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China's National Report Part II: Squid Jigging Fishery

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National Report of China to the 2016 SPRFMO Science 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. During June and September in 2001, the Chinese squid jigging industry made their first resource survey of jumbo flying squid in the high seas of Peru and Costa Rica, followed by commercial production (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 equipped auto-machined jiggers 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. Over the period 2005-2014, the number of Chinese vessels increased rapidly and peaked in 2014 and showed a small decrease in 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 2012-2014, the number of operational vessels was more than 150 for 5 or 6 months a year. In 2015, the number of active fishing vessels peaked in the first week of November, and a total of 252 vessels were recorded to operate in the Convention Area in that year (Figure 1).

Annual catch of jumbo flying squid presented similar trend as the number of vessels during 2001-2015. Only 17,770 tons squid caught by 22 vessels in the first fishing year, and increased rapidly in the following three years, 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).

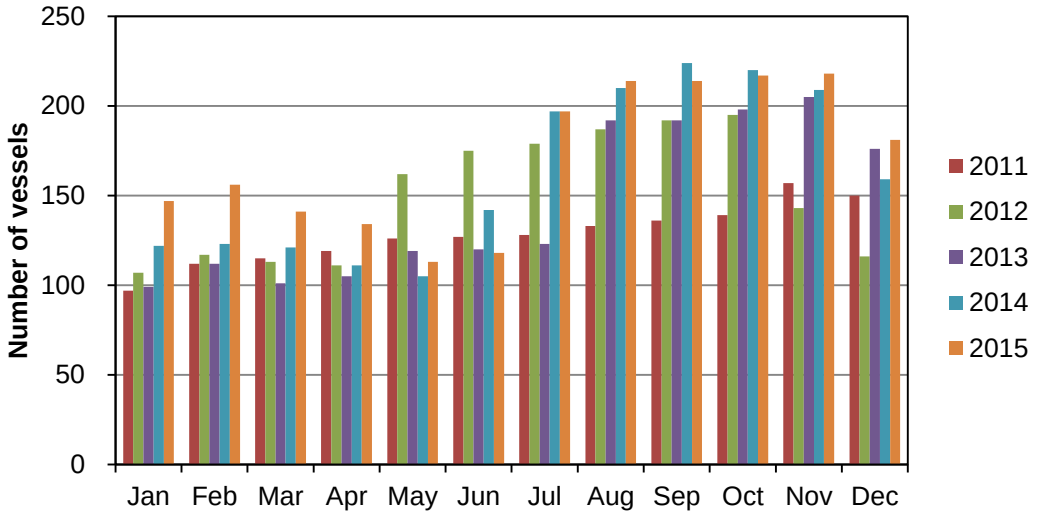


Figure 1 Monthly maximum active fishing vessels during 2011-2015.

Table 1 Number of vessels in the South East Pacific during 2001-2015

Year	Number of vessels	Catch in tons
2001	22	17,770
2002	43	50,483
2003	74	81,000
2004	119	205,600
2005	93	86,000
2006	43	62,000
2007	37	46,400
2008	50	79,064
2009	54	70,000
2010	104	142,000
2011	172	250,000
2012	254	261,000
2013	205	264,000
2014	264	325,000
2015	252	323,600

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, before that the highest catch was 205 thousand tons.

Fishing effort and CPUE during 2011-2015 are shown in Table 2. Effort decreased from 65,530 fishing days in 2012 to 58,831 fishing days in 2013, and showed a slight increase in the last two years. CPUE was relatively stable and fluctuated between 4.0 and 5.5 ton/day-vessel.

The monthly catches and CPUEs over the period 2011-2015 are presented in Figures 2 and 3, respectively. Monthly catches in the last 5 months increased obviously. The maximum was over 60 thousand tons, appeared in November 2014. Monthly nominal CPUEs showed the similar trends that they decreased from January

to June but increased in the second half of year. In 2011, this decreasing trend continued to September except for a small increase in June. The monthly CPUEs in 2010 fluctuated strongly, but overall they were on the rise.

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)
2011	250,000	46,493	5.4
2012	261,000	65,530	4.0
2013	264,000	57,771	4.6
2014	325,000	58,831	5.5
2015	323,600	60,116	5.4

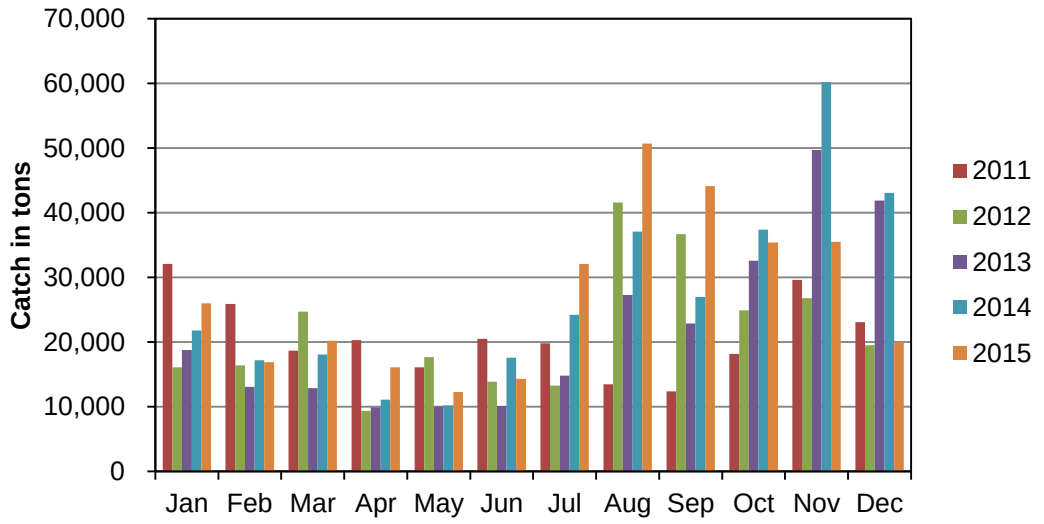


Figure 2 Monthly catches of the Chinese squid jigging vessels during 2011-2015

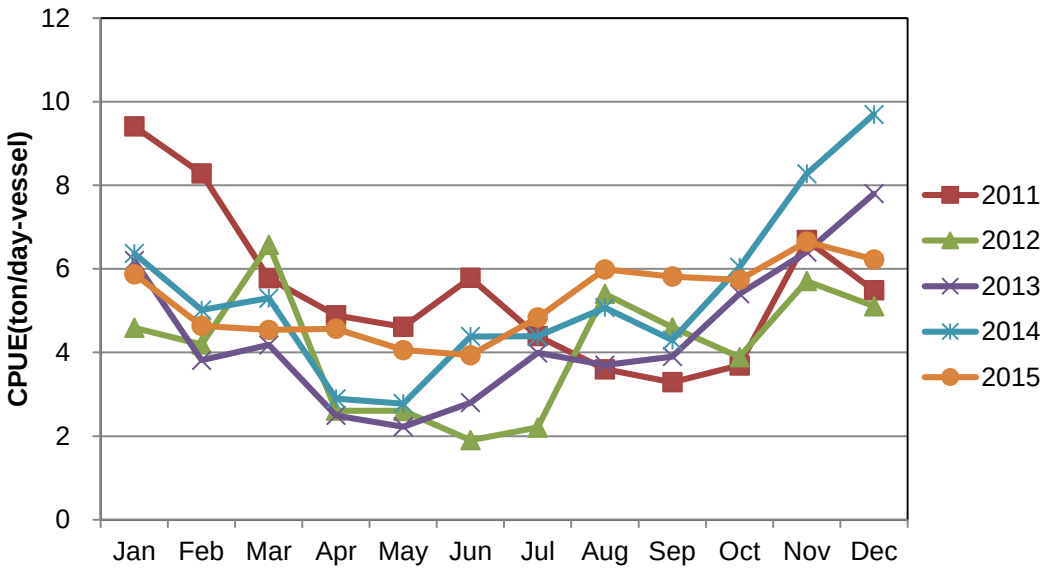


Figure 3 Monthly CPUE of the Chinese squid jigging vessels during 2011-2015

3 *Fisheries Data Collection and Research Activities*

China Distant Water Fisheries Association (CDWFA) and Shanghai Ocean University (SHOU) jointly took responsibility of the fisheries data collection in the past. Since 2015, data collection work has been in the charge of the National Data Center for Distant-water Fisheries of China (NDCDF). Data collection of the Chinese squid jigging fishery began in 2001, the same year as the Chinese scientists started research work for jumbo flying squid and its fishery in the South East Pacific.

Data collection was relatively simple early on in the Chinese squid jigging fishery. Fishery data collection system has been established and more detailed fishery data such as operating time, location and catch derived from logbooks have been collected since 2003. Moreover, the fishing companies were requested to report the estimated catch and number of fishing vessels with their status (operating, being repaired, returning or shifting) every week. Now NDCDF is planning to establish the electronic logbooks system for the Chinese squid jigging fishery.

As another important part of the data collection system, biological and environmental data were also collected by the Chinese scientists. The environmental data (such as temperature, and salinity of water columns) and some important biological information such as mantle length, weight, sex, stage of maturity were collected onboard by the scientists. Furthermore, the scientists cooperated with fishermen and entrusted them to collect samples of jumbo flying squid on the sea. These squid samples were transported to SHOU labs for various biological analyses to improve our understanding of key life history processes.

One of the purposes of the Fishery data collection system for the jumbo flying squid in the South East Pacific is to do scientific research, which mainly related to fisheries biology, stock structure, habitat and relationship with marine environment. In 2015, the scientific researches focused on the age, growth, population structure, geographic variations, habitat, trophic patterns for the jumbo flying squid. Based on the beak microstructure, Hu et al. (2016) successfully estimated age, growth and population structure of jumbo flying squid. The result showed that ages estimated were from 123 to 298 days for females and from 106 to 274 days for males. Back-calculated hatching dates were from December 2012 to May 2013. All of the samples were from the austral summer/autumn spawning cohort. Hatching peak occurred between January and March. The maximum absolute daily growth rate and instantaneous growth rate of mantle length were 2.12 mm/day and 0.59 mm /day, respectively.

Gong et al. (2016) used morphometric analysis to explore the geographic variation of population units within jumbo flying squid under distinct environmental conditions. The gladius were used to distinguish geographic populations and this variation in gladii shape occurs as an adaptation to environmental conditions. Seven morphometric characteristics were measured from 460 specimens collected off Peru, Costa Rica and equatorial central eastern Pacific. Sea surface temperature, chlorophyll-a concentration and current velocity were used to evaluate the potential effects of environmental conditions on phenotypic divergence in the gladius. Significant differences were found between sexes and population units. Discriminant analysis showed an overall correct classification rate of 84.3%. However, stable population substructuring did not happen.

Yu et al. (2015) used an integrated habitat suitability index model to evaluate the effects of climate variability (i.e. ENSO) on the habitat suitability for jumbo flying squid based on fishery and satellite data. The result implied that the squid habitat responded quickly to the climate variability. Both suitable habitat areas and catches of increased in La Niña periods and decreased in El Niño periods, because La Niña conditions yield favorable habitat for jumbo flying squid by strengthening the upwelling coupled with cool and nutrient-enhanced waters; whereas El Niño means unfavorable conditions for the squid by the weakened upwelling with warm and nutrient-depleted waters.

Li et al. (2016) measured the values of isotope $\delta^{13}C$ and $\delta^{15}N$ along the proostracum derived from 45 jumbo flying squid sampled in the high seas off Peru during 2009, 2013 and 2014 to reconstruct the feeding variations and to evaluate the potential effects of 2009-10 El Niño on the variability of the trophic patterns. They found strong variation in $\delta^{13}C$ and $\delta^{15}N$ values along the proostracum, and changes that could be determined by temporal variation of foraging as well as migration among regions with distinct baselines. El Niño conditions decrease the variation of trophic patterns of squid through compressing the space and time for foraging and migration. Time-based consecutive sampling of the gladius can back-calculate an ontogenetic shift and the possible migration patterns for jumbo flying squid more precisely and comprehensively. The isotopic values might be influenced much more by their migration behavior.

4 *Biological Sampling and Length Composition of Catches*

A total of 236 jumbo flying squid (106 male and 130 female) was sampled on the Chinese vessel in the high seas of Peru (79°W- 86 °W and 9°S-16°S) from June to September 2015. These samples were measured and examined in the laboratory of SHOU to get more detailed biological characteristics such as mantle length, body weight, age, gonad weigh, tentacle length, dimension of beak and statolith etc. Body weight ranged from 238 g to 3095 g with mean of 748 g and mantle length ranged from 20.7 cm to 49.0 cm with mean of 28.4 cm. Length frequency was presented in Figure 4. The first mode of mantle length was 23-30 cm and the second was 41-46 cm.

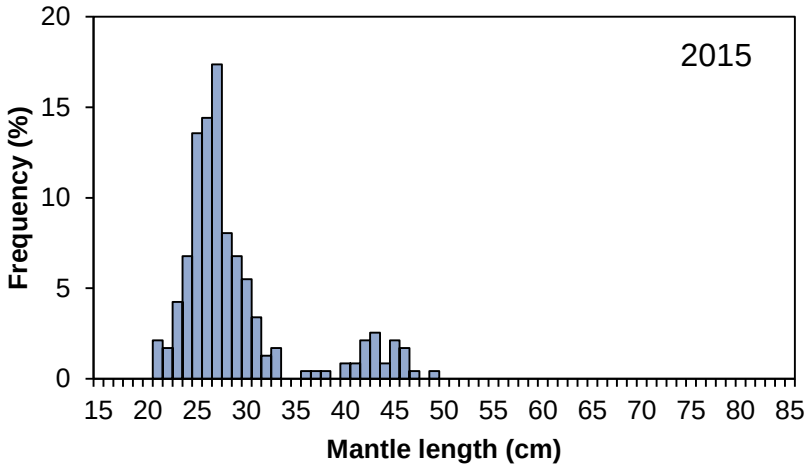


Figure 4. Mantle length frequency of the jumbo flying squid sampled in the high seas of Peru in 2015

Gonad maturity stage was different between the sexes. For the 63.08% female squid, their gonad maturity was stage I, followed by stage II (29.23%), stage III (4.62%) and IV (2.31%), which means that most of the female squid (92.31%) were immature. For male squid, the percentage mature squid was 53 % (stage III and IV), much higher than the females (Figure 5).

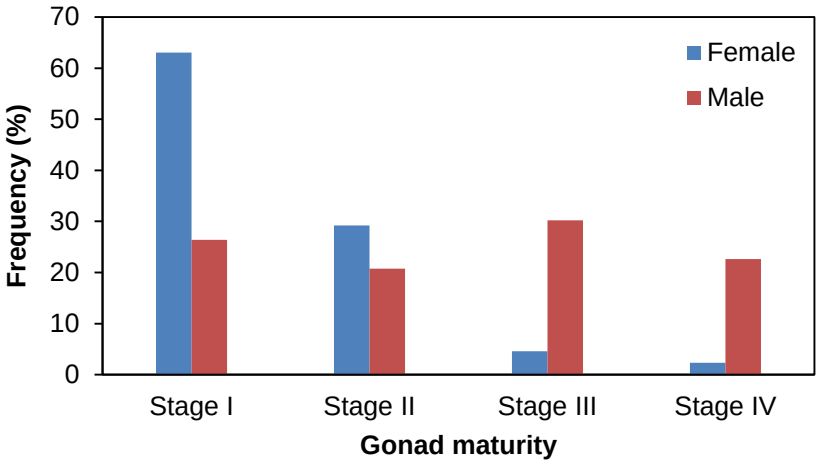
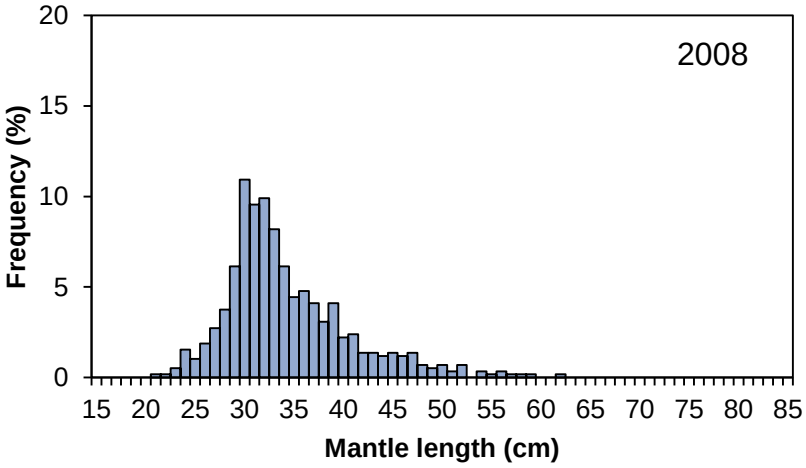
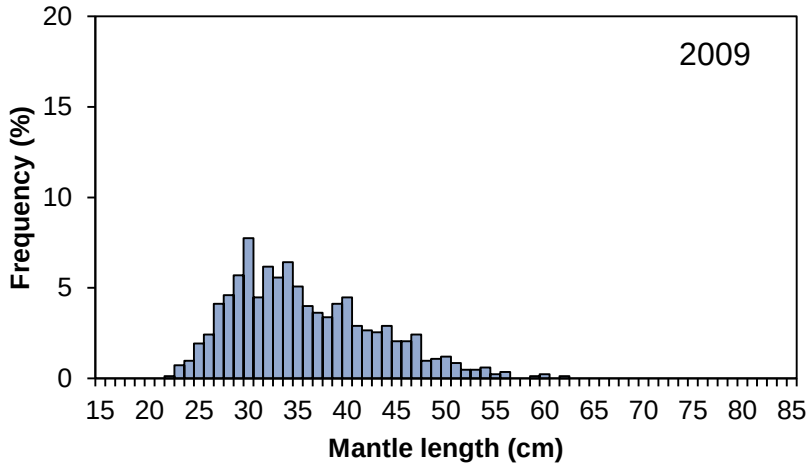
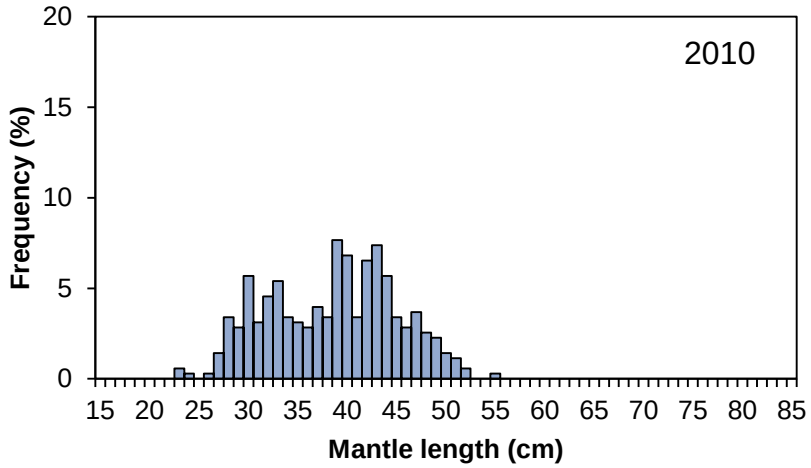


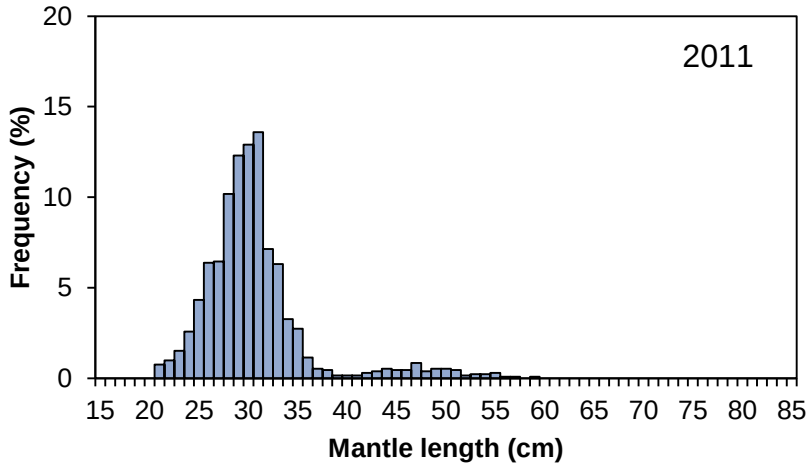
Figure 5. Maturity stage for the female and male jumbo flying squid sampled in the high seas of Peru in 2015

Figure 5 and 6 present the series of mantle length distributions based on the biological data collected in the international waters of Peru and Chile during 2006-2013. The squid caught in the north area (Peru) seems smaller than it caught in south area (Chile). However, additional measurement for the large squid were carried out in the 2009 survey outside Peru economic area, the maximum mantle length was 114.9 cm with body weight 61.9 kg.




2009
Frequency (%)
0
5
10
15
20
15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Mantle length (cm)


2010
Frequency (%)
0
5
10
15
20
15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Mantle length (cm)


2011
Frequency (%)
0
5
10
15
20
15 20 25 30 35 40 45 50 55 60 65 70 75 80 85
Mantle length (cm)

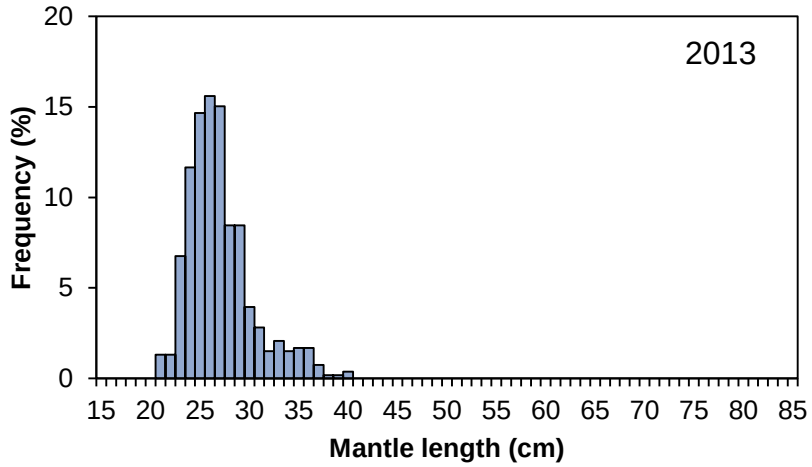
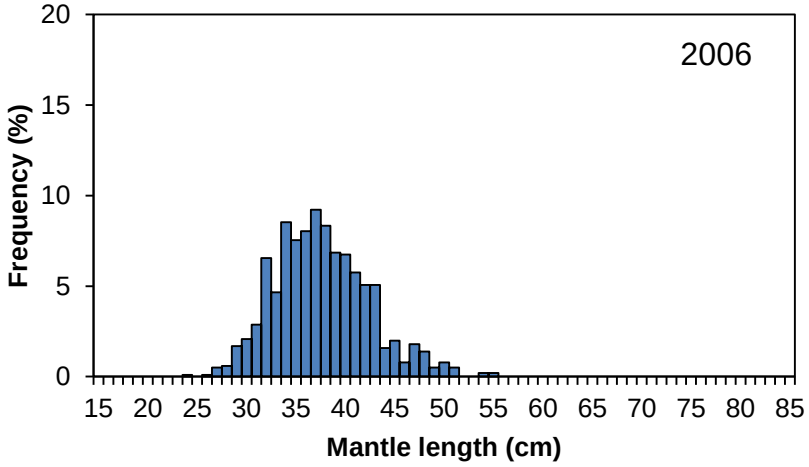
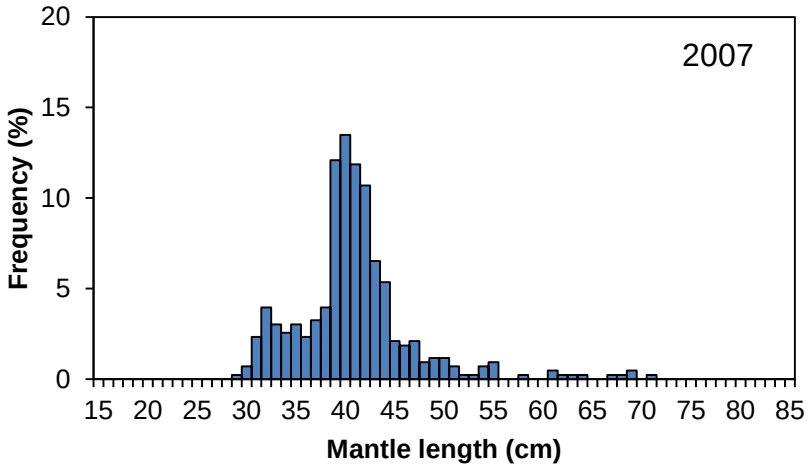


Figure 5. Mantle length frequency of the jumbo flying squid in the high seas of Peru





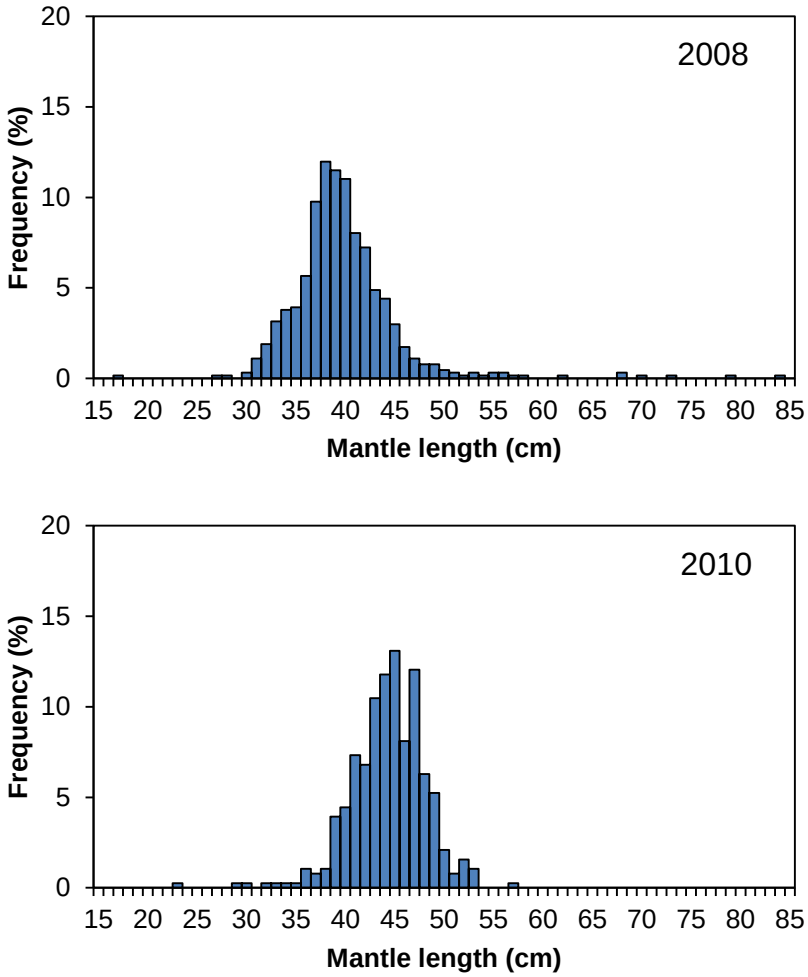


Figure 6. Mantle length frequency of jumbo flying squid in the high seas of Chile

5 *Summary of Observer Programme*

In 2001, China carried out the first survey for the jumbo flying squid in the South Pacific and sent the first scientist on board. Since 2007, CDWFA has cooperated with SHOU to send scientific observers on board to take charge of the survey. One of the main responsibilities of the observers is to collect fishery and environmental data to support the scientific research for jumbo flying squid in the South East Pacific. The details of these surveys are presented in Table 3. In 2015, no observers were sent to the squid jigging vessel, but random biological samples from catch also were collected by fishermen on the sea and were measured in the lab of SHOU.

Table 3. Survey information of the Chinese squid jigging fishery

Survey time	Survey area	Observer number	Vessel type
Jun-Sep 2001	high seas of Peru and Costa Rica	1	squid jigging
Jan-Jun 2007	high seas of Chile	1	squid jigging
Feb-Mar 2008	high seas of Chile	2	squid jigging
July-Nov 2009	high seas of Peru and Costa Rica	2	squid jigging
Apr-Jun 2013	eastern equatorial Pacific	2	squid jigging
Apr-Jun 2014	eastern equatorial Pacific	2	squid jigging

6 *Summaries*

The Chinese squid jigging vessels arrived in the South East Pacific for the first time for fishing jumbo flying squid in 2001. During the past years, this fishery continued to develop with annual catch reached to 325 thousand tons in 2014. However, annual catch, as well as fishing vessels and CPUE were all slightly decreased in 2015. The nominal CPUE remained restively steady over the past 5 years, fluctuating between 4.0 and 5.4 ton/day-vessel. No observers were sent to work on board but biological sampling continued into 2015.

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