Research on Special Stability of Scientific Research Equipment on Oceanographic Research Vessels

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Abstract. With the development of economy, countries all over the world have gradually recognized the importance of the exploitation of marine resources, development of marine economy, and protection of marine ecological environment. As an important carrier and tool for the implementation of China's national strategies such as "building China into a maritime power" and "Belt & Road", oceanographic research vessels also face new demands and development prospects. The current standards and specifications for oceanographic research vessels in China are generally old and outdated, lack of professional specifications, and deficient of standard guidance for the use of scientific research equipment on oceanographic research vessels. From the perspective of the classification and special stability of scientific research equipment on oceanographic research vessels, an evaluation system for the stability of scientific research equipment is proposed, in hope of providing reference for the use of scientific research equipment on oceanographic research vessels.

Keywords: oceanographic research vessel; scientific research equipment; stability; evaluation system.

1. Introduction

Oceanographic research vessel is a kind of special-purpose vessel, whose offshore operation mode is unique and obviously different from that of industrial vessels. As the operation process of oceanographic research vessels involves such activities as releasing marine sampling equipment, towing data acquisition equipment, and fishing marine biological samples, wind and waves will have a greater impact on the accuracy of data and sample collection. If the stability of oceanographic research vessels is investigated only by relevant safety standards or the standards for industrial vessels, oceanographic research tasks may fail to be smoothly implemented and the stability of oceanographic research equipment may fail to be ensured, thus affecting the economical efficiency of oceanographic survey vessels.

The current standards and specifications for oceanographic research vessels in China are generally identified with the following problems: 1) The standards and specifications are too old and some methods are too primitive. The guidance of new standards cannot keep pace with the increasing development of oceanographic research vessels; 2) there are quite few professional specifications for oceanographic research vessels, and only some general specifications are available, let alone standards for some special equipment on oceanographic research vessels; 3) the general specifications currently in force mainly focus on the design, manufacturing, inspection and verification of scientific research equipment on oceanographic research vessels, seldom involving such issues as how to use the scientific research equipment and how to ensure that such equipment is in the optimal operating state when performing scientific research tasks.

To make up for the deficiency of Chinese national and industrial standards in the field of oceanographic research vessels, the paper proposes an evaluation system for the special stability of scientific research equipment on oceanographic research vessels, in hope of guiding the use of scientific research equipment on oceanographic research vessels.

2. Classification and special stability of scientific research equipment on oceanographic research vessels

There is various equipment on oceanographic research vessels, which can, by function, be divided into deck crane, manipulation support system, research equipment, life-saving equipment, communication and navigation equipment, dynamic positioning system, propulsion device, etc. Different equipment has different requirements for stability.

2.1 Deck crane

Deck crane aims to hoist the equipment on oceanographic research vessels, which is mainly composed of telescopic crane, stern telescopic knuckle crane, stern A frame, side A frame, bow telescopic knuckle crane, shelter deck moving crane, etc. The stability of deck crane is mainly reflected in the process of equipment hoisting, while the stability of the equipment itself is not considered.

2.2 Manipulation support system

Serving as the final guarantee for equipment hoisting on oceanographic research vessels, the manipulation support system aims to assist deck crane in completing the task of equipment hoisting, which is mainly composed of CTD(Conductive-Temperature-Depth)winch, optical cable winch, steel cable winch, fiber cable winch, biological winch, trace metal winch, CTD retractable gear, long column sampler housing and extending gear, fin hoisting system, seismic air compressor, etc., with the winches being most frequently used by scientific research.

The winches for scientific research on oceanographic research vessels can be classified in various ways. Specifically, they can be divided into CTD winch, biological winch, geological winch, deep tow winch and trace metal winch by purpose, and be divided into electric winch, hydraulic winch and pneumatic winch by driving mode. Similar with deck crane, the stability of the manipulation support system is also reflected in the process of equipment hoisting.

2.3 Research equipment

The special stability of oceanographic research vessels is mainly reflected in the research equipment thereon, which is mainly composed of multi-beam sounding system available at full water depth, multi-beam sounding system available at medium and shallow water depth, parametric array shallow profiler, ultra-short baseline positioning system, navigational surface multi-factor measurement system, marine gravimeter, marine magnetic gradiometer, multi-channel seismic system, 10,000m sounder, fish finder, deep sea towing system, TV grab, CTD, acoustic Doppler current profiler (ADCP), remote operated vehicle (ROV), etc. Research equipment is mainly used for the measurement and sampling of various marine elements. The stability of some research equipment is not susceptible to the environment, while that of some others may be greatly influenced by the environment when put down, retracted and operating.

2.3.1 TV grab

TV grab is a kind of submarine sampling equipment with a TV camera. In the process of lowering, the grab is susceptible to ocean current and the disturbance of wind and waves, making it unable to be normally lowered, and deviate from the preset position. Besides, the direction adjustment of TV grab is not accurate and flexible enough underwater so that sampling position is often erroneous, resulting in quite low operating efficiency. What’s worse, the complex seabed terrain and time-consuming deep-sea operation under high pressure are likely to cause damage to the equipment’s parts or even loss of the equipment itself, thus affecting normal operation, and incurring high maintenance and replacement cost.

According to relevant specifications for grab dredgers and the research on the use of TV grab by Cheng Zhenbo[1,2] et al., to ensure safe lowering of TV grab, it is recommended that the operating environment of oceanographic research vessels be determined as follows: wind speed: less than

14kn - 16kn; wave height: less than 1.2m; sea condition: lower than level 4. To prevent cable from being pressed under hull bottom, TV grab should be lowered at the stern, and the countercurrent operation must be conducted at the stem prior to actual lowering. When the TV grab on an oceanographic research vessel is under normal operation, the oceanographic research vessel should navigate at a slow speed of 1kn - 2kn to facilitate the identification of sampling targets. Meanwhile, it is necessary to control the closing and hoisting speed of TV grab to shorten its stay in the seabed. To ensure the safety and success rate of TV grab, it is recommended to slowly hoist the grab prior to its unearthing, and accelerate the hoisting speed after it is unearthed.

2.3.2 Trawl

The plankton multilink sampling net, commonly known as the trawl, is an automated sampler used to collect marine plankton suspended in and moving with water. The use of trawl mainly involves the two processes of casting and towing. The towing process is generally not susceptible to sea condition, and can be completed even in case of high-level sea condition. However, high-level sea condition may make it difficult or even dangerous to cast and retract trawl. To ensure the safe use of trawl, it is recommended in combination with relevant experience to cast and withdraw trawl when wind force is below level 6, wave height lower than 3.5m, and sea condition at level 5 or below. Meanwhile, the navigation speed of the oceanographic research vessel should be maintained at roughly 5kn to ensure effective measurement.

2.3.3 Conductivity-temperature-depth (CTD) system

The conductivity-temperature-depth (CTD) system is the most traditional and widely applied marine research equipment in marine observation. The inherent water bottle of the CTD system can be adopted to extract water from the deep ocean to measure the temperature, conductivity (salinity), depth, chlorophyll, dissolved oxygen and turbidity and other factors of the marine vertical profile.

There are multiple factors influencing the quality of CTD data. When releasing the CTD system, the most important thing is to ensure the safety thereof, and prevent the probe thereof from touching the side or bottom of the vessel. Considering that the CTD system is sensitive to temperature, the difference between probe temperature and water temperature should not be excessively large. The lowering speed of the probe is another important factor influencing the quality of CTD data， which has different effects on the time constant of the temperature sensor and that of the conductivity sensor. According to relevant researches on the quality control of CTD and the manufacturer's instructions on the use of the equipment, the optimal lowering speed is determined as roughly 70cm/s. In the shallow sea area or the upper thermocline, the lowering speed should better range from 50cm/s to 100cm/s. Below the abyssal seasonal thermocline in the, the lowering speed may be slightly increased, but should better not exceed 150cm/s, so as to ensure the accuracy of experimental data. In addition, to reduce the impact of vessel turbulence on probe lowering speed, a high lowering speed should be selected in case of high-level sea condition.

2.3.4 Remote operated vehicle (ROV)

The remote operated vehicle (ROV) is a high-tech underwater operation system controlled on water surface, which can travel freely underwater. ROV can complete certain underwater tasks based on necessary observation through such gears as external camera, obstacle avoidance sonar or pipeline tracker in combination with the multi-function manipulator or other underwater tools.

Many factors may influence the safety of ROV retracting and releasing. Xiao Hong [3] et al. ever analyzed the safety issues of ROV. When the environmental wind force reaches or is greater than the critical value, the gantry structure of A-crane may be seriously deformed. According to relevant researches on ROV retracting and releasing safety[4,5], when ROV is retracting and releasing, wind force should be below level 6, wind speed less than 25kn, wave height less than 2.5m, and sea condition below level 5.

Meanwhile, sea waves may also influence the retracting and releasing of ROV. If the flow velocity of waves is excessively high, ROV may fail to reach the ideal water exit and entry point, or even be flushed to the dangerous area by sea waves, thus causing any unexpected accident. The surge wave has a long wavelength, and there exists a large drop between the wave crest and wave trough thereof. In case of excessively large surge wave, the ROV with soft cable may fail to be successfully locked in the process of retracting, or the umbilical cable may be stressed, pulled out of the terminal box or even torn off, leading to the serious consequence of ROV drift. Considering the above factors, during the operation of ROV, the flow velocity should be less than 1.5kn to ensure safe retracting and releasing of ROV.

2.3.5 Acoustic Doppler current profiler (ADCP)

The acoustic Doppler current profiler (ADCP) is an instrument for measuring the flow velocity of current profile by using the acoustic Doppler effect. ADCP is widely used in the structural investigation of ocean current field, the monitoring of the flow velocity and discharge of rivers, the analysis of the concentration of suspended matters in water, and the evaluation of engineering environment quality.

During the navigation of a vessel, the hull thereof is likely to shake due to the influence of external natural factors, which will influence the measurement accuracy of ADCP. In addition, noise generated by the hull will also cause interference to ADCP, resulting in inaccurate measurement results. The horizontal flow velocity has a cosine relationship between the pitching angle and the rolling angle, which has little influence when the angle is less than 5°. Considering that even a slight shake may greatly influence the measurement accuracy, it is necessary to install a shake compensation gear to ensure accurate calculation of vertical flow velocity.

Meanwhile, vessel navigation speed has a certain influence on the accuracy of discharge measurement by ADCP, and the faster the navigation speed, the worse the stability of discharge measurement by ADCP. In principle, vessel navigation speed should not be greater than flow velocity, but in practice, it is difficult to ensure that the former is lower than the latter. According to the Rules and Technical Guidelines for Discharge Measurement by ADCP published by the Office of Surface Water (OSW) of the United States Geological Survey (USGS), the analysis of ADCP error sources[6,7], and relevant statistical data, when the ratio of navigation speed to flow velocity is controlled at 1.3 - 2.5, the accuracy of discharge measurement by ADCP can be little influenced. When the ratio of navigation speed to flow velocity exceeds 3, the influence on the measurement accuracy of ADCP will gradually increase.

2.3.6 Multi-beam sounding system

The multi-beam sounding system is widely used in such fields as hydrographic survey, ocean engineering survey, ocean demarcation survey, marine resources survey, and underwater archaeological survey. The system can draw in real time the submarine geomorphic map and isobaths map, and accurately determine the position and depth of navigation obstacles.

Sea condition is the main factor influencing the quality of multi-beam measurement data, and terrible sea condition is the main cause of noise. When sea condition is terrible to a certain extent, the signal collected by the multi-beam system is likely to contain noise, which may even prevent the system from operating normally. During the navigation of a vessel, the attitude of the vessel and the transducer thereon may constantly change due to the influence of wind and waves, and the opening angle of the fan-shaped beam emitted by the transducer is limited to a certain interval. When the vessel oscillates slightly, the beams transmitted and received are basically covered in the fan-shaped area directly below the vessel. While when the vessel oscillates greatly, the coverage area of beams transmitted will be separated from that of beams received, with the edge beam failing to be received by the transducer. In extreme cases, even the central beam cannot be received, accompanied by cluttered echo signals. The Specifications for Hydrographic Survey has no requirements for the sea condition of multi-beam operation. Based on the use of multi-beam system and relevant experience[8], it is recommended that sea condition not exceed level 2, wind force not exceed level 4, and wave height not exceed 1m. Meanwhile, the rolling or pitching angle should not exceed 8° to ensure the accuracy of the measured data.

2.4 Life-saving equipment

Life-saving equipment is a kind of statutory safety equipment for vessels. Dinghy and the retractable gear thereof are an important part of life-saving equipment. The main task of a dinghy on a vessel is to assist relevant staff in completing operations on water surface, rescue drowning personnel, and help the vessel' s crew escape. The main task of the dinghy retractable gear on a vessel is to ensure that the dinghy and personnel on the vessel can be quickly and safely lowered to water surface, and then safely back to the vessel.

The dinghy demands high on sea condition in the process of lowering. In case of normal sea condition, the retracting and releasing operation is typically completed manually. High-level sea condition (above level 4) entails the operator to work in a terrible environment, which may threaten personal safety. Considering that in case of high-level sea condition, dinghy retractable gear is likely to cause collision accident, the dinghy retractable gear must have the function of wave compensation to stabilize the dinghy when sea condition is above level 3.

The hoisting point of a dinghy is typically in two forms: single hoisting point and double hoisting points. Dinghies with double hoisting points are usually suitable for life-saving dinghies, focusing on the releasing of dinghy. Dinghies with a single hoisting point are usually used in rescue dinghies that attach equal importance to escape and rescue of personnel in distress at sea. Based on the review of dinghy application at home and abroad and the study on the technologies for dinghy retracting and releasing[9,10], it is recommended to adopt single hoisting point for dinghies with a total length of less than 7.5m, and double hoisting points for dinghies with a total length of more than 7.5m. When sea condition is at level 4 -5, both single and double hoisting points are applicable; when sea condition is at level 5 - 6 or above, it is appropriate to adopt a single hoisting point. Considering dinghy hooks and the difficulties that a dinghy may encounter when operating at sea, sea condition should better not exceed level 5 during the operation of dinghy.

2.5 Communication and navigation equipment

The communication and navigation equipment on oceanographic research vessels aims to collect various elements to ensure safe vessel navigation, which is mainly composed of GNDSSA, navigation radar, SatcomoC Station, bridge navigational watch alarm system (BNWAS), ship security alert system (SSAS), voyage data recorder (VDR), electronic chart display and information system (ECDIS), electric gyrocompass, magnetic compass, depth sounder, log, Meteorological facsimile receiver, Nevoltaire receiver (NAVTEX), differential GPS positioning system (DGPS), Beidou positioning system, autopilot, etc. Most of the equipment has strong environmental adaptability and can maintain stable operation without being susceptible to sea condition, except that autopilot may be greatly influenced by sea condition.

Autopilot is a navigational aid system that can automatically control the steering gear according to command signals to achieve vessel navigation on a given course or track.

Autopilot has a certain demand for environmental sea condition and vessel navigation speed. It is not recommended to use autopilot in bad weather or complex sea condition. Uncontrolled continuous yaw may lead to excessive movement of autopilot, making it unable to ensure safe navigation against wind and waves, thus increasing the risk of accident, or even leading to other equipment or system problems[11]. Therefore, it is recommended to use autopilot when sea condition is below level 5, wind force below level 5, and wave height no more than 2.2m, so as to ensure the safety of navigation. The efficiency of the autopilot system may decrease with the decrease of vessel navigation speed. Therefore, it is not recommended to use autopilot at a low navigation speed. According to the regulations on the use of autopilot, to ensure the efficiency of autopilot, vessel navigation speed should not be lower than 8kn.

2.6 Dynamic positioning system

The dynamic positioning system (DPS) on a vessel can monitor in real time the deviation between the actual position and the target position of the vessel, calculate the dynamic required for the vessel to advance to the target position in combination with its own calculation capability while considering external factors such as current, wave and wind, and reasonably allocate the thrust required to all thrusters of the vessel. Each thruster concerned can generate corresponding thrust to make the vessel reach and stably stay at the target position at sea level.

Considering the economy and practicality, DP-1 DPS is typically adopted for oceanographic research vessels in China. According to DNV dynamic positioning specifications, and in combination with the use of DPS by oceanographic research vessels in China[12], to ensure the fixed-point positioning capability of DPS, it is generally required that sea condition not exceed level 4, wind force not exceed level 4 - 5, effective wave height not exceed 1.8m, and flow velocity not exceed 1.5kn.

3. Stability evaluation system

3.1 Stability evaluation indicator

It can be seen from the above analysis of the stability of scientific research equipment of oceanographic research vessels that the stability of scientific research equipment is influenced by a variety of factors, including environmental factors such as wind, wave and current, and human factors such as equipment lowering speed and vessel navigation speed and others.

Specifically, human factors are highly controllable, allowing the scientific research personnel to manually select the conditions suitable for equipment operation to release the equipment, so as to ensure the stability of equipment. Environmental factors are less controllable than human factors. Such environmental factors as wind, wave and current may largely influence the stability of equipment. The influence of wind on the stability of equipment on a vessel is mainly reflected in the following aspects. First, wind may shake the equipment on the vessel in the process of releasing and retracting, and accordingly lead to the collision between the equipment and the vessel, thus damaging the equipment, and even endangering the vessel and personnel thereon. The influence of wind may also be reflected indirectly through wave and current. Sea wave may cause the oscillation of a vessel, and accordingly lead to the collision between the vessel and the equipment thereon, which may also influence the stability of equipment. The influence of sea current on the stability of scientific research equipment is less than that of wind and wave, as sea current changes little overall from sea surface to the seabed area, and is thus unlikely to lead to the collision between a vessel and equipment thereon underwater.

In the paper, the three factors that have the most prominent influence on the stability of scientific research equipment, namely wind, wave and current, are selected, and the stability evaluation indicator ψ is introduced to investigate whether the aforesaid three factors in the target sea area satisfy the proposed operating conditions for the equipment concerned. ψ may be calculated through formula (1) as follows:

$$\psi = \mathrm{W_d} + \mathrm{W_a} + \mathrm{C} \quad (1)$$

Wherein: Wd, Wa and C respectively indicate the influence of wind, wave and current, which should be valued as 1 if the proposed operating conditions can be satisfied; otherwise, the deviation from the proposed operating conditions should be calculated. The factors excluded in the proposed operating conditions are generally considered with little influence on the stability of equipment, and thus satisfy the proposed operating conditions. The final sum of the influence of the factors involved will be deemed as ψ.

To ensure that the equipment on an oceanographic research vessel is in the best operating state and satisfy the requirements for stability, it is necessary to, when the oceanographic research vessel begins to implement scientific research tasks, firstly investigate the sea condition in the sea area where the oceanographic research vessel is located, and calculate the stability evaluation indicator ψ to evaluate the operating conditions of the equipment under the current sea condition.

If ψ ⩾ 2, it indicates that the equipment can be used under the current sea condition. If 1 ⩽ ψ < 2, it indicates that the equipment can basically satisfy the operating conditions, and can be used for scientific research on the premise of safety. If 0 ⩽ ψ < 1, it indicates that the operating environment of the equipment is relatively poor, and it is not recommended to use the equipment for scientific research. If ψ < 0, it indicates that the equipment cannot be used under the current sea condition.

It is supposed to calculate the stability evaluation indicators of different equipment under the current sea condition, as shown in the stability evaluation table (Table 1), which can guide scientific research personnel to choose scientific research tasks, and ensure the realization of safety benefits and economic benefits.

Table 1 Stability evaluation table

Equipment environment	Wind (Wd)	Wave (Wa)	Current (C)	ψ
TV grab	Wd_1	Wa_1	C1	ψ1
Trawl	Wd_2	Wa_2	C2	ψ2
ROV	Wd_3	Wa_3	C3	ψ3
Multi-beam sounding system	Wd_4	Wa_4	C4	ψ4
Autopilot	Wd_5	Wa_5	C5	ψ5
DPS	Wd_1	Wa_6	C6	ψ6

3.2 Application of the stability evaluation table

Here take the statistics of the real-time sea condition of the sea areas around Chinese Taiwan by the Central Weather Bureau (CWB) as an example. Figures 1 - 3 show the time-series changes of wind force, wave height and current velocity measured by Longdong buoys on Keelung sea surface in Pengjia Islet. The operating stability of different equipment can be evaluated simply in combination with the wind, wave and current data measured at different time and the stability evaluation table.

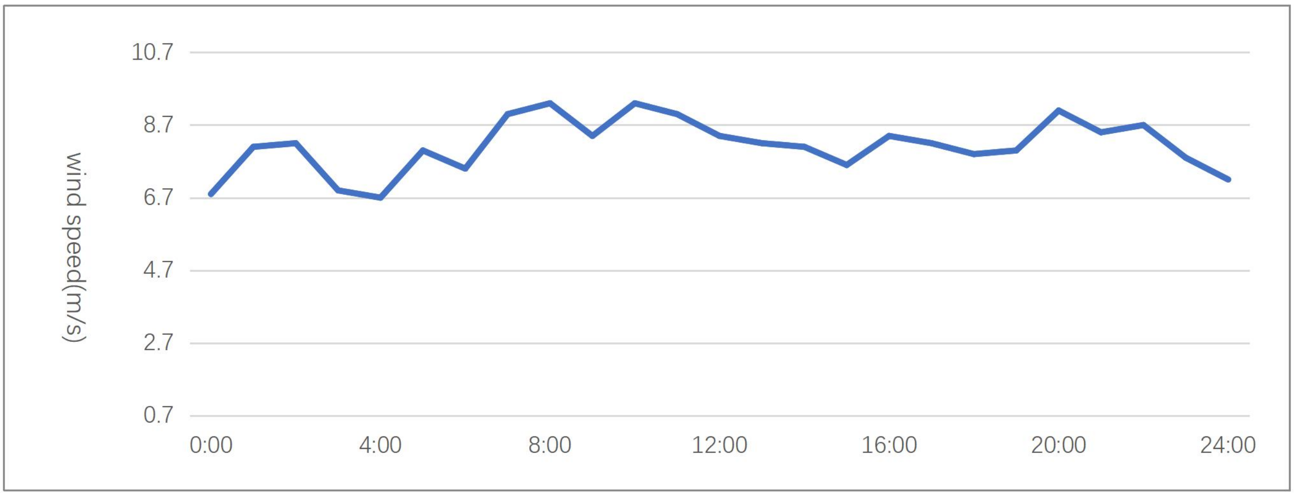


Figure 1 Time-series changes of wind force on Keelung sea surface in Pengjia Islet

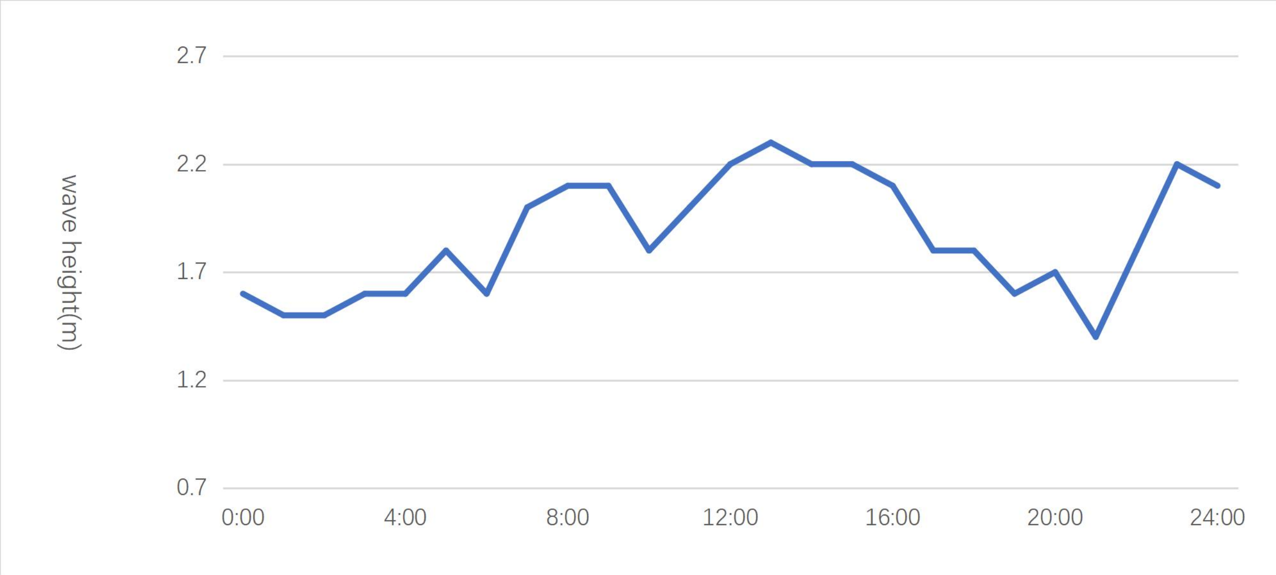


Figure 2 Time-series of wave height on Keelung sea surface in Pengjia Islet

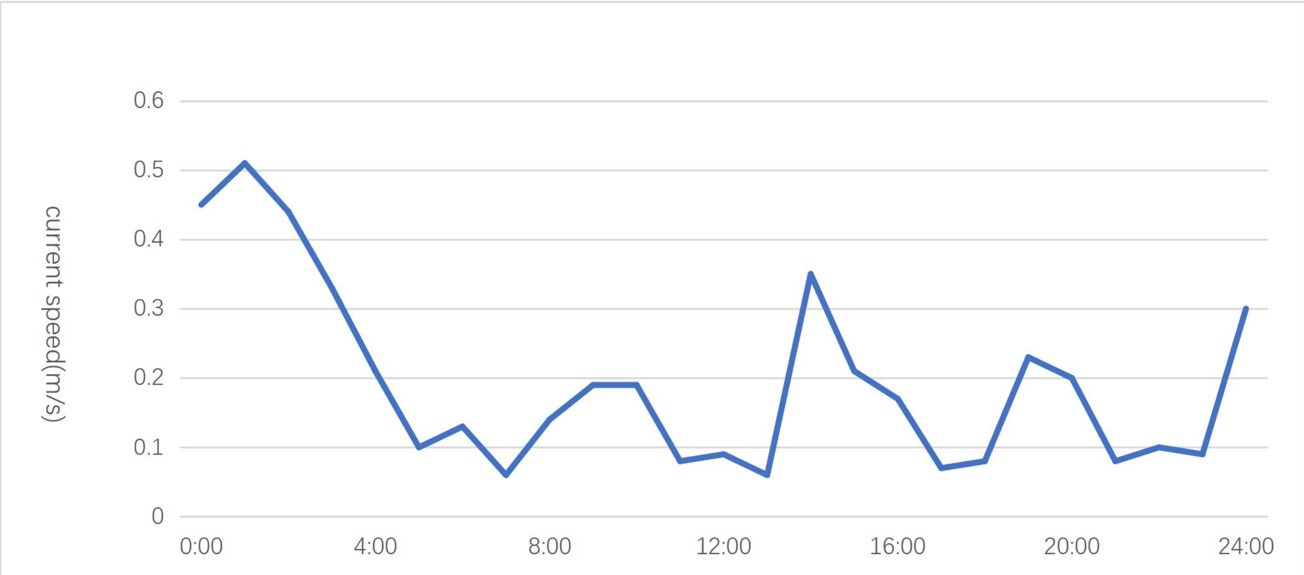


Figure 3 Time-series of current velocity on Keelung sea surface in Pengjia Islet

Here take the real-time sea condition measured by Longdong buoys at 12:00 on February 5, 2020 (wind speed: 8.4m/s; wave height: 2.2m; current velocity: 0.09m/s) as an example. The conservative circumstances involved in the supposed operating conditions are selected to calculate the stability evaluation indicator, as shown in the stability evaluation table (Table 2) below.

Table 2 Stability evaluation table

Equipment environment	Wind (Wd)	Wave (Wa)	Current (C)	ψ
TV grab	-0.17	-0.83	1	0
Trawl	1	1	1	3
ROV	1	1	1	3
Multi-beam system	-0.53	-1.2	1	-0.73
Autopilot	-0.05	1	1	1.95
DPS	-0.53	-0.22	1	0.25

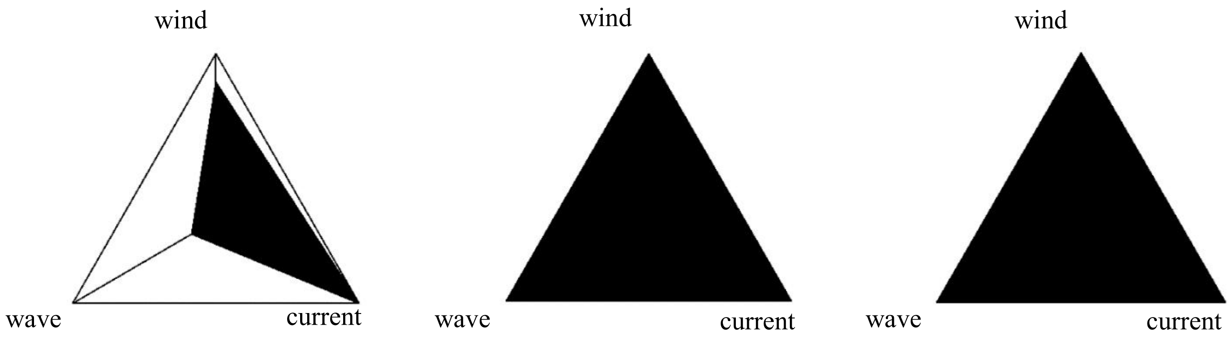
The Wd, Wa and Cparameters of equipment can be calculated as follows. Here take TV grab as an example, and the same goes for other equipment. $W_d = \frac{7.2-8.4}{7.2} =- 0.17$, $W_a = \frac{1.2-2.2}{1.2} =- 0.83$ and C are excluded in the proposed operating conditions, and are thus valued as 1.

It can be seen from the calculated data in Table 2 that the scientific research tasks based on trawl and ROV can be implemented under the current sea condition in the target sea area. The operating conditions of the autopilot system are basically satisfied, so the autopilot system and can be used on the premise of safety. The operating conditions for DP-1 DPS are relatively poor under the current sea condition, indicating that the DP-1 DPS may fail to achieve the expected operating effects, so it is not recommended to be used. TV grab sampling and multi-beam sounding are too risky to be implemented under the current sea condition, as such operations are likely to cause such problems as equipment damage and data inaccuracy, or even influence the safety of and even affect the safety of oceanographic research vessels.

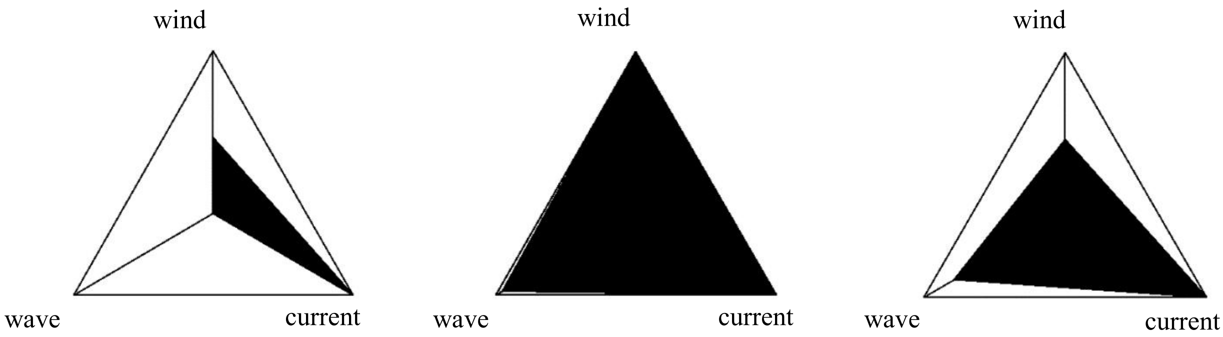
3.3 Stability evaluation diagram

The stability evaluation diagram can help understand the stability of equipment more intuitively, and express the influence of environmental factors in the stability evaluation table in the form of diagram. The influence of wind, wave and current on the stability of equipment can be intuitively seen from the diagram (the greater the proportion, the closer to the proposed operating conditions). Figure 4 shows the stability evaluation diagram corresponding to the sea condition in the Longdong buoy sea area at 12:00 on February 5, 2020.

It can be seen from the figure that all such environmental conditions as wind, wave and current for trawl and ROV satisfy the proposed operating conditions, indicating that the scientific research tasks based on trawl and ROV can be implemented; the autopilot basically satisfies the proposed operating conditions, indicating that autopilot can be implemented on the premised of safety; for TV grab, the wind and wave conditions fail to satisfy the proposed operating conditions, and there exists a large gap between the current wave conditions and the proposed operating conditions; the current wind and wave conditions of DPS also fail to satisfy the proposed operating conditions, but there only exists a small gap between the current wave conditions and the proposed operating conditions; for the multi-beam sounding system, the current wave conditions are more than twice the proposed operating conditions, which may greatly influence equipment stability and measurement results.



TV grab Trawl ROV



Multi-beam sounding system Autopilot DPS

Figure 4 Stability evaluation diagram corresponding to the sea condition in the buoy sea area at 12:00 on February 5, 2020.

3.4 Stability guarantee rate

The stability guarantee rate of equipment under the current sea condition can be extracted from the stability evaluation diagram, which can better guide the implementation of scientific research tasks on oceanographic research vessels, thus improving the safety and economy of equipment, and ensuring the accuracy of the measured data. The stability guarantee rate may be calculated as follows:

$$G = \frac{A_1}{A_2} \times 100\% \quad (2)$$

Wherein: G indicates the stability guarantee rate of equipment; A1 indicates the area of the black triangle in the stability evaluation diagram; A2 indicates the total area of the triangle composed of wind, wave and current.

It can be seen from Table 3 that, the operating conditions of both trawl and ROV satisfy the proposed operating conditions with a stability guarantee rate of 100%. The operating conditions of the autopilot basically satisfy the proposed operating conditions with a relatively high guarantee rate, while the stability guarantee rate of the other three equipment is relatively low.

The calculation of stability guarantee rate can better guide the implementation of scientific research tasks on oceanographic research vessels, which can improve both the safety and economy of oceanographic research, while enhancing China’s oceanographic research capability.

Table 3 Statistical table of stability guarantee rate

Scientific research equipment	Stability guarantee rate (%)
TV grab	38
Trawl	100
ROV	100
Multi-beam sounding system	15.7
Autopilot	96.7
DPS	53.9

4. Summary

This paper studies the special stability of relevant equipment on oceanographic research vessels, and proposes an evaluation system for the special stability of scientific research equipment on oceanographic research vessels, which can evaluate the stability of equipment on oceanographic research vessels under different sea conditions to ensure the smooth progress of different scientific research tasks, while providing a reference for promoting the establishment of a standard system for oceanographic research vessels, and forming special standards and specifications for the oceanographic research vessel industry in China.

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