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Historical developments of fishing devices in Japanese pole-and-line fishery

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Executive summary

This document provides the information on historical improvements of fishing devices in Japanese pole-and-line (JPPL) vessels. JPPL vessels currently utilize mainly 5 fishing devices (bait tank, sonar, NOAA meteorological satellite image receiver (NOAA receiver), and two types of bird radar) that are necessary for improving survival of live baits and searching and harvesting schools. Their installment has begun in the late 1970s to early 1980s depending on the devices, and the number of installed vessels has increased with the time. The effects of the device installment and developments of each device through install periods are discussed.

Introduction

The operation of Japanese pole-and-line (JPPL) fishery targeting skipjack tuna (Katsuwonus pelamis) has been developed over time with historical advances of fishing devices and the accumulation of fishery knowledge, etc. Such installment of the devices and subsequent updates of these (i.e., quality/resolution/power) through years would certainly affect the fishing efficiency via the several processes of the JPPL operation (searching, chasing and catching of skipjack). However, device information has not been collected as actual numbers in a form of logbook. Though we have limited information regarding fishing devices such as quality of devices or how equipment updates actually affect the operations, historic changes in installing certain equipment would be an useful indicator to infer the beginning year of the effort creep. Shono and Ogura (1999) collected the device installment information for the distant-water (DW) PL fishery by the questionary survey. Their work is the only information available so far to find a clue to estimate the effort creep the fisheries experienced. Other than that, there are also some components affecting the fishing efficiency in addition to the fishing devices such as changes in tackle, hiring foreign fishermen who are physically advantaged, and fishing master's accumulated experience, etc. For future designing of questionary research, it is worth documenting the potential candidates of the effort creep other than devices though no data available currently.

In this document, we first described the whole process of the JPPL operation with important components which could be potential candidates of effort creep. Subsequently, we specified the beginning when potential effort creep occurred based on the installment information of devices. Finally, we evaluated the installment effect of fishing devices on CPUE for DWPL by running a GLM.

Data and Methods

Overview of the Japanese pole-and-line fishery

Overall process of the JPPL operation from departure to landing and important component for the process were shown in Figure. 1 as a relationship diagram. The first process after departure is to load live baits (sardine or anchovy). Subsequently, fishing master roughly decides the fishery grounds by referring various types of environmental data via satellite (SST, chlorophyl concentration, mid water temperature, sea water current, and weather forecast), catch information from other vessels (fishermen shares the fishery information among vessels via the radio receiver), and their accumulated experiences (Searching process in Figure 1). While approaching targeting point of the fishery grounds, they utilize several devices (bird radar, sonar, and fish finder) to search for schools of birds and skipjack. Bird radars enable fishermen to select proper skipjack schools for fishing based on bird locations and size of flocks. In the process of searching, crew also search for the skipjack school and distinguish the types of the school by using binoculars. The searching efficiency also depends on the types of school (free school or associated with animals or logs) and their activeness (feeding prey/jumping on the surface/swimming fast), and the condition of the sea surface and weather, and visual and physical ability of the crews. As the fishing master decide which school to chase (Chasing process in figure 1), the vessel approaches to the school as fast as it can while confirming the direction of the school by utilizing sonar, fish finder, and binoculars. As the sound of vessel engine scares the school away, the fishing master slow down the vessel so it can approach to the school as quiet as possible. Then, fishermen start to throw live baits and splashing water on the surface to keep the skipjack around the vessel (Catching process in figure 1). During catching process, the fishing master has to keep the best position for catching skipjack, so he makes fine adjustment of the vessel position by using sonar and fish finder. The catching efficiency also depends on ability of crews and number of poles and tackles. The end of the operation occurs when the tank is full, or fuel/live bait/food is running out, or depending on market price and the vessel heads toward the port for landing. These are the typical flow of the JPPL operation. It should be noted that some of the important component has updated over time. For example, devices are replaced to the higher quality/resolution/power ones, which provide detailed and precise information to fishermen. Sharing information among vessels used to be conducted by telephone, radio receiver, and fax, but the communication tools have been changing to smartphone due to the advance of communication networks (wifi is now available on many vessels). Easy access to the fishermen's data network allows fishermen to utilize wider range of data for searching fishery grounds. In addition, hiring the foreign crews also improves the searching and fishing efficiency, as they usually physically advantaged. Such components are not reported as a form of data, but certainly worth exploring via questionary survey as potential indicators for the effort creep. In the following sections, only the installment information of the devices among factors mentioned above was selected to see the effect on the fishing efficiency through years.

<u>Device data</u>

As for fishing device data, the information of DW vessels described in Shono and Ogura (1999) were used. There were mainly five technological developments for JPPL devices, (1)the low temperature live bait tank , (2)onboard NOAA meteorological satellite image receiver (NOAA receiver), (3)first and (4)second generation bird radar, and (5)sonar. Device data were composed by each vessel name, status of each fishing device installment, and year.

<u>Fisheries data</u>

From Japanese logbook data, the operational level of catch and effort data of JPPL from 1972 -2020 were used as fishery data. JPPL has three types of vessel size in gross register tonnage (GRT), coastal (under 20 GRT), offshore (from 20 to 200 GRT), and distant-water (over 200 GRT) (Ogura and Shono, 1999). Fisheries data of DW were combined with device data based on vessel ID as described in Kinoshita et al (2019).

<u>Analysis of CPUE</u>

To verify the impact of development of fishing devices on effort, standardized CPUE of DW vessels were calculated by previous methods (Kinoshita et al., 2019). The formula of delta-GLM model was as following,

Model with device effect

(1) ZERO = YearQtr + VesselID + LatLong + NumPoles + Bait Tank + Sonar + NOAA+ Bird radar 1 + Bird radar 2 + Error

(2) CPUE = YearQtr + VesselID + LatLong + NumPoles + Bait Tank + Sonar + NOAA+ Bird radar 1 + Bird radar 2 + Error

Model without device effect

(1) ZERO = YearQtr + VesselID + LatLong + NumPoles + Error

(2) CPUE = YearQtr + VesselID + LatLong + NumPoles + Error

Standardized CPUE were generated by using INLA package in R software (version 4.1.2). In the delta-GLM model, the proportion of non-zero skipjack catch was standardized using binomial error structure to estimate probability of non-zero skipjack catch as the first formula. In the second formula, CPUE was standardized by logit function. Final standardized CPUE were calculated by multiplying the first and second formula. Fisheries data were screened by previous methods as follows (Kinoshita et al., 2019).

Filter 1. Remove data NOT included in any defined region

Filter 2. Remove data of a cruise where the proportion of skipjack catch during a cruise was less than 75% of the combined catch of skipjack and albacore

Filter 3. Remove data of a cruise that lasted less than five days

Filter 4. Remove data of a vessel that had operated for less than 5 years and less than 10

days per year

Filter 5. Remove data of a vessel that had no vessel IDs assigned in and after 1987, when fishing license numbers changed substantially

Due to confirming the impact of fishing devices on effort, Standardized CPUE with varying effort were also analyzed. The varying effort were calculated by raising to the power of effort (+ 0.025, 0.050 and 0.075%) as effort creep *K* in each quarter from 1980 to 2020. Standardized CPUE with varying effort were calculated by multiplying standardized CPUE without device effects and each effort/varying effort.

$$\text{varying effort}_t = \text{effort}_t * K^t$$

$$\text{CPUE}_{\text{with varting effort}} = \text{CPUE}_{\text{without device effects}} * \frac{\text{effort}_t}{\text{varying effortt}_t}$$

t ; time step in each quarter from 1980 to 2020

K; effort creep (1.00025, 1.00050, 1.00075)

Results and Discussion

Historical change of fishing devices installed in each vessel are shown in **Figure 2** and **Figure 3**. The proportion of bait tank and sonar installed on the JPPL vessels were increased from 1981 to 1990s. Also, the proportion of bird radar 1 and NOAA receiver installed on the JPPL vessels were increased from the mid-1980s to 1990s. In contrast, bird radar 2 was the slowest of the fishing devices to be installed from 1990 to 2006 (Figure 3). It is assumed that the proportion of operation days in vessels installed each device was decreased, since the number of vessels were also decreased.

As **Figure 4** shows the probability of non-zero catch rate of skipjack catch with and without fishing device effects. Non-zero catch rate with and without device effects shows similar trends. Non-zero catch rate with device effects were slightly lower than non-zero catch rate without device effects after 1990s.

Standardized CPUE with and without fishing device effects were shown in **Figure 5**. CPUE without fishing devices are slightly lower than CPUE with device effects from the mid-1980s to the early 1990s and 1.04-1.10 times higher than CPUE with device effects after 1990s (Figure 5). On the other hand, CPUE without device effects were lower than with device effect around the 1980s. It is assumed that some other factors which not considered in standardization influenced to the lower CPUE.

As shown in **Figure 6**, Standardized CPUE with and without fishing device effects and with varying effort showed similar trend. Especially, CPUE with varying effort 0.1 and 0.2% are basically fluctuated between standardized CPUE with and without fishing device effects.

Summary of this documents are as following,

- The targeted five types of fishing devices (bait tank, sonar, NOAA, and bird radar) for DW JPPL were installed from 1981 to 2006.
- Note that we assumed that effort creep from 1981 to 2020 had occurred, although the data on technical improvement of fishing devices were not available at this point.
- CPUE without device effects are 1.04-1.10 times higher than CPUE with device effects after the 1990s.
- As a result of the comparison between CPUE with and without fishing device efforts and CPUE with varying effort, at least 0.2% increase of fishing effort was estimated after installing five fishing devices.
- In future studies, analysis of the effects of other factors such as technical improvement of fishing devices or fishing master’s experience will be required,

therefore surveys for collecting those data should be conducted.

- In this document, we assumed that effort creep occurred each quarter from 1981 to 2020. Further analysis of standardized CPUE with effort creep occurring annually, quarterly, or rapidly and temporarily will be useful for implementation of sensitivity analysis considered effort creep.
- The method for evaluating the effort creep should be considered, although this document provided the provisional result for the effect of effort creep by comparing standardized CPUE.

References

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Shono, H. and Ogura, M. (2000) The standardized skipjack CPUE, including the effect of searching devices, of the Japanese distant water pole and line fishery in the western central pacific ocean. ICCAT SCRS/1999/059.

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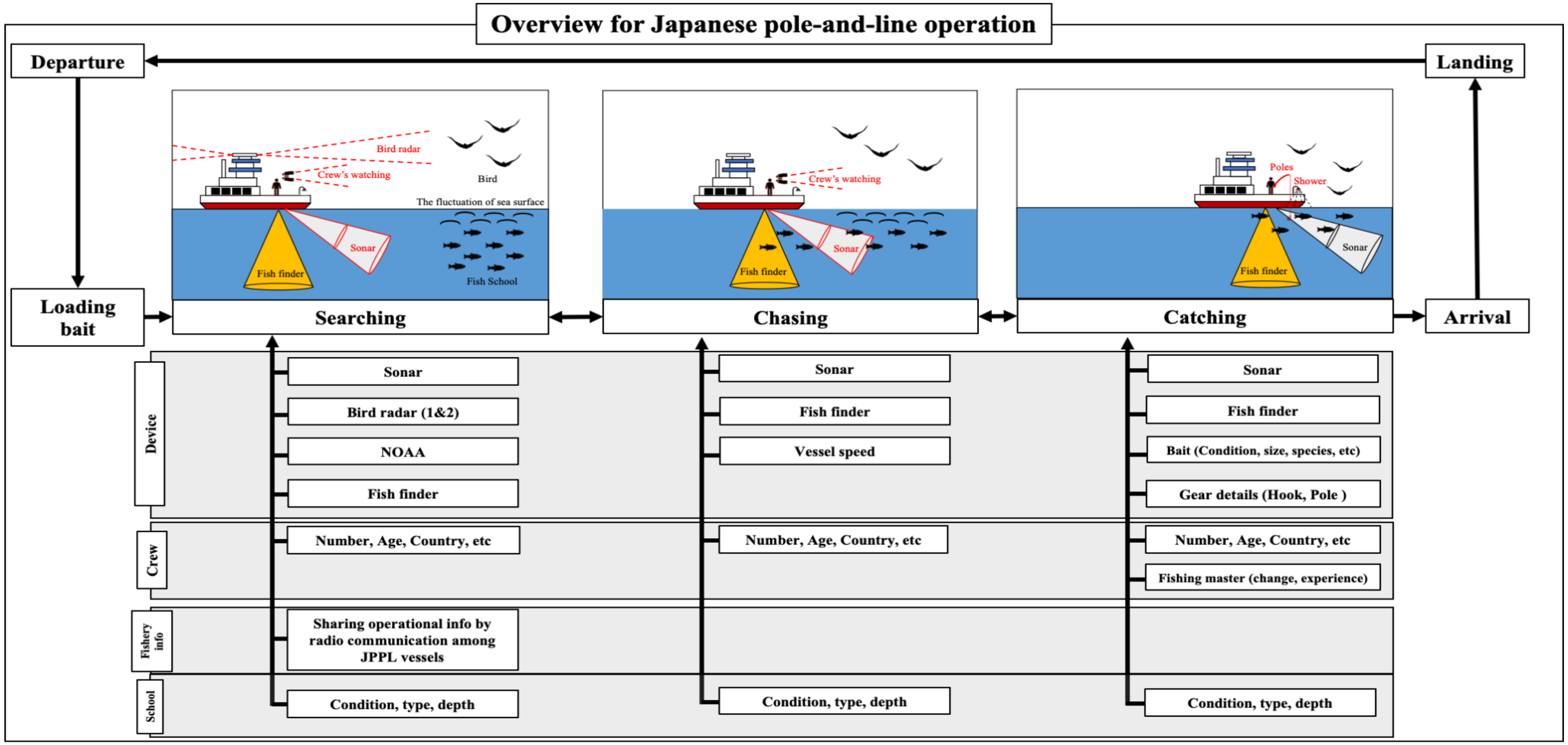

Figure 1 The overview for Japanese pole-and-line (JPPL) operation. JPPL operation is mainly composed of three processes, "Searching", "Chasing", and "Catching". Searching; fishermen of JPPL search for seabirds or water fluctuation on sea surface with binoculars, sonar, and bird radar. Chasing; JPPL vessel chase the Skipjack school watching the movement of seabirds and the school with binoculars and sonar. Catching; fishermen catch the skipjack by poles attached short-line and barbless hook, feeding live baits and showering by sea water. These processes are influenced by many effects such as fishing device, crews for JPPL, the skipjack school condition, and fishery information (such as the amount of catch, the location of catch, size composition, SST, etc) shared with other vessels by radio communication. Red character means the particularly important factor for each process of the operation.

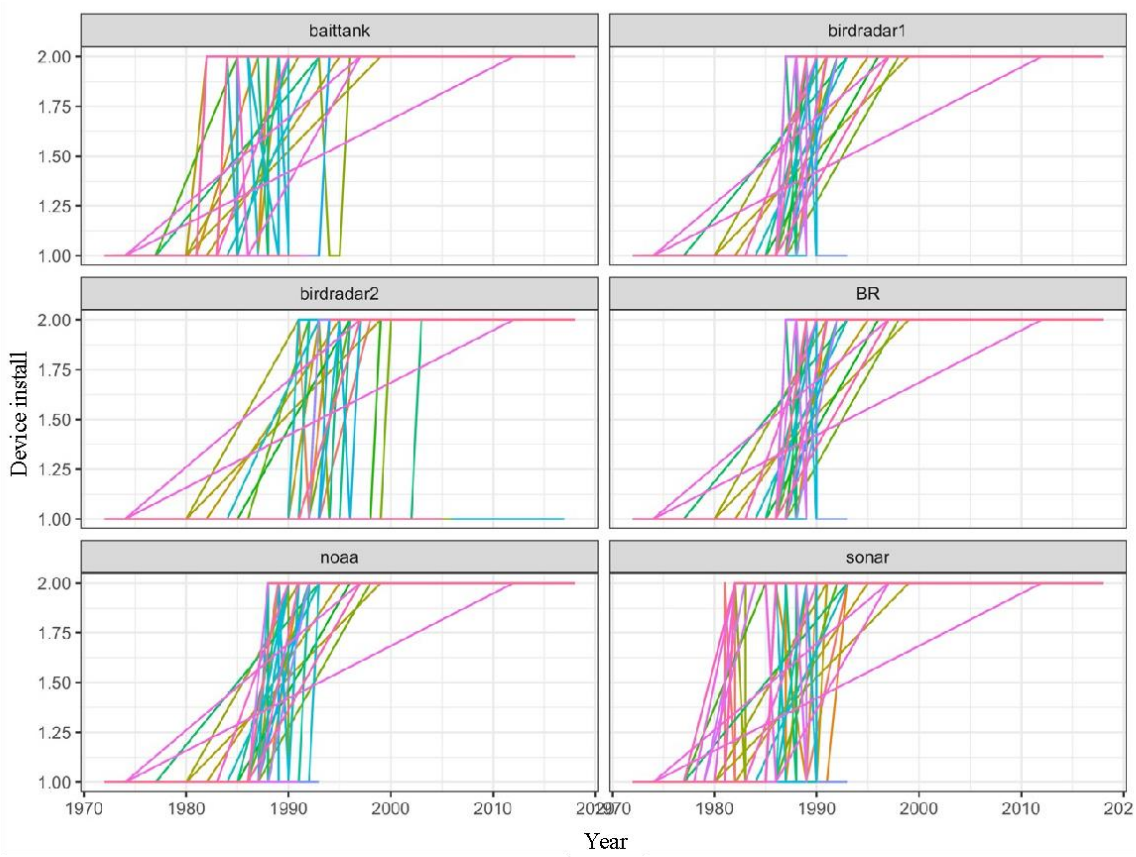

Figure 2 Annual shifting fishing devices installment in each vessel. Device install means that 1 is not installed the fishing device and 2 is installed the device. Bait tank is for keeping live baits in low temperature due to improve survival rate. Bird radar 1 and 2 are radars to search for seabirds around 15 miles and 25 miles. BR means status which installed bird radar 1 or 2 to vessels. NOAA shows the sea surface temperature to search for fishery grounds. Sonar is used for searching for fishes diving around vessels.

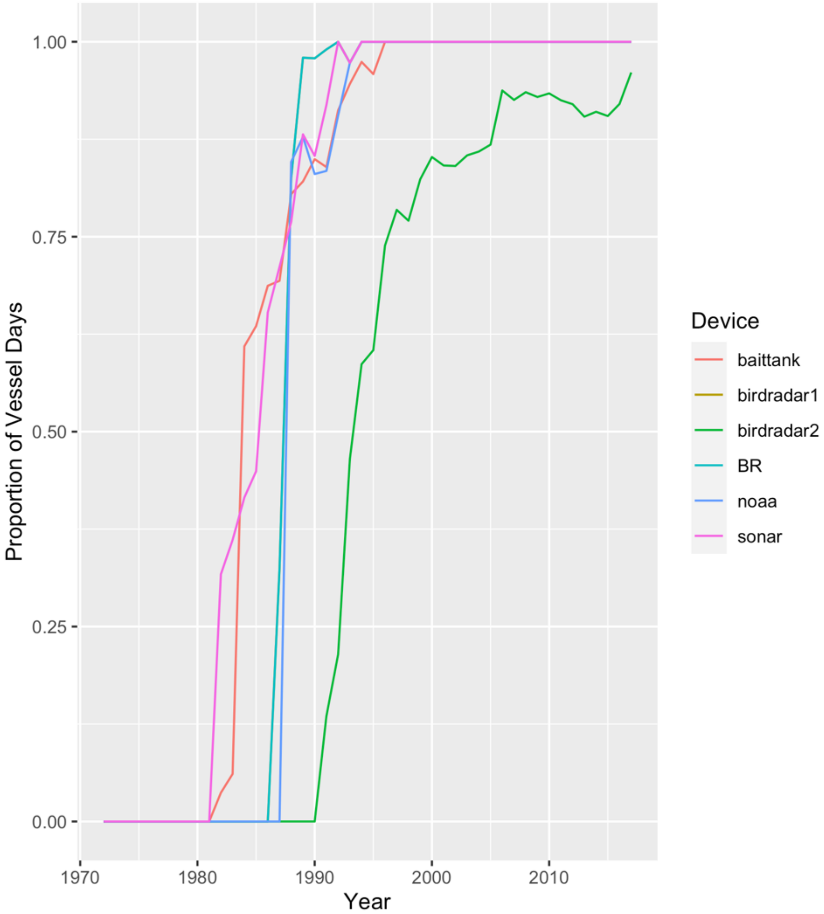

Figure 3 The proportion of vessel days installed each device in each year. Proportion of vessel days means that total operation days of vessels installed each fishing device divided by total operation days of all vessels.

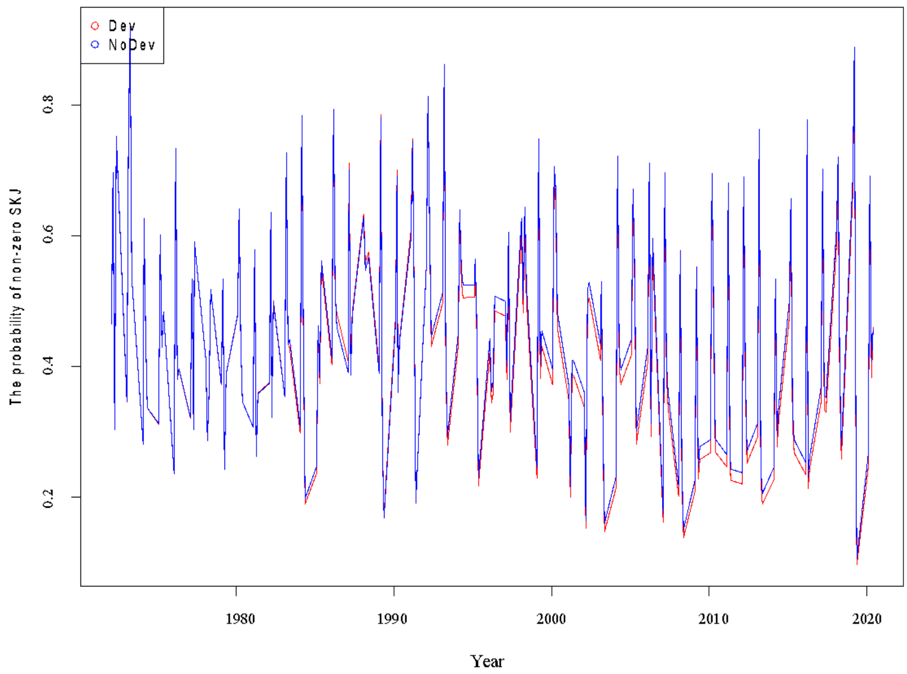

Figure 4 The quarterly probability of non-zero SKJ catch for standardized CPUE with and without device effect.

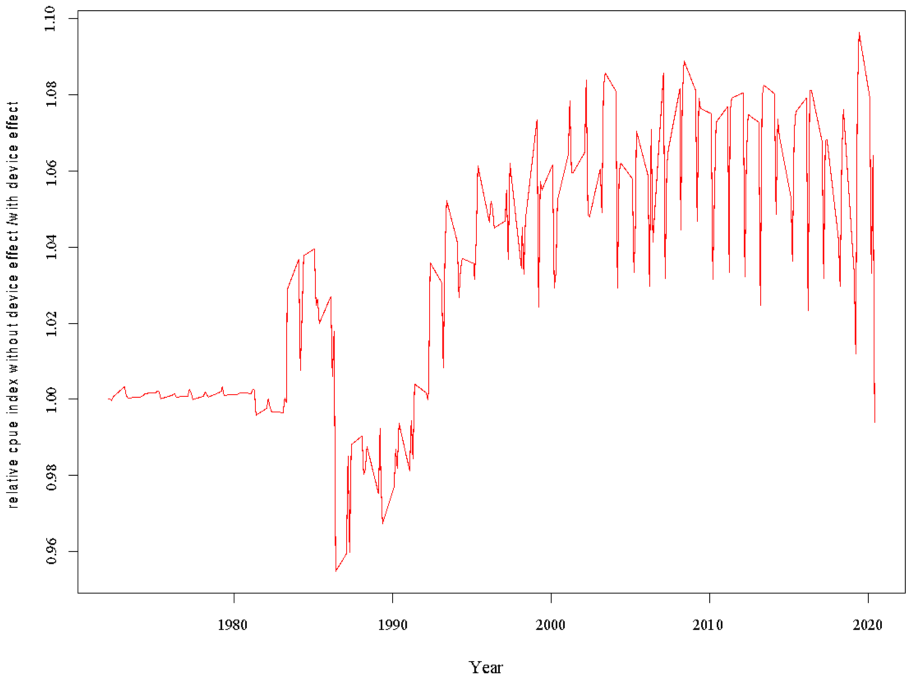

Figure 5 Comparison between relative CPUE index with and without device effect.

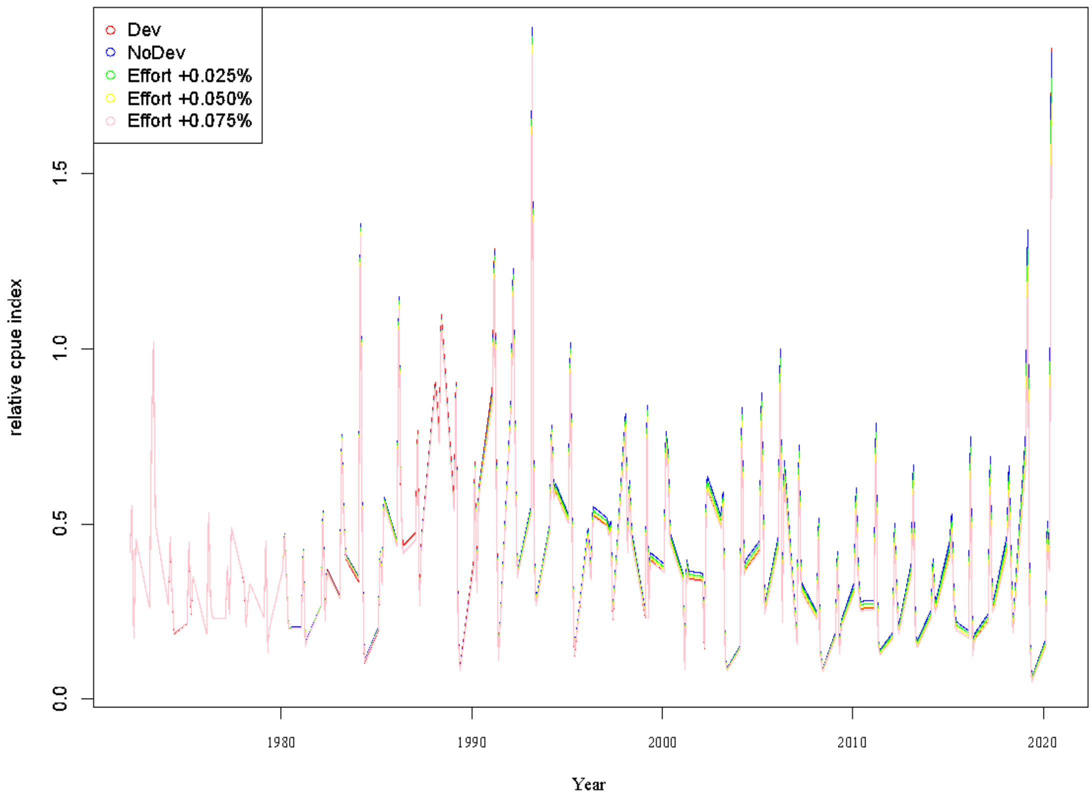

Figure 6 Comparison between standardized CPUE and CPUE with increased effort (+ 0.025, 0.050 and 0.075% in each quarter from 1980 to 2020).