METHODS AND SYSTEMS FOR AQUACULTURE

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Application No. 63/222,070, filed July 15th, 2021, which application is incorporated herein by reference

BACKGROUND

[0002] Commercial fishing and wild-caught seafood accounts for over 80% of seafood consumed in the United States. These methods can cause overfishing and population collapse of wild fish stocks. Additionally, environmental impacts caused by transporting seafood from its point of capture to inland markets can compound the negative effects that are seen from wild-caught seafood.

SUMMARY

[0003] Recognized herein is a need for farmed seafood with a low environmental and spatial footprint. By combining farmed seafoods with vertical stacking, seafood can be grown local to its consumption, improving both the quality of the seafood as well as the price and environmental impact.

[0004] In an example, the present disclosure provides a self-contained unit, comprising: (a) a region configured for growth of at least one water-growing organism, wherein the growth is at a feed conversion rate of at most about 1. In another example, the present disclosure provides a self-contained unit, comprising: (a) a region configured for growth of at least one water-growing organism, wherein the growth is at a feed conversion rate of at most about 1.3.

[0005] In some examples, the self-contained unit further comprises an umbilical portion configured for delivery of one or more of electrical energy, gasses, solids, liquids, or any combination thereof. In some examples, the self-contained unit comprises a plurality of water-growing organisms. In some examples, a water-growing organism of the water-

growing organisms is a water-growing plant. In some examples, the water-growing plant comprises an algae or a seaweed. In some examples, a water-growing organism of the water-growing organisms is a water-growing animal. In some examples, the water-growing animal comprises a fish or a shrimp. In some examples, a water-growing organism of the water-growing organisms is configured to subsist on waste generated by a second water-growing organism of the water-growing organisms. In some examples, the self-contained unit further comprises a lid configured to contain the region, wherein the lid is an insulated lid. In some examples, the insulated lid further comprises a heater or cooler. In some examples, the heater or the cooler is configured to maintain the temperature of water within the region at a temperature of at most about 1 °C from a set point temperature. In some examples, the heater or the cooler is configured to maintain the temperature of water within the region at a temperature of at most about 2 °C from a set point temperature. In some examples, the self-contained unit further comprises a nitrification moving bed bioreactor in fluid communication with the self-contained unit, which nitrification moving bed bioreactor comprises a containment vessel configured to enclose biofiltration media and a fluidizing aeration source. In some examples, the biofiltration media comprises a surface area of at least about 1000 square meters per gram (m^2/g). In some examples, the biofiltration media comprises a surface area of at least about 900 square meters per cubic meter (m^2/m^3). In some examples, the biofiltration media comprises an oxygen concentration of at least about 9 parts per million (ppm). In some examples, the biofiltration media comprises an oxygen concentration of at least about 4 milligrams per liter (mg/L). In some examples, the biofiltration media has a neutral buoyancy. In some examples, the containment vessel has a volume of at most about 3 cubic meters (m^3). In some examples, the containment vessel is substantially opaque. In some examples, the containment vessel is configured to permit flow of water through the containment vessel. In some examples, the nitrification moving bed bioreactor is contained within the self-contained unit. In some examples, the self-contained unit further comprises a

battery unit. In some examples, the battery unit is configured to power the self-contained unit for at least about 10 hours without use of other power sources. In some examples, the self-contained unit further comprises an algae reactor, wherein the algae reactor is configured to convert at least a portion of a waste generated by the at least one water-growing organism into food for the at least one water-growing organism. In some examples, the algae reactor is configured to stack on one or more additional algae reactors contained within the self-contained unit. In some examples, the region comprises a volume from about 19 m^3 to about 25 m^3. In some examples, the region comprises a volume from about 10 m^3 to about 25 m^3. In some examples, the one or more water-growing organisms comprise shrimp. In some examples, the one or more water-growing organisms comprise fish. In some examples, the one or more water-growing organisms comprise algae. In some examples, the one or more water-growing organisms comprise seaweed. In some examples, the self-contained unit further comprises a monitor configured for detection of one or more pathogenic microorganisms. In some examples, the self-contained unit does not comprise a raceway. In some examples, the self-contained unit further comprises a regulated feeding unit. In some examples, the regulated feeding unit is regulated by one or more sensors housed within the self-contained unit.

[0006] In a first aspect, the present disclosure provides a system, comprising: (a) a plurality of self-contained units configured for growth of at least one water-growing organism; (b) a storage bay; (c) a harvesting station; (d) a cleaning station; (e) a stocking station; and (f) an automated system configured to move the plurality of self-contained units between the storage bay, the harvesting station, the stocking station, and the cleaning station.

[0007] In some examples, the system further comprises a non-transitory computer readable medium comprising instructions that, when executed, direct the plurality of self-contained units between the storage bay, the harvesting station, the stocking station, and the cleaning station. In some examples, the storage bay, the harvesting station, the stocking

station, and the cleaning station are located within a single tower. In some examples, the storage bay and a second storage bay are stacked vertically such that a plurality of self-contained units are stored in a vertically stacked configuration. In some examples, the storage bay and a second storage bay are stacked horizontally such that a plurality of self-contained units are stored in a horizontally stacked configuration. In some examples, the storage bay is configured to couple to an umbilical portion of a self-contained unit of the plurality of self-contained units. In some examples, the umbilical portion is configured to transmit one or more of electrical power, gasses, liquids, or any combination thereof. In some examples, the system further comprises a system configured to generate saltwater from freshwater. In some examples, saltwater is not discharged during the operation of the system. In some examples, the plurality of self-contained units is at least about 100 self-contained units. In some examples, the plurality of self-contained units is at least about 25 self-contained units. In some examples, the system comprises a plurality of storage bays, a plurality of harvesting stations, a plurality of stocking stations, or a plurality of cleaning stations.

[0008] In a second aspect, the present disclosure provides a method, comprising: (a) providing a first self-contained unit and a second self-contained unit each configured for growth of at least one water-growing organism; (b) growing a first water-growing organism in the first self-contained unit, wherein the growing comprises providing a first feed source to the first water-growing organism; (c) growing a second water-growing organism in the second self-contained unit, wherein the first water-growing organism is a feed source for the second water-growing organism; and (d) regulating the providing the first feed source based on one or more of a biomass of the first water-growing organism, a biomass of the second water-growing organism, a behavioral feature of the first water-growing organism, a behavioral feature of the second water-growing organism, or any combination thereof.

[0009] In some examples, the regulating comprises use of one or more sensors configured to observe the first self-contained unit or the second self-contained unit, the first

water-growing organism, the second water-growing organism, or any combination thereof. In some examples, the sensors comprise at least one of temperature sensors, pH sensors, dissolved gas sensors, turbidity sensors, nitrate sensors, nitrite sensors, nitrate sensors, ammonia sensors, phosphate sensors, cameras, sensors to measure the presence or absence of bacterial species, or any combination thereof. In some examples, the regulating comprises use of a machine learning algorithm. In some examples, the machine learning algorithm comprises a computer vision algorithm. In some examples, the method further comprises transporting the first water-growing organism from the first self-contained unit to the second self-contained unit. In some examples, the first self-contained unit and the second self-contained unit are a same self-contained unit. In some examples, the method further comprises providing an additional water-growing organism to the first self-contained unit or the second self-contained unit. In some examples, the additional water-growing organism consumes waste from one or more of the first water-growing organism or the second water-growing organism. In some examples, the first water-growing organism is algae or seaweed. In some examples, the second water-growing organism is shrimp. In some examples, the second water-growing organism is fish.

[0010] In another aspect, the present disclosure provides a method, comprising: (a) providing a self-contained unit configured for the growth of a water-growing organism; and (b) growing the water-growing organism with a time to maturity of the water-growing organism of less than a time to maturity of a water-growing organism grown outside of the self-contained unit.

[0011] In some examples, the water-growing organism is a shrimp. In some examples, the time to maturity is less than about 80 days. In some examples, the time to maturity is less than about 55 days. In some examples, the water-growing organism brought to maturity with a feed conversion rate of at most about 1.3. In some examples, the water-growing organism brought to maturity with a feed conversion rate of at most about 1. In some examples, the self-contained unit does not comprise a raceway.

[0012] Another example of the present disclosure provides a non-transitory computer readable medium comprising machine executable code that, upon execution by one or more computer processors, implements any of the methods above or elsewhere herein.

[0013] Another example of the present disclosure provides a system comprising one or more computer processors and computer memory coupled thereto. The computer memory comprises machine executable code that, upon execution by the one or more computer processors, implements any of the methods above or elsewhere herein.

[0014] Additional aspects and advantages of the present disclosure will become readily apparent to those skilled in this art from the following detailed description, wherein only illustrative examples of the present disclosure are shown and described. As will be realized, the present disclosure is capable of other and different examples, and its several details are capable of modifications in various obvious respects, all without departing from the disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

INCORPORATION BY REFERENCE

[0015] All publications, patents, and patent applications mentioned in this specification are herein incorporated by reference to the same extent as if each individual publication, patent, or patent application was specifically and individually indicated to be incorporated by reference. To the extent publications and patents or patent applications incorporated by reference contradict the disclosure contained in the specification, the specification is intended to supersede and/or take precedence over any such contradictory material.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative.

CLAIMS

WHAT IS CLAIMED IS:

1. A system, comprising:
    (a) a plurality of self-contained units configured for growth of at least one water-growing organism;
    (b) a storage bay;
    (c) a harvesting station;
    (d) a cleaning station;
    (e) a stocking station; and
    (f) an automated system configured to move said plurality of self-contained units between said storage bay, said harvesting station, said stocking station, and said cleaning station.
2. The system of claim 1, further comprising a non-transitory computer readable medium comprising instructions that, when executed, direct said plurality of self-contained units between said storage bay, said harvesting station, said stocking station, and said cleaning station.
3. The system of claim 1, wherein said storage bay, said harvesting station, said stocking station, and said cleaning station are located within a single tower.
4. The system of claim 1, wherein said storage bay and a second storage bay are stacked vertically such that a plurality of self-contained units are stored in a vertically stacked configuration.
5. The system of claim 1, wherein said storage bay and a second storage bay are stacked horizontally such that a plurality of self-contained units are stored in a horizontally stacked configuration.
6. The system of claim 1, wherein said storage bay is configured to couple to an umbilical portion of a self-contained unit of said plurality of self-contained units.

7. The system of claim 6, wherein said umbilical portion is configured to transmit one or more of electrical power, gasses, liquids, or any combination thereof.
8. The system of claim 1, wherein saltwater is not discharged during the operation of the system.
9. The system of claim 1, wherein said plurality of self-contained units is at least about 25 self-contained units.
10. The system of claim 9, wherein said system comprises a plurality of storage bays, a plurality of harvesting stations, a plurality of stocking stations, or a plurality of cleaning stations.
11. The system of claim 1, wherein a self-contained unit of said plurality of self-contained units is in fluid communication with a nitrification bed bioreactor, which nitrification moving bed bioreactor comprises a containment vessel configured to enclose biofiltration media and a fluidizing aeration source.
12. The system of claim 1, wherein said at least one water-growing organism is grown at a feed conversion rate of at most about 1.3
13. A method, comprising:
    (a) providing a first self-contained unit and a second self-contained unit each configured for growth of at least one water-growing organism;
    (b) growing a first water-growing organism in said first self-contained unit, wherein said growing comprises providing a first feed source to said first water-growing organism;
    (c) growing a second water-growing organism in said second self-contained unit, wherein said first water-growing organism is a feed source for said second water-growing organism; and
    (d) regulating said providing said first feed source based on one or more of a biomass of said first water-growing organism, a biomass of said second water-growing organism, a behavioral feature of said first water-growing organism, a behavioral feature of said second water-growing organism, or any combination thereof.

14. The method of claim 13, wherein said regulating comprises use of one or more sensors configured to observe said first self-contained unit or said second self-contained unit, said first water-growing organism, said second water-growing organism, or any combination thereof.
15. The method of claim 14, wherein said sensors comprise at least one of temperature sensors, pH sensors, dissolved gas sensors, turbidity sensors, nitrate sensors, nitrite sensors, nitrate sensors, phosphate sensors, cameras, sensors to measure the presence or absence of bacterial species, or any combination thereof.
16. The method of claim 13, wherein said regulating comprises use of a machine learning algorithm comprising a computer vision algorithm.
17. The method of claim 13, further comprising transporting said first water-growing organism from said first self-contained unit to said second self-contained unit.
18. The method of claim 13, further comprising providing an additional water-growing organism to said first self-contained unit or said second self-contained unit.
19. The method of claim 18, wherein said additional water-growing organism consumes waste from one or more of said first water-growing organism or said second water-growing organism.
20. The method of claim 13, wherein said first water-growing organism is algae or seaweed.
21. The method of claim 13, wherein said second water-growing organism is shrimp or fish.