The importance of rapid development to produce more biomass on a year cycle: comparing some copepod species from the Humboldt Current

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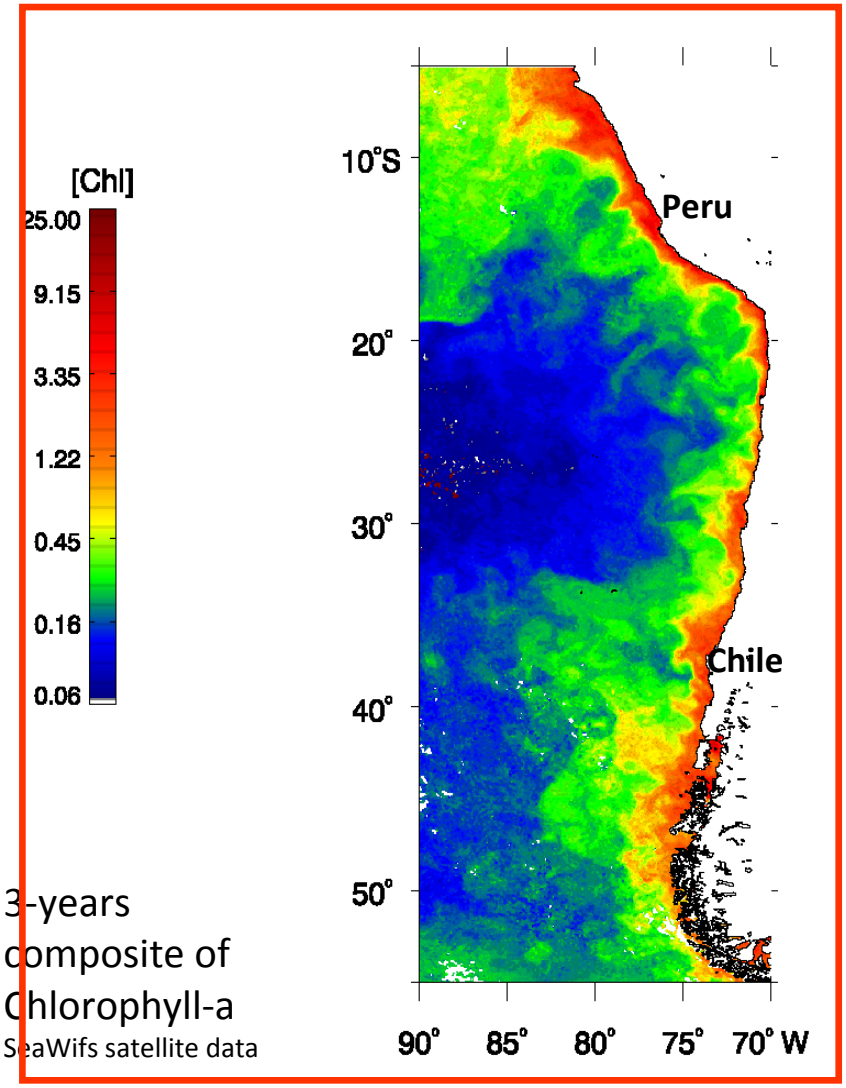
Humboldt Current Ecosystem



3-years composite of Chlorophyll-a
SeaWifs satellite data

- **Ecosystem: High production PP >10 g C m^{-2} d^{-1}**
- **Coastal zone concentrates the productivity**
- **High fish production: Pelagic fisheries**
- **Strong variability: inter-annual (ENSO cycle)**
- **Can respond to large-scale processes: climate change**
- **Diversity: mix of subtropical and subactarctic fauna**
- **Strong latitudinal variability of oceanographic conditions**
- **Presence of an OMZ (oxygen minimun zone) and AMZ (anoxic zone) (Ulloa et al. 2012 PNAS)**
- **Strong variation of upwelling : variable regimes, effects on OMZ dynamics.**

Some questions for copepod studies:

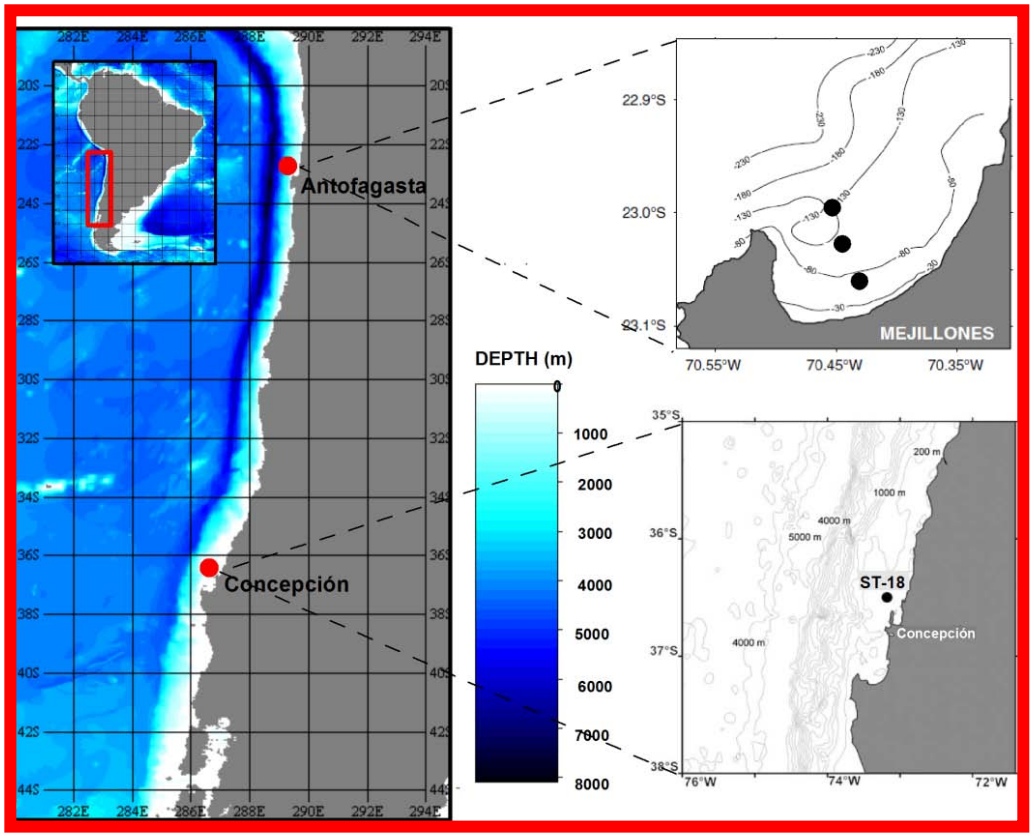
How copepods respond to oceanography variability: over different spatial and temporal scales, or upon changes in thermal and oxygen conditions ?

How environmental variation affects physiological responses, such as development, growth and production rates?

What are the implications for productivity of the HCS?

Scientific Problem: does *g (growth rate) determine the variations in abundance and production of dominant copepods which coexist in the HCS.*

Two upwelling centers under zooplankton studies: Mejillones (23°S) and Concepcion (36°S)



Field study:

- 3 bio-oceanography stations:
- Monthly sampled during 2010
- Zooplankton sampling

RESULTS FROM 2010 STUDIES

Laboratory study:

Moulting rate experiments (Runge & Roff, 2000) : For species and stages

Mejillones: ***Paracalanus indicus***
Acartia tonsa
Calanus chilensis

Concepcion: ***Paracalanus indicus***
Acartia tonsa
Calanoides patagoniensis

Similar characteristics among species:

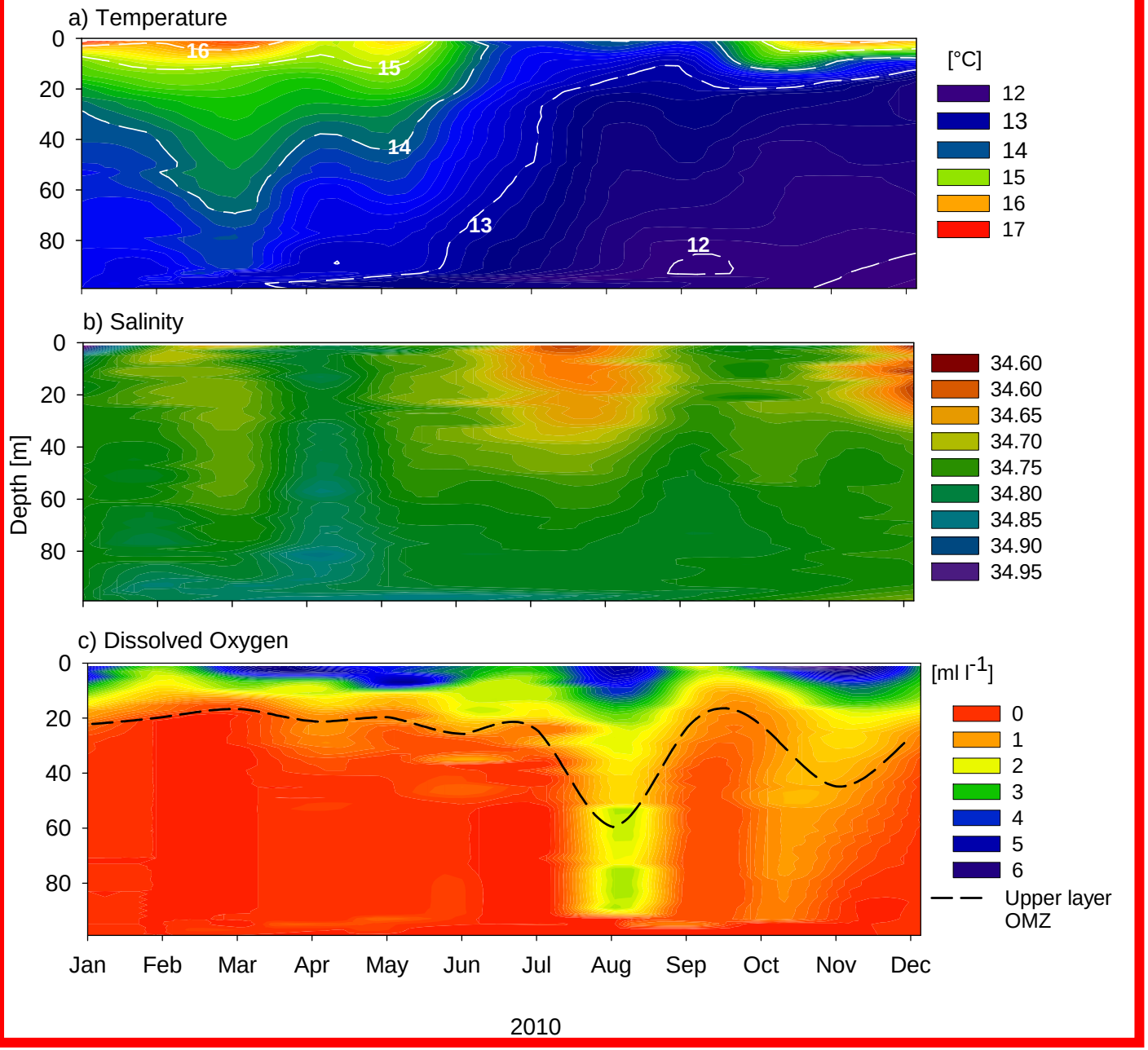
•All dominant (Escribano & Hidalgo, 2000; Hidalgo et al 2009; Morales et al., 2010; Hidalgo et al., 2012)

•Present year-round (Hidalgo & Escribano, 2000)

•Abundances not affected by the EL NIÑO events (Hidalgo & Escribano, 2001; Ulloa et al. 2001)

•Continuous reproduction (Escribano, 1998; Escribano & McLaren, 1999; Hidalgo & Escribano, 2007-2008 for *C.chilensis*; Vargas et al., 2010 for *A. tonsa* and *P. indicus*)

Oceanographlc conditions: Mejillones (23°S)

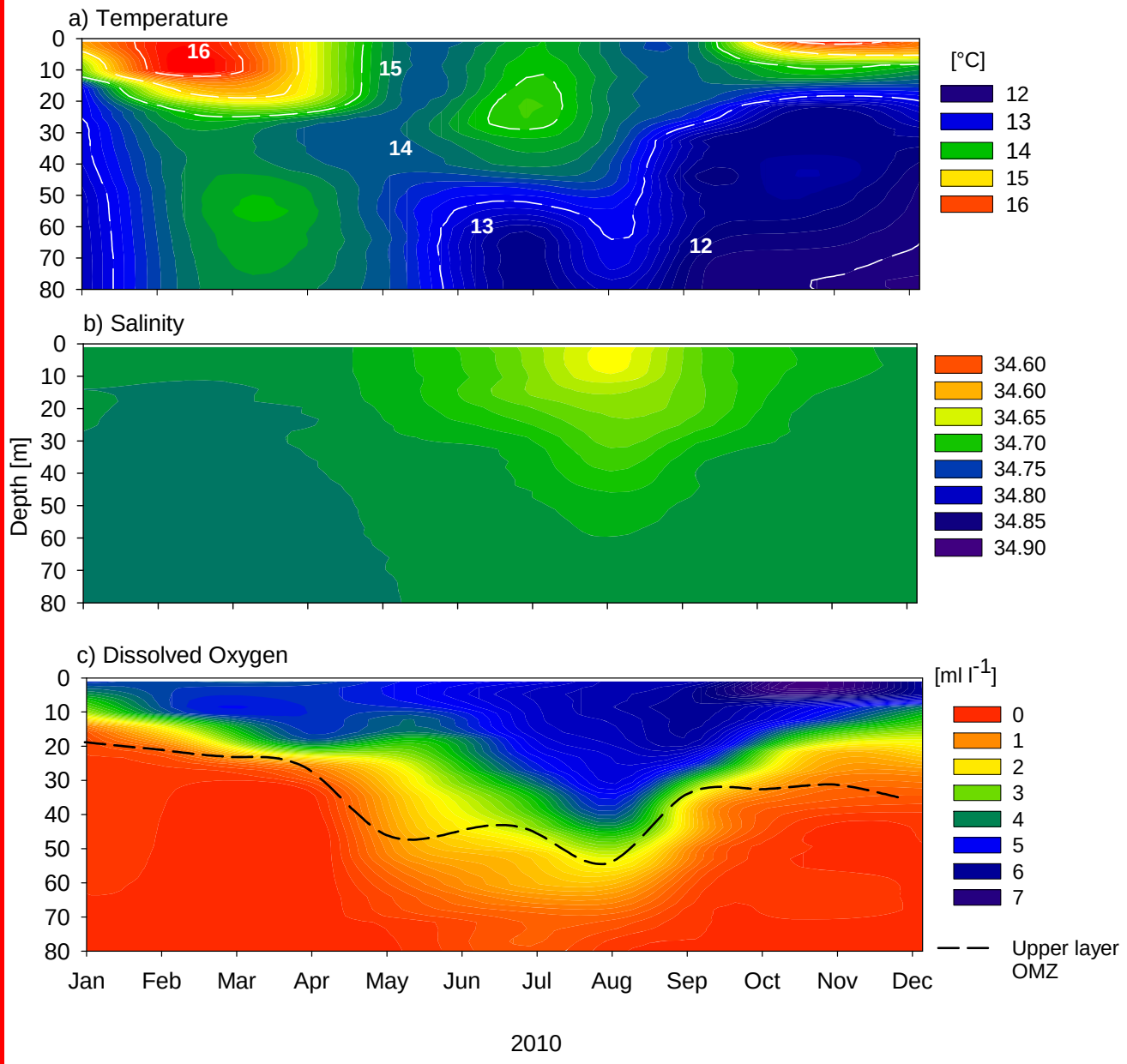


Two upwelling periods during the year cycle: stratified summer and more mixed in the winter

Water mass about the same year-round

Hipoxic conditions prevail year round below 20 m depth

Oceanographic conditions: Concepcion (36°S)



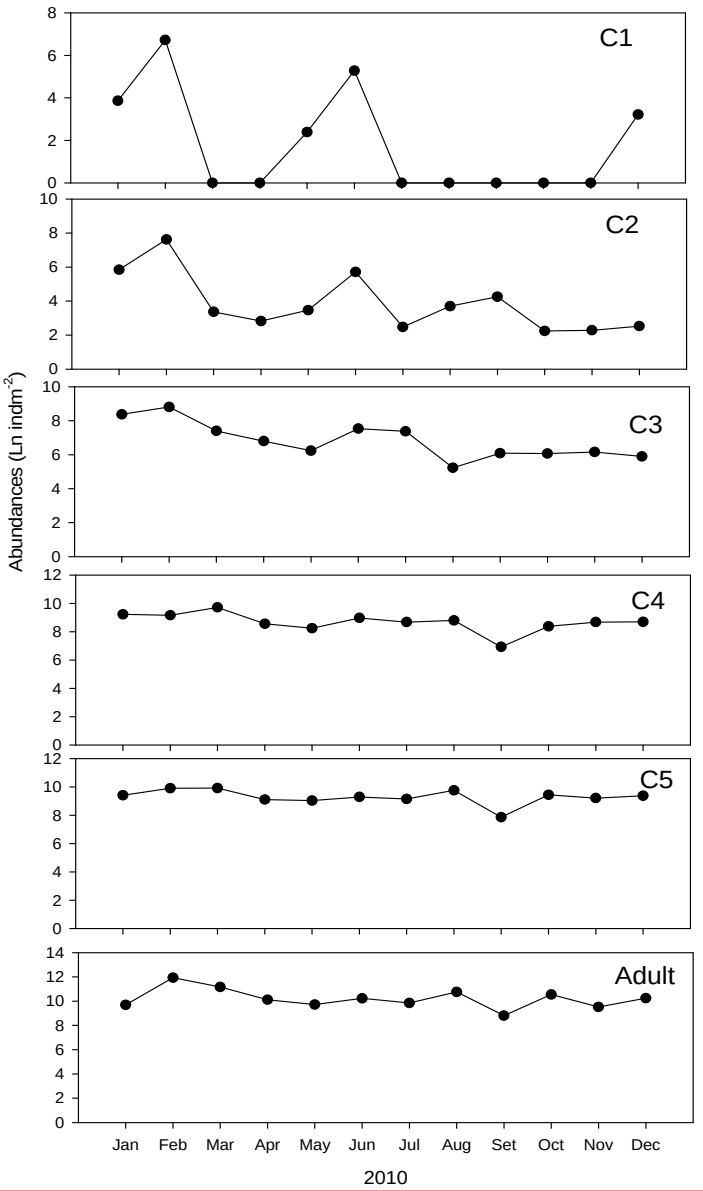
Strong seasonality with summer surface warming

Presence of runoff water in winter

Hipoxic conditions are seasonal. Shallow OMZ in spring-summer in the upper 50 m

Population abundances
Paracalanus indicus

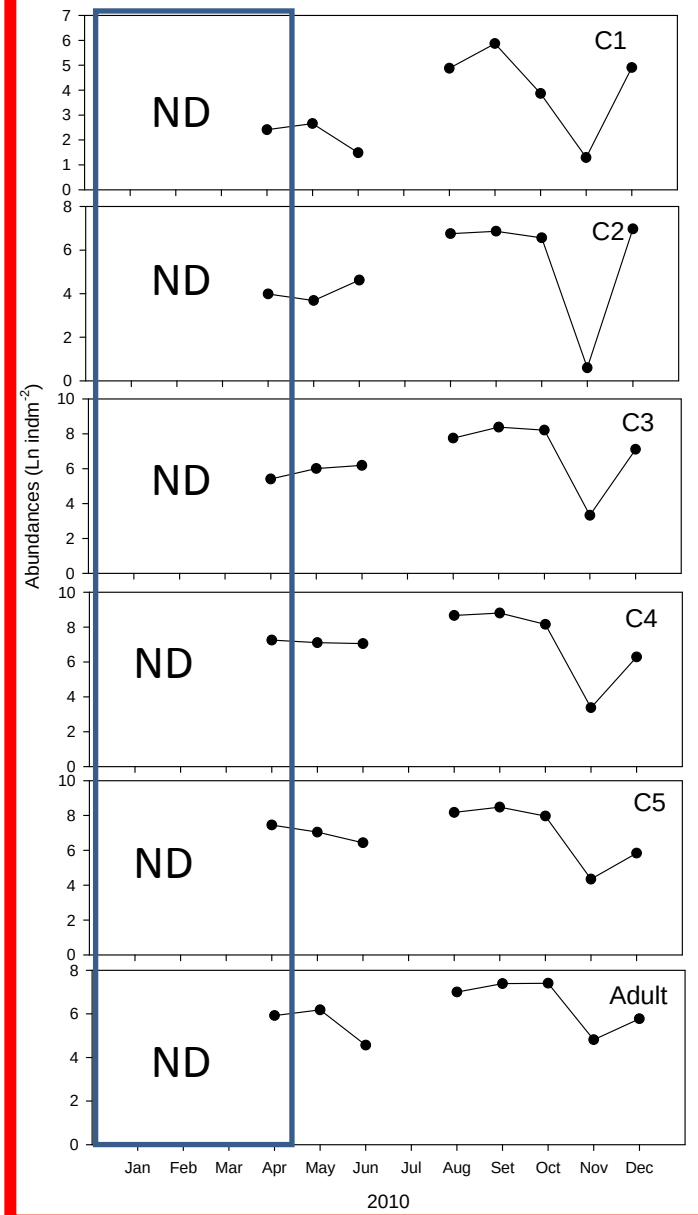
Mejillones



All stages present at both places, more abundant in Mejillones

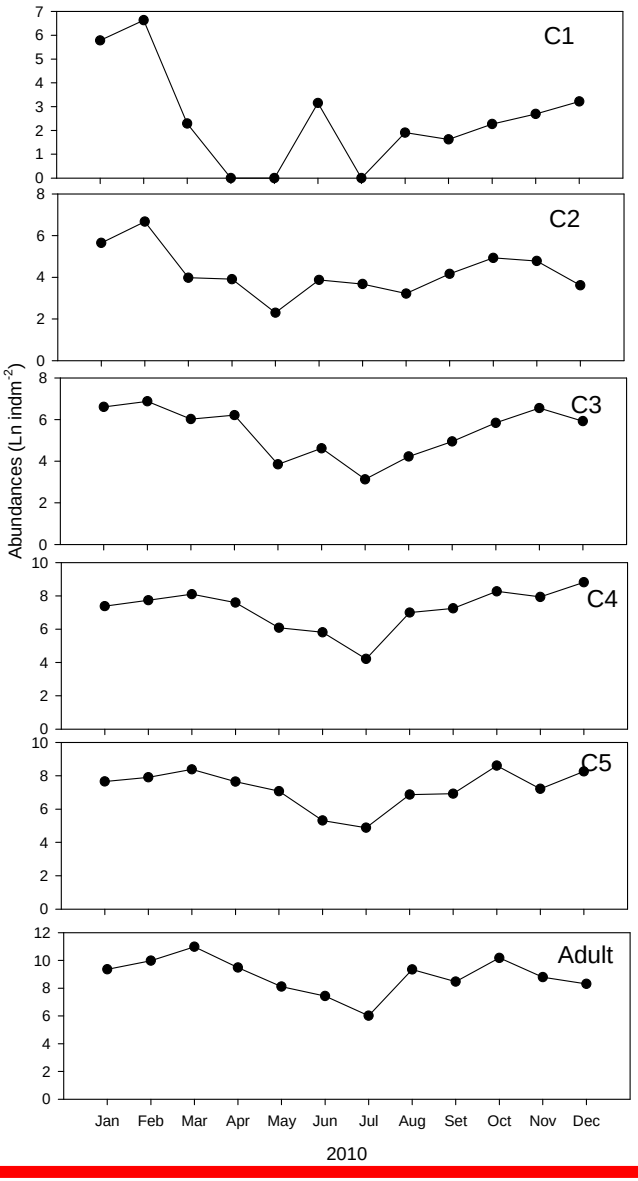
Older stages (C4-Ad) more abundant at Mejillones

Concepcion



Population abundance
Acartia tonsa

Mejillones

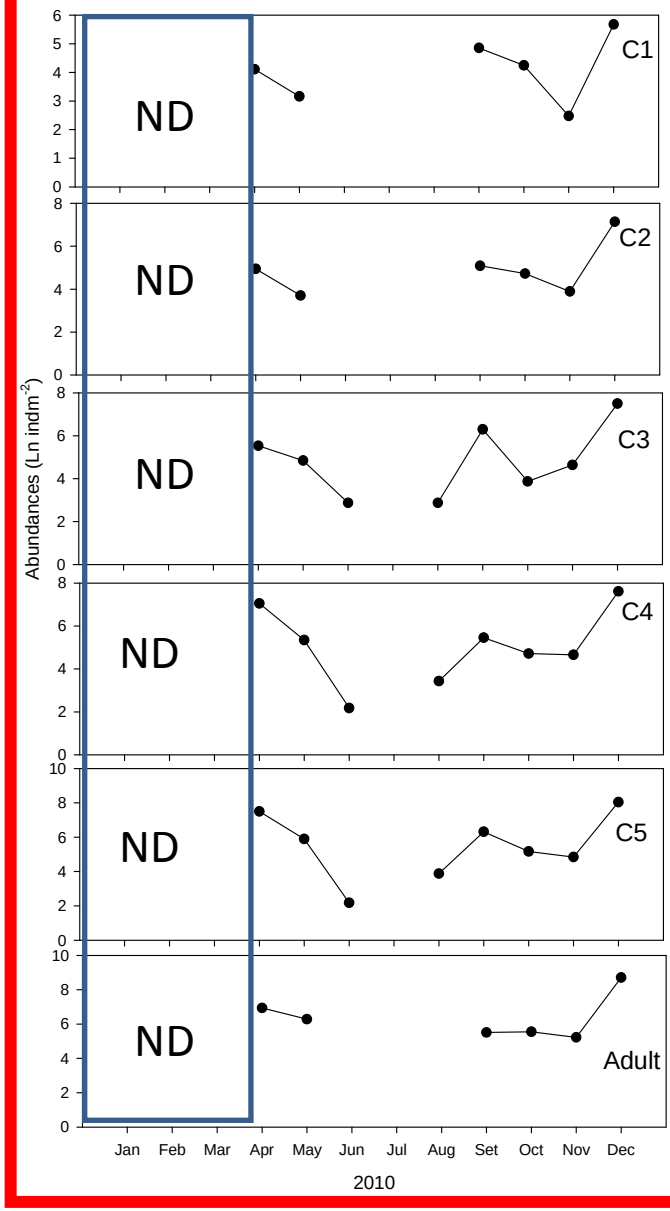


Same as *P. indicus*:

All stages present at both places, more abundant in Mejillones

Older stages (C4-Ad) more abundant at Mejillones

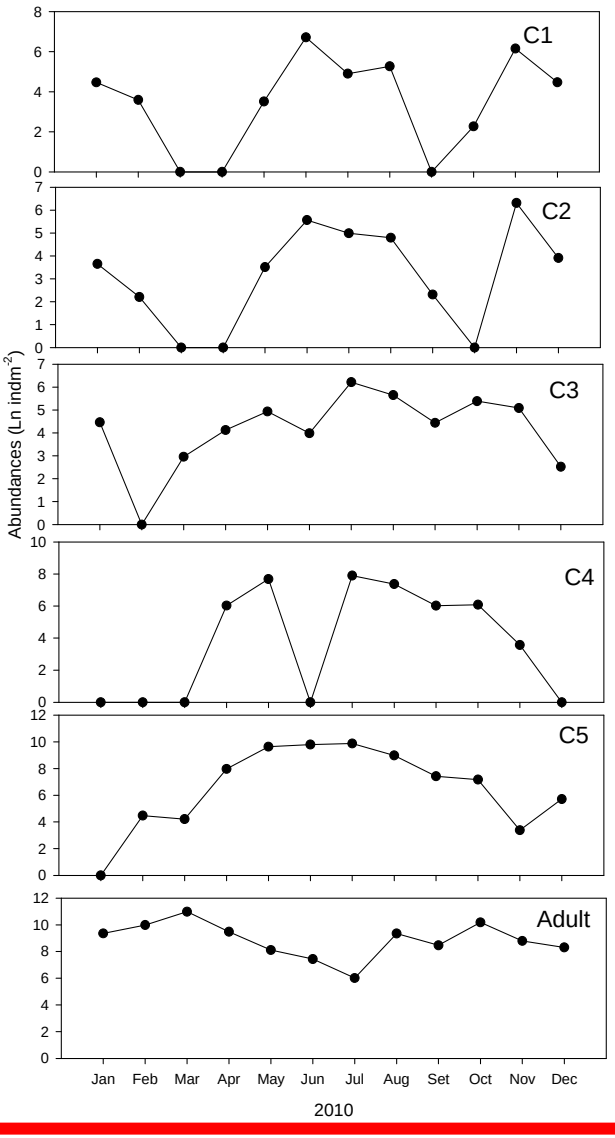
Concepcion



Population abundances

Calanus chilensis

Mejillones



Very similar species

Calanus present mostly in Mejillones

Calanoides mostly in Concepcion

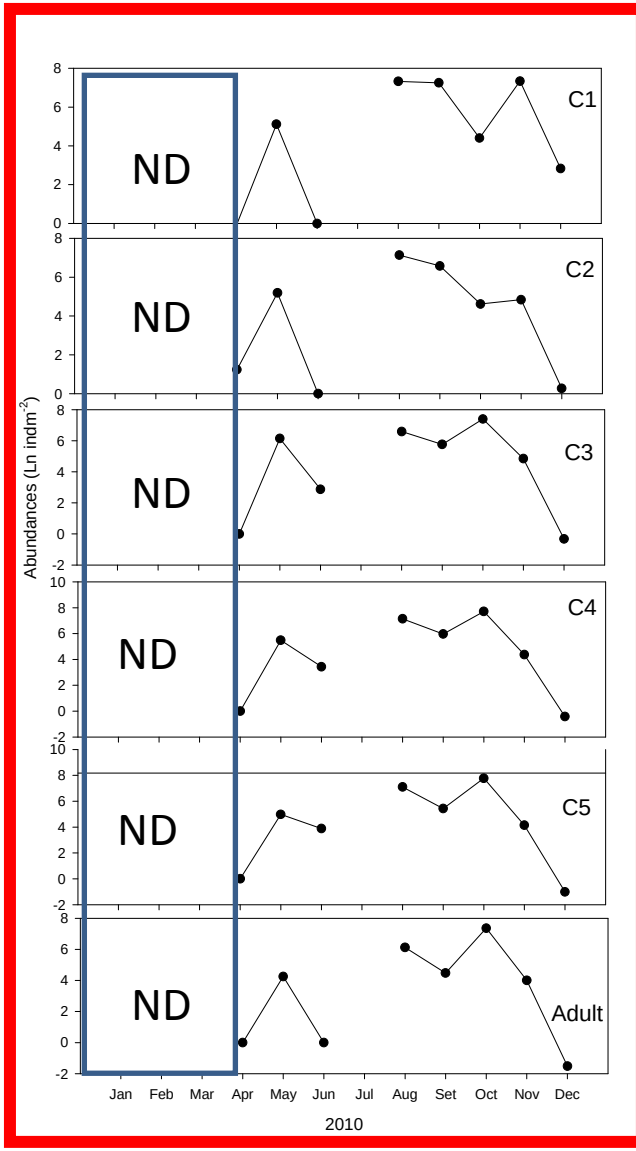
All stages present at both places, more abundant in Mejillones

Older stages more abundant (C4-Ad)

More variable in Concepcion

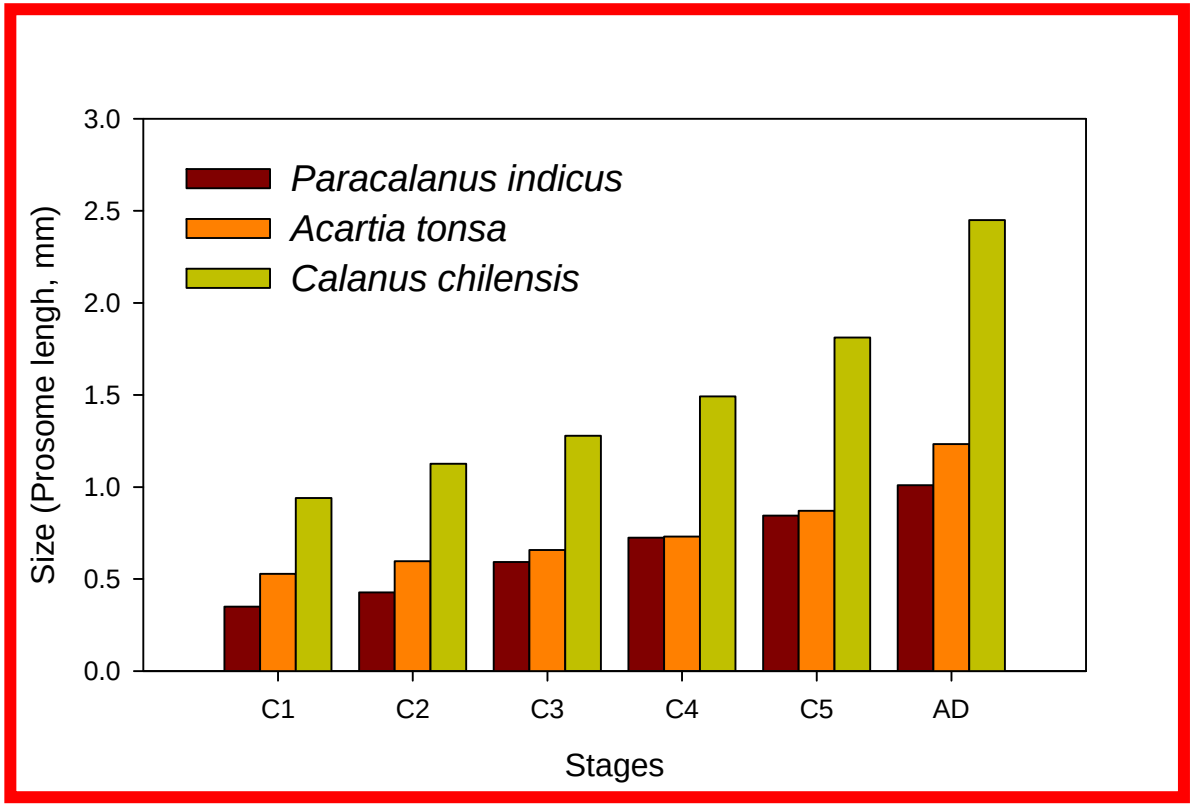
Calanoides patagoniensis

Concepcion

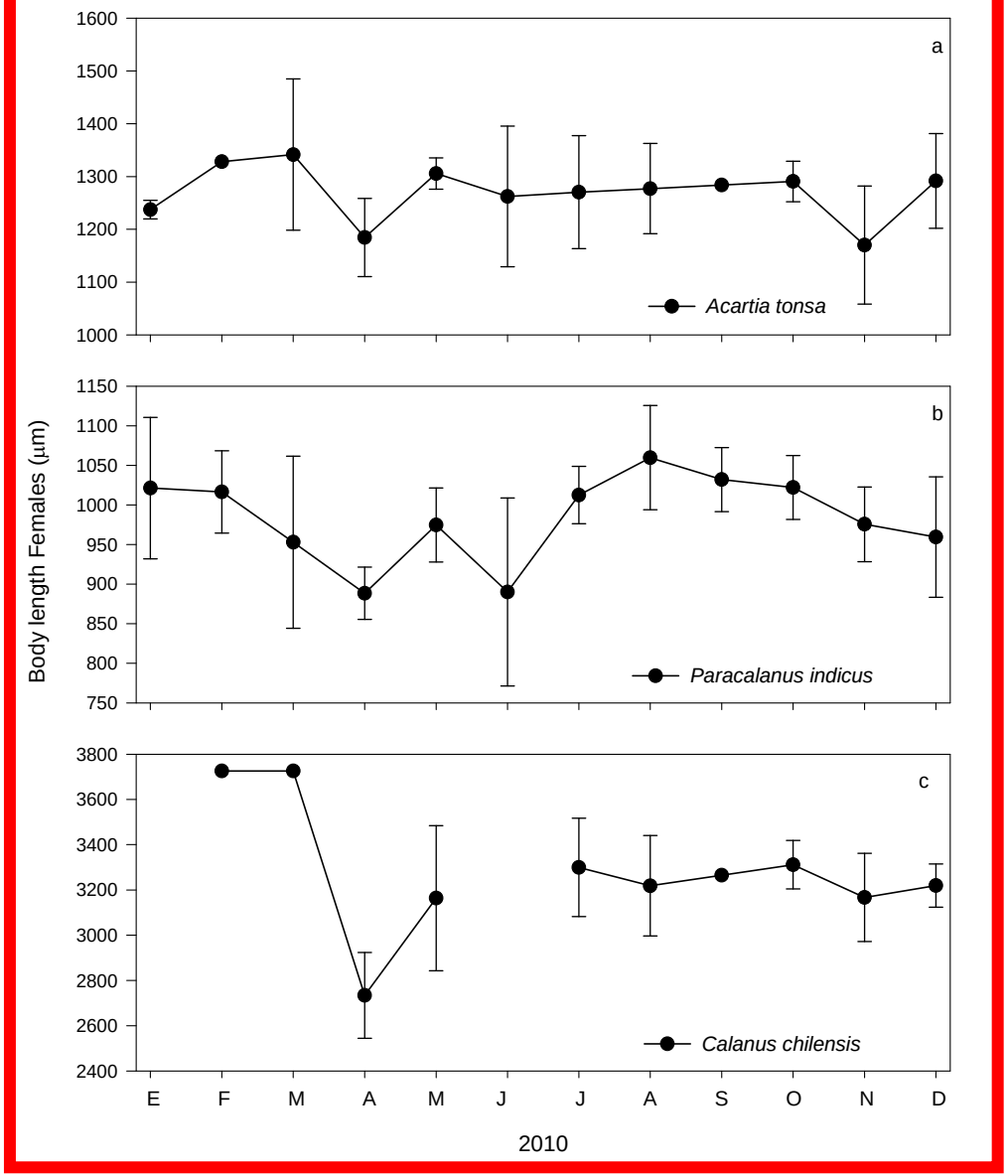


Size structure by stages

All stages are mixed, but they show different sizes



Variation of adult size (females)

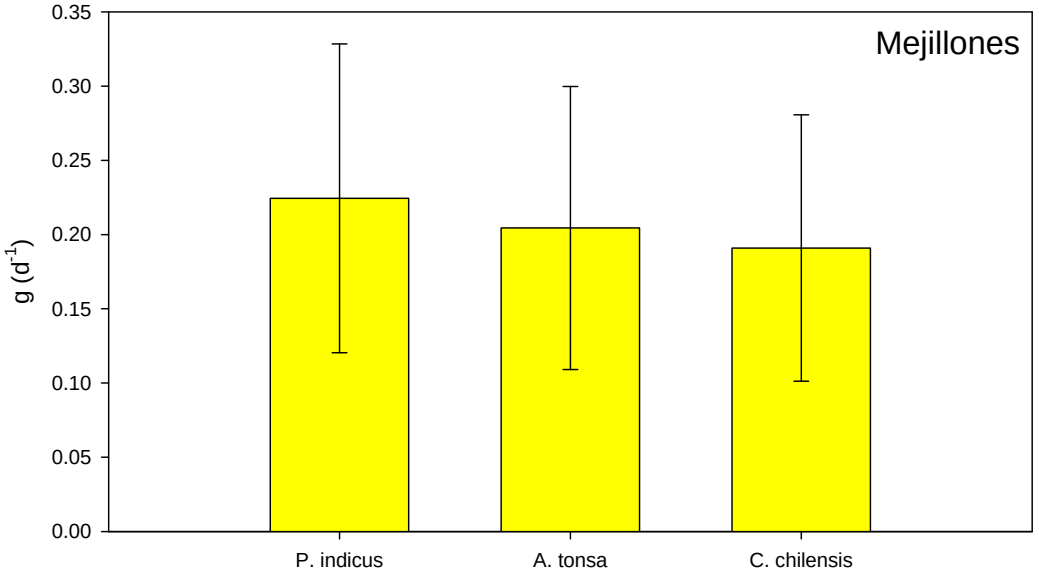


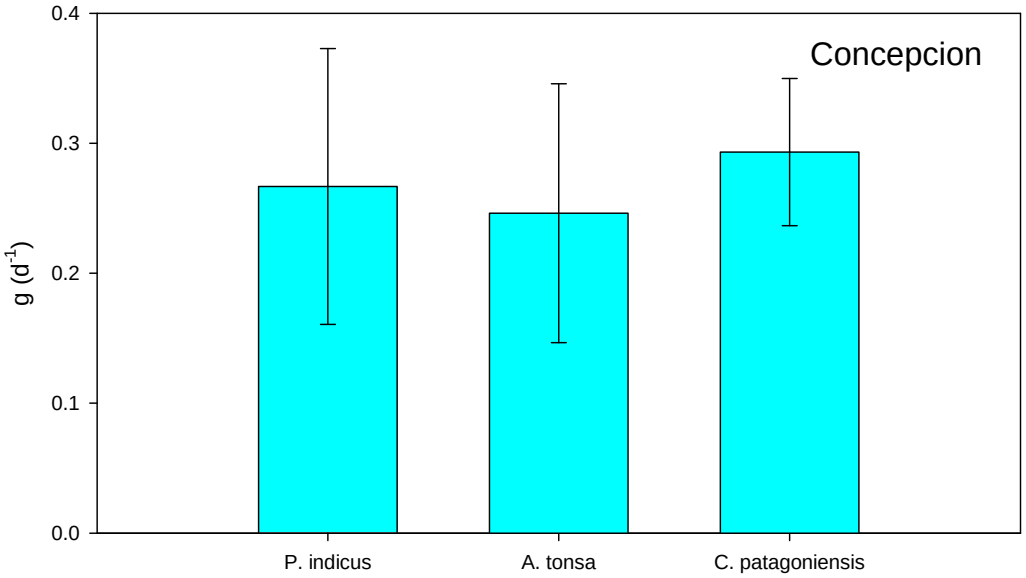
A. tonsa **showed significant diferences among months (One- way Anova, α = 0.05, p < 0.05, $F_{11,158}$ = 5.48). Smaller females are found in April and November**

P. indicus **showed significant diferences between spring-summer and late winter periods (One-way ANOVA, α = 0.05, p < 0.05, $F_{11,291}$ = 12.66). Samller females in late winter**

C. chilensis **was significantly smaller in April (One-way ANOVA, α = 0.05, p < 0.05, $F_{9,106}$ = 18.61).**

GROWTH RATES: MOULTING RATE METHOD



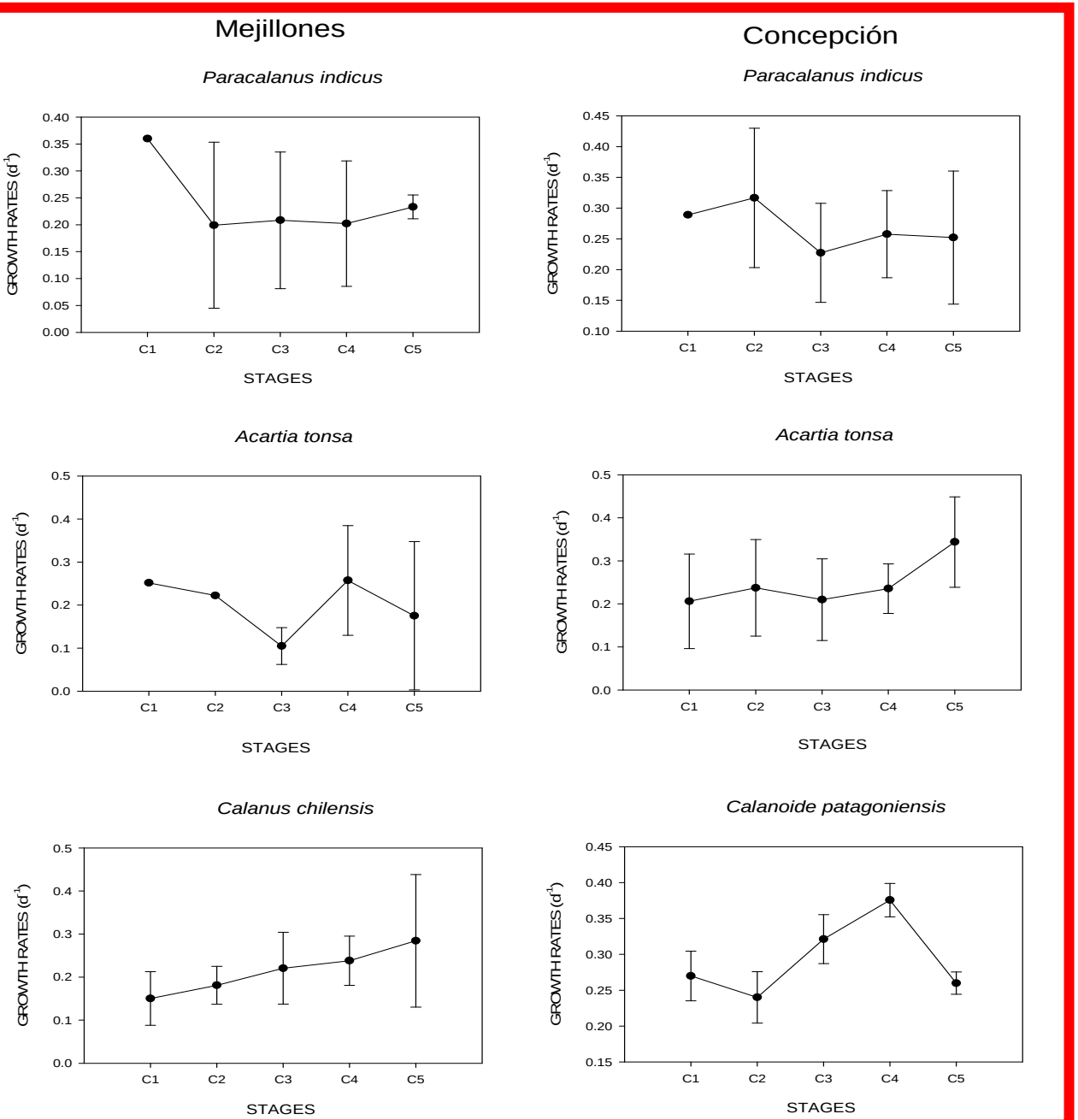


High variation in growth rates

Includes seasonal, intraseasonal, stages variation

No significant differences among species and places

IN MORE DETAIL



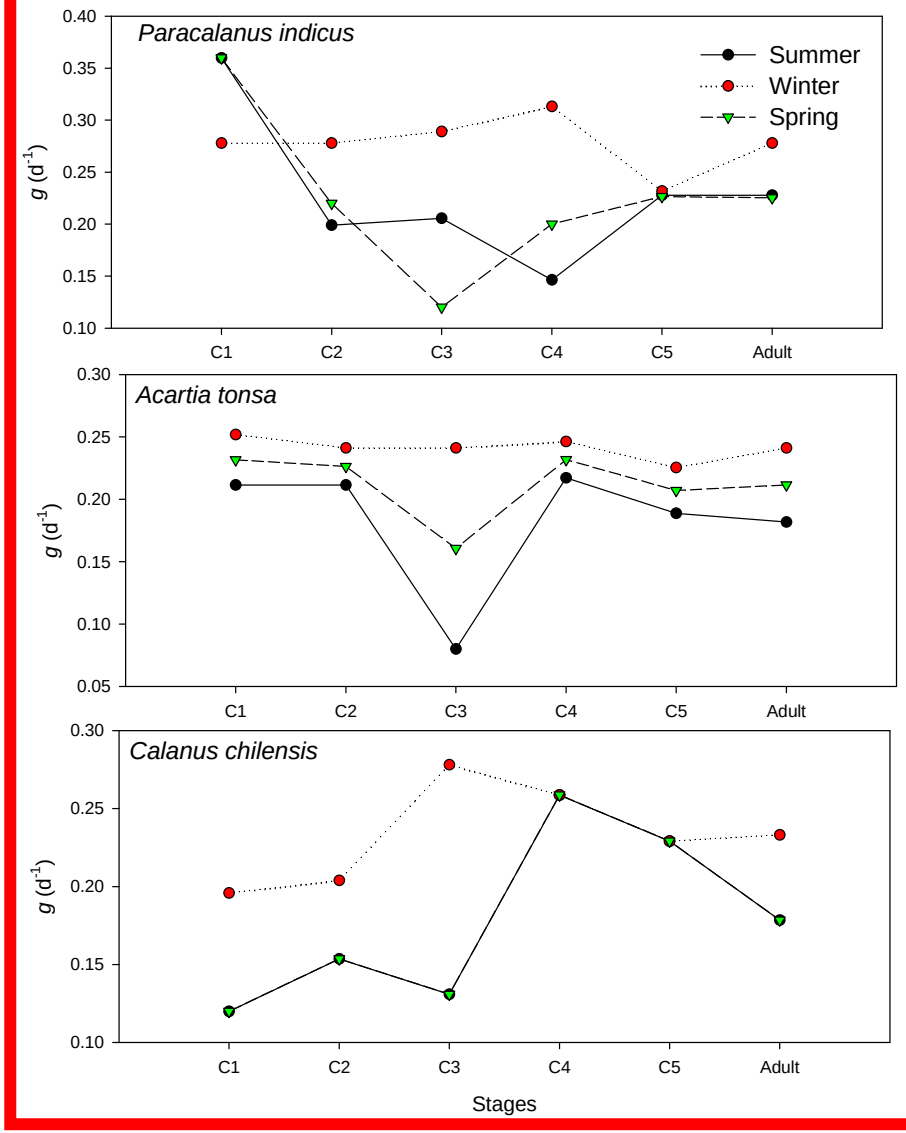
High variability within species and no apparent differences among stages

g can assumed at similar levels throughout development

This supports exponential and continuous growth

SEASONAL GROWTH PATTERNS

Mejillones



g increases in spring-summer for early C1 in P. indicus

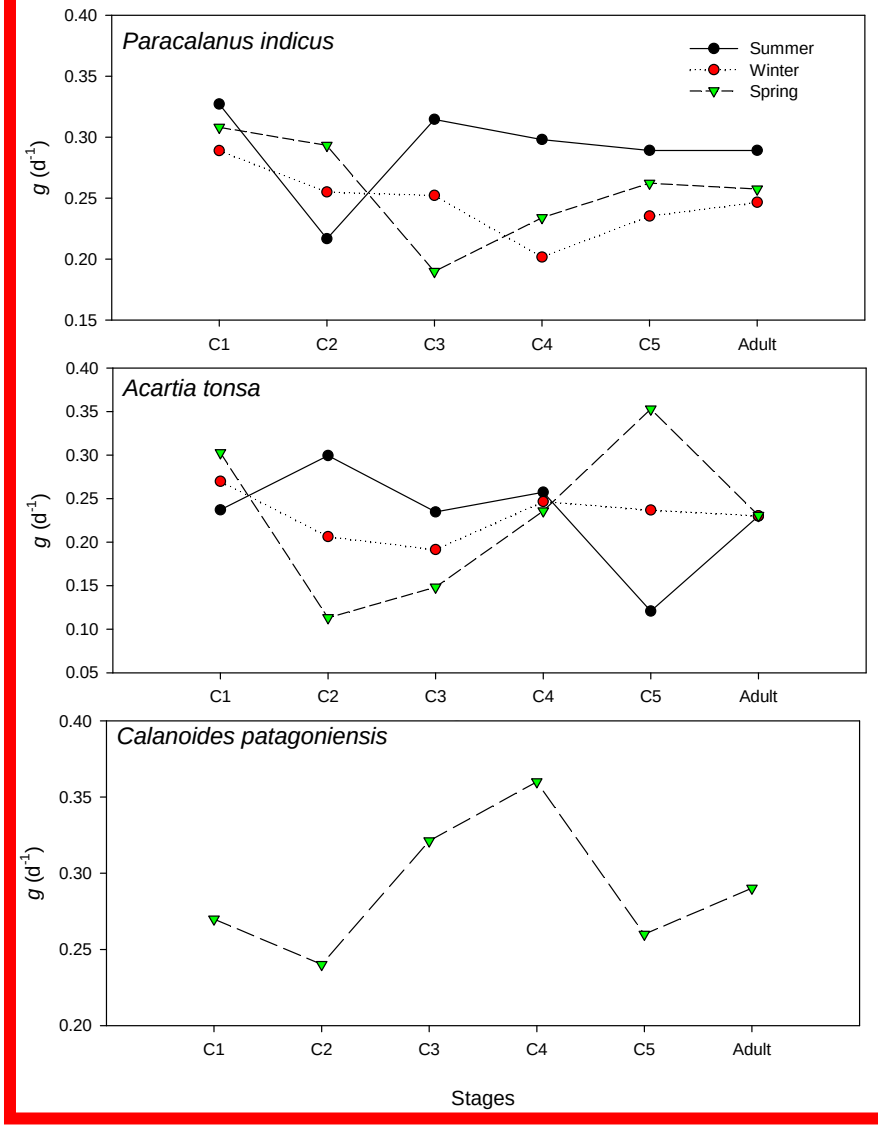
In A. tonsa C3 shows lower g in spring-summer

In C. chilensis early stage show greater g in winter

Therefore: there in no clear or unique seasonal pattern of g

SEASONAL GROWTH PATTERNS

Concepcion



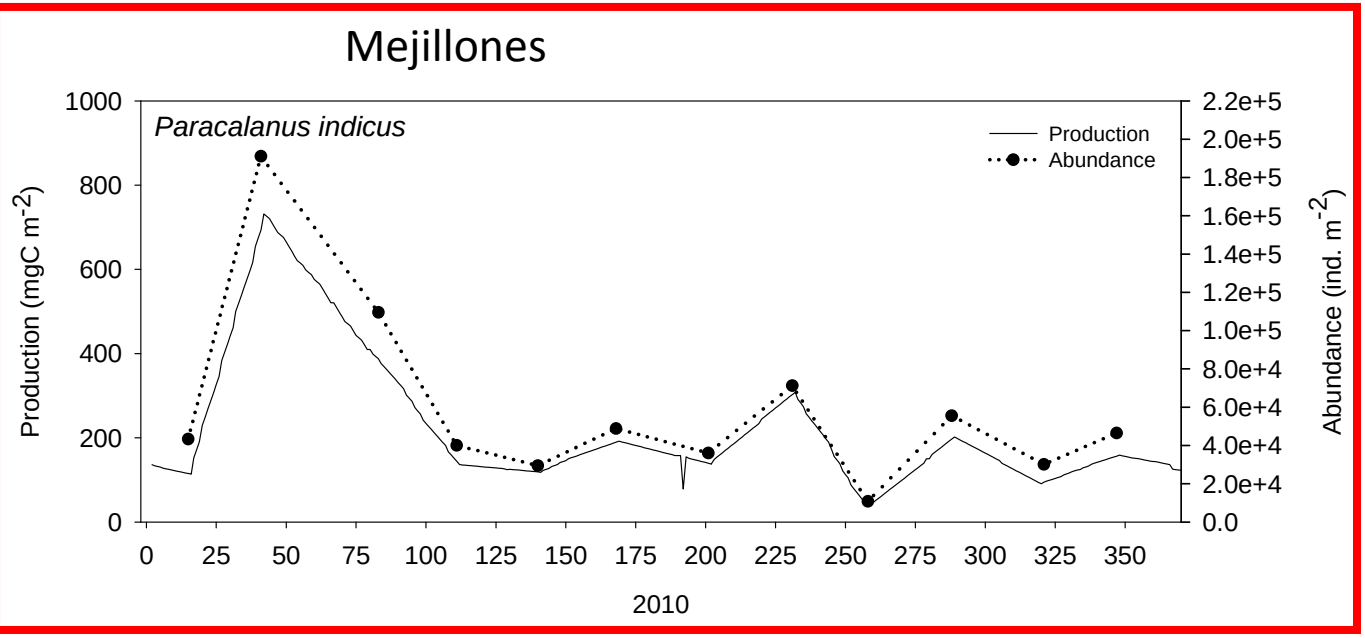
g increases in spring-summer for all stages in P. indicus

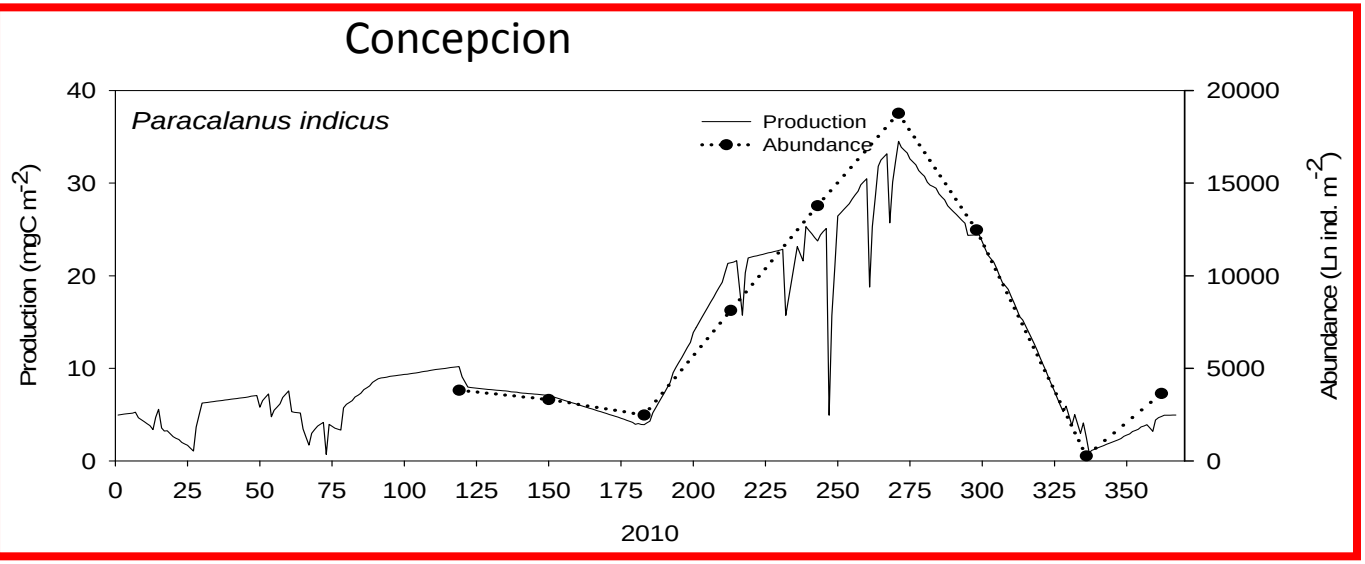
In A. tonsa early stages grow faster in summer and late stages in spring

In C. patagoniensis only spring data are available

Seasonality of g is also unclear in this upwelling center

P. indicus: temporal variability



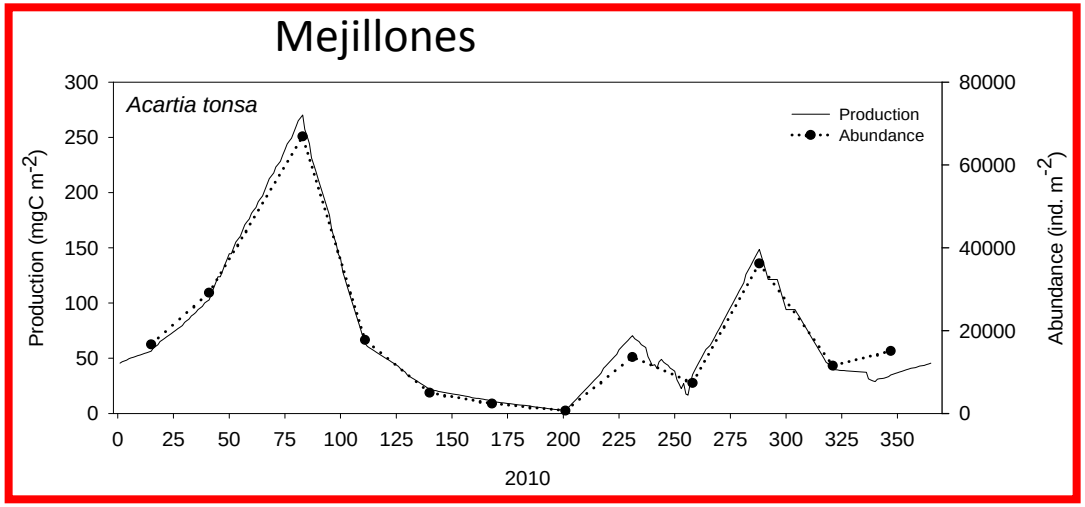


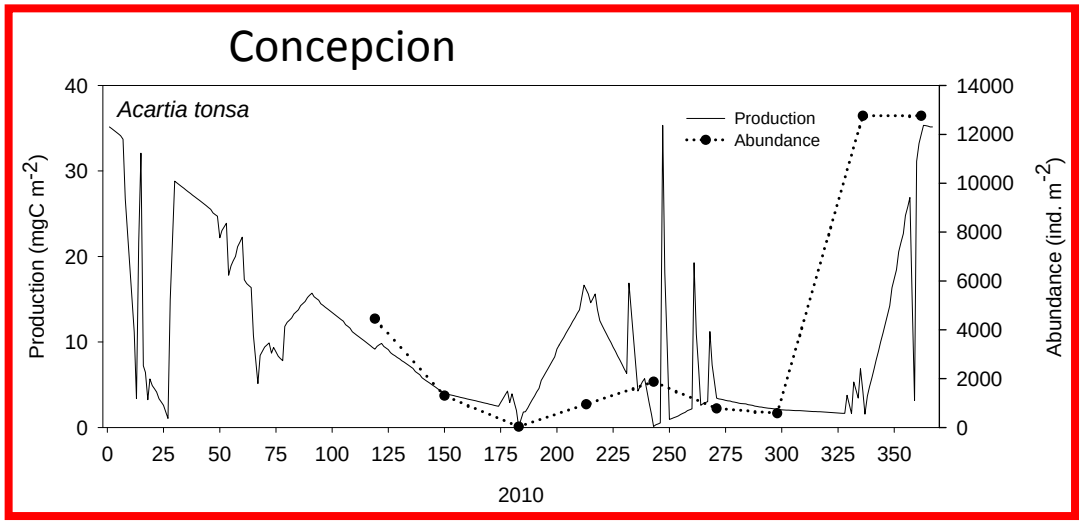
Seaonal production and abundance do not coincide

Both production and abundance are about one order of magnitude higher in Mejillones

Annual production in Concepcion depends on the spring peak

A. tonsa: spatial and temporal variability



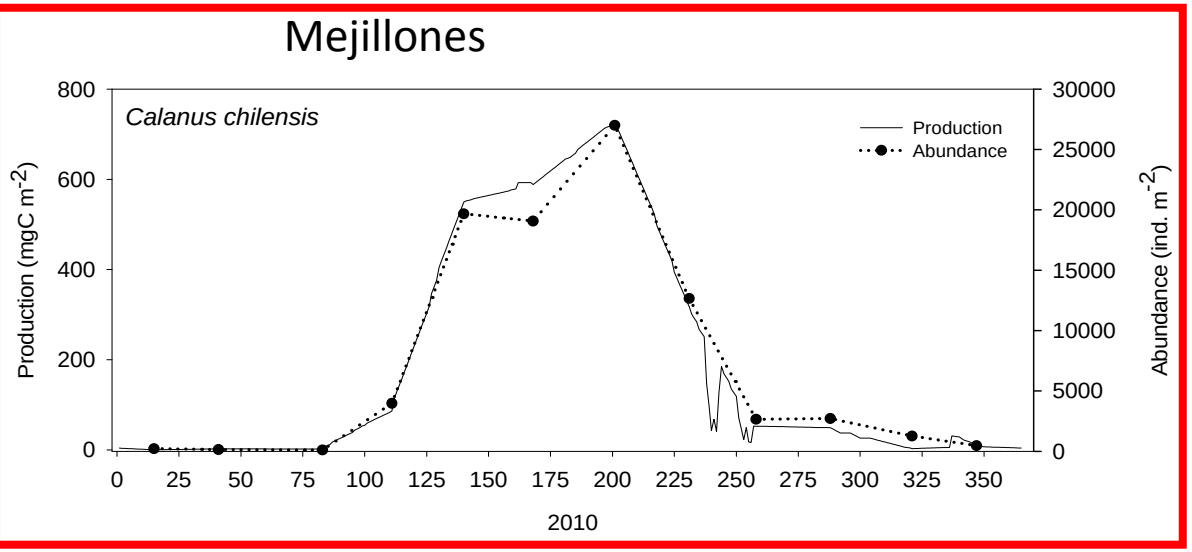


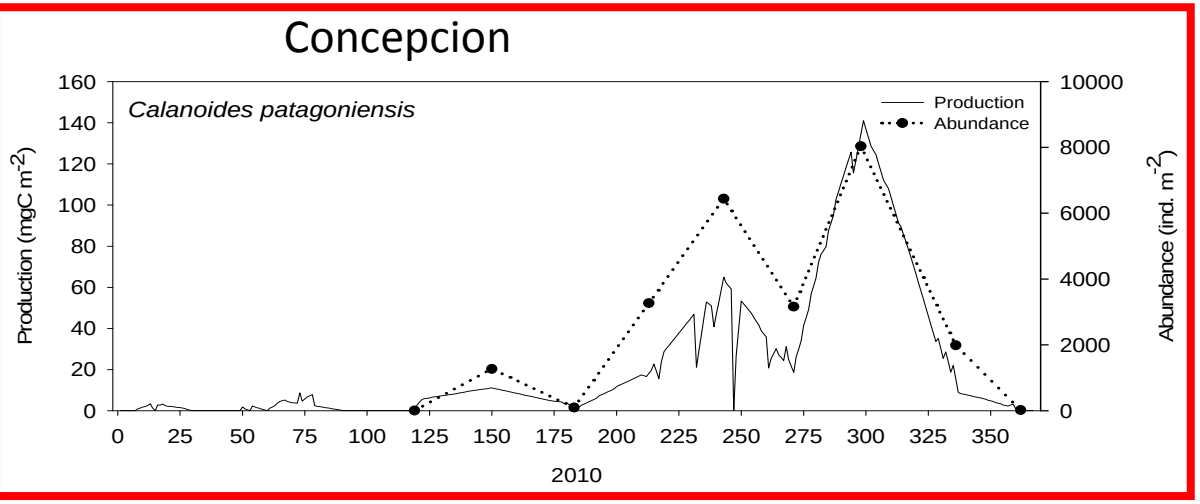
Seaonal production and abundance do not coincide

Both production and abundance are about one order of magnitude higher in Mejillones

Annual production in Concepcion depends on the spring and summer peaks

C. chilensis and *C. patagoniensis*: temporal variability



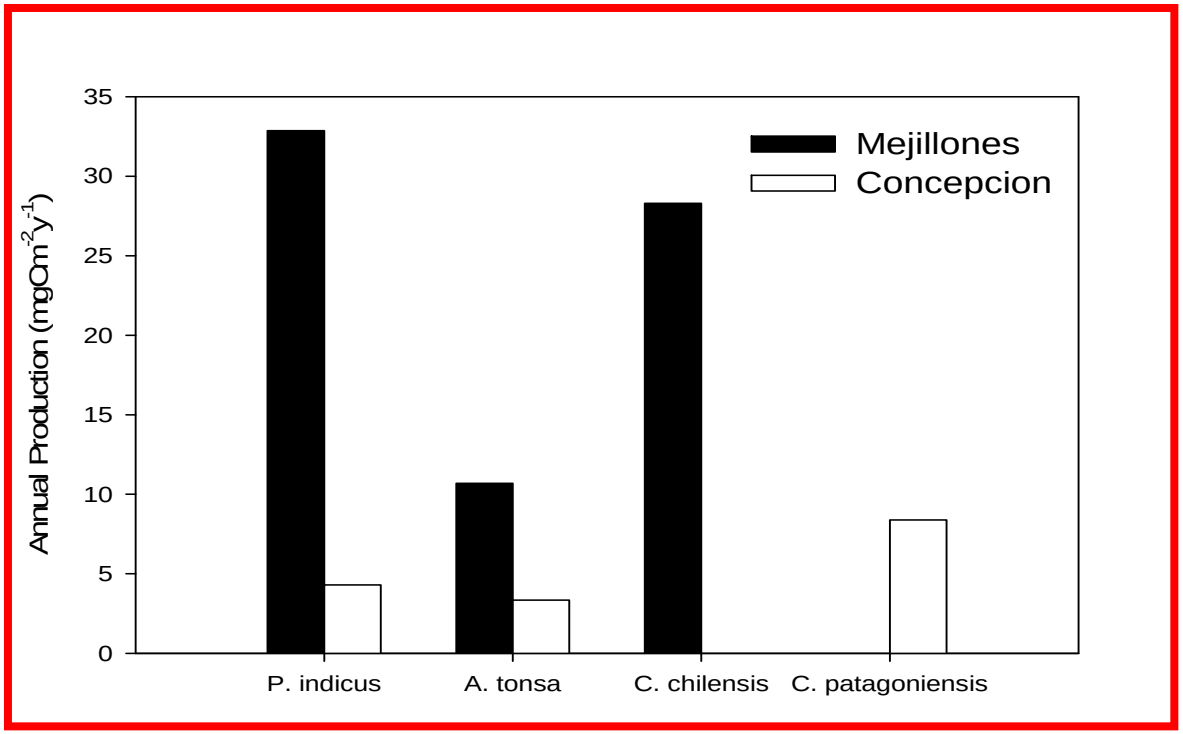


C. chilensis dominated in the winter period

Production of C. chilensis in Mejillones is much greater than that of C. patagoniensis in Concepcion

Annual production of C. patagoniensis in Concepcion depends on the spring peak

Annual Production: Mejillones vs Concepcion



Despite similar growth rates at both places production is much higher in Mejillones

Even though C. chilensis is larger in size than A. tonsa its production is greater

P. Indicus shows the greater production rate, because of faster development in early copepodids. Therefore fast development yields more productioon on an annual basis

Thanks you

PICES
CONICYT- FONDECYT N° 11090146 by P. Hidalgo