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Observer Report on Squid Jigging Fishery in the SPRFMO Convention Area

Korea

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Introduction

Global squid catch is showing a decreasing trend, and an increasing number of squid jigging vessels in the Southwest Atlantic, Korea's one of the major fishing grounds, have been relocating themselves to the Southeast Pacific to seek for an alternative fishing ground due to a decreased level of catch in the existing fishing grounds of the area. As the management of *Dosidicus gigas* (jumbo flying squid) resource has been gaining more importance at the South Pacific Regional Fisheries Management Organisation (SPRFMO), there has been a need for a survey to be undertaken to seek for alternative fishing grounds for distant water squid jigging fisheries. Accordingly, this survey is to collect biological information to assess jumbo flying squid for the sustainable use of fisheries resources in the South Pacific and to analyze the impacts of squid jigging fisheries on the marine ecosystem. Each scientific observer was on board two jigging vessels separately which targets jumbo flying squid in the SPRFMO Convention Area to conduct a scientific survey. The survey was conducted in the open seas of the Southeast Pacific (FAO area 87), mainly the area 14-21°S, 75-83°W. Total survey period was 175 days (Observer 1: 93, Observer 2: 82) from October 2018 to January 2019. The survey items include collection of fishing operation data; biological measurement of the target species; observations of bycatch species, marine mammals, seabirds and other species of concern; monitoring of marine environment and waste disposal; and biological sampling.

Details of Fishing Gear and Equipment

Squid jigging vessels mainly utilize fishing gear and equipment such as sea anchor, parachute, buoy, hook, sinkers, jig machine, echo sounder, etc. Korean squid jigging fleets who operate in the SPRFMO Convention Area use halogen and metal as the source of their light attraction; under-water lights are not used. Average deck light power was 542 kW. Use of a sea anchor, parachute, buoy, and sinkers allows the vessel to float along the current which assists handlines' vertical movements and vessel's natural movements to other fishing grounds. Regarding the jig machine, both of the squid jigging vessels use double jig machines to pull up squids which have taken the bait, and number of jigs per line was 1. There is also an echo sounder to search for a school of fish in a fishing ground. Handline consists of a main line and a branch line. The main line is for the actual fishing while the branch line is for preventing misguided squids fall out when passing the front roller (Figure 1).

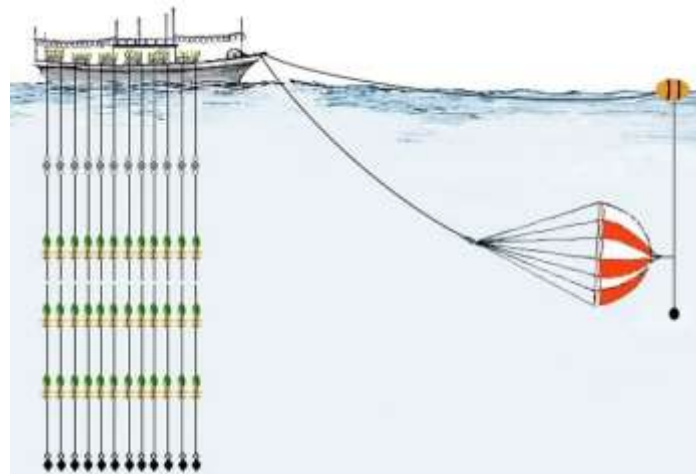


Figure 1. Illustration of squid jigging fisheries.

Observed Species

The target species, jumbo flying squid, and five bycatch species were observed during the survey: 2 species of cephalopods excluding the target species, 1 species of pisces, and 2 species of sharks each (Table 1 and Figure 2). The proportion of bycatch was quite low and total bycatch was 119.2 kg which is 0.03% of the total catch. However, there were some observations of species of concern during the survey period in the SPRFMO Convention Area. *Prionace glauca* (blue shark) and *Lamnidae* (Mackerel sharks) were bycaught through collision or entanglement in net.

Table 1. Lists of observed species in the SPRFMO Convention Area by Korean jigging vessels in 2018

Species code	Scientific name	English name
GIS	<i>Dosidicus gigas</i>	Jumbo flying squid
YUR	<i>Thysanoteuthis rhombus</i>	Diamondback squid
OCT	<i>Octopodidae</i>	Octopuses, etc. nei
DOL	<i>Coryphaena hippurus</i>	Common dolphinfish
BSH	<i>Prionace glauca</i>	Blue shark
MSK	<i>Lamnidae</i>	Mackerel sharks

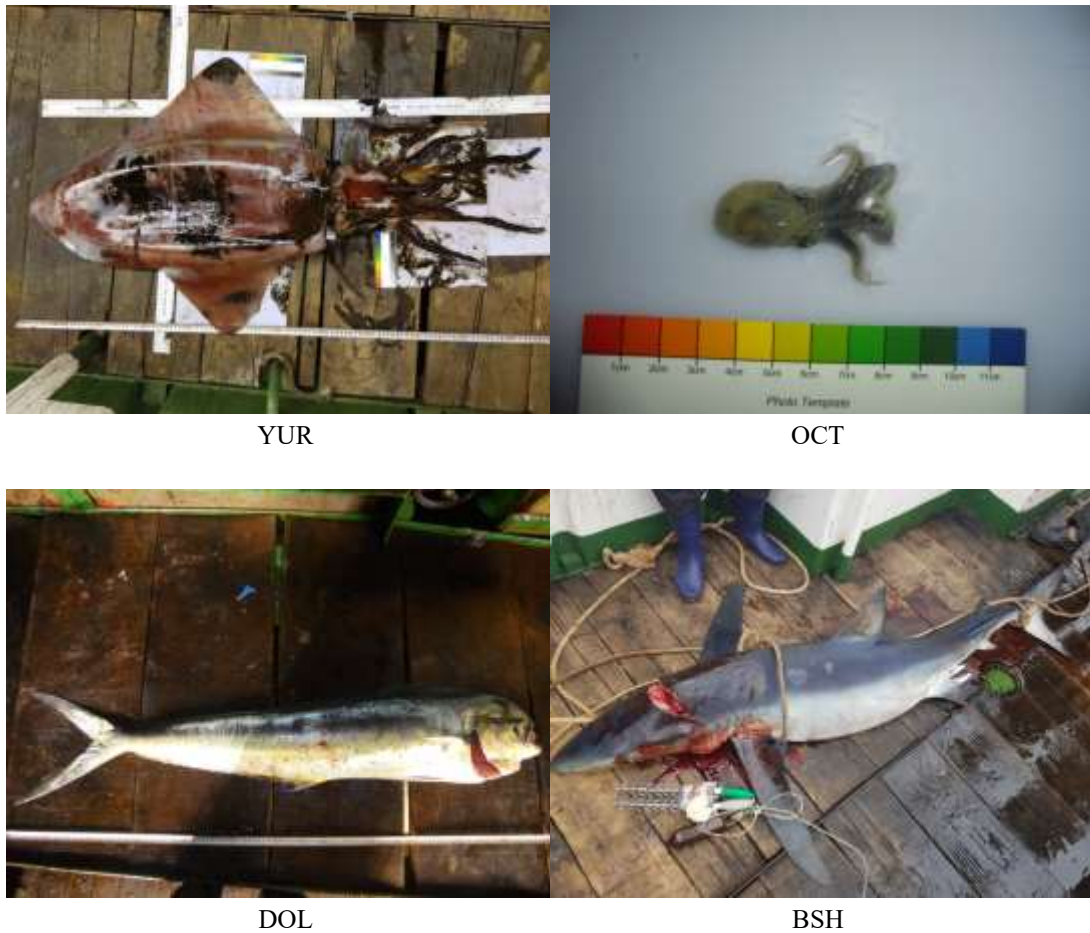


Figure 2. Photographs of bycatch species by Korean squid jigging vessels in the SPRFMO Convention Area in 2018.

Catch and Effort of Target Species

During the total survey, Observer 1 (Lee) conducted a total of 201 sets with the average daily sets being 2 sets for 93 days. The total operation time is from jigging of the first set to hauling of the last set and was 1,166 hours with the total catch of approx. 239 tons. The average operation time for a set was around 10 hours. Operating depth ranged from 30 to 240m, and the range of sea surface temperature (SST) at catch was 17.4°C-23.4°C. Observer 2 (Choi) conducted a total of 121 sets with the average daily sets being 2 sets for 82 days. The total operation time is from jigging of the first set to hauling of the last set and was 729 hours with the total catch of approx. 218 tons. The average operation time for a set was around 8 hours. Operating depth ranged from 120 to 200m, and the range of sea surface temperature (SST) at catch was 16.8°C-21.7°C (Table 2).

Table 2. Information on the operation and fishing environment

(a) Observer 1 (Lee)

Factors	Total	Range	Mean
Number of operation (set)	201	1-5	2
Total catch (kg)	238,950	81-39,420	2,060
Total hours fished (hr)	1,166.3	0.5-28.2	10.1
Operating depth (m)	-	30-240	133
Sea surface temperature (°C)	-	17.4-23.4	19.5

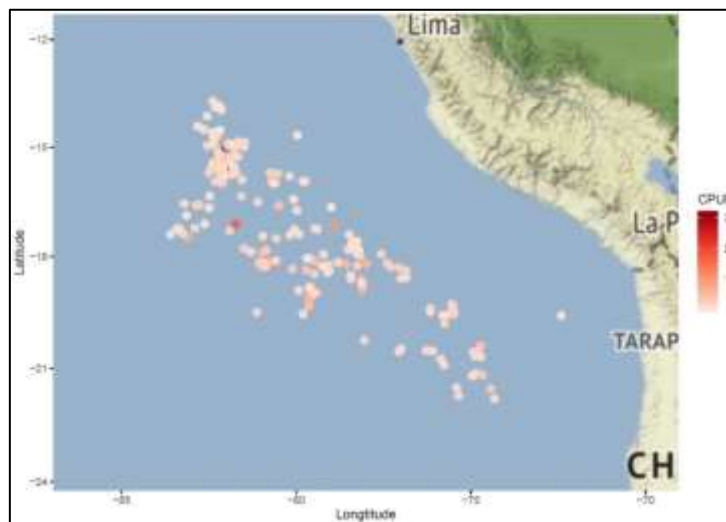
(b) Observer 2 (Choi)

Factors	Total	Range	Mean
Number of operation (haul)	121	1-4	2
Total catch (kg)	218,220	54-15,759	2,452
Total hours fished (hr)	728.5	0.9-16.8	8.2
Operating depth (m)	-	120-200	162.0
Sea surface temperature (°C)	-	16.8-21.7	18.5

Two squid jigging vessels each of which had a scientific observer onboard operated mainly in the area 14-21°S, 75-83°W in the SPRFMO Convention Area to conduct a scientific survey. The vessels had a frequent transfer of location to search for schools using an echo sounder. Total catch of jumbo flying squid, target species, was approx. 457 tons from October 2018 to January 2019. The largest monthly catch was in October, and the mean CPUE was 0.27 ton/hour (Figure 3).



(a) CPUE of total Korean squid jigging fleets



(b) CPUE of two vessels with an observer onboard

Figure 3. Distribution of CPUE (ton/hour) by Korean squid jigging vessels in 2018.

Biological Survey

A total of 1,777 individuals of jumbo flying squid were measured for biological survey. Mantle length of jumbo flying squid ranged from 30 to 98cm and more than two modes appeared in the range (Figure 4). The highest mode was at 77-89cm. The proportion of male individuals was slightly greater than that of females. Sex ratio was 50.9% for male and 49.1% for female. A few more males were in the length class greater than 80cm (large size group) than females; however, overall mode of mantle length frequency was similar between both sexes. In addition, mantle length-weight relationship by sex was little different (Figure 4).

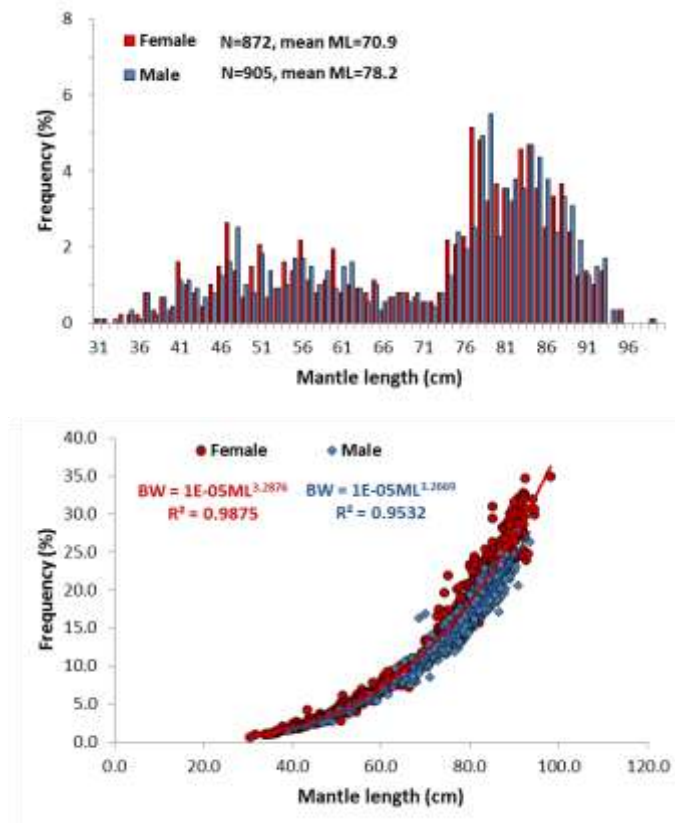


Figure 4. Length frequency (left) and length-weight relationship (right) of *D. gigas* by Korean jigging vessels in 2018.

The maturity of jumbo flying squid was classified into 5 stages, and the identification was conducted based on the pictures in Figure 5 which were taken by the scientific observers on board. Stage 3 (Developed) was the dominant stage of maturity observed for both male and female during the survey (Figure 6). Most of the males were observed to be in stage 3, especially in November, and spermatids are developed in the gonad in this stage. On the other hand, more females were observed to be in stage 4 (Gravid) than males, and in this stage, the part surrounded by follicles is replaced by yolks.

Maturity stages	Sex	
	Female	Male
1 Immature		-

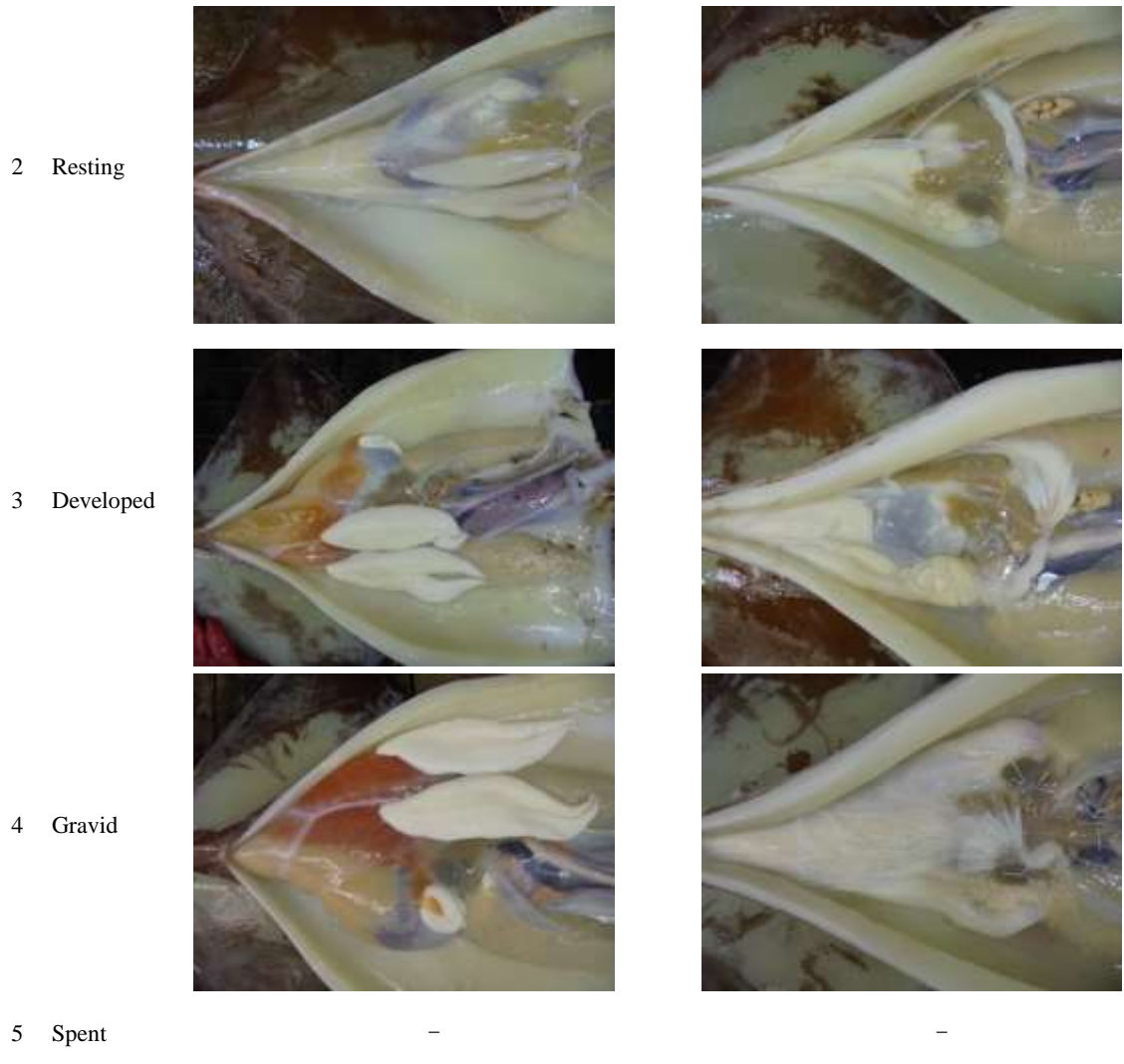


Figure 5. Photographs of maturity stages standards of *D. gigas*.

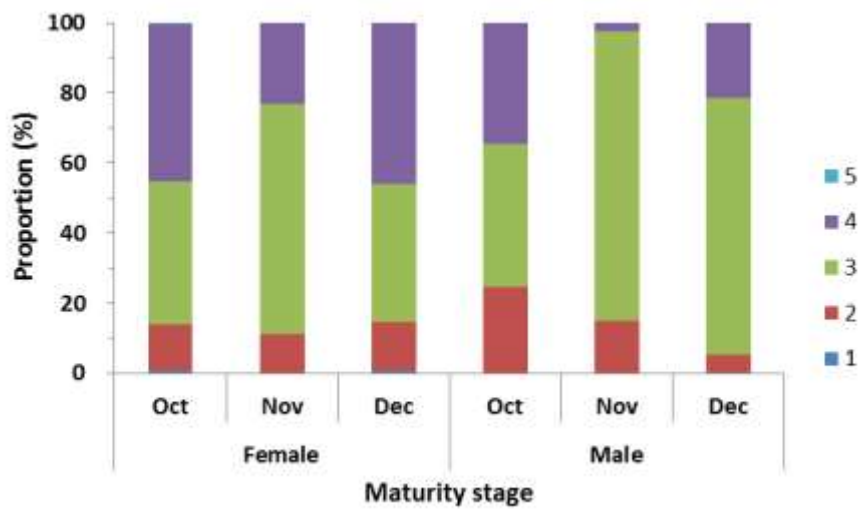


Figure 6. Monthly maturity proportions of *D. gigas* by sex.

Composition of Stomach Contents

In the sampled stomach contents of jumbo flying squid, a variety of prey were observed: Cephalopods, pisces, macrura, seaweed, etc. Accordingly, jumbo flying squid was identified as cannibalism, which is to feed on its cohorts (Figure 7).

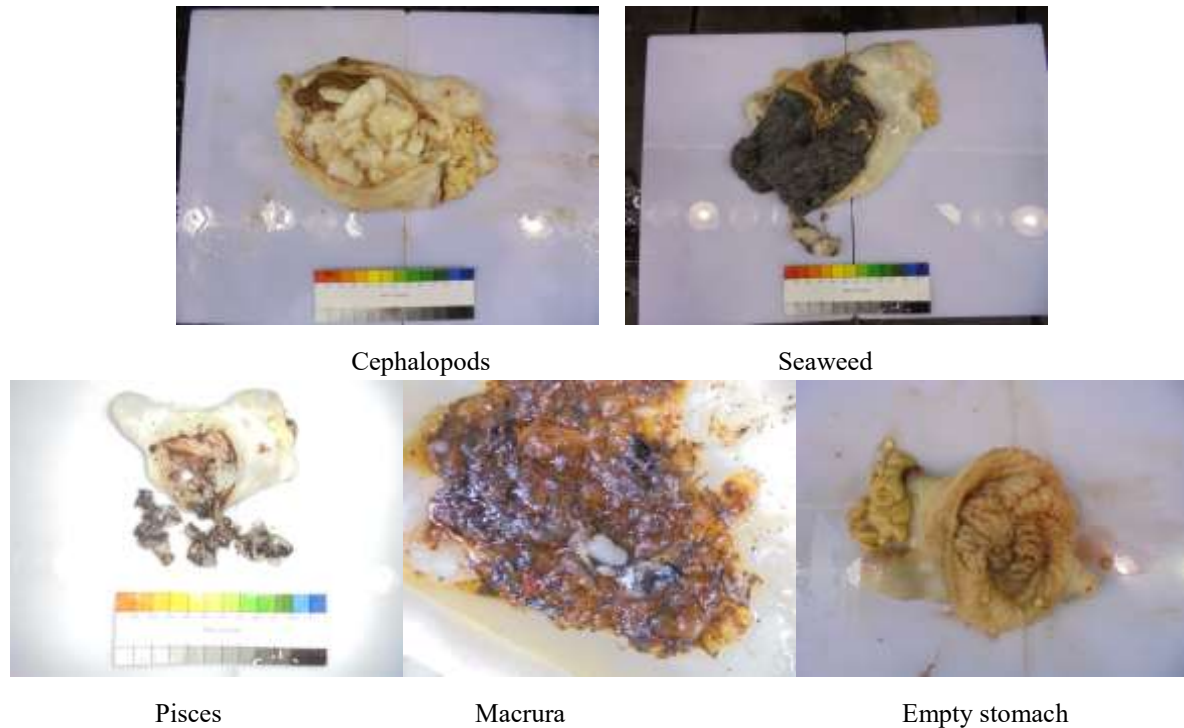


Figure 7. Stomach contents of *D. gigas* in the SPRFMO Convention Area.

Observations of Seabird, Marine Mammal and Other Species of Concern

For observation of seabirds, it was recommended that daily observation take place at least once every set for 15 minutes. Observers were instructed to observe whether the seabirds were dipping their beak or head into the water near the fishing gear to feed on their prey. The recording of observations on the abundance of seabirds and their encounter with the vessel was made quantitatively.

Squid jigging fishing is mainly operated in the night time due to fisheries properties and doesn't discharge offal or other byproduct during operations. Therefore, no entanglement of seabird in net was observed during fishing operations. Only two species of seabirds were observed during the survey in the SPRFMO Convention Area: *Fregetta tropica* (black bellied storm petrel) and *Puffinus spp.* (shearwaters nei) (Table 3 and Figure 8). The seabirds were not continuously observed during operations, but rather circled around the vessel several times and disappeared.

During operations in the daytime, marine mammals were observed six times. In case of *Globicephala macrorhynchus* (short-finned pilot whale), abundance was approx. 15 individuals, and they circled around the vessel with grouping behavior for a long time. However, observation was difficult during bad weather conditions, and it seems possible that they approached near the vessel in operation. Unidentified seals nei were also observed two times in the night time (Table 3 and Figure 8).

Table 3. List of observed seabirds and marine mammals in the SPRFMO Convention Area in 2018

Species Code	Scientific name	English name	Number of observation time	Abundance
FGQ	<i>Fregetta tropica</i>	Black bellied storm petrel	35	31.8
PQW	<i>Puffinus spp</i>	Shearwaters nei	30	27.8
SHW	<i>Globicephala macrorhynchus</i>	Short-finned pilot whale	4	15>
SXX	<i>Otariidae</i>	Unidentified seals nei	2	2>



FGQ



PQW



SHW



Unidentified seals nei

Figure 8. Photographs of observed seabirds and marine mammals in the SPRFMO Convention Area.

Marine Environment

Beaufort's wind scale was applied to record the sea condition by each operation set (Table 4). 'Light and Gentle breeze' was the dominant force over the total 322 sets and 'Strong breeze' was rarely observed.

Table 4. Beaufort scale observed during the jigging operations in the SPRFMO Convention Area

Force	WMO classification	Appearance of wind effects on the water	Wind (Knots)	Frequency	Rate (%)
1	Light air	Ripples with appearance of scales, no foam crests	1-3	13	4.0
2	Light breeze	Small wavelets, crests glassy, no breaking	4-6	174	54.0
3	Gentle breeze	Large wavelets, crests begin to break, scattered whitecaps	7-10	110	34.2

4	Moderate breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	11-16	14	4.3
5	Fresh breeze	Moderate waves 4-8 ft taking longer form, many whitecaps, some spray	17-21	5	1.6
6	Strong breeze	Larger waves 8-13 ft, whitecaps common, more spray	22-27	6	1.9

Waste Disposal

After the processing, approx. 26% of a whole jumbo flying squid were discarded. They are mainly offal and were kept until they were discharged when the vessel moves or seeks for the target. Waste including plastic and carton boxes were incinerated and kept on board, and only the food waste was discharged.

Biological sampling

During the survey, two observers separately collected biological samples of jumbo flying squid to investigate ecology of them and identify the possibility of alternative fishing ground through future analysis. Collected samples were statolith, beak, muscle tissue from dorsal mantle, stomach contents, etc. And they will be utilized for the future research on the age determination, prey composition, and genetic study.

Summary

Indirect information on the biology of the target species, *Dosidicus gigas* (jumbo flying squid) as well as components of the ecosystem which may be impacted by fishing was collected through the squid jigging fisheries survey in the SPRFMO Area. Six species including the target were observed. The largest monthly catch was in October, and the mean CPUE was 0.27 tons/hours. A total of 1,777 jumbo flying squids were measured for biological survey. Mantle length of jumbo flying squid ranged from 30 to 98cm. The proportion of male was marginally greater than that of females, and a few more males were in the length class greater than 80cm (large size group) than females. However, overall mode of mantle length frequency was similar between both sexes. In addition, mantle length-weight relationship by sex had no significant difference. The dominant stage of maturity observed for both male and female jumbo flying squids was stage 6 (Developed). Stomach contents of sampled jumbo flying squids consisted of cephalopods, pisces, macrura, seaweed, etc. Squid jigging fishing is mainly operated in the night time due to fisheries properties and doesn't discharge offal or other byproduct during operations. Therefore, no entanglement of seabird in net was observed during fishing operations. Conducting a total of 322 sets, and 'Light and Gentle breeze' was the dominant force and 'Strong breeze' was rarely observed. Using the collected biological samples from observers, there is a possibility of studying the age determination, prey composition, genetic, etc. in the future. Korea is planning to strengthen its efforts to conduct research on the composition of the ecosystem including the target and bycatch species, seabirds, and marine mammals by maintaining its interest in squid jigging surveys and dispatching observers on jigging vessels.