

短 報

Utilization of an electric fishing reel for water and sediment sampling in deep lakes

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Abstract

Deep lakes and reservoirs store large amounts of freshwater. Monitoring and studying these water systems is important for maintaining freshwater resources. However, research in deep lakes is highly restricted by the availability of research vessels with electric winches, which are required to control heavy research equipment safely and efficiently. In this study, we used an electric fishing reel as a substitute winch for water and sediment sampling. Commercial electric reels have enough winding power to control a water sampler (5-L Niskin bottle). Therefore, we could obtain multiple-layer water samples in deep lakes where the maximum depths ranged from 233 m to 668 m. The success of sediment sampling depends on the weight of the bottom sampler. We used a Dyneema® polyethylene line as a substitute for a wire rope because it has enough strength; however, it is susceptible to wears and bends. The connection of a thick rope at the tip of the line and the selection of an adequate knot for the connection prevent the line from breaking and losing research equipment.

Keywords : deep lakes, electric fishing reel, polyethylene line, sampling, substitute winch

1. Introduction

The hypolimnia of deep lakes contain unique microbial communities that differ from surface communities (Mukherjee et al., 2015; Okazaki et al., 2017 and 2017; Cabello-Yeves et al., 2020). Because of their large water volume, deep lakes and reservoirs are important for the storage of freshwater resources (Tilzer and Serruya, 1990; Herschy, 2012). Most of a lake's water exists in the hypolimnion; therefore, studies of such water systems and sampling from the hypolimnion are important for the management of

water resources.

Ocean research focuses on coastal areas and deep oceans. Therefore, most research vessels are equipped with large electric winches that can handle various types of heavy research equipment. A rosette sampler equipped with a conductivity-temperature-depth (CTD) profiler and multiple sampling bottles is commonly used in ocean research (Brügman et al., 1999). Furthermore, research vessels with electric winches have been used in some lakes that are important for academic studies, nature conservation, or

water uses (e.g., Lake Guardian on the Great Lakes: <https://www.epa.gov/great-lakes-monitoring/lake-guardian> and research vessel ‘Hasu’ on Lake Biwa: <https://www.ecology.kyoto-u.ac.jp/en/joint.html>).

However, lakes studied using research vessels with sufficient equipment are rare worldwide. Manual sampling using a rope is still common in several deep lakes, even for academic studies (Mukherjee et al., 2019). Generally, manual water sampling is effective up to a depth of 100–150 m; it is almost impossible or too laborious to conduct manual sampling in deeper lakes. This difficulty has partly prevented the study of microbial and limnological processes in the hypolimnia of deep lakes. Therefore, winches that are transportable among lakes and can be used without any installation are necessary for further studies.

In the present study, we utilized an electric fishing reel that is commercially offered for tuna and deep-sea fishing as an alternative electric winch for research in deep lakes. The applicability of the electric fishing reel depends on the strength of the fishing line and the winding power of the electric reels. Moreover, we used polyethylene (PE) lines instead of a wire rope because this metal-free line reduces the risk of metal contamination and facilitates inorganic studies (Crompton, 1989; Obata, 2007). We conducted water and sediment sampling in deep lakes and tested their performances. Furthermore, we discuss limitations and precautions regarding the application of this method, as well as improved methods that will enable the use of heavier research equipment.

2. Materials and Methods

A substitute electric winch for deep-lake research was assembled by combining commercially available products (Table 1). As the equipment used for lake research is expensive, it is most important to minimize the risk of equipment loss due to the fishing line breaking. Winches used in industry or for transportation purposes employ wire ropes with 3 to 10 times the strength of the actual load to ensure safety. In this study, the required strength was assumed to be 100 kg based on the weight of the equipment (5–15 kg, Table 2). A Dyneema® PE line (Power Hunter No. 30, 1 mm diameter, YGK YOZ-AMI Co., Ltd., Japan) was selected. To conduct sampling in Lake Issyk-Kul (maximum depth of 668 m) in the Kyrgyz Republic, we used a CZ-15 electric fishing reel (12 V, Miyamae Co., Ltd., Japan) with a PE-line winding capacity up to 700 m (Table 1). Because the maximum winding length depends on the diameter of the line, thicker and stronger PE lines can be used in shallower lakes. For the fishing rod, we used a cheap trolling rod with sufficient strength to control the research equipment (ROST 6'6, 100–130 lbs., Ocean Co., Ltd., Japan).

The commercially available Dyneema® PE line has the same or greater strength as wire ropes with the same diameter, and it is very light, weighing almost one-tenth of the weight of wire ropes (Table 1). Specifically, PE lines consist of bundles of thin fibers. These fibers are gradually cut on the knot or the bending point by loads. Similarly, strong rubbings gradually damage these fibers. Therefore, the strength becomes lower than the

Table1. List of products used for the substitute winch.

Item	Product (type)	Company	Weight (kg)	Performance and comment
Electric reel	CZ-15 (DC-12 V)	Miyamae	5.7	Max winding power 100 kg with minimum spool diameter.
Dyneema® PE line	Power Hunter No.30	YGK YOZ-AMI	0.57 / 1 km*	100 kg (1mm in diameter)
Rod	ROST 6'6	Ocean	1.4	For 100-130 lbs. line
Battery	12 V, 28 A	-	8.3	Calcium battery

*: This is not an official value. We measured it for this study.

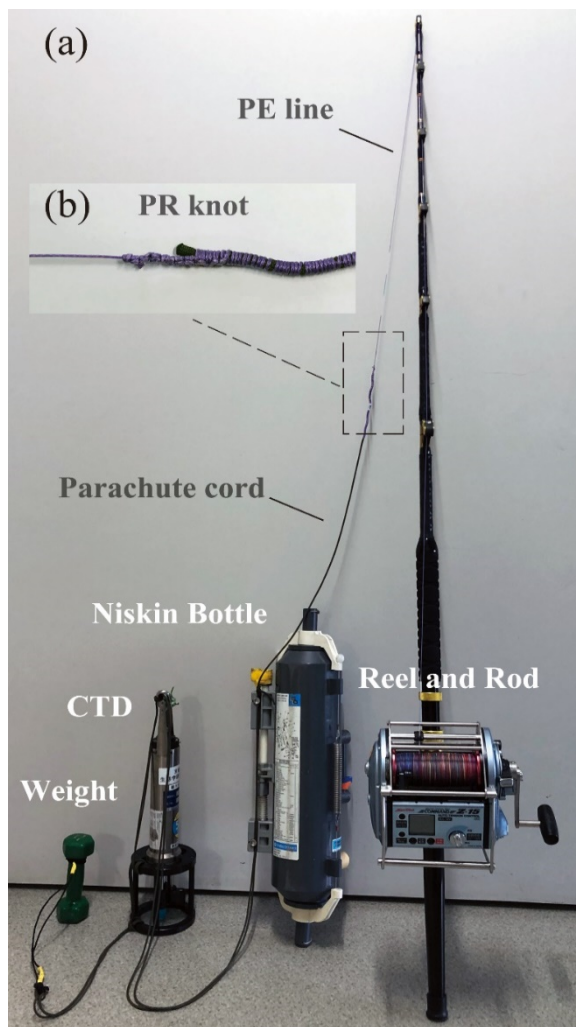


Figure 1.
(a) Water sampling system using an electric fishing reel and
(b) connection between a PE line and a rope.

breaking strength at these points. To overcome these problems, we connected a thick rope at the tip of the PE line and used it to clamp the research equipment and

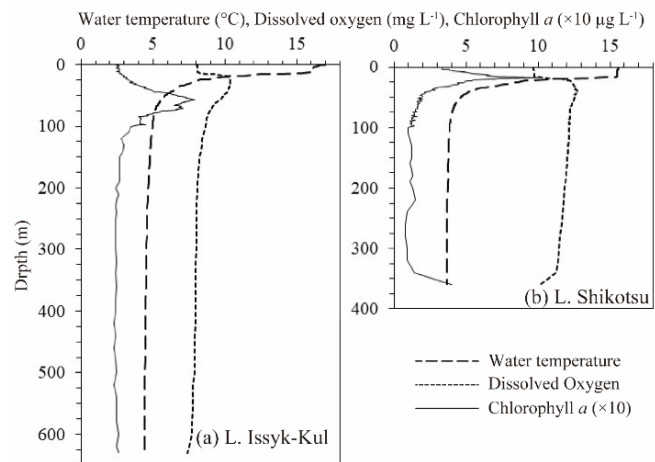


Figure 2.
Vertical profiles of water temperature, dissolved oxygen concentration, and chlorophyll *a* concentration in (a) Lake Issyk-kul and (b) Lake Shikotsu.

weight (Fig. 1a). A PR knot was tied to connect the rope to the PE line (Fig. 1b). This knot uses frictional forces for the connection and does not cause serious strength reduction. The effectiveness of this knot is confirmed in many fishing-related websites. A commercial bobbin knotter (PR Cool Knotter L, Vanguard Co., Ltd., Japan) was used for the PR knot connection. The rope attached to the tip also prevents wears of the PE line caused by direct contact with the research equipment. This rope should have a certain amount of strength and thickness; a thicker rope is preferable to attach research equipment but does not go through the guides of a fishing rod. A nylon parachute cord (paracord, 4 mm diameter) was used.

Table2. Research equipment tested for water and sediment samplings.

Equipment	Product	Company	Weight (kg)	Sampling
Water sampler	5L Niskin-X Sampler	General Oceanics	3.6	Possible*1
CTD profiler	RINKO-Profiler ASTD102-ZF	JFE Advantech	1 (in water)	Possible
Bottom sampler 1	Ekman-Birge Bottom Sampler	RIGO	4.8	Possible
Bottom sampler 2	KK Type Core Sampler*2	*3	11	Possible
Bottom sampler 3, 4*4	HR Type Core Sampler	RIGO	10 or 15	Conditional

*1: Water sampling was conducted with the CTD profiler (1 kg) and a weight (2 kg).

*2: We could not identify the distributor or the production company.

*3: Kimata et al. (1960)

*4: The main body weigh is 5 kg, and there are two removable weights (5 kg each).

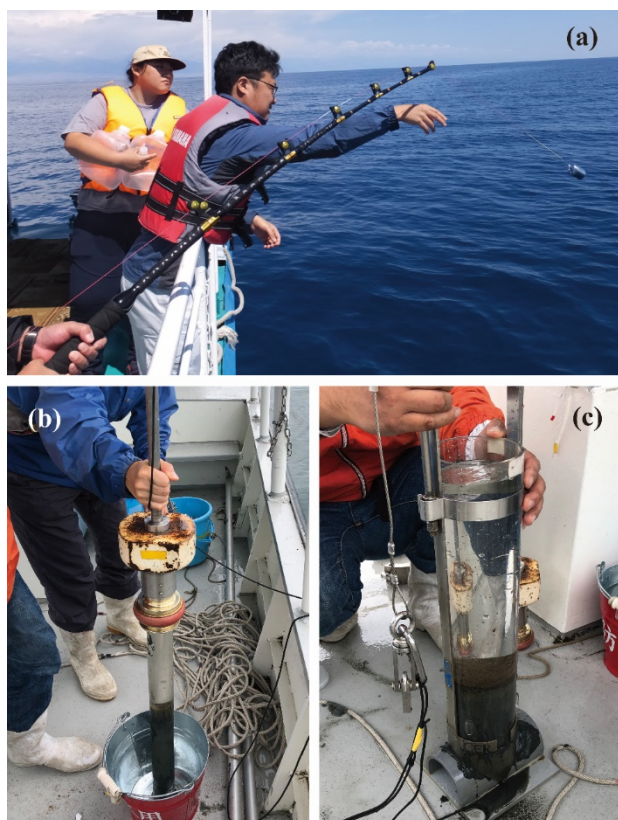


Figure 3.

(a) Water sampling in Lake Issyk-Kul, the Kyrgyz Republic, and sediment samplings using the (b) KK and (c) HR-type core samplers in Lake Biwa, Japan.

Using this apparatus, we sampled water in four deep lakes in Japan and Lake Issyk-Kul in the Kyrgyz Republic (Table 3). To reach the deepest point of Lake Issyk-Kul, 700 m of the PE line was wound to the electric reel. Approximately 10 m of the parachute cord was connected to the tip of the line and used by bending it in half. A 5-L Niskin water sampler (Niskin-X Sampler, General Oceanics, USA), CTD RINKO Profiler (ASTD102-2F, JFE Advantech Co., Ltd., Japan), and a 2-kg weight were connected to the rope (Fig. 1). Then, we measured the water temperature, dissolved oxygen concentration, and concentration of chlorophyll *a* and constructed their vertical profiles (Fig. 2). The sediment sampling was tested in Lake Biwa, Japan, using an Ekman-Birge bottom sampler (RIGO Co. Ltd., Japan) and two types of gravity core samplers (Table 2). When handling heavy equipment, it is important to maintain a minimal spool diameter because the winding power of the electric reel is

inversely proportional to the spool diameter. Therefore, this sampling was attempted by reducing the length of the PE line to 500 m at the second deepest point (73 m) in Lake Biwa.

3. Results

Because of the heavy weight of the electric reel and research equipment, water and sediment should be sampled by at least two people, one operating the electric reel and the other sinking the sampler from the deck to the lake and then pulling it up (Fig. 3). We chartered pleasure boats or cruise ships for sampling, except for the sediment sampling tests in Lake Biwa. A ship of more than 20 ft. is safer because all equipment needs to be handled in a standing position.

Water samples were collected from five lakes in Japan and the Kyrgyz Republic in 2017 and 2018 (Table 3). Multiple-layer water samples and vertical profile data of CTD were successfully obtained for all lakes. In the deepest lake (Lake Issyk-Kul), we obtained water samples and CTD data up to 630 m (Fig. 2). During these studies, we retied the knot between the PE line and the rope several times but did not replace them with new ones. The line did not break, and the knot was not loosened. The maximum winding speed was approximately 1 m s^{-1} for water samples, and the line length meter was accurate enough to estimate the approximate depth. However, it is necessary to attach a water depth sensor and submerge it with the sampler because the error between the values of the meter and the actual depth varies depending on weather conditions and steering during sampling.

We successfully obtained sediment samples under all conditions in Lake Biwa (Fig. 3). However, it was sometimes difficult to pull the sediment core samplers out of the bottom sediment only via electrical winding owing to its heavy weight and the friction with the sediment. In those cases, we pulled it out with additional manual force. After the tip of the fishing rod

Table 3. Information on studied deep lakes.

Lakes	Max Depth (m)	Area (km ²)	Location	Date
Lake Issyk-Kul	668.0	6236	42°23'26"N, 77°06'00"E	Aug. 22, 2017
Lake Tazawa	423.4	25.8	39°43'13"N, 140°39'43"E	Sep. 26, 2017
Lake Ikeda	233.0	10.9	31°14'17"N, 130°33'46"E	Nov. 25, 2017
Lake Shikotsu	360.1	78.5	42°46'17"N, 141°21'20"E	Oct. 15, 2018
Lake Towada	326.8	61.1	40°26'53"N, 140°53'29"E	Oct. 18, 2018

was lowered, it was manually raised based on the principle of leverage. This electric reel has a tension control function that prevents the cutting of the line; it is necessary to turn off this function to maximize the winding power before pulling the bottom sampler. In addition, the HR-type sediment core sampler was the heaviest sampler with a weight of 15 kg. When using this sampler, the winding speed significantly decreased, and the motor was overheated, which sometimes caused it to stop until recovery.

4. Discussion

The electric fishing reel apparatus can handle the minimal equipment required for water and sediment sampling (Figs. 2 and 3). Other substitutional winches may be available, such as an inexpensive small electric winch for industrial or personal use. However, as far as we know, most small electric winches have the following disadvantages: 1) low capacity of the winding wire rope, 2) low winding speed due to the high gear ratio, and 3) heavy weight. Although larger electric winches could cover some of these disadvantages, they require additional fitting work. Moreover, the use of wire rope for the electric winch increases the weight of the apparatus, as well as the risk of metal contamination in water samples (Crompton, 1989; Obata, 2007). Conversely, the electric fishing reel tested in this study is readily transportable among lakes and can be used on every type of ship that has sufficient size.

Using a 5-L Niskin water sampler and a CTD profiler,

we could obtain water samples even from depths of 630 m. The efficiency of the sampling was higher than that of manual sampling using a thick rope because the reel could maintain a high winding speed from the bottom to the surface. In deep lakes and oceans, anchors are not available to anchor ships, and ships are drifted easily by tidal currents and winds during surveys. As Dyneema® PE lines are thinner than normal ropes, they can reduce the effects of ship flow and submerge the sampler closer to the target depth.

We considered that this apparatus works for sediment core samplings with samplers of approximately 10 kg. When using heavier samplers, we need to adjust the conditions accordingly. For example, the substitution of the electric fishing reel with a stronger, higher-grade reel and a reduction in the length of the winding PE line will increase the maximum winding power. However, 15 kg appears to be the limit of total equipment weight when the rod needs manual support. Specialized holders that fix fishing rods to ships are commercially available, and this device would partly reduce the physical load on users. In this case, it is necessary to pay attention not to increase the breaking risk of the line under strong or frequent waves. Moreover, bottom samplers that use a messenger for the closing may not work without anchoring the ship. The messenger requires some time to attain the bottom sampler, during which the sampler may be moved or floated owing to waves and winds. Therefore, bottom samplers that do not require a messenger are suitable for sampling without anchoring the ship.

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釣り用の電動リールを用いた深い湖の深層水と堆積物のサンプリング

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要 旨

水深の深い湖や貯水池には大量の淡水が蓄えられている。淡水資源を維持管理するために、このような湖の環境監視と研究は重要であるが、観測機器を水中で安全に制御するために必要となる電動ウインチを備えた調査船が利用可能な湖は限られている。そのため、本研究では、湖の観測やサンプリングのための代替ウインチとして、釣り用の電動リールが利用可能か検討を行った。市販の電動リールには、5L の採水器を上げ下げするための十分な巻取り力があり、最大深度 668 m の湖でも採水を行う事が出来た。また、堆積物のサンプリングは、使用する採泥器の重量次第で可能であることも確認できた。金属製のワイヤーの代わりに用いたダイニーマ®ポリエチレンラインは十分な強度があるものの、磨耗や折れ曲がりに弱いという欠点もあるため、ラインの先端に太いロープを接続し、観測機器と接触するのを防ぐとともに、接続に適切な結び目を選択し、ラインの破損を防ぐ必要があった。

キーワード: サンプリング, 代用ウインチ, 釣り用電動リール, PE ライン, 深い湖