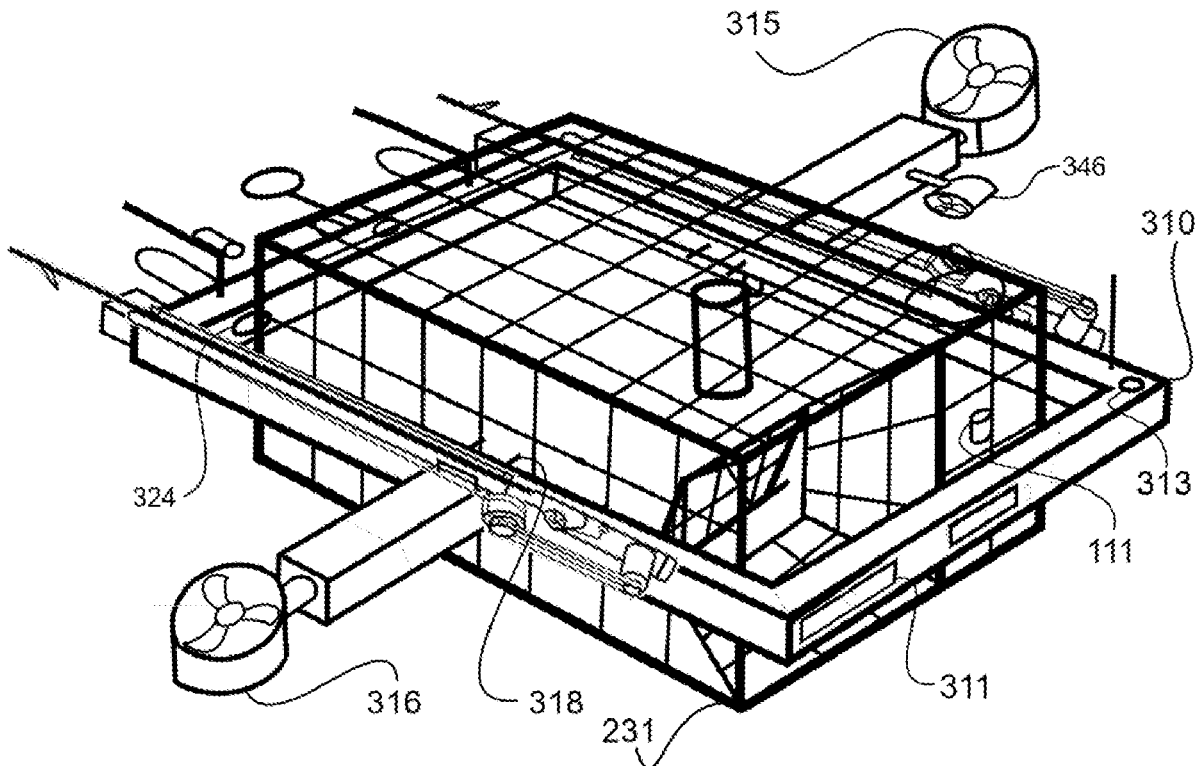




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(19) **United States**(12) **Patent Application Publication****Fu et al.**(10) **Pub. No.: US 2021/0307305 A1**(43) **Pub. Date: Oct. 7, 2021**(54) **NATURE-INSPIRED DESIGN AND
ENGINEERING OF AUTONOMOUS
SEAFOOD CAPTURING, SORTING AND
DELIVERING SYSTEM**(71) Applicants: **Lillian R. Fu**, San Jose, CA (US); **Eric
R. Fu**, San Jose, CA (US)(72) Inventors: **Lillian R. Fu**, San Jose, CA (US); **Eric
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(2013.01); **B64C 2201/128** (2013.01); **B64C**
39/024 (2013.01); **B64C 2201/027** (2013.01);
A01K 81/04 (2013.01)(57) **ABSTRACT**

Presented is a system and method via nature-inspired design and engineering to autonomously fish, sort and deliver the catch. It implements rope-less fishing via a novel variable buoyancy device and an autonomous aerial and underwater vehicle as a fishing gear carrier. Its versatile capabilities are comprised of the AI sorting capability to comply with regulations, the capability to capture renewable energy to reduce operating costs, the capability to both passively fish with bait and proactively hunt for fish and the capability to gather intelligence to find optimal fishing grounds.



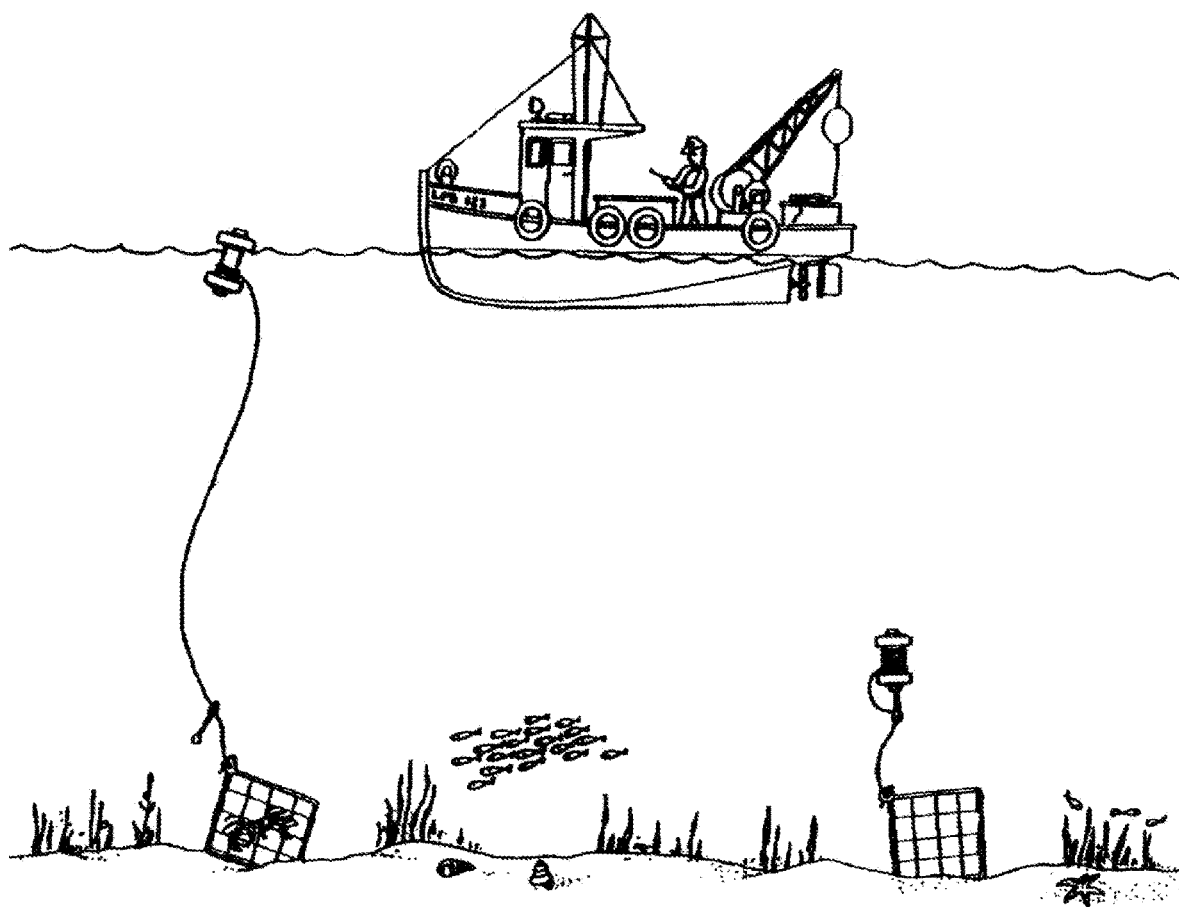


FIG. 1
PRIOR ART

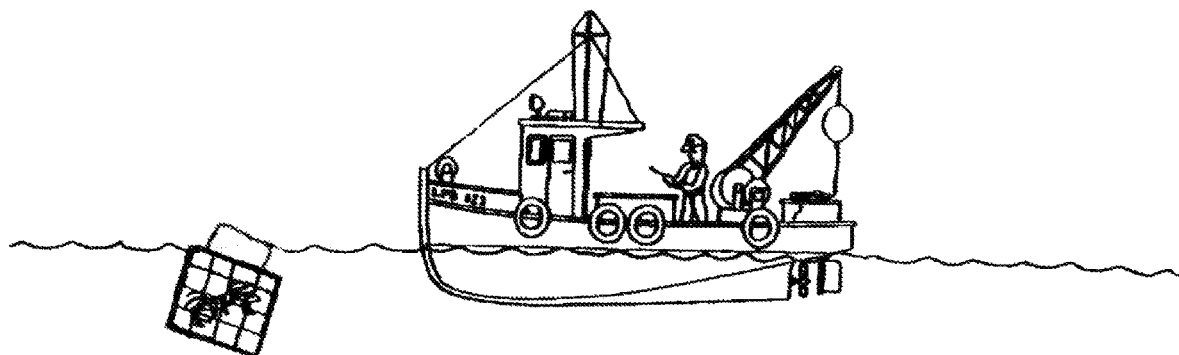


FIG. 2
PRIOR ART



FIG. 3
PRIOR ART

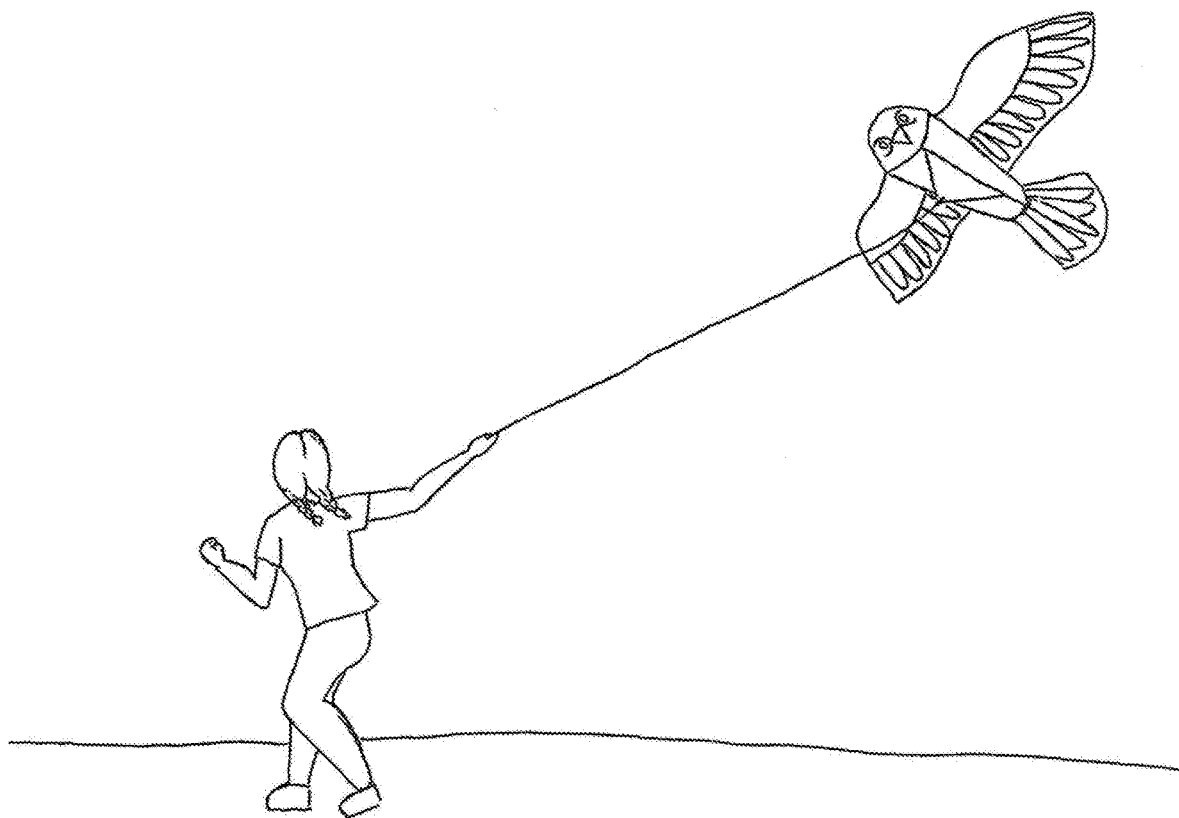


FIG. 4
PRIOR ART

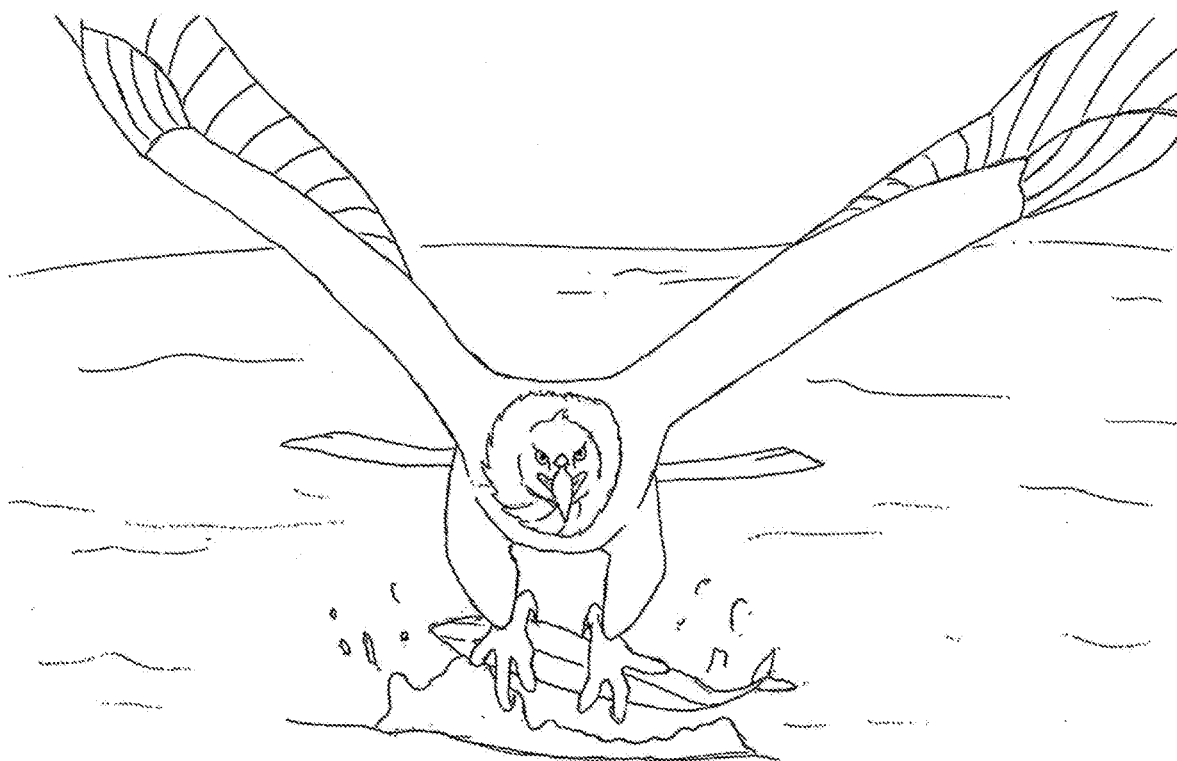


FIG. 5
PRIOR ART



FIG. 6
PRIOR ART

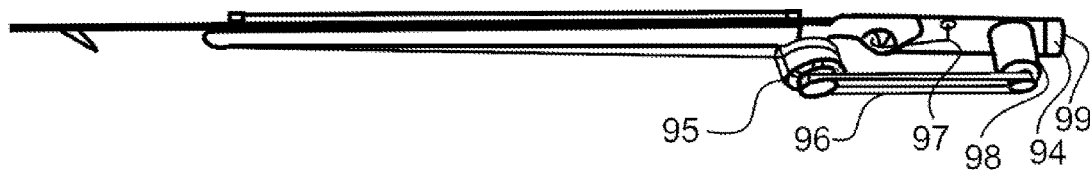


FIG. 7

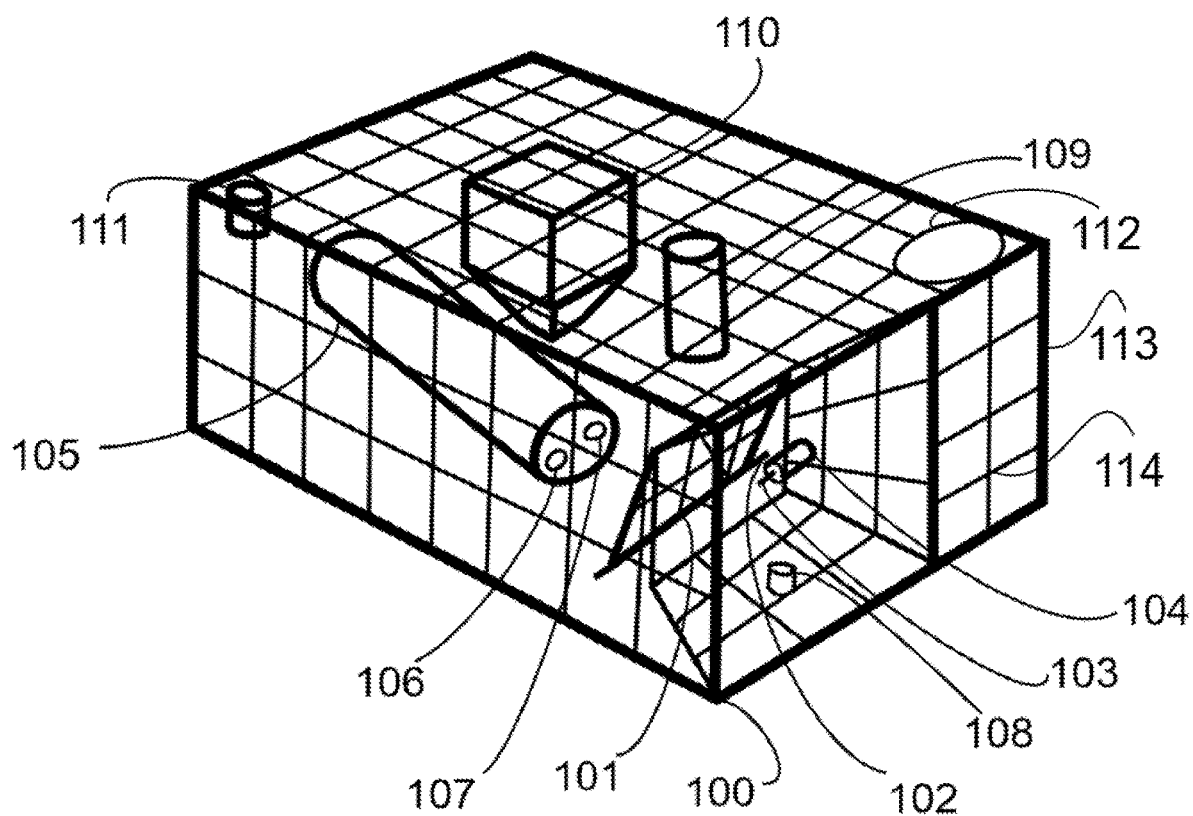


FIG. 8

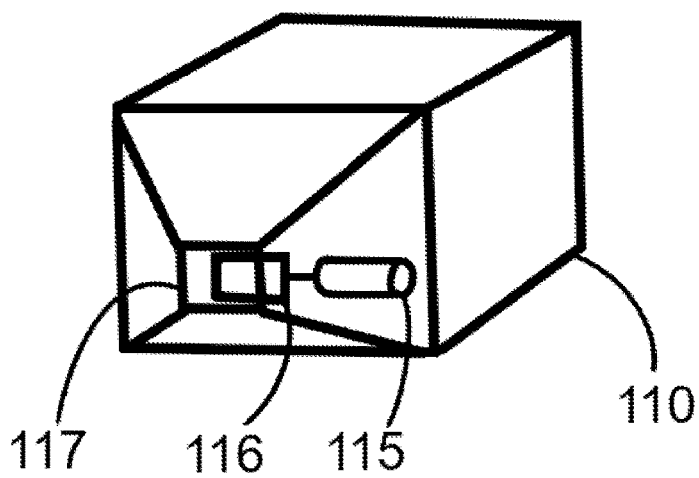


FIG. 9

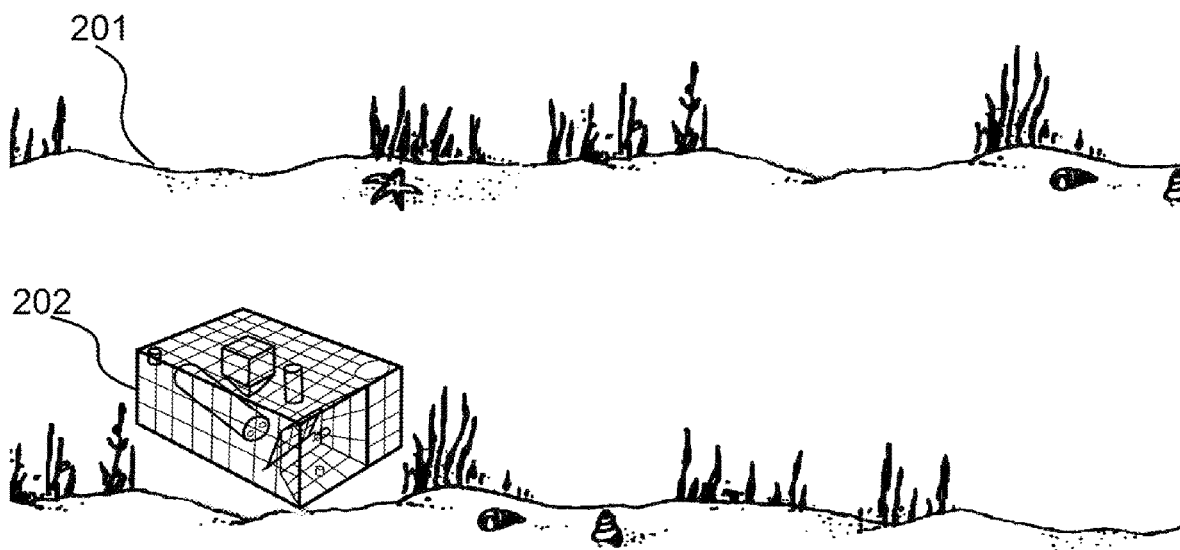
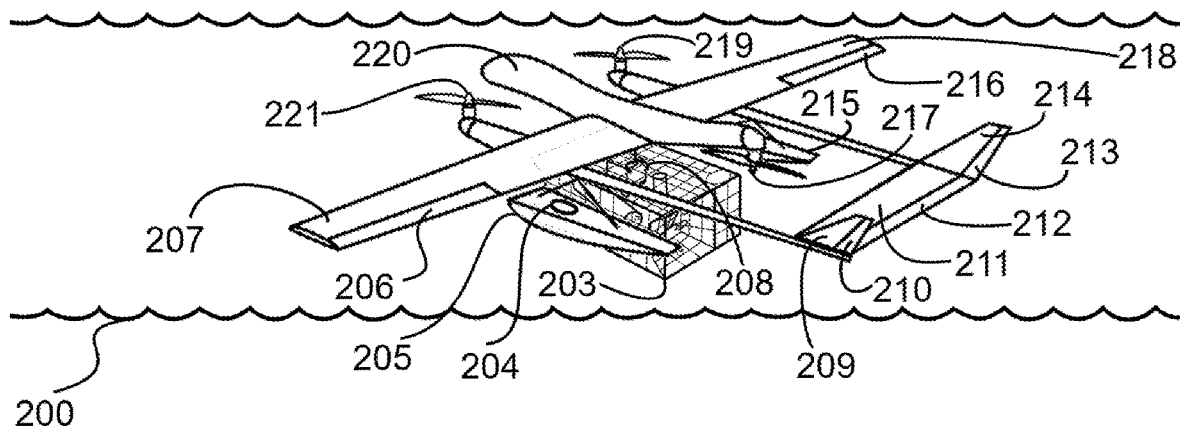


FIG. 10

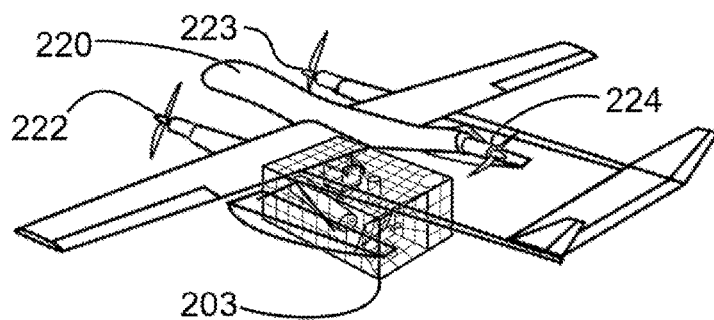


FIG. 11

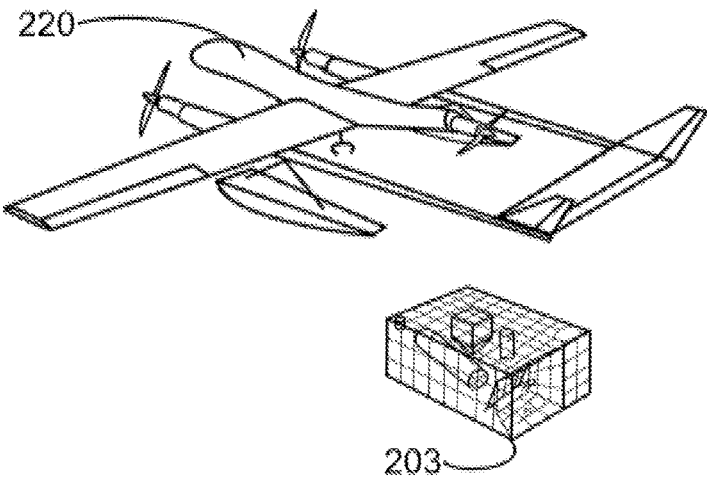


FIG. 12

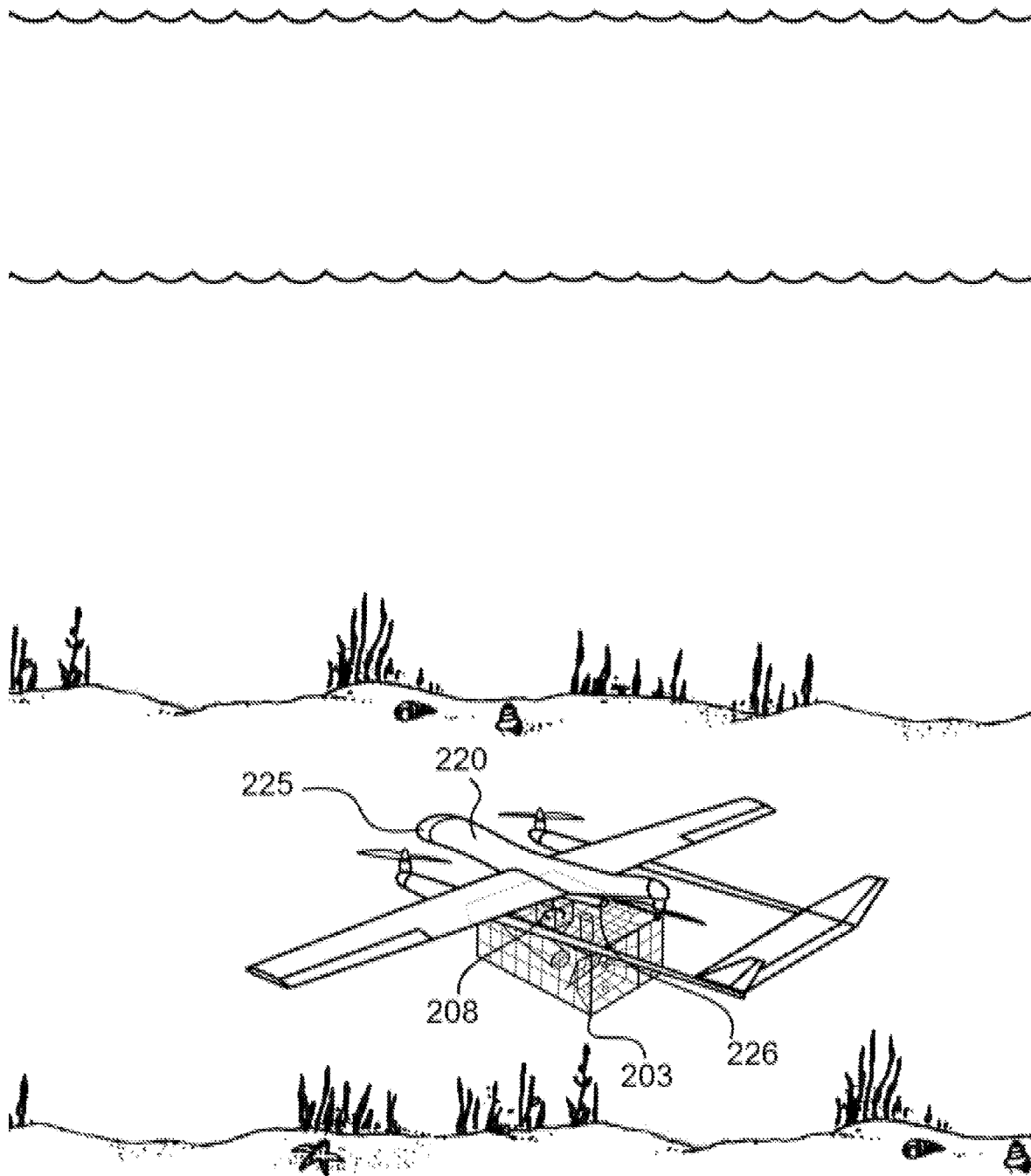


FIG. 13

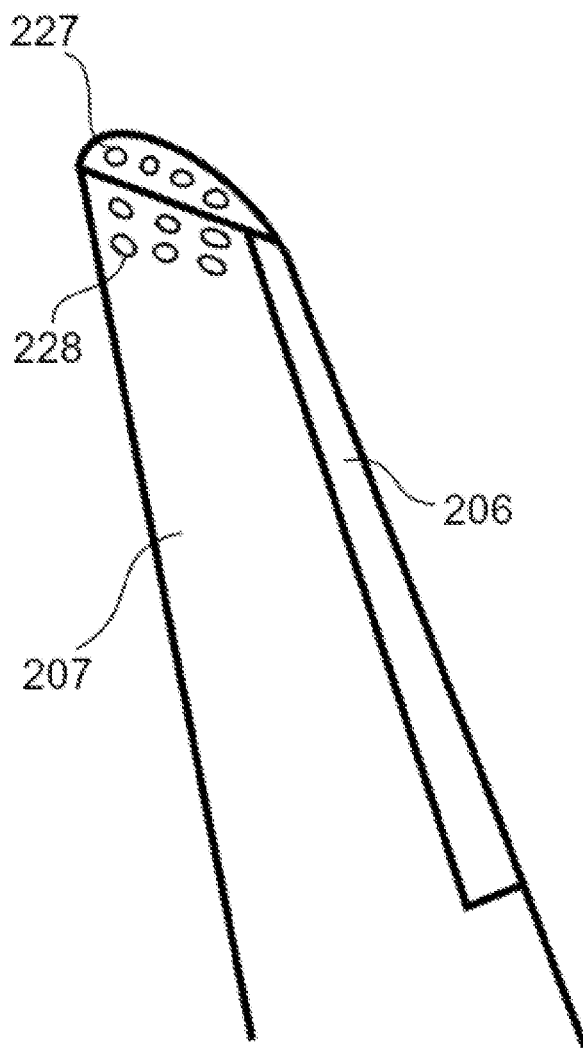


FIG. 14

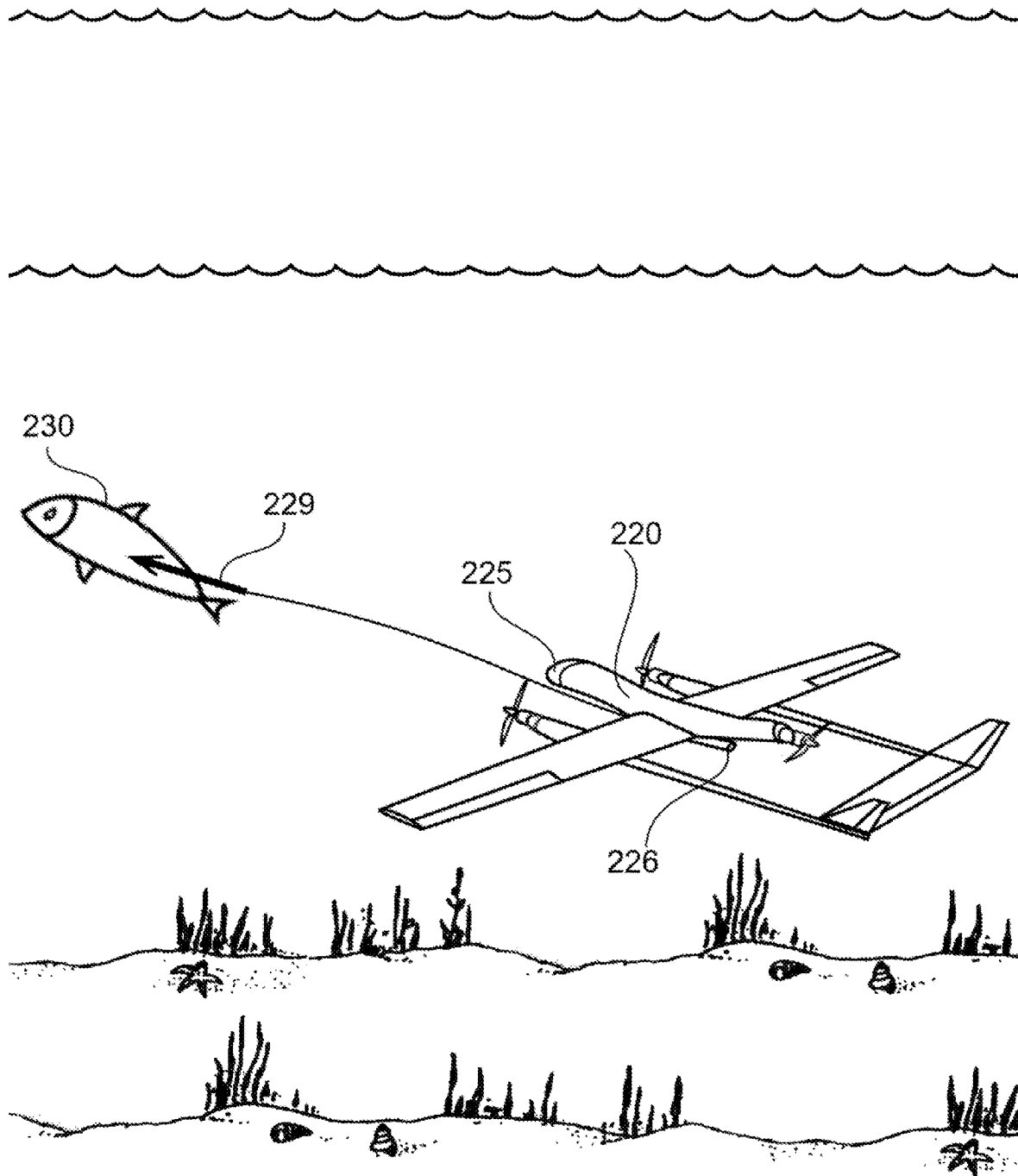


FIG. 15

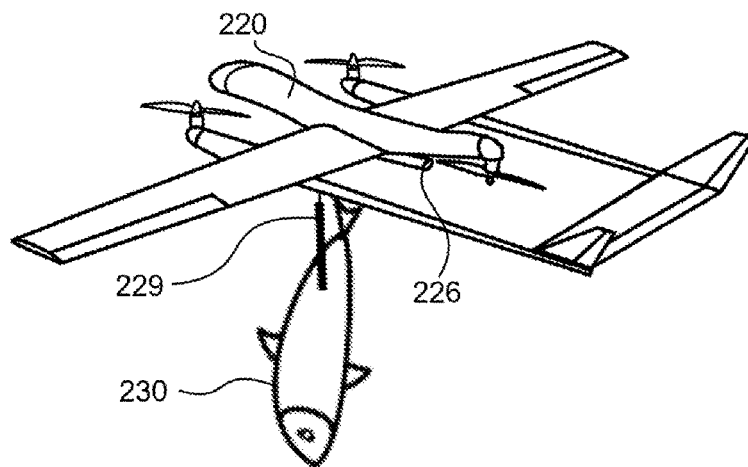


FIG. 16

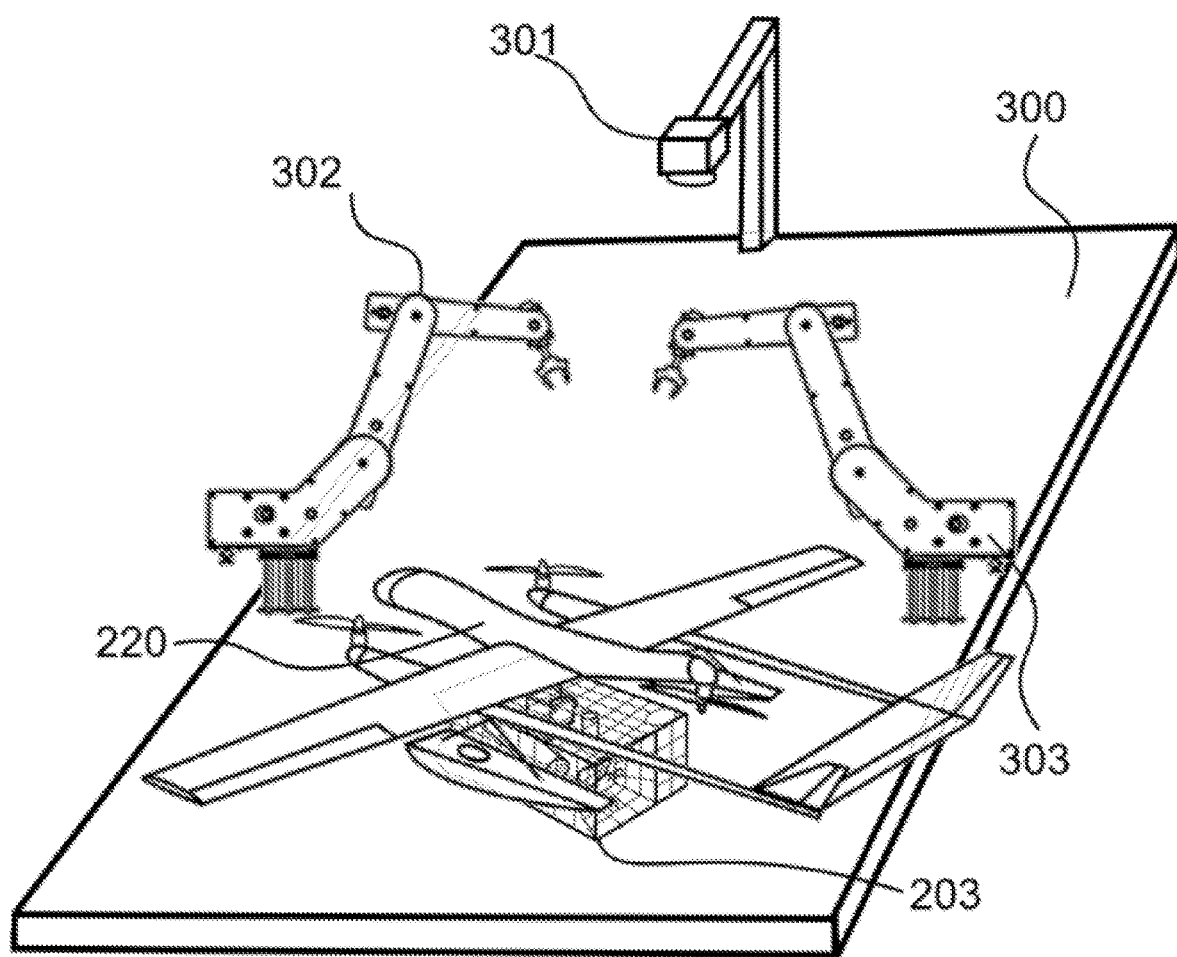


FIG. 17

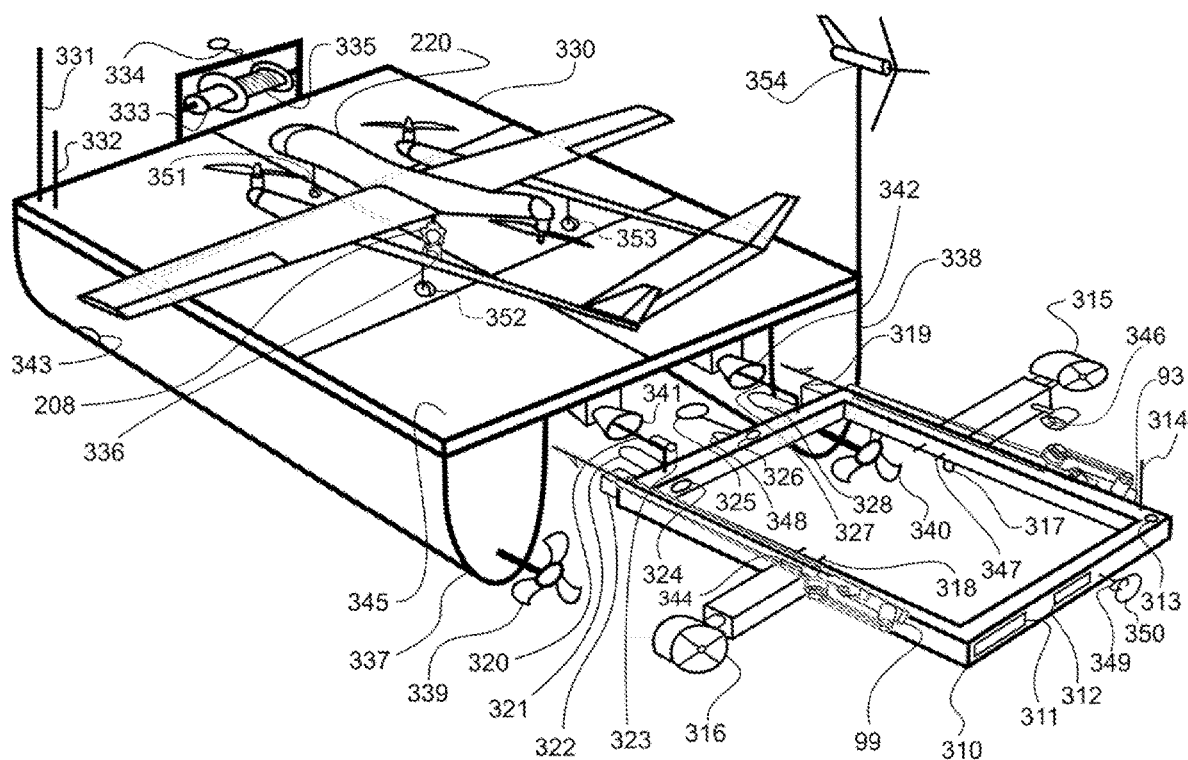


FIG. 18

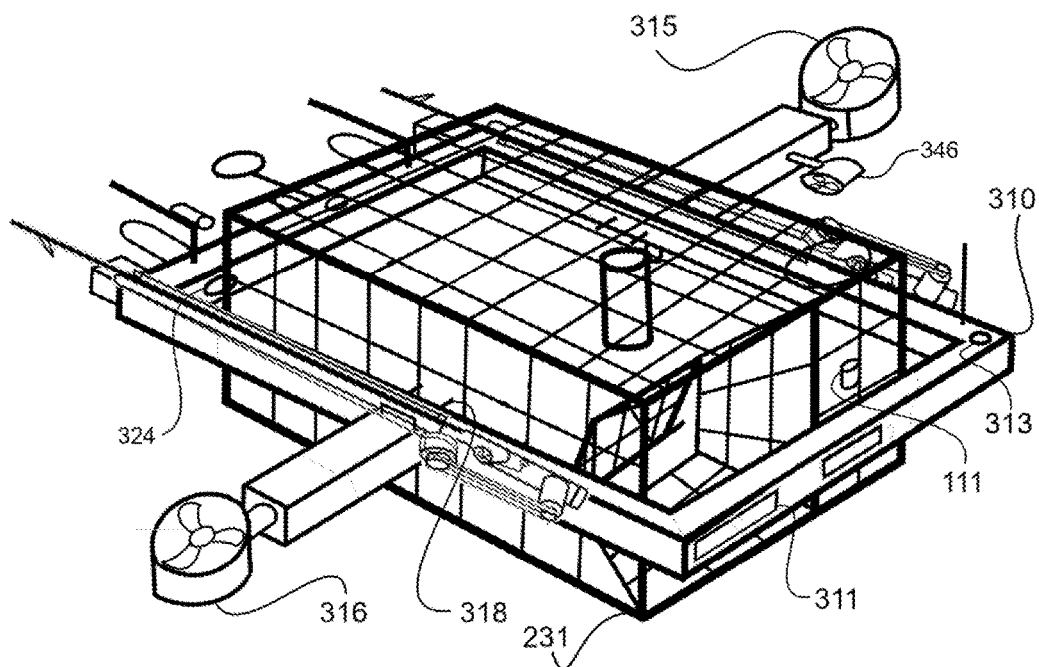


FIG. 19

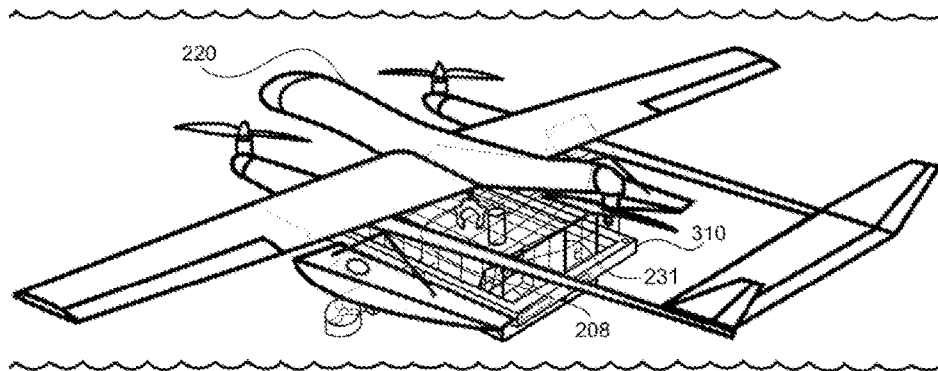


FIG. 20

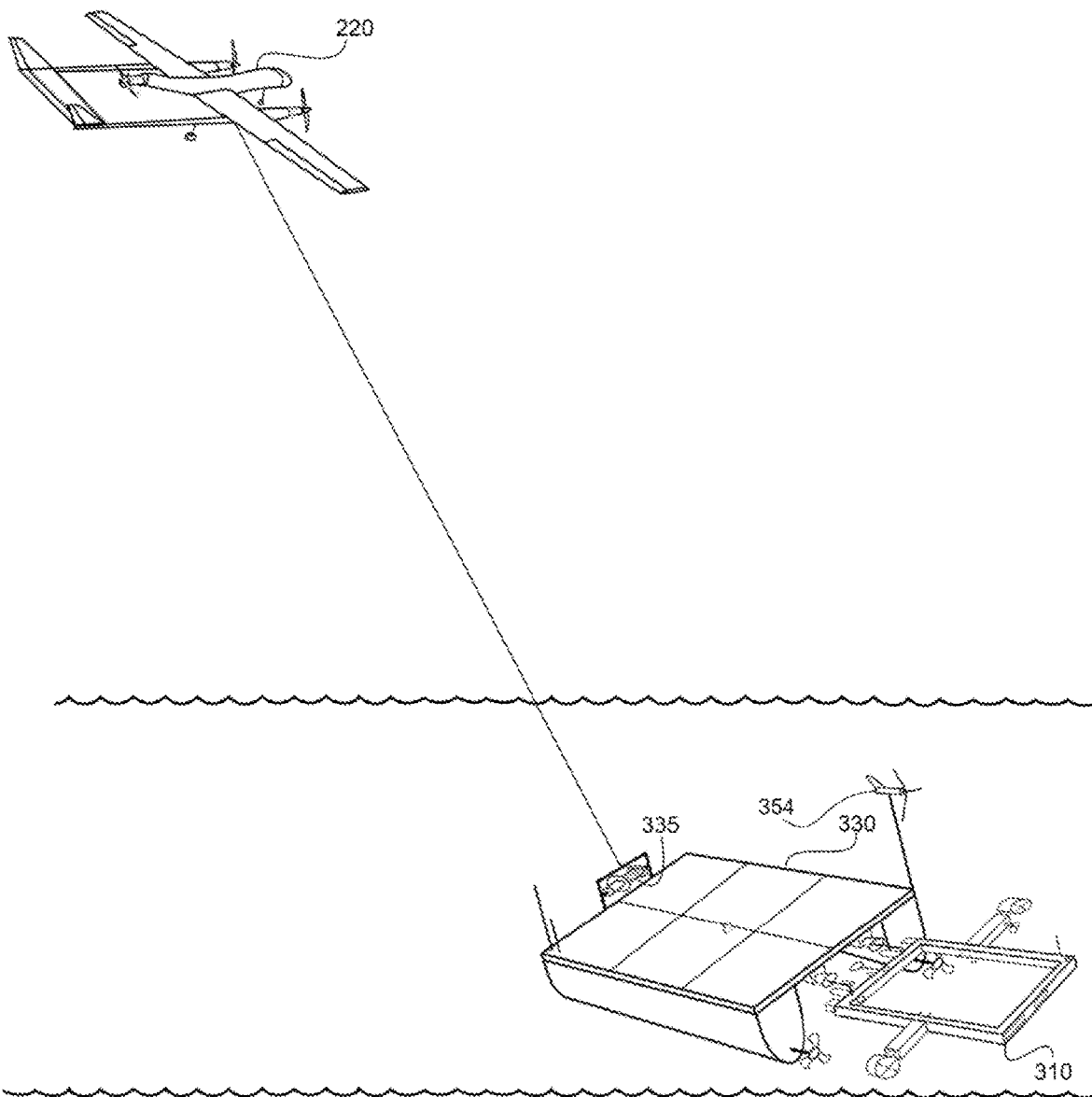
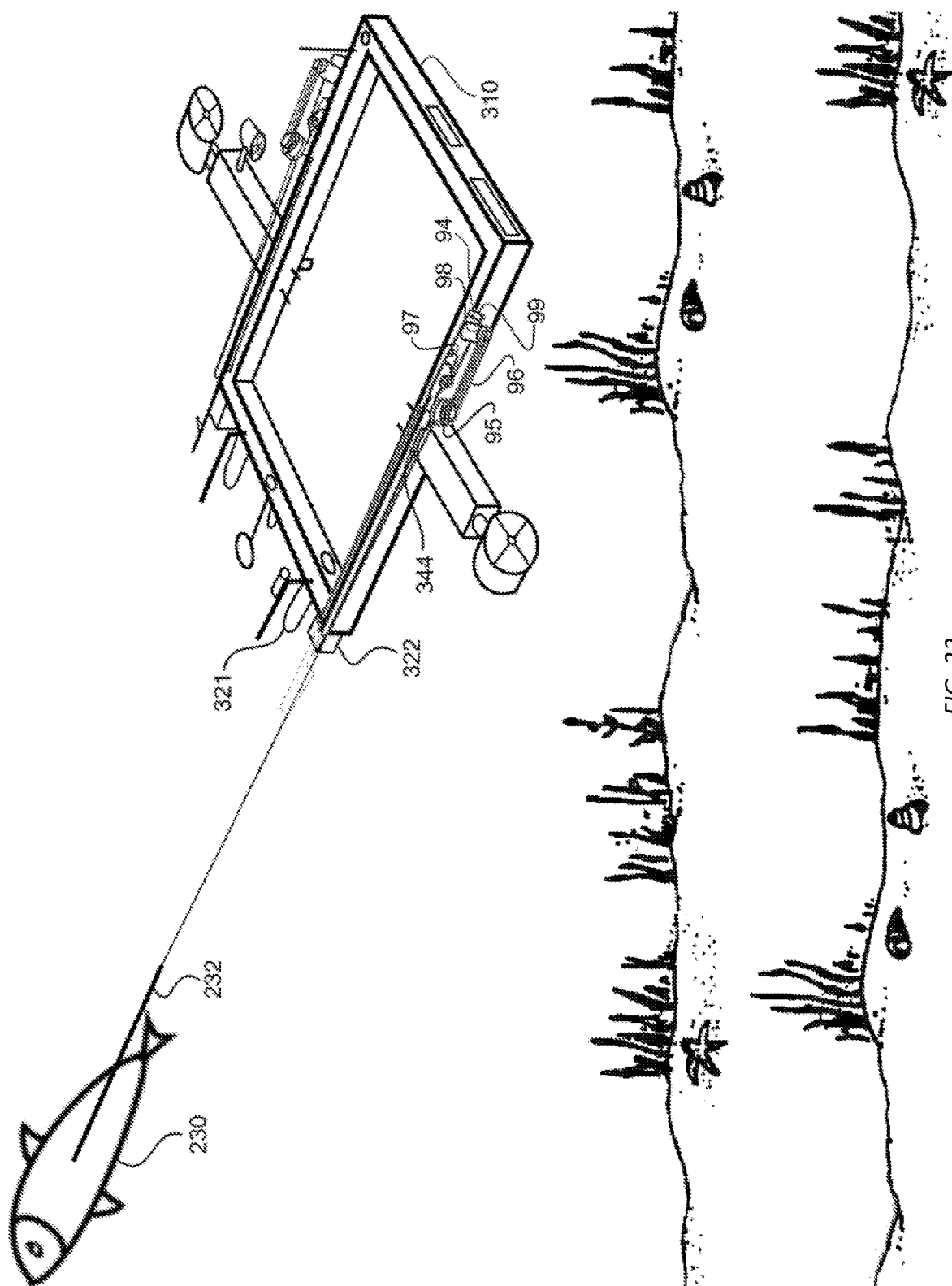
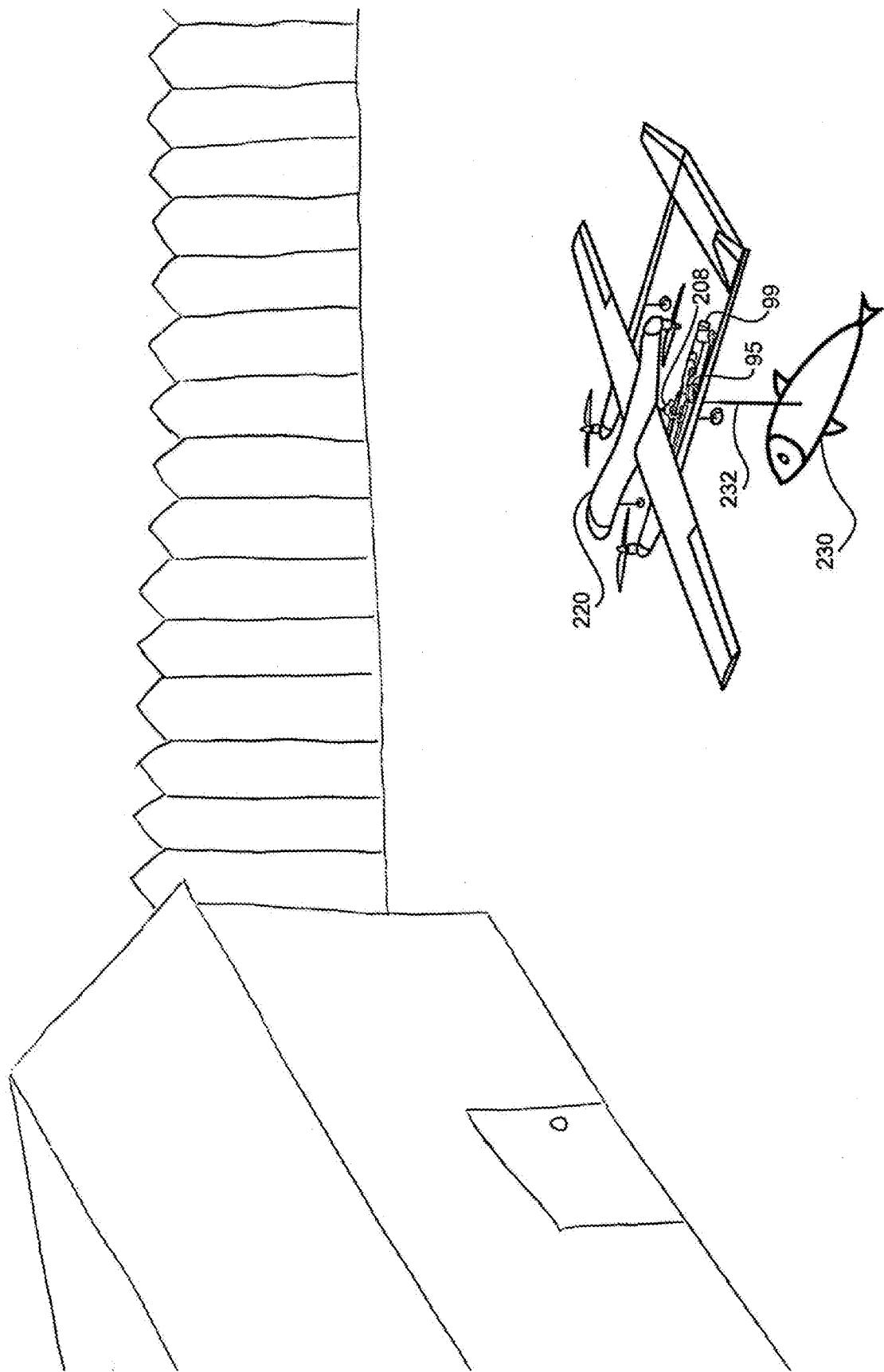


FIG. 21





NATURE-INSPIRED DESIGN AND ENGINEERING OF AUTONOMOUS SEAFOOD CAPTURING, SORTING AND DELIVERING SYSTEM

BACKGROUND OF THE INVENTION

[0001] Crabbing is well known for being an incredibly hazardous profession; professional crabbers run the risk of serious injury and/or death as a part of their livelihood. The fatality rate of crabbers is approximately 300 per every 100,000 workers in both the Alaskan king crab fishing industry as well as the West Coast Dungeness fishing industry. This figure is caused mainly by drowning and hypothermia; the areas where crabbers sail to for the best catches are oftentimes in rough patches of sea that can easily lead to sailing accidents.

[0002] Many similarly dangerous jobs have been streamlined and made more efficient while also eradicating occupational hazards by automating components of the process. The presented inventions would automate fishing processes such as crab catching, therefore eliminating many of the hazards involved in the fishing industry.

[0003] Some embodiments of the present invention utilize marine environment-friendly rope-less fishing technology. Traditional fishing using a trap involves a rope that connects a buoy on the water surface to a trap on the floor. Such ropes hanging vertically in water column pose risks to marine mammals. The latest assessment of the North Atlantic right whale population is bleak. Of the right whales whose cause of death can be determined, all but calves are found to die from fishing gear entanglements and ship strikes. Fishing gear entanglements currently account for 82% of documented right whale mortalities, while the remaining 18% are caused by ship strikes. An astounding 85% of all right whales bear scars from being entangled at least once in their lives, and more than half have been entangled two or more times. When whales get entangled, they entangle in ropes; they do not get caught in traps or buoys. Therefore, one of the most effective approaches to addressing the entanglement problem will be to remove ropes from fixed fishing gear, particularly for the trap/pot fishery. Rope-less fishing gear is a broad term describing developing technologies that either partially or fully eliminate the vertical rope or line between the fixed bottom-fishing gear (i.e., pots, traps) and a surface buoy. In the context of whale entanglements, the thinking is that reducing the vertical lines in the ocean could reduce, or eventually fully eliminate the entanglements of marine wildlife with fixed fishing gear in the ocean.

[0004] Recovery methods that allow a trap to surface on its own include bottom-stowed rope and variable buoyancy traps. The recovery methods disclosed in U.S. Pat. Nos. 6,261,142, 10,375,939 and 6,739,924 belong to the bottom-stowed rope category. The drawback of the recovery using bottom-stowed rope is that the rope is not totally eliminated, nor are such processes of handling the rope as rewinding the rope. There is also a cost to purchase and maintain the rope. Besides duration limitation due to battery capacity, the fishing method disclosed in U.S. Pat. No. 10,268,193 suffers similar drawbacks associated with the lines used in fishing. Variable buoyancy can be created by using a piston pump that changes the volume of a cylinder or compressed air to fill an inflatable bladder. U.S. Pat. No. 7,232,354 discloses a variable buoyancy device. Due to the high pressure at the ocean floor, compared with the method of creating variable

buoyancy in the present invention the two above-mentioned methods of creating variable buoyancy are expensive and also difficult to implement. The present invention utilizes heavier-than-water substances such as sand, which is abundant and almost cost-free, to create variable buoyancy. The present invention also has features not presented in the above-mentioned U.S. patents, such as utilizing artificial intelligence (AI) capability to sort catches for purposes including complying with regulations, capturing renewable energy to reduce operating costs and being able to proactively hunt fish besides passively fishing with bait.

[0005] As such, there is a need in the industry for this invention, which can save lives by using autonomous devices and artificial intelligence (AI).

[0006] There is a need in the art for an Autonomous Seafood Capturing, Sorting, and Delivering System. Additionally, there is a need in the art for an Autonomous Seafood Capturing, Sorting, and Delivering System comprising an unmanned aerial vehicle capable of vertical take-off and landing, which docks and/or connects with a submersible structure that is capable of capturing and sorting seafood.

SUMMARY OF THE INVENTION

[0007] This invention was initially inspired by one of nature's seamless fishing and delivering phenomena: as shown in FIG. 5, an eagle can catch a fish out of water on the fly and fly to its nest while carrying the prey.

[0008] One of objectives of the invention is to bring automation to labor-intensive and hazardous fishing industries such as the crabbing industry, thereby optimizing the process as well as reducing potential risks.

[0009] It is an objective of this invention to help reduce entanglement of marine wildlife by eliminating fishing rope via rope-less fishing. Besides a novel variable buoyancy device inspired by hourglasses, this invention also provides a way to retrieve fishing gear using an autonomous underwater vehicle (AUV) as a fishing gear carrier.

[0010] It is an objective of this invention to sort the catches via AI object detection to collect information on an individual catch such as the species of the catch, and the size and sex of the catch if applicable. Based on the detected information, only qualified catches will be kept in order to comply with regulations. This invention provides 2 types of sorting: one at the individual fishing gear and another at a specialized sorting table.

[0011] It is an objective of this invention to be able to deliver the catch to a desired destination such as a sorting table at a processing center or the backyard of a house belonging to either a customer or the owner of the fishing gear, just like an eagle brings its catch to its nest.

[0012] It is an objective of this invention to capture renewable energy in order to reduce operating costs. Fuel cost is a large portion of the total cost in a conventional fishing operation.

[0013] It is an objective of this invention to provide versatile fishing mechanisms. Besides passive fishing such as using a trap with bait or using a fishing line with a hook and bait at one end, this invention also provides a proactive fish hunting mechanism.

[0014] It is an objective of this invention to be able to provide intelligence on high concentrations of target fish or shellfish prior to deploying fishing gear or before a new fishing season starts by deploying one or more AI-capable AUVs as scouts to the fishing grounds. Such intelligence on

optimal fishing grounds will greatly improve productivity and business competitiveness. Deployed AI-capable AUVs with fishing gear can also provide information for determining where the best fishing spots are based on what it catches in each area.

[0015] This invention also provides a design of an autonomous aerial and underwater vehicle (A²UV), which is capable of flying both in the air and going underwater. An A²UV can perform both the tasks of a vertical take-off and landing (VTOL) unmanned aerial vehicle (UAV) and the tasks of an AUV.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] These as well as other features of the present invention will become more apparent upon reference to the accompanying drawings wherein like numerals designate corresponding parts in the several figures summarized as follows:

[0017] FIG. 1 shows a prior art depicting a method of recovering fishing trap in rope-less fishing using a buoyant spool.

[0018] FIG. 2 shows a prior art depicting a method of recovering fishing trap in rope-less fishing using variable buoyancy.

[0019] FIG. 3 shows a prior art depicting that sand is flowing down in an hourglass.

[0020] FIG. 4 shows a prior art depicting that a girl is playing with a kite.

[0021] FIG. 5 shows a prior art depicting that an eagle is flying away with a fish caught from water.

[0022] FIG. 6 shows a prior art depicting a speargun for spearfishing.

[0023] FIG. 7 shows a speargun enhancement of adding an automatic mechanism to rewind and to pull the trigger.

[0024] FIG. 8 is a perspective view of a fishing trap with an hourglass-like variable buoyancy device and artificial intelligence (AI) capability.

[0025] FIG. 9 is a perspective view of an hourglass-like variable buoyancy device, showing the door opening mechanism at the bottom of the device.

[0026] FIG. 10 is a perspective view of one embodiment of the invention, showing at water surface an unmanned aerial vehicle (UAV) capable of vertical take-off and landing (VTOL) is ready to take off vertically to transport a surfaced fishing trap.

[0027] FIG. 11 is a perspective view of one embodiment of the invention, showing a VTOL UAV in horizontal flight mode with a fishing trap picked up from the water surface.

[0028] FIG. 12 is a perspective view of one embodiment of the invention, showing a fishing trap being deployed from the air by a UAV.

[0029] FIG. 13 is a perspective view of one embodiment of the invention, showing an autonomous aerial and underwater vehicle (A²UV), which is capable of flying both in air and underwater, picking up a fishing trap from the sea floor.

[0030] FIG. 14 is a perspective view of one embodiment of the invention, showing part of wing of an A²UV with holes at the wing tip for water to enter and exit from the A²UV.

[0031] FIG. 15 is a perspective view of one embodiment of the invention, showing an A²UV spearfishing.

[0032] FIG. 16 is a perspective view of one embodiment of the invention, showing an A²UV vertically flying out of the water with a fish caught by a spear.

[0033] FIG. 17 is a perspective view of one embodiment of the invention, showing a VTOL UAV vertically landing to deliver a fishing trap onto an automatic sorting table with AI capability.

[0034] FIG. 18 is a perspective view of one preferred embodiment of the invention, showing an autonomous surface vehicle (ASV) charging and transporting an autonomous underwater vehicle (AUV) and a VTOL UAV.

[0035] FIG. 19 is a perspective view of one embodiment of the invention, showing an AUV docked with a fishing trap in vertical motion mode.

[0036] FIG. 20 is a perspective view of one embodiment of the invention, showing a fishing trap brought up to surface by an AUV being transferred over to a VTOL UAV.

[0037] FIG. 21 is a perspective view of the preferred embodiment of the invention, showing an UAV, an ASV and an AUV in kite mode to capture renewable solar and wind energy.

[0038] FIG. 22 is a perspective view of one embodiment of the invention, showing an AUV spearfishing.

[0039] FIG. 23 is a perspective view of one embodiment of the invention, showing a VTOL UAV carrying a speargun and a fish captured by the spear launched by the speargun is landing in the backyard of a house to deliver the catch.

[0040] Other features and advantages of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, various features of embodiments of the invention.

DETAILED DESCRIPTION

[0041] The following detailed description and accompanying drawings are provided for the purpose of illustrating and describing presently preferred embodiments of the present invention and are not intended to limit the scope of the invention in any way. It will be understood that various changes in the details, materials, arrangements of parts or operational conditions which have been herein described and illustrated in order to explain the nature of the invention may be made by those skilled in the art within the principles and the scope of the invention.

[0042] The various embodiments of the invention shown in FIGS. 8-12 utilize variable buoyancy fishing traps and VTOL UAVs. A fishing trap rises to the surface by changing buoyance, then a VTOL UAV catches and delivers the surfaced trap to destination.

[0043] FIG. 8 is a perspective view of a fishing trap with an hourglass-like variable buoyancy device and AI capability. The fishing trap 100 is comprised of an outer frame 113, a net 114 wrapped around the frame, a door 101, a long rod 102, a door locker 104 with a locking rod 103, a water-tight AI controller 105 with light 106, camera 107 and camera 108, a bait container 109, an hourglass-like variable buoyancy device 110, an acoustic modem 111, and a juvenile escape ring 112. Due to regulations, certain kinds of fish or shellfish such as female crabs have to be released if they are caught. The AI-capable sorting table shown in FIG. 17 can perform this task. Here the AI-capable fishing trap 100 complies with the regulations in another way. The door locker 104 can be configured to be normally locked with the locking rod 103 extended out to prevent the door 101 from opening. Bait inside the bait container 109 attracts fish or shellfish to the door 101. The light 106 provides lighting for the camera 107 and 108. The camera 107 captures the upper

front view of the visitor in front of the door **101**, and the camera **108** captures the bottom view. For a crab, the bottom view of the crab can be used to determine if the crab is female or male. Images of the visitor are processed by the AI controller **105** to categorize the visitor, including its size and sex if applicable. The door **101** will be unlocked only when no regulation will be violated as a result. For example, regulations prohibit capturing female crabs and crabs which are too small. Once a large visitor gets into the trap **100**, it cannot escape because the long rod **102** prevents the door **101** from opening from inside. The acoustic modem **111** communicates with modules on the surface in a predefined way such as communicating at a fixed interval or only starting to communicate after being pinged. Information of what is caught inside can also be sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of target fish or shellfish. After receiving the command to surface or when the battery level is below a predefined threshold, the hourglass-like variable buoyancy device **110** is activated to release substances contained inside. FIG. 9 is a perspective view of the device **110**, showing the door opening mechanism at the bottom of the device. When door opener **115** pulls open door **116**, heavier than water substances such as sand contained in the device **110** will start to flow out due to gravity, therefore reducing the total weight of the trap. When the total weight of the trap is reduced to be less than buoyancy, the trap will start to float up. There are many ways to implement the door opener **115** and the door locker **104**, such as using a solenoid or a servo.

[0044] FIG. 10 is a perspective view of one embodiment of the invention, showing a VTOL UAV **220** at water surface **200** ready to vertically take off to transport a surfaced fishing trap **203**. At the floor **201** of the body of water, such as the sea floor, lies an AI-capable fishing trap **202** with variable buoyancy. The VTOL UAV **220** is comprised of a left tilt rotor **221**, a right tilt rotor **219**, a rear tilt rotor **217**, a left wing **207**, a right wing **218**, a left aileron **206**, a right aileron **216**, a right float **215**, a left float **205** with an acoustic modem **204** inside to communicate with traps at the floor of the body of water, a mini robotic arm **208**, a left vertical stabilizer **209**, a right vertical stabilizer **214**, a left rudder **210**, a right rudder **213**, a horizontal stabilizer **211** and an elevator **212**. After landing at the water surface, the VTOL UAV **220** can find and communicate with traps also equipped with acoustic modems. After a trap reports the number of catches inside, it can be commanded to surface. Then the VTOL UAV **220** uses its mini robotic arm **208** to catch the surfaced trap, and vertically take off to transport the trap to a destination. The destination could be a boat on the surface of the body of water or a location on land such as the backyard of a house. FIG. 11 shows the VTOL UAV **220** carrying trap **203** flying horizontally above the water's surface with its rotors in horizontal flight mode. FIG. 12 shows the re-supplied trap **203** being deployed from the air by the UAV **220**. The UAV **220** records location information such as the GPS coordinates of the trap drop location, so that the location information can be used to find and retrieve the trap.

[0045] FIG. 13 is a perspective view of one embodiment of the invention, showing an autonomous aerial and underwater vehicle (A²UV) **220** picking up a fishing trap **203** from the sea (or lake or river) floor. Besides a sensor compartment

225 which houses various sensors such as camera, sonar and a speargun **226**, other shown components are the same as the corresponding components shown in FIG. 10. Since the A²UV can navigate underwater, it can pick up any trap equipped with an acoustic modem that can emit the information of the owner of the trap. It does not require the trap to have means of surfacing, because the A²UV can bring the trap to the surface. FIG. 14 shows the outer part of a wing of an A²UV with holes **227** at the wing tip and holes **228** under the wing tip. Through holes **227** and **228**, water enters the A²UV when it submerges therefore eliminating the need to have a strong water-tight vehicle body that can withstand the high pressures at the sea floor. When the A²UV surfaces, water exits from holes **227** and **228** due to gravity. The A²UV can further roll to the left and to the right to get rid of the remaining water onboard.

[0046] FIG. 15 is a perspective view of one embodiment of the invention, showing an A²UV **220** spearfishing. After sonar and camera inside a sensor compartment **225** find and guide A²UV onto a fish **230**, a spear **229** launched by a speargun **226** pierces into the fish to catch the fish. As shown in FIG. 16, after rewinding the line attached to the spear, the A²UV flies out of the water vertically with the fish caught by the spear. Later the A²UV will transit to horizontal flight mode to transport the fish to a processing destination.

[0047] FIG. 17 shows that a VTOL UAV **220** is vertically landing to deliver a fishing trap **203** onto an automatic sorting table with AI capability. The sorting table is located on a boat on the water's surface or at a processing center on land. The sorting table is comprised of a flat surface **300**, an image capturing and AI processing module **301**, a left robotic arm **302** and a right robotic arm **303**. Additional robotic arms and additional image capturing and AI processing modules can be added to speed up the sorting process. For trap fishing, the robotic arms take out catches from traps and resupply the traps. The UAV then takes the resupplied trap away to storage or to re-deploy. The robotic arms take out the catch individually, then the image capturing and AI processing module captures and analyzes the image of the catch to determine category of the visitor, and size and sex of the catch if applicable. The robotic arms then keep the catch that complies with regulations and release the rest. Therefore, for trap fishing this invention eliminates the need of a rope attached to a trap, a buoy attached to the rope, the manual process of throwing a hook to catch the buoy, a line hauler to pull up all of the rope to get the trap out of the water and the manual process of sorting the catch. For spearfishing, the UAV delivers the catch onto the sorting table, and under the guide of the image-capturing and AI processing module, the robotic arms separate the catch from the spear, and then help reload the spear into the speargun. The sorting process of spearfishing is the same as that of trap fishing.

[0048] FIG. 18 is a perspective view of one preferred embodiment of the invention, showing an autonomous surface vehicle (ASV) **330** charging and transporting an autonomous underwater vehicle (AUV) **310** and a VTOL UAV **220**. The ASV is in form of geometry-stabilized catamaran, and is comprised of solar panel **345** as the top platform, a wind turbine **354** to generate electricity by capturing wind energy, a left hull **337**, a right hull **338**, a left propeller **339**, a right propeller **340**, an acoustic modem **343**, a charging pole **336**, a longer antenna **331** for longer wave long-range radio communication, a shorter antenna **332** for

short-range radio communication, a reel **335** with a ring **334** attached to one end of its threads and a motor **333** to rewind, a left docking and charging receptacle **341** and a right docking and charging receptacle **342**. The propellers also act as propeller turbines to generate electricity in kite mode. The UAV can land onto and take off vertically from the top platform. With the support of the ASV, the UAV can use the normal wheel type of landing gear **351**, **352** and **353**. When a mini robotic arm **208** of the UAV catches the charging pole **336**, the ASV can recharge the UAV. The AUV is comprised of a left ducted propeller **316**, a right ducted propeller **315**, an auxiliary ducted propeller **346** that can move the AUV laterally in order to provide better positioning control when docking with a fish trap or when aiming at a fish during spearfishing, an optional left speargun **99** with a left latch **344** which can hold the left speargun in place, an optional right speargun **93**, an optional claw **349** which can open and close to catch or release an optional ring **350** for attaching additional fishing mechanism, such as a line with one end connecting to the ring **350** and the other end to attach one or more hooks and bait, an AI controller **311**, a battery compartment **312** holding and cooling batteries, an acoustic modem **313**, an antenna **310** for radio communication when the AUV comes to the water surface, a downward looking camera **317**, an inward looking camera **324** for docking control, an upward looking camera **326**, a forward looking camera **323** for navigation and docking with the ASV, a sonar **348** to search fish or other underwater objects, a left aiming camera **322**, a right aiming camera **319**, a left light **321**, a right light **328**, a hook up ring **325**, a left docking and charging plug **320**, a right docking and charging plug **327**, a left pair **318** of push rods and a right pair **347** of push rods, which are used to catch a fishing trap when docking with the fishing trap. The left and right ducted propeller can be tilted into horizontal mode and vertical mode to provide vectored thrust. When docking with the ASV, images captured by the forward looking camera **323** are fed into the AI controller **311**, which controls propeller **315**, **316** and **346** accordingly to move the docking and charging plug **320** and **327** into corresponding docking and charging receptacle **341** and **342** respectively. After the AUV is docked with the ASV, the ASV can charge the AUV through the docking and charging plug **320** and **327**. A VTOL UAV can use a mini robotic arm to catch the hook up ring **325**, then lift the AUV out of water and transport it to a destination.

[0049] FIG. 19 shows that an AUV **310** docks with a fishing trap **231**. During the docking process, the propeller **346** provides lateral movement as needed, and the ducted propeller **315** and **316** provides up and down movement in vertical mode and back and forth movement in horizontal mode. Camera **324**, **317** and **326** as shown in FIG. 18 provide various visual feedback to the AI controller **311** to control the docking approach. After the AUV gets into the right position, it pushes the push rod **318** and **347** inwards to catch the fishing trap. Then the ducted propeller **315** and **316** tilt into vertical mode to bring the trap up to water surface. The trap **231** is not required to have variable buoyance to surface on its own as the AUV can bring it up. After the trap **231** is brought up to the water surface, as shown in FIG. 20 a VTOL UAV **220** can dock with it and catch it, and then transport it to a destination.

[0050] FIG. 21 is a perspective view of the preferred embodiment of the invention, showing a UAV **220**, an ASV **330** and an AUV **310** in kite mode to capture renewable solar

and wind energy. With a thread from reel **335** connecting the UAV to the ASV, the UAV acts as a kite flying in the sky to capture wind energy with its propellers acting as wind turbines. The UAV acting like a kite drags the ASV to move, and the movement of the ASV turns the propellers of the ASV into water turbines to generate electric power. If the AUV is docked with the ASV, the AUV will also be dragged along, and such movement will turn the left and right propeller of the AUV into water turbines to generate electric power. A wind turbine **354** on the ASV **330** also captures wind energy to generate electricity. The solar panel on top of the ASV collects solar energy to generate electricity. The generated electric energy will be stored into rechargeable batteries onboard the UAV, the ASV and the AUV. By capturing renewable energy, this invention can greatly reduce operating costs while cost of fuel is a large portion of the total cost in a conventional fishing operation.

[0051] FIG. 22 shows an AUV **310** spearfishing. After sonar and camera onboard the AUV find and guide the AUV to a fish **230**, a spear **232** launched by a speargun **99** pierces into the fish to catch the fish. After catching the fish, a motor **98** is activated to rewind a reel **95** to pull the fish towards the AUV. Afterwards, the AUV surfaces while carrying the catch. After the AUV surfaces, a VTOL UAV comes down to catch the speargun **99** with its mini robotic arm. A latch **344** is activated to release the speargun, and as shown in FIG. 23 the VTOL UAV can then take over the speargun **99**, and transport the fish caught by the speargun **99** to a destination. The destination shown in FIG. 23 is a backyard of a house.

[0052] An Autonomous Seafood Capturing, Sorting, and Delivering System comprising: One or more submersible structures each such structure further comprising: a trap for capturing seafood within a cage, said cage volume contained therein; said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod; said cage has a water-tight AI controller with one or more lights and two or more cameras; said cage has a bait container; said cage has a variable buoyancy device; and said cage has an underwater acoustic modem; wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations; wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way; wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood; and wherein, the variable buoyancy device is activated to release substances contained inside, after receiving the command to surface or when the battery level is below a predefined threshold.

[0053] Wherein said submersible structures are autonomous, said autonomous submersible structure has a spear and a speargun for launching said spear to into a fish to catch said fish; wherein after catching said fish, a motor is activated to rewind a reel to pull said fish towards said autonomous submersible structure; wherein thereafter, said autonomous submersible structure will surface while carrying said fish and dock to an unmanned aerial vehicle capable of vertical take-off and landing and then transport said submersible structure to a destination.

[0054] Further comprising a tender boat that remains in the general vicinity of said structures, and communicates with said structures. Further comprising a juvenile escape ring. Further comprising robotic underwater devices to clean said cage enclosures and remove debris and fatalities from said enclosures.

[0055] Wherein said submersible structures are autonomous, said autonomous submersible structures have a docking station for connecting to said cage. Wherein during the docking process, said autonomous submersible structures have one or more propellers provides lateral movement as needed, and one or more ducted propellers provides up and down movement in vertical mode and back and forth movement in horizontal mode. Wherein during the docking process, said autonomous submersible structures have one or more Cameras to provide various visual feedback to said AI controller to control the docking approach. Wherein after said autonomous submersible structures gets into the right position, said AI controller pushes push rods inwards to catch said seafood in said trap. Wherein said ducted propeller and tilt into vertical mode to bring the trap up to water surface. Wherein after the trap is brought up to a water surface, an unmanned aerial vehicle capable of vertical take-off and landing can dock with said autonomous submersible structure and then transport said autonomous submersible structure to a destination.

[0056] Wherein said unmanned aerial vehicle is comprised of a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, a left aileron, a right aileron, a left float with an acoustic modem inside to communicate with one or more traps at the floor of a body of water, a right float, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator.

[0057] Wherein after the trap is brought up to the water surface, an unmanned aerial vehicle capable of vertical take-off and landing is docked to said submersible structure and then transport said submersible structure to a destination.

[0058] Wherein said destination is an automatic sorting table with AI capability, said sorting table is comprised of a flat surface, an image capturing AI processing module, at least one left robotic arm and at least one right robotic arm; wherein said robotic arms takeout said seafood from said traps and resupply said traps; and wherein said unmanned aerial vehicle is capable of taking away the resupplied trap to be re-deployed.

[0059] An Autonomous Seafood Capturing, Sorting, and Delivering System comprising: an unmanned aerial vehicle capable of vertical take-off and landing, which docks with a submersible structure; said unmanned aerial vehicle is comprised of a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, a left aileron, a right aileron, a left float with an acoustic modem inside to communicate with one or more traps at the floor of a body of water, a right float, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator; said submersible structure is comprised of: a trap for capturing seafood within a cage, said cage volume contained therein; said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod; said cage has a water-tight AI controller with one or more lights and two or more cameras;

said cage has a bait container; said cage has a variable buoyancy device; and said cage has an underwater acoustic modem.

[0060] Wherein, said unmanned aerial vehicle records location information such as the GPS coordinates of said trap drop location, so that the location information can be used to find and retrieve said trap; wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations; wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way; wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood; wherein, after landing at the water surface, the unmanned aerial vehicle can find and communicate with said traps also equipped with acoustic modems; and wherein, after said trap reports the number of catches inside, it can be commanded to surface.

[0061] Further comprise said submersible structure having a variable buoyancy device, which is activated to release substances contained inside, after receiving the command to surface at a predefined threshold.

[0062] Wherein said trap has a spear and a speargun for launching said spear to into a fish to catch said fish; wherein after catching said fish, a motor is activated to rewind a reel to pull said fish towards said autonomous submersible structure; wherein thereafter, said autonomous submersible structure will surface while carrying said fish and dock to an unmanned aerial vehicle capable of vertical take-off and landing and then transport said submersible structure to a destination.

[0063] Further comprising an unmanned aerial vehicle capable of going underwater to picking up said trap off the bottom of a sea floor, wherein said unmanned aerial vehicle is comprised of a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, said left wing and right wing have one or more holes at the wing tip, a left aileron, a right aileron, a left float with an acoustic modem inside to communicate with one or more traps at the floor of a body of water, a right float, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator; wherein when said unmanned aerial vehicle submerges water enters through said holes on said right and left wing therefore eliminating the need to have a strong water-tight vehicle body that can withstand the high pressures at the sea floor; and wherein said unmanned aerial vehicle surfaces, water exits from said wing tip holes due to gravity and said unmanned aerial vehicle can further roll to the left and to the right to get rid of the remaining water onboard as said unmanned aerial vehicle takes off.

[0064] Further comprising an autonomous surface vehicle in form of a geometry-stabilized catamaran, which is comprised of solar panel as the top platform, a left hull, a right hull, a left propeller, a right propeller, an acoustic modem, a charging pole, a longer antenna for longer wave long-range radio communication, a shorter antenna for short-range radio communication, a reel with a ring attached to one end of its threads and a motor to rewind, a left docking and charging receptacle and a right docking and charging recep-

tacle for connecting and docking to said submersible structure having said cameras for docking control, an upward looking camera, a forward looking camera for navigation and docking with said autonomous surface vehicle.

[0065] Wherein said propellers also act as propeller turbines to generate electricity when in kite mode to capture renewable wind energy for said autonomous surface vehicle, when said autonomous surface vehicle utilizes said thread from said reel to connect to said unmanned aerial vehicle that acts as a kite flying in the sky to capture wind energy with said autonomous surface vehicle having said propellers acting as wind turbines and said unmanned aerial vehicle acting like a kite drags the said autonomous surface vehicle to create movement and the movement of said autonomous surface vehicle turns said propellers of the autonomous surface vehicle into water turbines to generate electric power; and wherein said autonomous submersible structure is docked with said autonomous surface vehicle, said autonomous submersible structure will also be dragged along, and such movement will also turn the left and right propellers of said autonomous submersible structure into water turbines to further generate electric energy, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous submersible structure and said autonomous surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

[0066] Wherein said solar panel on top of the said autonomous surface vehicle collects solar energy to generate electricity, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous submersible structure and said autonomous surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

[0067] Wherein after the trap is brought up to the water surface, said unmanned aerial vehicle capable of vertical take-off and landing is docked to said submersible structure and then transport said submersible structure to a destination.

[0068] Further comprising said unmanned aerial vehicle has a robotic arm to catch said trap, when said trap is brought up to said water surface, and then said unmanned aerial vehicle can vertically take off to transport said trap to a destination; and wherein said destination is an automatic sorting table with AI capability, said sorting table is comprised of a flat surface, an image capturing AI processing module, at least one left robotic arm and at least one right robotic arm; wherein said robotic arms takeout said seafood from said traps and resupply said traps; and wherein said unmanned aerial vehicle is capable of taking away the resupplied trap to be re-deployed.

[0069] While the description above refers to particular embodiments of the present invention, it will be understood that many modifications may be made without departing from the spirit thereof. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive.

1. (canceled)

2. An Autonomous Seafood Capturing, Sorting, and Delivering System comprising:

One or more submersible structures, wherein each of such said submersible structure further comprising:

- (a) a trap for capturing seafood within a cage, said cage volume contained therein;
- (b) said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod and said long rod connects to said door to engage with said locking rod of said door locker;
- (c) said cage has a water-tight AI controller with one or more lights and two or more cameras;
- (d) said cage has a bait container;
- (e) said cage has a variable buoyancy device; and
- (f) said cage has an underwater acoustic modem;

wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations;

wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way;

wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood;

wherein, the variable buoyancy device is activated to release substances contained inside, after receiving the command to surface or when the battery level is below a predefined threshold; and

wherein said submersible structures are autonomous, said autonomous submersible structure has a spear and a speargun for launching said spear to into a fish to catch said fish; wherein after catching said fish, a motor is activated to rewind a reel to pull said fish towards said autonomous submersible structure; wherein thereafter, said autonomous submersible structure will surface while carrying said fish and dock to an unmanned aerial vehicle capable of vertical take-off and landing and then transport said submersible structure to a destination.

3. (canceled)

4. (canceled)

5. (canceled)

6. (canceled)

7. (canceled)

8. (canceled)

9. (canceled)

10. An Autonomous Seafood Capturing, Sorting, and Delivering System comprising:

One or more submersible structures, wherein each of such said submersible structure further comprising:

- (a) a trap for capturing seafood within a cage, said cage volume contained therein;
- (b) said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod and said long rod connects to said door to engage with said locking rod of said door locker;
- (c) said cage has a water-tight AI controller with one or more lights and two or more cameras;
- (d) said cage has a bait container;
- (e) said cage has a variable buoyancy device; and
- (f) said cage has an underwater acoustic modem;

wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations;

wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way;

wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood;

wherein, the variable buoyancy device is activated to release substances contained inside, after receiving the command to surface or when the battery level is below a predefined threshold;

further comprising an unmanned aerial vehicle capable of going underwater to picking up said trap off the bottom of a sea floor, wherein said unmanned aerial vehicle is comprised of the following parts: a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, said left wing and right wing have one or more holes at the wing tip, a left aileron, a right aileron, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator and means for connecting the parts to said unmanned aerial vehicle;

wherein when said unmanned aerial vehicle submerges water enters through said holes on said right and left wing therefore eliminating the need to have a strong water-tight vehicle body that can withstand the high pressures at the sea floor; and wherein said unmanned aerial vehicle surfaces, water exits from said wing tip holes due to gravity and said unmanned aerial vehicle can further roll to the left and to the right to get rid of the remaining water onboard as said unmanned aerial vehicle takes off.

11. (canceled)

12. (canceled)

13. An Autonomous Seafood Capturing, Sorting, and Delivering System comprising:

One or more submersible structures, wherein each of such said submersible structure further comprising:

- (a) a trap for capturing seafood within a cage, said cage volume contained therein;
- (b) said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod and said long rod connects to said door to engage with said locking rod of said door locker;
- (c) said cage has a water-tight AI controller with one or more lights and two or more cameras;
- (d) said cage has a bait container;
- (e) said cage has a variable buoyancy device; and
- (f) said cage has an underwater acoustic modem;

wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations;

wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way;

wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and

such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood;

wherein, the variable buoyancy device is activated to release substances contained inside, after receiving the command to surface or when the battery level is below a predefined threshold, wherein said submersible structures are autonomous, said submersible structures become an autonomous underwater vehicle have a docking station for connecting to said cage;

wherein during the docking process, said autonomous underwater vehicles have one or more propellers provides lateral movement as needed, and one or more propellers provides up and down movement in vertical mode and back and forth movement in horizontal mode;

wherein during the docking process, said autonomous underwater vehicle has one or more cameras to provide various visual feedback to said AI controller to control the docking approach;

wherein after said autonomous underwater vehicle gets into the right position, said AI controller has means to push rods inwards to eject and catch said seafood in said trap;

wherein said autonomous underwater vehicle has said propellers that tilt into vertical mode to bring the trap up to a water surface;

wherein after the trap is brought up to said water surface, an unmanned aerial vehicle capable of vertical take-off and landing can dock with said autonomous underwater vehicle and then transport said autonomous underwater vehicle to a destination; and

wherein said unmanned aerial vehicle is comprised of the following parts: a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, a left aileron, a right aileron, a left landing gear with an acoustic modem inside to communicate with one or more traps at the floor of a body of water, a right landing gear, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator and means for connecting the parts to said unmanned aerial vehicle.

14. (canceled)

15. (canceled)

16. An Autonomous Seafood Capturing, Sorting, and Delivering System comprising:

One or more submersible structures, wherein each of such said submersible structure further comprising:

- (a) a trap for capturing seafood within a cage, said cage volume contained therein;
- (b) said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod and said long rod connects to said door to engage with said locking rod of said door locker;
- (c) said cage has a water-tight AI controller with one or more lights and two or more cameras;
- (d) said cage has a bait container;
- (e) said cage has a variable buoyancy device; and
- (f) said cage has an underwater acoustic modem;

wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations;

wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way;

wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood;

wherein, the variable buoyancy device is activated to release substances contained inside, after receiving the command to surface or when the battery level is below a predefined threshold;

wherein said submersible structures are autonomous, said submersible structures become an autonomous underwater vehicle have a docking station for connecting to said cage;

further comprising an autonomous surface vehicle in form of a geometry-stabilized catamaran, which is comprised of the following parts: a solar panel as the top platform, a left hull, a right hull, a left propeller, a right propeller, an acoustic modem, a charging pole, a longer antenna for longer wave long-range radio communication, a shorter antenna for short-range radio communication, a reel with a ring attached to one end of its threads and a motor to rewind, a left docking and charging receptacle and a right docking and charging receptacle for connecting and docking to said autonomous underwater vehicle having said cameras for docking control, an upward looking camera, a forward looking camera for navigation and docking with said autonomous surface vehicle and means for connecting the parts to said geometry-stabilized catamaran.

17. The system of claim **16**, wherein said propellers also act as propeller turbines to generate electricity when in kite mode to capture renewable wind energy for said autonomous surface vehicle, when said autonomous surface vehicle utilizes said thread from said reel to connect to said unmanned aerial vehicle that acts as a kite flying in the sky to capture wind energy with said autonomous surface vehicle having said propellers acting as wind turbines and said unmanned aerial vehicle acting like a kite drags the said autonomous surface vehicle to create movement and the movement of said autonomous surface vehicle turns said propellers of the autonomous surface vehicle into water turbines to generate electric power; and wherein said autonomous submersible structure is docked with said autonomous surface vehicle, said autonomous underwater vehicle will also be dragged along, and such movement will also turn the left and right propellers of said autonomous underwater vehicle into water turbines to further generate electric energy, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous underwater vehicle submersible structure and said autonomous surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

18. The system of claim **16**, wherein said solar panel on top of the said autonomous surface vehicle collects solar energy to generate electricity, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous underwater vehicle and said autonomous

surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

19. An Autonomous Seafood Capturing, Sorting, and Delivering System comprising:

an unmanned aerial vehicle capable of vertical take-off and landing, which docks with a submersible structure; said unmanned aerial vehicle is comprised of the following parts: a left tilt rotor, a right tilt rotor, a rear tilt rotor, a left wing, a right wing, a left aileron, a right aileron, a left landing gear with an acoustic modem inside to communicate with one or more traps at the floor of a body of water, a right landing gear, a mini robotic arm, a left vertical stabilizer, a right vertical stabilizer, a left rudder, a right rudder, a horizontal stabilizer and an elevator and means for connecting the parts to said unmanned aerial vehicle;

said submersible structure is comprised of: a trap for capturing seafood within a cage, said cage volume contained therein; said cage has an outer frame, a net wrapped around said frame, a door, a long rod, and a door locker with a locking rod and said long rod connects to said door to engage with said locking rod of said door locker; said cage has a water-tight AI controller with one or more lights and two or more cameras; said cage has a bait container; said cage has a variable buoyancy device; and said cage has an underwater acoustic modem;

wherein, said unmanned aerial vehicle records location information such as the GPS coordinates of said trap drop location, so that the location information can be used to find and retrieve said trap;

wherein, said AI controller is capable of sorting seafood pursuant to the categorization of a seafood visitor, including its size and its sex if applicable pursuant to regulations;

wherein, once said seafood visitor gets into the cage, the acoustic modem communicates with one or more modules on the surface in a predefined way;

wherein, the information of what seafood is caught inside said cage is also sent out via the acoustic modem, and such information will enable a receiver module which receives the information from various traps to determine which fishing spot has higher concentrations of targeted seafood;

wherein, after landing at the water surface, the unmanned aerial vehicle can find and communicate with said traps also equipped with acoustic modems; and

wherein, after said trap reports the number of catches inside, it can be commanded to surface.

20. The system of claim **19**, wherein said unmanned aerial vehicle is capable of going underwater to pick up said trap off the bottom of a sea floor; wherein said unmanned aerial vehicle having said left wing and right wing have one or more holes at the wing tip; wherein when said unmanned aerial vehicle submerges water enters through one or more holes on said left wing and said right wing at the wing tip, therefore eliminating the need to have a strong water-tight vehicle body that can withstand the high pressures at the sea floor; and wherein said unmanned aerial vehicle surfaces, water exits from said wing tip holes due to gravity and said unmanned aerial vehicle can further roll to the left and to the right to get rid of the remaining water onboard as said unmanned aerial vehicle takes off.

21. The system of claim **19**, wherein said submersible structure having a variable buoyancy device, which is activated to release substances contained inside, after receiving the command to surface at a predefined threshold.

22. The system of claim **19**, wherein said submersible structures can be autonomous, when said submersible structures have a docking station for connecting an outer frame to said cage then said submersible structures becomes an autonomous underwater vehicle having said docking station for connecting to said cage; wherein said autonomous underwater vehicle having said cage and said outer frame for capturing seafood further utilizes a spear and a speargun for launching said spear to into a fish to catch said fish; wherein after catching said fish, a motor is activated to rewind a reel to pull said fish towards said autonomous underwater vehicle; wherein thereafter, said autonomous underwater vehicle will surface while carrying said fish and dock to an unmanned aerial vehicle capable of vertical take-off and landing and then transport said autonomous underwater vehicle to a destination.

23. The system of claim **19**, wherein said submersible structures are autonomous, said autonomous submersible structures become an autonomous underwater vehicle.

24. The system of claim **19**, wherein after the trap is brought up to the water surface, said unmanned aerial vehicle capable of vertical take-off and landing is docked to said submersible structure and then transport said submersible structure to a destination.

25. The system of claim **19**, further comprising said unmanned aerial vehicle has a mini robotic arm to catch said trap, when said trap is brought up to said water surface, and then said unmanned aerial vehicle can vertically take off to transport said trap to a destination.

26. The system of claim **20**, wherein said destination is an automatic sorting table with AI capability, said sorting table is comprised of a flat surface, an image capturing AI processing module, at least one left robotic arm and at least one right robotic arm, wherein said flat surface has at least one left robotic arm and at least one right robotic arm and said image capturing AI processing module; wherein said robotic arms takeout said seafood from said traps and resupply said traps; and wherein said unmanned aerial vehicle is capable of taking away the resupplied trap to be re-deployed.

27. The system of claim **19**, further comprising an autonomous surface vehicle in form of a geometry-stabilized catamaran, which is comprised of the following parts: a solar

panel as the top platform, a left hull, a right hull, a left propeller, a right propeller, an acoustic modem, a charging pole, a longer antenna for longer wave long-range radio communication, a shorter antenna for short-range radio communication, a reel with a ring attached to one end of its threads and a motor to rewind, a left docking and charging receptacle and a right docking and charging receptacle for connecting and docking to said submersible structure having said cameras for docking control, an upward looking camera, a forward looking camera for navigation and docking with said autonomous surface vehicle and means for connecting the parts to said geometry-stabilized catamaran.

28. The system of claim **27**, wherein said propellers also act as propeller turbines to generate electricity when in kite mode to capture renewable wind energy for said autonomous surface vehicle, when said autonomous surface vehicle utilizes said thread from said reel to connect to said unmanned aerial vehicle that acts as a kite flying in the sky to capture wind energy with said autonomous surface vehicle having said propellers acting as wind turbines and said unmanned aerial vehicle acting like a kite drags the said autonomous surface vehicle to create movement and the movement of said autonomous surface vehicle turns said propellers of the autonomous surface vehicle into water turbines to generate electric power; and wherein said submersible structure is docked with said autonomous surface vehicle, said autonomous submersible structure will also be dragged along, and such movement will also turn the left and right propellers of said submersible structure into water turbines to further generate electric energy, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous submersible structure and said autonomous surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

29. The system of claim **27**, wherein said solar panel on top of said autonomous surface vehicle collects solar energy to generate electricity, wherein said generated electric energy will be stored into rechargeable batteries onboard said autonomous submersible structure and said autonomous surface vehicle, thereby greatly reduce operating costs of fuel which is a large portion of the total cost in a conventional fishing operation.

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