[課程博士・論文博士共通]

博士学位論文内容要旨
Abstract

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論文題目 Title	Studies on evaluation of factors affecting efficiency of MOHT nets for sampling fish juveniles 稚魚採集装置 MOHT の効率に及ぼす影響要因の評価に関する研究		

Research on fish juveniles plays an important role in estimating the abundance of recruitment in fish stock assessment. In order to obtain accurate information about young fish, various sampling trawl gears are widely used. However, estimation of biomass from sampling trawl gear was often underestimated because all of mesopelagic fishes were not captured. For example, Isaacs-Kidd midwater trawls (IKMT), one of the most popularly used fishing gears had disadvantages that net mouth shape and towing depth were variable due to towing speed, which cause net avoidance of larger juvenile. To overcome these disadvantages of the sampling trawl gears, Matsuda-Oozeki-Hu Trawl (MOHT) were developed for quantitative catching. It has a rigid square frame net mouth and a cambered V-shaped depressor, which allow to be towed at high speed of 4 knot and to keep towing depth stable, irrespective of variation of towing speed. Based on MOHT, a new multi-layer quantitative sampling trawl gear with a net mouth opening/closing control system (MOC-MOHT) and with a codend opening/closing control system (COC-MOHT) were also developed. Catching efficiency is defined as the ratio of the number of caught fish to the number of fish existing in front of the net. This study assumed two hypothesis: before entering the net larger individuals to evade due to their faster swimming speed, that is, net avoidance; after young fish entering the trawl net, fish with enough small body escape through the mesh space of the net, which is called mesh selectivity. In this study, we attempted to clarify factors affecting the catching efficiency such as fish size associated with swimming ability, net mouth dimension, and towing speed, and through established models for mesh retention and net avoidance, evaluate the effect of net avoidance on fish stock assessment in comparison of fish density with acoustics survey results.

Comparative experiments were carried out to analyze mesh selectivity of the MOHT polyethylene net and size selectivity of net avoidance for small MOHT and IKMT nets. Four types of trawl net were used as follows: two size MOHT (standard and small one) with net of 1.59 mm-mesh polyethylene (PE) material, and two types of IKMT (one with net of 1.59 mm-mesh PE material and the other for plankton with net of 1.00 mm-mesh nylon material, hereafter IKPT). Of the four nets, selected two or three nets were alternatively towed: standard and small MOHTs and IKPT in Sagami Bay in 2003; standard and small MOHTs off Ibaraki and Iwate Prefecture in 2005; and standard MOHT, small MOHT and IKMT off Fukushima Prefecture in 2007, Pacific. Larvae and juveniles of Japanese anchovy *Engraulis japonicas* caught during the trials were sorted for measurement of body length in millimeter. Five models expressing net avoidance in small MOHT and two IKMTs and mesh selectivity of 1.59 mm-mesh net were performed, on the two assumptions: no net avoidance in standard MOHT with enough large net mouth to prevent fish evading in front of net mouth during towing; and no mesh selection in IKPT with 1.00 mm-mesh codend, i.e. enough small mesh to retain all larval and juvenile fish in the codend. The SELECT approach was applied to estimate model parameters from body length data of the successive two hauls for estimating the model parameters. The model which small MOHT and two IKMTs had different size selection for net avoidance was selected as an optimal model by Akaike' information criterion (AIC). Length of 50% retention and selection range in mesh selectivity of 1.59 mm-mesh codend were 12.20 and 2.82 mm, respectively. Our result was in accord with earlier research (Saiura *et al* 2006). Net

avoidance of juveniles was likely to occur in IKPT with fine mesh codend and small MOHT, compared with IKMT and standard MOHT, respectively.

Effect of towing speed on net avoidance was tested by using the MOHT nets in each sea trials. These trials included standard MOHT sampling in the East China Sea in August 2016, MOC-MOHT sampling in Sagami Bay in July 2015, and COC-MOHT sampling in Sagami Bay in October 2014. In each trial, the net was casted for targeting depth where fish aggregation was observed by acoustics, and towing speeds were changed into the three stages of 4, 3, and 2 knots in this order. Compared with alternative experiment of standard MOHT, multi-layer sampling MOC-MOHT and COC-MOHT with five codends have advantages on catching the same fish school at speed of 2, 3 and 4 knot in one cast. All lantern fish were picked out for body length measurement and grouped into 5mm standard length intervals. They were identified into species level as follows: *Diaphus Kuroshio*, *Diaphus* spp, *Ceratoscopelus warmingii*, *Myctophum asperum*, *Myctophum nitidulum*, *Diogenichthys atlanticus*, *Lampanyctus alatus*, *Lampanyctus* sp, *Myctophidae* spp. Length distribution of each species showed that the catch number of large fish decreased at lower towing speed. Here, several models were assumed with linear functions of towing speed V to express logistic parameters α and β. In addition, the split parameters p in two hauls (4 and 3 knot, 4 and 2knot) was estimated by log-likelihood method or calculated with practical filtered water volume in the experiments. Total of six models were tested to examine the effect of towing speed on net avoidance. Through AIC model selection, net avoidance curve of 4, 3 and 2 knots for *Diaphus Kuroshio* and *Diaphus* spp was successfully obtained. It indicated that there was a linear relationship between net avoidance and towing speed, lesser speed resulting in more obvious net avoidance, and also suggested that net avoidance occurred even at high speed of 4 knot in MOHT sampling

Catching efficiency for lantern fish by MOC-MOHT sampling was evaluated in comparing densities with acoustics survey. In Sagami Bay in July 2015, Sonic KFS-3000 echo-sounder system, operating at 38 kHz frequency, was also used to record acoustic data during all tows of MOC-MOHT. The area backscattering strength (SV) for the water column swept by MOC-MOHT was recorded automatically at Echoview® software. In order to calculate the mean TS for all the lantern fish, we made two assumptions: all the lantern fishes had a swim bladder; and for all the lantern fish, the same formula for *Diaphus garmani* estimated at 38 kHz between target strength and standard length was applicable. Meanwhile, lantern fish densities estimated by MOC-MOHT net sampling were calculated based on the actual fish number and filtered water in each haul. Without considering net avoidance in MOC-MOHT sampling, densities estimated by MOC-MOHT sampling was about 2 orders of magnitudes lower than acoustics. Net avoidance caused underestimation of catch number for larger fish in MOC-MOHT samples, which means underestimation not only in density estimation by MOC-MOHT but also in SV leading to density overestimation of the acoustics. With compensating length distributions for net avoidance with selection curve dependent of towing speed, the difference between the two methods reduced to be about one order of magnitude.

In this study, we established evaluation model of main factors affecting fishing efficiency, including fish size, net mouth dimension, mesh size and towing speed of several sampling trawl gear, and evaluated the effect of net avoidance on fish stock assessment in comparison with the acoustics. The methods and approaches established in this study are useful for many other species to obtain better estimation of fish stock from sampling trawl gear survey.