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**EXPERIMENTAL TAGGING RESEARCH FOR BIGEYE TUNA IN THE EASTERN
OFFSHORE OF JAPAN**

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Paper prepared by

Yasuko Semba¹, Takayuki Matusmoto¹, and Hiroaki Okamoto¹

¹ National Research Institute of Far Seas Fisheries, Fisheries Research Agency of Japan, Tropical Tuna Resources Division, Tropical Tuna Section

Experimental tagging research for bigeye tuna (*Thunnus obesus*) in the Eastern offshore of Japan.

Yasuko Semba, Takayuki Matsumoto and Hiroaki Okamoto

National Research Institute of Far Seas Fisheries
Fisheries Research Agency of Japan
Tropical Tuna Resources Division
Tropical Tuna Section

Summary

We introduce the outline of activity and preliminary results of the experimental tagging research for bigeye tuna (*Thunnus obesus*) in the northeastern Pacific off Japan. In this feasibility research, east-west and southward movement dominated in early summer (May-Jun.) and late fall (Oct.-Dec.), respectively. This preliminary results provides basic information for the planning the large scale tagging project for the future.

Introduction

In the Pacific Ocean, bigeye tuna (*Thunnus obesus*) distributes widely from the tropical to temperate waters. However, little is known on its stock structure, natural mortality and some kind of biological parameters. Tagging research provides basic information on the movement or mixing rate of populations if different stocks exist. In the past, SPC conducted large-scale tagging program on tropical tunas from 1989 to 1992 (Hampton and Williams 2004) and IATTC has conducted tagging cruises since 2000 (IATTC 2002 a, IATTC 2002 b, IATTC 2004 a, IATTC 2004 b, IATTC 2006). In these programs, main tagging area was limited to the tropical region of western-central (Coral Sea, the waters of Indonesia and Philippines) or eastern Pacific. The majority of the released fish in these researches was smaller than 100cm FL. Schaefer and Fuller (2002) investigated the movements of bigeye tuna using archival tag for the individuals in the eastern Pacific Ocean (EPO) and suggests the existence of regional fidelity for bigeye tuna and that the expected degree of mixing is quite low between the EPO and the central and western Pacific Ocean, combining the results of a range of tagging studies conducted in EPO and the central and western Pacific Ocean. On the other hand, there has been little information on the movements of this species which distributes in the northern and southern Pacific higher than 20 degrees of latitude. These points show there is not enough information to cover the movement patterns of this species in the

whole Pacific.

In the middle-high latitude area in the North Pacific (along 30-40 °N), it is known that bigeye in the longline catch consists mainly of sub-adult fishes and this area is considered as foraging area for this species. It would be valuable to understand the movement pattern in this middle-high latitude area for the interpretation of the migration of this species throughout its life history in this Ocean as well as for Japan which is exploiting bigeye tuna in that region.

We have conducted the tagging activities for tropical tunas around Nansei Islands of Japan (24-29°N, 123-130°E) (Matsumoto *et al.*, 2007). In this tagging, bigeye tunas associated with 'payao' (anchored floating or underwater fish aggregating devices) were caught by trolling, handline or pole and line and tagged with conventional dart tag and/or archival tag. The size of released bigeye tuna ranges mostly from 30 to 70 cm (FL), which corresponds to 0-1 year old. Although the recaptures within a short period dominates, some individuals were caught approximately 1000 days after release. The majority of recaptured individuals showed the northeastward movement and most of the northerly recoveries were obtained from waters off Joban coast (around 35°N, 145-155°E). However, there is no information on the subsequent movements and it has been unknown whether the juvenile bigeye tuna moves eastwards or northwards. That is, there is little information on the movement of bigeye tuna in the northern part of the Pacific Ocean.

In order to know the movements of small and sub-adult individuals after they reached to the eastern coast of Japan in the region around 35-40°N of the North Pacific Ocean, we started a preliminary tagging research for bigeye tuna in the eastern offshore area utilizing available tagging opportunities conducted by research vessels, chartered vessels and commercial vessels.

All these tagging programs including some trial tagging activities for bigeye tuna in that area were described.

The outline of the research

1) The bigeye tagging caught by the longline vessel

The tagging in the eastern offshore of Japan started in 2002 on an opportunistic basis, using bigeye caught by longline operations, in which the conventional dart tag was attached to 31 individuals (78-138cm in fork length, FL thereafter) in total and four archival tags (Lotek LTD-2310) were attached with a dart tag in 2006 (Table1, Fig1). In

2002 and 2003, 10 individuals (79-104 cm FL) and four individuals (78-106 cm FL) were tagged with dart tags in the region around 33-34 °N and 146-157 °E. In 2006, eight individuals (80-120 cm FL) were tagged with dart tags in the region around 28-33 °N and 144-147 °E, of which four individuals were also implanted with archival tag.

Collaterally, popup archival tag (PAT: Microwave Telemetry Inc. and Wildlife Computers Inc.) was attached to nine individuals in the eastern offshore of Japan (30-40 °N). This tagging was conducted in cooperation with commercial logline vessels between 2003 and 2007. These nine individuals were tagged with conventional dart tags. Table 1 shows the information on release and recapture by these activities.

2) The tagging research by R/V Shoyo-maru in the tropical and temperate Pacific.

In 2006, R/V Shoyo-maru (Fisheries Agency of Japan) conducted longline research through September to December at the temperate and tropical areas of western and central Pacific Ocean. Main purpose of this research was to compare the migration pattern of sub-adult with that of adult between equatorial and high latitudinal temperate region in western and central Pacific. This research cruise consisted of three legs (Fig 2), the first leg from 18th Sept. to 17th Oct. in tropical region (10°N -12°N, 160°E -175°E), the second leg from 21st Oct. to 21st Nov. in temperate region (30°N -35°N, 150°E -180°E), and the third leg from 25th Nov. to 26th Dec. in tropical region (2°N -6°N, 155°E -165°E). Through this research cruise, total of 36 longline operations were conducted and we attached PAT to 14 bigeye tunas and released.

In this research, we used two kind of PAT, i.e, standard type which was set to be popped off six months after attachment, and High Rate type (data storage per four minutes). In this document, we introduce the results of only standard type tags. The detailed information of the release is shown in Table2.

3) The bigeye tagging caught by the pole and line vessel

While the release by longline gear is useful for the sub-adult or adult individuals, it is inadequate to target the small individuals of 0-1 year old and is difficult to tag very large number of individuals in a short time. In the area around 30 °N , the tagging for small individuals of 0-1 year old using trolling (partly by rod and reel) and handline around payao cannot be expected because such fishery utilizing payao is not operated in this region. Based on the record of bigeye catch in the past research of pole and line fishery targeting albacore (*Thunnus alalunga*), we thought pole and lone might be an appropriate gear to tag and release the small bigeye tuna in the middle-high latitude area. In order to test the feasibility of pole and line fishing for tagging small bigeye tuna in

the middle-high latitude area, we have conducted feasibility study, using pole and line research cruises by Shinmiyagi-maru targeting albacore in 2006 and 2007.

In 2006 cruise, 49 individuals (51-57cm FL) were released with dart tag in the region around 34.8°N and 146.4°E.

In 2007 cruise, 77 individuals (31-80cm FL) were released with dart tag in the region around 34-35 °N and 142-146 °E (Fig. 3).

Recaptures and movements of bigeye tuna

The length at release of 39 individuals which were caught by the longline gear ranged from 80 to 142.1 cm. This was larger than that of 126 individuals caught by pole and line, ranging from 31 to 80cm (Fig 4). Out of 156 tunas which were tagged with conventional dart tag totally, 41 tunas were recaptured. The linear movement for the recaptured fish was shown in the Figs. 5- 8 including the release and pop-off points of PAT tagged individuals.

1) The bigeye tagging caught by the longline vessel

Table 1 shows the information on recaptures released from longline vessels. At present, two individuals were recaptured, one of which was attached with conventional dart tag only and the other one was attached with an archival and a dart tag. Fig. 5 shows the movement of the two bigeye tunas which were tagged with archival and/or conventional tag. The fork length of these recaptured individuals was 98cm and 120cm at release, which corresponded to 2-3 years old. These sub-adult tunas were recaptured 157 and 343 days after release in May and moved northwestwards. Unfortunately, the archival tag was not retrieved from the individual tagged with an archival tag.

While only two recaptures were obtained from the longline-released individuals, days at liberty (157 and 343 days) tend to be longer than those (3-47 days) released by pole and line gear.

Regarding PAT, three of nine PAT released were not popped off and another six PAT were popped off and transmitted the data for 15-37 days. Fig. 6 shows the linear movement of five bigeye tunas for which data for movement was successfully retrieved during the research from 2003 to 2006.

Of three individuals released in June 2003, one PAT was not popped off, one individual moved eastwards, and the other one moved southwards. For the five individuals released in November 2004, two PATs were not popped off. Two of three individuals moved southward and one individual moved eastwards. One individual

released in June 2007, PAT was detached from the fish eight days after the release. The data is still being analyzed and therefore the result is not indicated in the Fig. 6.

2) The tagging research by R/V Shoyo-maru in the tropical and temperate Pacific

Out of 14 PATs releases, five PATs were popped off shortly within two weeks after they were attached, and other nine tags were popped off 19-76 days after release. Fig. 7 shows the linear movements of six individuals which transmitted data on movement for more than two weeks.

The individual released in the first leg (October- equatorial: 10°N-12°N, 160°E -175°E) moved northeastward. Of eight individuals released in the second leg (October and November—temperate: 30°N-35°N, 150°E-180°E), two individuals, which provided movement data for 19 and 76 days, respectively, moved toward south and southeast. Another five individuals released in the same leg (not indicated in the figure) moved eastward, but provided data only for 4 to 11 days. One High Rate tag was popped off 23 days after attachment. Out of five individuals released in the third leg (December-equatorial: 2°N-6°N, 155°E-165°E), three individuals provided movement data for 31-59 days. Two of these three individuals moved northwestward and one individual moved southeastward. Two High Rate tags were popped off 23 days after attachment.

For the individual which provided data for longer than two weeks, two types of movement, i.e., southward and northwestward movements were observed in both regions. Combining this result with those obtained for sub-adults released by longline vessels, southward movement dominated in the temperate region, after late fall. In tropical region, southward and northwestward movements were observed simultaneously during winter.

3) The bigeye tagging caught by the pole and line vessel

In two research cruises, 49 and 77 bigeye tuna were tagged and released, respectively. At the present, 39 individuals were recaptured so far (Table3).

Fig. 8 shows the linear movements of 39 bigeye tunas which were tagged with conventional dart tag in the cruise by Shinmiyagi-Maru. The fork length at release for these recaptured tunas is 57-58cm, which corresponds to nearly one year old. The recaptured tunas released in 2006 and 2007 were caught after 23-47, 3-5 days after the release, respectively. Although the information is limited to short-term observation from the release, every tuna tends to move eastward after release in June, regardless of the released year.

The majority of recaptured tunas in this feasibility tagging research were fish of one year old released by pole and line and recaptured in a short time (within one year). These individuals were caught by commercial vessels engaged in pole and line or purse seine fishing, which suggests they were caught while swimming in schools. Especially, the 35 of 77 individuals released in 2007 were caught within one week and almost all was caught by one purse seine operation, so useful information on the movement was not obtained. But this indicates that at least half of tagged fishes survived and the original school was maintained, which suggests that the tagging procedure might be appropriate.

This feasible tagging research by pole and line indicates that the tagging by this gear enables us to tag relatively large number of tunas. However, whether it succeeds or not fully depends on how successful in finding fish schools which contain enough amounts of bigeye tuna. Therefore, it is necessary to consider this kind of trade-off when tagging activities will be taking place in the middle-high latitudinal area between 30-40 °N.

Future Plan

While these results are not enough to delineate meaningful movements of bigeye tuna population in the northwestern Pacific, Kume (1979) suggested the hypothesis that small bigeye tuna moves northward from the south of the Japanese archipelago and then migrate eastward.

In order to test this hypothesis, we have to collect more data of northwestern movements to discuss with the data of migration collected in tropical by SPC. The tagging results from the juvenile and sub-adult bigeye around Japan would provide important source of information if the sufficient number of fish were released in this area. Additionally, Kume (1969) also presumed the migration and distribution of bigeye could be different by growth stage, based on the geographic distribution of catch by age class.

In the future study for examining the complex migration of bigeye tuna, it would be crucial to design the efficient research plan followed by consideration of the results in the past feasibility studies and appropriate gear and season need to be identified and used when tagging is going to be conducted.

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Table 1. Bigeye tuna tag release and recapture (Longline Vessel).

Tagged date Year	Month	vessel	Tag type	fishery	Number of Tagged fish	Location		size at release (FL:cm)				Recaptured (pop- off) number	
						latitude	longitude	range	mode	median	average		SD
2002	5	No.2 Taikai-Marui	Conventional	Longline	10	33N	151-155E	79-104	98	98	95.6	8.9	0
2003	6	No.17 Shinei-Marui	Conventional & PAT	Longline	3	33-37N	151-153E	109-130	n.a.	110	116.3	11.8	2
2003	5-6	No.2 Taikai-Marui	Conventional	Longline	4	34N	146-157E	78-106	n.a.	97.5	94.8	11.9	1
2004	11	Ryohsei-Marui	Conventional & PAT	Longline	5	36N	143-151E	120-138	125	125	125.6	7.4	3
2006	5	No.2 Taikai-Marui	Conventional	Longline	8	28-33N	144-147E	80-120	n.a.	92.5	93.9	11.9	1
2006	5	No.2 Taikai-Marui	archival	Longline	4	28-33N	145-147E	80-120	n.a.	88.5	94.25	18.0	1
2007	6	No.2 Taikai-Marui	PAT	Longline	1	34N	142E	118	-	-	-	-	1

Table 2. Attachment of PAT for bigeye tuna by Shoyo-marui. (Longline)

Tagged date Year	Month	Leg	Tag type	fishery	Number of Tagged fish	Location		size at release (FL:cm)				pop-off number	
						latitude	longitude	range	mode	median	average		SD
2006	10	1	Standard	Longline	1	2N	158E	116.4	-	-	-	-	1
2006	10-11	2	Standard(7) *HR(1)	Longline	8	33N	175-177E	99.5-142.1	104.1	104.1	112.8	16.8	8
2006	12	3	Standard(3) HR(2)	Longline	5	11N	175-176E	112-148	-	115	121.0	15.17	5

*HR denotes High Rate type.

Table 3. Bigeye tuna tag release and recapture (Pole and Line Vessel).

Tagged date Year	Month	vessel	Tag type	fishery	Number of Tagged fish	Location		size (FL:cm)				Recaptured number	
						latitude	longitude	range	mode	median	average		SD
2006	6	Shinmiyagi-Marui	Conventional	Pole and line	49	34.8N	146.4E	51-57	n.a.	n.a.	n.a.	n.a.	4
2007	6	Shinmiyagi-Marui	Conventional	Pole and line	77	34-35N	142-146E	31-80	74	60	64.1	10.2	35

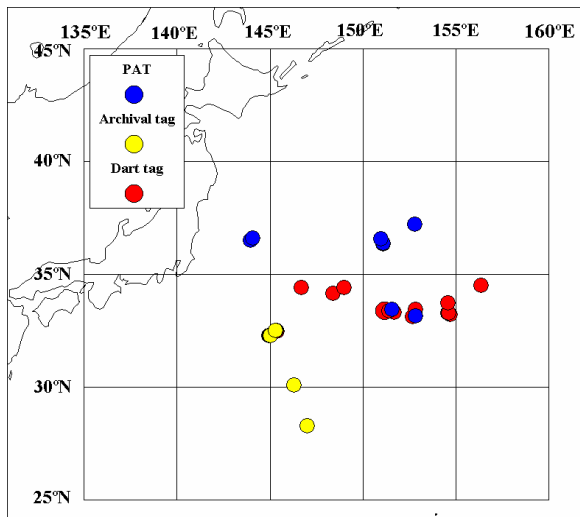


Figure1. Release location of tagging for bigeye tuna by longline vessel.

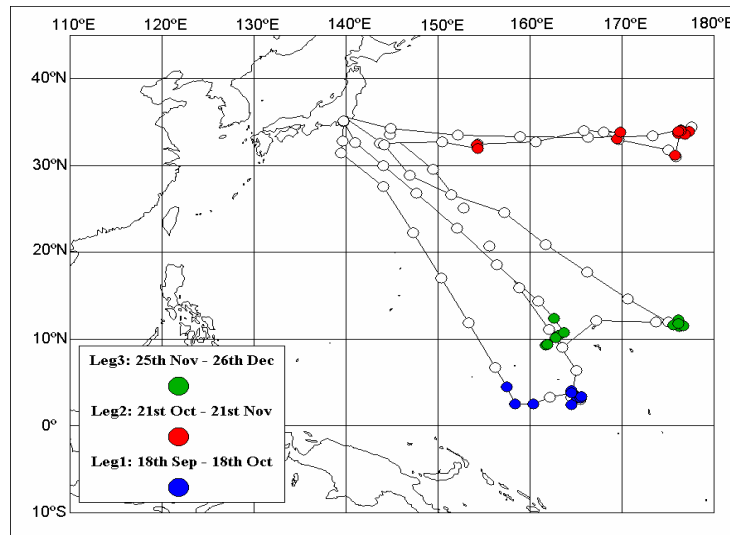


Figure2. Navigation chart of research cruise by R/V Shoyo-maru in 2006. The color and white circle denote the operation point and location at noon in each leg, respectively .

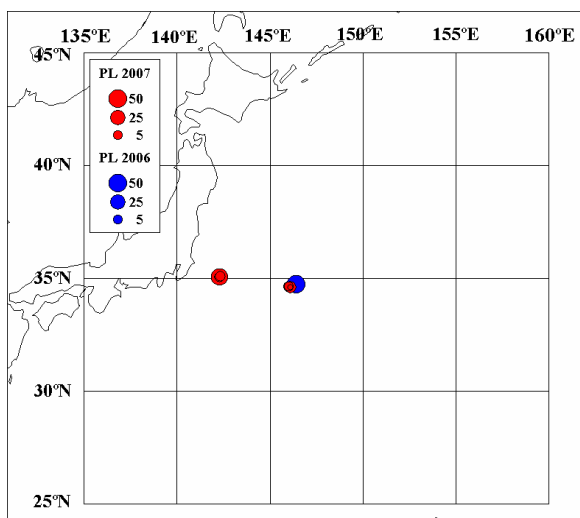


Figure3. Release location of tagging for bigeye tuna by pole and line vessel.

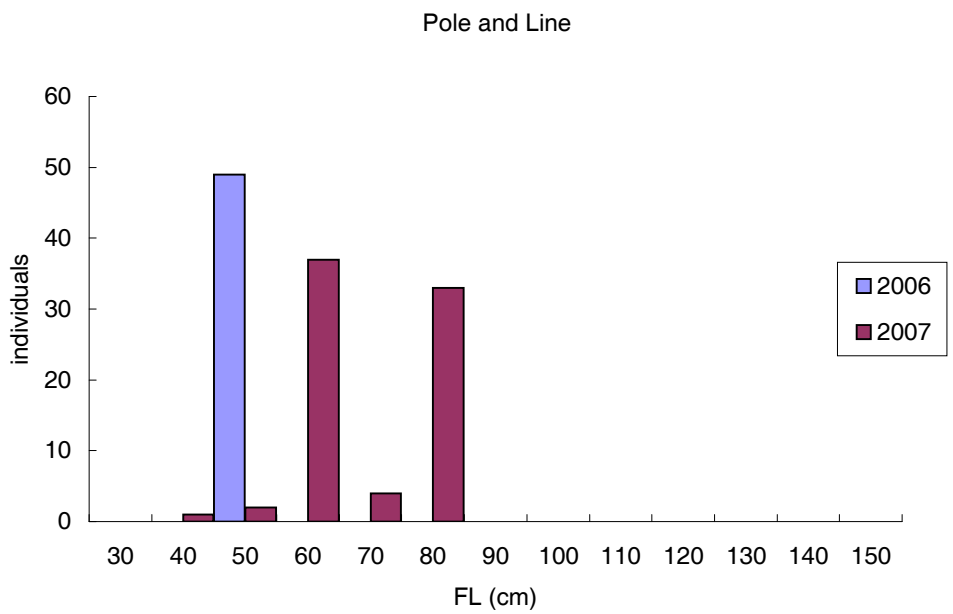
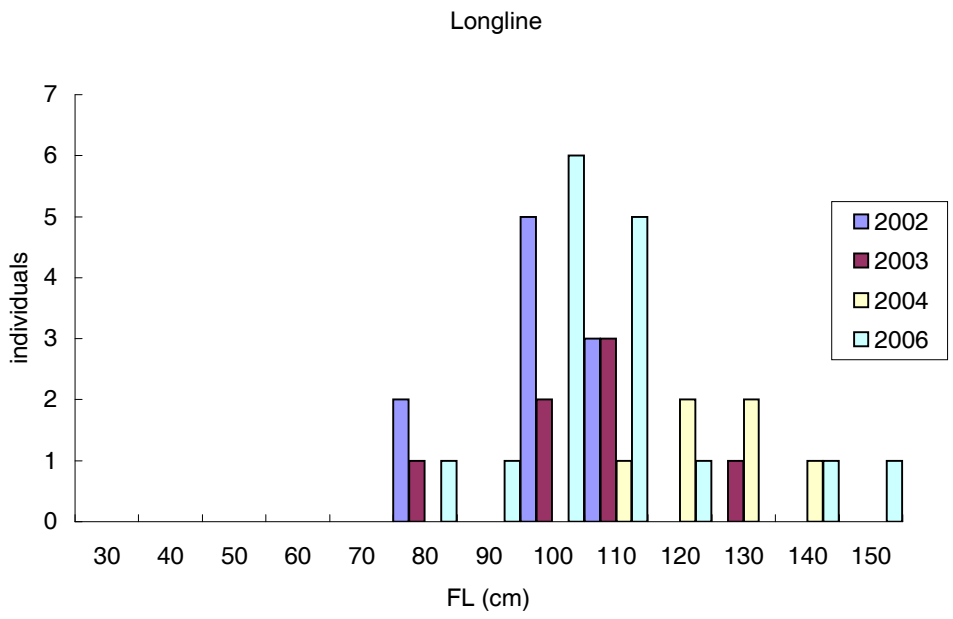


Figure4. Body length of released bigeye by fishing gear.

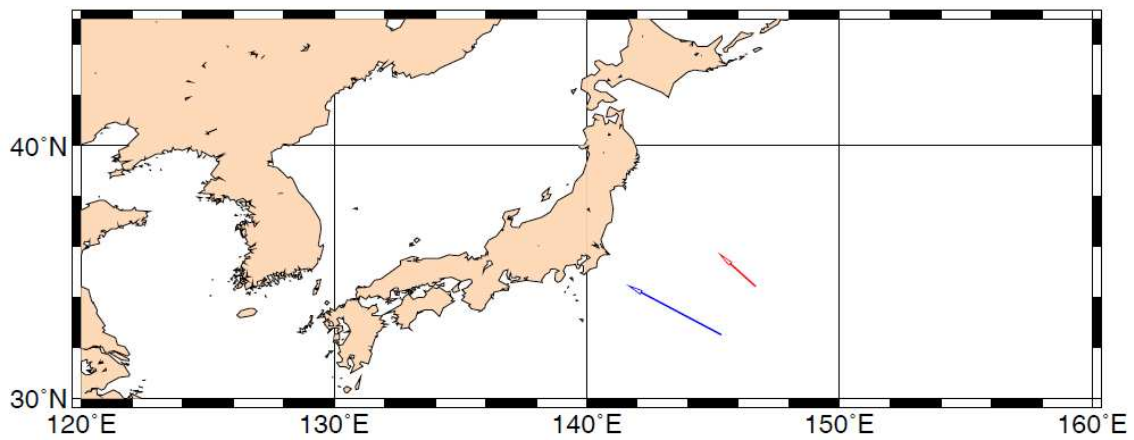


Figure5. Linear movement of bigeye tuna released with archival tag and/or dart tag by longline vessel. Red and blue lines denote release in May 2003 and May 2006, respectively.

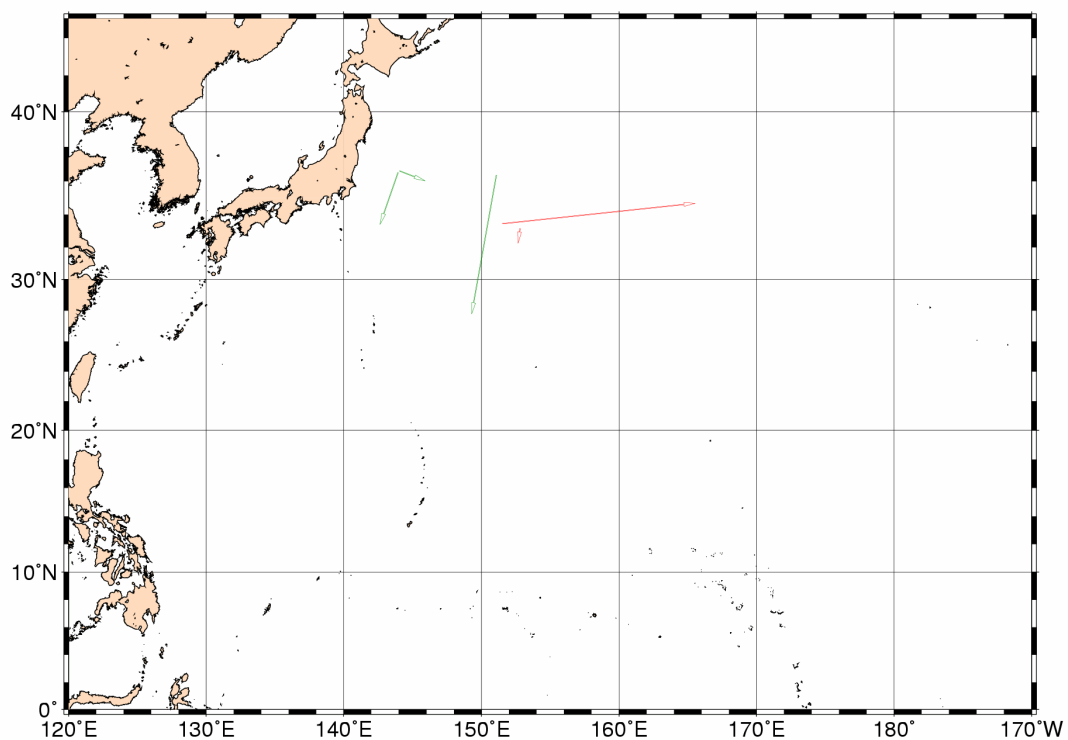


Figure6. Linear movement of bigeye tuna released with PAT and dart tag by longline vessel. Red and green lines denote release in June 2003 and November 2004, respectively.

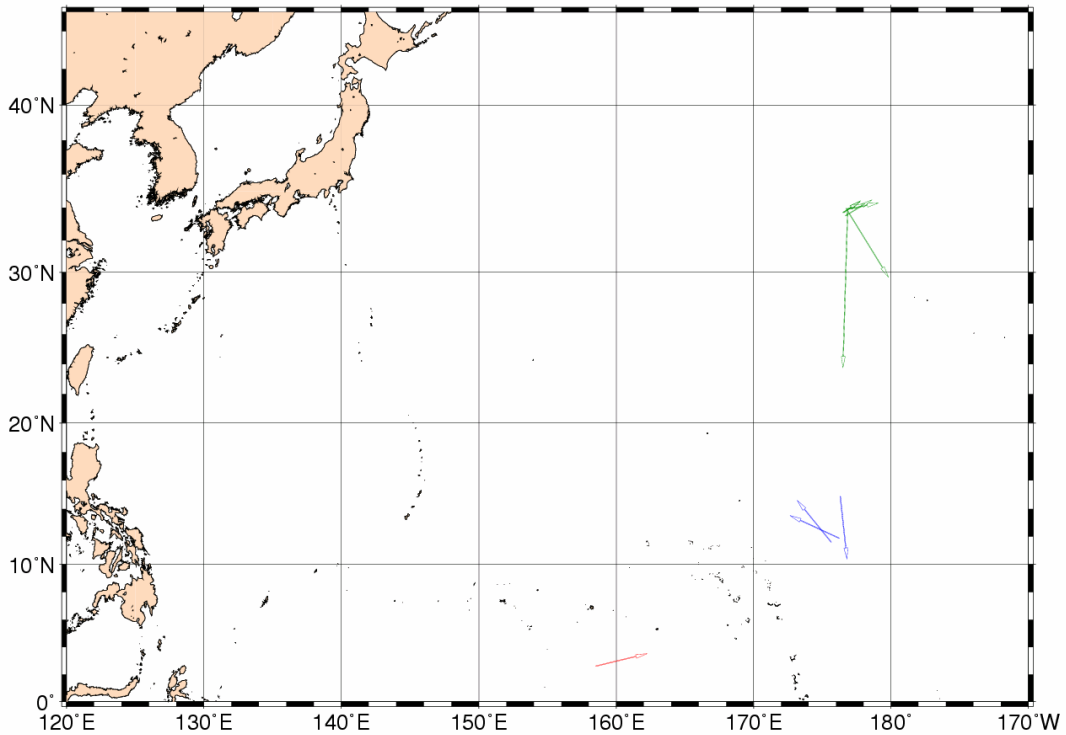


Figure7. Linear movement of bigeye tuna released with PAT by R/V Syoyo-maru.

Red, green and blue lines denote release in the first(Oct.), second(Oct.-Nov.) and third (Dec.) leg, respectively.

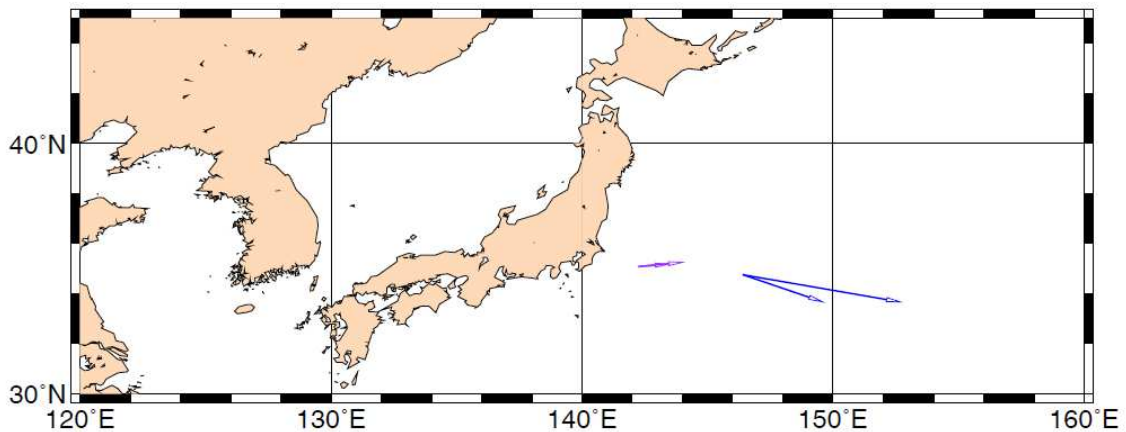


Figure8. Linear movement of bigeye tuna released with dart tag by pole and line vessel.

Blue and purple lines denote release in June 2006 and June 2007, respectively.