**GENERAL CURRICULUM CONCEPTS**

**Aquaculture**

UN Ocean Decade 10 Challenges: <https://www.oceandecade.org/challenges/>

**Section One – Introduction to Aquaculture**

**Week One - What is Aquaculture**

Aquaculture is the oceanic counterpart to agriculture—it is the business of cultivating and harvesting aquatic species, including fish, shellfish, and algae, for consumption or commercial use. The United Nations Food and Agriculture Organization calculates that aquaculture production has risen 527% since 1990, with a majority of yield being finfish.

Cultivation of mollusks, including shellfish such as mussels, clams, and oysters, only constitutes about 20 percent of current global aquaculture. But shellfish production is gaining popularity due to its sustainability. Because shellfish grow quickly and do not require freshwater, land, or fertilizer, they are one of the most sustainable sources of protein available. At AltaSea’s campus in the Port of Los Angeles, Holdfast Aquaculture is working to develop local shellfish species for aquaculture production.

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| **NGSS met:**  Blue = SEP  Yellow = DCI  Green = CCC | **UN Sustainable Development Goals (SDG) met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-8: Obtain and evaluate information about aquaculture background | Goal 14: Life Below Water – shellfish aquaculture sustainably utilizes the ocean’s resources | Challenge 3: Sustainably feed the global population – Understand how aquaculture is a growing industry due to its contribution to feeding the growing global population |
| ESS3: Understand human impact on Earth’s oceans and aquatic species due to fishing and aquaculture |  |  |
| CCC2: Understand scale and quantity of aquaculture and fishing, understand proportions of species that comprise aquaculture and fishing yield |  |  |

**Week Two - Why is Aquaculture important**

1. Aquaculture is a Resource Efficient Food Production Method for a Changing Environment

2. Shellfish Beds Help Restore Our Waterways

3. Producing More Seafood Can Alleviate Food Insecurity

4. Sustainable Aquaculture Advances Technology

4. Aquaculture Creates Economic Opportunities

6. Wild and Farmed Seafood is Good for Your Health

7. Aquaculture Can Preserve Cultural Heritage

8. Sustainability Fosters International Collaboration

9. Aquaculture combats climate change – carbon sequestration

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-1: Ask questions about importance of aquaculture and how to solve problems (e.g. food insecurity, climate change, etc.) through aquaculture, define problems that can be solved by aquaculture | Goal 2: Zero Hunger – Food production in aquaculture can alleviate food insecurity | Challenge 2: protect and restore ecosystems and biodiversity – shellfish beds can restore nutrient overloaded waterways, aquaculture can mitigate impacts of climate changes via carbon sequestration |
| ESS3: Understand how human activity has led to changing environment and climate change, understand how humans depend on Earth’s resources (e.g. reliance on oceans for food) | Goal 14: Life Below Water – shellfish aquaculture sustainably utilizes the ocean’s resources | Challenge 3: Sustainably feed the global population – Understand how aquaculture is a resource efficient food production method suitable in changing environmental, social, and climate conditions |
| ETS2: Understand how society depends on science, technology, and engineering in aquaculture (e.g. for food security) | Goal 9: Industry, Innovation, and Infrastructure – Aquaculture advances technology and fosters innovation | Challenge 4: Develop a sustainable and equitable ocean economy – Understand how pursuing sustainable aquaculture promotes innovation, understand that the growing aquaculture industry creates economic activity |
|  | Goal 8: Decent Work and Economic Growth – Aquaculture creates economic opportunities | Challenge 5: Unlock ocean-based solutions to climate change – Understand how carbon sequestration in aquaculture mitigates impacts of climate change |
|  | Goal 3: Good Health and Well-Being – Wild and farmed seafood is good for your health |  |
|  | Goal 17: Partnerships for the Goal – working towards sustainability fosters international collaboration and revitalizes global partnerships |  |
|  | Goal 13: Climate Action – carbon sequestration in aquaculture (e.g. in kelp aquaculture) helps combat and mitigate effects of climate change |  |

**Week Three - Aquaculture and our changing planet**

**Week Four - What are the challenges to Aquaculture**

Parasites in aqua cultured fish

Antibiotic use to promote growth and prevent diseases

The source of aquafeed(s) supplied to the farmed fishes

Excessive release of nutrients to natural water bodies

Accumulation of aquaculture wastes in the seabed

Impacts on wild populations and on the introduction of non-indigenous species

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-1: Ask questions about the challenges of aquaculture, define problems in aquaculture | Goal 14: Life Below Water – managing parasites, excessive nutrient release to natural water bodies, accumulation of aquaculture wastes in the seabed, and the impact of non-indigenous species introduction contributes to sustainable use of marine resources for sustainable development. | Challege 1: Understand and beat marine pollution – understand that excessive nutrient release in water bodies causes nutrient pollution |
| LS2: Understand aquatic ecosystems, understand interactions between wild and non-indigenous species |  | Challenge 2: Protect and restore ecosystems and biodiversity – Understand how aquaculture impacts marine ecosystems when non-indigenous species are introduced |
| ESS3: Understand how aquaculture impacts Earth’s aquatic ecosystems through nutrient overloading and introduction of invasive species |  |  |
| ETS2: Understand that society drives demand for aquaculture products which in turn drives science, tech, and engineering in aquaculture to accommodate demand |  |  |
| CCC3: Learn quantity and scale of aquaculture wastes in seabed, nutrients released to natural water bodies, and antibiotics used in aquaculture |  |  |

**Section Two – The Business of Aquaculture**

**Week Five - History of Aquaculture**

Aquaculture is an old practice thought to have begun over two thousand years ago in China. Crafted fish farming is known for hundreds of years throughout the world. However, it has only been in the last four to five decades that commercial production became widespread, moving from an annual output of 4.7 million tons in 1980 to 80 million tons in 2016. Owing to an increasing food demand, combined with fish stock depletion, it is now recognized that fisheries will not be able to meet the projected global needs in high-quality protein. In face of this development need, aquaculture is currently the food production sector showing the fastest growth in the world, with an average rate of 5.8% in the last 15 years and is a priority of the Blue Growth strategy adopted by the European Union (EU). This sector is expected to supply 109 million tons of fish by 2030.

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-8: Obtain and evaluate information regarding history of aquaculture | Goal 2: Zero Hunger – Increasing aquaculture output helps support the food demands of an increasing global population. | Challenge 3: Sustainably feed the global population – Understand how aquaculture is the solution to feeding the increasing global population as fish stocks are depleted and unable to meet demand |
| ESS3: Understand how human fishing activity has impacted Earth’s fish stocks and aquatic ecosystems |  | Challenge 4: Develop a sustainable and equitable ocean economy – Understand how the growing aquaculture industry creates greater economic opportunity |
| ETS2: Understand how societal food needs drive growth in aquaculture through science, tech, and engineering |  |  |
| CCC3: Comprehend scale of aquaculture and fishing operations over time, learn quantity of aquaculture output |  |  |

**Week Six - What is the value of Aquaculture**

Seaweed has a number of health benefits and can be found in a variety of foods

Seaweed is an excellent source of protein, fiber, and iron and other essential nutrients like Vitamin K and the healthy long-chain omega-3 fatty acids found in seafoods.

When you think of eating seaweed, you might be most familiar with seaweed wrapped around sushi rolls or as dried snacks. But it can be used for so many other delicious and nutritious dishes! Seaweed makes an excellent ingredient in salsa, soups, salads, kimchis, and slaws. It can also be found in pastas or used as seasoning for adding a umami flavor to chips and popcorn.

Seaweed has many uses besides food!

You can find seaweed in ice creams (to keep the ice cream thick and prevent ice crystals from forming), cosmetics, pharmaceuticals, fertilizer, and animal feeds.

Seaweed can also be used to make biodegradable packaging, a great alternative to plastic packaging that contributes to pollution in our oceans.

Red seaweeds can be used in feeds for cows to help them reduce their methane emissions. Methane is a greenhouse gas that contributes to climate change.

Uses for Kelp [Processing kelp at Atlantic Sea Farms](https://www.youtube.com/watch?v=QJgwZxAAU_4)

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-6: Learn about solutions to problems in various industries are designed using seaweed (e.g. climate, packaging, pharmaceuticals, cosmetics) | Goal 3: Good Health and Well-Being – Seaweed has many nutritional benefits that promotes healthy living and well-being in people of all ages. | Challenge 1: Understand and beat marine pollution – Understand that plastic packaging contributes to marine plastic pollution and that using biodegradable seaweed-based packaging instead can reduce this |
| ESS3: Understand how humans rely on Earth’s aquatic resources (seaweed) in industry | Goal 12: Responsible Consumption and Production – Using seaweed in biodegradable packaging contributes to establishing responsible and sustainable consumption and production patterns | Challenge 3: Sustainably feed the global population – Learn how seaweed is an environmentally beneficial and healthy aquaculture product |
| ETS1: Learn how products like biodegradable packaging and cattle feed can be engineered using seaweed |  | Challenge 5: Unlock ocean-based solutions to climate change - Understand how red seaweeds can be used in cattle feed to reduce methane emissions that contribute to climate change |
| ETS2: Learn how progression in science, technology, and engineering in aquaculture is driven by societal demand (e.g. societal demand for sustainable packaging) |  |  |
| CCC2: Learn how the molecular/chemical/structural composition of seaweed cause it to have properties that are useful in various industries (cause = composition, effect = useful properties) |  |  |

**Week Seven - Occupations and Education in Aquaculture**

Fish farm technician

•Farm manager

•Saltwater production manager

•Hatchery technician

•Hatchery manager

•Environmental and regulatory affairs manager

•Fish health technician

•Aquaculture engineer

•Research scientist

•Instructor

•Policy advisor

•Research and development coordinator

•Regulatory affairs officer

•Aquaculture development specialist

•Aquaculture extension officers

•Habitat biologist

•Environmental assessment technician

•Research technician

•Aquaculture diver

•Feed production technician

•Aquatic veterinarian

•Processing line supervisor

•Processing line operator

Waste management

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| ETS2: Learn how societal demands lead to occupations in aquacultural science, tech, and engineering | Goal 8: Decent Work and Economic Growth – Aquaculture is a growing industry that promotes sustained and sustainable economic growth as well as decent employment. | Challenge 4: Develop sustainable and equitable ocean economy – Learn about the plentiful economic opportunity offered by the aquaculture industry |

**Section Three – Aquaculture in Practice**

**Week Eight - Starting an Aquaculture farm**

Site Selection

Environmental resources

Water Resources (typically surface water or groundwater) to supply aquaculture operations

Water quality (historical and current data)

Topography and potential nearby pollutant sources (e.g. farms)

Water Discharge

Industrial infrastructure

Roads

Airports

Reliable electrical power

Ponds

Site: slope (erosion and harvesting logistics), soil composition (water retention), and depth (water quality)

Recirculating Aquaculture Systems

Circulation and discharge

Solids separation, biofiltration, re-aeration/degassing, some form of water sterilization, protein skimming

Many things to consider when Starting an Aquaculture farm:

What species of fish do you want to farm? This matters because some fish require freshwater, and some require saltwater

What farming method do you want to use?

~ Flow-through system: fish are raised in well build tanks, are in fresh stream water, and are fed with commercial food pellets

~ Single species: can be indoors or outdoors, just raises one species, for beginners

~ Composite Fish Culture: Multitude of different non-competing species (usually 5 or 6) are raised in the same area

Some essential equipment: Pumps, water testing, water treatment system, hydroponic beds, etc. Varies for what type of aquaculture farm is being created

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-1: Ask questions about aquaculture in practice, define common problems in starting an aquaculture farm | Goal 9: Industry, Innovation, and Infrastructure – Building aquaculture farms promotes resilient infrastructure, sustainable industrialization, and fosters innovation. | Challenge 1: Understand and beat marine pollution – understand sources of pollution in aquaculture operations (e.g. farms) and learn to plan around them |
| SEP-6: Design solutions to common problems in starting an aquaculture farm |  | Challenge 10: Change humanity’s relationship with the ocean – Understand how aquaculture is reliant on ocean resources and how these resources must be sustainably managed |
| ESS3: Understand how aquaculture activity impacts Earth’s ecosystems when learning considerations for location, resources, water discharge, etc. for an aquaculture farm |  |  |
| ETS1: Learn how aquaculture farms can be engineered in different ways based on needs (e.g. flow-through system, single species, composite fish culture) |  |  |
| ETS2: Learn how engineering an aquaculture farms is impacted by factors linked to society like roads, airports, and reliable electrical power |  |  |

**Week Nine - Aquaculture management**

Many things to consider when Starting an Aquaculture farm:

What species of fish do you want to farm? This matters because some fish require freshwater, and some require saltwater

What farming method do you want to use?

~ Flow-through system: fish are raised in well build tanks, are in fresh stream water, and are fed with commercial food pellets

~ Single species: can be indoors or outdoors, just raises one species, for beginners

~ Composite Fish Culture: Multitude of different non-competing species (usually 5 or 6) are raised in the same area

Some essential equipment: Pumps, water testing, water treatment system, hydroponic beds, etc. Varies for what type of aquaculture farm is being created

A multitude of things go into managing an aquafarm well! This includes:

Maintaining good health of the aquafarm

Shipment, transportation and sale of the farmed products

~ Aquaculture Certificate of Registration number (AQ#), must be identified when transported from harvest to the point of sale

Economics of Aquaculture:

~ Micro-economics: Management measures and elements affecting the efficiency of operation at the farm level

~ Macro-economics: Assessment of social benefits and costs of an aquaculture project

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| SEP-1: Ask questions about aquaculture in practice, define common problems in starting an aquaculture farm | Goal 14: Life Below Water – maintaining good health of aquafarms promotes sustainable usage of marine resources. |  |
| SEP-6: Design solutions to common problems in starting an aquaculture farm | Goal 9: Industry, Innovation and Infrastructure – Taking the aforementioned factors into account when building aquafarms develops resilient and sustainable aquaculture infrastructure. |  |
| ETS1: Learn about considerations in engineering an aquaculture farm |  |  |
| ETS2: Learn how assessment of social benefits of aquaculture project is important and influences science, tech, and engineering of aquaculture project |  |  |
| CCC-7: Learn about maintenance of an aquafarm requiring stability and adaptation to changes, learn about factors that could cause changes in the aquafarm |  |  |

**Week Ten - Health and Aquaculture**

<https://www.asc-aqua.org/what-we-do/our-standards/seaweed-standard/>

To farm good products, the health of the farm needs to be upheld! What does this look like?

Disease prevention based off good husbandry practices

What are good animal husbandry practices?

~ Avoid over crowding

~ Maintain optimal nutritional programs

~ Maintain water quality standards and parameters

Health Surveillance: can help with disease control and upholds good culture conditions

All of this can vary depending on the species of animal or plant being farmed

**‘Hands-on’ or practical activities**

Grow your own seaweed and kelp [How to Spore Out Sugar Kelp](https://www.youtube.com/watch?v=CjyfFmVCxdM&t=121s)

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| **NGSS met:** | **UN SDG met:** | **UN Ocean Decade Challenges Addressed:** |
| SEP-6: Learn about and engineer solutions to disease in aquaculture farms | Goal 14: Life Below Water – Maintaining aquaculture farm health promotes sustainable utilization of marine resources. |  |
| ETS1: Engineer a small system to spore out kelp |  |  |
| CCC-2: Understand cause and effect of steps of the method (e.g. pretreatment of kelp sorus tissue (cause) eliminates epiphytic diatoms (effect)) |  |  |