Growth and shrinkage is sex-dependent in Antarctic krill

Geraint Tarling[1], Simeon Hill[1], Helen Peat[1], Sophie Fielding[1], Christian Reiss[2], Angus Atkinson[3]

1. British Antarctic Survey, Natural Environment Research Council, Madingley Rd, Cambridge, CB3 0ET, UK
2. Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, USA
3. Plymouth Marine Laboratory, Prospect Place, The Hoe, Plymouth PL1 3DH, UK

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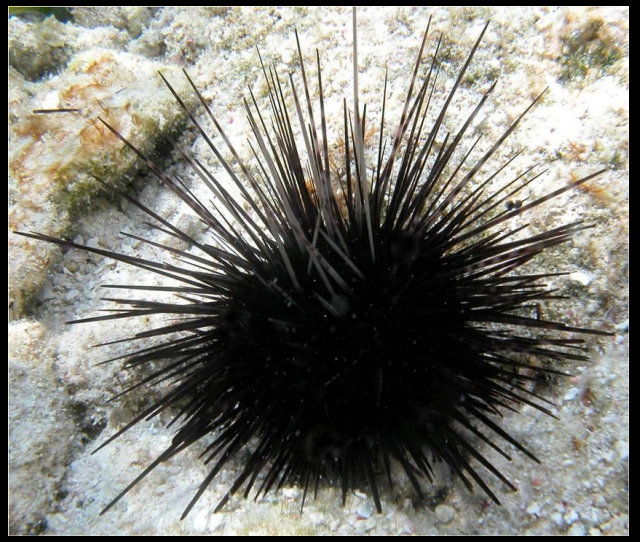
A number of taxa can shrink

Degrowth is a common trait in taxa with indeterminate growth

Coelenterates (*Anthopleura elegantissima*)



Echinoderms (*Diadema antillarum*)

Urochordates (*Clavelina moluccensis*)

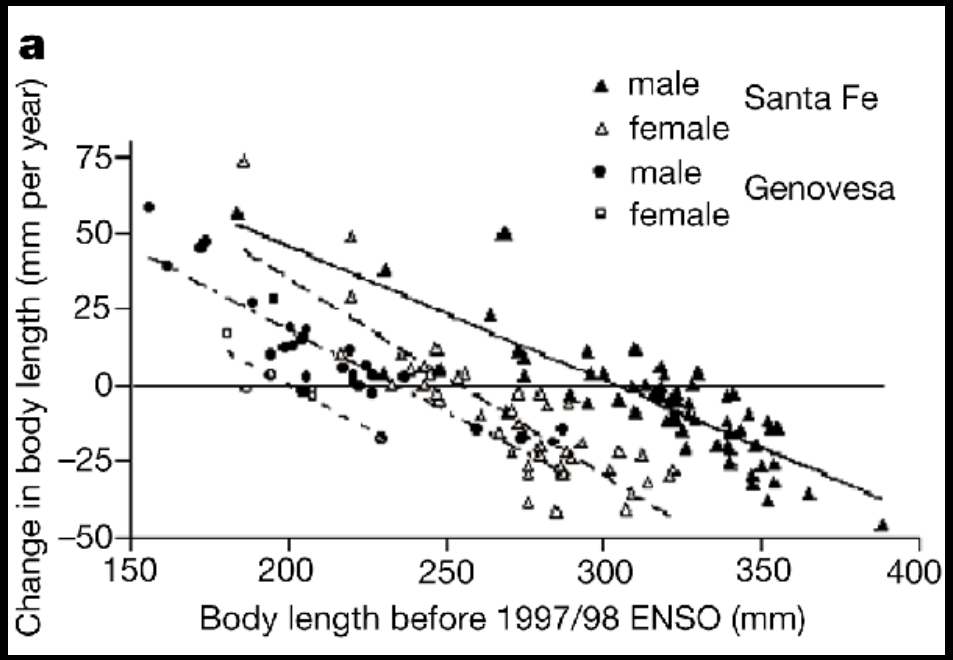
Molluscs (*Chiton pelliserpentis*)

Degrowth is constrained in vertebrates and arthropods

….with a few exceptions

Marine Iguana - larger individuals decreased in body length during ENSO years

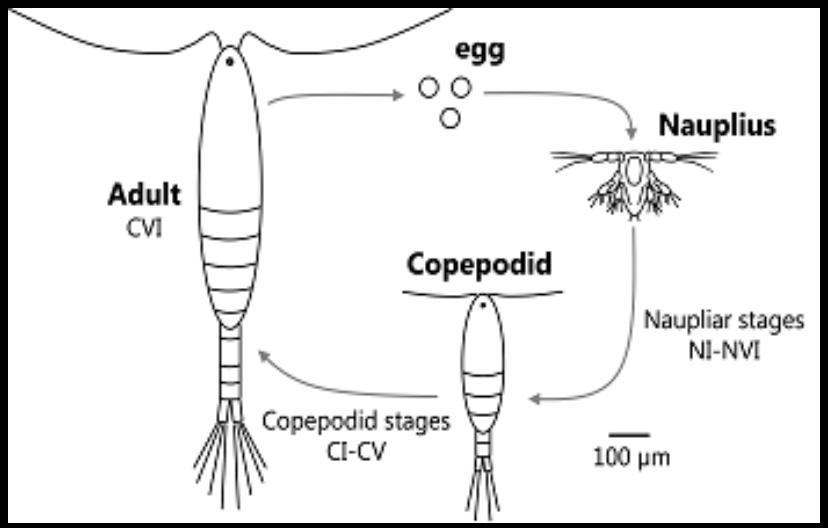
Amblyrhynchus cristatus



Wikelski and Thom 2000

Crustaceans – must moult in order to grow

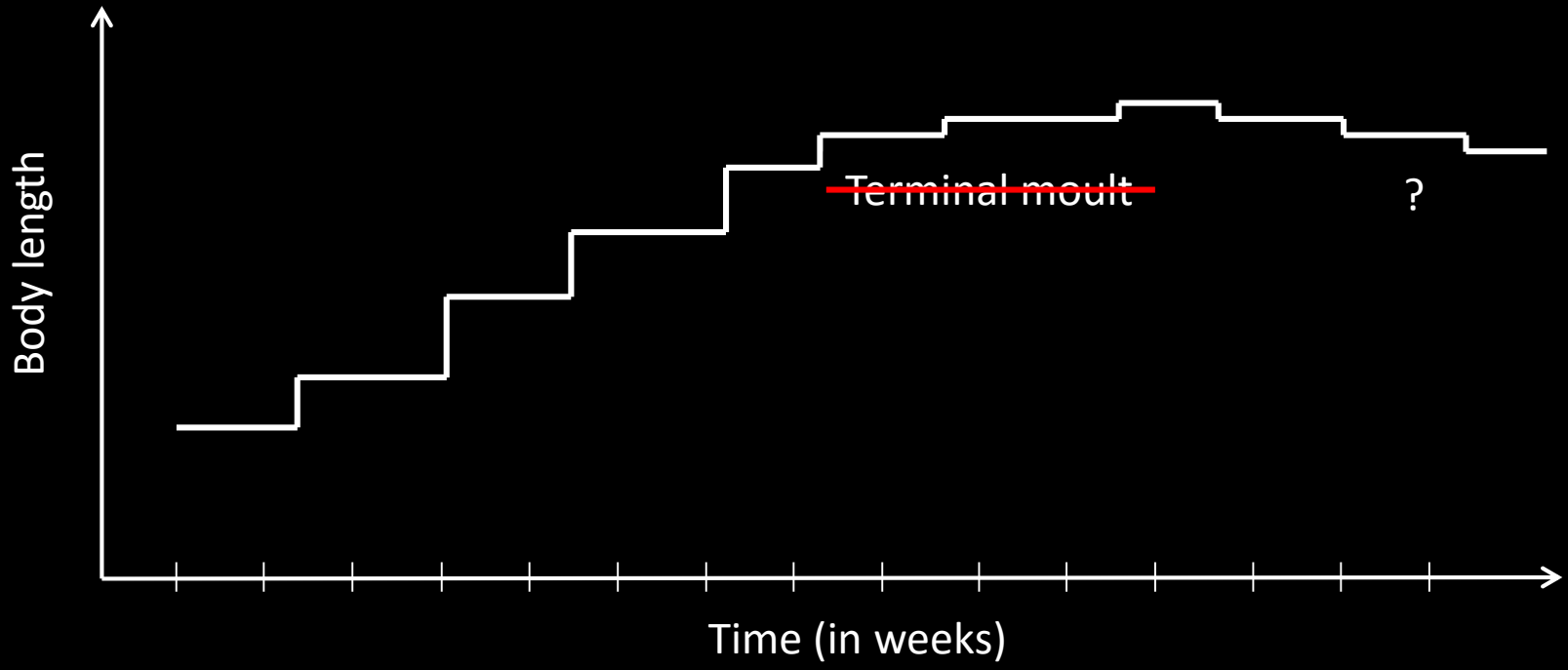
Terminal moult
e.g. copepods



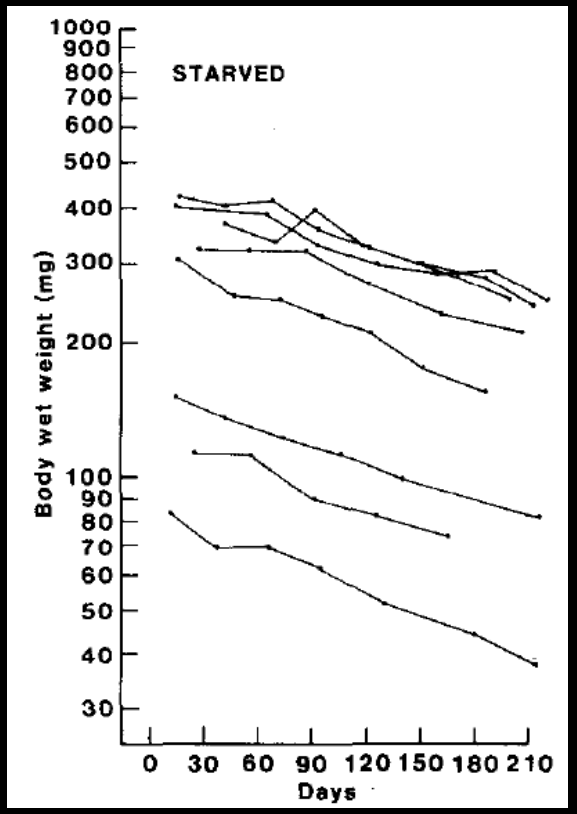
Seasonal or infrequent moulting
e.g. crabs and lobsters

Decrease in body length at moult is not widely observed

Euphausiids – moult continuously



Laboratory evidence that starved krill shrink in body-length

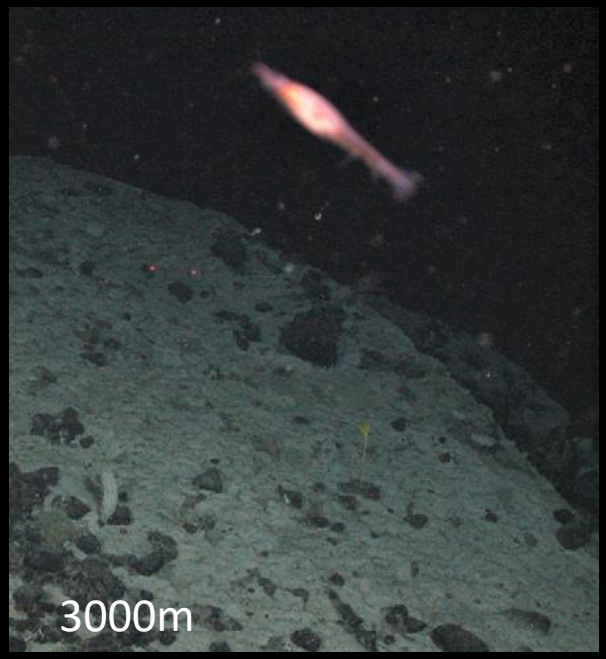


Ikeda and Dixon (1982)

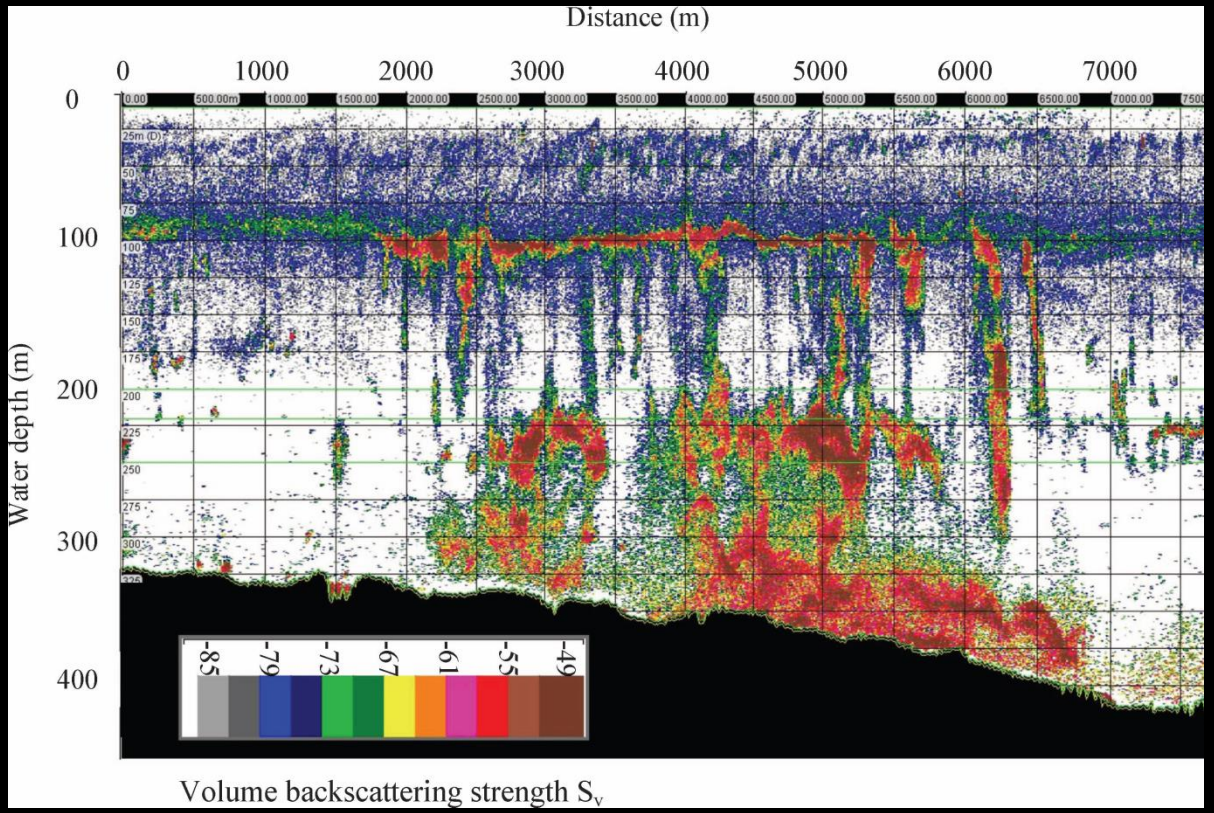
45% decrease in body mass, 7 mm decrease in body length over 211 days

Do krill shrink during winter in their natural environment?

Abyssal feeding by krill - could provide winter food banks



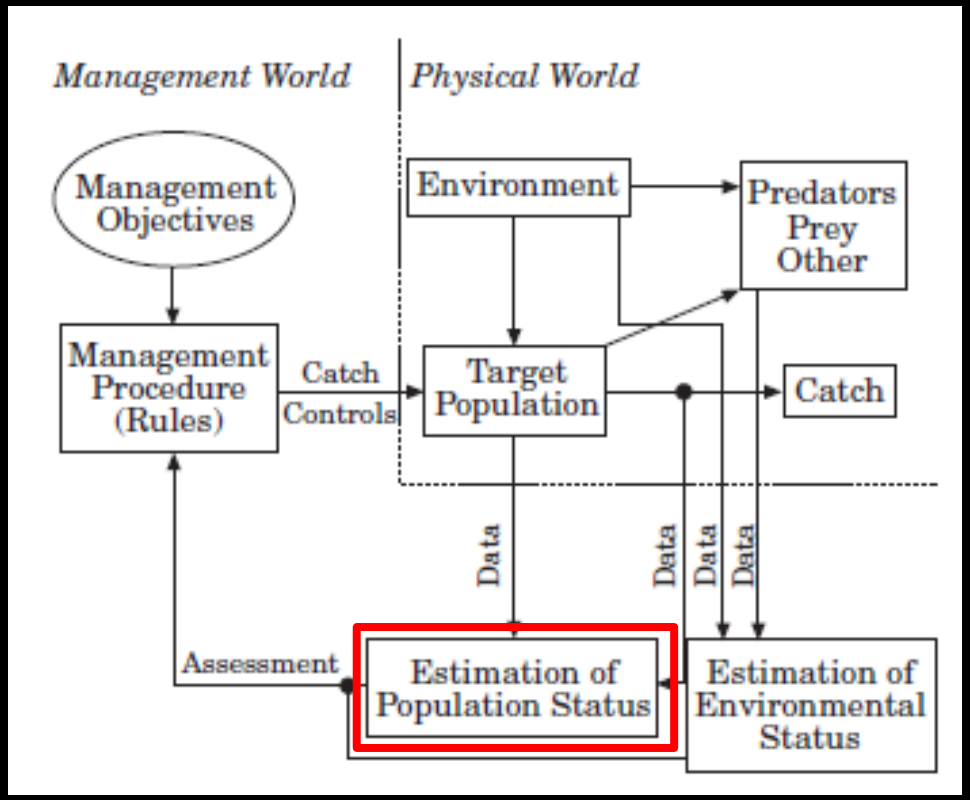
Clarke and Tyler 2011



Schmidt et al. 2011

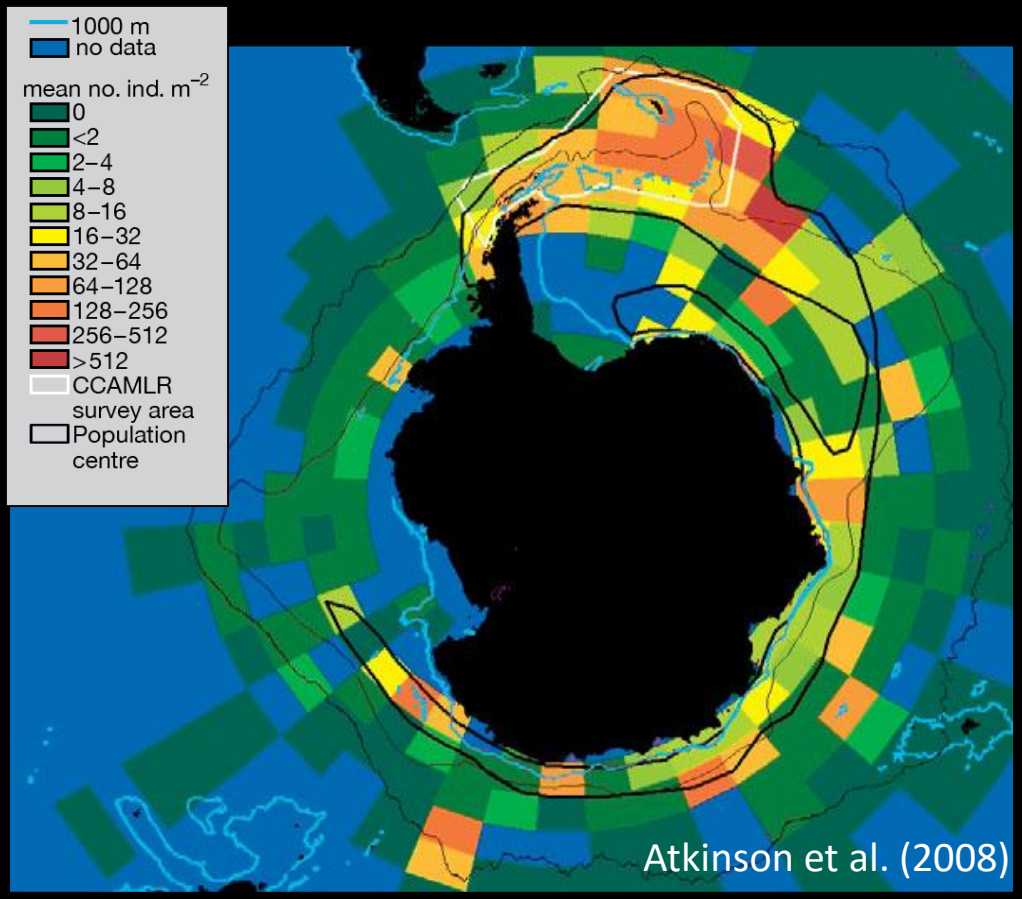
Accurate age-structures are required by fisheries yield models to regulate harvesting

Ecosystem-based fishery management model for the Southern Ocean



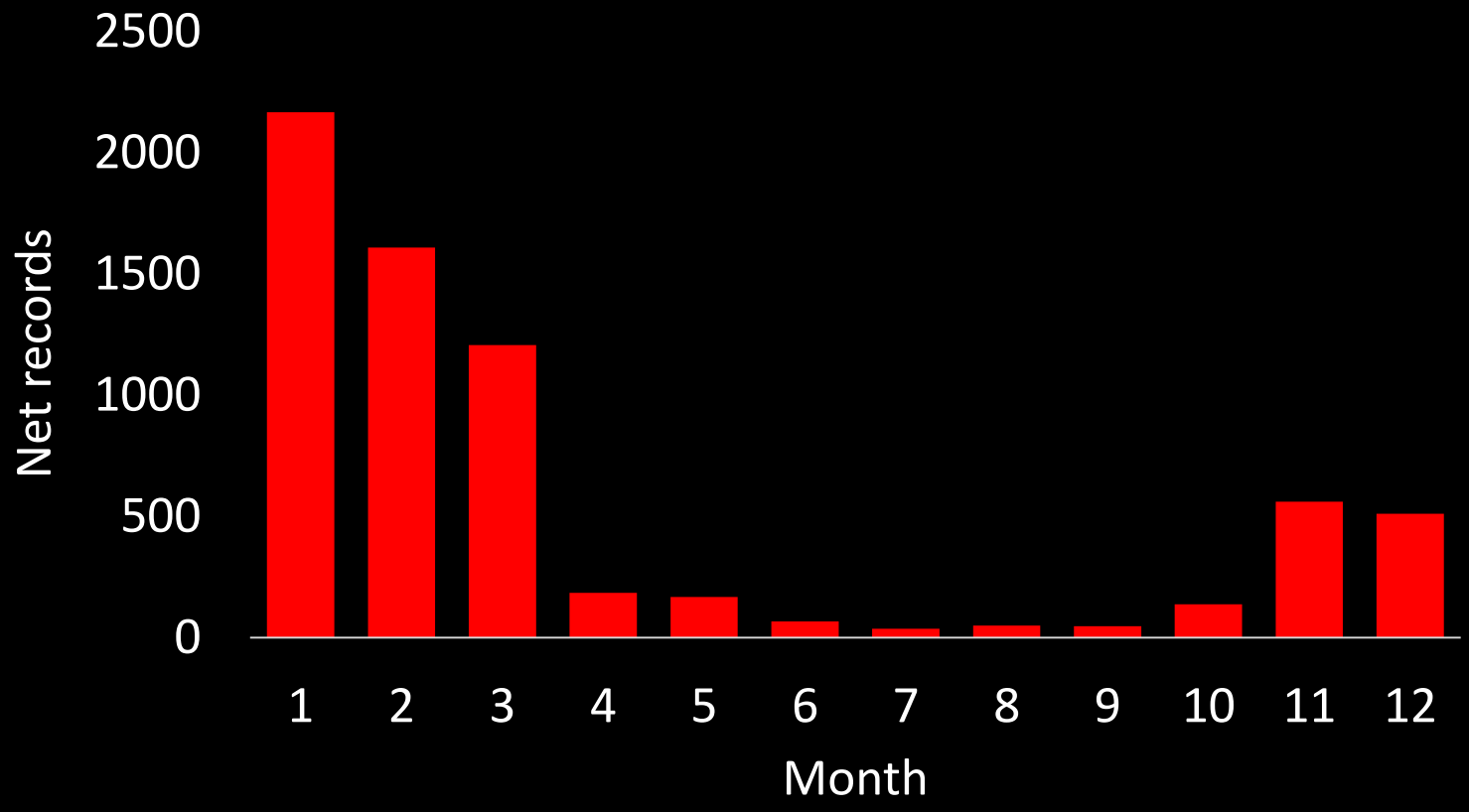
Constable et al. (2000)

Krillbase – spatially comprehensive database of krill body-length frequency information since 1920s



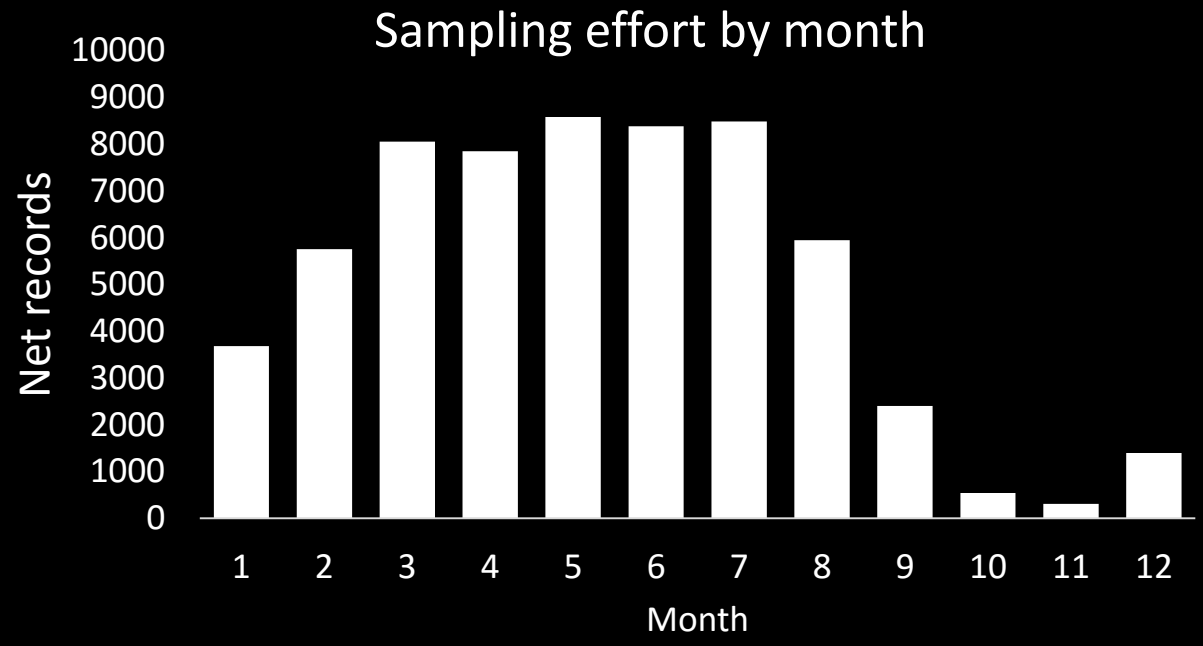
Circumpolar abundance of Antarctic krill

Krillbase sampling effort by month



Poor winter coverage

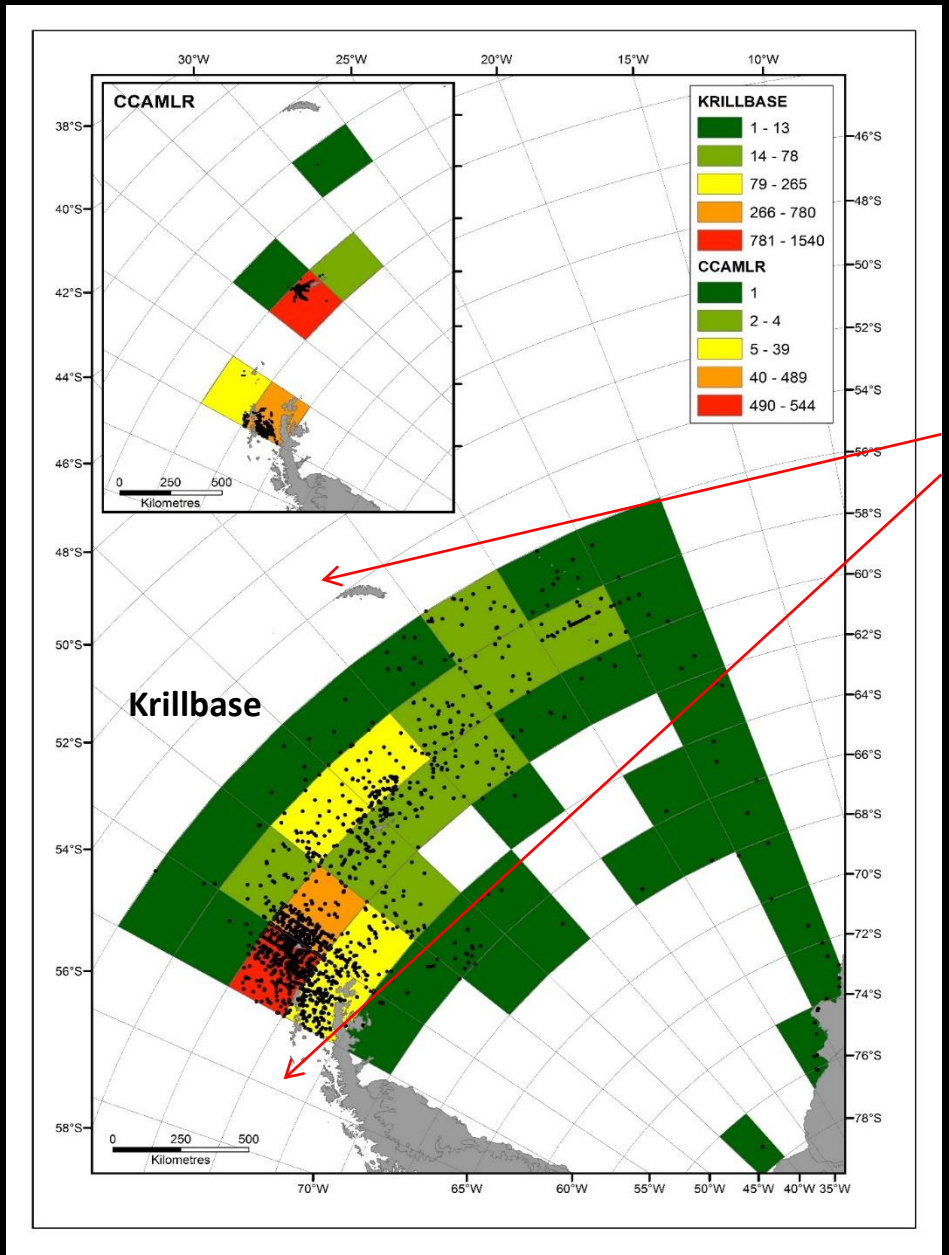
CCAMLR krill fishery observer programme



Good winter coverage

Spatial coverage of Krillbase and CCAMLR data

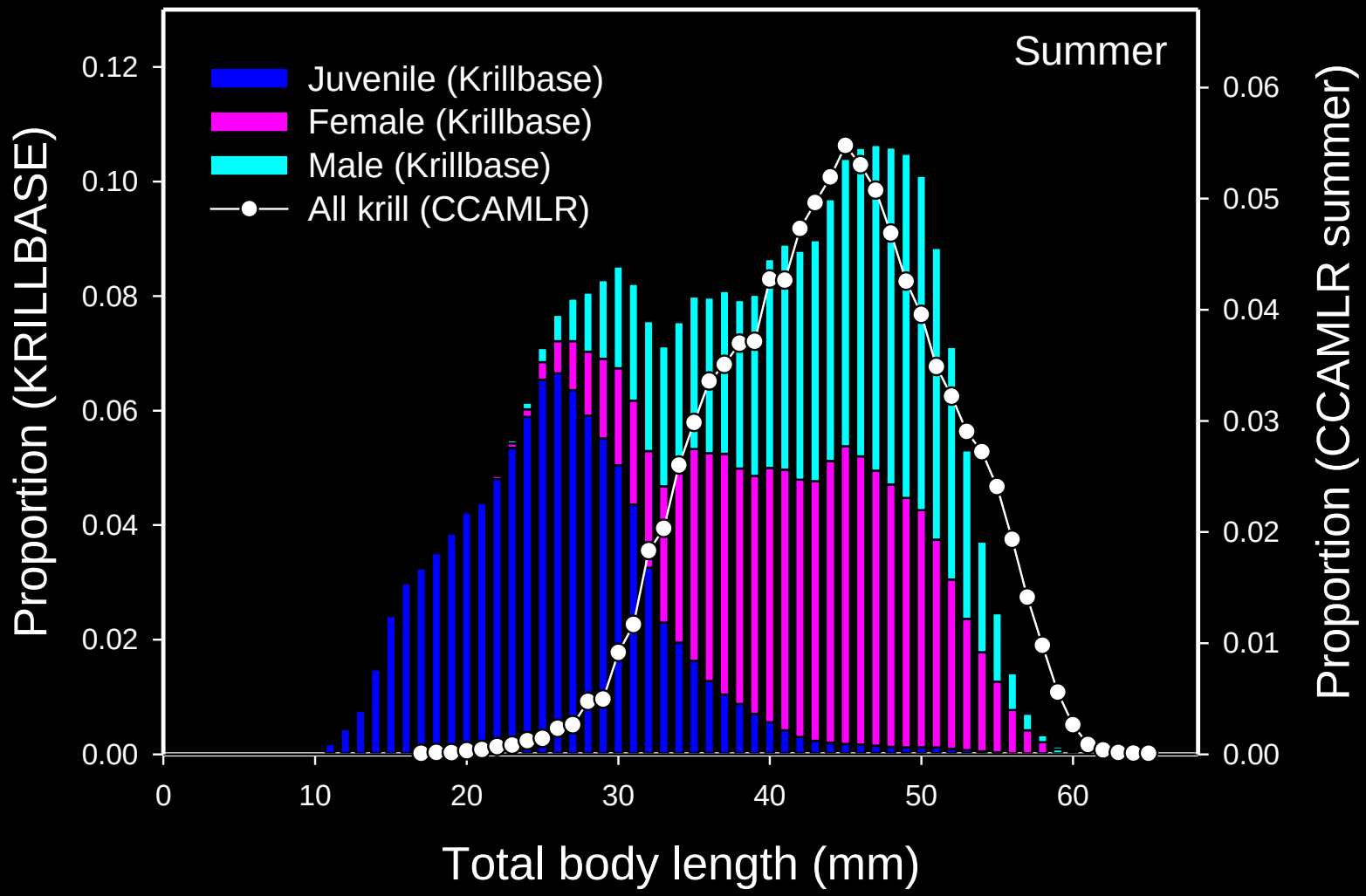
SW Atlantic region



Further datasets for

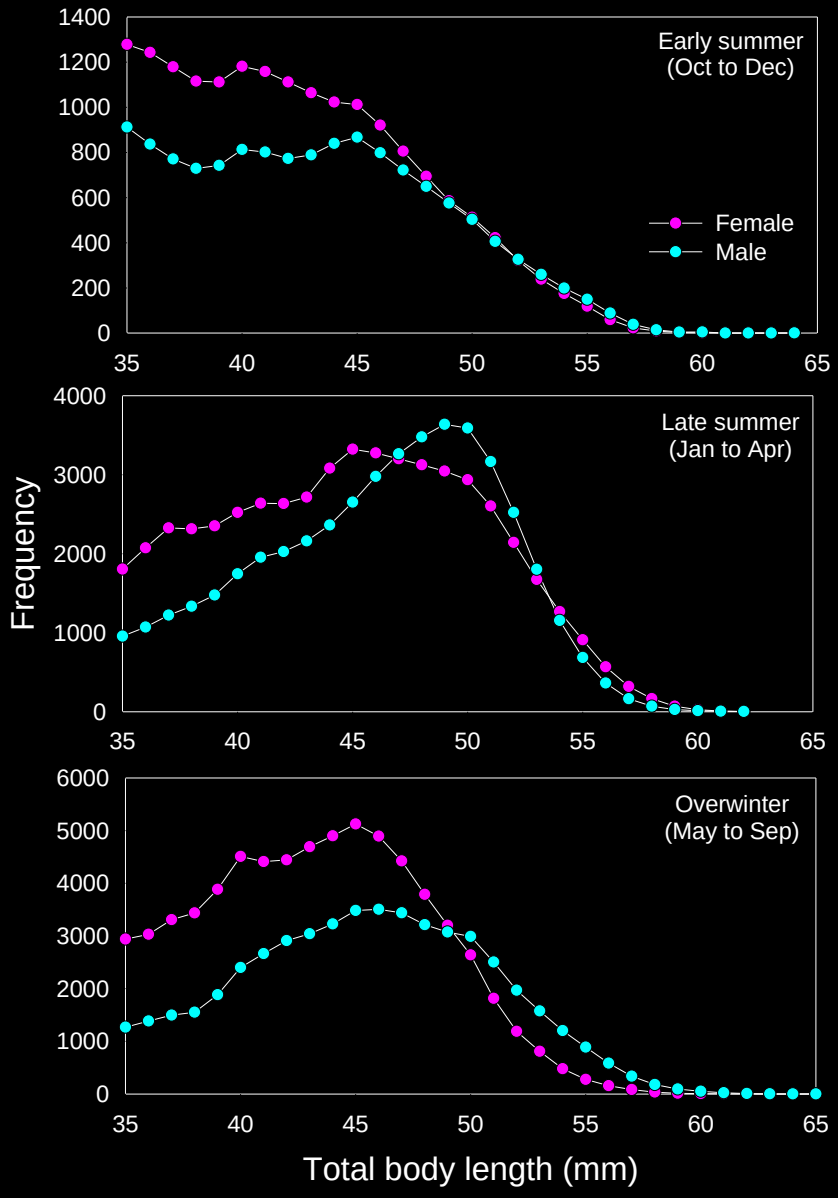
1) South Georgia
2) Western Antarctic Peninsula

Accommodation of sampling bias

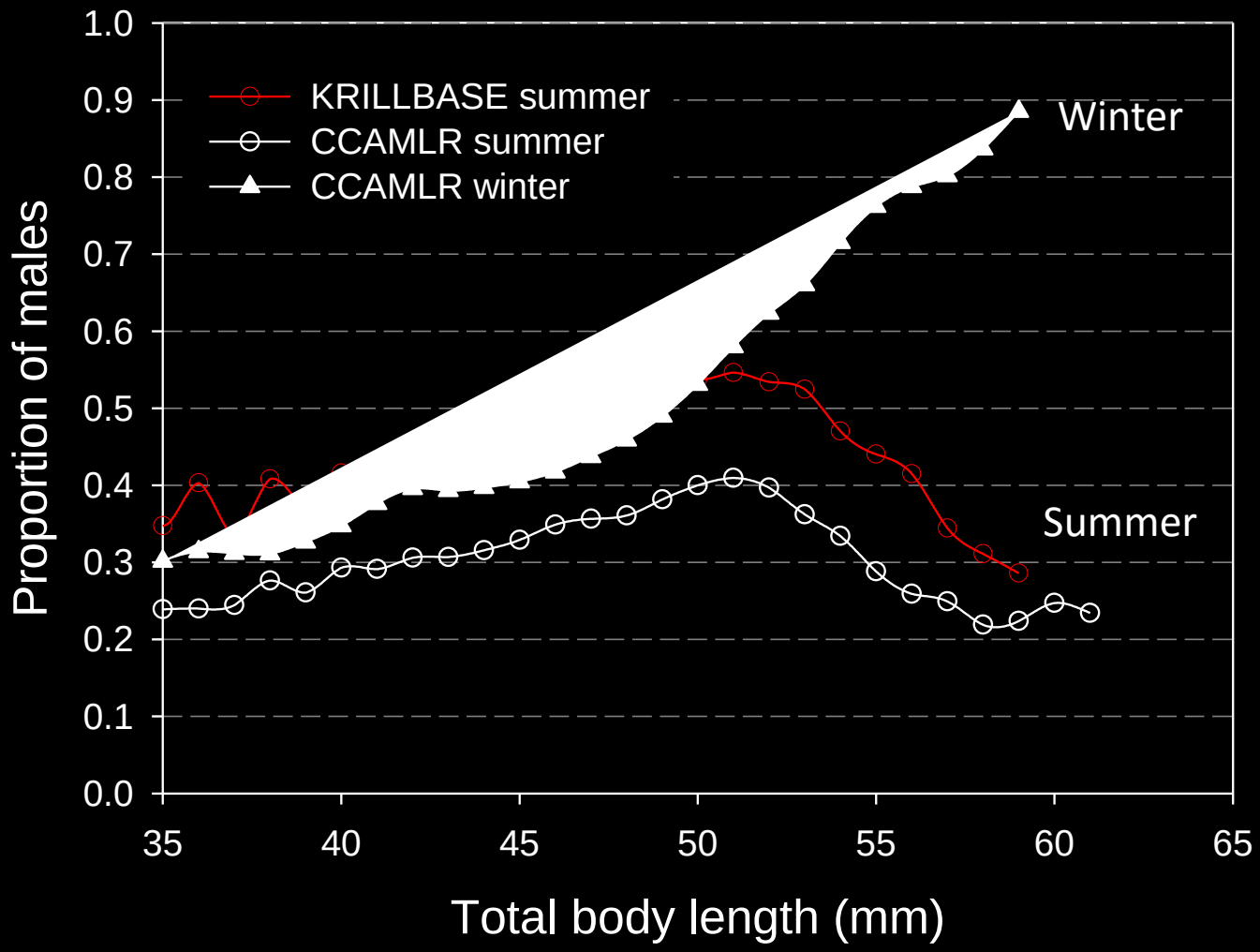


Therefore, individuals <35 mm body length were not considered

Body-length frequency trajectories differed seasonally between sexes

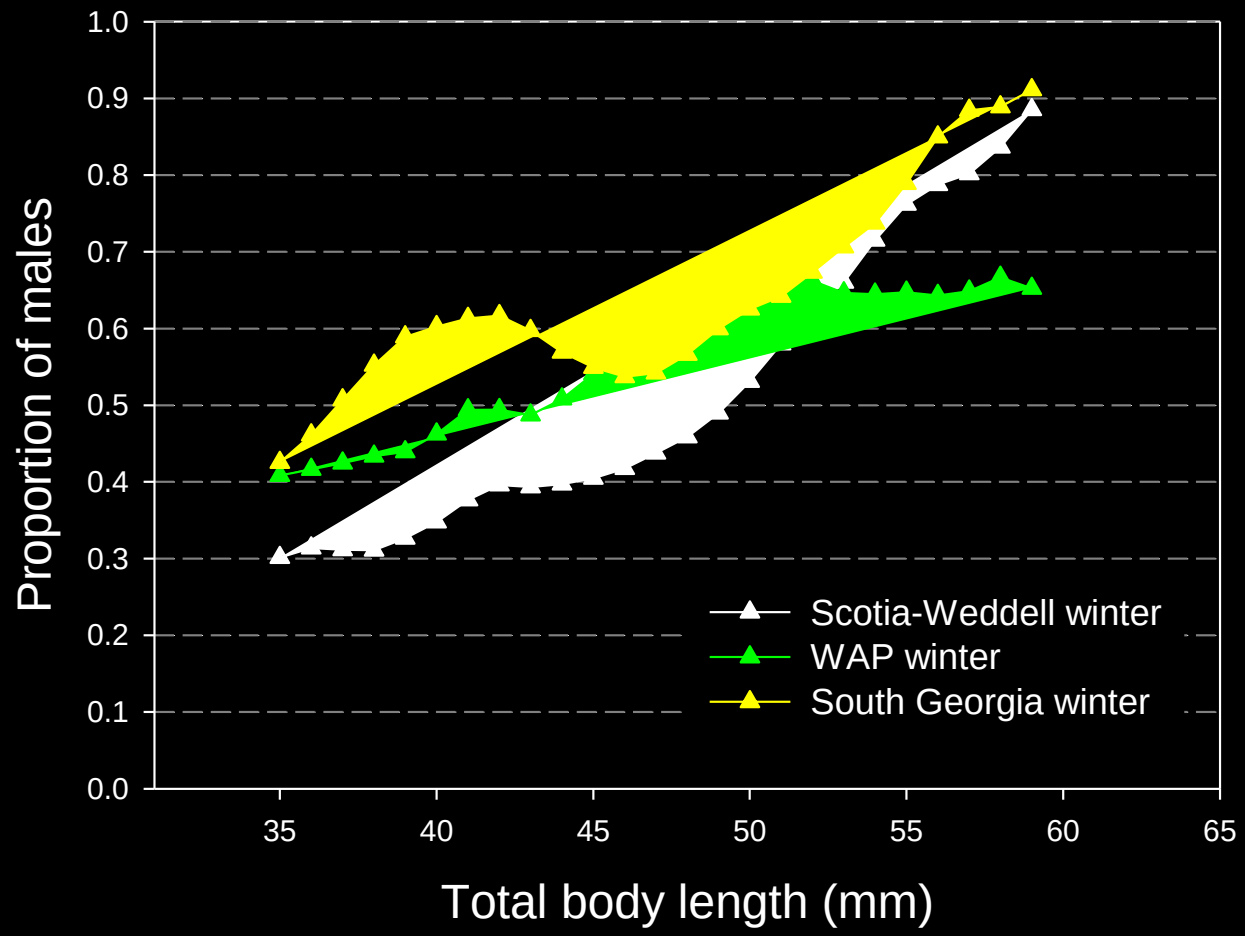


Sex-ratio of larger individuals was highly skewed towards males during overwinter



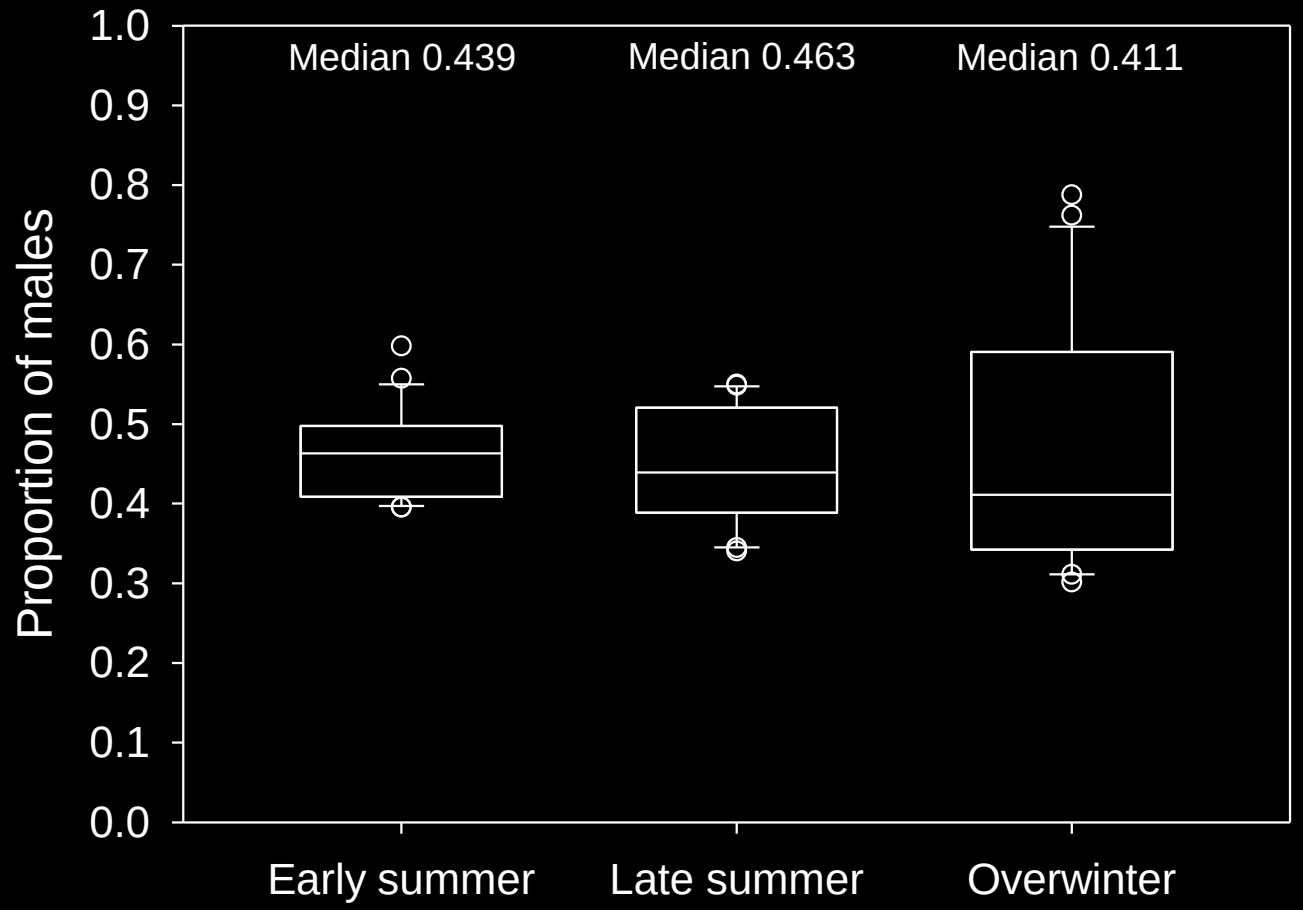
Is differential degrowth between sexes the only explanation?

Is immigration or emigration a factor?



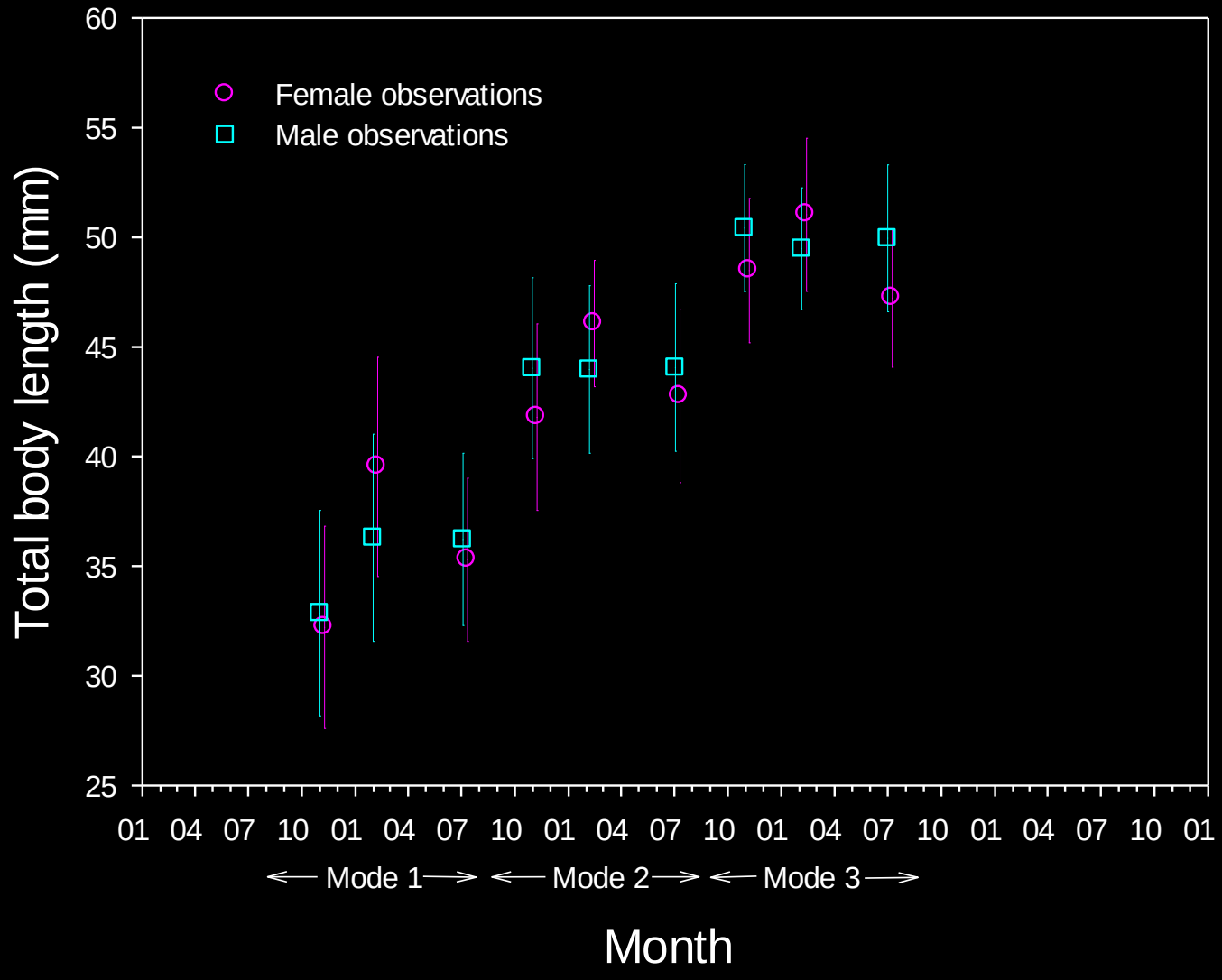
No sex-biased migration from one region to the next

Is there a sex-bias in seasonal mortality?



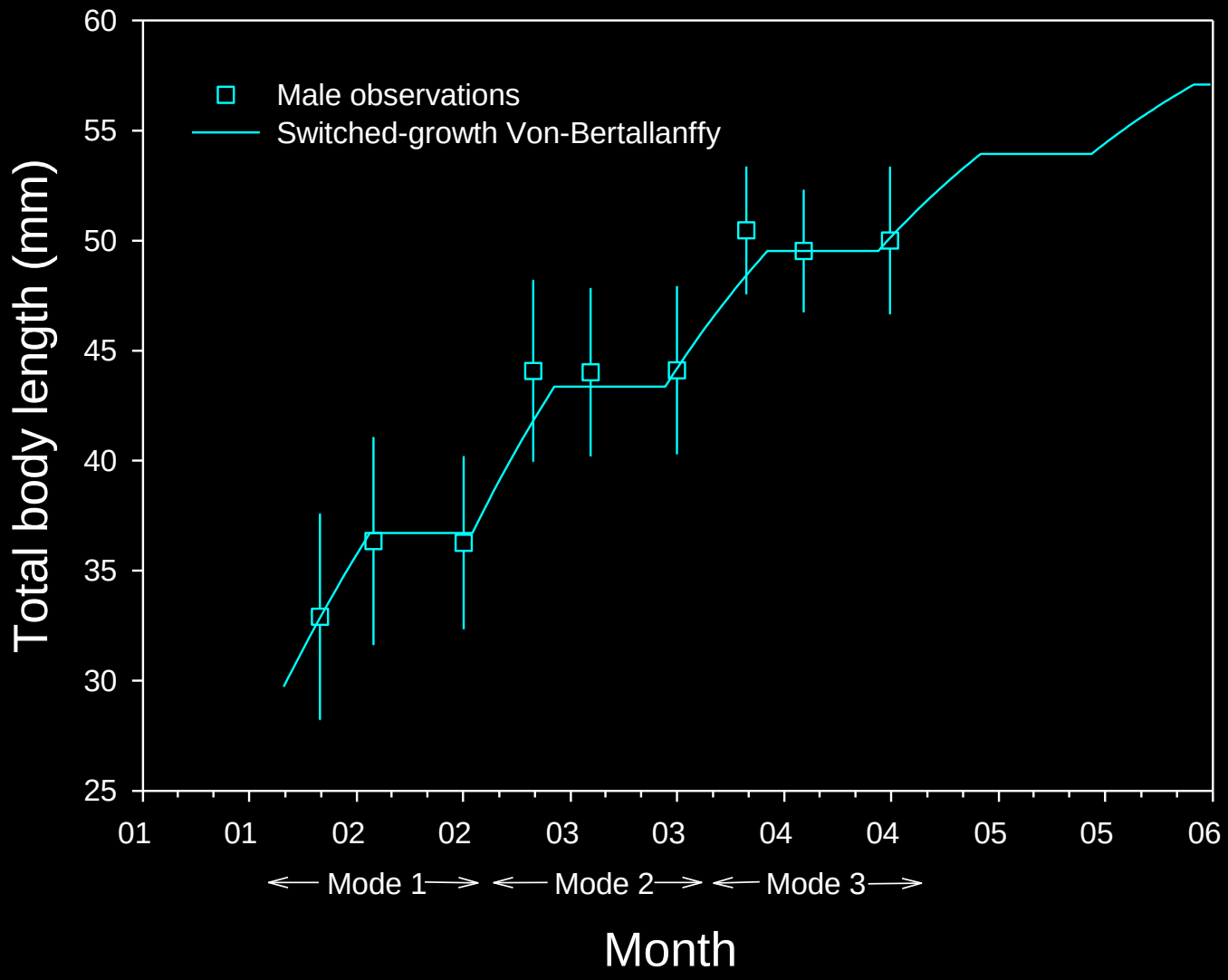
Overall sex-ratio is the same between seasons –
even in favour of females during overwinter

Different trajectories of growth between males and females



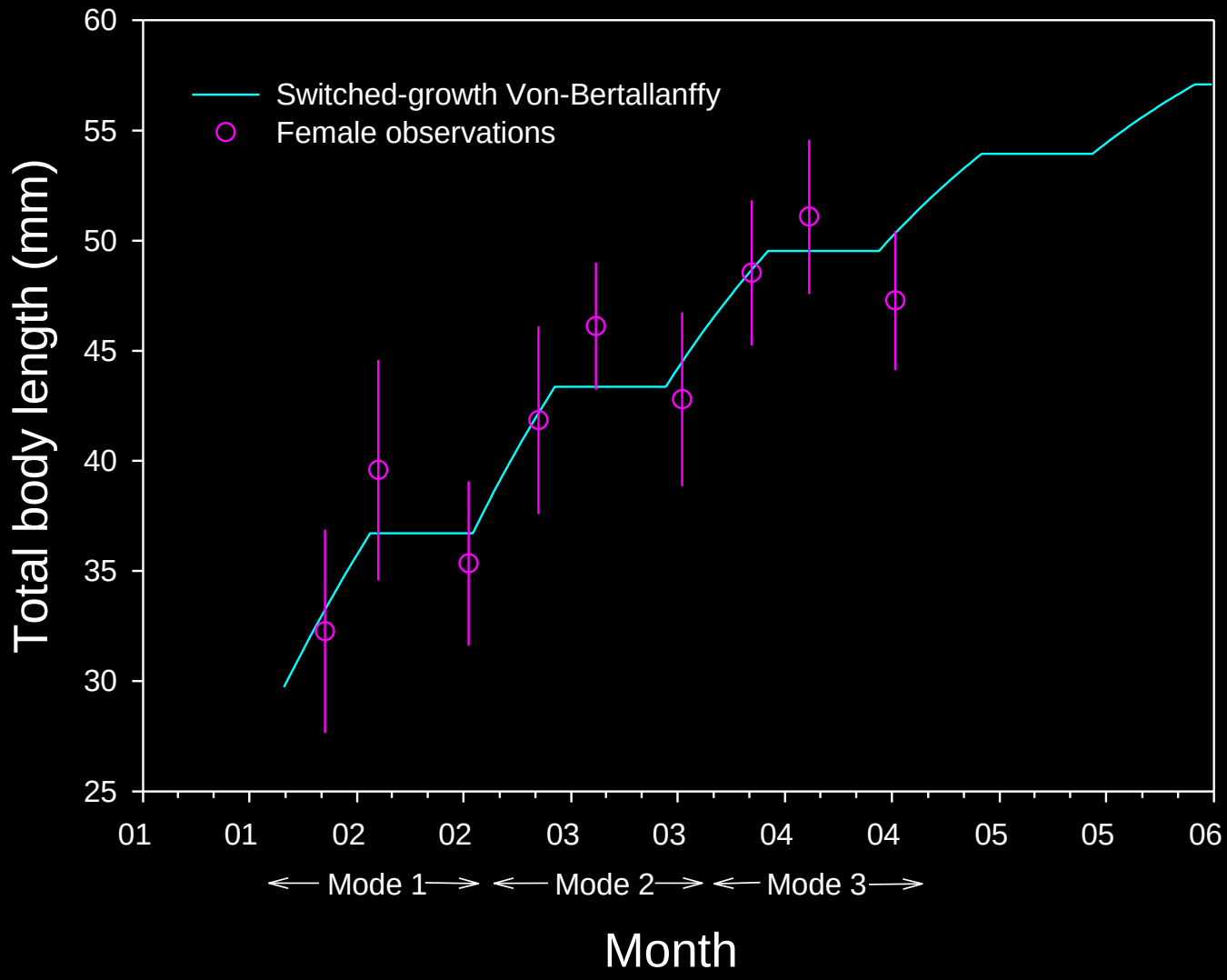
Largest body-lengths switch between males and females depending on season

Different trajectories of growth between males and females



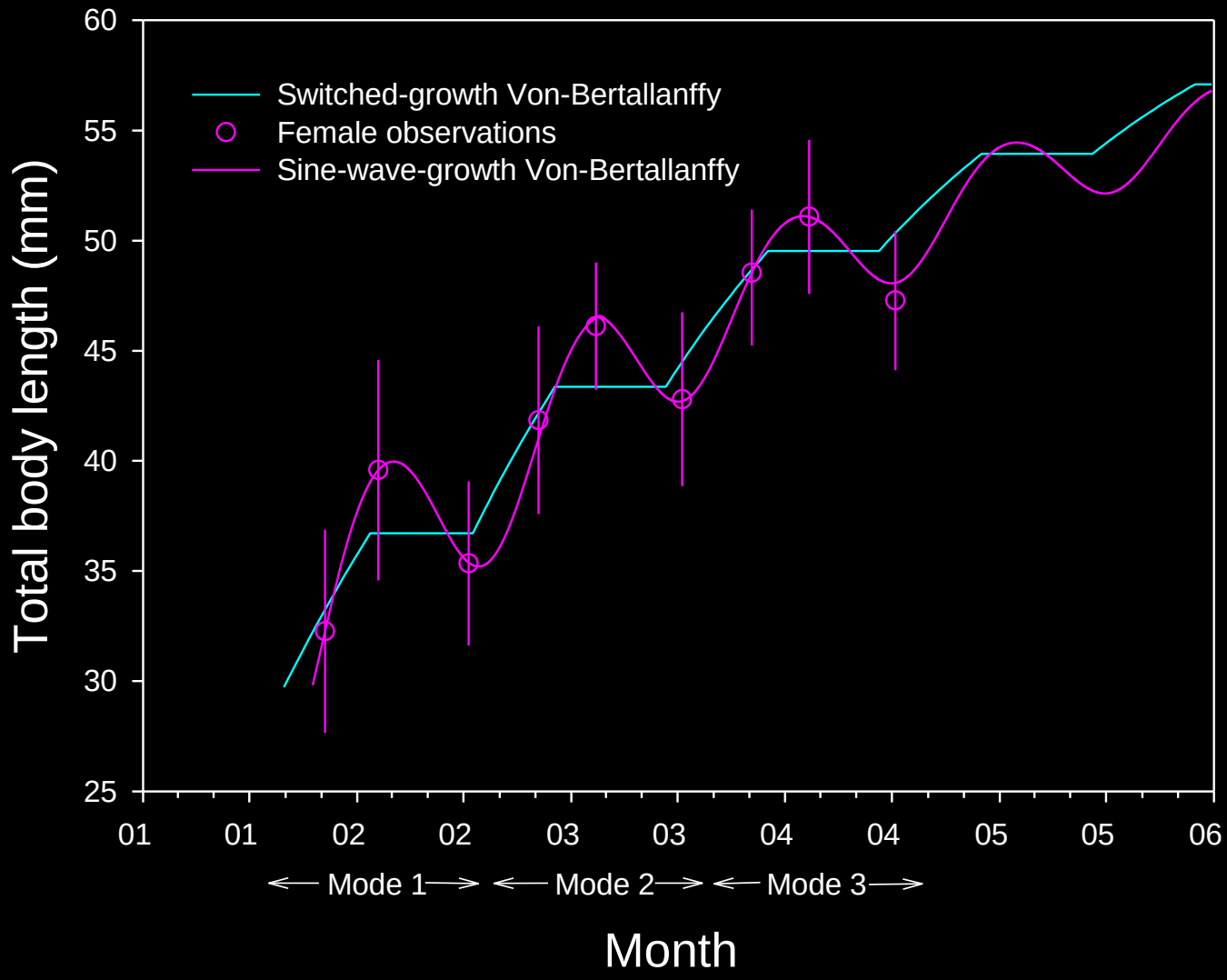
Males grow fast in the early season

Different trajectories of growth between males and females



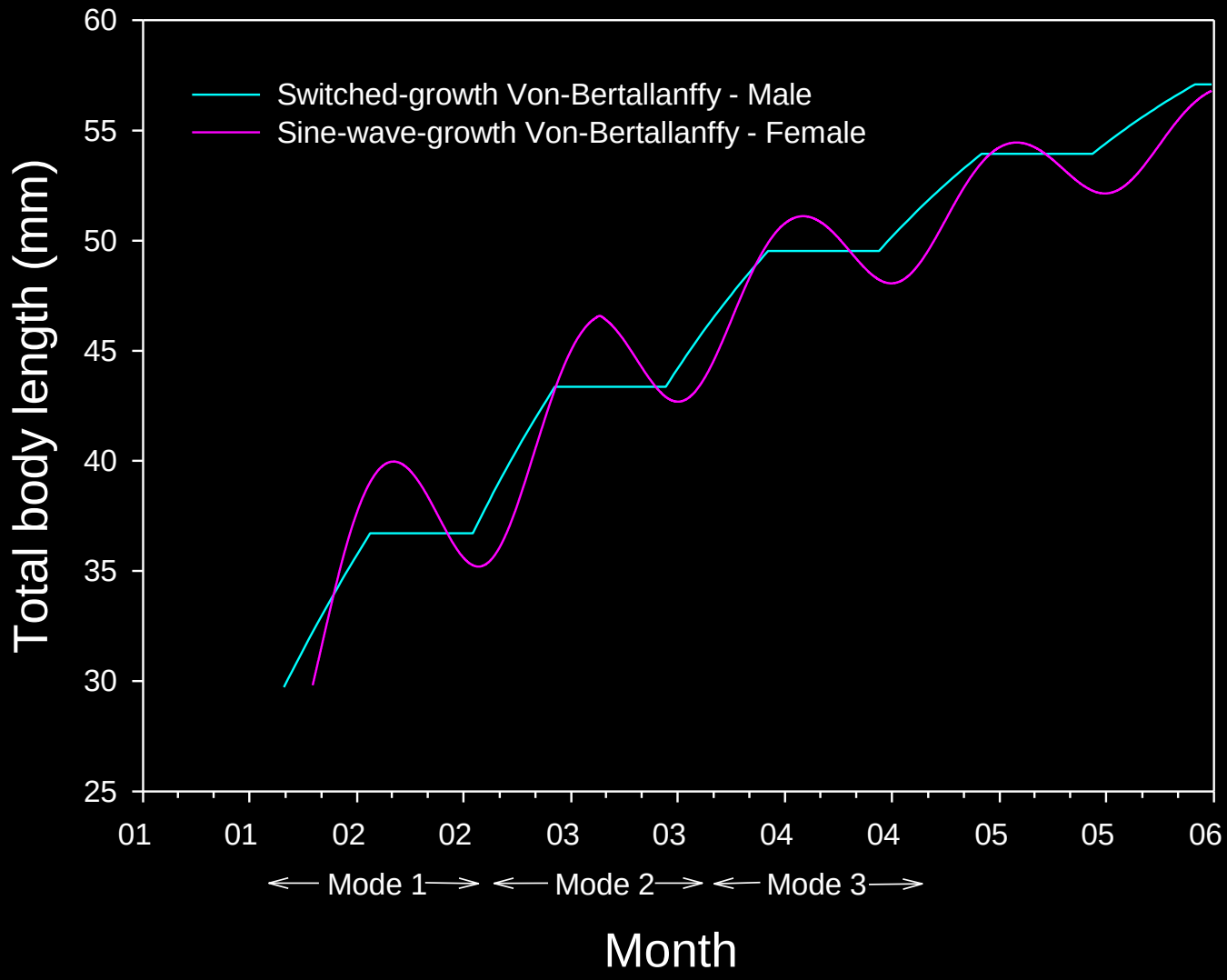
Females reach larger body lengths by midsummer, but are shorter during overwinter

Different trajectories of growth between males and females



Female growth conforms to a sine-wave growth function

Different trajectories of growth between males and females



Female and male growth are out of phase – but reach similar maxima

Krill ovaries are large and regress over winter

Ov - ovary

>40% of wet body mass during summer

The seasonal regression of the ovary in females may result in a shrinkage of body-length

Conclusions

1. Krill shrink in body length in the natural environment
2. Shrinkage occurs in females but not males during overwinter
3. Shrinkage is more likely to be a function of the life-cycle than a response to starvation
4. Different growth trajectories of male and female krill must be factored into fishery-production and -management models

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