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Foraging areas of streaked shearwaters in relation to seasonal changes in the marine environment of the Northwestern Pacific

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“Hotspots”

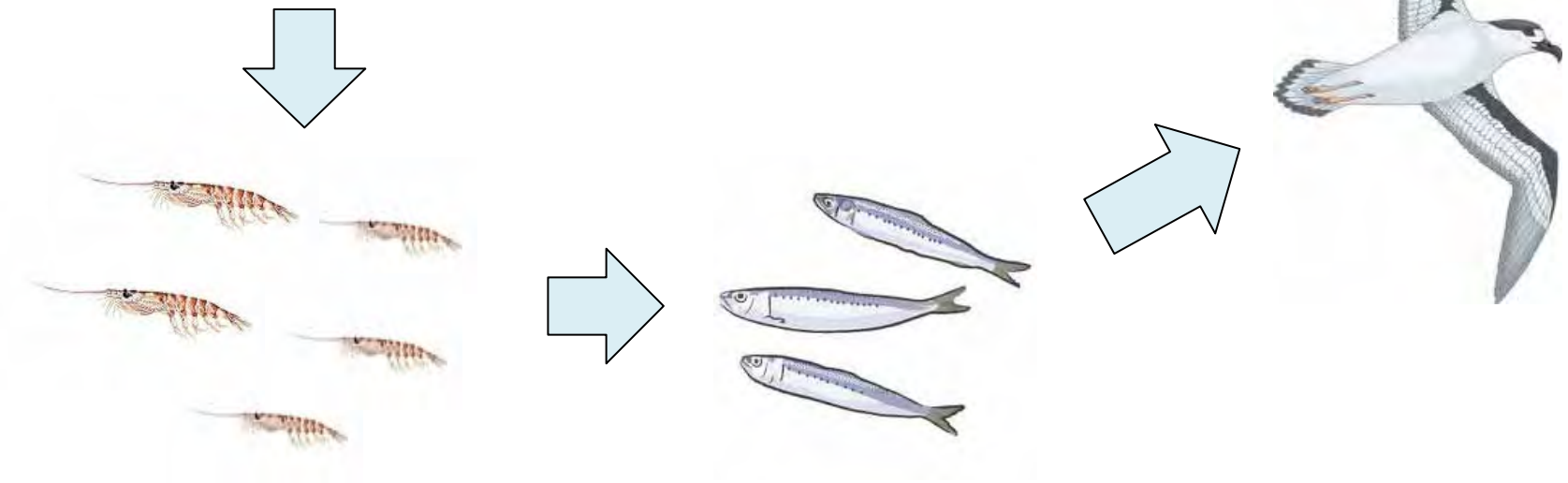
Areas encompassing high species diversity, high abundance of individuals, or of high economic value

- √ Understanding the relationship between physical and biological processes
- √ Conservation & resource management

Hotspots may be not stable in space and time due to <u>the seasonality in marine environment</u>

Seabirds range widely and may track the spatial and temporal dynamics of their prey, induced by seasonal changes in marine environment

Seasonal changes in marine environment



Streaked shearwaters *Calonectris leucomelas*

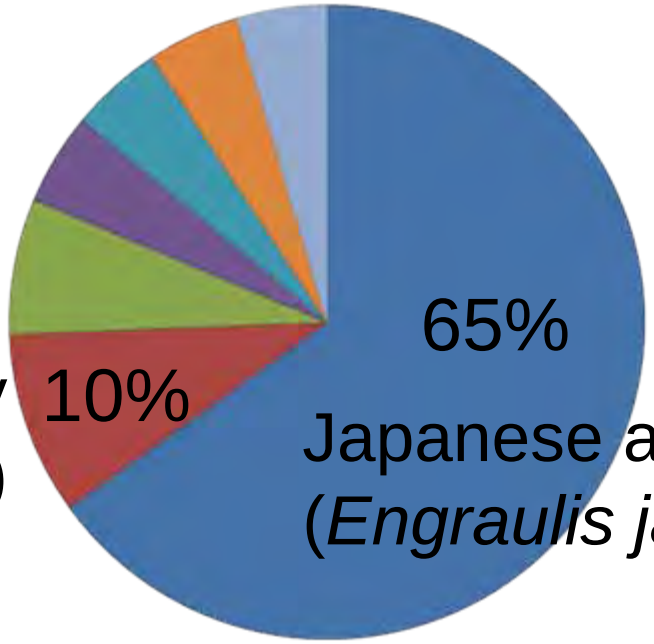
Principal top predator in the Northwestern Pacific

- Total population: 2.5-4.3 million birds
- Foraging over large area (~1,000 km)

Breeding colonies (Oka 2004)

Diet of streaked shearwaters

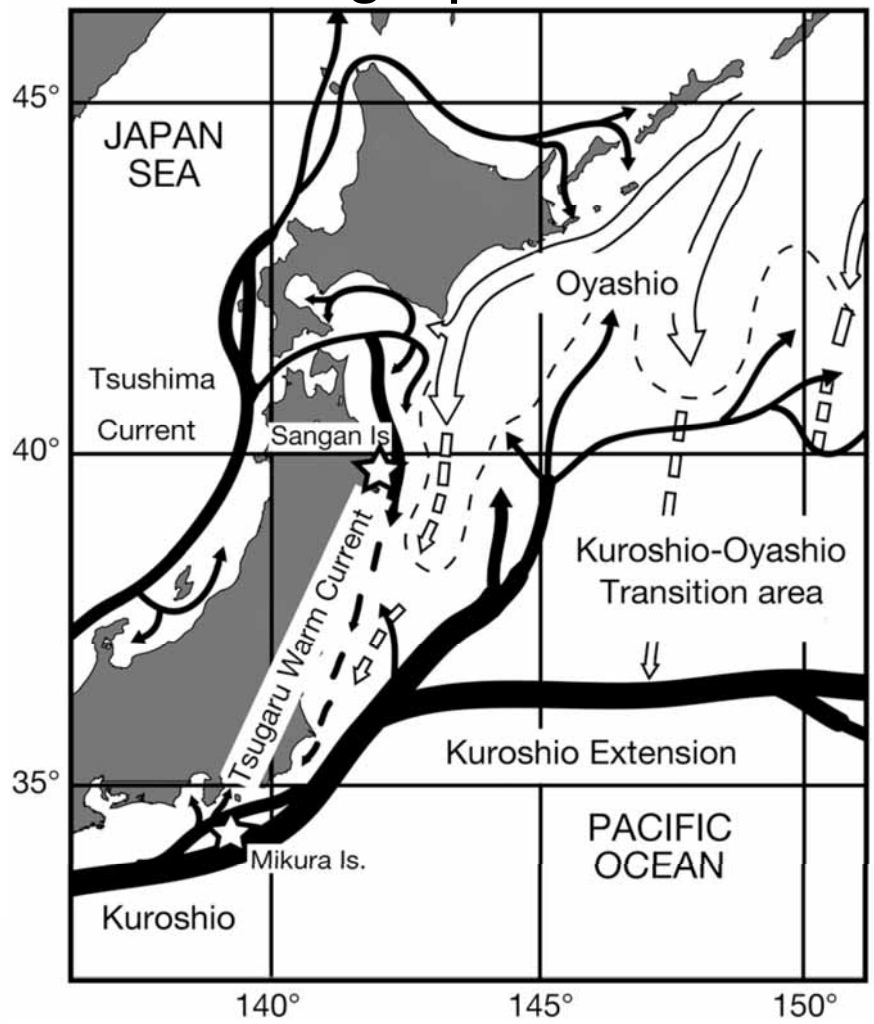
(Matsumoto 2008)



Streaked shearwaters predominantly feed on Japanese anchovy and Pacific saury

Marine environment in Northwestern Pacific

Oceanographic features



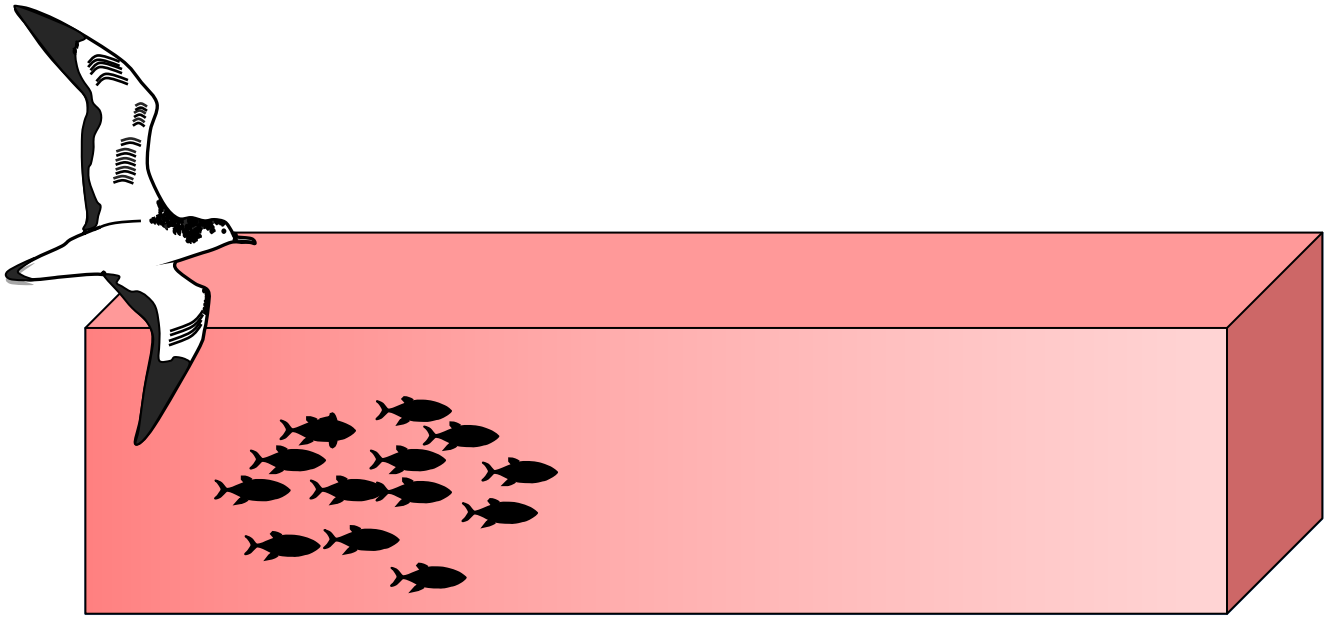
Water temperatures increase from spring to summer (>10ºC)

- by solar heating
- by seasonal decrease of cold water transport of the Oyashio current (Kawai 1972, Qiu 2001)

Seasonal changes in water temperature should affect distribution and availability of shearwater's prey

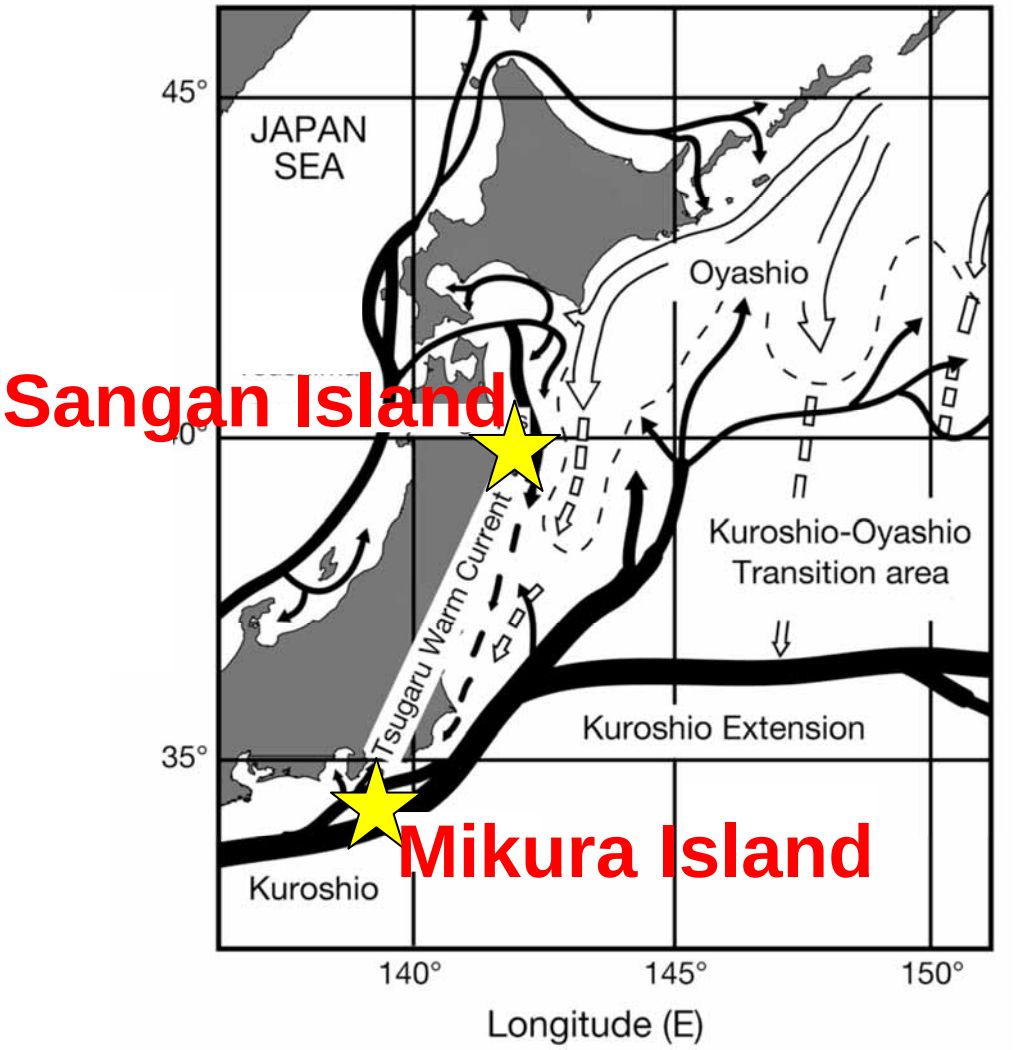
The aims of this study

We examined how streaked shearwaters changed their foraging areas in response to seasonal changes in marine environment from spring to summer

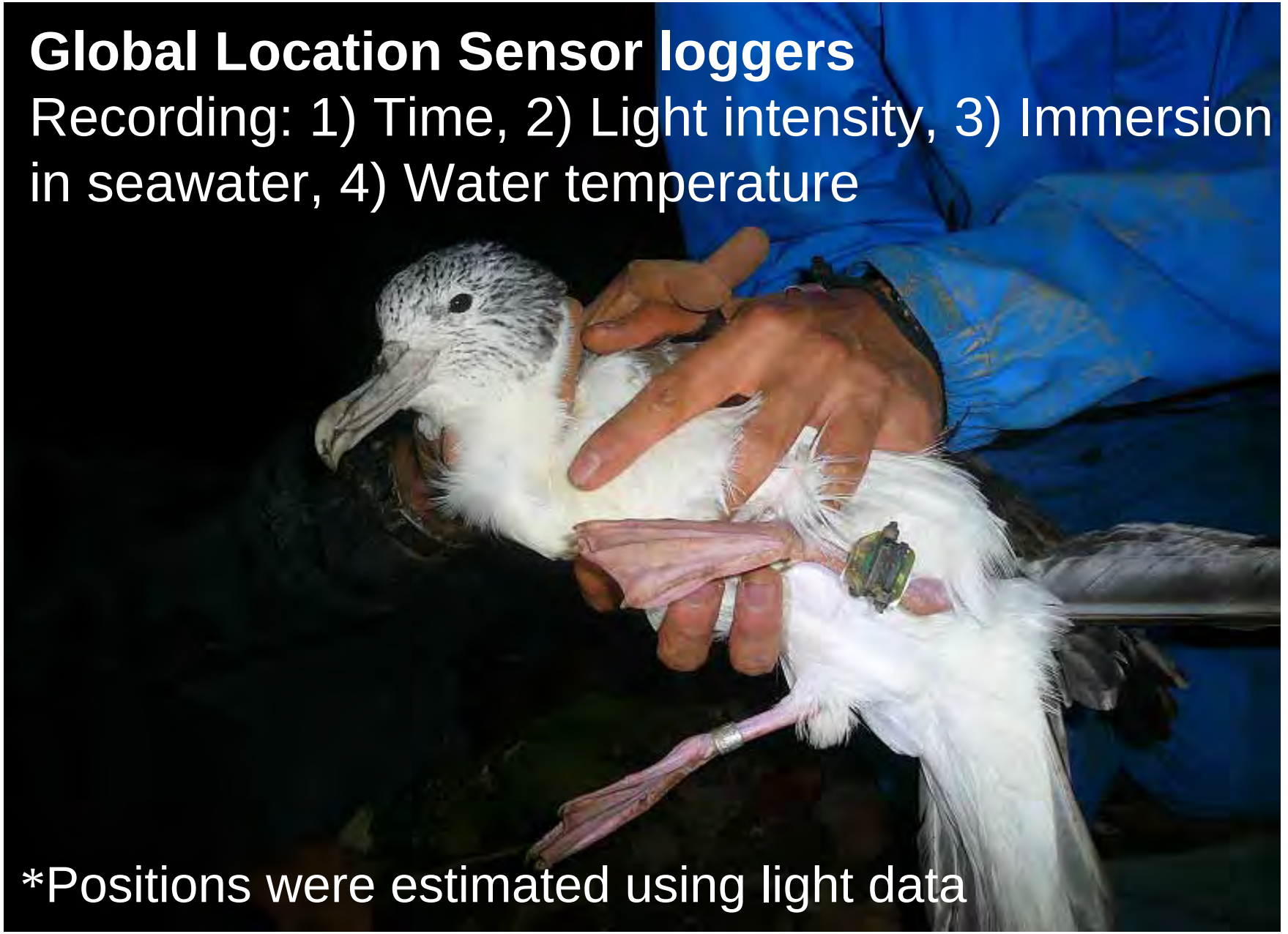


Study site

- **Sangan Island** in the Kuroshio-Oyashio transition area
- **Mikura Island** in the Kuroshio area



Tracking streaked shearwaters



Oceanographic data

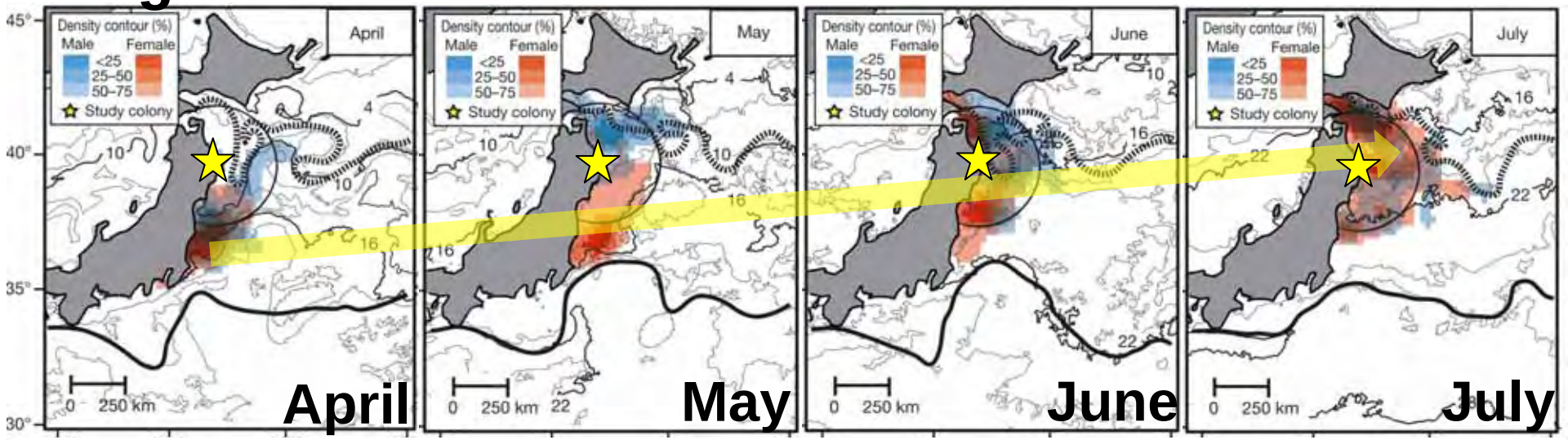
We obtained oceanographic data from Ocean Color Web (http://oceancolor.gsfc.nasa.gov)

- Monthly composite chlorophyll a concentration (resolution of 9 km, SeaWiFS)

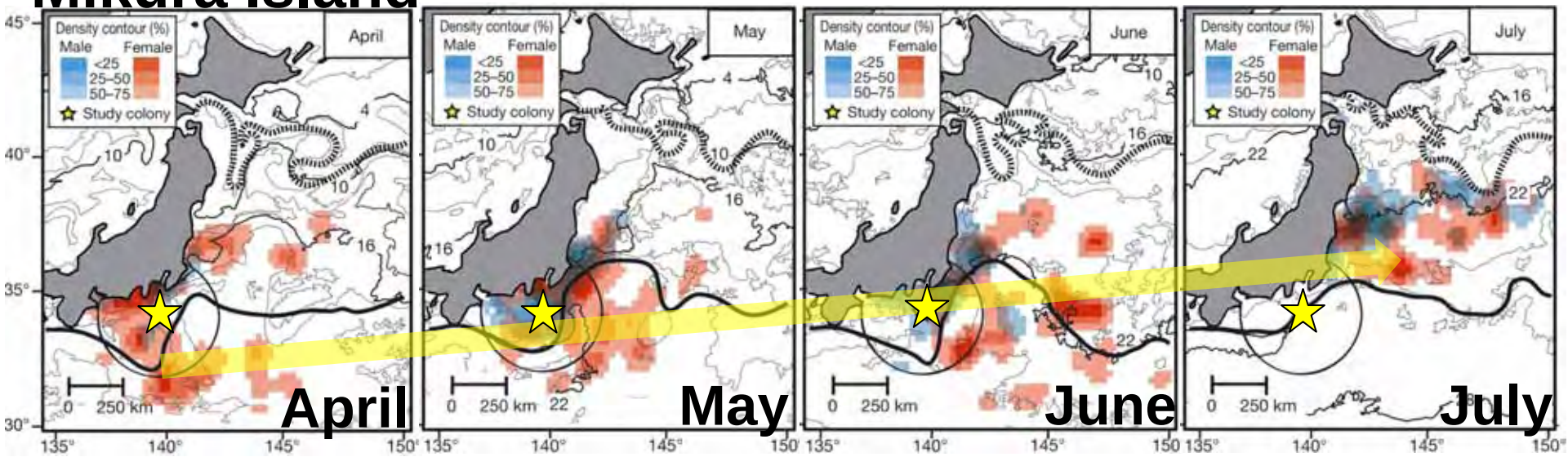
- Monthly composite sea surface temperature (resolution of 9 km, Aqua-MODIS)

Foraging area of streaked shearwaters

Sangan Island

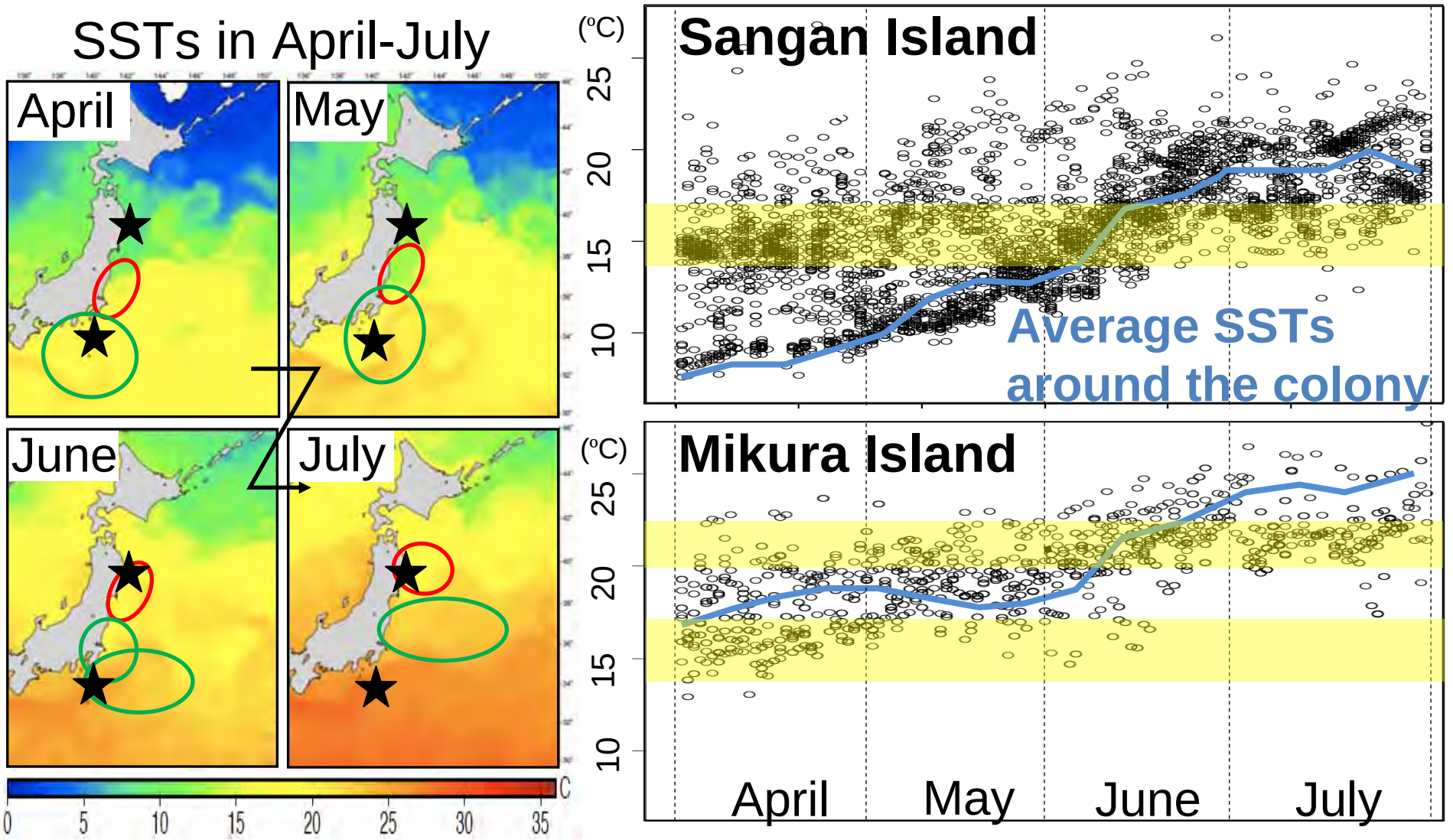


Mikura Island



Foraging areas shifted seasonally towards north

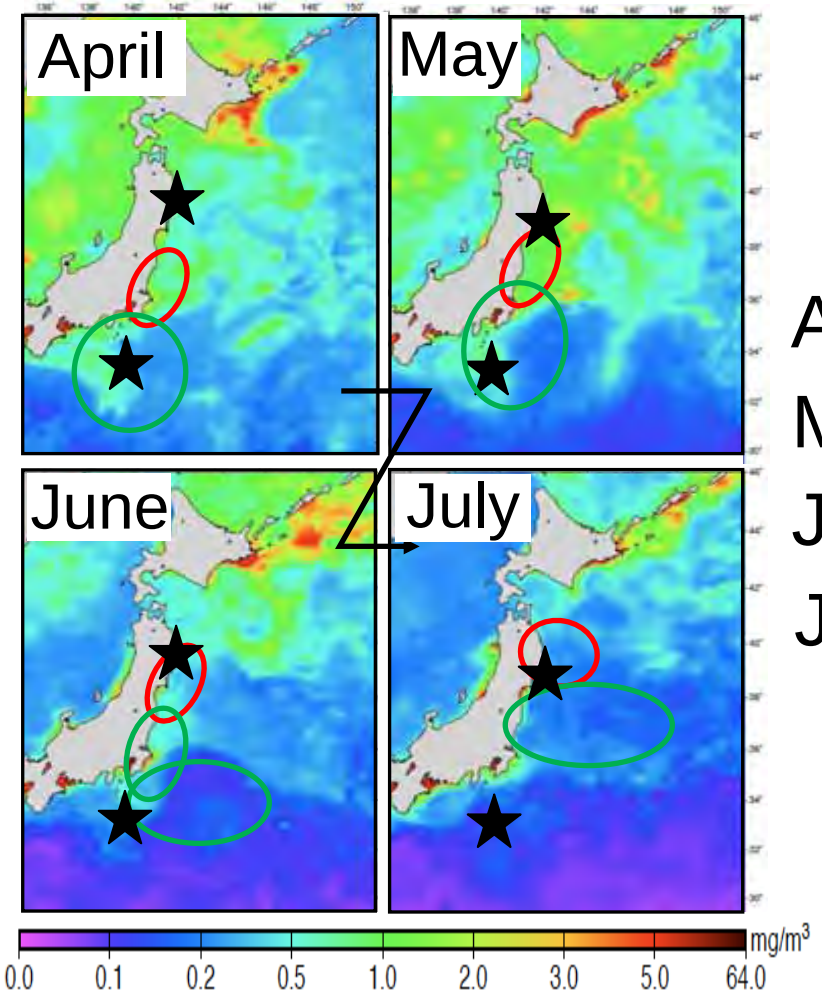
Water temperatures used by shearwaters



Streaked shearwaters appeared to occupy areas with a restricted range of SSTs (14−17ºC, 20−22ºC)

Chlorophyll a concentration in foraging area

Chl a concentration in April-July



	Sangan Island	Mikura Island
April:	0.97±0.47	0.97±1.24
May:	1.37±0.39	0.75±0.63
June:	0.54±0.30	0.38±0.29
July:	0.37±0.15	0.24±0.09

* Values are in mg m^{-3}

Foraging area of streaked shearwaters did not always coincide with areas of high chlorophyll a concentration

Discussion

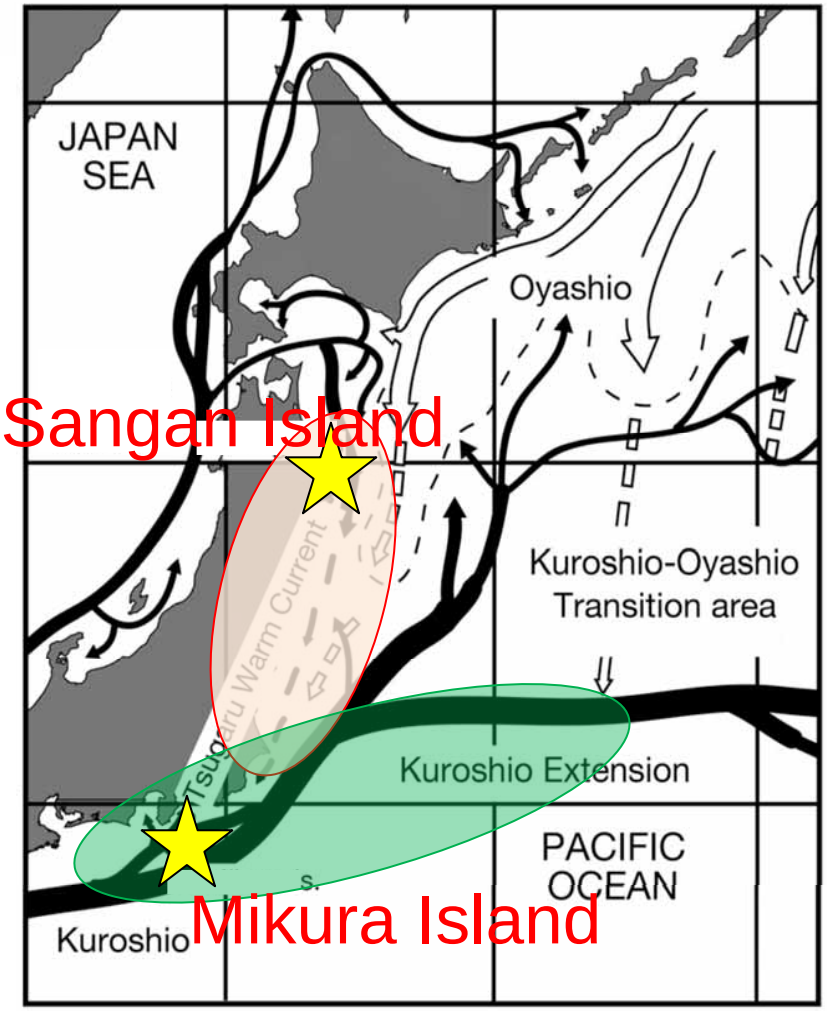
Distribution of pelagic fish is affected by water temperature

e.g.) Japanese anchovy prefer 13-15ºC for feeding and >20ºC for spawning (Mihara 1998, Oozeki et al. 2007)

Pelagic fishes, including anchovy, migrate northward in association with increasing SST from spring to summer (Odate 1994, Mihara 1998, Iwahashi et al. 2006)

Streaked shearwaters changed their foraging areas to follow the northward migration of their fish prey

Inter-colony differences in foraging area



Sangan Island

Kuroshio-Oyashio transition

Mikura Island

Kuroshio & Kuroshio Extension

- Accessibility from the colony (Cairns 1989)
- Avoidance of intra-specific resource competition (Lewis et al. 2001)

Sexual differences in foraging area

Males returned to the colony more frequently, probably to engage in territorial defence

Percentage of nights returned to the colony

April−June (Pre-laying period)
Males 48−70% Females 24−40%

July (Incubation period)
Males 52−56% Females 52−60%

Time available for foraging may be limited for males by the need to attend the colony

Summary

- **Streaked shearwaters changed foraging areas, moving northwards as sea surface temperatures increased seasonally in the Northwestern Pacific**
  - Responding to the general northward movement of their prey fish species
- **Patterns of change in foraging area differed between colonies as well as between sexes**
  - Accessibility from the colony or avoidance of intra-specific resource competition
  - Sexual differences in breeding role

Conclusion

“Hotspots” representing for seabirds can change seasonally in response to seasonal change in the distribution of their prey

Environmental responses of seabirds may be limited by colony location and sex-specific breeding constraints