

Assessments of Sea of Japan Area A stock



Kay Sakuma

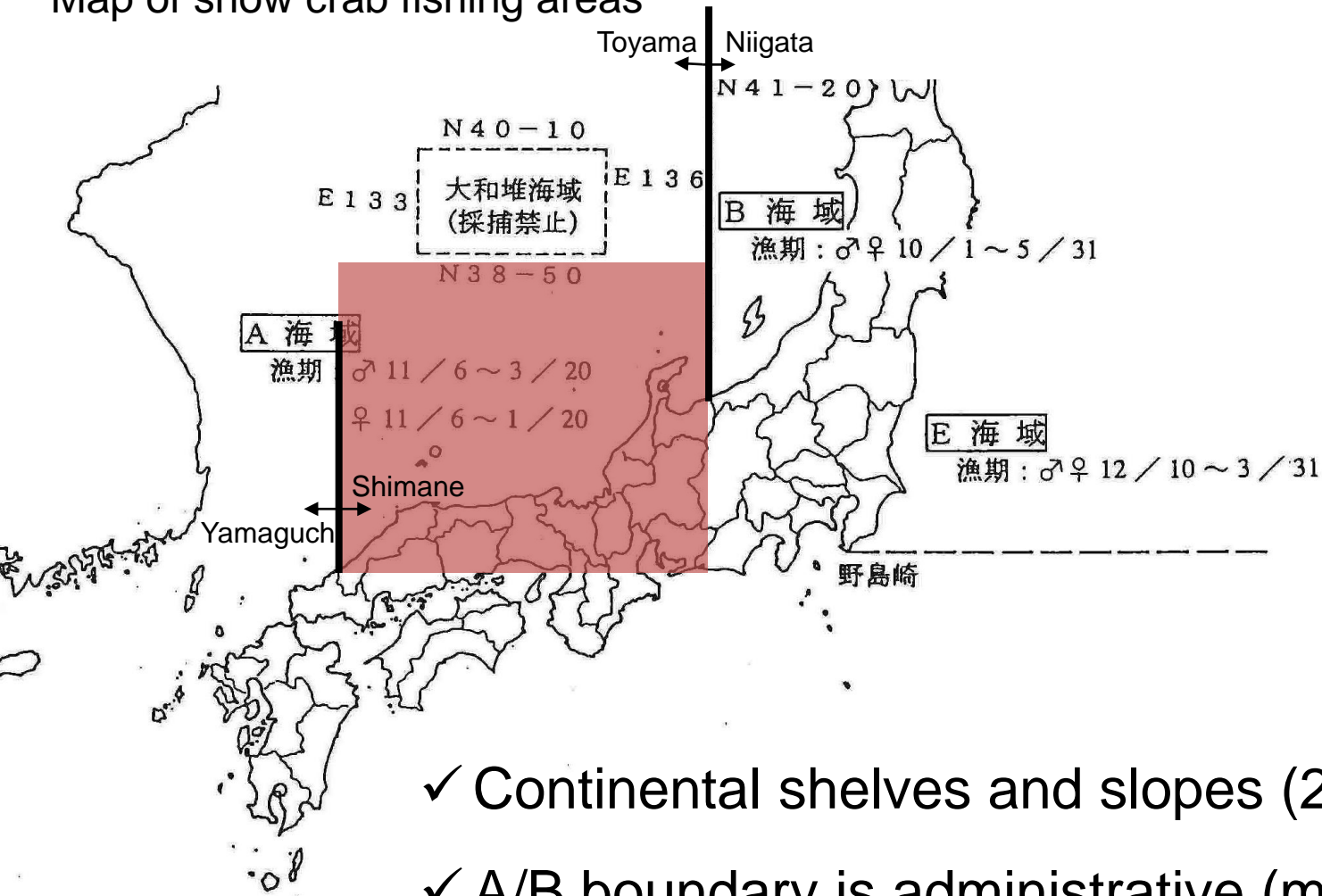


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Sea of Japan Area A stock



Map of snow crab fishing areas



- ✓ Continental shelves and slopes (200–500 m depth)
- ✓ A/B boundary is administrative (management units)
- ✓ Danish seiners and crab pod fisheries are allowed

Sea of Japan Area A/B stocks



Sea of Japan Area A stock

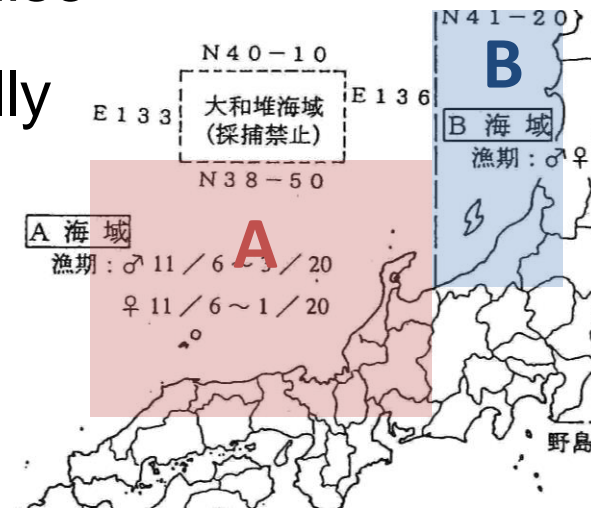


- Large vessels
(<100 T, gross tonnage)
- 3~5 days / cruise
- Annual catch of 2,000~3,000 t
- Targeted by higher prices
- Strict rules for self-regulations

Sea of Japan Area B stock



- small vessels (<15 T)
- One-day cruise
- 200 t annually
- Lower price

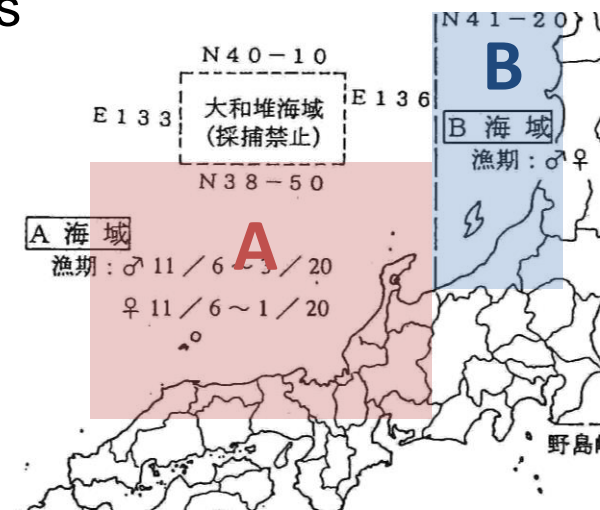


Questions regarding Stock area



- The split of the snow crab in the Sea of Japan into 2 stocks is surprising. It would be a good idea to discuss stock structure of the Sea of Japan A and B stocks at the same time (Teo, general comment)
- Given the geography of the Sea of Japan and the biology of snow crabs, one would expect a single snow crab stock around the whole Sea of Japan. What is the evidence for having two snow crab stocks in the Sea of Japan (Area A ad B)? Or is the separation due to management units? (Teo #1)

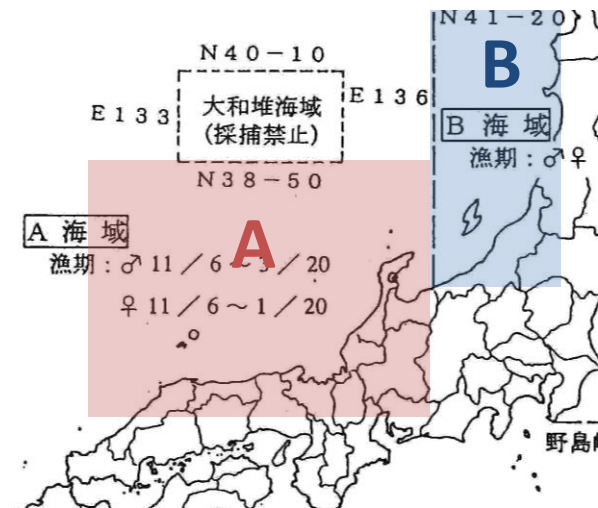
- ✓ Boundaries between Area A/B are administrative (management units)
- ✓ Different types of fisheries and fishing rules accordingly
- ✓ Currently no biological evidence of stock structure has been found
- ✓ Quality and quantity of available data is also different in Area A/B
- ✓ Integrated model analyses (SAM etc.) in future



Questions regarding different assumption of M



- Assumptions regarding natural mortality are consistent for Areas A and B (M is time-invariant, but different for immature and mature individuals), but differ for the North Pacific stock (M is time-varying, and assumed to be the same for immature and mature individuals). Further justification of the biological and/or environmental basis for these differences would be helpful (Dick #1)
- ✓ Time-varying M is for better fitting, relaxing assumptions in M (North Pacific)
- ✓ Time-invariant M is a “base-case” (in the Sea of Japan A/B) but can be useful as an alternative in future (by applying state-space models)



Questions regarding male-only retention



- What are the pros and cons of implementing a male-only retention fishery, in addition to requiring minimum sizes and implementing seasonal closures? (Dick #2)

Pros

- ✓ Closing of female snow crab fishery is effective for maintaining SSB
- ✓ Snow crab is polygamic and a single male can contribute multiple spawnings
- ✓ Balance of males and females may not be required for maintaining stock abundance

Cons

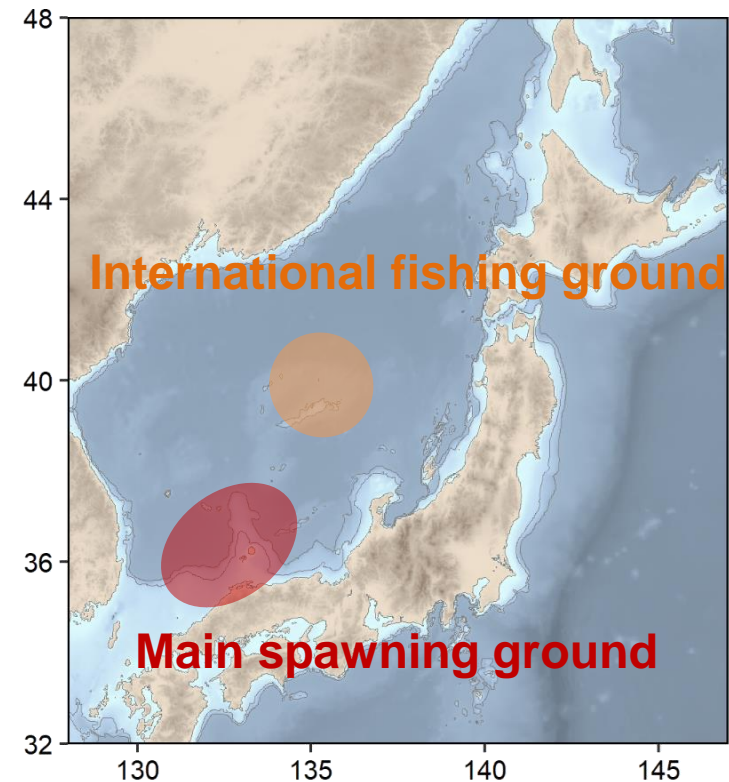
- ✓ Severely imbalanced sex-ratio can cause sperm-limitation (insufficient egg fertilization due to limited quality/quantity of sperms) that potentially trigger stock decline
(Carver et al., 2005; Sainte-Marie et al., 2008; Baker et al., 2022)
- ✓ Closure of female fishing can cause concentration of fishing pressure upon males

Questions regarding international fishery



- Are there snow crabs along the Korean peninsula and Russian sides of the Sea of Japan? If so, are these crabs included in this or the Area B assessment? (Teo #2)
- Are any parts of the Sea of Japan considered international waters? (Teo #4)
- It looks like the catch by South Korea in Fig 7-1 and Suppl Table 5-1 is included in this assessment. Is that correct? (Teo #5)
- Is there likely to be catch by China, North Korea and Russia? (Teo #6)

- ✓ Korean and Russian fleets catch snow crabs in their EEZ but not included in the assessment.
- ✓ Chinese catch has not been reported
- ✓ Know main spawning area is in Area A and no migration is assumed after larval settlement.
- ✓ Korean catch in Japan-Korea provisional fishing zone is treated as unknown constant mortality and probably included in transition rate.
- ✓ No snow crab catch in international waters.

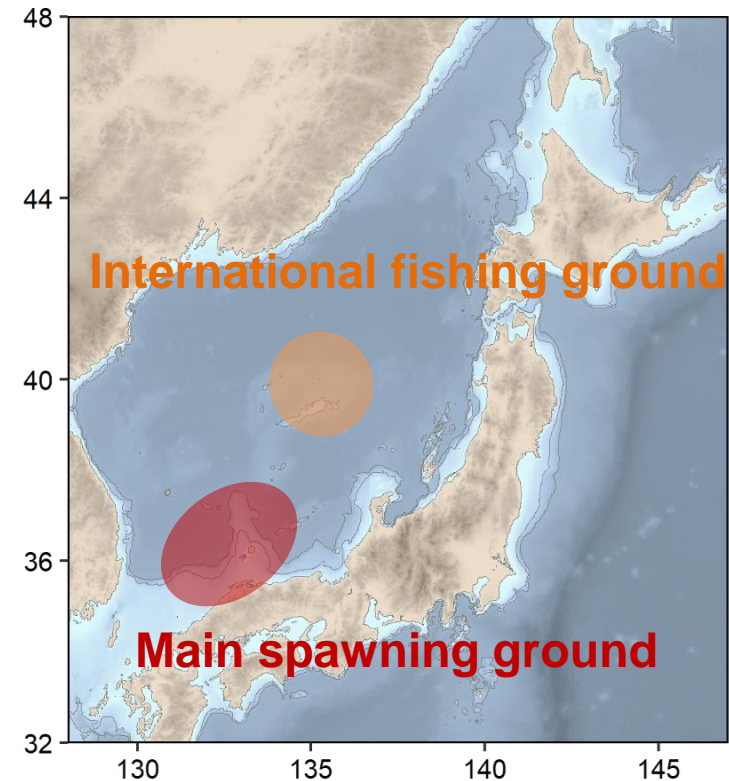


Questions regarding international fishery



- Reported catches could be scaled to reflect rough estimates of South Korean catch based on ratios of total catch by each country shown in Fig. 7-1. Alternative assumptions about the fraction of South Korean catch that comes from the Japanese EEZ could be explored to determine the sensitivity of model outcomes to possible sources of unreported catch. (Dick #19)

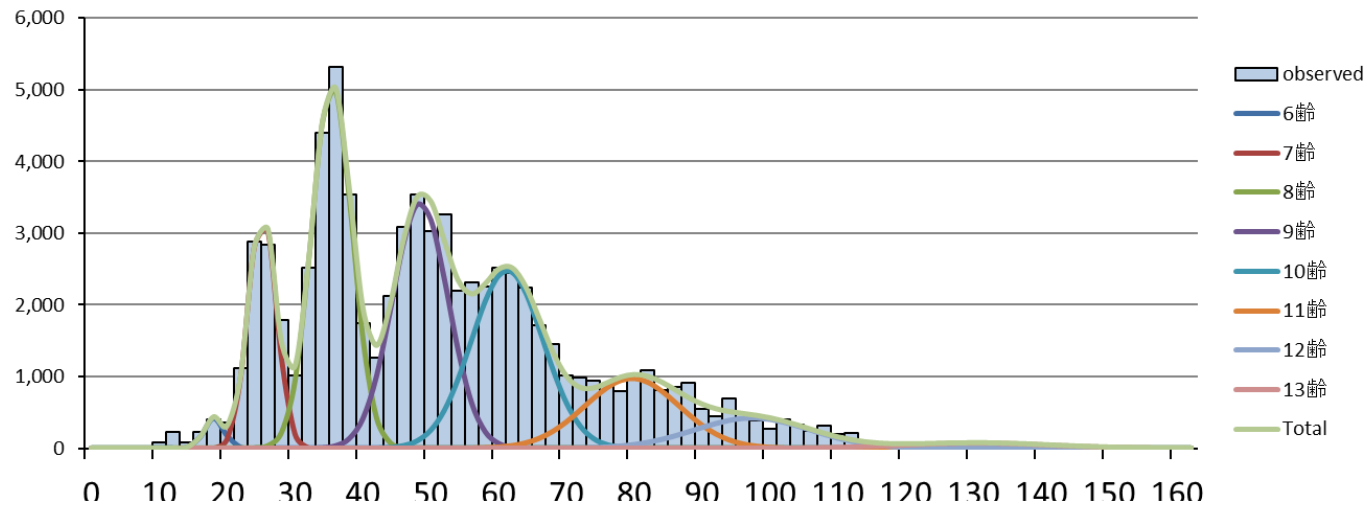
- ✓ Korean fleets catch snow crabs is not included in the assessment.
- ✓ No regional information about Korean catch (in/out of Japanese EEZ)
- ✓ If detailed information is available thanks to Korean government, we would include Korean catch in the model.



Questions regarding data (size/instars)



- Is there any uncertainty with regards to the sizes associated with each instar? (Teo #9)
 - Is my reading correct that the data is sliced into instars before being fit in the model? (Teo #10)
 - Please add lines in Fig 4-3 and 4-4 to show where the splits occur. And also please show the same figures for the females. Also show the same for the catch data. (Teo #11)
 - Please show the uncertainty in the N-at-instar observations from the survey in Supplementary Table 2-1 and Supplementary Figure 2-1. (Teo #19)
- ✓ Size (Carapace width) frequency data is converted into instar-composition by applying gaussian mixture model (not cohort slicing).
- ✓ Uncertainty regarding Gaussian mixture model but not considered in the following VPA, reference points and projection.



Questions regarding data (size/instars)

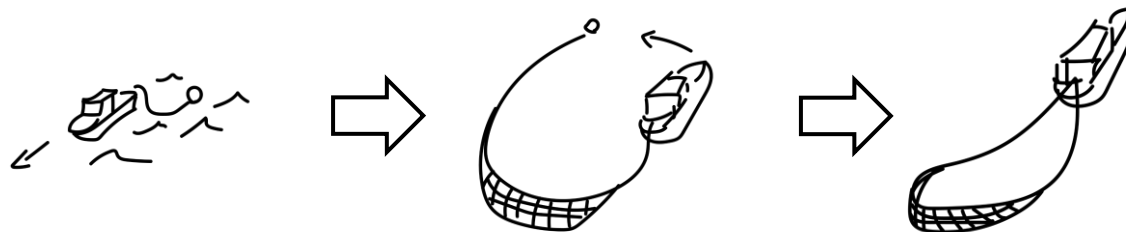


- I see Appendix 7 is a document on revisions of the Hyogo commercial size category key. Does that mean that there is no size sampling of the commercial catch? Does that mean the commercial size category catch data is converted directly into catch-at-instar data? If so, please show the keys and how they have changed over time. What is the evidence that the CSC keys do a good job of converting into catch-at-instar data? And what is the uncertainty in the CSC keys? (#Teo 12)
- ✓ Commercial catch size frequency is collected from the three prefectures of Hyogo, Kyoto and Tottori
- ✓ Hyogo data is based on commercial size category key but with annual sampling of carapace width at each commercial size category and cohort slicing
- ✓ Tottori and Kyoto data is based on exhaustive sampling of carapace width through all fisheries size categories and cohort slicing

Questions regarding abundance indices



- Table 3-3. The unit of effort seems to be nets, which is relatively crude. Is there any data on the size of nets and length of time a single trawl lasts and the variability of these trawls? (Teo#13)
 - Table 4-1. Is this the nominal CPUE from the commercial bottom trawl fishery? Is this commercial trawl CPUE fitted in the assessment? (Teo#15)
 - What are the commercial abundance indices in Appendix 6 used for? Please plot these indices over the survey indices for the same classes. (Teo#16)
 - Q21. The unit of effort for the logbook index is the number of nets. Do tow durations differ systematically among vessels, areas, or other factors? If so, this could bias the CPUE calculation used to derive the index. (Dick #21)
-
- ✓ Number of casts is only available effort data in Japanese trawlers' logbooks
 - ✓ Difficulties in defining length of time, swept area and net efficiency for Danish seiners, the main fishery of snow crab in SJA
 - ✓ Density index is area-average of catch-only CPUE and currently not used in the stock assessment model

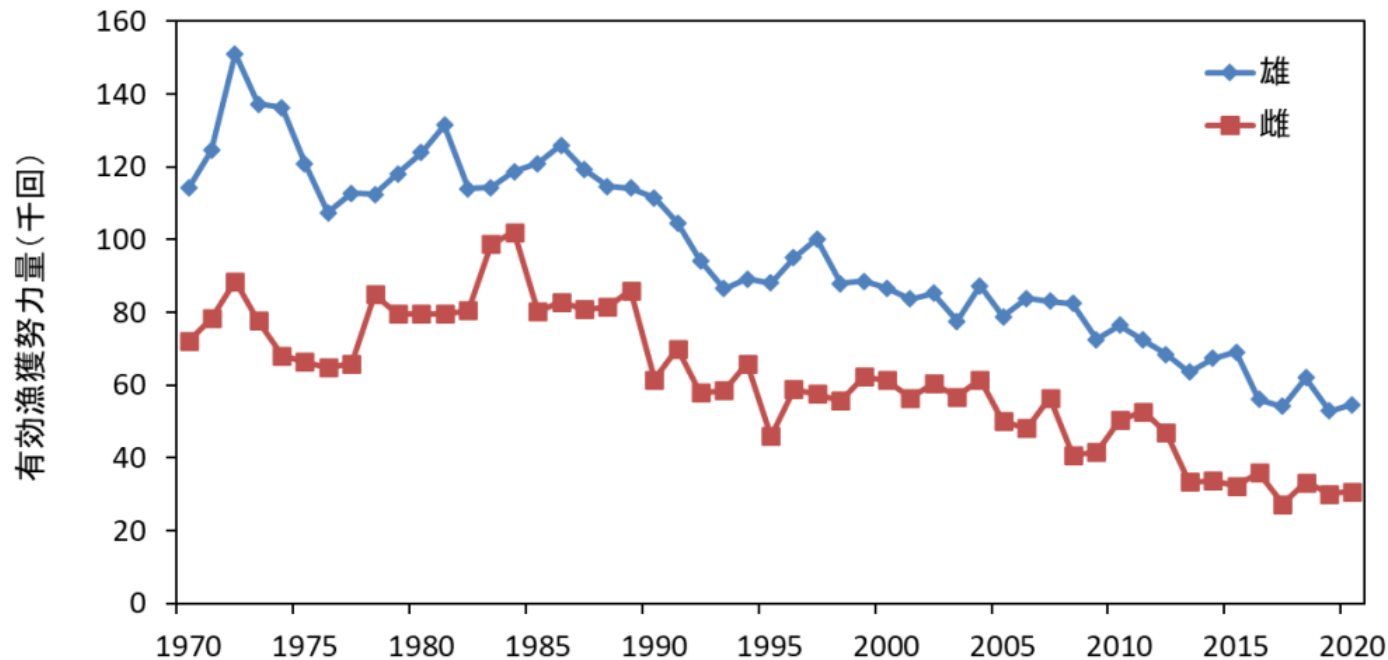


Questions regarding data (size/instars)



- How do you tell if the effort is for male or female crabs? (Teo#14)
- In the description of fishing effort, “effective effort” is reported by sex (55,000 casts for males, and 31,000 for females). Can you describe why effective effort differs so much by sex? (Dick #15)

- ✓ Effective effort is calculated by number of casts with male/female snow crab catch
- ✓ Male/female snow crabs are completely sorted onboard in SJA
- ✓ The duration of the fishing season is different (231d for males, 55d for females)



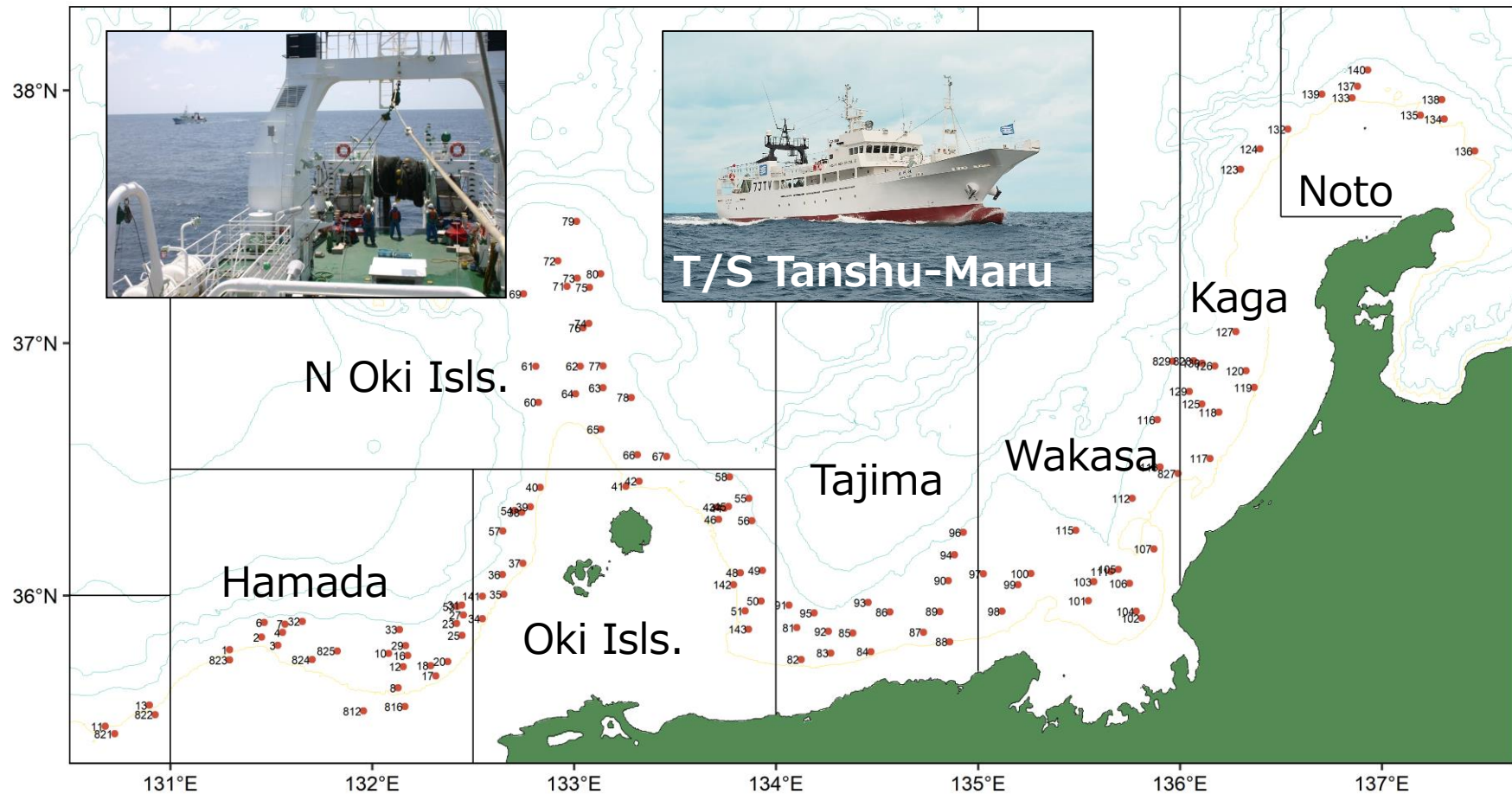
Questions regarding trawl surveys



- Given that population estimates from the survey are being used as N-at-instar observations to which the model is trying to fit to, it is important to understand the survey design and operations, and how those N-at-instar observations were estimated. Please explain in detail the survey design and operations, and how the N-at-instar observations were estimated. (Teo #17)
 - Importantly, it is important to know if the survey covers the entire stock range, and if not how to compensate for the excluded areas? (Teo #18)
 - Are there snow crabs in deeper areas that are harder to fish? (Teo #3)
 - The transition rate for mature individuals (Appendix 2, equation 2) assumes 100% capture efficiency. Does the stock extend outside the fished area, or deeper than fishing gear is deployed by the fleet? Does the average size of individuals continue to increase for depths deeper than the fishing grounds? This would result in a dome-shaped pattern in catch efficiency, and an assumption of 100% efficiency could underestimate the stock size (Teo #20)
- ✓ The coverage of the survey is assumed to be enough for assessment

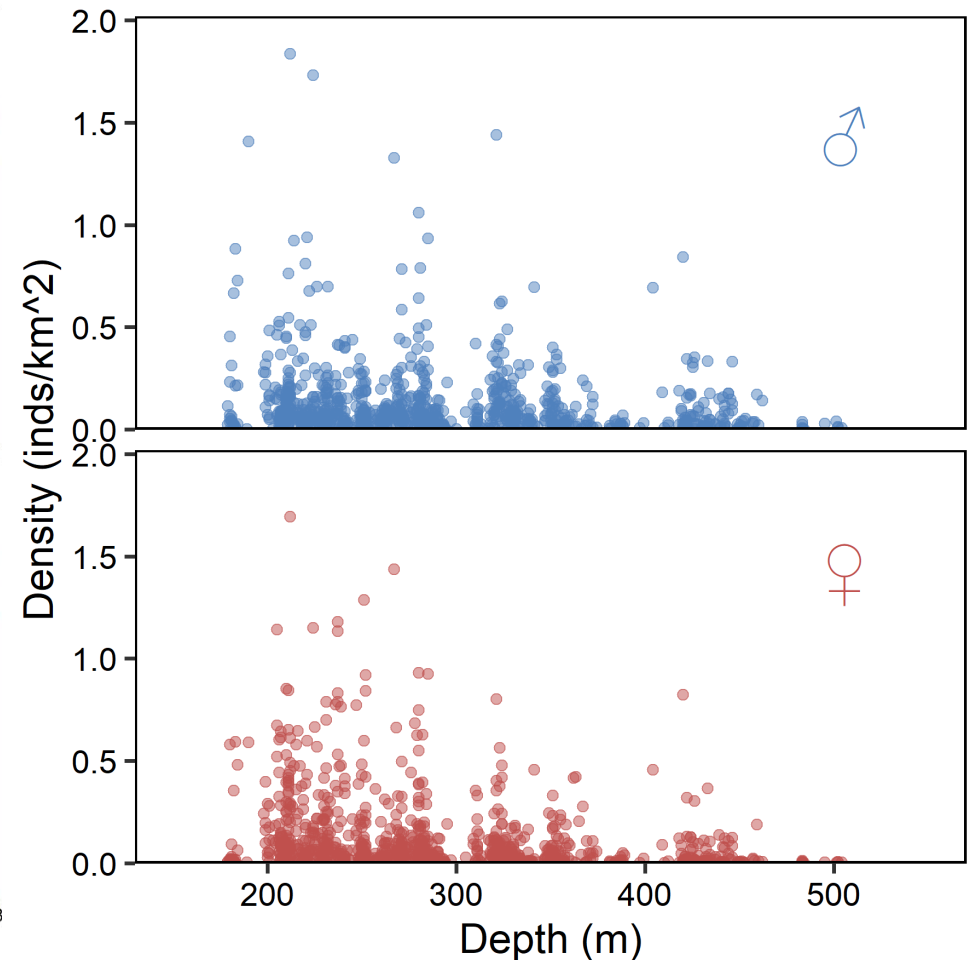
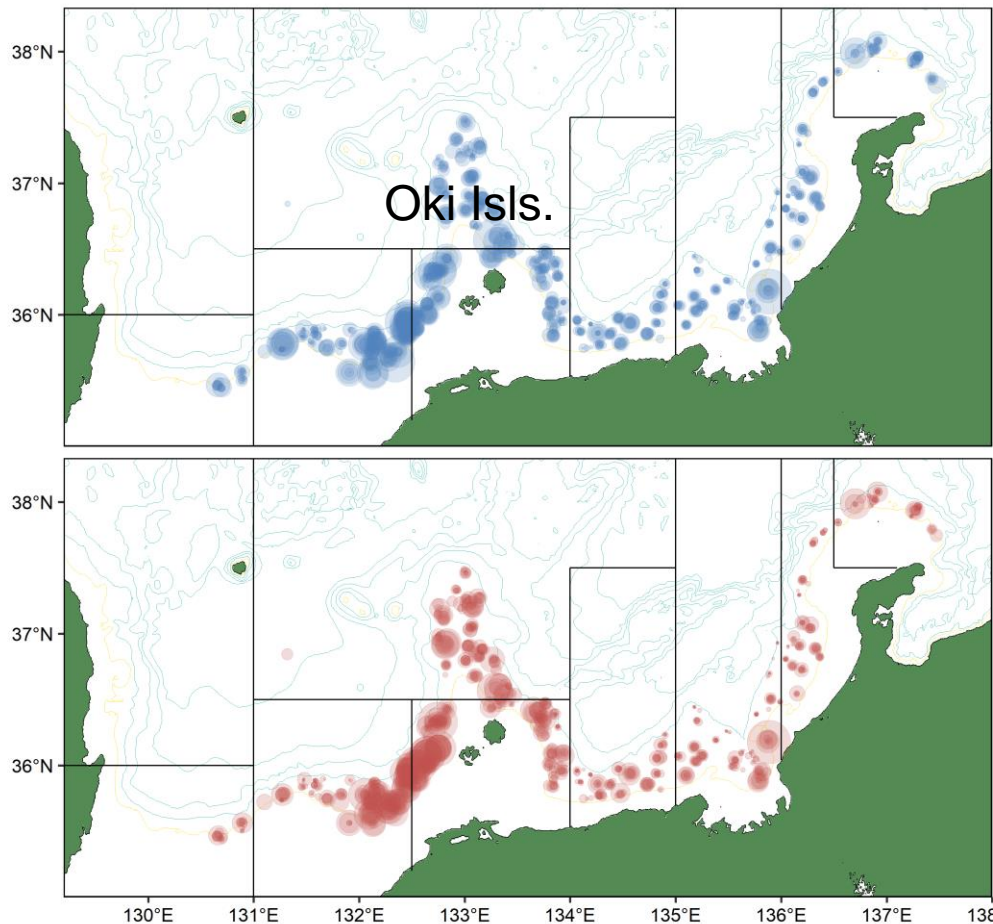
Stratified sampling

- 140 sites in 23 layers
- 7 areas × 4 depth range (150-190, 190-300, 300-400, 400-500)



Coverage of the habitat area/depth

- Main fishing ground around Oki Islands is covered by the survey
- Depth range is also sufficiently covered





Trawl operations

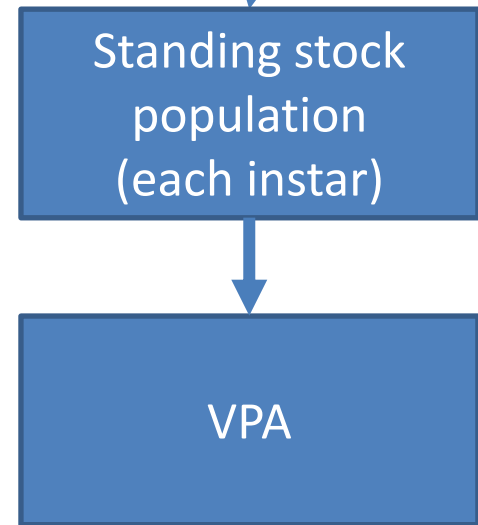
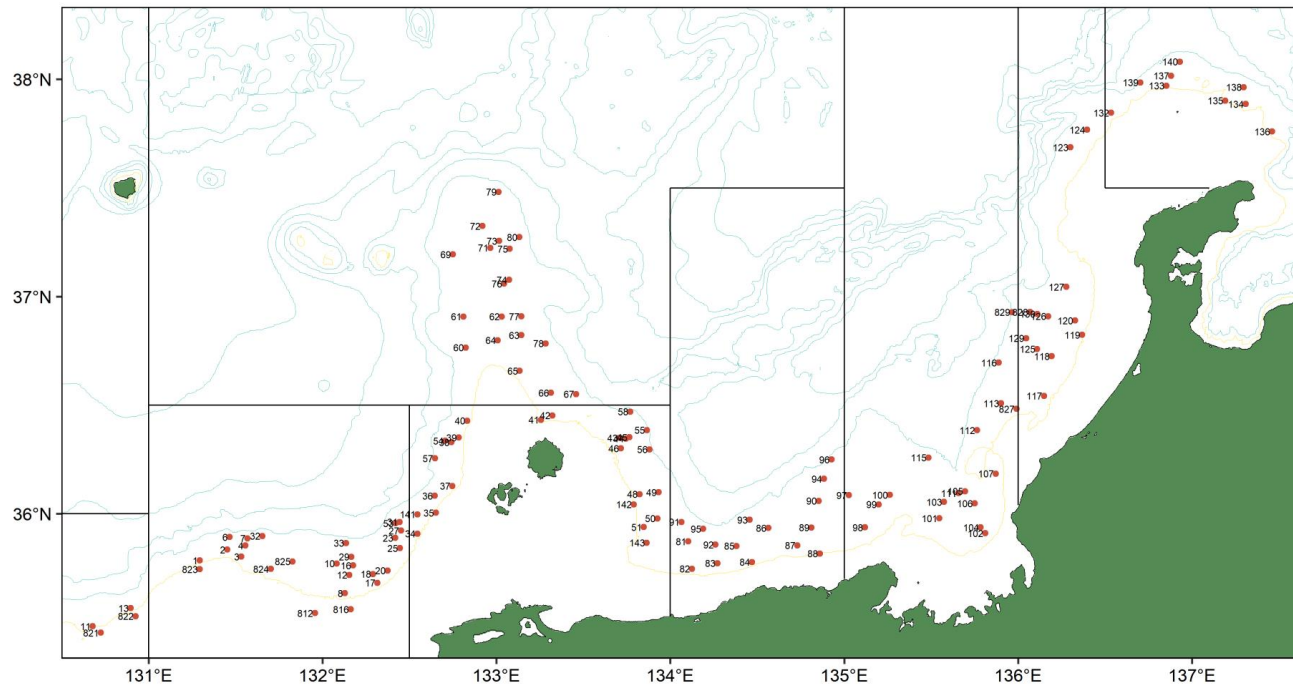
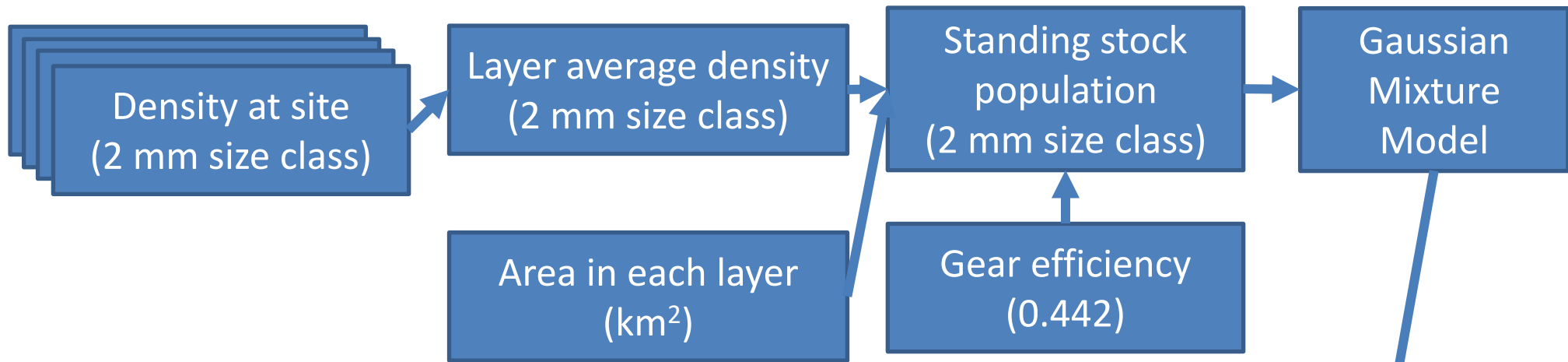
- Otter trawl net towed from double warp
- net mouth opening ca. 17×3.5 m
- Standard haul time of 30 min with 3.0 knot (1.5 nm)
- SCANMAR system (Scanmar AS, Norway) for door and net mouth monitoring
- Actual towed distances from GPS

Measurement

- 5,000~10,000 individuals / year (all individuals)
- Carapace width (nearest 0.01 mm), sex, maturation stage, shell condition, etc.



Annual trawl surveys: data analysis





- In Appendix 3, it was stated that capture efficiency was 0.442. Is this the same for all sizes and all years? How was this capture efficiency estimated? (Teo #20)
 - In Appendix 4, the capture efficiency of the new net was estimated relative to the old nets. However, there was no explanation of how the capture efficiency of the old net was estimated. It seems implausible that the capture efficiency would be constant for all instars. Have there been experiments to estimate the capture efficiency by instar? (Teo #21)
-
- ✓ Catch efficiency of mature individuals is originally based on video observation
 - ✓ We assume 0.442 for mature, fisheries targeted males and females
 - ✓ Changes in catchability in smaller individuals are included in transition rates

Questions regarding natural mortality M



- M is subsumed into S for the main equations. However, in eqn 12 and 13, you somehow have M estimates? Please explain what these M estimates are.
(Teo #22)

- ✓ M is used for estimating number at the beginning of the fishing season (Nov 6) from estimated standing stock population at the survey (June 1)
- ✓ M is estimated for soft-shell and hardshell individuals by rearing experiment.

Questions regarding the cohort model

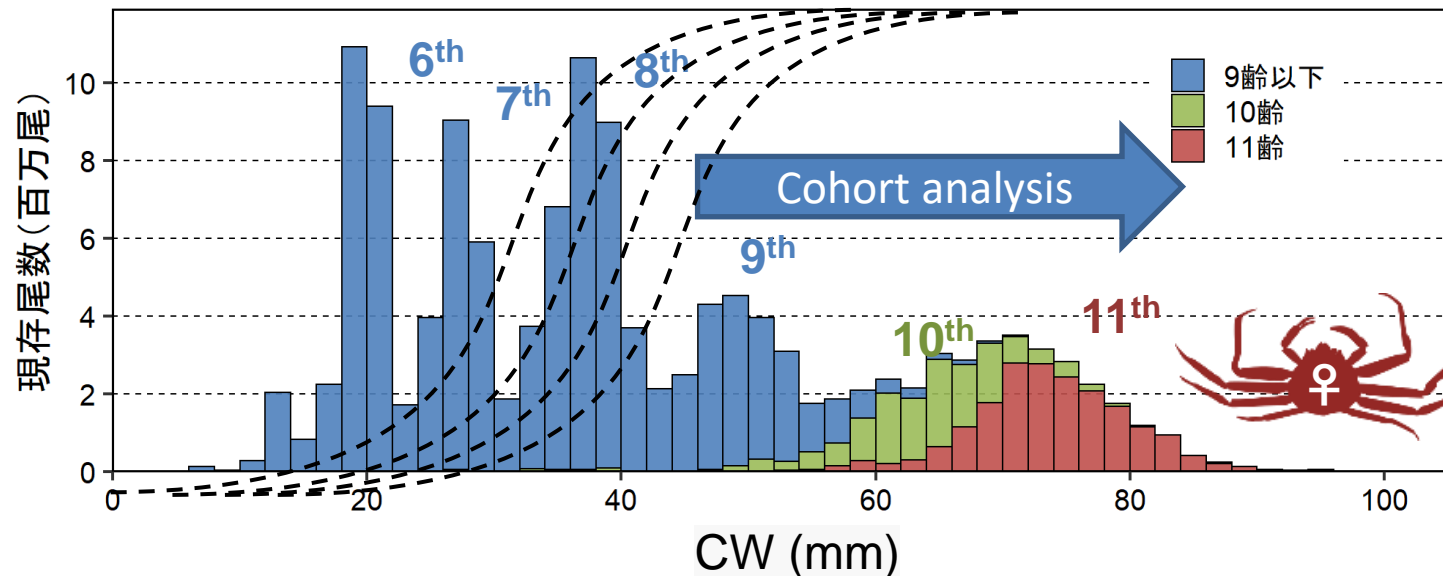
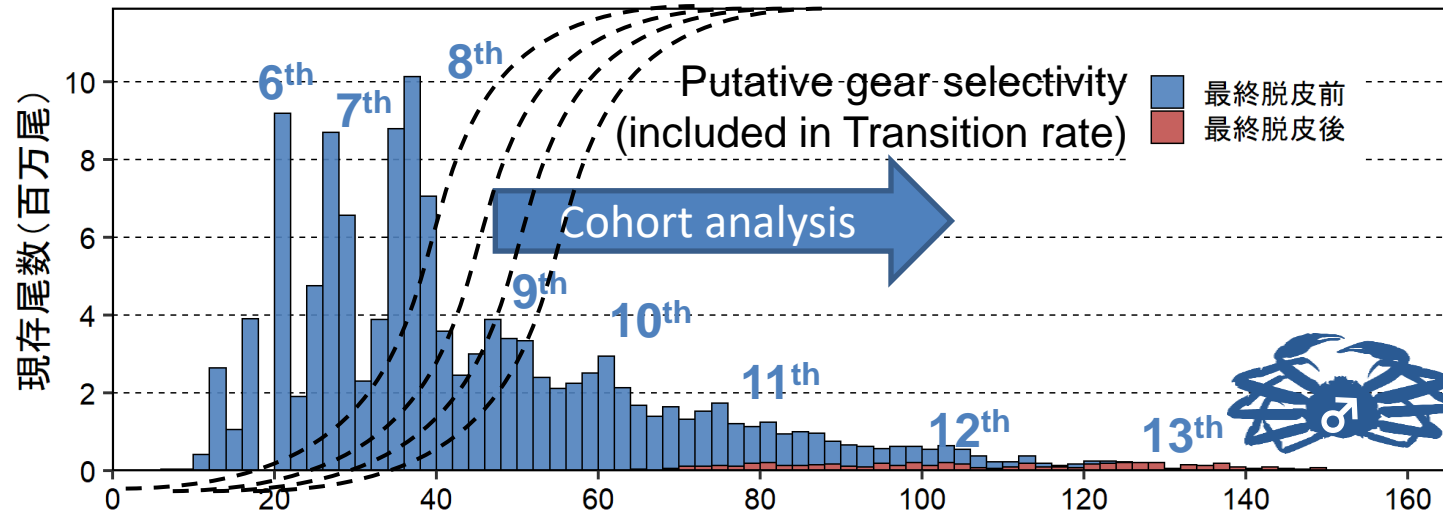


- The version of cohort analysis used in this stock assessment appears to be non-standard and somewhat unusual. If possible, please explain the model in detail so that I can understand it better.(Teo #23)
- Please explain why trawl efficiency differences by age would be put into the $S_{i,a}$ parameter. Wouldn't this be in the catch-at-age data? Or is this the survey trawl efficiency? If this is the survey trawl efficiency, experiments would be able to estimate this efficiency by size.(Teo #25)
- Why are the transition rates for the 9 and 10 instars >1 in Suppl Table 2-2?
(Teo #28)

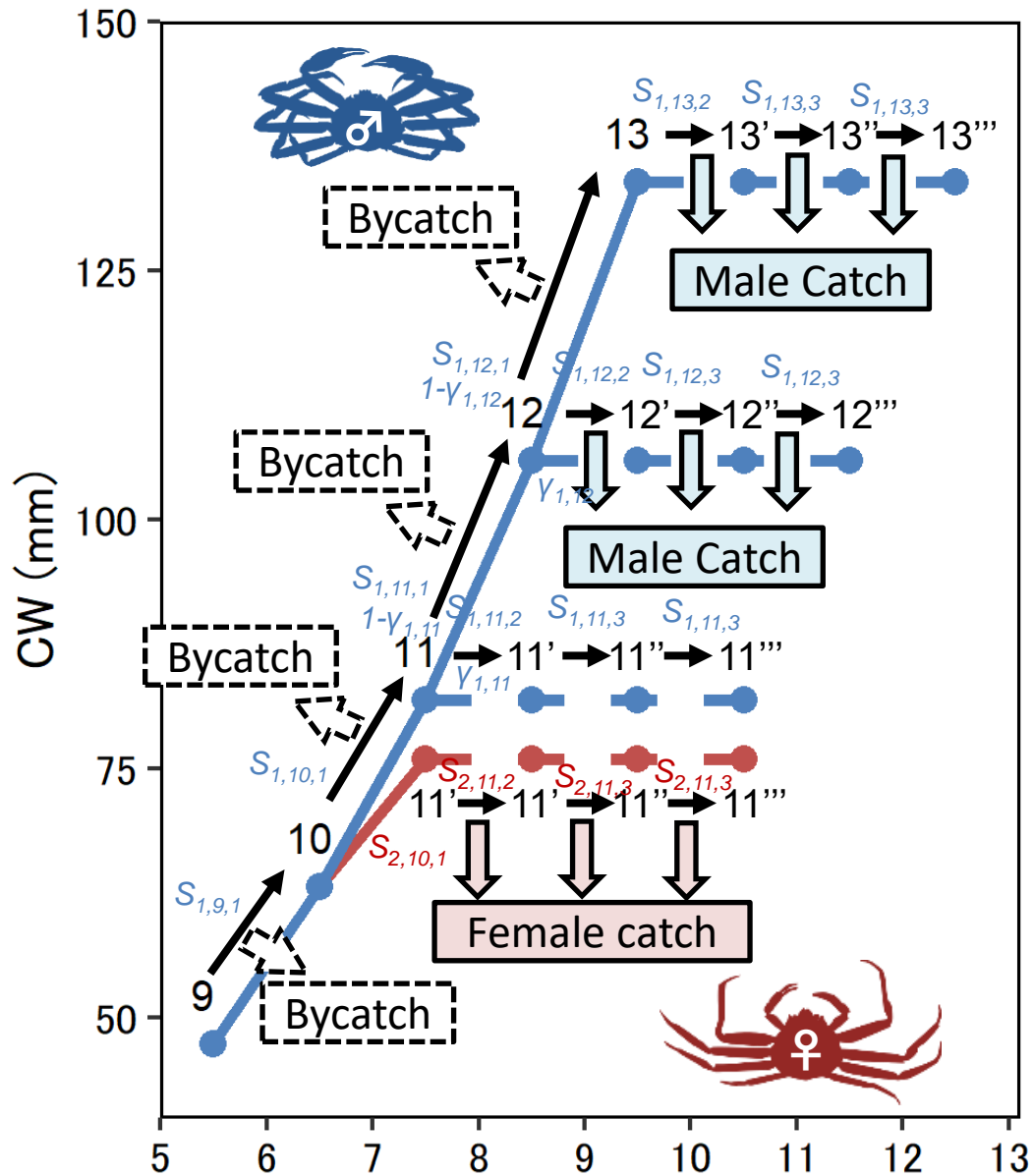
- ✓ Detail of the age-structured model is described in the following slides
- ✓ “Trawl efficiency” here means survey gear efficiency for each instars.
- ✓ We recognize the importance of exploring survey gear efficiency.

Questions regarding the cohort model

- Transition rate exceed 1 because of difference in gear efficiency between a^{th} and $a+1^{\text{th}}$ instar
- For large, fisheries targeted individuals, transition rate reflects natural and bycatch mortality and, increment due to difference of transition rates are not assumed



Structure of the cohort model



Assumptions

- ✓ Transition rate contains...
 - Mortality (M , bycatch, Korean catch, etc.)
 - changes in catchability (for juveniles)
 - emigration/immigration
- ✓ Ignore softshell catch
(bycatch mortality is much higher than F)
- ✓ Terminal molting rate and transition rates are constant throughout the time
(as a constraint, but can be time-varying)
- ✓ CAA is directly subtracted from NAA

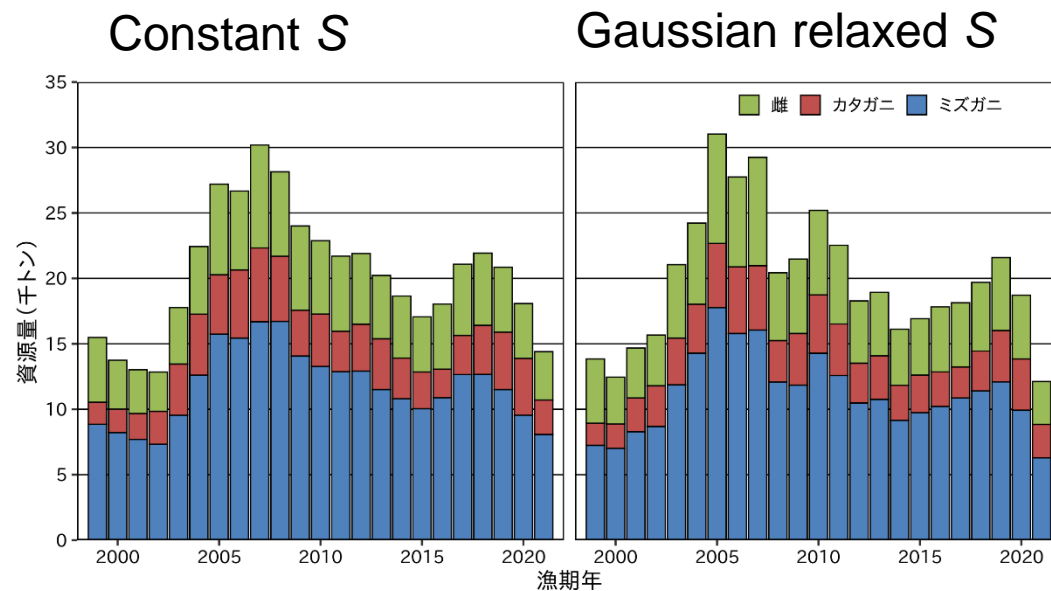
Questions regarding the cohort model



- The $S_{i,a}$ parameters seem to incorporate many processes (e.g., survival, discards, Korean catches) into a single parameter that is constant for all years for a single instar-class. I am not sure that this assumption all these processes form a constant proportion of the instar-class for all years is reasonable. For example, in Fig 7-1, there is one year when the Korean catches were the similar to Japanese catches while other years not so much. Also, discards should be more related to the effort of the non-crab bottom trawl effort rather than constant. Please explain why this constant S assumption is reasonable.

(Teo #24)

- ✓ Transition rate parameter can be time-varying (more realistic)
- ✓ Relaxing constraint upon transition rate causes overfitting
- ✓ Implement SAM in future...



Questions regarding the cohort model



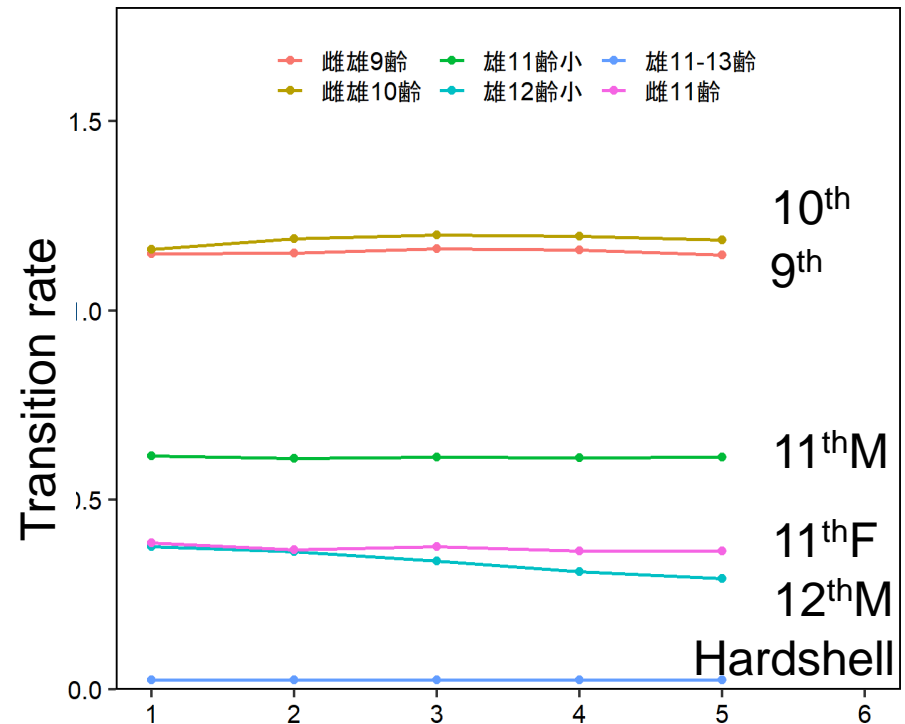
- Why are the transition rates for the male 11-13 instar so low in Suppl Table 2-2? (Teo #29)

✓ We assume that...

1. stock size of 11-13 hardshell males are underestimated (too high exploitation rate)

2. catch number of 11-13 hardshell males are overestimated

- Underestimation of survey efficiency
- Potential problems in cohort slicing

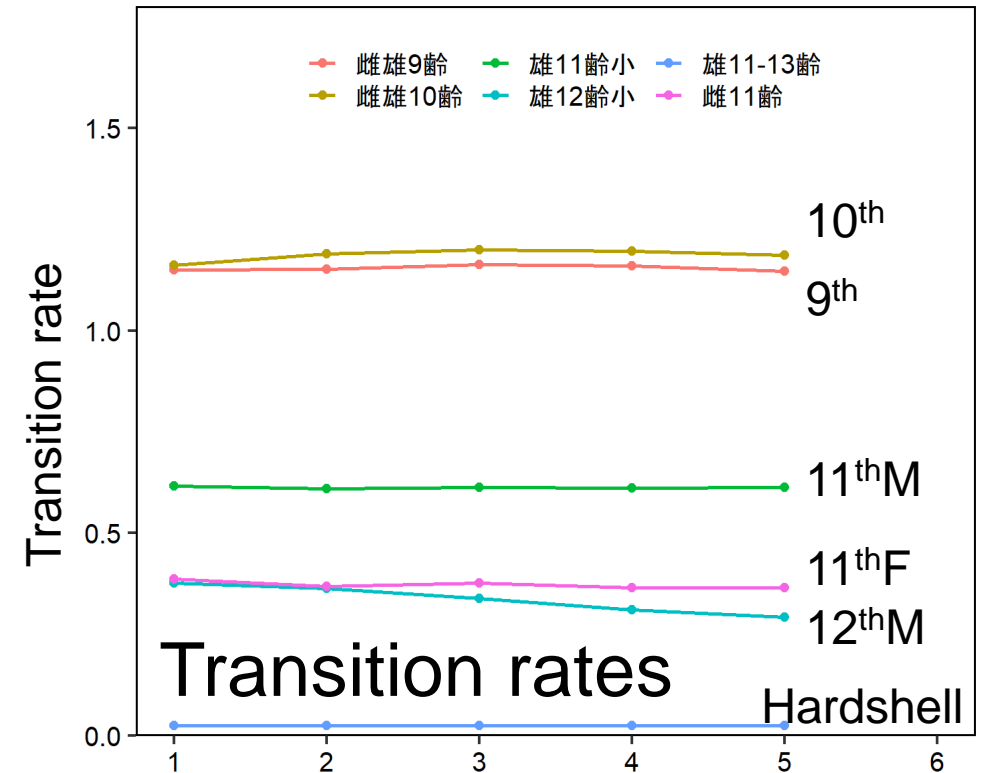
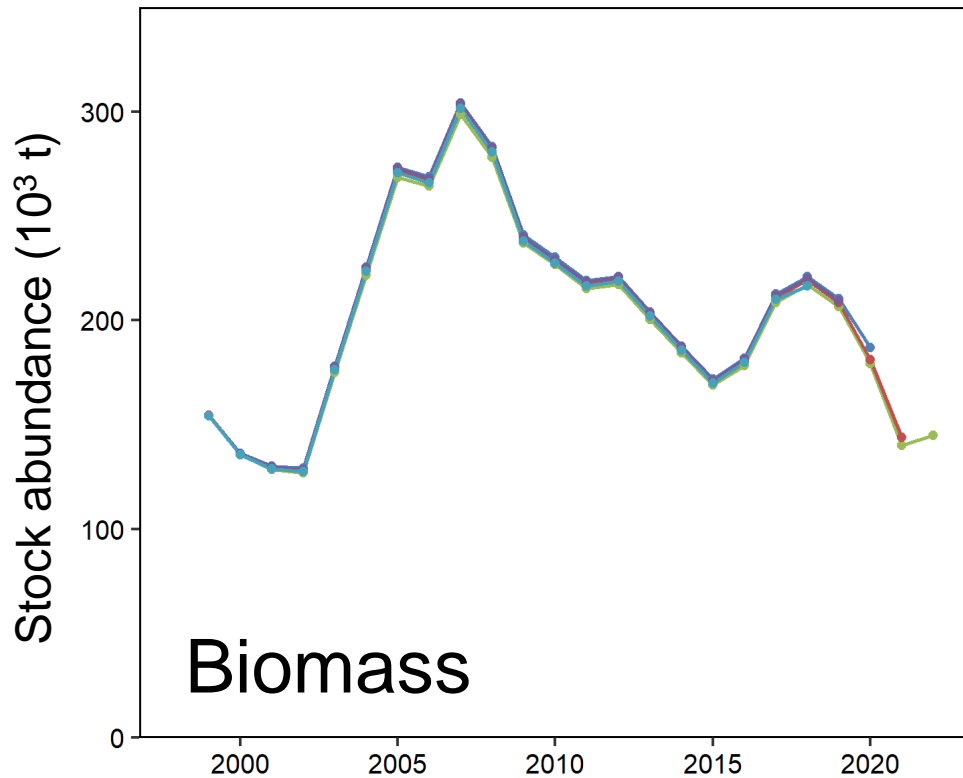


Retrospective patterns in iomass and Transition rates.

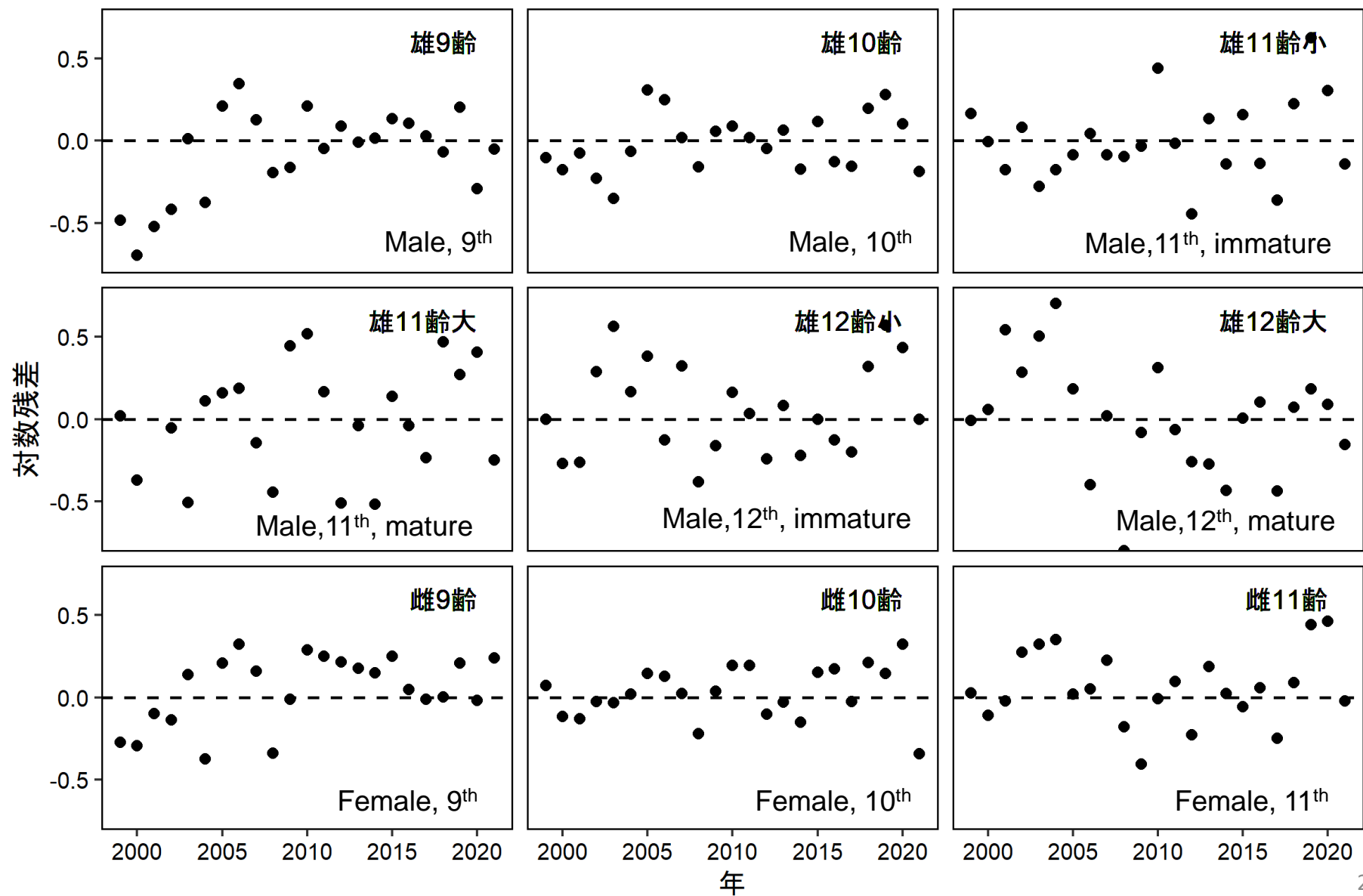


- Please show model diagnostics. For example, retrospective patterns. (Teo #32)

✓ Retrospective bias in biomass and transition rate is not prominent

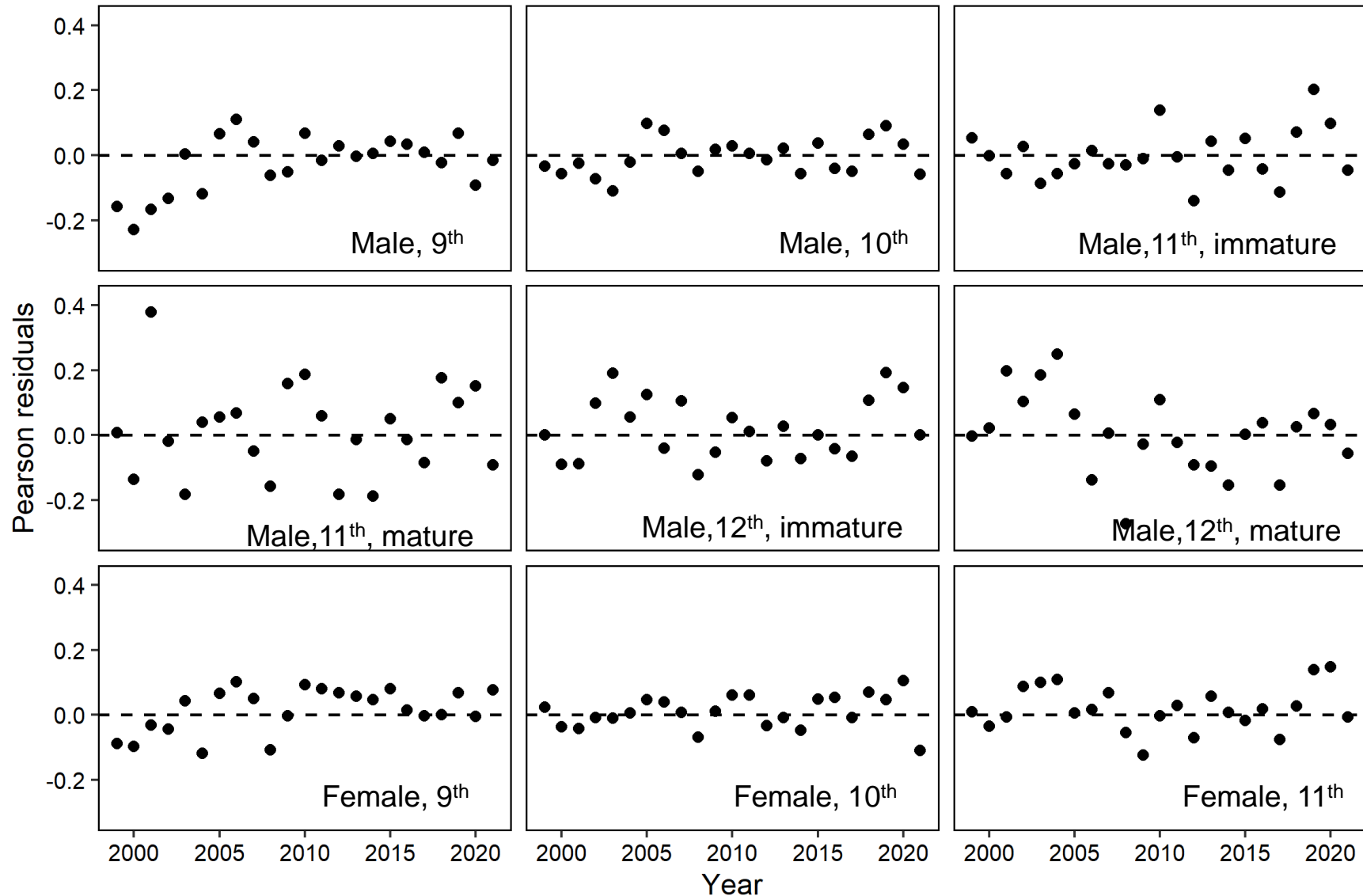


Log residuals



Pearson residuals

- Please show the Pearson residuals similar to Supp Fig 2-3 (Teo #27)





- Are there sources and estimated amounts of bycatch and dead discards? Has it been included in the assessment?
(Teo #7)
- It is strange that the future projections attempt to separate the bycatch mortality (G) from the S_i, a parameters by assuming that the G is a constant proportion of the F . I would think that the G would be a function of all the bottom trawl effort, including effort not targeted at snow crabs. Please explain why this assumption that the G is a constant proportion of the F is reasonable.
(Teo #26)

Assumption

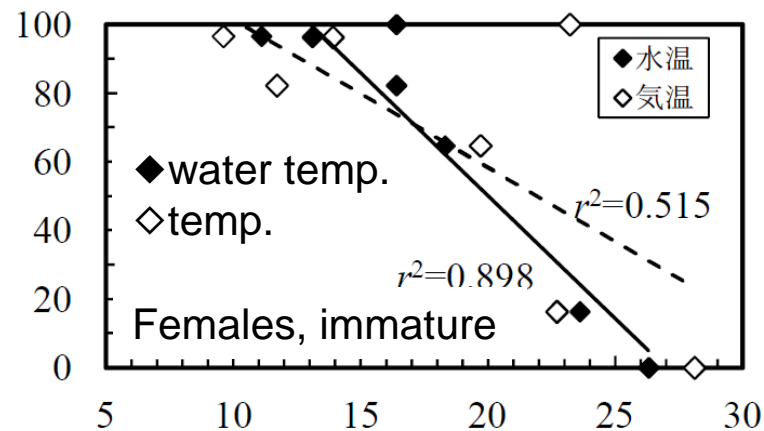
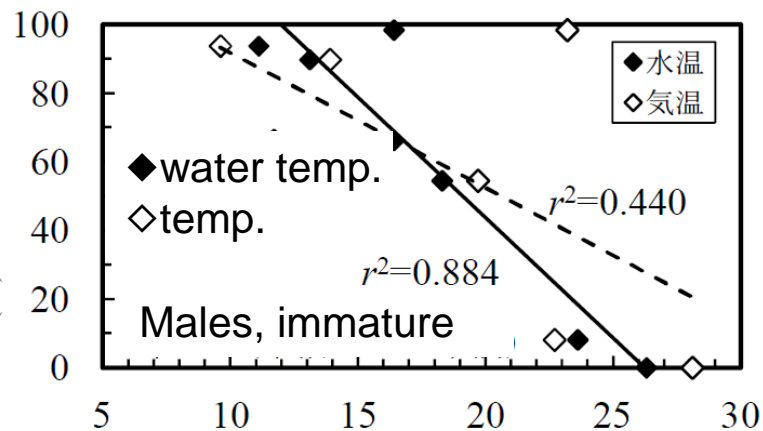
- G is a constant proportion of the F ($G=0.5 \times F$)
- Bycatch mortality itself is included in transition rate and we cannot observe it
- When F increases/decreases in projection, we assume more/less bycatch mortality in future.
- ✓ Effort in trawler's logbook may not be proportional to bycatch mortality, as complex annual self-regulations on catch number (for hardshell, softshell, females, respectively), days of closure after landing and landing size limits
- ✓ More detailed logbook data has been collected and analyzed for exploration of bycatch death and thus estimation of G

Questions regarding bycatch mortality



- To account for bycatch mortality in the forecasts, a proportionality constant ($\alpha=0.5$) is used to relate the bycatch coefficient to the fishing mortality rate, and applied to the 8th and 9th instar. Does this imply that instars less than 8 are not contacted by the gear, and if so, is that consistent with observations of the fishing fleet? (Dick #18)

- ✓ We assume bycatch death due to heat shock by high sea surface temperature in early fishing season (Yamasaki and Miyajima, 2013)
- ✓ Instars less than 8 are not considered because typical mesh size of Danish seiners is large enough for juvenile snow crabs to pass through



Yamasaki and Miyajima, 2013

Questions regarding SR

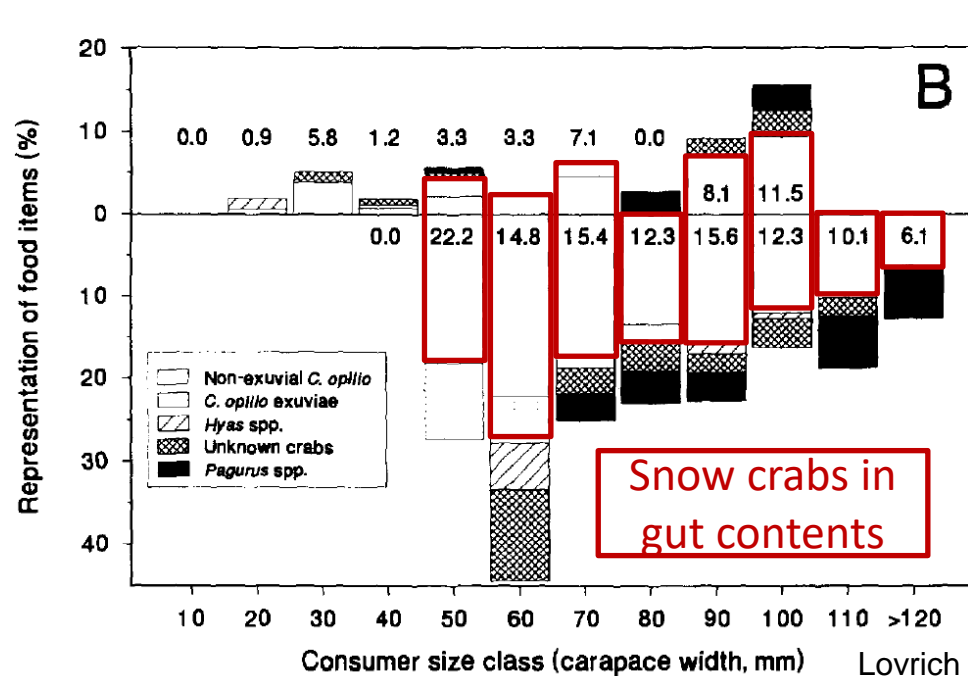


- It is surprising to me that a Ricker SR was used here. What were the reasons for using a Ricker? Is there any biological evidence of overcompensation? Or was the decision primarily due to management concerns, which would be outside the scope of this review? (Teo #33)

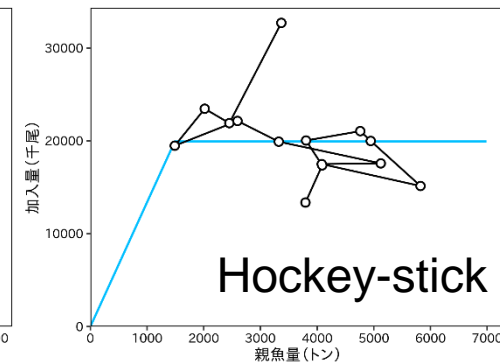
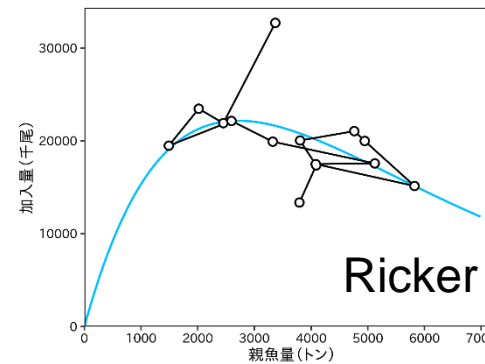
- ✓ Ricker is used because of density-dependent cannibalism

(Lovrich and Sainte-Marie, 1997; Sainte-Marie and Lafrance 2002)

- ✓ Ricker was chosen by AICc from Beverton-holt, Ricker and Hockey-stick



Immature & Adolescent
Adult



Questions regarding projections



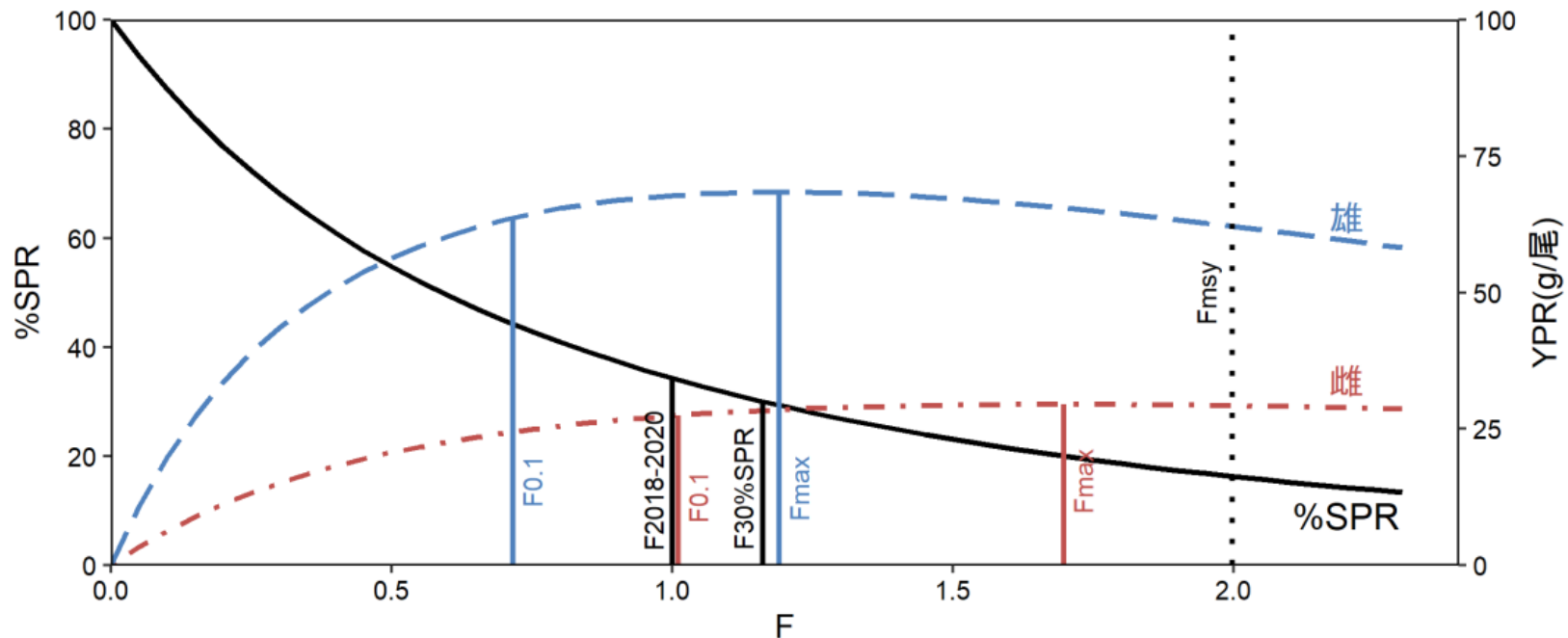
- If projections are important, please provide more detailed explanation of how the projections are done. (Teo #34)
 - In the future projections, was there consideration of uncertainty in the recruitment and N-at-stage estimates?(Teo #35)
 - Does future recruitment after 2023 include some amount of estimated variability around the SRR? (Teo #36)
 - If projections are important, it would be especially useful to test the prediction skill of the model over a range of horizons. Has there be an attempt to do so?
-
- ✓ Uncertainty in the recruitment is considered but that in N-at-stage estimates is not incorporated
 - ✓ Future recruitment is log-normally distributed around the model value.

Questions regarding projections



- Figure 4-10 indicates that F_{msy} (vertical dotted line) is greater than F_{max} (the F that maximizes yield per recruit) for both males and females. Can you describe why the estimate for F_{msy} is greater than F_{max} for both sexes? Typically, $F_{max} \geq F_{msy}$ because F_{max} does not account for the stock-recruitment relationship. (Dick #16)

- ✓ F_{msy} is estimated for total catch including males and females while F_{max} is for each of males and females.



Questions regarding uncertainty



- In general, is uncertainty in the assessment results important for the management of this stock?
- ✓ Japanese quantitative regulations (TAC) is deterministic and evaluation of the uncertainty in the assessment results was not mandatory.
- ✓ We are now trying to incorporate uncertainty stems from NAA, F, G and SR, following the change in the Japanese stock assessment scheme in recent years



- Would it be appropriate to change the modelling approach to more of a length-structured model? (Teo #39)
- I recommend exploring integrated analysis models for this stock (c.f. Turnock and Rugalo, 2015). The combination of a strong cohort signal in the size composition data and a long-term index of abundance (1970-present) would allow for simultaneous estimation of natural mortality and stock-recruitment parameters, recruitment deviations, growth parameters, and gear selectivity.
(Dick #22)

- ✓ I am now thinking about applying new model (i.e., state-space models), integrating growth function and mixed gaussian function
- ✓ Standardization of long-term indices is also required for the model implementation