of the ship. In either instance, the effective range of the bottom contour measurement is too short to allow sufficient distance for the ship to make evasive maneuvers around unexpected underwater hazards. For above-ground hazards, some ships may be equipped with a radar system, but radar systems are limited to line-of-sight, and are not effective to "see" around points, bluffs, or man-made structures, which may be required when navigating in fjords, rivers, bays, rugged coastlines, or the like. Other surface objects and debris may be avoided by careful observation by the ship's crew, but many hazards, such as currents, eddies, and gusting wind are difficult to detect with the unaided eye, and thus are not noticed until it is too late for the ship to make an evasive maneuver.

In some areas, international laws place regulations on ships to comply with low speed requirements in certain areas, for example in seasons and areas known for whale feeding and breeding. However, such restrictions do not always prevent ships from colliding with the whales. In some cases, ships do not comply with the speed requirements because of operational limits such as maneuverability, engine, or time constraints, thus placing the ships and wildlife at risk for collisions.

Thus, a need exists for a navigation and hazard avoidance system that addresses the above issues.

BRIEF DESCRIPTION

In one aspect, there is provided an unmanned aquatic surface vehicle, comprising: a propulsion system configured to impart a propulsive force to the vehicle; a steering system configured to impart a change in the direction of travel of the vehicle; and a hazard detection

system configured to: detect and locate at least one of a subsurface, surface or above-water hazard; determine whether the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel; and transmit a warning signal to the command vessel in response to a determination that the detected at least one subsurface, surface or above-water hazard affects a performance constraint of the command vessel.

In another aspect, there is provided a method of navigating a command vessel in a waterway using an unmanned aquatic surface vehicle, comprising: commanding the aquatic surface vehicle to follow an intended route of the command vessel; receiving a communication from the unmanned aquatic surface vehicle indicating that at least one subsurface, surface or above-water hazard detected by the unmanned aquatic surface vehicle affects a performance constraint of the command vessel; and modifying the intended route of travel of the command vessel in response to the indication that the at least one subsurface, surface or above-water hazard affects the performance constraint.

In yet another aspect, there is provided a system for detecting and locating hazards, comprising: an aquatic surface vehicle including a controllable propulsion system and a steering system; a hazard detection system coupled to the aquatic surface vehicle configured to: detect at least one of a subsurface, surface or above-water hazard; and determine whether the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel; a communications system coupled to the aquatic surface vehicle configured to transmit a warning signal to the command vessel in response

to a determination that the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel; and a power system for providing power to the propulsion system, the steering system the hazard detection system and the communications system.

In one embodiment~~aspect~~, an unmanned aquatic surface vehicle for detecting and locating hazards is disclosed. The vehicle includes a propulsion system configured to impart a propulsive force to the vehicle and a steering system configured to impart a change in the direction of travel of the vehicle. A hazard detection system is configured to detect and locate at least one of a subsurface, surface or

above-water hazard. A communications device configured to transmit hazard data associated with a detected hazard to a remote receiver.

In another embodiment~~aspect~~, a method of navigating a command vessel in a waterway using an unmanned aquatic surface vehicle is disclosed. The method includes commanding the aquatic surface vehicle to follow an intended route of the command vessel. A communication from the unmanned aquatic surface vehicle including hazard data is received by the command vehicle. Navigation data of the command vessel is updated based upon the received hazard data.

In yet another embodiment~~aspect~~, a system for detecting hazards is disclosed. The system includes an aquatic surface vehicle having a controllable propulsion system and a steering system. A hazard detection system is coupled to the aquatic surface vehicle and configured to detect at least one of a subsurface, surface or above-water hazard. A communications system is coupled to the aquatic surface vehicle and configured to transmit hazard data associated with a detected hazard to a remote receiver. A power source provides power to the propulsion system, the steering system, the hazard detection system, and the communications system.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 illustrates an implementation of a system for detecting hazards.

Fig. 2 is a schematic view of a command vessel of the system of Fig. 1.

Fig. 3 is a schematic view of an unmanned aquatic surface vehicle of the system of Fig. 1.

Fig. 4 is a block diagram of an implementation of navigating a command vessel in a waterway using an unmanned aquatic surface vehicle.

WHAT IS CLAIMED IS:

1. An unmanned aquatic surface vehicle, comprising:

a propulsion system configured to impart a propulsive force to the vehicle;

a steering system configured to impart a change in the direction of travel of the vehicle;

a hazard detection system configured to detect and locate at least one of a subsurface, surface or above-water hazard;

a communications device configured to transmit hazard data associated with a detected hazard to a remote receiver

2. The unmanned aquatic surface vehicle according to claim 1 further comprising a navigation system in communication with the propulsion system and the steering system, the navigation system configured to use navigation data to control the amount of propulsive force imparted to the vehicle by the propulsion system and the change in direction of travel of the vehicle imparted by the steering system.

3. The unmanned aquatic surface vehicle according to claim 2 further comprising a receiver configured to receive a control signal from a remote transmitter, wherein the receiver is in communication with the navigation system and provides the navigation data to the navigation system.

4. The unmanned aquatic surface vehicle according to claim 2 wherein the navigation system is programmed with the navigation data.

5. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard detection system includes at least one sensor capable of detecting at least one of location, water depth, bathymetric contours, submerged hazards, floating debris, icebergs, buoys, pilings, other vessels, local water currents or eddies, and wind.

6. The unmanned aquatic surface vehicle according to claim 2, wherein the navigation system is programmed to maintain the vehicle a predetermined distance ahead of a command vessel.

7. The unmanned aquatic surface vehicle according to claim 2 wherein the communications device is configured to transmit a warning signal to the receiver if the detected hazard meets a predetermined condition.

8. The unmanned aquatic surface vehicle according to claim 7 wherein the predetermined condition is based on a performance constraint of a command vessel.

9. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard data includes location data of the detected hazard.

10. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard detection system includes at least one of a navigation sensor, an echo sounder, a sonar transceiver, a current sensor, a salinity sensor, a water temperature sensor, a range sensor, a proximity sensor, a radar, an anemometer, and a video camera.

11. A method of navigating a command vessel in a waterway using an unmanned aquatic surface vehicle, comprising:

commanding the aquatic surface vehicle to follow an intended route .of the command vessel;

receiving a communication from the unmanned aquatic surface vehicle including hazard data; and

providing information to the command vessel based upon the received hazard data.

12. The method according to claim 11 further comprising providing an alert to the command vessel based on the received hazard data.

13. The method according to claim 11 further comprising commanding the unmanned aquatic surface vehicle to change speed or direction.

14. The method according to claim 11 wherein the received hazard data includes data related to at least one of location, water depth, bathymetric contours, submerged hazards, floating debris, icebergs, buoys, pilings, other vessels, and local water currents, eddies, and wind.

15. The method according to claim 11 wherein updating the navigation data of the command vessel includes modifying the intended route of travel of the command vessel.

16. A system for detecting and locating hazards, comprising:

an aquatic surface vehicle including a controllable propulsion system and a steering system;

a hazard detection system coupled to the aquatic surface vehicle configured to detect at least one of a subsurface, surface or above-water hazard;

a communications system coupled to the aquatic surface vehicle configured to transmit hazard data associated with a detected hazard to a remote receiver; and

a power system for providing power to the propulsion system, the steering system the hazard detection system and the communications system.

17. The system according to claim 16, wherein the power source comprises an electrical energy storage device.

18. The system according to claim 17, further comprising a power regenerating device that regenerates the electrical energy.

19. The system according to claim 16 wherein the hazard detection system includes at least one of a navigation sensor, an echo sounder, a sonar transceiver, a current sensor, a salinity sensor, a water temperature sensor, a range sensor, a proximity sensor, a radar, an anemometer, and a video camera.

20. The system according to claim 16 wherein the hazard data is configured for updating a navigation chart or electronic navigation chart display and information system (ECDIS).

CLAIMS

What is claimed is:

1. An unmanned aquatic surface vehicle, comprising:

a propulsion system configured to impart a propulsive force to the vehicle;

a steering system configured to impart a change in the direction of travel of the vehicle; and

a hazard detection system configured to:

detect and locate at least one of a subsurface, surface or above-water hazard;

determine whether the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel; and

transmit a warning signal to the command vessel in response to a determination that the detected at least one subsurface, surface or above-water hazard affects a performance constraint of the command vessel.

2. The unmanned aquatic surface vehicle according to claim 1 further comprising a navigation system in communication with the propulsion system and the steering system, the navigation system configured to use navigation data to control the amount of propulsive force imparted to the vehicle by the propulsion system and the change in direction of travel of the vehicle imparted by the steering system.

3. The unmanned aquatic surface vehicle according to claim 2 further comprising a receiver configured to receive a control signal from a remote transmitter, wherein the receiver is in communication with the navigation system and provides the navigation data to the navigation system.

4. The unmanned aquatic surface vehicle according to claim 2 wherein the navigation system is programmed with the navigation data.

5. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard detection system includes at least one sensor capable of detecting at least one of location, water depth, bathymetric contours, submerged hazards, floating debris, icebergs, buoys, pilings, other vessels, local water currents or eddies, and wind.

6. The unmanned aquatic surface vehicle according to claim 2, wherein the navigation system is programmed to maintain the vehicle a predetermined distance ahead of the command vessel.

7. The unmanned aquatic surface vehicle according to claim 2 wherein the hazard detection system is further configured to transmit recommended evasive maneuvers to the command vessel.

8. The unmanned aquatic surface vehicle according to claim 1 wherein the performance constraint is one of a waterway width, waterway depth, and waterway height.

9. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard detection system is further configured to transmit location data of the detected hazard.

10. The unmanned aquatic surface vehicle according to claim 1 wherein the hazard detection system includes at least one of a navigation sensor, an echo sounder, a sonar transceiver, a current sensor, a salinity sensor, a water temperature sensor, a range sensor, a proximity sensor, a radar, an anemometer, and a video camera.

11. A method of navigating a command vessel in a waterway using an unmanned aquatic surface vehicle, comprising:

commanding the aquatic surface vehicle to follow an intended route of the command vessel;

receiving a communication from the unmanned aquatic surface vehicle indicating that at least one subsurface, surface or above-

water hazard detected by the unmanned aquatic surface vehicle affects a performance constraint of the command vessel; and

modifying the intended route of travel of the command vessel in response to the indication that the at least one subsurface, surface or above-water hazard affects the performance constraint.

12. The method according to claim 11 wherein the performance constraint is one of a waterway width, waterway depth, and waterway height.

13. The method according to claim 11 further comprising commanding the unmanned aquatic surface vehicle to change speed or direction.

14. The method according to claim 11 wherein the communication includes data related to at least one of location, water depth, bathymetric contours, submerged hazards, floating debris, icebergs, buoys, pilings, other vessels, and local water currents, eddies, and wind.

15. A system for detecting and locating hazards, comprising:

an aquatic surface vehicle including a controllable propulsion system and a steering system;

a hazard detection system coupled to the aquatic surface vehicle configured to:

detect at least one of a subsurface, surface or above-water hazard; and

determine whether the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel;

a communications system coupled to the aquatic surface vehicle configured to transmit a warning signal to the command vessel in response to a determination that the detected at least one subsurface, surface or above-water hazard affects a performance constraint of a command vessel; and

a power system for providing power to the propulsion system, the steering system the hazard detection system and the communications system.

16. The system according to claim 15, wherein the power source comprises an electrical energy storage device.

17. The system according to claim 16, further comprising a power regenerating device that regenerates the electrical energy.

18. The system according to claim 15 wherein the hazard detection system includes at least one of a navigation sensor, an echo sounder, a sonar transceiver, a current sensor, a salinity sensor, a water temperature sensor, a range sensor, a proximity sensor, a radar, an anemometer, and a video camera.

19. The system according to claim 15 wherein the performance constraint is one of a waterway width, waterway depth, and waterway height.