information about Kampachi.

Amont Per 100g			
Calories	**141 kcal (590 kj)**		
Calories from fat	**54 kcal**		
		% Daily value*	
Total Fat	6g	9%	
Saturated Fat	2g	10%	
Cholesterol	40mg	13%	
Sodium	41mg	2%	

* Percent Daily Values are based on a 2000 calorie diet. your daily values may be higher or lower depending on your calorie needs.

from www.recipeofhealth.com

Glossary

Fill in the definitions of these terms from the information packet – look up words you do not know and use clues from the packet to help refine your definition.

Fill in the definitions of these terms from the information packet – look up words you do not know and use clues from the packet to help refine your definition. *Possible definitions in red.*

Broodstock *a group of adult fish used to breed aquaculture populations*

Genetically Modified *referring to an organism whose genetic material (DNA) has been altered in a way that does not occur through natural reproduction*

Heavy Metals *metallic chemical elements with a high density. Heavy metals are typically toxic at low concentrations.*

Larvae *a form that many animals go through after the egg stage, before developing into adults*

Microorganism *a small, microscopic organism such as virus, bacteria, or fungus.*

Spawn *to release or deposit eggs*

Research Questions

Do some research in order to answer the following questions. This information will help you better understand mariculture practices of the Kona Kampachi industry.

1. What are the dangers of releasing genetically modified species into a wild population?
    - *Genetically modified fish released in the wild could threaten wild fish species by outcompeting them for food, territory, and mating opportunities.*
    - *They could also interbreed with wild fish populations, permanently altering the genetic make-up of the fish populations.*

2. How do mariculture operations ensure higher egg survival rates?
    - *Mariculture operations ensure higher egg survival rates by incubating eggs in environments controlled for temperature, water hardness, disease, and other threats, as well as the elimination of natural predators.*

3. What is an area where even more cost savings could occur in farming Kampachi? What are some of the economic challenges the industry faces compared to traditional open sea fishing?
    - *If an affordable, locally produced feed alternative existed in Hawaii, Kona-based facilities would not need to import feed from a large company on the mainland. This change would save costs. Also, if they increased the rate of egg survival, they could produce and sell more fish.*
    - *Some of the economic challenges faced by the Kampachi industry, compared to traditional open sea fishing, are the costs of feeding and caring for the fish, as well as the costs to maintain the facilities needed to raise the fish through all stages of development.*

3. Read through Seafood Watch's report on Kampachi. Which of their practices are considered the *least* sustainable? What are some of the areas in which they could improve their scores? What are the best arguments for *maintaining* these practices, despite the lower scores?
    - *Feed is the least sustainable area of Kampachi aquaculture. A locally sourced sustainable feed would improve this score. A strong argument for maintaining this practice, however, is that there aren't alternatives available, or the alternatives are so costly that they would not permit to the operation to run as required.*

4. What are the typical nutritional benefits of other similar fish on the market? What is the average cost per pound?
    - *Kampachi is a type of amberjack fish, similar to yellowtail. Other yellowtail and amberjack fish provide high levels of protein and omega threes. Wild Japanese yellowtail is sold wholesale for approximately $4/lb. Aquaculture-based yellowtail cultured in Japan, China, and Mexico sells for $3.50-$5 per lb. These are the prices paid to producers by distributors. Consumers will likely pay twice as much for these fish at the market.*

PERFORMANCE TASK - STUDENT MODULES

In the following modules, students will continue their research and work to create an outreach and education strategy for Kona Mariculture. Students should think about what questions they still have about sustainable seafood, Kona Mariculture, and aquaculture. Use these questions to guide your research.

MODULE I:
Students conduct individual research on mariculture, sustainable seafood, and processes at Kona-based mariculture facilities.

Kampachi Mariculture facilities in Kona:

- http://www.kampachifarm.com/
- http://www.bofish.com/

**to differentiate their product, Blue Ocean Mariculture uses the name "Kanpachi" while Kampachi Farms uses "Kampachi."*

Some additional links:

- https://thefishsite.com/articles/kona-kampachi-holds-answer-to-sustaining-oceans
- https://oceantoday.noaa.gov/oceanasalab_fishfarm/
- http://www.noaa.gov/stories2013/pdfs/2013_PriceandMorris_MarineCageCultureandTheEnvironment(5).pdf
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4559559/
- https://eos.ucs.uri.edu/EOS_Linked_Documents/pru/CaribbeanAquaBMP.pdf

MODULE II:
Students formulate an argumentative position supporting Kona's mariculture industry and conduct further research on that topic.

- Focus on its benefits to ocean life
- The dangers and challenges
- Its role in changing the way Hawaii, or the world at large, eats
- Its contribution to Kona's economy and job market

MODULE III:

Students design and develop content for an educational outreach program about Kona mariculture.
Program must include a presentation and a multi-media or social media element.
Possible forms include an online video, animation, presentation meant for a group of visitors, a series of posters, a promotional zine, an illustrated special report
The presentation must convey the student's message clearly, including their own researched information and key details about Kona mariculture, and the form they choose effectively. Presentations should also include some visual, digital, or social media element.

MODULE IV:

Students present their educational program.

PERFORMANCE ASSESSMENT RUBRIC

How to use this rubric:

Collect the Student Logs once the project is completed.

Student performance is graded on a scale from 0-3, 0 indicating that the student did not participate in the activity assessed by the standard, and 3 indicating that the student is demonstrating the highest level of expected performance and competency.

The CCSS is used to assess students' reading, writing, research, speaking and listening skills, including those associated with collaboration, conversation, and presenting.

The NGSS is used to assess students' ability to understand scientific reasoning, information, and processes.

Both sets of standards incorporate Critical Thinking and Analytical Reasoning skills, including student's ability to analyze information and synthesize ideas to create a coherent argument or solution to a problem.

Total points should not be tallied and there is no final score. Instead, the rubric should be used to identify areas of strength and growth areas, either with individuals or with your entire class, so that you may tailor your instruction to address these areas.

PERFORMANCE ASSESSMENT RUBRIC

Standard	No Score	1	2	3
RST11-12.2 (CCSS) Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.	Student does not conduct independent research **and/or** Student does not demonstrate an understanding of central ideas and conclusions.	After conducting independent research, student demonstrates a limited understanding of central ideas and conclusions related to the research topic. Student does not accurately paraphrase complex concepts and processes, but does summarize central ideas.	After conducting independent research, student demonstrates an understanding of central ideas and conclusions related to the research topic by paraphrasing a few concepts and processes.	After conducting independent research, student demonstrates a strong understanding of central ideas and conclusions related to the research topic by accurately paraphrasing complex concepts and processes.
RST11-12.6 (CCSS) Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.	Student does not conduct independent research **and/or** Student does not demonstrate an analysis of research sources and does not identify unresolved issues.	After conducting independent research, student demonstrates a limited understanding of the purpose of research sources. Student identifies an issue on which to focus and narrow further research.	After conducting independent research, student demonstrates an understanding of the purpose of research sources. Student identifies one or two unresolved issues on which to focus and narrow further research.	After conducting independent research, student demonstrates a thorough analysis of the purpose of research sources. Student identifies multiple unresolved issues on which to focus and narrow further research.
HS-ETS.1-1 (NGSS) Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	Student does not conduct independent research related to the problem of overfishing and the practice of mariculture.	After conducting independent research, student demonstrates a limited understanding of the problem of overfishing, capturing just one or two pieces of quantitative or qualitative data related to the practice of mariculture.	After conducting independent research, student demonstrates an understanding of the problem of overfishing, capturing a few pieces of quantitative or qualitative data related to the practice of mariculture.	After conducting independent research, student demonstrates a thorough analysis of the problem of overfishing, capturing multiple pieces of **both** quantitative and qualitative data related to the practice of mariculture.
WHST11-12.7 (CCSS) Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.	Student does not conduct further research in order to develop an argumentative position supporting Kona Kampachi.	Student conducts limited research to support argumentative position supporting Kona Kampachi, using only one or two reliable sources. Student demonstrates a limited understanding of how to support the argument.	Student conducts focused research to support argumentative position supporting Kona Kampachi, using a few reliable sources. Student demonstrates an understanding of how to support the argument.	Student conducts focused and thorough research to support argumentative position supporting Kona Kampachi, using multiple reliable sources. Student demonstrates a comprehensive understanding of how to support the argument.
WHST11-12.1 (CCSS) Write arguments focused on discipline-specific content.	Student does not develop an argumentative position supporting Kona Kampachi.	Student develops a weak position supporting Kona Kampachi Mariculture, incorporating little relevant research into argument.	Student develops a position supporting Kona Kampachi Mariculture, incorporating relevant scientific research into argument.	Student develops a sound and thorough position supporting Kona Kampachi Mariculture, incorporating relevant and detailed scientific research into argument.

HS-ETS1-3 (NGSS) Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	Student does not evaluate Mariculture programs and processes in order to develop a supporting argumentative position.	Student's supporting position demonstrates a limited evaluation of Mariculture solution to the problem of over-fishing, and does not include an understanding of the constraints, costs, and cultural and environmental impacts.	Student's supporting position demonstrates an evaluation of Mariculture solution to the problem of over-fishing, including an understanding of some of the constraints, costs, and cultural and environmental impacts.	Student's supporting position demonstrates a thorough evaluation of Mariculture solution to the problem of over-fishing, including a clear understanding of the constraints, costs, and cultural and environmental impacts.
WHST11-12.2 (CCSS) Write informative/ explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.	Student does not develop an educational outreach program for Kona Kampachi.	Student develops a presentation about Kona Kampachi, but does not support any position and does not include scientific or technical details.	Student develops an informative presentation supporting Kona Kampachi, including details related to the scientific procedures and technical processes.	Student develops a detailed and informative presentation supporting Kona Kampachi, including important and relevant details related to the scientific procedures and technical processes.
RST11-12.7 (CCSS) Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.	Student does not develop an educational outreach program for Kona Kampachi.	Student demonstrates a limited understanding of one or two sources of information, integrating a limited amount of information from these sources into educational outreach program.	Student demonstrates an understanding of a few sources of information presented in a variety of media, including print and digital, integrating information from these sources into educational outreach program.	Student demonstrates a clear and thorough understanding of multiple sources of information presented in a variety of media, including print and digital, integrating supporting relevant information from these sources into educational outreach program.
RST11-12.9 (CCSS) Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.	Student does not develop an educational outreach program for Kona Kampachi.	Student includes information from one or two sources into presentation, demonstrating a limited understanding of processes, concepts, and conflicting ideas.	Student synthesizes information from multiple sources into a coherent presentation, demonstrating an understanding of processes, concepts, and conflicting ideas.	Student effectively synthesizes multiple pieces of information from a diverse range of sources into a coherent presentation, demonstrating a thorough understanding of processes, concepts, and conflicting ideas.

SL11-12.4 (CCSS) Present information, findings, and supporting evidence, conveying a clear and distinct perspective, such that listeners can follow the line of reasoning, alternative or opposing perspectives are addressed, and the organization, development, substance, and style are appropriate to purpose, audience, and a range of formal and informal tasks.	Student does not present an educational outreach program.	Student's presentation of educational program lacks clarity, using evidence sporadically or inappropriately. Student's presentation does not clearly outline reasoning, processes and procedures, purpose, and argumentative position.	Student presents educational program clearly, using evidence in order to support multiple points. Student's presentation outlines reasoning, processes and procedures, purpose, and argumentative position.	Student presents educational program clearly and articulately, using evidence when appropriate to support important points. Student's presentation clearly outlines reasoning, processes and procedures, purpose, and argumentative position.
SL11-12.5 (CCSS) Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.	Student does not use any form of digital or social media in the educational outreach program.	Student utilizes one form of media for presentation, incorporating limited graphics into presentation without enhancing understanding of reasoning and position.	Student utilizes two forms of media, including a digital aspect, incorporating graphics into presentation in order to enhance understanding of reasoning and position.	Student utilizes multiple forms of media, including a digital aspect, incorporating a social media video and/or graphic into presentation in order to enhance understanding of reasoning and position.

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