7th MEETING OF THE SCIENTIFIC COMMITTEE

La Havana, Cuba, 7 to 12 October 2019

SC7-SQ06

Preliminary Simulation study of the Observer Coverage Rate Estimation or the squid jigging fishery based on the 2018 China Observer program

China

Preliminary Simulation Study of the Observer Coverage Rate Estimation for the squid jigging fishery based on 2018 China Observer Program

Jiaqi Wang, Gang Li, Luoliang Xu, Xinjun Chen, Yong Chen

National Data Center for Distant-water Fisheries, Shanghai Ocean University, University of Maine

Introduction

Independent observer monitoring of target and non-target fisheries catch is a well-recognized component of best-practice fisheries management (Kennelly, 1999; Lutchman, 2014). Scientific observer data are key to conducting robust stock assessments, identifying and understanding trends and patterns in nominal and standardized catch and survival rates and catch levels, and assessing the performance of conservation and management measures (Davies, 2003; Gilman et al., 2017). Regional Observer Programs (ROPs) in Regional Fisheries Management Organizations (RFMOs) play an important role in ensuring the integrity of the fisheries management system and describing the characteristics of the catch (Lawson, 2006). But in most cases, the required OCR was not above 5%, and the extent of coverage was defined differently as a percentage of the catch, or fishing days, sets or trips (Anderson et al., 2013). At coverage of levels of 5%, bycatch estimates will likely remain highly imprecise for low occurrence bycatch, but it is better than no coverage at all (Gilman et al., 2012). Further, it has been argued that 5% observer coverage is sufficient to identify simply where and when bycatch is occurring. This level of OCR can almost certainly result in a lack of precision in bycatch estimates (Amande et al., 2012; Wolfaardt, 2016).

However, the required observer coverage depends on the objectives of the observer program (Amande et al., 2012). In a fishery with highly selective, the main project of an observer program might be describing the characteristics of the catch, the bycatch estimates might not be essential because only very few bycatches occurred. Thus, in jumbo flying squid fishery in the southeastern Pacific Ocean, the possible main object of the observer program could be to estimate the size composition, sex proportion, maturity or other characteristics of squid catch.

Statistic resampling of simulated and empirical data sets have been used to estimate the suitable sample sizes for estimating length composition (Vokoun et al., 2001; Miranda, 2007). The required sample size for describing length composition tends to be related to the life history processes of fishes like growth, mortality, migration or Spatio-temporal distribution, and is affected by estimation methods such like length-frequency distributions (LFD), mean length (ML), proportional stock density or length interval of LFD (Vokoun et al., 2001; Miranda, 2007; Schultz et al., 2016)). For small fishes (i.e., those with maximum length ≤30 cm), 300-400 individuals are often an appropriate sample size for describing LFD, and smaller sample sizes may be suitable for smaller fishes. Many large (i.e., maximum length >1 m) pelagic fishes are highly migratory species with wider spatial distribution (Schultz et al., 2016). Small samples for them often fail to capture the true length composition of the whole population or of the total catches within a limited Spatio-temporal range.

The purpose of this report is to introduce the current scientific survey program and observer monitoring program for jumbo flying squid fishery in Southeastern Pacific Ocean, and evaluate the effects of coverage rate on the precision and accuracy of the estimates of length-frequency of jumbo flying squid catch in Southeastern Pacific Ocean. We prefer this report could provide some scientific references for the observer monitoring program design for the jumbo flying squid fishery.

Data collection

The data used here was from China's scientific survey and observer monitoring program for jumbo flying squid fishery in the Southeastern Pacific Ocean. Figure 1 showed the month variation of sampling area.

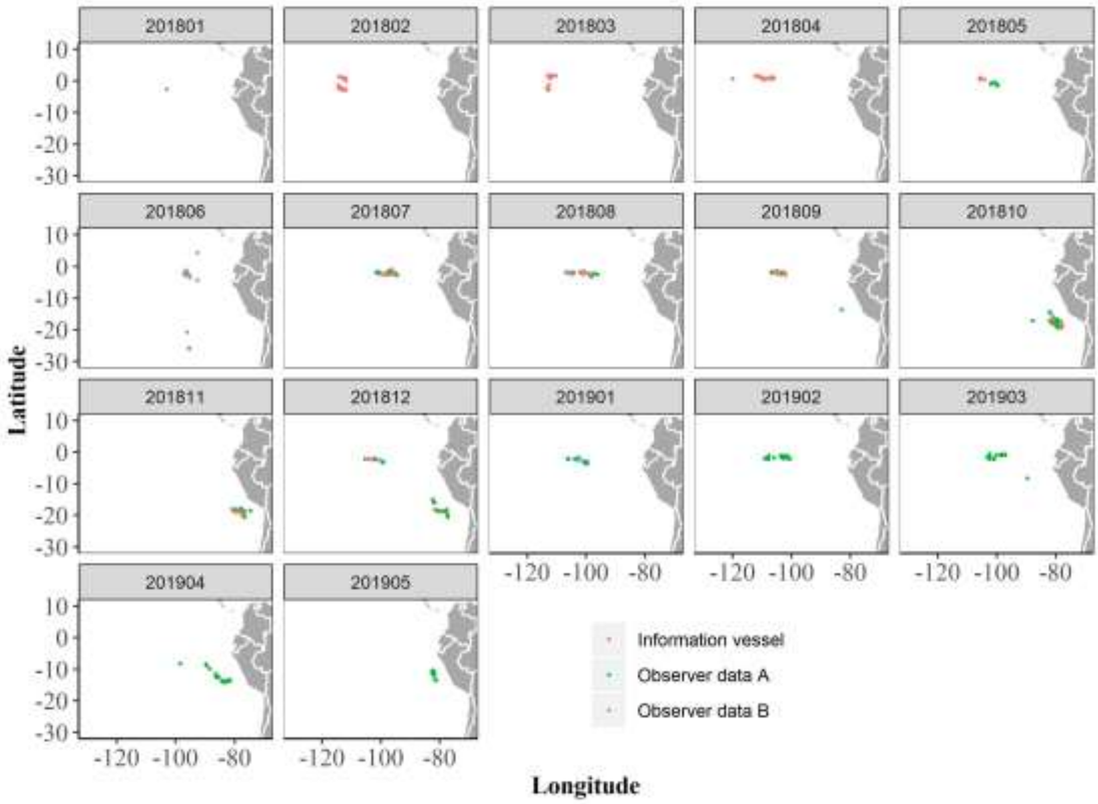

Fig.1 Month variation of the sampling area

Scientific survey program:

The scientific survey program has started in the early years of the fishery, two or more investigators would be selected from graduate students each year who major in squid fishery resources, and then they will be sent to a fishing vessel after some training in Shanghai Ocean University. During the trips, the investigators would record the fishing information (e.g. fishing position, effort, and total catch) at each fishing day. At least 30 fish individuals were selected randomly from the total catch at each fishing day to record their biological information (e.g. sex, maturity, and mantle length). One box of fish would be selected randomly after the crew packed all the catch, and frozen on board, then defrosted in the laboratory for some researches (e.g. the growth, reproduction and feeding). Sometimes, one or more fishing vessels would be selected from all the fishing vessels as the information vessel. The crew on that vessels were required to select randomly at least 30 individuals from total catch at each fishing day for the length information (Information vessel). Also, some samples would be selected randomly from those fishing vessels, and frozen on board, then defrosted in the laboratory (Observer data B).

Observer program:
As the requirement of jumbo flying squid stock assessment and management, China determined to start the observer monitoring program. Two observers were trained and sent to the fishing vessels by Shanghai Ocean University to collect the biological information of the catch including the sex, maturity, mantle length, and weight. At least 80 fish individuals (all of the individuals if the catch numbers were no more than 80) selected randomly from total catches at each fishing day would be recorded (Observer data A).

Simulation procedure
In order to find the relationship between coverage rate and accuracy and precision of length-frequency estimates, we developed a simulation framework. First, we estimated the length-frequency with original data as the true value. Second, we resample original data 1000 times randomly or continuously at a specific coverage level without replacement. Then, we calculated the estimates of length-frequency with the resample data and compared the estimates with the true values. At last, we summarized the result to find the difference. We did the simulation separately for different datasets (Observer data A and data from information vessel) because they were from different programs. The coverage rate here which was defined as a percentage of total fishing days ranged from 1% to 95%. The random sampling means the observer randomly determines the fishing days which they need to observe at a specific coverage rate (Scenario A). The continuous sampling means the observers need to do their observation works at each fishing day after onboarding a fishing vessel until the required coverage rate was reached (Scenario B).

In order to know whether the scale of the sample population would affect the magnitude of MSD values which represented the precision and accuracy of the estimates, we took random samples from the current dataset as a new sample population and then repeat the simulation procedure mentioned above to find the MSD difference from different sizes of sample populations at a same coverage rate level. The size of the new sample population ranged from 100 to 600 fishing days.

Measure for evaluating performance
MSD was used to quantify the performance of estimated length frequency (Vokoun et al., 2001).

$$MSD_j = \left. \sum_{i=1}^{N} \left(\frac{f_i - \hat{f}_i}{f_i}\right)^2 \middle/ N \right.$$

where j is the selected CR, N is the number of length intervals, f_i is the original length frequency (%), and $\hat{f}i$ is the sample length frequency (%) of the i^{th} length interval.

Result

The data

Only one fishing vessel as an information vessel provided the size composition data of their total catch from Feb. 2018 to Dec. 2018. The mantle length data of 4470 individuals were collected, covered 333 days at sea and 288 fishing days. The observer data were collected by two observers during 368 days-at-sea involving a total of 320 fishing days from May 2018 to May 2019. The overall observer data covered 3 fishing vessels and included 20811 fish individuals. 1495 samples that were from the fishing vessels which had the observers onboard during Jan. 2018 to Jan. 2019 processed in the laboratory. Most of the samples were from observers and information vessels. The sampling days of each month was shown in Fig.2. The observers or the crew on the information vessel should sample every fishing day if there was no other interference.

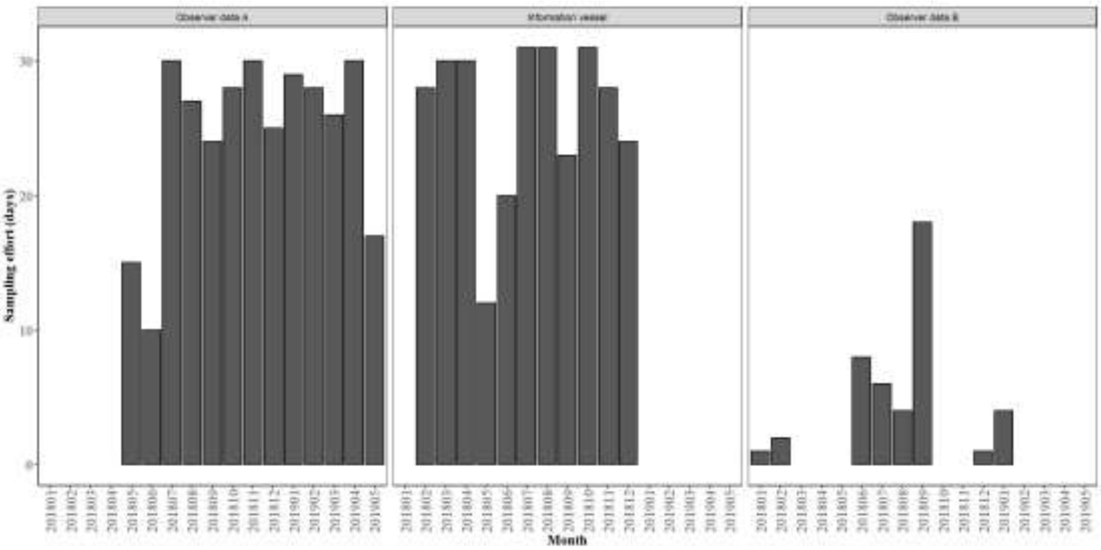

Fig.2 Month variation of the sampling effort

Biological information

The mantle length range from 10 cm to 98 cm and the length frequencies were presented in Fig.3. The observer samples and the samples form information vessels showed a similar length frequency, but the laboratory data had a different size composition because there was almost no individuals with a mantle length larger than 50 cm (Fig.3). And then we compared the month variation of the length frequencies using the observer data and information vessel data. Both of the data showed that large size individuals were often captured in October, November, and December that might be caused by the difference of the fishing areas among different months (Fig.1 and 3).

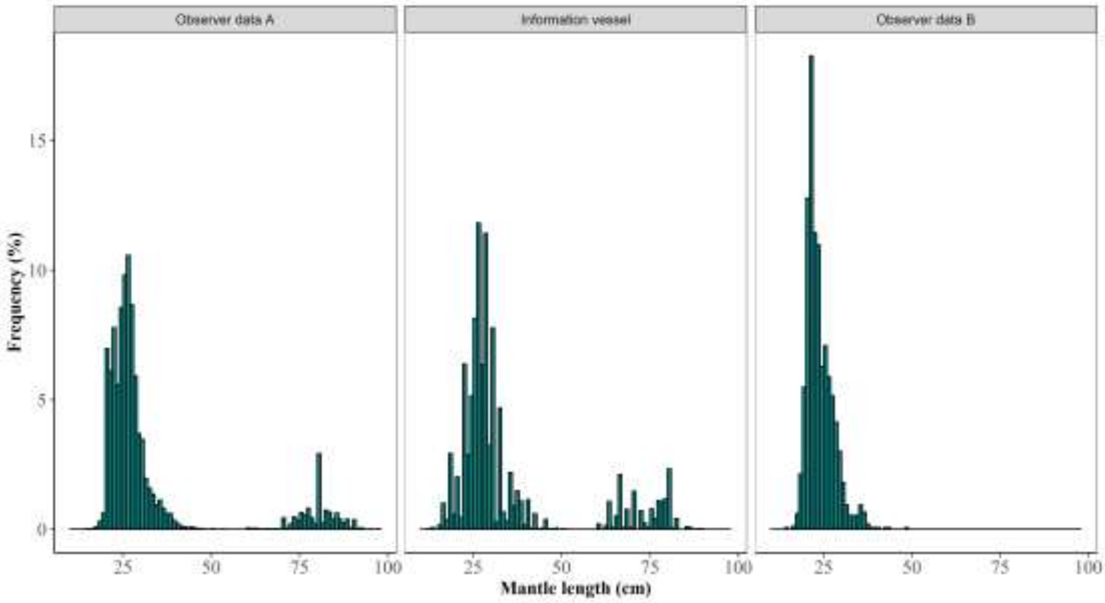

Fig.3 Mantle length-frequency distribution among different datasets.

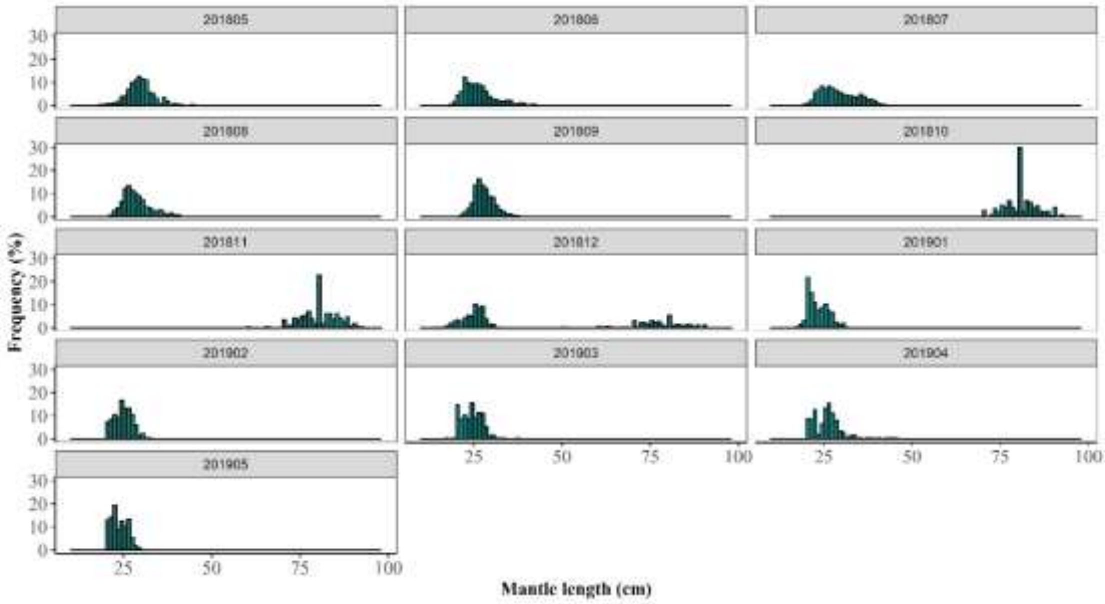

Fig.4 Month variation of the mantle length-frequency distribution (Observer data A)

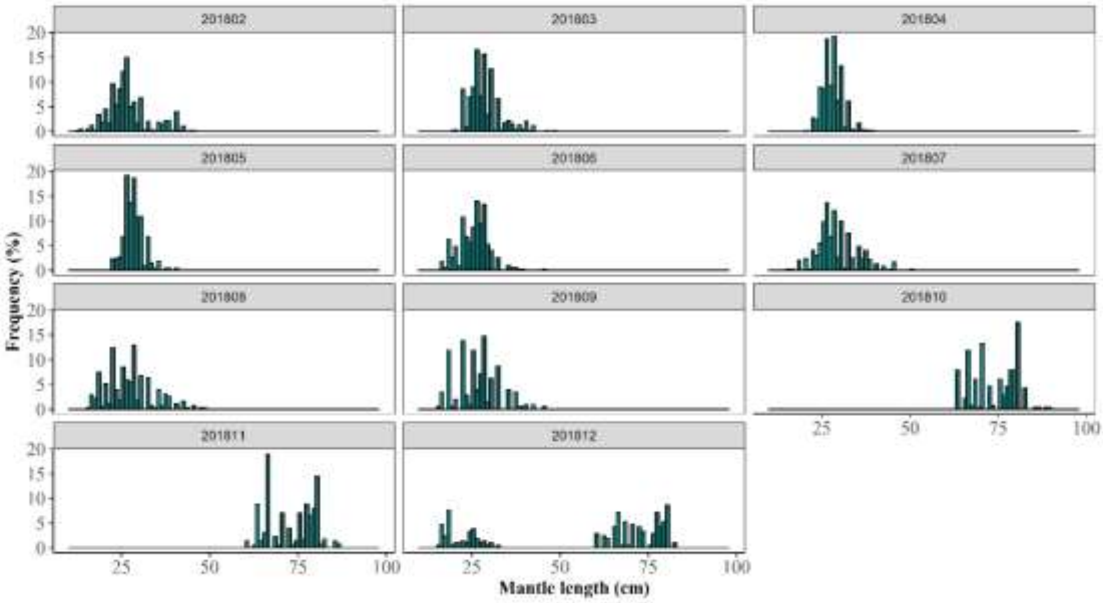

Fig.5 Month variation of the mantle length frequency distribution (Information vessel data)

The Gonad maturity

There is no sex or gonad maturity information in the samples from the information vessel. The sex ratio was similar between observer data and laboratory data, both are about 7:3 for females and males. Most of individuals were at maturity stage I and II. But the laboratory samples showed a higher ratio of individuals were at maturity stage II. Also, no individuals at maturity stage V were found from the samples processed in the lab (Fig.6).

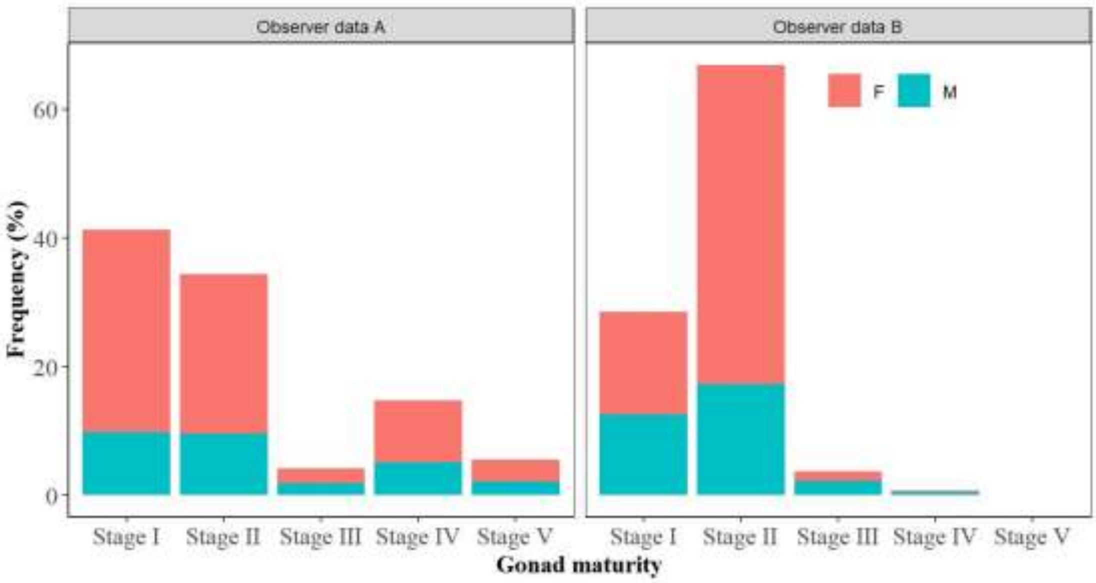

Fig.6 Gonad maturity frequency distribution among different datasets.

The simulation result

The simulation result showed that the MSD decreased with the coverage increased. The consecutive samples (Scenario A) had a higher level of bias than the random samples (Scenario

B) (Fig.6 and 7). 10% might be the optimal coverage for continuous sampling methods because above that coverage level, increases in the accuracy of length-frequency estimates accrue more slowly. For random sampling methods, the optimal coverage might be lower than 5%.

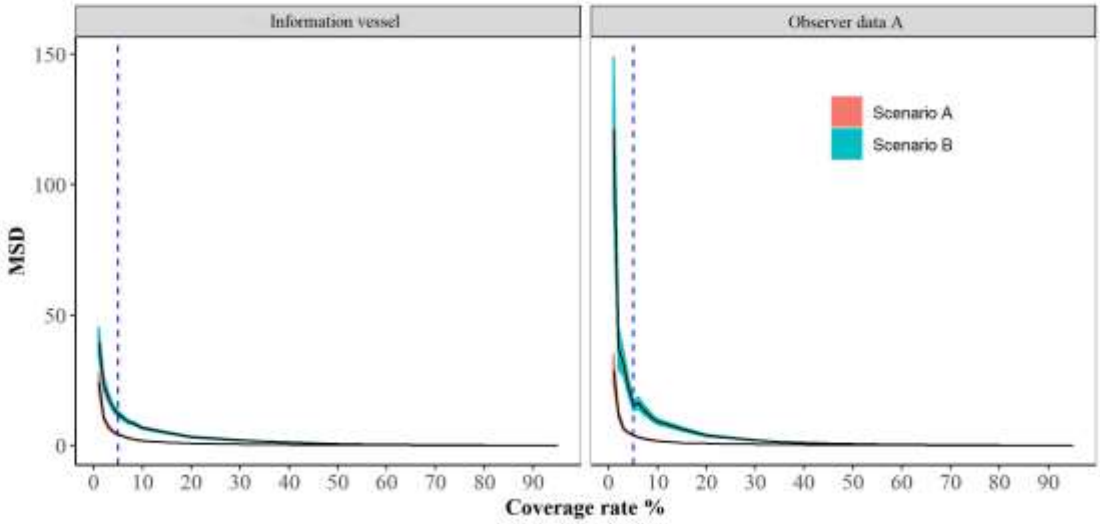

Fig.7 The relationship between MSD and the coverage rate for different scenarios. (The blue dashed line means the coverage is 5%)

Further analysis found that the MSD values decreased with the size of the sample population increased with the same coverage rate. It means that less coverage rate was required to get an estimate of length-frequency with a specific bias for a sample population with a larger size (for jumbo flying squid the total fishing days were more than 60000 in recent years).

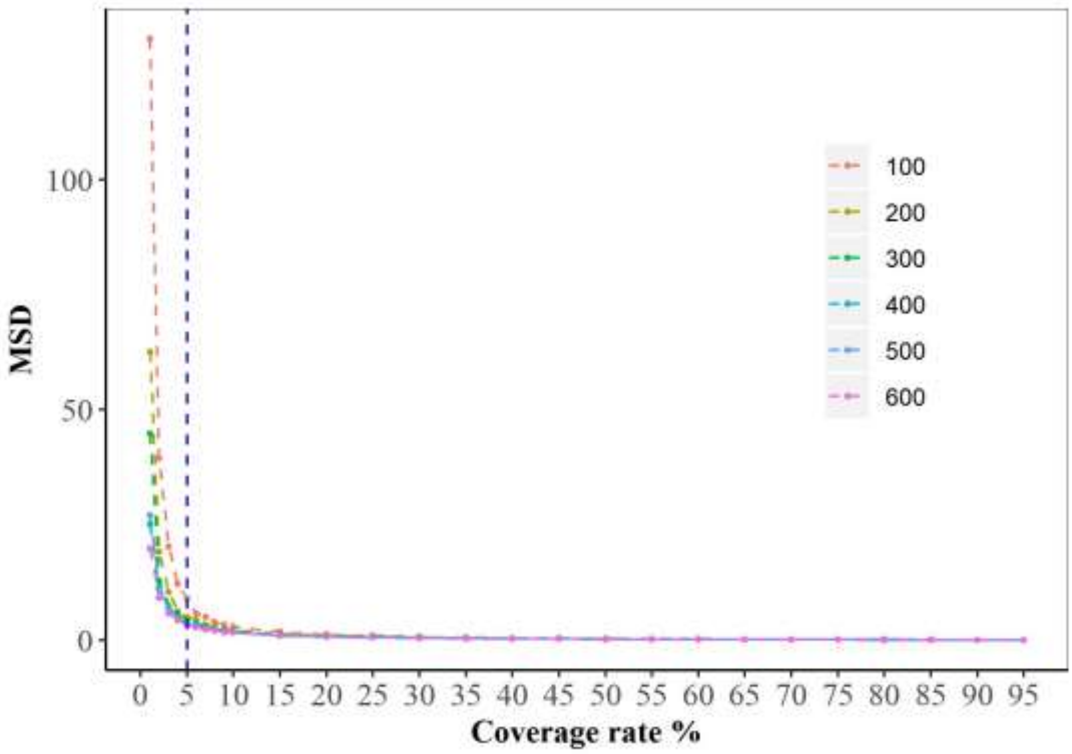

Fig.8 The relationship between the sizes of the sample population and the magnitude of MSD values.

Summary and suggestion

A total of more than 25000 samples were collected from different scientific survey programs from 2018 to 2019, and most of them were from observer monitoring program. These samples from different programs reflected a slightly different conclusion on the size composition or the maturity, and observer program could provide information with higher quality and quantity (like the Spatio-temporal trends of length-frequency) than other scientific survey programs. However, it is not practical to have a 100% observer coverage rate for such a large scale fishery with more than 300 vessels because of the financial and logistic limits. Currently, we could not conclude that how to define the coverage rate (a percentage of total vessels, total fishing days or total days at sea) would be more effective or what the optimal coverage rate is for the whole fishery. But, the simulation results showed that 100% coverage for one fishing vessel was not necessary. Actually, less than 50% was required for one vessel. Also, the size of the sample population would affect the decisions. To some extent, the little difference of the length-frequency between the observer data and information vessel data could also show that the length-frequency may be similar among all the fishing vessels.

Based on the analysis above, we considered:

1. More observer data are needed to estimate the difference in size composition of catch among fishing vessels.
2. The sampling methods for observer programs and the scientific survey program should be improved. For example, the sampling at each fishing day could divide into three or four times based on the fishing time, at least 30 individuals should be sampled for each time. Thus, we could get more information about the spatial distribution of the size composition.
3. The observer data or other survey data are encouraged to be shared among each fishing entity for designing a science-based observer program for the whole jumbo flying squid fishery in southeastern Pacific Ocean.
4. A more detailed protocol for observer program and the scientific survey program will be developed in the recent future, and also will be improved based on the future analysis by using all the information available.

Reference

Amande, M. J., Chassot, E., Chavance, P., Murua, H., de Molina, A. D., & Bez, N. (2012). Precision in bycatch estimates: the case of tuna purse-seine fisheries in the Indian Ocean. *ICES Journal of Marine Science, 69*(8), 1501-1510.

Anderson, O. R., & Small, C. J. (2013). Review of tuna Regional Fisheries Management Organisations longline scientific observer programmes. *Collect. Vol. Sci. Pap. ICCAT, 69*(5), 2220-2232.

Davies, S. L. (2003). *Guidelines for developing an at-sea fishery observer programme*: Fao.

Gilman, E., Passfield, K., & Nakamura, K. (2012). *Performance assessment of bycatch and discards governance by regional fisheries management organizations*: IUCN.

Gilman, E., Weijerman, M., & Suuronen, P. (2017). Ecological data from observer programmes underpin ecosystem-based fisheries management. *ICES Journal of Marine Science, 74*(6), 1481-1495.

Kennelly, S. J. (1999, Febraury). *The role of fisheries monitoring programmes in identifying and reducing problematic bycatches.* Paper presented at the Proceedings of the FAO symposium of the International Conference on Integrated Fisheries Monitoring.

Lawson, T. (2006, August). *Scientific aspects of observer programmes for tuna fisheries in the western and central Pacific Ocean.* Paper presented at the Scientific Committee Second Regular Session of the Western and Central Pacific Fisheries Commission, Manila, Philippines.

Lutchman, I. (2014). A review of best practice mitigation measures to address the problem of bycatch in commercial fisheries. *Marine Stewardship Council Science Series, 2*, 1-17.

Miranda, L. E. (2007). Approximate sample sizes required to estimate length distributions. *Transactions of the American Fisheries Society, 136*(2), 409-415.

Schultz, L. D., Mayfield, M. P., & Whitlock, S. L. (2016). Sample sizes needed to describe length-frequency of small-bodied fishes: An example using larval pacific lamprey. *Journal of Fish and Wildlife Management, 7*(2), 315-322.

Vokoun, J., Rabeni, C., & Stanovick, J. (2001). Sample‐size requirements for evaluating population size structure. *North American Journal of Fisheries Management, 21*(3), 660-665.

Wolfaardt, A. (2016). Data Collection Requirements for Observer Programmes to Improve Knowledge of Fishery Impacts on Seabirds. *Collective Volume of Scientific Papers, 72*(8), 1975-1983.