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Collaborative adaptive management for bigfin squid applied to tourism-related activities in coastal waters of Northeast Taiwan

Tsen-Chien Chen [a], Kuo-Cheng Ku [b], Chih-Shin Chen [c, *]

[a] Department of Leisure Management, Minghsin University of Science and Technology, No.1, Xinxing Rd., Xinfeng, Hsinchu 30401, Taiwan, ROC
[b] Department of Industrial Engineering and Management, Minghsin University of Science and Technology, No.1, Xinxing Rd., Xinfeng, Hsinchu 30401, Taiwan, ROC
[c] Institute of Marine Affairs and Resource Management, National Taiwan Ocean University, Keelung 20224, Taiwan, ROC

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ABSTRACT

The bigfin squid *Sepioteuthis lessoniana*, a commercially important fishery resource and also an object of sightseeing for diving, are under risk situation arising from current management procedure in Taiwan. Significant decline in abundance of bigfin squid and destruction of suitable substrates for spawning of neritic squids in coastal waters of Northeast Taiwan has been noted by local fishermen in recent years. Local divers arbitrarily deployed bamboo clusters as a squid aggregation device, for mating and spawning, in order to restore the abundance of squid. The deployment of the devices was not approved by the government, in particular the fishery authorities. Following conflict and compromises, the bamboo clusters were placed in restricted regions with permission from the local government. However, the interim management measure faced a serious challenge. The fishing activity of fishermen and recreational anglers, who were not consulted for the interim measure, targeted the aggregated squids putting them at risk. To prevent hazards, a theoretical management model was proposed to involve and direct essential stakeholders in conservation and sustainable utilization of the resource. A fishbone diagram and spiral model was created to analyze and illustrate the potential problems. Collaborative management tools were applied to coordinate the participants' duties and responsibilities and build the interrelationships between them. Finally, a modified management model based on adaptive management strategies was developed to cope with the changing situations. This modified management model process might further serve as an example for conservation and management measures of other fisheries resources.

1. Introduction

Coastal waters, the most productive regions of the oceans, comprise various marine ecosystems and support a large number of creatures (Kaiser et al., 2005). The ecosystem services, including physical structures, biotic and social services, have made great contributions toward human needs, e.g. food, economics, recreation and local custom and culture (Worm et al., 2006; Barbier et al., 2011). However, the habitats have faced numerous anthropogenic threats and hazards. The strategies and practices for coastal management are critical for the conservation and sustainability of these resources (Beatley et al., 2002).

Coasts, the interface between land and sea, have always attracted people. Various coastal landscapes, such as steep cliffs excavated by the waves from rocky structures and beaches comprised of boulders and sand that become finer and finer towards the sea, create distinctive scenery. Tourists may gain great satisfaction from the dramatic scenery, as well as from observing wildlife (Orams, 2002; Curtin, 2003; Ergin et al., 2006; Carter, 2008; Velando and Munilla, 2011). In addition, water sports and water-based recreation are often found at scenic spots (Jennings, 2007). Coastal tourism is one of the industries which has grown rapidly in recent decades (Hall, 2001), and the commercial value of tourism activities may contribute significantly to local economies (Rudd and Tupper, 2002; Tapsuwan and Asafu-Adjaye, 2008; Stoeckl et al., 2010). Therefore, natural characteristics, both biotic and abiotic, are essential for the development of coastal tourism (Garrod, 2003).

* Corresponding author. Address: Institute of Marine Affairs and Resource Management, National Taiwan Ocean University, 2, Pei-Ning Rd., Jhong-Jheng District, Keelung City 20224, Taiwan, ROC.
E-mail address: cschen@mail.ntou.edu.tw (C.-S. Chen).

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Recreational scuba diving is an essential component of the coastal tourism industry (Davis and Tisdell, 1995; Buzzacott, 2008; Shani et al., 2012), and the financial gains from diving services contributes greatly to local economies (Oh et al., 2008; Tapsuwan and Asafu-Adjaye, 2008; Stoeckl et al., 2010). However, many factors damage the environment of coastal waters, resulting in the degradation of the diving quality (Barker and Roberts, 2004; Worachananant et al., 2008; Ku and Chen, 2013). This may reduce tourist divers' enjoyment of the environment (Needham, 2010), and lead to fewer divers and reduced income (Kragt et al., 2009). Deploying small artificial reefs has been suggested as a possible approach to reduce the impact of diving on the natural environment (Feary et al., 2011; Jaafar and Maideen, 2012; Polak and Shashar, 2012; Shani et al., 2012; Kirkbride-Smith et al., 2013). Studies evaluating the economic value of small artificial reefs have been made in recent years (Polak and Shashar, 2013). These artificial devices, however, should be carefully managed under the supervision of competent authorities, or the aggregated marine resources could be damaged even more severely (Baine, 2001).

A conservation project of squid was submitted by the local divers to the Keelung City Government in 2013. This project was considered as a case study and aimed to develop a theoretical management model to involve essential collaborative stakeholders in order to organize robust conservation and management measures for fisheries resources. The concepts of problem-solving skill were used to structure this article. This skill is often employed in business management (Liang and Zhang, 2010), but either coastal or fisheries management. Therefore, the objectives of this study are: (a) to analyze the potential influences on squid populations; (b) to illustrate the potential persons' involvement with actions and pertaining affairs, and each one's duties and responsibilities; (c) to propose a modified management model of monitoring, control and surveillance (MCS) process of actions to adapt to changing situations and future applications.

2. Background to the case study

The waters off Northeast Taiwan are an important fishing ground for the neritic and coastal fisheries of Taiwan (Chen and Chiu, 2003; Anonymous, 2013; Wang et al., 2013). Among the hundreds of exploited species, *Sepioteuthis lessoniana*, commonly known as the bigfin reef squid, is a bycatch of trawling and is of great commercial value due to its excellent flavor. The unit price of *S. lessoniana* is generally 4–5 times higher than that of other loliginid squids, such as *Uroteuthis* (*Photololigo*) *edulis* and *U.* (*P.*) *chinensis* (Anonymous, 2013). The bigfin squids migrate to coastal waters during the spawning season, and can be caught by anglers using rods and jigs with lures of wooden shrimp. During the spawning season, the squid are also an object of sightseeing for recreational scuba divers. Tourist divers can enjoy observing a school of slowly moving squid demonstrating a variety of interesting behaviors, such as aggression for mating, waving their large fins and tentacles, occasional bizarre color changes, as well as their pale or semitransparent strings of eggs. Tourist diving trips can make a substantial contribution to the economy.

Severe declines in fisheries production are observed on scales from the local to the global (Stobutzki et al., 2006; Wilberg et al., 2011; Worm et al., 2013), and the neritic squid fisheries of Taiwan are no exception. The annual production of neritic squid (Loliginidae) off North Taiwan over the past 20 years (1993–2012) peaked in 1998, but dropped by half in the next year, followed by further decreases (Fig. 1). The landing data of *S. lessoniana* (or any or other squid species), however cannot be independently extracted for analysis, because the data are compiled and recorded as a single item for all neritic squids in the Fisheries Statistical Yearbook of Taiwan. But it can be assumed that the landings of *S. lessoniana* share the overall pattern.

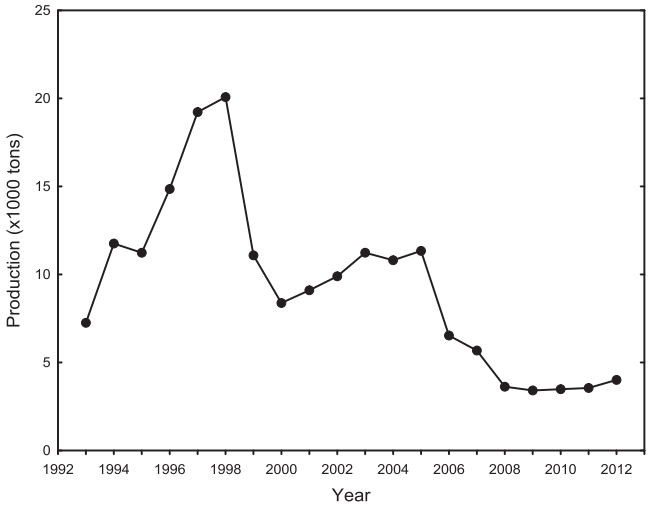

Fig. 1. Annual landings of neritic squids (Loliginidae) off North Taiwan between 1993 and 2012.

Local divers have also noted that the populations of bigfin squid have declined in diving locations. In order to restore squid abundance, some local divers voluntarily deploy artificial aggregation devices to draw more bigfin squids to diving spots. After several experimental trials, they successfully gathered squid using floating bamboo clusters that were moored with three to four ropes to sand bags on the sea bottom (Ke, 2007, Fig. 2). The aggregation devices (bamboo clusters) were similar to those used in the Philippines (White et al., 1990). Squid then gathered around the bamboo clusters and attached egg strings to them after mating. Tourist divers greatly enjoy closely observing the squid's mating behavior, and were astonished to see the “bamboo-with-egg-string” that resulted from numerous females laying eggs in the bamboo strips (Fig. 2).

Nevertheless, the diver's actions were not approved by officers of the Fisheries Agency, Council of Agriculture of the Executive Yuan in Taiwan, which considers the arbitrary deployment of fish aggregation devices in coastal waters around Taiwan as unacceptable, despite good intentions. The divers retorted that the fisheries authority had no constructive programs to cope with the long-term

Fig. 2. A squid aggregation device (bamboo clusters) located at coastal waters off Northeast Taiwan.