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SEA CONDITION INFORMATION PROVIDING DEVICE, SEA CONDITION INFORMATION PROVIDING SYSTEM, SEA CONDITION INFORMATION PROVIDING PROGRAM, AND SEA CONDITION INFORMATION PROVIDING METHOD

Abstract

A first layer tidal current data acquirer acquires first layer tidal current data that represent a first layer vector quantity representing a direction and a speed of a tidal current in a first layer. A second layer tidal current data acquirer acquires second layer tidal current data that represent a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in a second layer. An inter-layer tidal current difference calculator calculates inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity. A display controller performs inter-layer tidal current difference display control for displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data.

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Background/Summary

TECHNICAL FIELD
[0001] The present disclosure relates to a sea condition information providing device, a sea condition information providing system, a sea condition information providing program, and a sea condition information providing method.
BACKGROUND ART
[0002] When fishing is performed, tidal currents in a plurality of layers having different water depths in the sea may be checked. Note that, in the present specification, a “layer” indicates a horizontal layered virtual region having a thickness in the sea.
[0003] For example, fishing with a round haul net is performed after it is checked that there is no great change in a direction and a speed of tidal currents between layers having different water depths in a place where the net is to be laid. The reason is that there is a case where a direction or a speed of tidal currents between layers greatly varies, and, in such a case, it is difficult to appropriately lay a net in the sea.
[0004] As disclosed in Patent Literature 1, a tidal current measuring device installed in a ship is known as means for measuring tidal currents in a plurality of layers in the sea. The tidal current measuring device has functions of measuring a direction and a speed of tidal currents in a plurality of layers directly below a ship, and displaying the measured direction and the measured speed of the tidal currents by layer in a graph.
CITATION LIST
Patent Literature
[0005] Patent Literature 1: Unexamined Japanese Patent Application Publication No. S57-44859
SUMMARY OF INVENTION
Technical Problem
[0006] In the tidal current measuring device according to Patent Literature 1, only a local tidal current directly below a ship can be checked. Therefore, whether tidal currents resemble each other between layers in a place being a candidate for a fishing ground needs to be checked by a ship actually going to the place. Thus, it may take time to search for a fishing ground where tidal currents resemble each other between layers.
[0007] An objective of the present disclosure is to provide a technique being able to easily find a region where tidal currents resemble each other between layers having different water depths.
Solution to Problem
[0008] A sea condition information providing device according to the present disclosure includes:
[0009] a first layer tidal current data acquirer to acquire first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer; [0010] a second layer tidal current data acquirer to acquire second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer; [0011] an inter-layer tidal current

difference calculator to calculate, by using the first layer tidal current data and the second layer tidal current data, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer; and [0012] a display controller to perform inter-layer tidal current difference display control for displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data.
[0013] The sea condition information providing device may further include [0014] a deep layer tidal current data acquirer to acquire deep layer tidal current data that represent an in-plane distribution in a deep layer of a deep layer vector quantity representing a direction and a speed of a tidal current in the deep layer closer to a sea bottom than the second layer, [0015] wherein the display controller may further perform deep layer tidal current display control for displaying, over the map expressing relief of the sea bottom, a deep layer tidal current distribution map that visualizes the in-plane distribution of the deep layer vector quantity represented by the deep layer tidal current data.
[0016] The first layer tidal current data acquired by the first layer tidal current data acquirer may include the in-plane distribution of the first layer vector quantity as a future predicted value, [0017] the second layer tidal current data acquired by the second layer tidal current data acquirer may include the in-plane distribution of the second layer vector quantity as a future predicted value, [0018] the sea condition information providing device may further include a local region designation acceptor to accept, from a user, designation of a local region in the sea on the map displayed by the display controller, and, [0019] when designation of the local region is accepted by the local region designation acceptor, [0020] (i) the inter-layer tidal current difference calculator may calculate, by using the first layer tidal current data and the second layer tidal current data, the inter-layer tidal current difference data about the local region for future n (note that n≥is a natural number equal to or more than two) unit periods, and [0021] (ii) the display controller may perform local tidal current difference image display control for creating, by the unit period, a local tidal current difference image in which the inter-layer tidal current difference distribution map of the local region overlaps the map of the local region, by using the inter-layer tidal current difference data about the local region for future n unit periods, and displaying the created local tidal current difference image for future n unit periods.
[0022] The sea condition information providing device may further include [0023] a catch quantity predictor to predict, for each of the unit periods, a catch quantity in the local region for future n unit periods by using at least the first layer tidal current data and the second layer tidal current data, [0024] wherein the display controller may display, by the unit period, a prediction result of the catch quantity predictor together with the local tidal current difference image for future n unit periods in the local tidal current difference image display control.
[0025] The sea condition information providing device may further include [0026] a sea water temperature data acquirer to acquire sea water temperature data that represent an in-plane distribution of sea water temperature parallel to the first layer and the second layer, the sea water temperature data including the in-plane distribution of the sea water temperature as a future predicted value, [0027] wherein, in the local tidal current difference image display control, the display controller may create, for future n unit periods by the unit period, a local sea water temperature distribution image representing the in-plane distribution of the sea water temperature in the local region, and display, for future n unit periods by the unit period, the created local sea water temperature distribution image together with the local tidal current difference image.
[0028] In the local tidal current difference image display control, the display controller may create, for future n unit periods by the unit period, a local tidal current distribution image representing the in-plane distribution of the first layer vector quantity in the local region, and display, for future n

unit periods by the unit period, the created local tidal current distribution image together with the local tidal current difference image.
[0029] A sea condition information providing system according to the present disclosure includes: [0030] the above-described sea condition information providing device according to the present disclosure; and [0031] a data providing device to provide the first layer tidal current data to the first layer tidal current data acquirer of the sea condition information providing device, and also provide the second layer tidal current data to the second layer tidal current data acquirer of the sea condition information providing device.
[0032] A sea condition information providing program according to the present disclosure causes a computer to function as: [0033] a first layer tidal current data acquirer to acquire first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer; [0034] a second layer tidal current data acquirer to acquire second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer; [0035] an inter-layer tidal current difference calculator to calculate, by using the first layer tidal current data and the second layer tidal current data, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer; and [0036] a display controller to perform inter-layer tidal current difference display control for displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data.
[0037] A sea condition information providing method according to the present disclosure includes steps of: [0038] (A) storing, in a storage device of a computer in advance before departure of a ship from port, first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer, the first layer tidal current data including the in-plane distribution of the first layer vector quantity as a future predicted value; [0039] (B) storing, in the storage device in advance before departure of the ship from port, second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer, the second layer tidal current data including the in-plane distribution of the second layer vector quantity as a future predicted value; [0040] (C) by the computer in the ship after departure from port, calculating, by using the first layer tidal current data and the second layer tidal current data stored in the storage device, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer, and displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the calculated in-plane distribution of the difference vector quantity; [0041] (D) by the computer, accepting designation of a local region on the map displayed in the step (C) from a crew; and [0042] (E) by the computer, calculating, by using the first layer tidal current data and the second layer tidal current data stored in the storage device, the inter-layer tidal current difference data for future n (note that n≥is a natural number equal to or more than two) unit periods in the local region designated in the step (D), creating, by the unit period, a local tidal current difference image in which the inter-layer tidal current difference distribution map of the local region overlaps the map of the local region, by using the calculated inter-layer tidal current difference data for future n unit periods, and displaying the created local tidal current difference image for future n unit periods.
Advantageous Effects of Invention

[0043] According to the present disclosure, an inter-layer tidal current difference distribution map that visualizes an in-plane distribution of a difference vector quantity is displayed over a map. Thus, a region where tidal currents resemble each other between layers of a first layer and a second layer can be easily found.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0044] FIG. **1** is a schematic diagram illustrating a configuration of a sea condition information providing system according to Embodiment 1;

[0045] FIG. **2** is a schematic diagram illustrating a configuration of a sea condition information providing device according to Embodiment 1;

[0046] FIG. **3** is a schematic diagram illustrating functions of the sea condition information providing device according to Embodiment 1;

[0047] FIG. **4** is a schematic diagram illustrating a screen displayed on a display device by inter-layer tidal current difference display control according to Embodiment 1;

[0048] FIG. **5** is a schematic diagram illustrating a screen displayed on the display device by local tidal current difference image display control according to Embodiment 1;

[0049] FIG. **6** is a flowchart illustrating a use method of the sea condition information providing device according to Embodiment 1;

[0050] FIG. **7** is a schematic diagram illustrating a part of functions of a sea condition information providing device according to Embodiment 2;

[0051] FIG. **8** is a schematic diagram illustrating a screen displayed on a display device by deep layer tidal current difference display control according to Embodiment 2; and

[0052] FIG. **9** is a schematic diagram illustrating a part of functions of a sea condition information providing device according to Embodiment 3.

DESCRIPTION OF EMBODIMENTS

[0053] Hereinafter, a sea condition information providing system according to embodiments is described with reference to the drawings. In the drawings, the same or corresponding portion has the same reference sign.

Embodiment 1

[0054] As illustrated in FIG. **1**, a sea condition information providing system **500** according to the present embodiment includes a data distribution server **400** that distributes sea condition data **200** being data about a sea condition, a data providing device **300** connected to the data distribution server **400** through a communication line NE, and a sea condition information providing device **100** installed in a ship FS.

[0055] The data providing device **300** acquires the sea condition data **200** from the data distribution server **400**, and provides the acquired sea condition data **200** to the sea condition information providing device **100**. The sea condition information providing device **100** uses the sea condition data **200** provided from the data providing device **300**, and provides information about a sea condition (hereinafter described as sea condition information) to a crew FP being a user during navigation of the ship FS.

[0056] Note that, after departure of the ship FS from port, communication between the sea condition information providing device **100** in the ship and the data providing device **300** outside the ship may be difficult to establish. Then, the data providing device **300** provides latest sea condition data **200** including a predicted value to the sea condition information providing device **100** before departure of the ship FS from port. Thus, the sea condition information providing device **100** can provide sea condition information in an off-line state where communication with the data providing device **300** is disconnected during navigation of the ship FS.

[0057] In the present embodiment, a case where the ship FS is a fishing boat that catches fish with a round haul net is illustratively described. Sea condition information provided to the crew FP by the sea condition information providing device **100** is used for estimating a fishing ground. A configuration of the sea condition information providing device **100** is described below.
[0058] As illustrated in FIG. **2**, the sea condition information providing device **100** includes a communication device **120** being hardware for receiving the sea condition data **200** from the data providing device **300** described above, and a storage device **150** for storing the received sea condition data **200**. FIG. **2** illustrates a state where the sea condition data **200** are already stored in the storage device **150**.
[0059] The sea condition data **200** include first layer tidal current data **210**, second layer tidal current data **220**, sea water temperature data **230**, and moon phase data **240**.
[0060] The first layer tidal current data **210** represent an in-plane distribution in a first layer of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer of the sea. The first layer tidal current data **210** include not only an in-plane distribution of the first layer vector quantity when the ship FS departs from port, but also an in-plane distribution of the first layer vector quantity as a future predicted value, that is, a predicted value after departure from port.
[0061] The second layer tidal current data **220** represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer. The second layer tidal current data **220** include not only an in-plane distribution of the second layer vector quantity when the ship FS departs from port, but also an in-plane distribution of the second layer vector quantity as a future predicted value, that is, a predicted value after departure from port.
[0062] Note that, in the present specification, the “first layer” and the “second layer” each indicate a horizontal layered virtual region having a thickness in the sea. In the present embodiment, a water depth of a center portion in a thickness direction of the first layer is equal to or more than 1 m and equal to or less than 5 m. A water depth of a center portion in a thickness direction of the second layer is equal to or more than 20 m and equal to or less than 40 m.
[0063] The sea water temperature data **230** represent an in-plane distribution of sea water temperature parallel to the first layer and the second layer. The sea water temperature data **230** include not only an in-plane distribution of sea water temperature at a time of departure from port, but also an in-plane distribution of sea water temperature as a future predicted value, that is, a predicted value after departure from port. In the present embodiment, the sea water temperature data **230** represent an in-plane distribution of sea water temperature in the first layer. Further, the moon phase data **240** represent a moon phase at a time of departure from port and in the future.
[0064] Further, the storage device **150** stores, in advance, map data **151** representing a map, a learned model **152** for estimating a catch quantity, and a sea condition information providing program **153** that defines procedures of processing of providing sea condition information.
[0065] Further, the sea condition information providing device **100** includes a display device **130** that displays, over a map, a condition of a tidal current, an in-plane distribution of sea water temperature, and the like, and an input device **140** for the crew FP to perform various input operations of designating a region as a candidate for a fishing ground on the map displayed on the display device **130**. The display device **130** and the input device **140** constitute a graphical user interface.
[0066] Further, the sea condition information providing device **100** includes a processor **110** that executes the sea condition information providing program **153**. Functions achieved by the processor **110** executing the sea condition information providing program **153** are described below.
[0067] As illustrated in FIG. **3**, the sea condition information providing device **100** includes a first layer tidal current data acquirer **110***a* that acquires the first layer tidal current data **210** from the storage device **150**, a second layer tidal current data acquirer **110***b* that acquires the second layer

tidal current data **220** from the storage device **150**, a sea water temperature data acquirer **110***c* that acquires the sea water temperature data **230** from the storage device **150**, a moon phase data acquirer **110***d* that acquires the moon phase data **240** from the storage device **150**, and a map data acquirer **110***e* that acquires the map data **151** from the storage device **150**.

[0068] Further, the sea condition information providing device **100** includes an inter-layer tidal current difference calculator **110***f* that calculates inter-layer tidal current difference data **290** by using the first layer tidal current data **210** and the second layer tidal current data **220**. The inter-layer tidal current difference calculator **110***f* calculates a difference vector quantity being a difference between a first layer vector quantity represented by the first layer tidal current data **210** and a second layer vector quantity represented by the second layer tidal current data **220** at the same time. Data about the difference vector quantity representing an in-plane distribution parallel to the first layer and the second layer are the inter-layer tidal current difference data **290**.

[0069] Further, the sea condition information providing device **100** includes a display controller **110***g* that visualizes the inter-layer tidal current difference data **290** calculated by the inter-layer tidal current difference calculator **110***f*, and displays the inter-layer tidal current difference data **290** on the display device **130**. Specifically, the display controller **110***g* performs inter-layer tidal current difference display control for displaying, over a map represented by the map data **151**, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data **290**.

[0070] FIG. **4** illustrates a screen displayed on the display device **130** by the inter-layer tidal current difference display control. The inter-layer tidal current difference distribution map is an image that expresses, by a line segment, a difference vector quantity in each coordinate defined in a lattice shape in the sea. A direction of the line segment represents a direction of a difference between the first layer vector quantity and the second layer vector quantity. A length of the line segment represents magnitude of the difference vector quantity.

[0071] The inter-layer tidal current difference data **290** have a data structure that associates the difference vector quantity with each coordinate described above. Thus, by associating a coordinate represented by the inter-layer tidal current difference data **290** with a coordinate represented by the map data **151**, the inter-layer tidal current difference distribution map can be displayed over the map represented by the map data **151**. Note that a difference vector quantity in each coordinate may be set as an initial value, and a state of a time change in the initial value may be indicated by a simulation.

[0072] In the screen (hereinafter, described as a global inter-layer tidal current difference distribution display screen) illustrated in FIG. **4**, the in-plane distribution of the difference vector quantity in a global region where the ship FS may move between departure from port and return to port is expressed in a visually recognizable manner. Thus, the crew FP can easily find a region having a relatively small difference vector quantity in the sea.

[0073] As described above, a fishing ground of fishing with a round haul net is preferably a region having a relatively small difference vector quantity. In other words, according to the global inter-layer tidal current difference distribution display screen illustrated in FIG. **4**, a region (hereinafter, described as a local region) being a candidate for a fishing ground can be easily estimated without the ship FS actually going to the local region being the candidate for the fishing ground.

[0074] Returning to FIG. **3**, and description continues. The sea condition information providing device **100** also includes a local region designation acceptor **110***h* that accepts designation of a local region estimated as described above from the crew FP. Specifically, the local region designation acceptor **110***h* accepts, from the crew FP, designation of a desired local region in the sea on the map displayed on the above-described global inter-layer tidal current difference distribution display screen by the display controller **110***g*.

[0075] In other words, the crew FP designates, by using the input device **140** illustrated in FIG. **2**, a local region being a candidate for a fishing ground in the sea displayed on the map illustrated in

FIG. **4**. The local region designation acceptor **110***h* accepts the designation.

[0076] Further, the sea condition information providing device **100** also includes a catch quantity predictor **110***i* that predicts a catch quantity. The catch quantity predictor **110***i* predicts a catch quantity in a local region when designation of the local region is accepted by the local region designation acceptor **110***h*.

[0077] Specifically, by using the first layer tidal current data **210**, the second layer tidal current data **220**, and the sea water temperature data **230**, the catch quantity predictor **110***i* predicts, for each unit period, a catch quantity in a local region on a current day on which the local region is designated, and a catch quantity in the local region in future n (note that n≥is a natural number equal to or more than two) unit periods with reference to the current day.

[0078] Herein, the "unit period" means a predetermined period being a unit. In the present embodiment, the unit period is set to one day. Further, n is set to 5. In other words, the catch quantity predictor **110***i* predicts, by day, a catch quantity in the local region for a current day and future five days.

[0079] The catch quantity predictor **110***i* predicts a catch quantity by using the learned model **152** illustrated in FIG. **2**. In other words, the learned model **152** illustrated in FIG. **2** is subjected to machine learning for estimating a catch quantity by using geographic data that determine a local region, the first layer tidal current data **210**, the second layer tidal current data **220**, and the sea water temperature data **230**.

[0080] When designation of a local region is accepted by the local region designation acceptor **110***h*, the catch quantity predictor **110***i* inputs geographic data that determine the local region, the first layer tidal current data **210**, the second layer tidal current data **220**, and the sea water temperature data **230** to the learned model **152**. The learned model **152** outputs, for a current day and future five days, a prediction result of a catch quantity for each day in the local region represented by the input geographic data.

[0081] Further, when designation of the local region is accepted by the local region designation acceptor **110***h*, the above-described inter-layer tidal current difference calculator **110***f* calculates, for each day, the inter-layer tidal current difference data **290** about the local region on the current day on which the local region is designated and the inter-layer tidal current difference data **290** about the local region for the future five days with reference to the current day by using the first layer tidal current data **210** and the second layer tidal current data **220**.

[0082] Then, the display controller **110***g* performs local tidal current difference image display control for visualizing the inter-layer tidal current difference data **290** about the local region on the current day and the future five days being calculated by the inter-layer tidal current difference calculator **110***f*, and displaying the inter-layer tidal current difference data **290** on the display device **130**.

[0083] FIG. **5** illustrates a screen displayed on the display device **130** by the local tidal current difference image display control. A map **660** of a designated local region is displayed on the screen of the display device **130**.

[0084] Further, a local tidal current difference image **610** for today and future five days is displayed by day on the screen of the display device **130**. The local tidal current difference image **610** is an image in which the above-described inter-layer tidal current difference distribution map of the local region overlaps the map of the local region. Note that "today" herein means a current day on which the local region is designated in the global inter-layer tidal current difference distribution display screen illustrated in FIG. **4**.

[0085] In this way, in the local tidal current difference image display control, the display controller **110***g* creates, by day, the local tidal current difference image **610** by using the inter-layer tidal current difference data **290** about the local region for today and the future five days being calculated by the inter-layer tidal current difference calculator **110***f*, and displays the created local tidal current difference image **610** for today and the future five days.

[0086] Further, a local tidal current distribution image **620** for today and the future five days is also displayed by day on the screen of the display device **130**. The local tidal current distribution image **620** is an image representing an in-plane distribution of a first layer vector quantity in the local region.
[0087] In this way, in the local tidal current difference image display control, the display controller **110***g* creates, by day, the local tidal current distribution image **620** by using the first layer tidal current data **210**, and displays, by day, the created local tidal current distribution image **620** for today and the future five days together with the local tidal current difference image **610**.
[0088] Further, a local sea water temperature distribution image **630** for today and the future five days is also displayed by day on the screen of the display device **130**. The local sea water temperature distribution image **630** is an image representing an in-plane distribution of sea water temperature in the local region.
[0089] In this way, in the local tidal current difference image display control, the display controller **110***g* creates, by day, the local sea water temperature distribution image **630** by using the sea water temperature data **230**, and displays, by day, the created local sea water temperature distribution image **630** for today and the future five days together with the local tidal current difference image **610** and the local tidal current distribution image **620**.
[0090] Further, a catch index image **640** for today and the future five days is also displayed by day on the screen of the display device **130**. The catch index image **640** is an image representing a catch quantity predicted by the catch quantity predictor **110***i* by the number of icons. A greater number of the icons means a greater predicted catch quantity.
[0091] In this way, in the local tidal current difference image display control, the display controller **110***g* creates, by day, the catch index image **640** by using a prediction result of the catch quantity predictor **110***i*, and displays, by day, the created catch index image **640** for today and the future five days together with the local tidal current difference image **610**, the local tidal current distribution image **620**, and the local sea water temperature distribution image **630**.
[0092] Further, a moon phase display image **650** for today and the future five days is also displayed by day on the screen of the display device **130**. The moon phase display image **650** is an image that visualizes a moon phase.
[0093] In this way, in the local tidal current difference image display control, the display controller **110***g* creates, by day, the moon phase display image **650** by using the moon phase data **240**, and displays, by day, the created moon phase display image **650** for today and the future five days together with the local tidal current difference image **610**, the local tidal current distribution image **620**, the local sea water temperature distribution image **630**, and the catch index image **640**.
[0094] As described above, in the local tidal current difference image display control, the display controller **110***g* displays the local tidal current difference image **610**, the local tidal current distribution image **620**, the local sea water temperature distribution image **630**, the catch index image **640**, and the moon phase display image **650** in a form of a table **600**.
[0095] Returning to FIG. **3**, and description continues. As described above, the display controller **110***g* performs the inter-layer tidal current difference display control and the local tidal current difference image display control. A mode of displaying the global inter-layer tidal current difference distribution display screen illustrated in FIG. **4** on the display device **130** by the inter-layer tidal current difference display control is referred to as a global display mode below. Further, a mode of displaying the table **600** illustrated in FIG. **5** on the display device **130** by the local tidal current difference image display control is referred to as a table display mode.
[0096] The sea condition information providing device **100** includes a display mode switcher **110***j* that accepts an instruction to switch between the global display mode and the table display mode. The crew FP can instruct switching between the global display mode and the table display mode by using the input device **140**.
[0097] Hereinafter, a use method of the sea condition information providing device **100** according

to the present embodiment is described with reference to FIG. **6**.
[0098] As illustrated in FIG. **6**, before departure of the ship FS from port, the data providing device **300** stores, in advance, the sea condition data **200** including a future predicted value of a physical quantity related to a sea condition in the storage device **150** of the sea condition information providing device **100** (step S**1**). Note that step S**1** is one example of steps (A) and (B) according to the present disclosure.
[0099] After departure of the ship FS from port, the crew FS selects the global display mode by using the input device **140** in order to estimate a fishing ground (step S**2**). Then, the selection of the global display mode is accepted by the display mode switcher **110***j*.
[0100] In response to this, the inter-layer tidal current difference calculator **110***f* calculates the inter-layer tidal current difference data **290** about a global region where the ship FS may move between departure from port and return to port. Then, the display controller **110***g* displays the global inter-layer tidal current difference distribution display screen illustrated in FIG. **4** on the display device **130** by using the inter-layer tidal current data **290**. Note that step S**2** is one example of step (C) according to the present disclosure.
[0101] The crew FS views the global inter-layer tidal current difference distribution display screen being displayed on the display device **130**, and designates a region having a relatively small difference vector quantity as a local region being a candidate for a fishing ground by using the input device **140** (step S**3**). Further, the crew FS selects the table display mode by using the input device **140**.
[0102] Then, the designation of the local region is accepted by the local region designation acceptor **110***h*, and the selection of the table display mode is accepted by the display mode switcher **110***j*. Note that the acceptance of the designation of the local region is one example of step (D) according to the present disclosure.
[0103] Next, in response to the acceptance of the designation of the local region and the selection of the table display mode, the display controller **110***g* displays the table **600** illustrated in FIG. **5** on the display device **130**. Note that the display of the table **600** is one example of step (E) according to the present disclosure.
[0104] The crew FS checks, by the table **600** displayed on the display device **130**, a sea condition for a current day and future five days in the local region designated in step S**3** (step S**4**). When the crew FS does not adopt the local region designated in step S**3** as a fishing ground as a result of the check in step S**4** (step S**5**; NO), the crew FS switches the display mode from the table display mode to the global display mode by using the input device **140** in order to find a different candidate for a fishing ground, and returns to step S**2**.
[0105] On the other hand, when the crew FS adopts the local region designated in step S**3** as a fishing ground as a result of the check in step S**4** (step S**5**; YES), the crew FS ends the present flow.
[0106] As described above, according to the present embodiment, the global inter-layer tidal current difference distribution display screen that visualizes an in-plane distribution of a difference vector quantity is displayed as illustrated in FIG. **4** in the global display mode achieved by the inter-layer tidal current difference display control. Thus, the crew FS can easily find a region where tidal currents resemble each other between layers of the first layer and the second layer by viewing the global inter-layer tidal current difference distribution display screen. In other words, a local region being a candidate for a fishing ground can be easily estimated without the ship FS actually going to the region being the candidate for the fishing ground.
[0107] Further, in the table display mode achieved by the local tidal current difference image display control, as illustrated in FIG. **5**, the table **600** representing the sea condition for the current day and the future five days of the local region designated as the candidate for the fishing ground is displayed. Thus, the crew FS can easily determine whether to adopt the designated local region as the fishing ground by viewing the table **600**.
[0108] Further, before departure of the ship FS from port, the first layer tidal current data **210**

including an in-plane distribution of the first layer vector quantity as a future predicted value, the second layer tidal current data **220** including an in-plane distribution of the second layer vector quantity as a future predicted value, the sea water temperature data **230** including an in-plane distribution of sea water temperature as a future predicted value, and the like are stored in the storage device **150** of the sea condition information providing device **100**. Thus, the sea condition information providing device **100** can provide sea condition information in an off-line state where communication with the data providing device **300** is disconnected during navigation of the ship FS.

Embodiment 2

[0109] A sea condition information providing device **100** may further have a function of displaying a condition of a tidal current in a deep layer close to a sea bottom. A specific example thereof is described below.

[0110] As illustrated in FIG. **7**, the sea condition information providing device **100** according to the present embodiment further includes a deep layer tidal current data acquirer **110***k* that acquires deep layer tidal current data **250**. The deep layer tidal current data acquirer **110***k* acquires the deep layer tidal current data **250** from a storage device **150**. In other words, in the present embodiment, the above-described sea condition data **200** stored in the storage device **150** of the sea condition information providing device **100** before departure from port include the deep layer tidal current data **250**.

[0111] The deep layer tidal current data **250** represent an in-plane distribution in a deep layer of a deep layer vector quantity representing a direction and a speed of a tidal current in the deep layer closer to a sea bottom than a second layer. The deep layer tidal current data **250** include not only an in-plane distribution of the deep layer vector quantity at a time of departure from port, but also an in-plane distribution of the deep layer vector quantity as a future predicted value, that is, a predicted value after departure from port.

[0112] In the present embodiment, a display controller **110***g* further performs deep layer tidal current display control for visualizing and displaying the deep layer tidal current data **250**. Specifically, in the deep layer tidal current display control, the display controller **110***g* displays, over a map representing relief of a sea bottom, a deep layer tidal current distribution map that visualizes the in-plane distribution of the deep layer vector quantity represented by the deep layer tidal current data **250**.

[0113] FIG. **8** schematically illustrates a screen displayed on a display device **130** by the deep layer tidal current display control. The deep layer tidal current distribution map is an image that expresses, by an arrow or a line segment, a deep layer vector quantity in each coordinate in the sea. A direction of the arrow or the line segment represents a direction of a tidal current. A length of the arrow or the line segment represents a speed of a tidal current. As illustrated in FIG. **8**, an in-plane distribution of a deep layer vector quantity is displayed over a map representing relief of a sea bottom.

[0114] The deep layer tidal current data **250** have a data structure that associates the deep layer vector quantity with each coordinate described above. Thus, by associating a coordinate represented by the deep layer tidal current data **250** with a coordinate represented by map data **151**, the deep layer tidal current distribution map can be displayed over a map represented by the map data **151**. Note that a deep layer vector quantity in each coordinate may be set as an initial value, and a state of a time change in the initial value may be indicated by a simulation.

[0115] As described above, according to the present embodiment, a crew FP can check a distribution of a tidal current in a deep layer. Similarly to the global inter-layer tidal current difference distribution display screen illustrated in FIG. **4**, a condition of a tidal current in a deep layer may also become a determination element of selection of a fishing ground. According to the present embodiment, the crew FP can more appropriately estimate a fishing ground by considering not only the global inter-layer tidal current difference distribution display screen illustrated in FIG.

4, but also a global distribution of a tidal current in a deep layer.

[0116] Note that the crew FP can also check a condition of a tidal current in a deep layer of a local region designated as a candidate for a fishing ground. An image representing a condition of a tidal current in a deep layer of a local region may be presented by being included in the table **600** illustrated in FIG. **5**.

[0117] Further, as described above, the relief of the sea bottom is represented in the map on which the deep layer tidal current distribution map is displayed. Thus, the crew FP can easily find, from the image illustrated in FIG. **8**, a place where a tidal current hits an elevated portion from the sea bottom.

[0118] For example, according to the image illustrated in FIG. **8**, it is quite obvious that a tidal current in a deep layer hits an elevated portion from the sea bottom in a region FR. An ascending current is generated in such a region FR, and thus the region FR is often a suitable fishing ground. In this way, the region FR being a candidate for a fishing ground can be easily found.

Embodiment 3

[0119] In Embodiment 1, as illustrated in FIG. **4**, a difference vector quantity between layers of a first layer and a second layer is visualized and displayed in a global display mode. Furthermore, a tidal current in a third layer may also be taken into consideration. A specific example thereof is described below.

[0120] As illustrated in FIG. **9**, a sea condition information providing device **100** according to the present embodiment further includes a third layer tidal current data acquirer **1101** that acquires third layer tidal current data **260**. The third layer tidal current data acquirer **1101** acquires the third layer tidal current data **260** from a storage device **150**. In other words, in the present embodiment, the above-described sea condition data **200** stored in the storage device **150** of the sea condition information providing device **100** before departure from port include the third layer tidal current data **260**.

[0121] The third layer tidal current data **260** represent an in-plane distribution in a third layer of a third layer vector quantity representing a direction and a speed of a tidal current in the third layer having a deeper water depth than a second layer. The third layer tidal current data **260** include not only an in-plane distribution of the third layer vector quantity at a time of departure from port, but also an in-plane distribution of the third layer vector quantity as a future predicted value.

[0122] Further, the sea condition information providing device **100** according to the present embodiment includes a second inter-layer tidal current difference calculator **110***m* that calculates second inter-layer tidal current difference data **280** by using second layer tidal current data **220** and the third layer tidal current data **260**. The second inter-layer tidal current difference calculator **110***m* calculates a difference vector quantity being a difference between a second layer vector quantity represented by the second layer tidal current data **220** and the third layer vector quantity represented by the third layer tidal current data **260** at the same time. Data about the difference vector quantity representing an in-plane distribution parallel to the second layer and the third layer are the second inter-layer tidal current difference data **280**.

[0123] A display controller **110***g* according to the present embodiment has not only a function of visualizing inter-layer tidal current difference data **290** as illustrated in FIG. **4** and displaying the inter-layer tidal current difference data **290** on a display device **130**, but also a function of visualizing the second inter-layer tidal current difference data **280** calculated by the second inter-layer tidal current difference calculator **110***m* and displaying the second inter-layer tidal current difference data **280** on the display device **130**.

[0124] A state of visualizing the inter-layer tidal current difference data **290** and displaying the inter-layer tidal current difference data **290** on the display device **130** and a state of visualizing the second inter-layer tidal current difference data **280** and displaying the second inter-layer tidal current difference data **280** on the display device **130** may be switched by an operation of a crew FP, or the inter-layer tidal current difference data **290** and the second inter-layer tidal current

difference data **280** may be visualized and displayed together.
[0125] Embodiments 1 to 3 are described above. Modification described below is also possible.
[0126] FIG. **6** illustrates the technique for storing, in advance, all the sea condition data **200** in the storage device **150** of the sea condition information providing device **100** before departure of the ship FS from port. In other words, in Embodiment 1, each of the first layer tidal current data acquirer **110***a*, the second layer tidal current data acquirer **110***b*, the sea water temperature data acquirer **110***c*, and the moon phase data acquirer **110***d* acquires the sea condition data **200** from the storage device **150**. According to the technique, the sea condition information providing device **100** can be used in an off-line state where communication with the data providing device **300** is disconnected after departure of the ship FS from port.
[0127] However, a part or the whole of the sea condition data **200** may be transmitted from the data providing device **300** to the sea condition information providing device **100** at a point in time at which communication between the data providing device **300** and the sea condition information providing device **100** is established after departure of the ship FS from port. In other words, at least any of the first layer tidal current data acquirer **110***a*, the second layer tidal current data acquirer **110***b*, the sea water temperature data acquirer **110***c*, and the moon phase data acquirer **110***d* may acquire the sea condition data **200** from the data providing device **300**.
[0128] FIG. **5** illustrates the case where the "unit period" is one day, but the "unit period" may be a few hours less than one day, for example, 6 hours, or may be a period of two days or more. Further, FIG. **5** illustrates the configuration for presenting a predicted condition of a sea condition for future five unit periods, but a predicted condition of a sea condition for less than five unit periods, for example, three unit periods may be presented, or a predicted condition of a sea condition for equal to or more than five unit periods, for example, seven unit periods may be presented.
[0129] By installing the sea condition information providing program **153** illustrated in FIG. **2** onto existing smartphone, tablet, and other computer, the function of the sea condition information providing device **100** can also be achieved by the computer. The sea condition information providing program **153** may be distributed via a communication network, or may be stored in a computer-readable non-transitory recording medium and be distributed.
[0130] The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equivalents to which such claims are entitled.
[0131] This application claims the benefit of Japanese Patent Application No. 2022-106410, filed on Jun. 30, 2022, the entire disclosure of which is incorporated by reference herein.
REFERENCE SIGNS LIST
[0132] **100** Sea condition information providing device [0133] **110** Processor [0134] **110***a* First layer tidal current data acquirer [0135] **110***b* Second layer tidal current data acquirer [0136] **110***c* Sea water temperature data acquirer [0137] **110***d* Moon phase data acquirer [0138] **110***e* Map data acquirer [0139] **110***f* Inter-layer tidal current difference calculator [0140] **110***g* Display controller [0141] **110***h* Local region designation acceptor [0142] **110***i* Catch quantity predictor [0143] **110***j* Display mode switcher [0144] **110***k* Deep layer tidal current data acquirer [0145] **110***l* Third layer tidal current data acquirer [0146] **110***m* Second inter-layer tidal current difference calculator [0147] **120** Communication device [0148] **130** Display device [0149] **140** Input device [0150] **150** Storage device [0151] **151** Map data [0152] **152** Learned model [0153] **153** Sea condition information providing program [0154] **200** Sea condition data [0155] **210** First layer tidal current data [0156] **220** Second layer tidal current data [0157] **230** Sea water temperature data [0158] **240** Moon phase data [0159] **250** Deep layer tidal current data [0160] **260** Third layer tidal current data [0161] **280**

Second inter-layer tidal current difference data [0162] **290** Inter-layer tidal current difference data [0163] **300** Data providing device [0164] **400** Data distribution server [0165] **500** Sea condition information providing system [0166] **600** Table [0167] **610** Local tidal current difference image [0168] **620** Local tidal current distribution image [0169] **630** Local sea water temperature distribution image [0170] **640** Catch index image [0171] **650** Moon phase display image [0172] **660** Map of local region [0173] NE Communication line [0174] FP Crew (user) [0175] FR Region [0176] FS Ship

Claims

1. A sea condition information providing device comprising: a first layer tidal current data acquirer to acquire first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer and that include the in-plane distribution of the first layer vector quantity as a future predicted value; a second layer tidal current data acquirer to acquire second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer and that include the in-plane distribution of the second layer vector quantity as a future predicted value; an inter-layer tidal current difference calculator to calculate, by using the first layer tidal current data and the second layer tidal current data, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer; a display controller to perform inter-layer tidal current difference display control for displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data; and a local region designation acceptor to accept, from a user, designation of a local region in the sea on the map displayed by the display controller, wherein, when designation of the local region is accepted by the local region designation acceptor, (i) the inter-layer tidal current difference calculator calculates, by using the first layer tidal current data and the second layer tidal current data, the inter-layer tidal current difference data about the local region for future n (note that n is a natural number equal to or more than two) unit periods, and (ii) the display controller performs local tidal current difference image display control for creating, by the unit period, a local tidal current difference image in which the inter-layer tidal current difference distribution map of the local region overlaps the map of the local region, by using the inter-layer tidal current difference data about the local region for future n unit periods. and displaying the created local tidal current difference image for future n unit periods.
2. The sea condition information providing device according to claim 1, further comprising a catch quantity predictor to predict, for each of the unit periods, a catch quantity in the local region for future n unit periods by using at least the first layer tidal current data and the second layer tidal current data, wherein the display controller displays, by the unit period, a prediction result of the catch quantity predictor together with the local tidal current difference image for future n unit periods in the local tidal current difference image display control.
3. The sea condition information providing device according to claim 1, further comprising a sea water temperature data acquirer to acquire sea water temperature data that represent an in-plane distribution of sea water temperature parallel to the first layer and the second layer, the sea water temperature data including the in-plane distribution of the sea water temperature as a future predicted value, wherein, in the local tidal current difference image display control, the display controller creates, for future n unit periods by the unit period, a local sea water temperature distribution image representing the in-plane distribution of the sea water temperature in the local region, and displays, for future n unit periods by the unit period, the created local sea water

temperature distribution image together with the local tidal current difference image.

4. The sea condition information providing device according to claim 1, wherein, in the local tidal current difference image display control, the display controller creates, for future n unit periods by the unit period, a local tidal current distribution image representing the in-plane distribution of the first layer vector quantity in the local region, and displays, for future n unit periods by the unit period, the created local tidal current distribution image together with the local tidal current difference image.

5. The sea condition information providing device according to claim 1, further comprising a deep layer tidal current data acquirer to acquire deep layer tidal current data that represent an in-plane distribution in a deep layer of a deep layer vector quantity representing a direction and a speed of a tidal current in the deep layer closer to a sea bottom than the second layer, wherein the display controller further performs deep layer tidal current display control for displaying, over the map expressing relief of the sea bottom, a deep layer tidal current distribution map that visualizes the in-plane distribution of the deep layer vector quantity represented by the deep layer tidal current data.

6. (canceled)

7. A sea condition information providing system comprising: the sea condition information providing device according to claim 1; and a data providing device to provide the first layer tidal current data to the first layer tidal current data acquirer of the sea condition information providing device, and also provide the second layer tidal current data to the second layer tidal current data acquirer of the sea condition information providing device.

8. A non-transitory computer-readable recording medium storing a sea condition information providing program, the sea condition information providing program causing a computer to function as: a first layer tidal current data acquirer to acquire first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer and that include the in-plane distribution of the first layer vector quantity as a future predicted value; a second layer tidal current data acquirer to acquire second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer and that include the in-plane distribution of the second layer vector quantity as a future predicted value; an inter-layer tidal current difference calculator to calculate, by using the first layer tidal current data and the second layer tidal current data, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer; a display controller to perform inter-layer tidal current difference display control for displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the in-plane distribution of the difference vector quantity represented by the inter-layer tidal current difference data; and a local region designation acceptor to accept, from a user, designation of a local region in the sea on the map displayed by the display controller, wherein, when designation of the local region is accepted by the local region designation acceptor. (i) the inter-layer tidal current difference calculator calculates, by using the first layer tidal current data and the second layer tidal current data, the inter-layer tidal current difference data about the local region for future n (note that n is a natural number equal to or more than two) unit periods, and (ii) the display controller performs local tidal current difference image display control for creating, by the unit period, a local tidal current difference image in which the inter-layer tidal current difference distribution map of the local region overlaps the map of the local region, by using the inter-layer tidal current difference data about the local region for future n unit periods, and displaying the created local tidal current difference image for future n unit periods.

9. A sea condition information providing method comprising steps of: (A) storing, in a storage device of a computer in advance before departure of a ship from port, first layer tidal current data that represent an in-plane distribution in a first layer of the sea of a first layer vector quantity representing a direction and a speed of a tidal current in the first layer, the first layer tidal current data including the in-plane distribution of the first layer vector quantity as a future predicted value; (B) storing, in the storage device in advance before departure of the ship from port, second layer tidal current data that represent an in-plane distribution in a second layer of a second layer vector quantity representing a direction and a speed of a tidal current in the second layer having a deeper water depth than the first layer, the second layer tidal current data including the in-plane distribution of the second layer vector quantity as a future predicted value; (C) by the computer in the ship after departure from port, calculating, by using the first layer tidal current data and the second layer tidal current data stored in the storage device, inter-layer tidal current difference data that represent an in-plane distribution of a difference vector quantity being a difference between the first layer vector quantity and the second layer vector quantity, the in-plane distribution being parallel to the first layer and the second layer, and displaying, over a map, an inter-layer tidal current difference distribution map that visualizes the calculated in-plane distribution of the difference vector quantity; (D) by the computer, accepting designation of a local region on the map displayed in the step (C) from a crew; and (E) by the computer, calculating, by using the first layer tidal current data and the second layer tidal current data stored in the storage device, the inter-layer tidal current difference data for future n (note that n is a natural number equal to or more than two) unit periods in the local region designated in the step (D), creating, by the unit period, a local tidal current difference image in which the inter-layer tidal current difference distribution map of the local region overlaps the map of the local region, by using the calculated inter-layer tidal current difference data for future n unit periods, and displaying the created local tidal current difference image for future n unit periods.