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Pacific Tuna and Ecosystem Research Cruise Project - Skipjack, yellowfin and bigeye tuna are important fisheries resources in the Pacific

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Pacific Tuna and Ecosystem Research Cruise Project

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Summary:

Skipjack, yellowfin and bigeye tuna are important fisheries resources in the Pacific Ocean and the catches of these species represent the largest tuna catch in the world. Understanding spawning habitat, larval ecology and dynamics of these species in the Pacific Ocean is important not only for improving our knowledge of survival and recruitment process but also to validate underlying biological assumptions used in stock assessment. The larval distribution surveys conducted in 1956-1981 have reported that the main spawning grounds for skipjack, bigeye tuna, and yellowfin tuna are mainly located in the tropical regions. In recent years, climate related changes such as extensive marine heat waves have been reported as well as El Niño and La Niña oscillations, but the impacts of the changes on the survival process, particularly in early life history of tropical tunas are still unknown. Main objectives of this research project are (1) to describe spatial and vertical distribution of larvae and juvenile skipjack, yellowfin and bigeye tuna and its relation to oceanographic features and biological environment, and (2) to understand early survival and recruitment process in the Pacific Ocean.

Keywords: Tuna and tuna like fishes, Larval survey, International collaborative research, Pacific Ocean, Climate changes

Introduction

Skipjack tuna *Katsuwonus pelamis*, yellowfin tuna *Thunnus albacares* and bigeye tuna *Thunnus obesus* are highly migratory species that migrate over a wide area of the Pacific Ocean, from the tropical to the temperate waters, and are an important resource in this area. The catches of these species represent the largest tuna catch. To continue to utilize these species sustainably, it is necessary to understand the survival and recruitment process in the early life stage. Understanding spawning habitat, larval

ecology and dynamics of these species in the Pacific Ocean is important not only for improving our knowledge of survival and recruitment process but also to validate underlying biological assumptions applied in stock assessment model.

The larval survey targeted at the tropical tuna fishes in the Pacific Ocean have been actively conducted since the 1950s (e.g. Matsumoto, 1958, Nishikawa et al., 1985). In the initial survey, the main focus was on establishing methods for identifying tuna larvae (Matsumoto et al., 1972, Nishikawa and Rimmer, 1987), and on identifying spawning grounds from the horizontal distribution of these speices (Nishikawa et al., 1985). The larval distribution surveys conducted in 1956-1981 have reported that the main spawning grounds for skipjack, bigeye tuna, and yellowfin tuna are mainly located in the tropical regions (Nishikawa et al., 1985). In the 1960s, small midwater trawl nets (net mouth 10×10m), beam trawls, and Isaacs-Kidd Midwater Trawls began to be used and were successful in collecting juvenile tuna (Matsumoto, 1961, King and Iversen, 1962). These midwater trawl nets have been improved in various ways to date (Tanabe and Niu, 1998, Tanabe et al., 2017), and efficient methods for collecting juvenile tuna have been established (Kiyofuji et al., 2019). The most recent tropical tuna survey was conducted in the period of 2012-2018. As a result of this survey, juvenile skipjack were mainly found in relatively deeper water compared to other tunas where of high chlorophyll-a and temperate around 25°C were observed, and these characteristics may have affected and limited their vertical distributions. Thus, the larval survey on tropical tuna has a long history, and a great deal of knowledge has been gained about their early life ecology. However, the early survival and recruitment processes of these species remain unclear in the Pacific Ocean.

In recent years, climate related changes such as extensive marine heat waves have been reported as well as El Niño and La Niña oscillations (Sen Gupta et al., 2020). It has been suggested that the warm pool, which plays a vital role in the circulation of the atmosphere and ocean, may be expanding due to global warming in the western and central Pacific Ocean (Meyers, 1996). Such large-scale climate changes are known to have a significant impact on marine ecosystems (Doney et al., 2012, Smale et al., 2019), however the impacts of the changes on the survival process, particularly in early life history of tropical tunas are still unknown.

We have been established international collaborative research and planed a new research project on tropical tuna larvae and juveniles in the Pacific Ocean. In the most recent project focusing on tropical tuna larvae, that was focused mainly on the WCPO (Kiyofuji et al., 2019), but the new research project will cover a wider area of the Pacific Ocean. Main objectives of this research project are (1) to describe spatial and

vertical distribution of larvae and juvenile skipjack, yellowfin and bigeye tuna and its relation to oceanographic features and biological environment, and (2) to understand early survival and recruitment process in the Pacific Ocean. This project aims not only to elucidate the ecology of tuna larvae and juveniles, but also to conduct comprehensive research that considers the relationship between that kind of ecology and marine ecosystems and climate change.

Cruise plan

This survey will be conducted by R/V Kaiyo-maru (Fig. 1) belonging to Fisheries Agency and at tropical-subtropical region in the west-central Pacific Ocean (20N, 149E - 0.5S, 171W, Fig. 2). The cruise is composed by three legs in 2024; the first leg (Leg1) is going to depart Harumi, Tokyo on September 4th and arrive in Pohnpei on October 1st; the second leg (Leg2) is going to depart Pohnpei on October 4th and arrive in Saipan on October 21st; third leg (Leg3) is going to depart Saipan on October 24th and arrive in Harumi, Tokyo on October 29th. The main survey will take place in the Leg 1 and leg 2, respectively. A total of 16 stations could be divided into two types which are "Short station" and "Long station". The former is a survey conducted at one station per day, mainly targeting zooplankton and larval fish. The latter is a three-day, one-station survey mainly targeting juvenile tuna using midwater trawls.

Research plan

Oceanographic observations and acoustic surveys

During the cruise, an acoustic doppler current profiler (ADCP) will be conducted to obtain data on current direction and velocity. A quantitative echo sounder (Simrad EK80) will be also used for obtaining data on the biomass of tropical tuna and their prey species (zooplankton and micronekton etc.).

During the fixed point, conductivity, temperature, and depth (CTD) are measured until 1500 m depth. To analysis nutrients, chlorophyll-a concentration, salinity, dissolved oxygen, stable isotope for particulate organic matter and nutrients, and environmental DNA (eDNA), it will be collected the sea water from each layer by niskin bottles attached CTD.

We will conduct acoustic survey to monitor the presence and abundance zooplankton and micronekton within the water column by three equipment that are Wide Band Autonomous Transceiver (WBAT), Tracor Acoustic Profiling System (TAPS) and Acoustic Zooplankton Fish Profiler (AZFP). WBAT and AZFP will survey the water column up to a depth of 600m, while TAPS will survey the water column up

to a depth of 200m.

Collection methods of biological samples using the net gears (Fig. 1)

To investigate the feeding environment of tuna larvae and the relationship between the marine environment and zooplankton distribution, small and large zooplankton will be collected using a twin-type North Pacific standard (NORPAC) net and Vertical Multiple Plankton Sampler (VMPS). The surveys by the NORPAC net (mouth diameter, 0.45 m and mesh size, 0.1 mm) will be conducted by vertical tow from 200 m depth to the surface. That by the VMPS (mouth size, 0.5×0.5 m and mesh size, 0.1 mm) will be conducted by vertical tow at four layers such as 600-400, 400-200, 200-100 and 100-0 m. The volume of water filtered by the NORPAC net and VMPS estimates with a mechanical flowmeter installed at the mouth of the net respectively.

To investigate the presence and horizontal distribution for tuna larvae and early juvenile in the surface area, two types of ring net (mouth diameter, 0.45 m) with different mesh size (0.334 and 1.0 mm) will be conducted by surface horizontal tow. Additionally, to investigate vertical distribution for tuna larvae and early juvenile, Matsuda-Oozeki-Hu Midwater Trawl (MOHT) with a mouth area of 5 m^2 and 1.4 mm mesh will be conducted by oblique tow at three different depth layers. The depth of the three trawl operations by MOHT will be determined in relation to the warm pool.

Midwater trawl (NST-660-SR) with height ca. 45×width ca. 40 m net mouth size and 60 mm mesh size in cod end, the operations will be conducted at predetermined nine depth layer to collect juvenile tropical tuna (skipjack, yellowfin, bigeye and albacore tuna). Considering past survey results (Tanabe et al., 2017, Kiyofuji et al., 2019), the trawl depths are planned to be 190, 170, 150, 130, 110, 90, 70, 50 and 30 m. Additionally, in order to compare the species composition of micronekton obtained from eDNA with that obtained from actual midwater trawl data, eDNA collections will be conducted using the Metaprobe.

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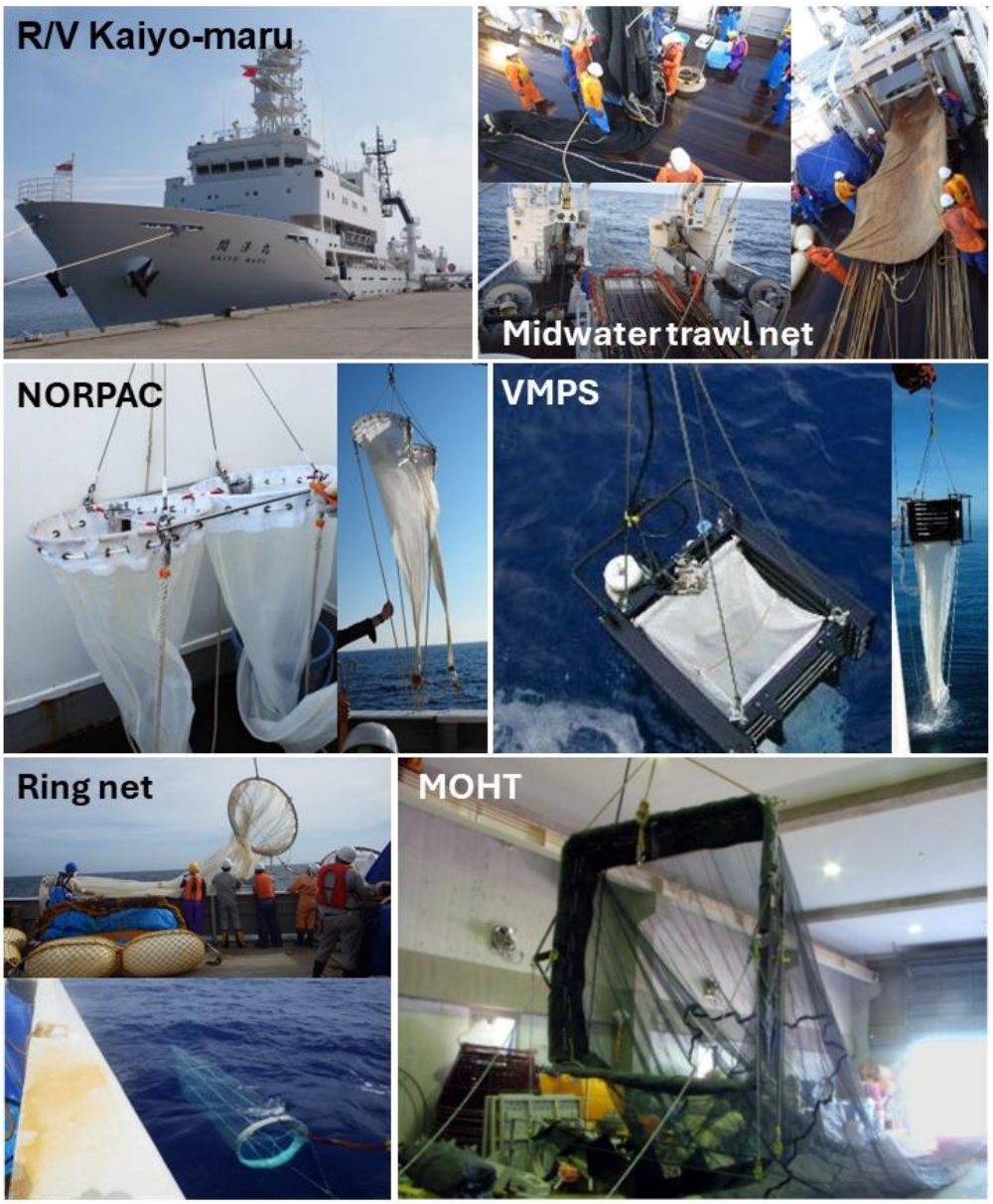

Figure 1 Photograph of R/V Kaiyo-maru and the net gear to be used in the 2024 biological survey

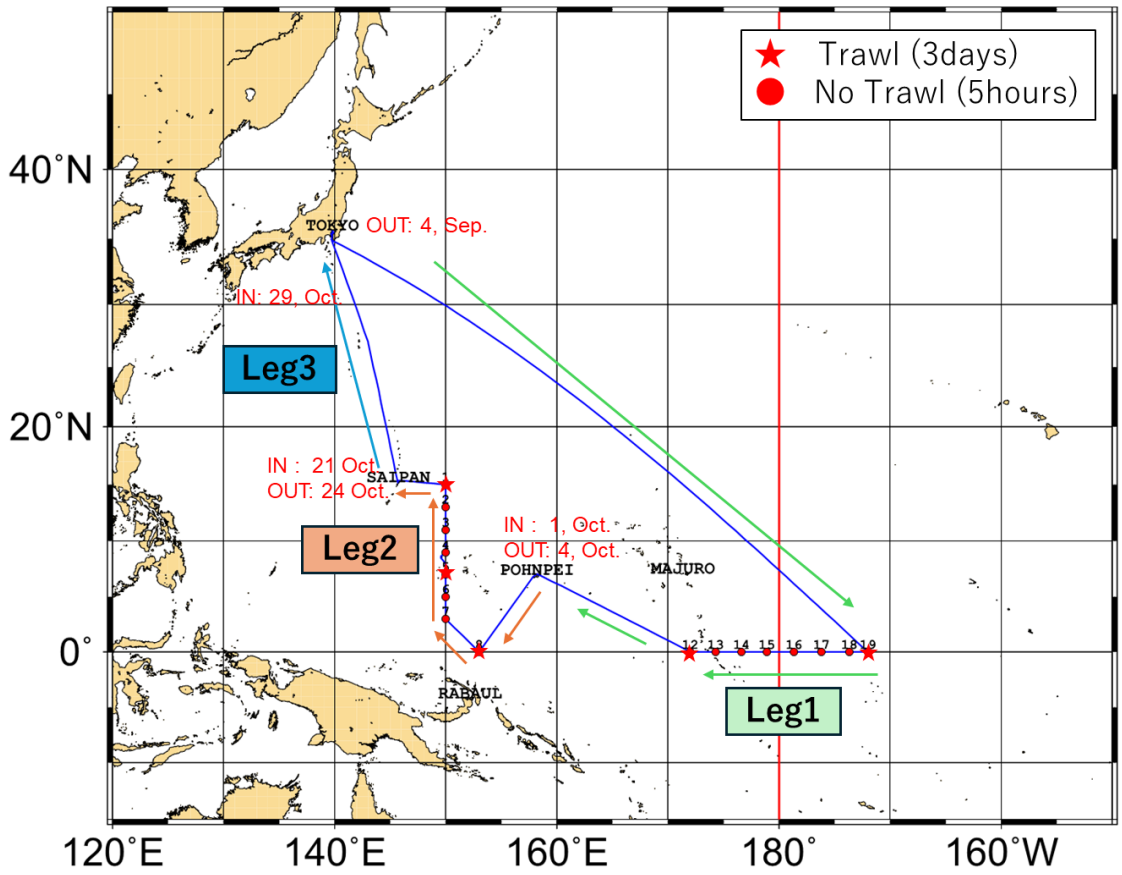

Figure 2 Map of 2024 survey area in the new research cruise by R/V Kaiyo-maru belonging to Fisheries Agency. Red star and circle show “Long station” and “Short station”, respectively.