

## **Ecosystem modeling in the western North Pacific using Ecopath, with a focus on small pelagic fishes**

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### **SUPPLEMENT OUTLINE**

**Supplement 1.** Details of basic input parameters and appropriate references for the western North Pacific Ecopath model, focusing on ecosystem-based management of small pelagic fishes.

**Supplement 2.** Definitions and results of pedigree for the western North Pacific Ecopath model, based on: Gaichas et al. (2015).

**Supplement 3.** Results of pre-balance diagnostics (PREBAL) for the western North Pacific Ecopath model, based on: Link (2010).

**Supplement 4.** Mixed trophic impact (MTI) relationships between species/groups in the western North Pacific in 2013.

### **SUPPLEMENT 1.**

#### **Details of basic input parameters and appropriate references for the western North Pacific Ecopath model, focusing on ecosystem-based management of small pelagic fishes.**

##### **1. BALEEN WHALES**

###### Species

Included in the group are: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), Bryde's whale (*Balaenoptera edeni* [in the sense of the International Whaling Commission]), common minke whale (*Balaenoptera acutorostrata*), and humpback whale (*Megaptera novaeangliae*).

###### Distribution blocks

It is assumed that the species are distributed in the coastal Oyashio (OYC) and offshore (OF) blocks.

###### Biomass (B)

Biomass of each baleen whale species was calculated using the latest abundance estimates in the survey areas (Hakamada & Matsuoka 2016a, b) and mean body weights estimated by Trites & Pauly (1998) and Tamura et al. (2016).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the value was used as the P/B of baleen whales. Each natural mortality coefficient was estimated by the calculation method described in Ohsumi (1979) and by IWC (2008, 2014). Fishing mortality coefficient in 2013 was calculated using catch statistics.

Pedigree rank: 3, Data is proxy.

Consumption/biomass ratio (Q/B)

Mean (weighted by biomass) of the value was used as the Q/B of baleen whale. Each Q/B value was estimated by the calculation method described in Tamura et al. (2016).

Pedigree rank: 3, Data is proxy.

Diet compositions

The diet compositions described by Tamura et al. (2016) are used for sei, Bryde's and common minke whales. The standardized diet compositions for the rest of species described in Pauly et al. (1998) were used as the basic information. Specific diet compositions based on the information are then assigned based on the authors' expert knowledge. The mean of compositions were calculated taking biomass as weight.

Pedigree rank: 3, Data is proxy.

Catch

Catch data of sei, Bryde's and common minke whales in the surveys are used. The above-mentioned mean body weights are used to calculate catch biomass.

Pedigree rank: 1, Data is established and substantial.

## 2. TOOTHED WHALES

Species

Included in the group are: sperm whale (*Physeter macrocephalus*), killer whale (*Orcinus orca*), Dall's porpoise (*Phocoenoides dalli*), Baird's beaked whale (*Berardius bairdii*), large-sized dolphins [comprising: common bottlenose dolphin *Tursiops truncatus*, Risso's dolphin *Grampus griseus*, false killer whale *Pseudorca crassidens*, short-finned pilot whale *Globicephala macrorhynchus*, and melon-headed whale *Peponocephala electra*], small-sized dolphins [comprising: rough-toothed dolphin *Steno bredanensis*, spinner dolphin *Stenella longirostris*, pantropical spotted dolphin *Stenella attenuata*, striped dolphin *Stenella coeruleoalba*, *Delphinus* spp., and Pacific white-sided dolphin *Lagenorhynchus obliquidens*], and species of Ziphiidae (beaked whales, apart from Baird's beaked whale).

Distribution blocks

It is assumed that this group is distributed in all blocks.

Biomass (B)

Biomass of each toothed whale species was calculated using the latest abundance estimates for the area, as described in Okamura et al. (2012), Hakamada & Matsuoka (2016c), and Kanaji et al. (2017). Mean body weight of each toothed whale species was taken from Trites & Pauly (1998).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the value was used as the P/B of toothed whales. Each natural mortality coefficient was estimated by the calculation method described by IWC (1983) and in Ohsumi (1979). Fishing mortality coefficient in 2013 was calculated using biomass and catch data. Catch in 2013 was derived from the Fisheries Agency and Fisheries Research Agency of Japan (2015a).

Pedigree rank: 5, Estimation based on same species but in different time period.

Consumption/biomass ratio (Q/B)

Mean (weighted by biomass) of the value was used as the Q/B of toothed whales. Each Q/B value was estimated by the calculation method described in Tamura et al. (2016), but it is assumed that the species of toothed whales (except for sperm whale) remain in the modelled area for 180 days.

Pedigree rank: 5, Estimation based on same species but in different time period.

Diet compositions

The standardized diet compositions described in Pauly et al. (1998) are used as the basic information. The mean of compositions were calculated taking biomass as weight. Specific diet compositions are assigned based on published qualitative information summarized in Ohizumi (2008).

Pedigree rank: 7, General literature review from wide range of species and outside of region.

Catch

Catch in 2013 was derived from the Fisheries Agency and Fisheries Research Agency of Japan (2015a).

Pedigree rank: 1, Data is established and substantial.

### **3. SEABIRDS**

Species

The species included are: black-footed (*Phoebastria nigripes*) and Laysan (*Phoebastria immutabilis*) albatrosses; sooty (*Puffinus griseus*), short-tailed (*Puffinus tenuirostris*), Buller's (*Bulweria bulwerii*) and flesh-footed (*Puffinus carneipes*) shearwaters.

Distribution blocks

It is assumed that this group is distributed in all blocks.

Biomass (B)

Biomass of these species as given in Hunt et al. (2000) is used.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors or extrapolation.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value in the Ecopath model for the central Gulf of Alaska, as described in Ruzicka et al. (2013), is used, as no such value for our modelled area is available.

Pedigree rank: 6, General life-history proxies.

Consumption/biomass ratio (Q/B)

Consumption of these species as reported in Hunt et al. (2000) is divided by the biomass.

Pedigree rank: 5, Estimation based on same species but in outside of region.

Diet compositions

Diet compositions of these species as given in Hunt et al. (2000) is used as the basic information.

Pedigree rank: 7, General literature review from wide range of species and outside of region.

Catch

There were no catches in 2013.

#### **4. SHARKS**

Species

Assumed in the group are: blue shark (*Prionace glauca*) and mesopelagic sharks, such as spiny dogfish (*Squalus suckleyi*).

Distribution blocks

It is assumed that the species are distributed in all blocks.

Biomass (B)

Biomass is estimated using the values reported by ISC (2014a) and in Yonezaki et al. (2016).

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the value was used as the P/B of sharks, as reported by ISC (2014a) and in Yonezaki et al. (2016).

Pedigree rank: 4, Direct estimate with incomplete coverage.

Consumption/biomass ratio (Q/B)

Mean (weighted by biomass) of the value was used as the Q/B of sharks, as reported in Cox et al. (2002) and Yonezaki et al. (2016). It is assumed that the blue shark stays in the modelled area for 180 days.

Pedigree rank: 5, Estimation based on same species but in a general model specific to the area.

Diet compositions

Diet compositions given in Yonezaki et al. (2016) are used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 6, Similar species in same region.

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

#### **5. TUNAS**

Species

Included in the group are: bigeye (*Thunnus obesus*), yellowfin (*Thunnus albacares*) and bluefin (*Thunnus orientalis*) tunas, and albacore (*Thunnus alalunga*).

#### Distribution blocks

It is assumed that this group is distributed in all blocks.

#### Biomass (B)

Biomass of bigeye, yellowfin and bluefin tunas and albacore in 2012, as reported by Davies et al. (2014), Harley et al. (2014) and ISC (2014b,c), were scaled to our modelling area.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the values for 2012, as reported by Davies et al. (2014), Harley et al. (2014) and ISC (2014b, c), are used.

Pedigree rank: 5, Estimation based on same species but in different period.

#### Consumption/biomass ratio (Q/B)

Mean (weighted by biomass) of the values reported in Cox et al. (2002), Essington (2003) and Olson & Watters (2003) are used, but it is assumed that the group stays in the modelled area for 180 days.

Pedigree rank: 5, Estimation based on same species but in a general model specific to the area.

#### Diet compositions

Mean (weighted by biomass) diet compositions as given in Olson & Watters (2003) are used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 6, Same species in neighboring region.

#### Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## 6. SKIPJACK

#### Species

One species, skipjack (*Katsuwonus pelamis*), is considered.

#### Distribution blocks

It is assumed that this species is distributed in all blocks.

#### Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.771, as reported in Cox et al. (2002), is used.

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Rice et al. (2014) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The value reported in Essington (2003) is used, but it is assumed that this species stays in the modelled area for 180 days.

Pedigree rank: 5, Estimation based on same species but in a general model specific to the area.

Diet compositions

Diet composition presented in Olson & Watters (2003) is used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 6, Same species in neighboring region.

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **7. MISCELLANEOUS PISCIVORES**

Species

Though no specific target species are considered, various piscivores are categorized in the group, including: swordfish (*Xiphias gladius*), dolphinfish (*Coryphaena hippurus*) and Pacific pomfret (*Brama japonica*).

Distribution blocks

It is assumed that this group is distributed in all blocks.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.62, as reported in Cox et al. (2002) for swordfish and other billfishes, is used.

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The mean of the value for swordfish and other billfishes, as given in Cox et al. (2002), is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The mean of the value for swordfish and other billfishes, as reported in Cox et al. (2002), is used.

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on information in Yokota et al. (1961). Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **8. YELLOWTAIL**

Species

One species, yellowtail (*Seriola quinqueradiata*), is considered.

Distribution blocks

It is assumed that this species is distributed in the KC and OYC blocks.

Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate but with limited coverage.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Mitani (1960). Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) and the Fisheries Agency and Fisheries Research Agency of Japan (2015b) are used.

Pedigree rank: 1, Data is established and substantial.

## **9. JAPANESE SARDINE**

Species

One species, the Japanese sardine (*Sardinops melanostictus*), is considered.

Distribution blocks

It is assumed that this species is distributed in all blocks.

#### Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

#### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

#### Diet compositions

Diet compositions are assigned based on reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period..

#### Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## 10. JAPANESE ANCHOVY

#### Species

One species, the Japanese anchovy (*Engraulis japonicus*), is considered.

#### Distribution blocks

It is assumed that this species is distributed in all blocks.

#### Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

#### Consumption/biomass ratio (Q/B)



The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period..

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## 11. PACIFIC SAURY

Species

One species, Pacific saury (*Cololabis saira*), is considered.

Distribution blocks

It is assumed that this species is distributed in all blocks.

Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2014).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Odate (1977).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) are used, which include catches by Japan, Republic of Korea, Russian Federation and Chinese Taipei.

Pedigree rank: 1, Data is established and substantial.

## 12. CHUB MACKEREL

### Species

One species, chub mackerel (*Scomber japonicus*), is considered.

### Distribution blocks

It is assumed that this species is distributed in all blocks.

### Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

### Diet compositions

Diet compositions are assigned based on reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period.

### Catch

Catch statistics data reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) are used.

Pedigree rank: 1, Data is established and substantial.

## 13. SPOTTED [BLUE] MACKEREL

### Species

One species, spotted [blue] mackerel (*Scomber australasicus*), is considered.

### Distribution blocks

It is assumed that this species is distributed in all blocks.

### Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period..

Catch

Catch statistics data reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) are used.

Pedigree rank: 1, Data is established and substantial.

#### **14. ROUND HERRING IN COASTAL KUROSHIO (KC) BLOCK**

Species

One species, round herring (*Etrumeus teres*), is considered.

Distribution block

It is assumed that this species is distributed in the KC block.

Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

#### **Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])**

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Hirota et al. (2003).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **15. JACK MACKEREL**

Species

One species, jack mackerel (*Trachurus japonicus*), is considered.

Distribution blocks

It is assumed that this species is distributed in the KC and OYC blocks.

Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Kawasaki (1959).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) are used.

Pedigree rank: 1, Data is established and substantial.

## **16. RIGHTEYE FLOUNDERS IN COASTAL OYASHIO (OYC) BLOCK**

Species

Included in the group are species belonging to the Pleuronectidae (righteye flounders) and the bastard halibut (*Paralichthys olivaceus*).

Distribution block

It is assumed that this group is distributed in the OYC block.

Biomass (B)

Biomass is calculated using the amount of the catch of the group and the catch rate of Pacific cod, as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 3, Data is proxy, proxy may have known but consistent bias.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean values for willow flounder (*Tanakius kitaharai*) and bastard halibut (*Paralichthys olivaceus*), as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b), are used.

Pedigree rank: 3, Data is proxy.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions of flounders, as described in Yonezaki et al. (2016) and based on the work of Mikawa (1953, 1955), Hashimoto et al. (1982), Yokoyama et al. (1994), Yamamura (1994) and Honda et al. (2000), were used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period..

Catch

Catch statistics data are as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015).

Pedigree rank: 1, Data is established and substantial.

## **17. WALLEYE POLLOCK IN COASTAL OYASHIO (OYC) BLOCK**

Species

One species, walleye pollock (*Gadus chalcogrammus*), is considered.

Distribution block

It is assumed that this species is distributed in the OYC block.

Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

## Diet composition

Diet composition for walleye pollock, as described in Yonezaki et al. (2016) and based on the work of Hashimoto et al. (1982), Yamamura (1994) and Takatsu et al. (1995, 2002), is used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

## Catch

Catch statistics data reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **18. PACIFIC COD IN COASTAL OYASHIO (OYC) BLOCK**

### Species

One species, Pacific cod (*Gadus macrocephalus*), is considered.

### Distribution block

It is assumed that this species is distributed in the OYC block.

### Biomass (B)

Biomass in 2013 is as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 2, Data is direct estimate while sub-regional resolution is poor.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

### Diet compositions

Diet composition for Pacific cod, as described in Yonezaki et al. (2016) and based on Hashimoto et al. (1982) and Yamamura (1994), is used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

## Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **19. MISCELLANEOUS BOTTOM FISHES IN COASTAL OYASHIO (OYC) BLOCK**

### Species

Included in the group are bottom fishes in the OYC block, as described in Yonezaki et al. (2016), other than righteye flounders, Pacific cod and walleye pollock.

Distribution block

It is assumed that this group is distributed in the OYC block.

Biomass (B)

Biomass is calculated using the amount of the catch of the group and the catch rate of broadbanded thornyhead (*Sebastes macrochir*) of northern Pacific stocks, as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 3, Data is proxy, proxy may have known but consistent bias.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The same value as for Pacific cod (above) is assumed.

Pedigree rank: 4, Proxy with limited confidence.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Honda et al. (2000).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **20. FLATFISHES IN COASTAL KUROSHIO (KC) BLOCK**

Species

Included in the group are species belonging to the Pleuronectidae (righteye flounders) and the bastard halibut (*Paralichthys olivaceus*) distributed in the KC block.

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.95 is assumed for highly exploited by fisheries in this area.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the values for bastard halibut of central and south Pacific stocks, as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b), is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **21. SEABREAMS**

Species

Seabreams and seabream-like species (e.g. red seabream *Pagrus major*) are included in the group.

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Biomass is calculated using the amount of the catch of the group and the catch rate of red seabream of central Pacific and south Pacific stocks, as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 3, Data is proxy, proxy may have known but consistent bias.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean (weighted by biomass) of the values for red seabream of central and south Pacific stocks as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b) is used.

Pedigree rank: 2, Data is direct estimate but sub-regional resolution is poor.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions



Diet compositions are assigned based on Shimamoto (1999) and reports by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **22. DEMERSAL PISCIVORES IN COASTAL KUROSHIO (KC) BLOCK**

Species

Included in the group are demersal piscivores distributed in the KC block and recorded in catch statistics of offshore bottom-trawl fisheries, including: daggertooth pike conger (*Muraenesox cinereus*), barracuda (*Sphyraena pinguis*) and hairtail (*Trichiurus japonicus*).

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.95 is assumed for highly exploited by fisheries in this area, as used in Doiuchi et al. (2013) and Tokumitsu et al. (2013).

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Mean values for daggertooth pike conger and hairtail, as reported in Doiuchi et al. (2013), Tokumitsu et al. (2013) and Watari et al. (2014), are used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions are assigned based on Hayashi & Yamaguchi (1960) and Doiuchi et al. (2012). Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **23. MISCELLANEOUS BOTTOM FISHES IN COASTAL KUROSHIO (KC) BLOCK**

### Species

Included in the group are miscellaneous bottom fishes (i.e. other than flatfishes, seabreams and demersal piscivores) distributed in the KC block and recorded in catch statistics of offshore bottom-trawl fisheries.

### Distribution block

It is assumed that this group is distributed in the KC block.

### Biomass (B)

Biomass is calculated using the amount of the catch of the group and the catch rate for miscellaneous bottom fishes in the OYC block, as reported by the Fisheries Agency and Fisheries Research Agency of Japan (2015b).

Pedigree rank: 3, Data is proxy, proxy may have known but consistent bias.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The same value as for demersal piscivores in the KC block (above) is assumed.

Pedigree rank: 4, Proxy with limited confidence.

### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

### Diet compositions

Diet compositions are assigned based on Honda et al. (2000).

Pedigree rank: 5, Estimation based on same species but in different time period.

### Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **24. MESOPELAGIC FISHES IN COASTAL OYASHIO (OYC) BLOCK**

### Species

Though no specific target species are considered, various myctophids (lanternfishes) are assumed to be categorized in the group.

### Distribution block

It is assumed that this group is distributed in the OYC block.

### Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.90 is used, based Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.25 for this species, based on Christensen et al. (2005) and Yonezaki et al. (2016).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions of mesopelagic fishes, as given in Yonezaki et al. (2016), are used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

No catches are assumed for this group.

## **25. MESOPELAGIC FISHES IN COASTAL KUROSHIO (KC) BLOCK**

Species

Though no specific target species are considered, various myctophids (lanternfishes) are assumed to be categorized in the group.

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.90 is used, based on Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 6, General life-history proxies.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.25, based on Christensen et al. (2005) and Yonezaki et al. (2016).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions of mesopelagic fishes, as described in Yonezaki et al. (2016), are used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data are as reported for offshore bottom-trawl fisheries by the Fisheries Research Agency (2015).

Pedigree rank: 1, Data is established and substantial.

## **26. MESOPELAGIC FISHES IN OFFSHORE (OF) BLOCK**

### Species

Though no specific target species are considered, various myctophids (lanternfishes) are assumed to be categorized in the group.

### Distribution block

It is assumed that this group is distributed in the OF block.

### Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.90 is used, based on Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) 0.25, based on Christensen et al. (2005) and Yonezaki et al. (2016).

Pedigree rank: 6, General life-history proxies.

### Diet compositions

Diet compositions of mesopelagic fishes, described in Yonezaki et al. (2016), are used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

### Catch

No catches are assumed for this group.

## **27. EPIPELAGIC CEPHALOPODS**

### Species

Though no specific target species are considered, epipelagic squids, such as Japanese flying squid (*Todarodes pacificus*) and spear squid (*Heterololigo bleekeri*), are assumed to be categorized in the group.

### Distribution blocks

It is assumed that this group is distributed in all blocks.

### Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.95 is used, based on Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The values reported in Aydin et al. (2003) and Murata & Shimazu (1982) are used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The value reported in Brodeur et al. (1999) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Diet compositions

Mean diet compositions for Japanese flying squid and spear squid, described in Yonezaki et al. (2016), are used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **28. MESOPELAGIC CEPHALOPODS**

Species

Various mesopelagic cephalopods are assumed to be categorized in the group.

Distribution blocks

It is assumed that this group is distributed in all blocks.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.95 is used, based on Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Mean diet compositions for mesopelagic cephalopods, described in Yonezaki et al. (2016), are used as the basic information. Diet composition is adjusted to achieve thermodynamic balance in the model from original one.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

No catches are assumed for this group.

## **29. BENTHOS IN COASTAL OYASHIO (OYC) BLOCK**

Species

Though no specific target species are considered, crabs, shrimps and other macrobenthos distributed in the OYC block are assumed to be categorized in the group.

Distribution block

It is assumed that this group is distributed in the OYC block.

Biomass (B)

Biomass is estimated by Ecopath. To estimate biomass, an ecotrophic efficiency (EE) value of 0.90 is used, based on Yonezaki et al. (2016).

Pedigree rank: 8, Estimated by Ecopath.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The values and information reported in Fujita (1988), Kojima & Ohta (1989), and Tumbiolo & Downing (1994) are used.

Pedigree rank: 6, General life-history proxies.

Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

Diet compositions

Diet compositions of macrobenthos, as described by Yonezaki et al. (2016) and based on Fujita (1988), are used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **30. BENTHOS IN COASTAL KUROSHIO (KC) BLOCK**

Species

Though no specific target species are considered, shrimps and other macrobenthos distributed in the KC block are assumed to be categorized in the group.

#### Distribution block

It is assumed that this group is distributed in the KC block.

#### Biomass (B)

The value reported in Tamai & Nagata (1977) is used.

Pedigree rank: 4, Direct estimate or proxy with incomplete coverage.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The values reported in Tanaka and Kikuchi (1970, 1972) and Tanaka et al. (1973) are used.

Pedigree rank: 6, General life-history proxies.

#### Consumption/biomass ratio (Q/B)

The value of Q/B is calculated assuming a production and consumption ratio (P/Q) of 0.3 for the species, based on Christensen et al. (2005).

Pedigree rank: 6, General life-history proxies.

#### Diet compositions

Diet compositions of macrobenthos, as described in Yonezaki et al. (2016) and based on Fujita (1988), are used as the basic information.

Pedigree rank: 5, Estimation based on same species but in different time period.

#### Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

### **31. KRILL IN COASTAL OYASHIO (OYC) BLOCK**

#### Species

Species of Euphausiidae (krill) are assumed to be categorized in the group.

#### Distribution block

It is assumed that this group is distributed in the OYC block.

#### Biomass (B)

Mean biomass in the OYC block as estimated by Murase et al. (2007) is used, but due to the limitations of coverage by acoustic surveys, the mean biomass estimate is doubled here.

Pedigree rank: 2, Data is direct estimate but with limited coverage.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Aydin et al. (2003) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

#### Consumption/biomass ratio (Q/B)

The value reported in Aydin et al. (2003) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

### Diet compositions

Diet compositions given in Yonezaki et al. (2016) and based on Nakagawa et al. (2001) and Taki et al. (2002) are used.

Pedigree rank: 4, Direct estimate with incomplete coverage.

### Catch

Catch statistics data as reported by the Ministry of Agriculture, Forestry and Fisheries of Japan (2015) are used.

Pedigree rank: 1, Data is established and substantial.

## **32. KRILL IN OFFSHORE (OF) BLOCK**

### Species

Species of Euphausiidae (krill) are assumed to be categorized in the group.

### Distribution block

It is assumed that this group is distributed in the OF block.

### Biomass (B)

Mean biomass in the OF block as estimated by Murase et al. (2007) is used, but due to the limitations of coverage by acoustic surveys, the mean biomass estimate is doubled here.

Pedigree rank: 2, Data is direct estimate but with limited coverage.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Aydin et al. (2003) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

### Consumption/biomass ratio (Q/B)

The value reported in Aydin et al. (2003) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

### Diet compositions

Diet compositions described in Yonezaki et al. (2016) and based on Nakagawa et al. (2001) and Taki et al. (2002) are used.

Pedigree rank: 4, Direct estimate with incomplete coverage.

### Catch

No catches are assumed for this group.

## **33. ZOOPLANKTON IN COASTAL OYASHIO (OYC) BLOCK**

### Species

Though no specific target species are considered, various plankton groups distributed in the OYC block, such as copepods and chaetognaths (arrow worms), are assumed to be categorized in the group.

### Distribution block

It is assumed that this group is distributed in the OYC block.



## Biomass (B)

Mean biomass in 2013 was calculated using data of NORPAC (North Pacific standard net), from egg and larval surveys off the Pacific coast of Japan (Takasuka et al. 2008), and the values in Ikeda et al. (2008).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

## Consumption/biomass ratio (Q/B)

The assumed production and consumption ratio (P/Q) is 0.3, based on Ikeda & Motoda (1978) and Christensen et al. (2005).

Pedigree rank: 5, Estimation based on same species but in different period.

## Diet compositions

Prey–predation relationships for this functional group was obtained from the work of Ikeda et al. (2008).

Pedigree rank: 4, Direct estimate with incomplete coverage.

## Catch

No catches are assumed for this group.

## **34. ZOOPLANKTON IN COASTAL KUROSHIO (KC) BLOCK**

### Species

Though no specific target species are considered, various plankton groups distributed in the KC block, such as copepods and chaetognaths (arrow worms), are assumed to be categorized in the group.

### Distribution block

It is assumed that this group is distributed in the KC block.

## Biomass (B)

Mean biomass in 2013 is calculated using data of NORPAC (North Pacific standard net), from the egg and larval surveys off the Pacific coast of Japan (Takasuka et al. 2008), and the values in Ikeda et al. (2008).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

## Consumption/biomass ratio (Q/B)

The assumed production and consumption ratio (P/Q) is 0.3, based on Ikeda & Motoda (1978) and Christensen et al. (2005).

Pedigree rank: 5, Estimation based on same species but in different period.

Diet compositions

Prey–predation relationships for this functional group was obtained from the work of Ikeda et al. (2008).

Pedigree rank: 4, Direct estimate with incomplete coverage.

Catch

No catches are assumed for this group.

### **35. ZOOPLANKTON IN OFFSHORE (OF) BLOCK**

Species

Though no specific target species are considered, various plankton groups distributed in the OF block, such as copepods and chaetognaths (arrow worms), are assumed to be categorized in the group.

Distribution block

It is assumed that this group is distributed in the OF block.

Biomass (B)

Mean biomass in the block is calculated using all NORPAC (North Pacific standard net) data (1978–2013), from egg and larval surveys off the Pacific coast of Japan (Takasuka et al. 2008), and the values of Ikeda et al. (2008).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The value reported in Yamamura (2004) is used.

Pedigree rank: 5, Estimation based on same species but in different period.

Consumption/biomass ratio (Q/B)

The assumed production and consumption ratio (P/Q) for this species is 0.3, based on Ikeda & Motoda (1978) and Christensen et al. (2005).

Pedigree rank: 5, Estimation based on same species but in different period.

Diet compositions

Prey–predation relationship of this functional group was obtained from the work of Ikeda et al. (2008).

Pedigree rank: 4, Direct estimate with incomplete coverage.

Catch

No catches are assumed for this group.

### **36. PHYTOPLANKTON IN COASTAL OYASHIO (OYC) BLOCK**

Species

No target species are assumed.

Distribution block

It is assumed that this group is distributed in the OYC block.

#### Biomass (B)

Annual means of chlorophyll-*a* volume concentrations ( $\text{mg m}^{-3}$ ) from 2003–2013, obtained by Moderate Resolution Imaging Spectroradiometer aboard the Aqua Satellite (Aqua MODIS), were first converted to surface concentrations ( $\text{mg m}^{-2}$ ), based on the methods of Morel & Berthon (1989). The surface chlorophyll-*a* concentrations were multiplied by a conversion factor of 400 to convert to wet weight ( $\text{mg m}^{-2}$ ), as described in Link et al. (2006).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Annual means for primary production (P) in the OYC block, from unpublished data of Kameda, are used.

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

### **37. PHYTOPLANKTON IN COASTAL KUROSHIO (KC) BLOCK**

Species

No target species are assumed.

Distribution block

It is assumed that this group is distributed in the KC block.

#### Biomass (B)

Annual means of chlorophyll-*a* volume concentrations ( $\text{mg m}^{-3}$ ) from 2003–2013, obtained by Moderate Resolution Imaging Spectroradiometer aboard the Aqua Satellite (Aqua MODIS), were first converted to surface concentrations ( $\text{mg m}^{-2}$ ), based on the methods of Morel & Berthon (1989). The surface chlorophyll-*a* concentrations were multiplied by a conversion factor of 400 to convert to wet weight ( $\text{mg m}^{-2}$ ), as described in Link et al. (2006).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Annual means for primary production (P) in the KC block, from unpublished data of Kameda, are used.

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

### **38. PHYTOPLANKTON IN OFFSHORE (OF) BLOCK**

Species

No target species are assumed.

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Annual means of chlorophyll-*a* concentrations ( $\text{mg m}^{-3}$ ) from 2003–2013, obtained by Moderate Resolution Imaging Spectroradiometer aboard the Aqua Satellite (Aqua MODIS), were first converted to surface concentrations ( $\text{mg m}^{-2}$ ), based on the methods of Morel & Berthon (1989). The surface chlorophyll-*a* concentrations were multiplied by a conversion factor of 400 to convert to wet weight ( $\text{mg m}^{-2}$ ), as described in Link et al. (2006).

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

The same annual means of primary production (P) as in the OYC block (above) are used.

Pedigree rank: 1, Data is estimated with resolution on multiple spatial scales.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

### **39. DETRITUS IN COASTAL OYASHIO (OYC) BLOCK**

**Species**

Not applicable.

Distribution block

It is assumed that this group is distributed in the OYC block.

Biomass (B)

Biomass was calculated using data from Pauly et al. (1993) on the phytoplankton distributed in this block.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Not applicable.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

#### **40. DETRITUS IN COASTAL KUROSHIO (KC) BLOCK**

Species

Not applicable.

Distribution block

It is assumed that this group is distributed in the KC block.

Biomass (B)

Biomass was calculated using data from Pauly et al. (1993) on the phytoplankton distributed in this block.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Not applicable.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

#### **41. DETRITUS IN OFFSHORE (OF) BLOCK**

Species

Not applicable.

Distribution block

It is assumed that this group is distributed in the OF block.

Biomass (B)

Biomass was calculated using data from Pauly et al. (1993) on the phytoplankton in this block.

Pedigree rank: 5, Estimate requires inclusion of highly uncertain scaling factors.

Production/biomass ratio (P/B) or total mortality (Z: natural mortality rate [M] plus fishing mortality rate [F])

Not applicable.

Consumption/biomass ratio (Q/B)

Not applicable.

Diet compositions

Not applicable.

Catch

No catches are assumed for this group.

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## SUPPLEMENT 2.

### **Definitions and results of pedigree for the western North Pacific Ecopath model, based on: Gaichas S, Aydin K, Francis RC (2015) Wasp waist or beer belly? Modeling food web structure and energetic control in Alaskan marine ecosystems, with implications for fishing and environmental forcing, *Progress in Oceanography* 138: 1–17.**

Table S2-1. Criteria for grading the quality of input data (pedigree) for the parameters biomass, P/B, Q/B, catch, and diet composition (source: Gaichas et al. 2015 see above, their Table 3).

Rank and corresponding data characteristics	
1	Data is established and substantial, includes more than one independent method (from which best method is selected) with resolution on multiple spatial scales
2	Data is direct estimate but with limited coverage/corroboration, or established regional estimate is available while subregional resolution is poor
3	Data is proxy, proxy may have known but consistent bias
4	Direct estimate or proxy with high variation/limited confidence or incomplete coverage
Biomass and Catch	P/B, Q/B, and Diet
5	Estimate requires inclusion of highly uncertain scaling factors or extrapolation
6	Historical and/or single study only, not overlapping in area or time
7	Requires selection between multiple incomplete sources with wide range
8	No estimate available (estimated by Ecopath)
5	Estimation based on same species but in "historical" time period, or a general model specific to the area
6	For P/B or Q/B, general life-history proxies; For diets, same species in neighboring region, or similar species in same region
7	General literature review from wide range of species, or outside of region
8	Functional group represents multiple species with diverse life history traits

Table S2-2. Data quality (pedigree index) for each functional group in the Ecopath model for the western North Pacific, based on Gaichas et al. (2015, their Table 3). (OYC: coastal Oyashio block; KC: coastal Kuroshio block; OF: offshore block).

No	Group name	B	P/B	Q/B	Diet	Landings
1	Baleen whales (OYC & OF)	1	3	3	3	1
2	Toothed whales (all)	2	5	5	7	1
3	Seabirds (all)	5	6	5	7	-
4	Sharks (all)	5	4	5	6	1
5	Tunas (all)	5	5	5	6	1
6	Skipjack (all)	8	5	5	6	1
7	Miscellaneous piscivores (all)	8	5	6	5	1
8	Yellowtail (OYC & KC)	2	2	6	5	1
9	Japanese sardine (all)	2	2	6	5	1
10	Japanese anchovy (all)	2	2	6	5	1
11	Pacific saury (all)	1	2	6	5	1
12	Chub mackerel (all)	2	2	6	5	1
13	Spotted mackerel (all)	2	2	6	5	1
14	Round herring (KC)	2	2	6	5	1
15	Jack mackerel (OYC & KC)	2	2	6	5	1
16	Righteye flounders (OYC)	3	3	6	5	1
17	Walleye pollock (OYC)	2	2	6	5	1
18	Pacific cod (OYC)	2	2	6	5	1
19	Miscellaneous bottom fishes (OYC)	3	4	6	5	1
20	Flatfishes (KC)	5	2	6	5	1
21	Seabreams (KC)	3	2	6	5	1
22	Demersal piscivores (KC)	5	5	6	5	1
23	Miscellaneous bottom fishes (KC)	3	4	6	5	1
24	Mesopelagic fishes (OYC)	8	5	6	5	-
25	Mesopelagic fishes (KC)	8	6	6	5	1
26	Mesopelagic fishes (OF)	8	5	6	5	-
27	Epipelagic cephalopods (all)	8	5	5	5	1
28	Mesopelagic cephalopods (all)	8	5	6	5	-
29	Benthos (OYC)	8	6	6	5	1
30	Benthos (KC)	4	6	6	5	1
31	Krill (OYC)	2	5	5	4	1
32	Krill (OF)	2	5	5	4	-
33	Zooplankton (OYC)	1	5	5	4	-
34	Zooplankton (KC)	1	5	5	4	-
35	Zooplankton (OF)	1	5	5	4	-
36	Phytoplankton (OYC)	1	1	-	-	-
37	Phytoplankton (KC)	1	1	-	-	-
38	Phytoplankton (OF)	1	1	-	-	-
39	Detritus (OYC)	5	-	-	-	-
40	Detritus (KC)	5	-	-	-	-
41	Detritus (OF)	5	-	-	-	-

### SUPPLEMENT 3.

## Results of pre-balance diagnostics (PREBAL) for the western North Pacific Ecopath model, based on: Link JS (2010) Adding rigor to ecological network models by evaluating a set of pre-balance diagnostics: a plea for PREBAL, *Ecological Modelling* 221: 1580–1591.

Table S3-1. Summary of the pre-balance diagnostics (PREBAL) for the western North Pacific Ecopath model in 2013 (source: Link 2010, Tables 1–5).

Diagnostic criterion	Results	Diagnostics		
		Good	Acceptable	Caution
<i>Class of diagnostic: Biomasses across taxa/TLs</i>				
1 Biomass should span 5–7 orders of magnitude	Figure S3-1.	x		
2 Slope (on log scale) should be ~5–10% decline		x		
3 Taxa notably above or below slope-line may need more attention			x	
<i>Class of diagnostic: Biomass ratios</i>				
4 Compared across taxa, predators biomass should be less than that of (1 relative to) their prey	Table S3-2.	x		
5 Number of zeroes indicates potential trophic difference between predators and prey		x		
6 Compared across taxa, ratios indicate major pathways of trophic flows (e.g. benthic vs pelagic)		x		
<i>Class of diagnostic: Vital rates across taxa/TLs</i>				
7 Normal biomass decomposition of C, P and R (exception for homeotherms at upper TLs)	Figure S3-2.		x	
8 Taxa notably above or below trend merit further attention			x	
<i>Class of diagnostic: Vital rate ratios</i>				
9 Compared across taxa, predators' C/B, P/B and R/B should be less than 1 relative to their prey	Table S3-3.	x		
10 Number of zeroes indicates potential trophic difference between predators and prey		x		
11 P and B relative to PP approximate TL	Figure S3-3.		x	
12 Compared across vital rates; P/Cs or P/Rs near 1 merit reevaluating	Figure S3-4.		x	
<i>Class of diagnostic: Total production and removals</i>				
13 Total, scaled values of P, C and R should again follow a decomposition with increasing TL	Figure S3-5.		x	
14 Consumption of a taxa should be less than production by that taxa		x		
15 Consumption by a taxa should be more than production by that taxa		x		
16 Total human removals should be less than total production of a taxa	Figure S3-6.	x		
17 Total human removals should be compared to consumption of a taxa		x		

B: Biomass, C: Consumption, P: Production, PP: Primary production, R: Respiration, TL: Trophic level

Table S3-2. Biomass ratios corresponding to diagnostic criteria 4–6 in Table S3-1. TL: trophic level.

Predator / Prey	Biomass ratio
Top predator / Small pelagic fishes	0.247
Top predator / [Small pelagic fishes + Mesopelagic fishes]	0.152
Top predator / Zooplankton	0.032
Top predator / Krill	0.139
Cetacean / Zooplankton	0.010
Cetacean / Small pelagic fishes	0.076
[Cetacean + Seabirds] / Small pelagic fishes	0.077
Small pelagic fishes / Zooplankton	0.129
[Small pelagic fishes + Mesopelagic fishes] / Zooplankton	0.209
Zooplankton / Phytoplankton	3.756
Small pelagic fishes / Phytoplankton	0.483
[Small pelagic fishes + Mesopelagic fishes] / Phytoplankton	0.784
Demersal fishes / Benthos	0.595
Small pelagic fishes / all fishes	0.427
MesoSmall pelagic fishes / all fishes	0.266
Demersal fishes / all fishes	0.223
Top predator / all fishes	0.106
Top predator / Demersal fishes	0.475
Benthos / Zooplankton	0.113
TL4 / <TL3	0.010

Table S3-3. Vital rate ratios corresponding to diagnostic criteria 9 and 10 in Table S3-1.

Predator / Prey	Production ratio	Consumption ratio	Respiration ratio
Top predator / Small pelagic fishes	0.093	0.384	0.558
Top predator / [Small pelagic fishes + MesoSmall pelagic fishes]	0.074	0.277	0.384
Top predator / Zooplankton	0.001	0.004	0.006
Top predator / Krill	0.007	0.020	0.024
Cetacean / Zooplankton	0.000	0.005	0.009
Cetacean / Small pelagic fishes	0.018	0.497	0.784
[Cetacean + Seabirds] / Small pelagic fishes	0.012	0.345	0.544
Small pelagic fishes / Zooplankton	0.011	0.011	0.011
[Small pelagic fishes + MesoSmall pelagic fishes] / Zooplankton	0.014	0.015	0.016
Zooplankton / Phytoplankton	0.146		
Small pelagic fishes / Phytoplankton	0.002		
[Small pelagic fishes + MesoSmall pelagic fishes] / Phytoplankton	0.002		
Demersal fishes / Benthos	0.022	0.022	0.022

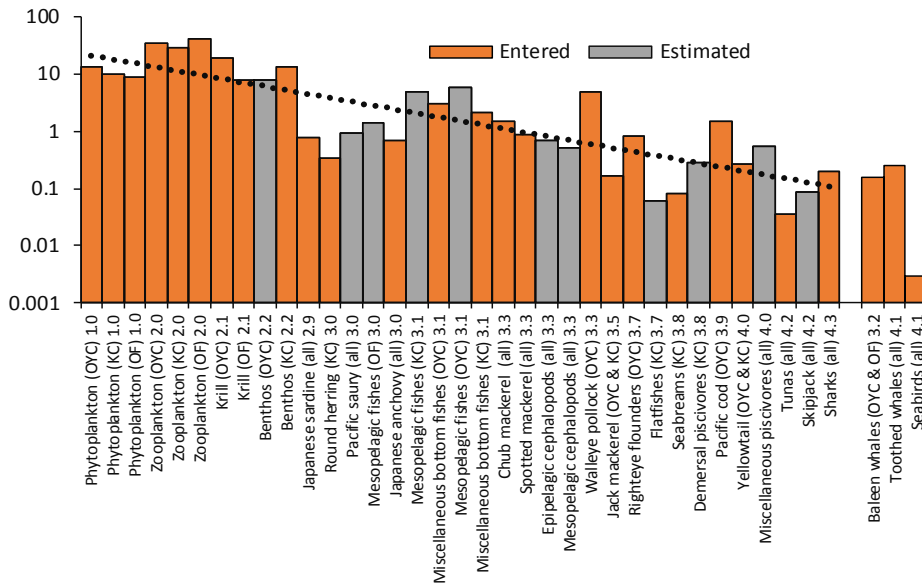


Figure S3-1. Trophic decomposition (trend line) showing variously declining levels of biomass with increasing trophic level (log scale) with the exception for homeotherms. The trophic level increases from left to right. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to the diagnostic criteria 1–3 in Table S3-1.

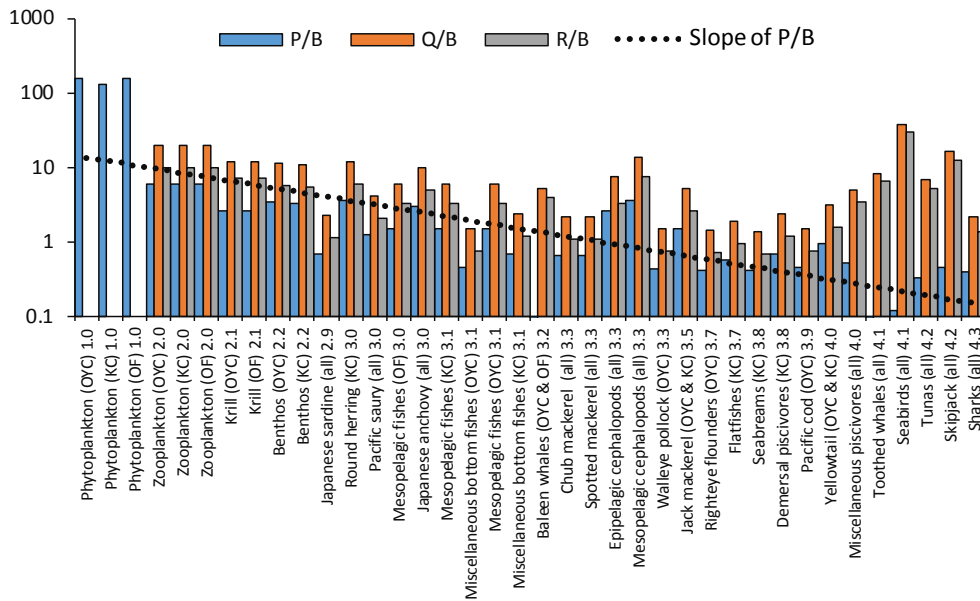


Figure S3-2. Vital rates (log scale) expressing trophic decomposition (trend line), with the exception of consumption and respiration by homeotherms. The trophic level increases from left to right. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to diagnostic criteria 7 and 8 in Table S3-1.



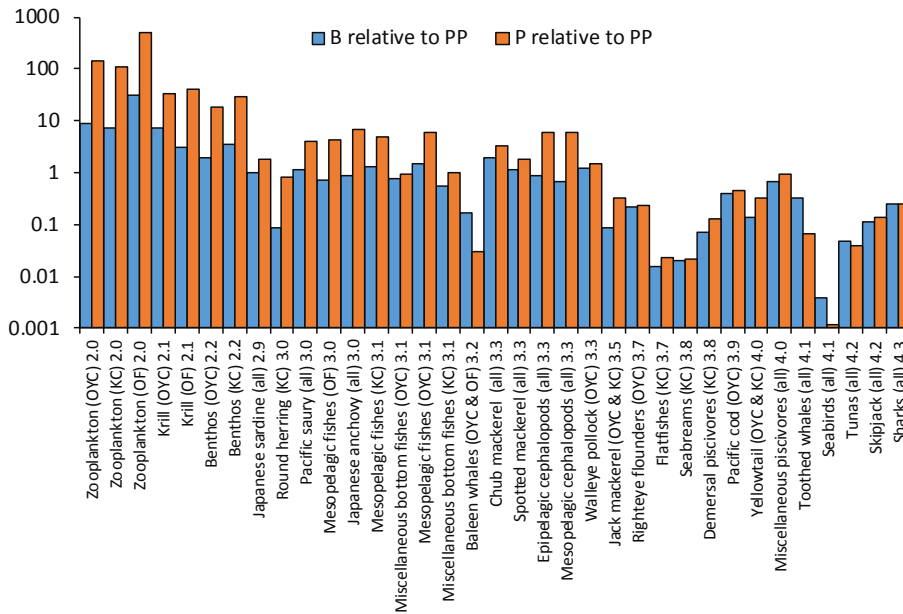


Figure S3-3. Vital rate ratios (log scale) compared with the primary producers. The trophic level increases from right to left. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to diagnostic criterion 11 in Table S3-1.

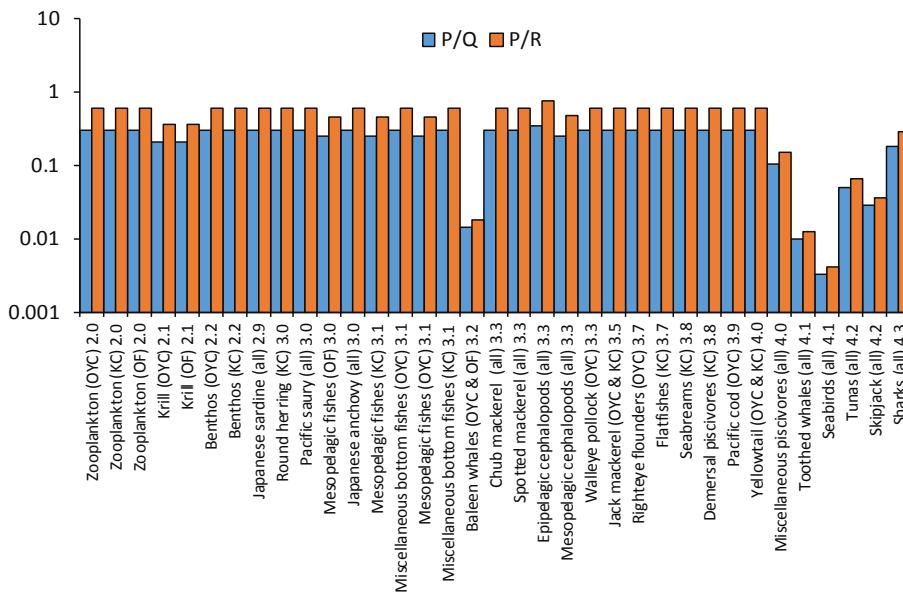


Figure S3-4. Vital rate ratios compared across rates for each taxa. The trophic level increases from right to left. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to diagnostic criterion 12 in Table S3-1.

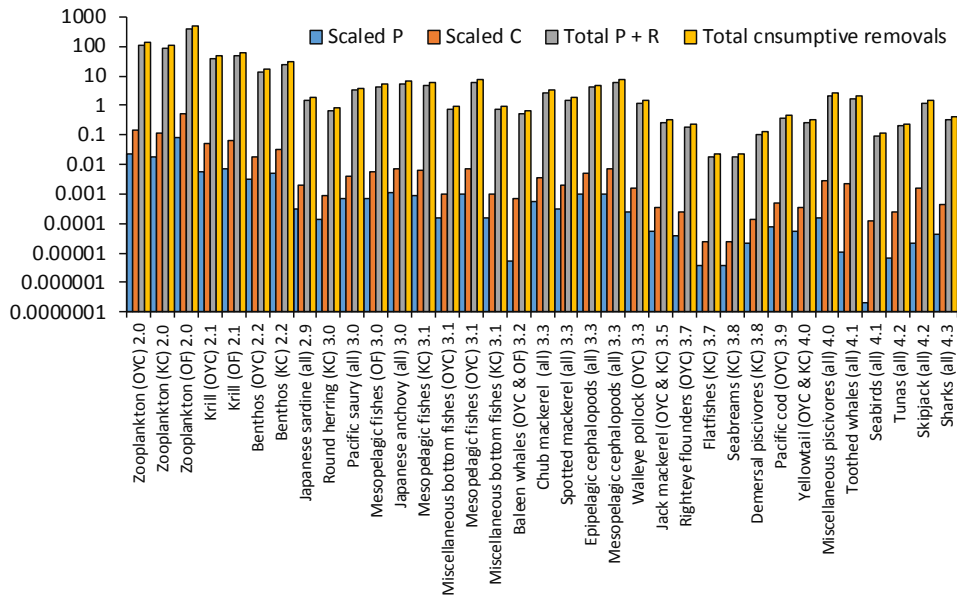


Figure S3-5. Total production and removals, scaled to the full ecosystem, comparing internal flows. The trophic level increases from right to left. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to diagnostic criteria 13–15 in Table S3-1.

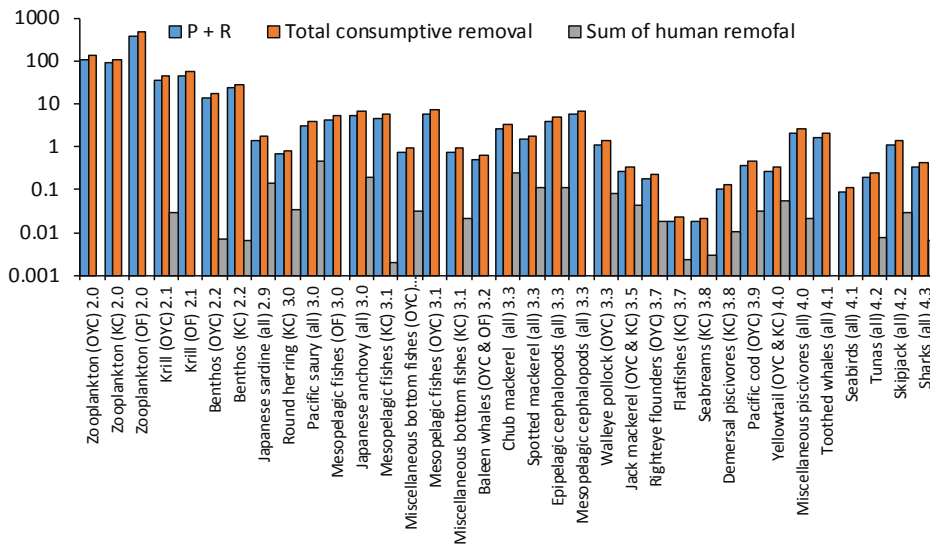


Figure S3-6. Flows relative to external removals. The trophic level increases from right to left. (OYC: coastal Oyashio block, KC: coastal Kuroshio block, and OF: offshore block.) This figure corresponds to diagnostic criteria 16 and 17 in Table S3-1.

## SUPPLEMENT 4.

### Mixed trophic impact (MTI) relationships between species/groups in the western North Pacific in 2013.

Table S4-1. Mixed trophic impact (MTI) relationships between species/groups in the western North Pacific in 2013. Column shows impacting group and row shows impacted group.

Impacting / Impacted	1	2	3	4	5	6	7	8	9	10	11
1 Baleen whales (OYC & OF)	-0.0123	0.0047	-0.0069	0.0040	0.0002	0.0021	-0.0048	0.0058	-0.0127	-0.0053	-0.0093
2 Toothed whales (all)	0.0451	-0.1010	-0.0555	-0.0279	-0.0374	-0.0485	0.0037	-0.0352	0.0150	-0.0230	0.0030
3 Seabirds (all)	0.0071	0.0011	-0.0067	0.0014	-0.0017	-0.0012	-0.0025	0.0035	-0.0160	0.0039	-0.0072
4 Sharks (all)	0.0273	0.0213	-0.0100	-0.0653	0.0096	0.0134	-0.0137	0.0184	-0.0250	0.0097	-0.0106
5 Tunas (all)	-0.0022	-0.0034	-0.0021	0.0025	-0.0308	-0.0174	-0.1030	0.0059	-0.0175	-0.0042	-0.0005
6 Skipjack (all)	-0.0155	-0.0311	-0.0049	0.0141	-0.1770	-0.1080	-0.5900	0.0342	0.0030	0.0001	-0.0032
7 Miscellaneous piscivores (all)	0.0999	0.0204	-0.0889	-0.0275	0.0501	0.0587	-0.1700	-0.0232	-0.1130	0.0970	-0.1190
8 Yellowtail (OYC & KC)	-0.0186	-0.0207	-0.0051	-0.0400	-0.0182	-0.0205	0.0018	-0.0471	-0.0264	-0.0140	-0.0023
9 Japanese sardine(all)	-0.0697	-0.0479	0.0890	-0.0086	0.0336	-0.0115	0.0279	-0.0125	-0.0281	0.0020	-0.0407
10 Japanese anchovy (all)	-0.0844	-0.0603	0.0892	-0.0459	0.0107	-0.0337	0.0482	-0.0117	-0.0730	-0.1460	-0.0935
11 Pacific saury (all)	-0.2020	-0.1680	0.0767	-0.1620	-0.0773	-0.1060	0.1110	-0.2020	-0.0511	0.0128	-0.1230
12 Chub mackerel (all)	-0.0937	-0.0661	0.0400	-0.0435	-0.0137	-0.0041	0.0431	-0.1040	-0.0685	-0.3270	-0.0268
13 Spotted mackerel (all)	-0.0336	-0.0220	0.0639	0.0130	0.0331	0.0434	0.0023	-0.0442	-0.0410	-0.1820	-0.0127
14 Round herring (KC)	-0.0146	-0.0137	0.0006	-0.0126	-0.0081	-0.0108	0.0077	-0.0119	-0.0034	-0.0001	-0.0106
15 Jack mackerel (OYC & KC)	-0.0051	-0.0162	-0.0018	-0.0144	-0.0137	-0.0147	0.0115	-0.0157	-0.0058	-0.0261	-0.0056
16 Righteye flounders (OYC)	-0.0035	-0.0071	-0.0010	0.0378	-0.0046	-0.0056	-0.0007	-0.0218	0.0009	0.0008	-0.0013
17 Walleye pollock (OYC)	-0.0354	-0.0459	-0.0079	0.0082	-0.0331	-0.0415	0.0143	-0.0532	-0.0033	0.0034	-0.0155
18 Pacific cod (OYC)	-0.0057	-0.0174	-0.0045	0.0140	-0.0104	-0.0128	0.0090	0.0192	-0.0003	0.0008	-0.0026
19 Miscellaneous bottom fishes (OYC)	-0.0150	-0.0173	-0.0051	0.0472	-0.0125	-0.0153	0.0209	0.0651	-0.0084	0.0014	-0.0105
20 Flatfishes (KC)	-0.0007	-0.0009	-0.0001	0.0074	-0.0007	-0.0008	-0.0006	-0.0021	0.0000	0.0001	-0.0002
21 Seabreams (KC)	-0.0013	-0.0014	0.0001	-0.0036	-0.0009	-0.0012	-0.0001	-0.0023	0.0006	0.0001	-0.0003
22 Demersal piscivores (KC)	-0.0007	-0.0012	-0.0020	0.0460	-0.0024	-0.0020	-0.0037	-0.0115	-0.0143	-0.0026	0.0003
23 Miscellaneous bottom fishes (KC)	-0.0035	-0.0110	-0.0085	0.0443	-0.0059	-0.0074	0.0565	0.0576	-0.0126	0.0056	-0.0134
24 Mesopelagic fishes (OYC)	0.0076	0.0799	0.0588	0.0508	0.0613	0.0970	-0.0048	0.0764	-0.0275	-0.0009	-0.0235
25 Mesopelagic fishes (KC)	0.0204	0.0850	0.0644	0.0492	0.0579	0.0884	0.0018	0.0742	-0.0182	-0.0045	-0.0265
26 Mesopelagic fishes (OF)	-0.0209	0.1730	0.0615	0.0639	0.0564	0.0944	-0.0837	0.0175	-0.0326	-0.0303	-0.0393
27 Epipelagic cephalopods (all)	-0.0420	0.0997	0.0100	-0.0001	0.0049	-0.0044	0.0280	0.0499	-0.0980	0.0291	-0.0570
28 Mesopelagic cephalopods (all)	-0.0514	0.0473	0.0028	0.0127	0.0079	-0.0086	0.0234	0.0380	-0.0031	0.0002	0.0068
29 Benthos (OYC)	-0.0076	0.0246	-0.0058	0.0167	-0.0019	0.0012	0.0493	0.0671	-0.0153	0.0003	-0.0209
30 Benthos (KC)	0.0085	0.0261	-0.0057	0.0193	0.0024	0.0050	0.0435	0.0584	-0.0130	-0.0015	-0.0161
31 Krill (OYC)	-0.0081	-0.0031	0.0448	0.0074	0.0055	0.0046	0.0191	-0.0147	0.0254	0.0139	0.0115
32 Krill (OF)	0.3670	0.0110	0.0258	0.0008	0.0104	0.0056	0.0128	-0.0052	0.0785	-0.0666	-0.0227
33 Zooplankton (OYC)	0.0315	-0.0136	0.0179	-0.0006	-0.0032	-0.0079	0.0224	0.0013	-0.0051	0.0397	0.0466
34 Zooplankton (KC)	-0.0349	0.0048	0.0438	0.0057	0.0125	0.0157	0.0371	0.0149	-0.0080	0.0389	0.0339
35 Zooplankton (OF)	-0.1480	0.0026	0.0891	-0.0310	0.0124	0.0044	0.0154	-0.0598	0.0649	0.1720	0.1790
36 Phytoplankton (OYC)	0.0215	-0.0156	0.0531	0.0058	0.0022	-0.0052	0.0420	-0.0030	0.0597	0.0496	0.0505
37 Phytoplankton (KC)	-0.0375	0.0050	0.0476	0.0072	0.0145	0.0156	0.0429	0.0201	0.0393	0.0388	0.0302
38 Phytoplankton (OF)	0.1050	0.0079	0.1120	-0.0309	0.0214	0.0078	0.0257	-0.0641	0.1680	0.1260	0.1610
39 Detritus (OYC)	-0.0069	0.0166	0.0049	0.0131	-0.0002	0.0018	0.0383	0.0440	-0.0056	0.0030	-0.0123
40 Detritus (KC)	0.0059	0.0183	-0.0040	0.0135	0.0017	0.0035	0.0305	0.0409	-0.0091	-0.0011	-0.0112
41 Detritus (OF)	0.0735	0.0022	0.0052	0.0002	0.0021	0.0011	0.0026	-0.0010	0.0157	-0.0133	-0.0045
42 Fisheries	-0.8280	-0.6930	0.0068	-0.8160	-0.5550	-0.6910	0.4540	-0.7870	-0.0952	0.0881	-0.3380

Table S4-1. (continued)

Impacting / Impacted	12	13	14	15	16	17	18	19	20	21	22
1 Baleen whales (OYC & OF)	-0.0125	-0.0167	0.0074	-0.0638	-0.0011	0.0040	-0.0003	0.0001	-0.0003	0.0074	-0.0025
2 Toothed whales (all)	0.0104	0.0073	0.0908	0.0008	0.0030	0.0038	-0.0390	0.0246	-0.0116	-0.0275	-0.0027
3 Seabirds (all)	-0.0101	-0.0160	0.0011	0.0003	0.0007	0.0037	-0.0003	0.0015	0.0005	0.0045	-0.0009
4 Sharks (all)	-0.0191	-0.0351	-0.0001	-0.0011	-0.2880	-0.1910	-0.1660	0.0157	-0.6030	-0.0109	-0.6530
5 Tunas (all)	0.0023	-0.0062	-0.0015	0.0089	-0.0064	-0.0021	0.0264	0.0173	0.0105	0.0109	0.0061
6 Skipjack (all)	0.0200	-0.0274	-0.0085	0.0559	-0.0363	-0.0154	0.1460	0.1010	0.0580	0.0581	0.0404
7 Miscellaneous piscivores (all)	-0.1850	-0.2000	-0.0030	-0.0465	0.0669	0.0611	-0.2240	-0.1210	-0.0708	-0.0477	-0.0515
8 Yellowtail (OYC & KC)	-0.0023	0.0027	-0.0100	-0.0219	0.0428	-0.0038	-0.1510	-0.0942	0.0022	-0.0373	-0.0038
9 Japanese sardine(all)	-0.0266	-0.0184	-0.0274	-0.0179	-0.0076	-0.0448	-0.0241	-0.0100	-0.0197	-0.0597	0.0458
10 Japanese anchovy (all)	0.1350	0.1500	-0.0545	0.1050	-0.0103	-0.0733	-0.0407	-0.0254	-0.0214	-0.1010	0.0456
11 Pacific saury (all)	-0.0862	-0.0494	-0.0865	-0.0868	0.0086	-0.1190	-0.0140	-0.0199	0.0251	-0.2030	0.0550
12 Chub mackerel (all)	-0.1120	-0.1020	-0.0162	-0.0845	0.0000	-0.0378	-0.0019	0.0015	0.0035	-0.0674	-0.0110
13 Spotted mackerel (all)	-0.0627	-0.0629	-0.0065	-0.0419	-0.0097	-0.0196	-0.0022	0.0050	-0.0158	-0.0234	-0.0278
14 Round herring (KC)	-0.0075	-0.0047	-0.0374	-0.0126	0.0019	-0.0077	-0.0004	-0.0012	-0.0063	-0.0170	0.0075
15 Jack mackerel (OYC & KC)	-0.0099	-0.0063	-0.0026	-0.0126	0.0006	-0.0100	-0.0046	-0.0015	0.0007	-0.0181	0.0074
16 Righteye flounders (OYC)	-0.0001	0.0008	0.0018	-0.0001	-0.0606	-0.0118	0.0218	-0.1820	-0.0275	-0.0080	-0.0374
17 Walleye pollock (OYC)	-0.0083	-0.0005	-0.0213	-0.0232	-0.0185	-0.0548	-0.0400	-0.0017	-0.0225	-0.0428	-0.0191
18 Pacific cod (OYC)	-0.0006	0.0019	-0.0005	-0.0039	-0.3550	-0.0126	-0.0560	-0.1130	-0.0188	-0.0145	0.0346
19 Miscellaneous bottom fishes (OYC)	-0.0094	-0.0068	-0.0040	-0.0122	0.1340	-0.0361	0.0565	-0.0705	-0.0409	-0.0184	0.0196
20 Flatfishes (KC)	0.0000	0.0001	0.0004	-0.0001	-0.0027	-0.0023	-0.0011	0.0005	-0.0083	-0.0044	-0.0071
21 Seabreams (KC)	0.0001	0.0004	0.0005	0.0000	0.0001	-0.0002	0.0029	0.0008	-0.0009	-0.0057	-0.0288
22 Demersal piscivores (KC)	-0.0004	-0.0007	-0.0022	-0.0067	0.0052	-0.0103	-0.0776	-0.0198	-0.0403	0.0360	-0.0468
23 Miscellaneous bottom fishes (KC)	-0.0161	-0.0154	-0.0145	-0.0107	-0.0080	-0.0134	-0.0412	-0.0158	0.1380	0.1620	0.0421
24 Mesopelagic fishes OYC)	-0.0318	-0.0423	0.0185	-0.0384	-0.0628	-0.0261	0.0803	-0.1180	-0.0318	0.0130	-0.0383
25 Mesopelagic fishes KC)	-0.0276	-0.0374	-0.1340	-0.0238	-0.0080	0.0034	-0.0215	-0.0040	-0.0272	0.0271	0.0010
26 Mesopelagic fishes OF)	-0.0293	-0.0405	0.0217	0.0147	-0.0194	0.0026	0.0077	0.0195	-0.0274	0.0253	-0.0388
27 Epipelagic cephalopods (all)	-0.0718	-0.0931	-0.3900	-0.1590	0.0479	-0.0268	0.0397	-0.0305	0.0714	0.0648	0.0293
28 Mesopelagic cephalopods (all)	-0.0036	0.0009	0.1060	0.1070	0.0003	0.0613	0.0950	-0.0311	0.0448	0.0545	0.0202
29 Benthos (OYC)	-0.0227	-0.0227	0.0054	-0.0291	0.0747	0.1450	0.1060	0.0848	-0.0241	-0.0151	-0.0087
30 Benthos (KC)	-0.0176	-0.0190	-0.0683	-0.0188	0.0032	0.0000	-0.0413	-0.0151	0.1410	0.2470	0.1800
31 Krill (OYC)	0.0282	0.0307	-0.0582	0.0885	0.0900	0.1270	0.1140	0.0288	-0.0047	-0.0275	0.0030
32 Krill (OF)	0.0904	0.0880	-0.0470	-0.0535	0.0040	-0.0065	0.0168	-0.0090	0.0123	0.0025	0.0051
33 Zooplankton (OYC)	0.0270	0.0305	-0.0165	0.0635	0.0513	0.0436	-0.0030	0.1650	-0.0091	-0.0255	0.0060
34 Zooplankton (KC)	0.0212	0.0229	0.4000	0.0699	-0.0023	-0.0260	-0.0196	-0.0121	0.1270	0.0167	0.0242
35 Zooplankton (OF)	0.0637	0.0742	-0.0368	0.0021	-0.0092	-0.0575	-0.0101	-0.0061	-0.0107	-0.0805	0.0142
36 Phytoplankton (OYC)	0.0432	0.0489	-0.0581	0.1220	0.1210	0.1450	0.0863	0.1930	-0.0157	-0.0493	0.0095
37 Phytoplankton (KC)	0.0181	0.0201	0.3920	0.0672	-0.0024	-0.0282	-0.0250	-0.0141	0.1400	0.0384	0.0445
38 Phytoplankton (OF)	0.1260	0.1350	-0.0711	-0.0363	-0.0068	-0.0643	0.0005	-0.0129	-0.0030	-0.0817	0.0200
39 Detritus (OYC)	-0.0103	-0.0098	-0.0079	-0.0027	0.0703	0.1270	0.0970	0.0651	-0.0178	-0.0161	-0.0055
40 Detritus (KC)	-0.0123	-0.0133	-0.0478	-0.0131	0.0023	0.0000	-0.0289	-0.0106	0.0986	0.1730	0.1260
41 Detritus (OF)	0.0181	0.0176	-0.0094	-0.0107	0.0008	-0.0013	0.0034	-0.0018	0.0025	0.0005	0.0010
42 Fisheries	-0.2100	-0.0385	-0.2760	-0.2950	0.1120	-0.4100	0.0027	-0.0603	0.2410	-0.8020	0.3600

Table S4-1. (continued)

Impacting / Impacted	23	24	25	26	27	28	29	30	31	32
1 Baleen whales (OYC & OF)	0.0029	0.0005	0.0031	-0.0002	-0.0090	-0.0054	0.0001	-0.0005	-0.0022	-0.0389
2 Toothed whales (all)	0.0109	-0.0302	-0.0530	-0.1850	-0.1570	-0.1610	-0.0145	-0.0015	0.0476	0.0639
3 Seabirds (all)	0.0024	-0.0037	-0.0046	-0.0059	-0.0040	-0.0044	0.0001	0.0005	0.0028	0.0038
4 Sharks (all)	-0.0284	0.0153	-0.0119	-0.0303	-0.0066	0.0130	0.0094	0.0062	0.0037	0.0038
5 Tunas (all)	0.0636	0.0064	0.0088	-0.0139	0.0020	0.0021	0.0015	-0.0017	-0.0027	0.0017
6 Skipjack (all)	0.3660	0.0158	0.0281	-0.1110	0.0123	0.0111	0.0126	-0.0068	-0.0118	0.0058
7 Miscellaneous piscivores (all)	-0.4970	-0.1090	-0.1370	0.0294	-0.0789	-0.0815	-0.0105	0.0215	0.0669	0.0468
8 Yellowtail (OYC & KC)	-0.0840	-0.0013	-0.0115	0.0132	-0.0070	-0.0010	0.0005	0.0025	0.0056	0.0028
9 Japanese sardine(all)	-0.0236	0.0004	-0.0033	0.0025	0.0030	0.0021	0.0050	0.0011	-0.0120	-0.0352
10 Japanese anchovy (all)	-0.0476	-0.0051	-0.0136	-0.0272	-0.0187	-0.0179	0.0131	0.0031	-0.0397	-0.0441
11 Pacific saury (all)	-0.0617	0.0064	-0.0049	0.0232	0.0151	0.0310	0.0101	0.0025	-0.0261	-0.0159
12 Chub mackerel (all)	-0.0163	0.0072	0.0075	0.0333	-0.0062	-0.0013	0.0012	-0.0002	-0.0042	-0.0459
13 Spotted mackerel (all)	0.0029	0.0017	0.0015	0.0076	-0.0029	-0.0055	0.0012	0.0001	-0.0011	-0.0245
14 Round herring (KC)	-0.0170	0.0012	-0.0209	0.0048	0.0077	0.0018	0.0002	0.0034	-0.0003	0.0002
15 Jack mackerel (OYC & KC)	-0.0070	0.0050	0.0049	0.0142	-0.0082	-0.0101	0.0000	-0.0004	-0.0029	0.0049
16 Righteye flounders (OYC)	0.0007	-0.0065	0.0048	0.0058	-0.0083	-0.0074	0.0021	-0.0003	0.0041	0.0021
17 Walleye pollock (OYC)	-0.0079	-0.0736	0.0198	0.0334	0.0213	-0.0549	-0.0327	-0.0019	-0.0039	0.0073
18 Pacific cod (OYC)	-0.0119	-0.0317	0.0104	0.0186	-0.0098	-0.0331	-0.0007	-0.0011	0.0160	0.0062
19 Miscellaneous bottom fishes (OYC)	-0.0243	-0.0166	-0.0003	0.0092	-0.0056	-0.0033	-0.0265	0.0005	-0.0108	0.0030
20 Flatfishes (KC)	-0.0157	0.0008	-0.0008	0.0005	-0.0008	-0.0005	0.0000	0.0002	0.0000	0.0002
21 Seabreams (KC)	-0.0134	0.0004	-0.0003	0.0009	-0.0006	-0.0006	-0.0001	-0.0001	-0.0001	0.0001
22 Demersal piscivores (KC)	-0.0481	0.0060	-0.0077	-0.0001	-0.0016	0.0014	0.0011	-0.0013	-0.0005	0.0008
23 Miscellaneous bottom fishes (KC)	-0.0758	-0.0037	-0.0273	0.0060	-0.0058	-0.0023	0.0000	-0.0368	0.0044	0.0036
24 Mesopelagic fishes (OYC)	-0.0022	-0.1710	-0.0104	-0.0231	-0.0348	-0.0265	-0.1300	0.0008	-0.2640	0.0177
25 Mesopelagic fishes (KC)	-0.1320	-0.0185	-0.1560	-0.0379	-0.0116	0.0084	0.0012	-0.1050	0.0093	0.0081
26 Mesopelagic fishes (OF)	0.0527	-0.0072	-0.0102	-0.1420	-0.0199	-0.0139	-0.0010	-0.0005	0.0107	-0.0578
27 Epipelagic cephalopods (all)	-0.0119	-0.1200	-0.1190	-0.1550	-0.1050	-0.0795	0.0314	0.0140	-0.0280	-0.0748
28 Mesopelagic cephalopods (all)	-0.0022	-0.1830	-0.1760	-0.2230	-0.2000	-0.1970	0.0413	0.0217	-0.0295	-0.1020
29 Benthos (OYC)	-0.0373	0.0773	-0.0018	0.0089	-0.0221	-0.0371	-0.4200	0.0004	-0.0716	0.0136
30 Benthos (KC)	0.1400	-0.0046	0.0461	-0.0021	-0.0159	-0.0088	-0.0011	-0.5490	0.0066	0.0070
31 Krill (OYC)	-0.0105	0.2380	-0.0394	-0.0471	0.1010	0.0884	-0.2250	0.0052	-0.1690	-0.0316
32 Krill (OF)	-0.0040	-0.0442	-0.0425	-0.0304	0.1030	0.1040	0.0119	0.0053	-0.0114	-0.1840
33 Zooplankton (OYC)	-0.0162	0.0211	-0.0117	-0.0104	0.0104	0.0269	0.0442	0.0018	-0.2630	-0.0138
34 Zooplankton (KC)	0.1630	-0.0178	0.2910	-0.0219	0.0436	0.0188	0.0055	-0.0451	-0.0038	-0.0114
35 Zooplankton (OF)	-0.0109	-0.0107	-0.0169	0.3470	0.0005	0.0249	0.0085	0.0024	-0.0161	-0.3010
36 Phytoplankton (OYC)	-0.0285	0.1950	-0.0397	-0.0423	0.0792	0.0852	-0.0550	0.0056	0.3100	-0.0363
37 Phytoplankton (KC)	0.1760	-0.0182	0.2960	-0.0220	0.0421	0.0181	0.0056	0.0000	-0.0037	-0.0125
38 Phytoplankton (OF)	-0.0149	-0.0416	-0.0468	0.3260	0.0726	0.0977	0.0171	0.0062	-0.0247	0.2680
39 Detritus (OYC)	-0.0282	0.1020	-0.0092	-0.0032	0.0048	-0.0083	0.3610	0.0014	0.1160	0.0032
40 Detritus (KC)	0.0981	-0.0032	0.0323	-0.0015	-0.0111	-0.0062	-0.0008	0.3160	0.0046	0.0049
41 Detritus (OF)	-0.0008	-0.0088	-0.0085	-0.0061	0.0206	0.0208	0.0024	0.0011	-0.0023	0.1630
42 Fisheries	-0.2180	0.0751	0.0530	0.2620	0.1050	0.2030	0.0101	-0.0003	-0.0285	-0.0082

Table S4-1. (continued)

Impacting / Impacted	33	34	35	36	37	38	39	40	41	42
1 Baleen whales (OYC & OF)	-0.0018	0.0005	0.0073	0.0018	-0.0005	-0.0037	0.0008	0.0005	0.0389	-0.0082
2 Toothed whales (all)	0.0004	0.0136	0.0172	-0.0091	-0.0132	-0.0208	-0.0121	0.0015	-0.0639	-0.0083
3 Seabirds (all)	0.0000	0.0013	0.0008	-0.0005	-0.0012	-0.0010	-0.0013	-0.0005	-0.0038	-0.0052
4 Sharks (all)	-0.0006	0.0027	0.0033	-0.0003	-0.0027	-0.0034	-0.0069	-0.0062	-0.0038	-0.0252
5 Tunas (all)	0.0002	-0.0024	0.0019	0.0004	0.0024	-0.0019	0.0003	0.0017	-0.0017	0.0027
6 Skipjack (all)	-0.0010	-0.0122	0.0112	0.0029	0.0121	-0.0107	-0.0021	0.0068	-0.0058	0.0193
7 Miscellaneous piscivores (all)	-0.0008	0.0402	-0.0038	-0.0119	-0.0396	-0.0001	-0.0227	-0.0215	-0.0468	-0.0742
8 Yellowtail (OYC & KC)	0.0011	0.0050	0.0000	-0.0019	-0.0049	-0.0002	-0.0027	-0.0025	-0.0028	0.0194
9 Japanese sardine(all)	-0.0022	-0.0044	-0.0073	0.0035	0.0035	0.0093	0.0023	-0.0011	0.0352	0.0579
10 Japanese anchovy (all)	-0.0231	-0.0311	-0.0644	0.0259	0.0302	0.0629	0.0095	-0.0031	0.0441	0.0900
11 Pacific saury (all)	-0.0130	-0.0164	-0.0455	0.0153	0.0160	0.0432	0.0055	-0.0025	0.0159	0.1990
12 Chub mackerel (all)	0.0056	0.0036	0.0214	-0.0037	-0.0034	-0.0162	0.0011	0.0002	0.0459	0.0635
13 Spotted mackerel (all)	0.0029	0.0022	0.0131	-0.0021	-0.0021	-0.0101	-0.0002	-0.0001	0.0245	0.0220
14 Round herring (KC)	0.0003	-0.0296	0.0001	-0.0002	0.0288	-0.0001	0.0000	-0.0034	-0.0002	0.0143
15 Jack mackerel (OYC & KC)	0.0000	-0.0016	0.0009	0.0005	0.0015	-0.0012	0.0013	0.0004	-0.0049	0.0156
16 Righteye flounders (OYC)	0.0017	-0.0006	-0.0008	-0.0022	0.0006	0.0005	-0.0030	0.0003	-0.0021	0.0050
17 Walleye pollock (OYC)	0.0005	-0.0018	-0.0032	0.0007	0.0018	0.0024	0.0204	0.0019	-0.0073	0.0380
18 Pacific cod (OYC)	0.0017	-0.0008	-0.0022	-0.0044	0.0008	0.0015	-0.0065	0.0011	-0.0062	0.0101
19 Miscellaneous bottom fishes (OYC)	-0.0067	0.0013	-0.0006	0.0077	-0.0013	0.0003	0.0197	-0.0005	-0.0030	0.0139
20 Flatfishes (KC)	0.0000	0.0003	-0.0001	0.0000	-0.0003	0.0000	0.0000	-0.0002	-0.0002	0.0008
21 Seabreams (KC)	0.0000	0.0003	-0.0001	0.0000	-0.0003	0.0001	0.0001	0.0001	-0.0001	0.0014
22 Demersal piscivores (KC)	0.0003	0.0030	0.0003	-0.0001	-0.0028	-0.0004	-0.0004	0.0013	-0.0008	0.0007
23 Miscellaneous bottom fishes (KC)	0.0002	-0.0074	-0.0003	-0.0010	0.0082	0.0000	-0.0019	0.0368	-0.0036	0.0051
24 Mesopelagic fishes (OYC)	0.0338	0.0042	0.0034	0.0243	-0.0041	-0.0045	0.1880	-0.0008	-0.0177	-0.0222
25 Mesopelagic fishes (KC)	0.0001	-0.1360	0.0058	-0.0018	0.1350	-0.0060	-0.0046	0.1050	-0.0081	-0.0165
26 Mesopelagic fishes (OF)	0.0015	0.0041	-0.0803	-0.0032	-0.0039	0.0785	-0.0040	0.0005	0.0578	-0.0213
27 Epipelagic cephalopods (all)	-0.0002	0.0171	0.0252	0.0052	-0.0169	-0.0175	-0.0060	-0.0140	0.0748	0.0103
28 Mesopelagic cephalopods (all)	-0.0125	0.0190	0.0259	0.0151	-0.0191	-0.0160	-0.0110	-0.0217	0.1020	-0.0015
29 Benthos (OYC)	-0.0310	0.0031	-0.0002	0.0324	-0.0031	-0.0009	-0.3010	-0.0004	-0.0136	0.0013
30 Benthos (KC)	0.0005	-0.0693	0.0012	-0.0016	0.0560	-0.0016	-0.0022	-0.4510	-0.0070	-0.0053
31 Krill (OYC)	-0.2630	0.0033	0.0042	0.0556	-0.0033	-0.0015	-0.2280	-0.0052	0.0316	0.0429
32 Krill (OF)	-0.0017	0.0060	-0.1620	0.0033	-0.0060	0.0865	-0.0019	-0.0053	-0.8160	0.0158
33 Zooplankton (OYC)	-0.3780	-0.0014	-0.0041	-0.4480	0.0013	0.0049	0.0877	-0.0018	0.0138	0.0259
34 Zooplankton (KC)	-0.0024	-0.5640	-0.0024	0.0026	-0.4230	0.0031	-0.0015	0.0451	0.0114	0.0323
35 Zooplankton (OF)	-0.0087	-0.0098	-0.4890	0.0099	0.0094	-0.4480	0.0020	-0.0024	0.3010	0.0810
36 Phytoplankton (OYC)	0.4350	0.0010	-0.0015	-0.4060	-0.0012	0.0042	-0.1020	-0.0056	0.0363	0.0590
37 Phytoplankton (KC)	-0.0025	0.4290	-0.0026	0.0026	-0.4180	0.0034	-0.0016	0.0000	0.0125	0.0346
38 Phytoplankton (OF)	-0.0100	-0.0058	0.3970	0.0124	0.0054	-0.3870	0.0008	-0.0062	-0.2680	0.0949
39 Detritus (OYC)	-0.0743	0.0029	0.0007	0.0338	-0.0028	-0.0009	0.0000	-0.0014	-0.0032	0.0095
40 Detritus (KC)	0.0003	-0.0485	0.0008	-0.0011	0.0392	-0.0011	-0.0015	0.0000	-0.0049	-0.0037
41 Detritus (OF)	-0.0003	0.0012	-0.0324	0.0007	-0.0012	0.0173	-0.0004	-0.0011	0.0000	0.0032
42 Fisheries	0.0088	0.0079	-0.0177	-0.0017	-0.0076	0.0170	0.0065	0.0003	0.0082	-0.1880