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China's Annual Report to the 2017 SPRFMO scientific Committee Part II: the squid Jigging fishery

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1 *Description of Chinese Squid Jigging Fishery*

Jumbo flying squid (*Dosidicus gigas*) has been targeted by the Chinese distant-water squid jigging fleet since 2001 (Chen et al., 2008). The Chinese squid jigging vessels only operate in the high seas of the South East Pacific. In general, small vessels with hand jiggers catch jumbo flying squid all year round, while the big vessels move to the South East Pacific from the south-western Atlantic to catch jumbo flying in a few months of the year.

The total of 22 fishing vessels arrived at the international waters of the South East Pacific in 2001.The number of vessels increased to 119 in 2004 and then declined continuously in the flowing three years. During the period 2012-2016, the number of Chinese squid jigging vessels fluctuated between 205 and 276, and it showed a small increase in 2016 compared to 2015 (Table 1).

The number of active fishing vessels tends to change from time to time (even in a fine scale of weekly) in a calendar year. During 2012-2015, the number of operational vessels was more than 150 for 5 or 6 months a year. In 2015, it peaked in the first week of November, and a total of 252 vessels were recorded to operate in the Convention Area. In 2016, a total of 276 Chinese squid jigging vessels were reported to catch the jumbo flying squid in the South East pacific, however the maximum number was 242 occurred in December (Figure 1). The number of vessels from July to December in 2016 exceed 200 and increased obviously when compare to the same period of previous four-year, especially in July and December 2016.

Annual catch of jumbo flying squid presented similar trend as the number of vessels during 2001-2015, however, catches in 2016 didn't increase with the number of fishing vessel. Only 17,770 tons squid caught by 22 vessels in 2001, and annual catch increased rapidly in the flowing three-year, however, it declined continuously in the next three years. Staring from 2008, the catch increased again and reached a record 325 thousand tons in 2014, and fell slightly in 2015 (Table 1). In 2016, the catches dropped to 223 thousand tons, the lowest level in the past five years.

Table 1 Number of vessels and annual catch of the Chinese squid jigging fisheries in the South East Pacific during 2012-2016

Year	Number of vessels	Catch in tons
2012	254	261,000
2013	205	264,000
2014	264	332,500
2015	252	323,600
2016	276	223,300

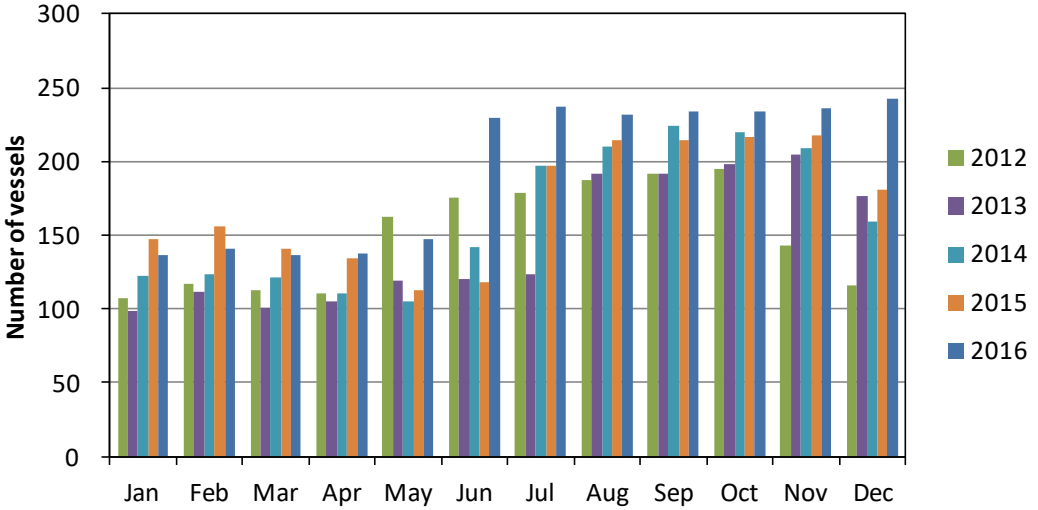

Figure 1 The number of monthly maximum active fishing vessels during 2012-2016

2 *Catch, Effort and CPUE Summaries*

Annual total catches of the Chinese squid jigging fishery in the South East Pacific were over 250 thousand tons during the period of 2011-2015, but the catches decreased sharply in 2016 and reduced over 100 thousand tons compared to 2015 and 2014.

Fishing effort and CPUE during 2012-2016 are presented in Table 2. Effort decreased from 65,530 fishing days in 2012 to 57,771 fishing days in 2013, and kept growing in the next three years and reached 62,258 days in 2016. CPUE was relatively stable and fluctuated between 4.0 and 5.5 ton/day-vessel from 2012 to 2015, but it also dropped in 2016 with the annual catches decrease. Overall, the time series of annual CPUE showed an opposite trend to fishing effort during 2012-2016.

The monthly catches and CPUEs over the period 2012-2016 are showed in Figures 2 and 3, respectively. Monthly catches and nominal CPUEs showed similar trends that they decreased from January to June both but increased in the second half of year and peaked in December or January. The maximum monthly catches was over 60 thousand tons, appeared in November 2014 and the minimum occurred in May 2016, only 6,600 tons. Catches from April to September in 2016 are significantly less than that in the previous four years, however it seemed to recover in the last season and reached 43.4 thousand tons in December, the highest level in the last five years.

Table 2 Catch, effort and CPUE of the Chinese squid jigging fleet in the past five years

Year	Catch in tons	Fishing days	CPUE (ton/day-vessel)
2012	261,000	65,530	4.0
2013	264,000	57,771	4.6
2014	332,500	58,831	5.5
2015	323,600	60,116	5.4
2016	223,300	62,258	3.6

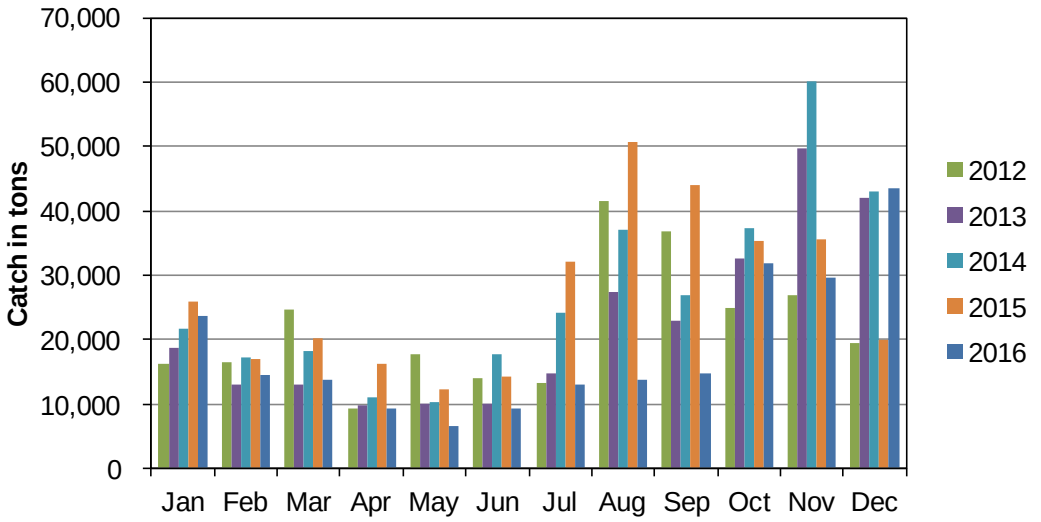

Figure 2 Monthly catches of the Chinese squid jigging vessels during 2012-2016

Monthly CPUEs fluctuated between to 1.8 (July 2016) to 9.7 ton per day per vessel (December 2014). Monthly CPUEs in the second half year are more than that in the first half year, and the maximum appears in December basically. Overall, monthly CPUEs in 2015 were the best during the period of 2012-2016, then in 2014. While the monthly CPUEs in 2016 showed the lowest level and dropped to the minimum in July. As usual month CPUE began to increase from the third quarter in 2016 and reached 6.6 tons per day per vessel, higher than that in 2012 and 2015.

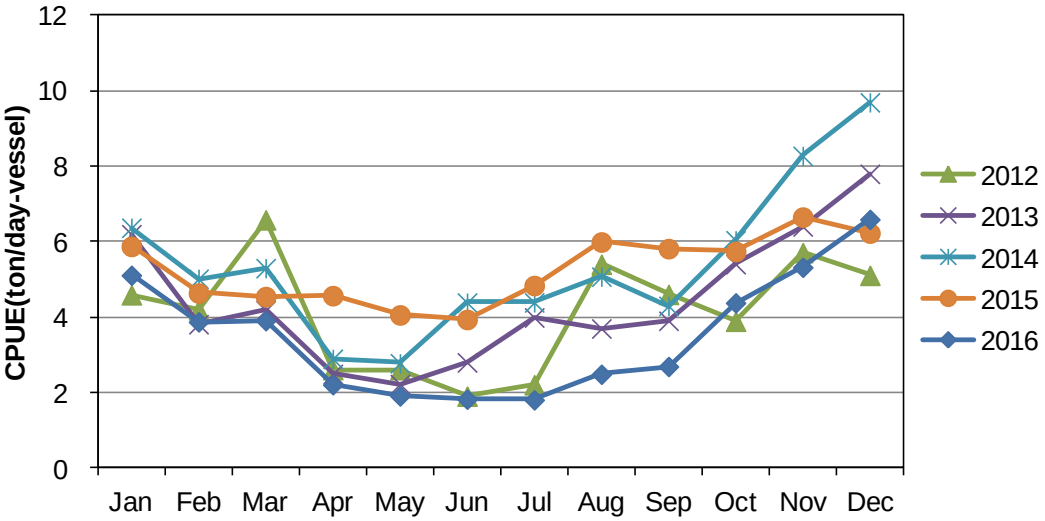

Figure 3 Monthly CPUE of the Chinese squid jigging vessels during 2012-2016

Month catch distributions based on the received logbook of the Chinese squid jigging vessels are showed in Figure 4. These geographical distributions showed that the Chinese fishing boats operated in the high seas and distributed outside of the Peruvian and Chilean Exclusive Economic zones. The high seas off Peru are the main fishing ground, but some jumbo flying squid were also caught from the high seas off Chile and Ecuador waters. In the first season of 2016, the squid jigging vessels operated in a wide area that extends from 15 to 30 degree south latitude. Most of these vessels moved to north, while few moved to the south-central Chile in the second season. In the next season, the squid vessels kept moving northwards and some of them reached the southeast of Galapagos Islands. In the fourth season, the fishing ground distributed mainly in the high seas off southern Peru, but some vessels operated just in south of the Equator with 115-125 degree west in December 2016 (not showed in Figure 4d).

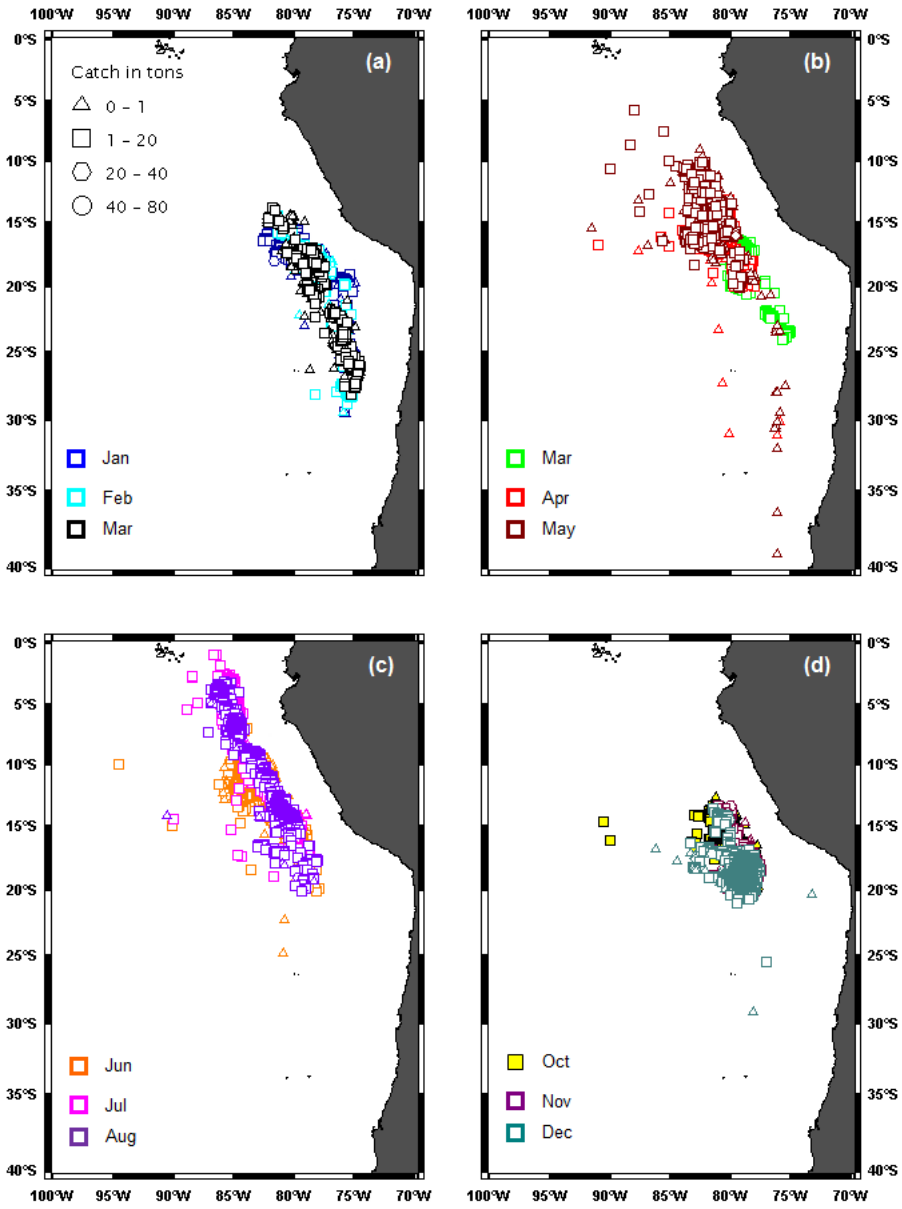

Figure 4 Monthly catch distribution of the Chinese squid jigging fishery during in 2016

3 *Fisheries Data Collection and Research Activities*

Two types of fishery data were collected for the squid jigging fishery, the catch data derived from the logbook of the Chinese squid jigging boats and biological data of jumbo flying squid. The logbook was designed and make by China Distant Water Fisheries Association (CDWFA). Some key information such as the fishing vessel (name, engine power, total light power, etc.) and fishing activities (start and end locations and time, catch and by-catch species of marine mammals, birds and turtles) are all list in the logbook. Fishing companies were request to fill in and submit the logbooks every year. Catch data collection was relatively simple early, however data collection system has been established and more detail fishery data including the vessel name, operating time, location and catch have been collected since 2003. Moreover, the fishing companies were request to report the estimated catch and number of fishing vessels with their status (operating, being repaired, returning or shifting) every week. Since 2015, data collection work has been in the charge of the National Data Center for Distant-water Fisheries of China (NDCDF). Over 25 thousand recorders of fishing activity data in 2016 derived from 97 fishing vessels have been collected by NDCDF up to July 2017. Most of vessels have not yet submitted their logbooks because they have been working on the sea and haven't returned to the port. In order to wrestle with this problem, the electronic logbooks system

will be put into practice by NDCDF, and 5 squid jigging vessels have been installed the data transmission devices and being tested on the sea this year.

A total of 508 jumbo flying squid were collected by a studying vessel from August to September 2016. These biological samples with information of sampling location and time were transported to the laboratory of Shanghai Ocean University (SHOU) in 2017.

The research activities of the squid research team of SHOU focused on the biology, biochemistry, geographic distribution, stock assessment etc. for the jumbo flying squid in South East Pacific. Hu et al. (2017a) analyzed the relationship between morphometric characteristics of the beaks and age and size of jumbo flying squid. 12 morphometric parameters such crest length, rostrum length, and lateral wall length were selected. The results showed these relationships can be described by the linear model and the beaks can be used to estimate daily age, mantle length and body weight for this squid.

Hu et al. (2017b) used the Artificial Neural Network to study the relationships between pigmentation stage of beak and age, body weight, maturity stage and morphometric parameters. They found that the beak pigmentation stage increased with age, mantle length, body weight and morphometric indices of beaks, and the relationships between them were significantly positive. Meanwhile, the beak pigmentation degree increased with the sexual maturity stage.

Wei et al. (2017) measured and investigated the energy density and accumulation of somatic tissues for the jumbo squid off Peru. The maximum energy density was detected in mantle, followed by the arms and fins. For the same somatic tissue, there was no statistical difference in the energy density between sexes ($P>0.05$). The energy accumulated in different somatic tissues, however, was significantly different between each other ($P<0.05$), in which the mantle tissue was the unit of the maximum energy accumulation. In females, the percentage of energy accumulation was about 63.14%、25.23% and 11.63% for, respectively, mantle, arms and fins. In males, whereas, the percentage was about 65.89%、22.91% and 11.20% for, respectively, mantle, arms and fins. Energy accumulated in the soma of mantle, arms and fins was significantly increased with body growth ($P<0.05$), and the energy was significantly increased along with the distribution from lower latitude to higher latitude ($P<0.05$). These findings indicate that the process of energy accumulated of jumbo flying squid off Peru is the procedure of feeding and body growth.

Fang et al. (2017) evaluated and compared the spatial estimation of CPUE of the Chinese squid jigging fishery using Ordinary Kriging and CoKriging method. The best fitting CoKriging models were based on correlated environmental factors including sea surface temperature (SST), sea surface height (SSH), sea surface salinity (SSS) and chlorophyll-a (Chl-a). SST was identified as the best auxiliary CoKriging variable in September. The cross-validation results showed CoKriging increased prediction accuracy by 2.93% in August and 1.81% in September, compared to ordinary Kriging. The results indicated that CoKriging is slightly better than Ordinary Kriging in predicting the spatiotemporal distribution of jumbo flying squid off Peru.

Yu et al. (2017) evaluate impacts of climatic and oceanographic variability on spatial distribution of jumbo flying squid in the Southeast Pacific Ocean off Peru. Results indicated that the SSTA in the Niño 1 + 2 region played crucial influences on SST, Chl-a and SSH on the fishing ground. The spatial pattern of latitudinal gravity centres largely responded to climate induced oceanographic variability on the squid fishing ground: the Niño 1 + 2 SSTA became warm, the most favorable SST and SSH would move southward, resulting in a southward movement of the fishing ground; however, the Niño 1 + 2 SSTA shifted into cold episodes, the most favorable SST and SSH, as well as the fishing ground would shift northward. SSTA in the Niño 1 + 2 region coupled with the most favorable contour lines of SST and SSH were the major drivers regulating the latitudinal movement of fishing ground.

Stock assessment for jumbo flying squid was updated this year. Based on the annual catch data derived from FAO and CPUE data from the Chinese squid jigging fishery, a Bayesian state-space surplus production model was developed to assess the stock status of jumbo flying squid. The results showed that jumbo flying squid stock in the Southeast Pacific was not overfished and overfishing did not occur during 2003-2015. Catch level was sustainable and much lower than the estimated MSY. The CPUE data from Chinese vessels may be a good proxy to represent the stock abundance.

4 *Biological Sampling and Length Composition of Catches*

The 508 individuals of jumbo flying squid were sampled by studying fleet in the high seas (81°W- 86 °W and 4°S-13°S) from August to September 2016. These samples were measured and examined in the laboratory of SHOU in 2017. The measurement includes length or width of mantle, fin, head and tentacles, body weight, gonad weight, sex, maturity, stomach fullness. The hard structures, statolith, beak, gladius and lenses of eyes were also extracted for further examination, age determination for example.

Body weight ranged from 133 g to 1013 g with mean of 394 g and mantle length ranged from 17.8 cm to 35.8 cm with mean of 24.4 cm. Length frequency was presented in Figure 5 (sample size n=503). The first mode of mantle length was 21-23 cm and the second was 28-30 cm. Compared with the historic length composition, it can be seen that the ratio of the small squid was higher in 2016 but the big size squid with mantle length over 35 cm were absent from the catches, which might be related to the area of sampling. In 2016, most of the squid were sampled from the high sea seas off northern Peru with 4-6 degree south, but the squid samples were collected off central Peru (10-15 degree south) in 2015 and 2013.

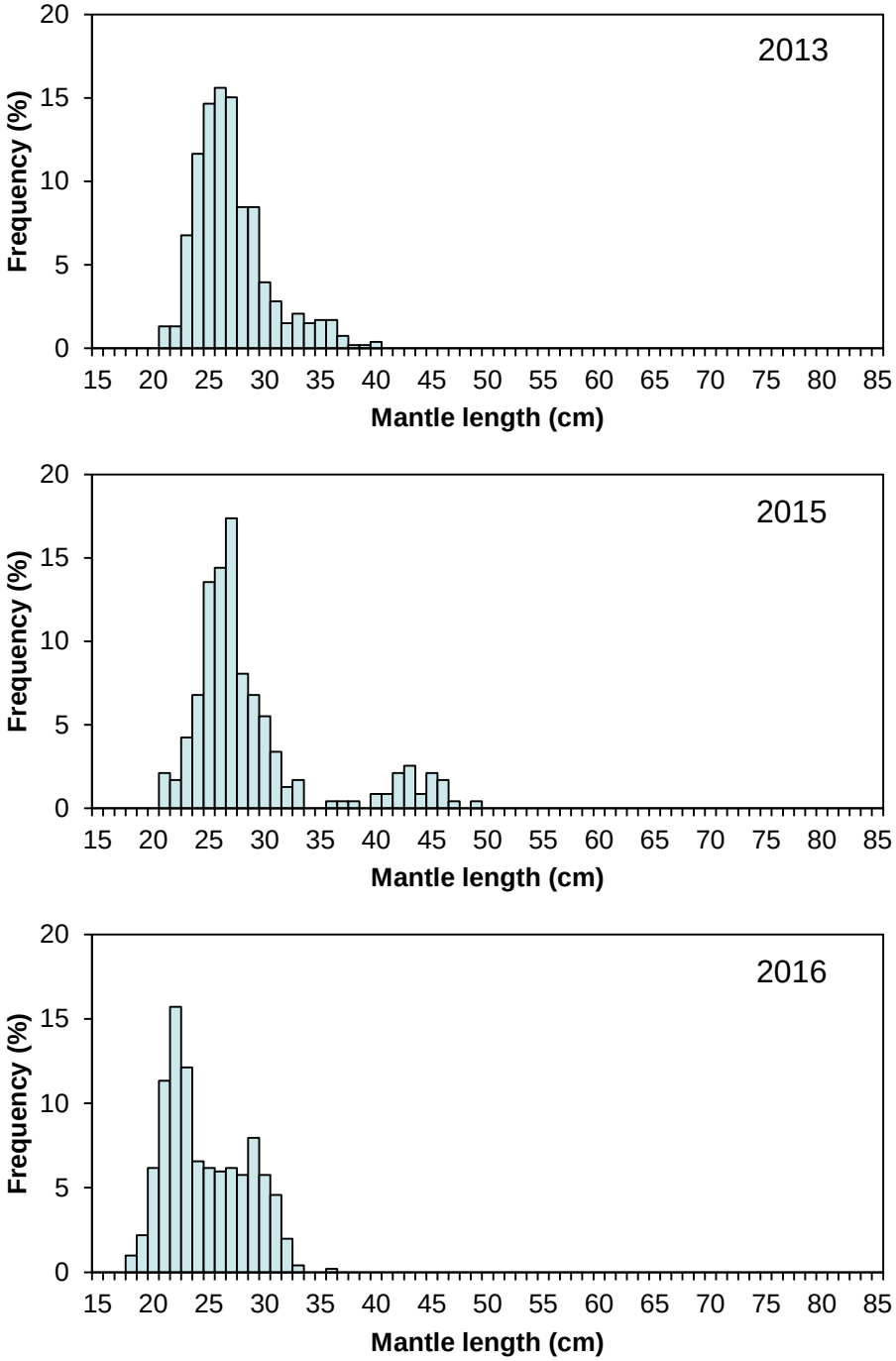

Figure 5 Size frequency of the jumbo flying squid sampled in the high seas of Peru

Gonad maturity stage of jumbo flying squid sampled in 2016 showed significant difference between sexes. For the female, gonad maturity stage I accounted for 69.10% of the total, followed by stage II (23.26%), stage III (4.86%) and IV (2.78%), which means that most of the female squid (92.36%) were immature in August and September. However, over 50% males were matured (stage III and IV), much higher than the females. The status of sexual maturity for the jumbo flying squid was very similar in 2015 and 2016 (Figure 6), although the sampling time and area were different in the two years.

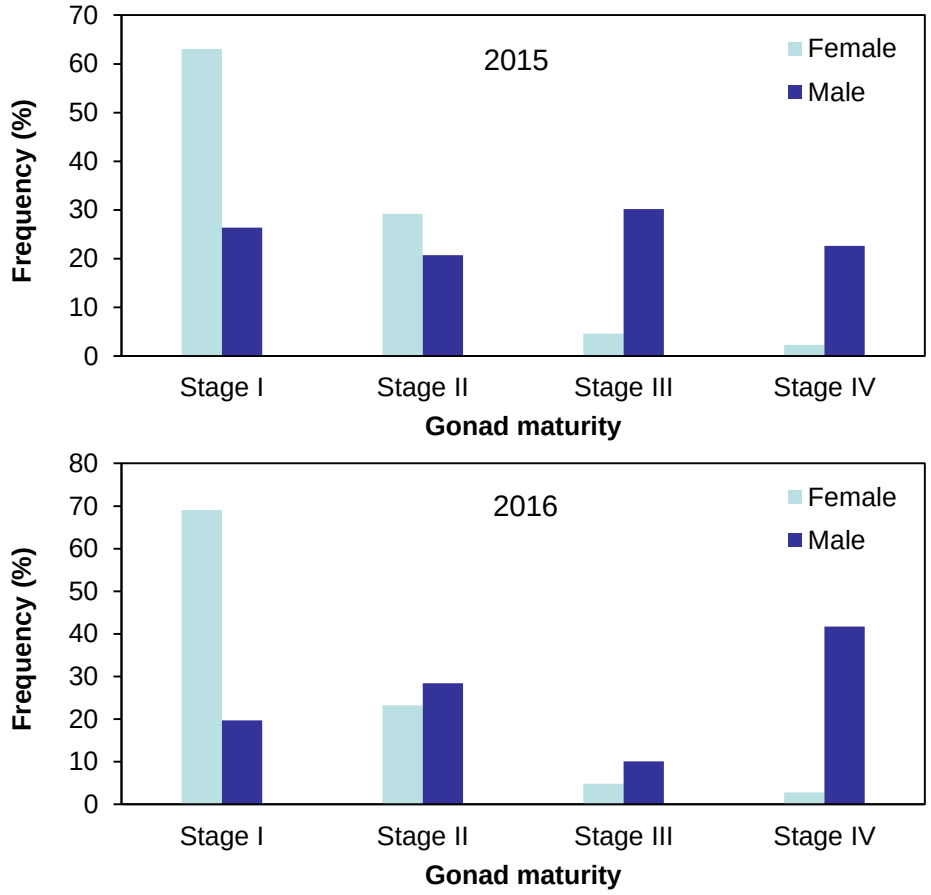

Figure 6 Maturity stages of the jumbo flying squid sampled in the high seas of Peru

5 *Ecosystem Approach Considerations*

The Chinese squid jigging vessels are request to report and submit data and information about by-catch species through the logbook supplied by CDWFA. No birds, mammals, sharks and turtles occurred in the catches.

6 *Observer Implementation Reports*

A total of 508 squids were sampled by studying vessels during August and September 2016. These samples were caught in the high seas that covered the main fishing ground off Peru (Figure 7). In order to reduce the interference to the operations of the vessel and improve the accuracy of data, the mission of studying vessels is to collect and store the samples, and ensure that these samples can be delivered to SHOU on good condition.

7 *Summaries*

276 Chinese squid jigging vessels were recorded to target jumbo flying squid in the South East Pacific in 2016. Comparing with 2015, the total annual catch in 2016 dropped to 223,300 tons, however, the number of operated fishing vessels and fishing days showed a small increase, resulting in the nominal CPUE in 2016 decreased sharply, only 3.6 tons per day per vessel. The squid fishery is a year-round fishery, but lots of Chinese vessels only operated several months and move in or out of the SPRFMO area. The fishing grounds mainly located in the high seas off Peru, while some fishing boats might be operate in the waters off Chile and Ecuador, even near the equator. No observers were sent to work on board but biological sampling continued into 2016. A total of 508 biological samples of the jumbo flying squid were collected by studying vessels during August-September. These samples were sent to SHOU for measurement and analysis in 2017.

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