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Update on analyses of abundance estimation from the NPA acoustic survey

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Update on analyses of abundance estimation from the NPA acoustic survey

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Introduction

Japan has been conducting the bottom environmental and prey organisms surveys on the Southern Emperor-Northern Hawaiian Ridge seamounts since 2006, and acoustic surveys using a quantitative echosounder for North Pacific armorhead (NPA, *Pentaceros wheeleri*), splendid alfonsino (*Beryx splendens*) and prey organisms since 2014. To clarify distribution and habits of the demersal fish on the Emperor Seamounts, scientific surveys using a quantitative echosounder have been conducted on Colahan and C-H Seamounts since 2016 (Yonezaki *et al*., 2017, Sawada *et al*., 2017, Matsuura *et al*., 2017, Matsuura *et al*., 2018). This paper updates the distribution and abundance of Japanese scientific survey on demersal fish that was conducted on Colahan and C-H Seamounts from 2016 to 2020.

Materials and Methods

Acoustic surveys for demersal fish were conducted by R/V Kaiyo-Maru (2630 ton) of the Fisheries Agency of Japan in the area of Colahan and C-H Seamounts in 2016, 2017, 2019 and 2020. Acoustic data were collected at 38, 70, 120 and 200 kHz bands (EK80, Simrad Co. Ltd.) while the research vessel was cruising at 6 knots along the track lines during the daytime and the nighttime. Mid-water trawl with a mouth of 30 m x 50 m, fishing rod survey (Yonezaki *et al*., 2017) and J-QUESTχ (Sawada *et al*., 2011) were conducted for identifying echoes that were obtained using the quantitative echosounder. Horizontal and vertical distribution of NPA and the other demersal fish were clarified and the abundance of NPA was estimated. We selected NPA echoes according to the information of fishing and camera observation and chose echoes from fish that were as close to the bottom as possible on echograms using a software ((Echoview ver.13.0.378, Echoview Software Pty Ltd.)).

The nautical area scattering coefficients (NASC, m^2 nautical $mile^{-2}$) of NPA on the track lines per 0.1 nautical miles were calculated for the selected echoes using the software at 38 kHz that is popular frequency for demersal fish. NASC is the linear value of SA (Area back-scattering strength) and is calculated from the following formula (*MacLennan et al*., 2002).

$$NASC = 4\pi \times 1852^2 \times 10^{\frac{SA}{10}} \quad (1)$$

NASC maps were described to show the horizontal distribution of NPA. the average *SA* value and coefficient of variation (CV) of NASC on the survey area were calculated. The average density (<*n*>) of fish school per unit area was estimated from average *SA* value and average target strength

(*TS*) that was calculated from average fork length and the regression equation between average TS and fork length (Eq.(3)).

$$<n> = \frac{<SA>}{<TS>} \quad (2)$$

$$<TS> = 20log_{10} < L > (cm) + TS_{cm} \quad (3)$$

TS_{cm} is the standardized TS by the squared fork length (L) in cm and is known to be a fixed value depending on species, frequency, and physiological conditions. TS measurements of NPA at 38 and 70 kHz as a function of tilt angle of fish were conducted in a tank of Fisheries Technology Institute by the suspension method (Sawada, 2002). In the tank experiments, calculated TS_{cm} at 38 kHz was lower than that at 70 kHz by 2.17 dB for the same specimen. *In situ* measurements using J-QUESTχ (Sawada *et al*., 2018) in 2016, TS_{cm} of -70.0 dB at 70 kHz was obtained based on the measured fork length (30.6 cm, n=94 scenes) by stereo camera and average TS (-40.3 dB, n=1945). Considering the TS_{cm} difference by frequency (38 and 70 kHz), the TS_{cm} of -72.17 dB at 38 kHz was obtained. The abundance is estimated from the density of fish school obtained from average NASC and average TS, averaged wet weight and survey area.

Results and Discussion

Demersal fish species and characteristics obtained from acoustic survey

Typical demersal fish species that were detected during the acoustic survey with sampling were NPA, splendid alfonsino, golden redbait (*Emmelichthys struhsakeri*), pacific barrelfish (*Hyperoglyphe japonica*) and oilfish (*Ruvettus pretiosus*).

NPA were collected on the position where the triangular shape echoes were detected near the bottom using the hull-mounted quantitative echosounder in the daytime (Fig. 1). They weren't caught by mid-water trawl but were caught by the fishing rod survey because they were distributed near the bottom. They were constantly moving up and down, and the triangular-shape echo could be detected even using the quantitative echosounder and stereo video camera of the J-QUESTχ. Although NPA echoes were distributed separately from the bottom echo on the J-QUESTχ echograms, the estimated abundance of them was underestimated because of the difficulty to separate the NPA echoes from the bottom echo using the hull-mounted quantitative echosounder.

Splendid alfonsinos were mainly caught from 150 to 350 m depth on the flat top of C-H Seamount by mid-water trawl and these echoes were detected using the hull-mounted quantitative echosounder in the nighttime (Fig. 2). They migrate down to the deeper slope of seamount by diel vertical migration and weren't detected using the hull-mounted quantitative echosounder in the daytime. Only a few splendid alfonsinos were captured by the stereo video camera of the J-QUESTχ because they seemed to avoid from red LED lightings of J-QUESTχ. Although it was possible to estimate their abundance using the hull-mounted quantitative echosounder, the issue remained how we identify this species from similar echoes such as golden redbaits.

Golden redbaits were caught using mid-water trawl in 2019 when echoes resembling that of splendid alfonsinos was detected on the flat top of C-H Seamount (Fig. 3). Echo shapes were like those of splendid alfonsino but there was only one prominent occurrence in the trawl catch and there are few previous acoustic studies. Therefore, the information for species identification of them was not sufficient.

Pacific barrelfish were collected on the fishing rod survey in the daytime. They were captured using stereo video camera of J-QUESTχ and were distributed within the school of NPA on Colahan and C-H Seamounts (Fig. 4). Although the number of individuals was few, it was possible to be a factor of error in the estimated abundance of NPA.

Oilfish were captured using stereo video camera of J-QUESTχ and weren't caught by mid-water trawl and fishing rod survey in the nighttime on the flat top of C-H Seamount in 2020 (Fig. 5). They and NPA appeared alternately nighttime and daytime during the survey. Their habitat depth was different from that of splendid alfonsino and golden redbaits and it is considered that their echoes have a small influence on the abundance estimation of splendid alfonsino.

Estimated abundance of NPA

Acoustic surveys indicated that, the horizontal distribution of NPA was varied little in the daytime on C-H Seamount from 2016 to 2020 (Fig. 6). They were detected by the hull-mounted quantitative echosounder on the bottom shallower than about 400 m (line 4-8). Especially, they were most abundant on the line 4 where depth was the shallowest (330 m) and was observed on the line 4-6 in all survey years. On Colahan Seamount, NPA was mostly distributed on the north-western slope of seamount (Fig. 7). Their echoes on the flat top of Colahan Seamount (275 m) were fewer than the echoes of C-H Seamount, although they were detected on the bottom shallower than about 400 m (line 3-6) as on C-H Seamount.

The estimated abundances of C-H Seamount in 2016, 2017, 2019 and 2020 were 361.3, 231.5, 543.4 and 643.5 ton, respectively (Table 1), indicating an increasing trend. Because C-H Seamount is a fishing-closed area and no strong recruitment occurred during the period, it is natural that no significant change was observed. The estimated abundances of Colahan Seamount in 2016, 2017, 2019 and 2020 were 596.9, 553.3, 397.9 and 722.7 ton, respectively (Table 2). Though the abundance was almost similar to the value of C-H Seamount, the estimated density per unit area was lower because the area of Colahan Seamount is larger than the one of C-H Seamount. From our observations, NPA was mainly distributed on the slope where it is difficult to detect using quantitative echosounder because vertical distribution of them is deeper than the flat top of Colahan Seamount. In addition, unidentified large floating echoes that overlapped with the NPA echoes occasionally appeared on the Colahan seamount in the daytime and species composition of Colahan seamount was not completely elucidated.

In this paper, we compared the relative abundance of NPA on the C-H and Colahan Seamounts on four years and demonstrated the utility of acoustic monitoring method of demersal fish. The further

partitioning to species level is necessary by reference to the composition of the trawl or fishing catches for the abundance estimation of each fish species. The effect of acoustic dead zone (Ona *et al*., 1996) where bottom echo interferes with weaker echoes from near bottom fish should be considered to estimate the NPA abundance more accurately.

Acknowledgements

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Table 1 Estimated abundance of NPA on the C-H Seamount.

C-H Seamount	2016	2017	2019	2020	Remark
Area (km^2)	12.2	11.8	11.8	11.6	five lines where NPA were detected
<NASC> (m^2/nm^2)	160.8	100.5	258.7	276.0	
<SA> (dB)	-54.3	-56.3	-52.2	-51.9	
<TS> (dB)	-42.7	-42.4	-42.9	-42.4	Calculated by Eq.(1)
<Weight> (g)	426.6	489.0	397.1	498.8	fishing sample data
<FL> (cm)	29.9	30.0	29.2	30.8	fishing sample data
Density (ton/km^2)	29.5	19.6	46.0	55.4	Density = $10^{(<SA>-<TS>)/10}$
CV	0.43	0.41	0.63	0.80	
Abundance (ton)	361.3	231.5	543.4	643.5	

Table 2 Estimated abundance of NPA on the Colahan Seamount.

Colahan Seamount	2016	2017	2019	2020	Remark
Area (km^2)	23.6	23.5	24.2	24.6	four lines where NPA were detected
<NASC> (m^2/nm^2)	131.6	117.6	92.4	149.3	
<SA> (dB)	-55.2	-55.6	-56.7	-54.6	
<TS> (dB)	-42.3	-42.1	-42.9	-42.2	Calculated by Eq.(3)
<Weight> (g)	485.2	536.0	397.1	514.5	fishing sample data
<FL> (cm)	31.1	32.0	29.2	31.6	fishing sample data
Density (ton/km^2)	25.3	23.5	16.4	29.4	Density = $10^{(<SA>-<TS>)/10}$
CV	0.83	0.34	0.38	0.75	
Abundance (ton)	596.9	553.3	397.9	722.7	

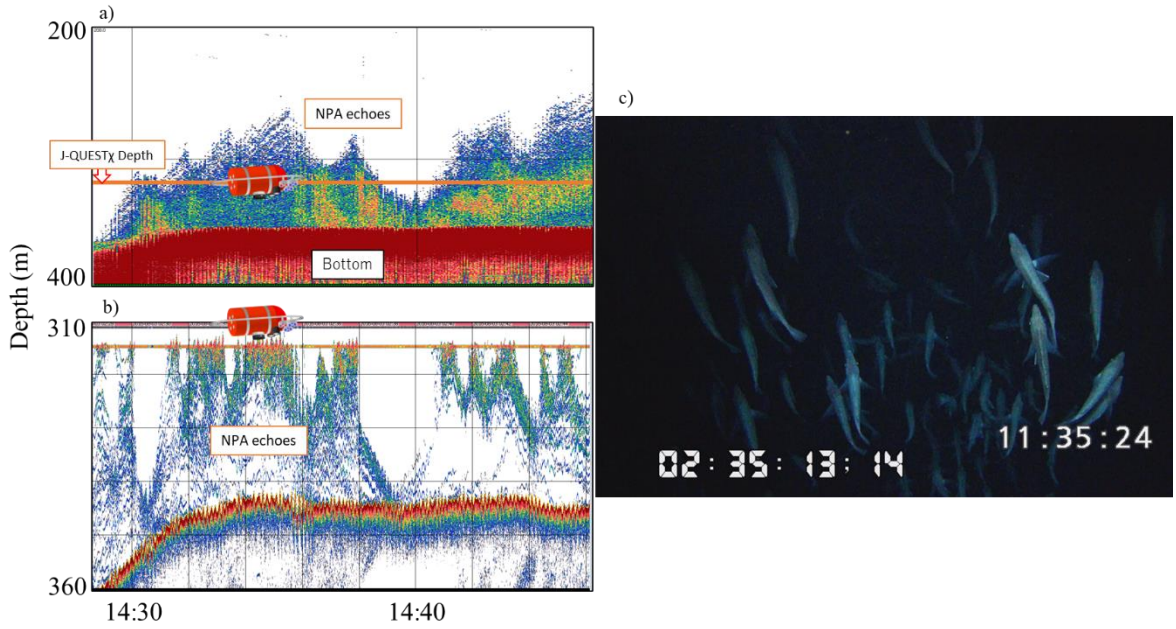

Fig. 1. a) NPA echogram obtained using the hull-mounted quantitative echosounder on the flat top of C-H Seamount in the daytime. Orange solid line indicates the J-QUESTχ depth. b) NPA echogram obtained using the quantitative echosounder of J-QUESTχ at 310 m depth. c) Captured NPA school using the stereo video camera and white LED lightings of J-QUESTχ.

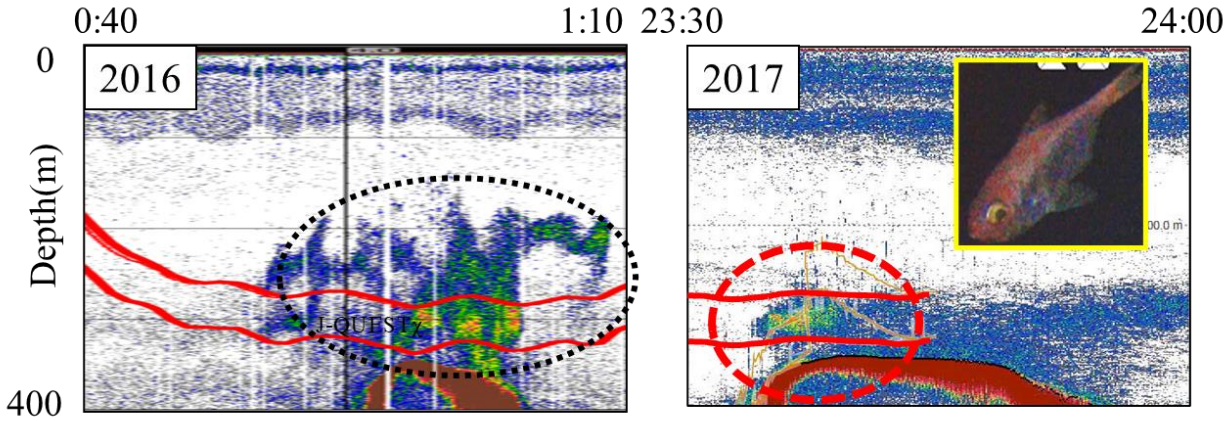

Fig. 2. Splendid alfonsino echogram of towing the mid-water trawl on the flat top of C-H Seamount in the nighttime in 2016 and 2017. Upper and lower red solid lines indicate the head rope and the ground rope depth, respectively. The picture was captured using the stereo video camera of J-QUESTχ.

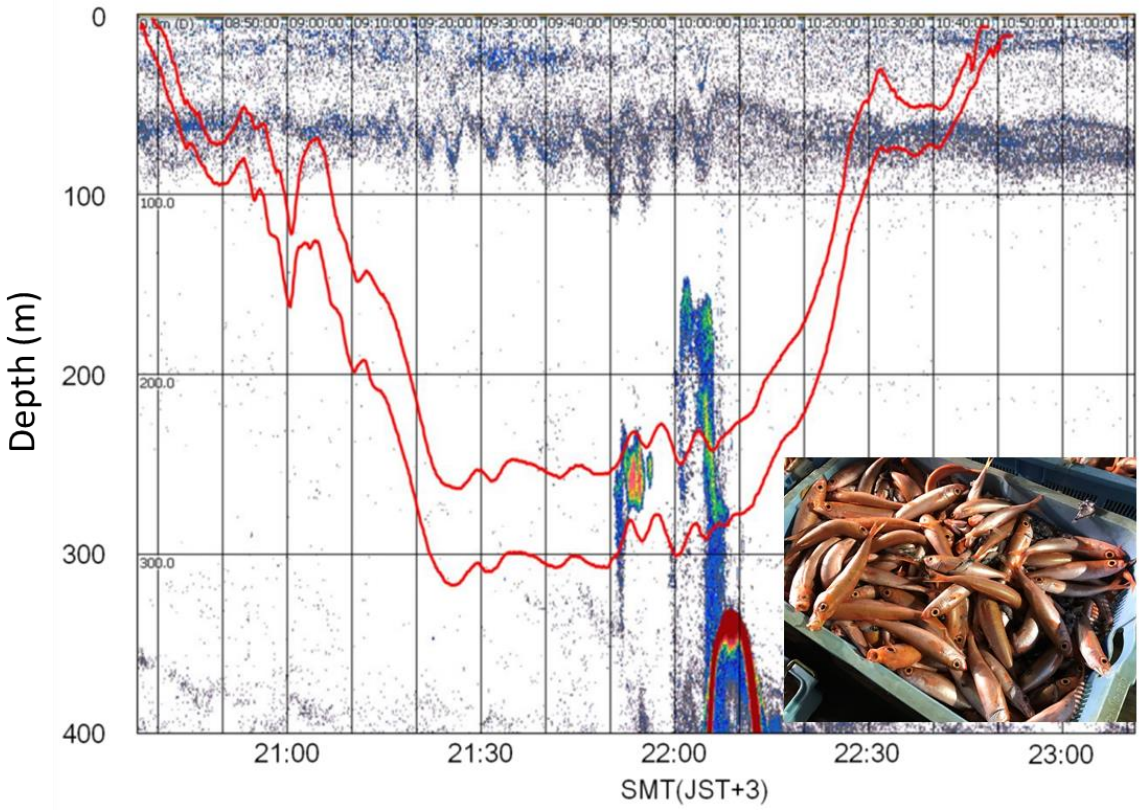

Fig. 3. Golden redbaits echogram of towing the mid-water trawl on the flat top of C-H Seamount in the nighttime. Upper and lower red solid lines indicate the head rope and the ground rope depth, respectively. The picture was the caught golden redbaits samples.

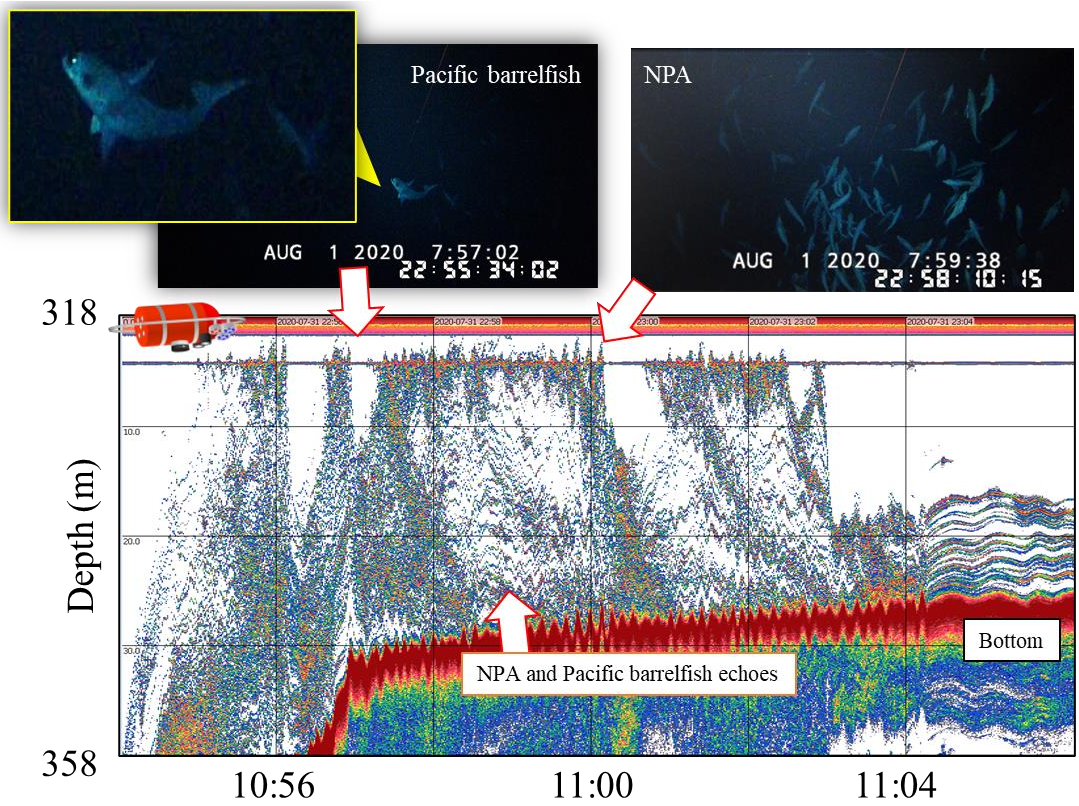

Fig. 4. Echogram that Pacific barrelfish and NPA were mixing obtained using the quantitative echosounder of J-QUESTχ on the flat top of C-H Seamount in the daytime. their pictures were captured using the stereo video camera and white LED lightings of J-QUESTχ.

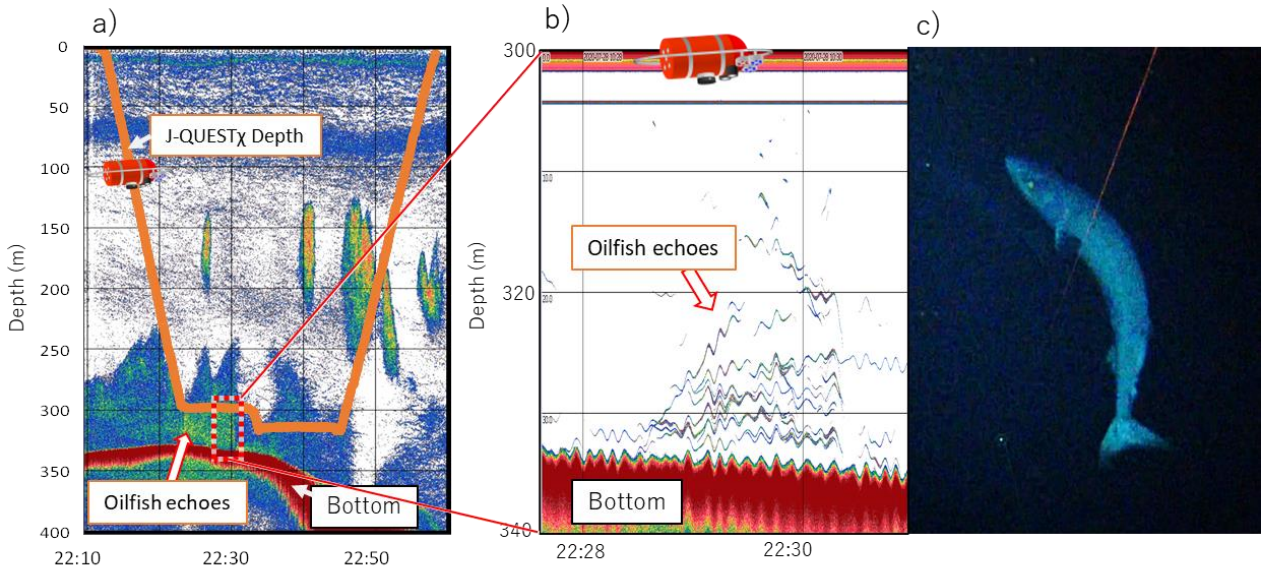

Fig. 5. a) Oilfish echogram obtained using the hull-mounted quantitative echosounder on the flat top of C-H Seamount in the nighttime. Orange solid line indicates the J-QUESTχ depth. b) Oilfish echogram obtained using the quantitative echosounder of J-QUESTχ at 300 m depth. c) Captured Oilfish using the stereo video camera and white LED lightings of J-QUESTχ.

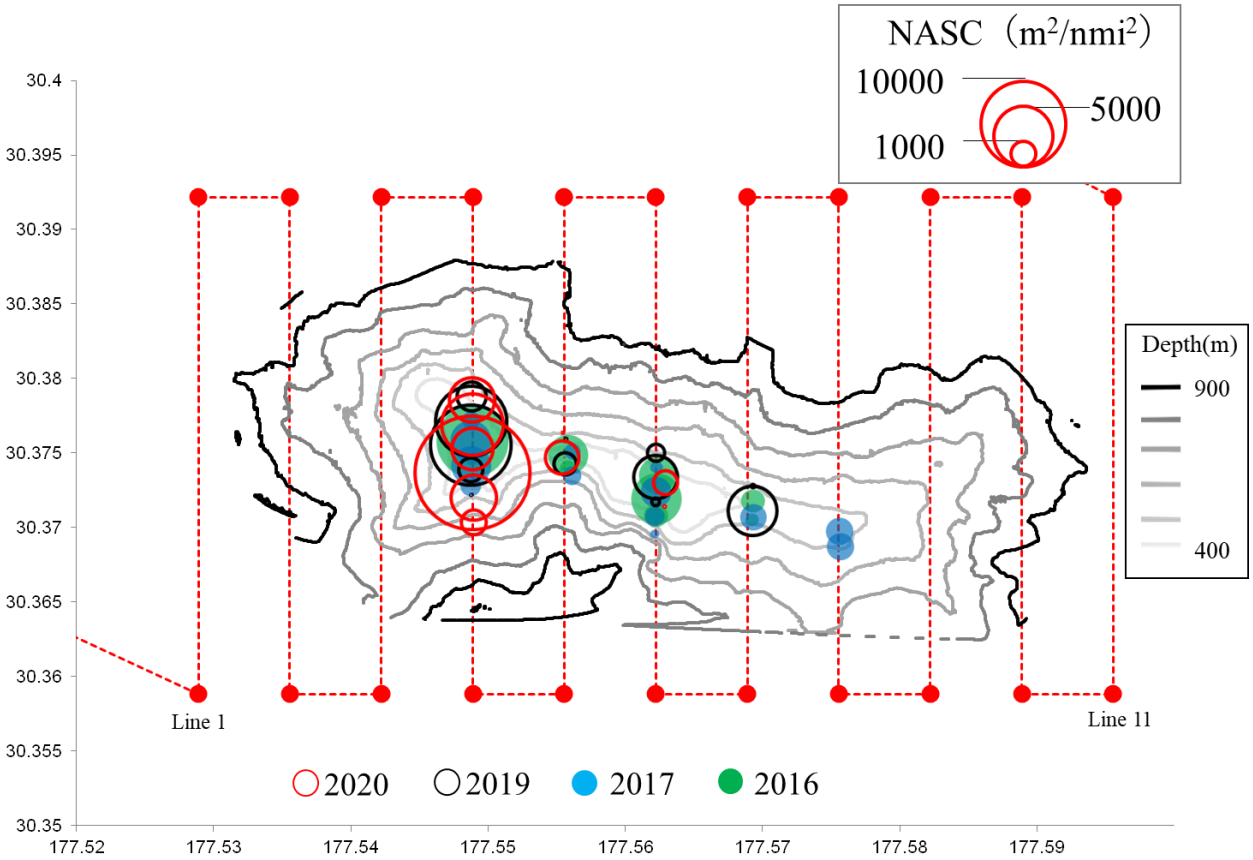

Fig. 6. Horizontal distribution of NPA on the acoustic survey lines of C-H Seamount in the daytime. Circle colors and sizes show the survey year and calculated NASC of NPA. Red dashed lines are shown the survey lines.

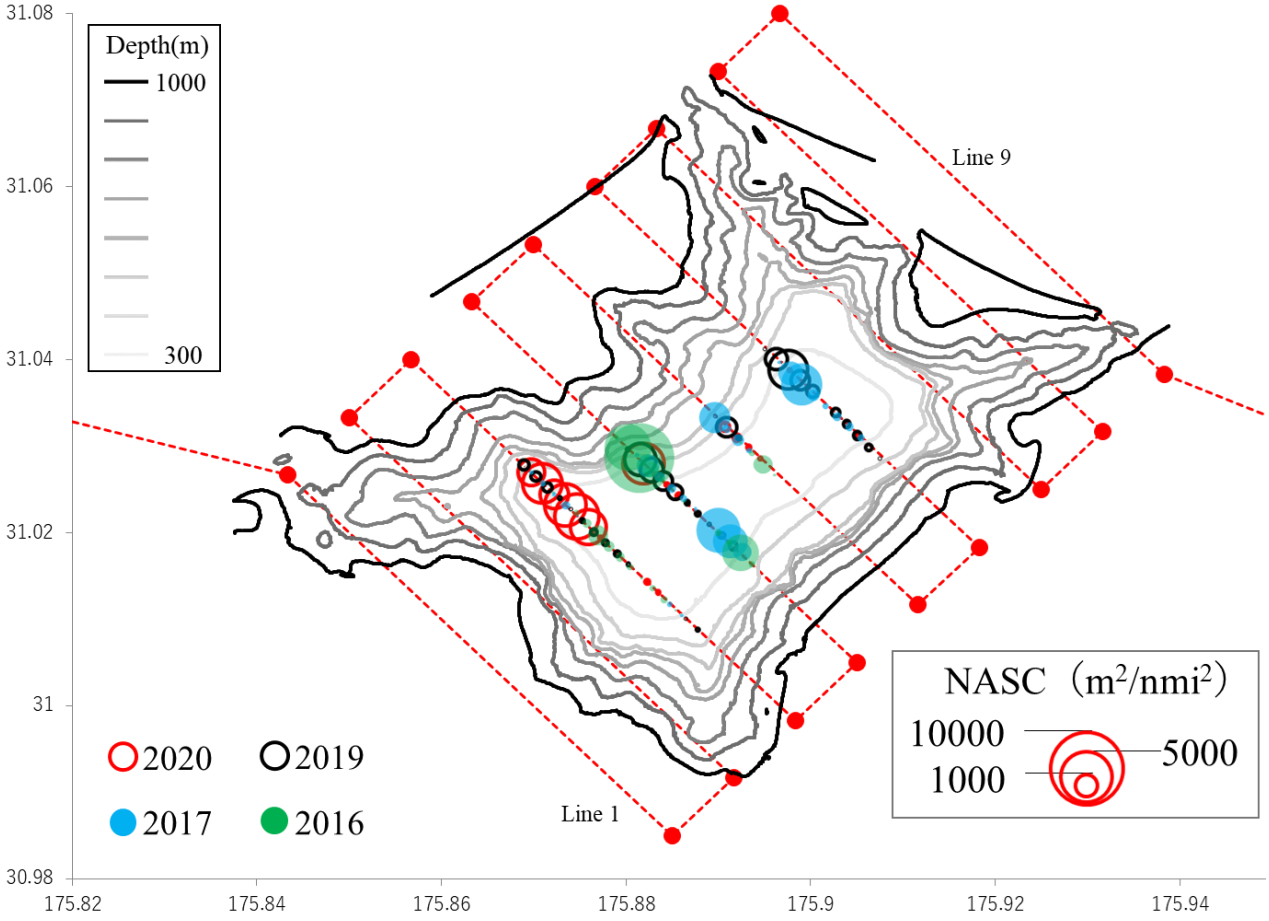

Fig. 7. Horizontal distribution of NPA on the acoustic survey lines of Colahan Seamount in the daytime. Circle colors and sizes show the survey year and calculated NASC of NPA. Red dashed lines are shown the survey lines.