Estimating potential habitat for chum salmon (*Oncorhynchus keta*) in the Western Arctic using a bioenergetics model coupled with a three-dimensional lower trophic ecosystem model

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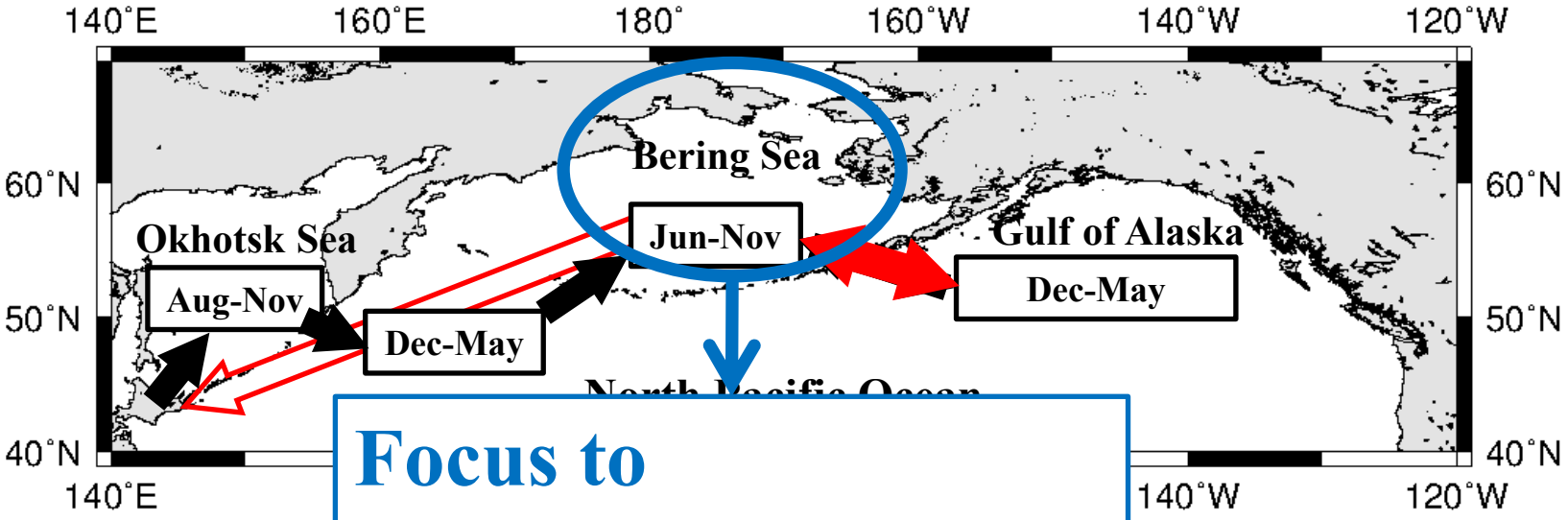
Today's Contents

1. Introduction
2. Model description
3. Global warming scenario
4. Potential habitat for chum salmon
5. Conclusions

Migration route of Japanese chum salmon

(modified Urawa, 2000)



① Japanese chum [illegible] m Hokkaido, Japan, and are distributed in t[illegible]umn,

② overwinter in the western North Pacific.

③ Immature chum salmon enter the Bering Sea by the following summer,

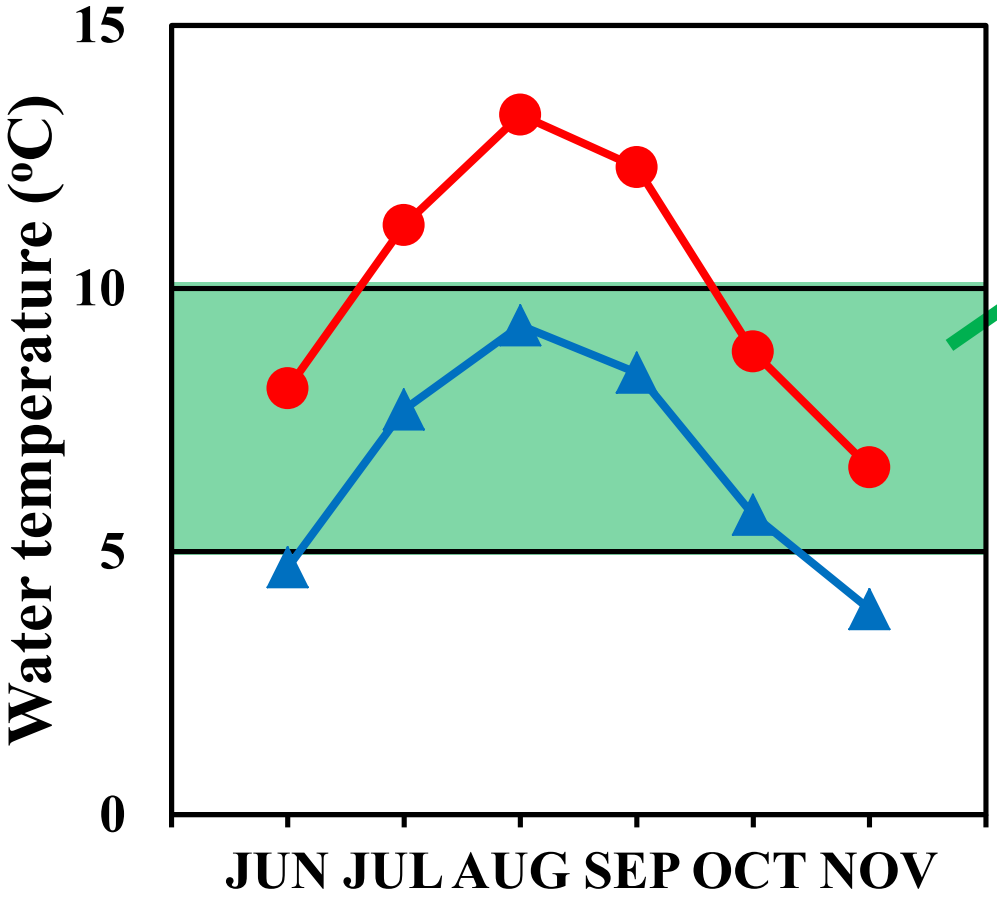
④ migrate to the Gulf of Alaska during winter,

⑤ migrate to the Bering Sea during summer to remain in preferred water temperature.

⑥ They repeat the southward/northward migration for 3-4 times seasonally.

⑦ When they are ready to mature in the fourth/fifth year summer, they return to their home rivers in Hokkaido.

SST in the Bering Sea
Present & 2095yr under the SRES-A1B



Optimal Temp. for chum salmon
: 5°C – 10°C
(Kishi et al., 2010)

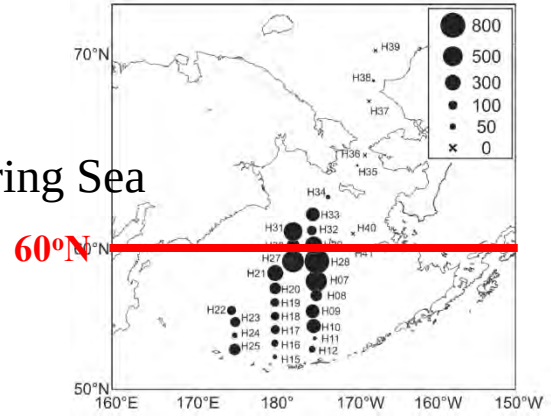
WOA05

2095-A1B
(Kawamiya et al., 2005)

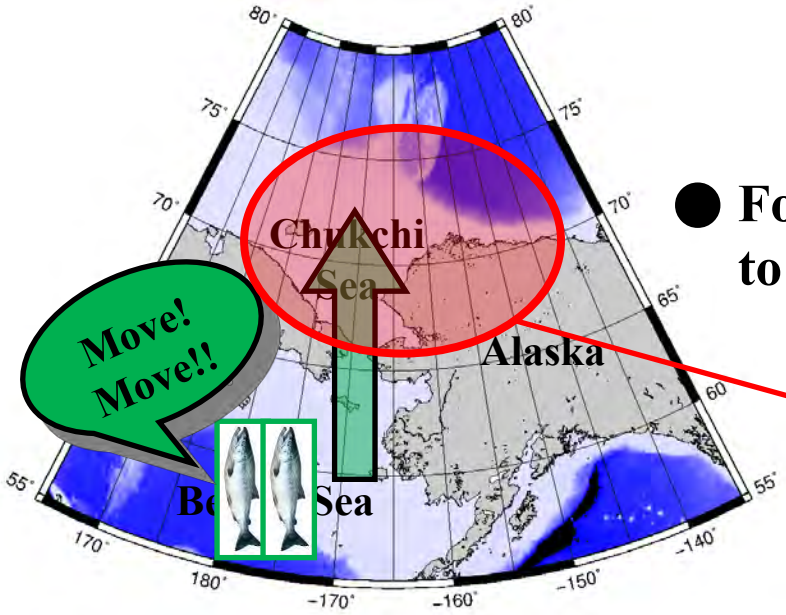
Objectives

● **SST increase affect to salmon northing directly.**

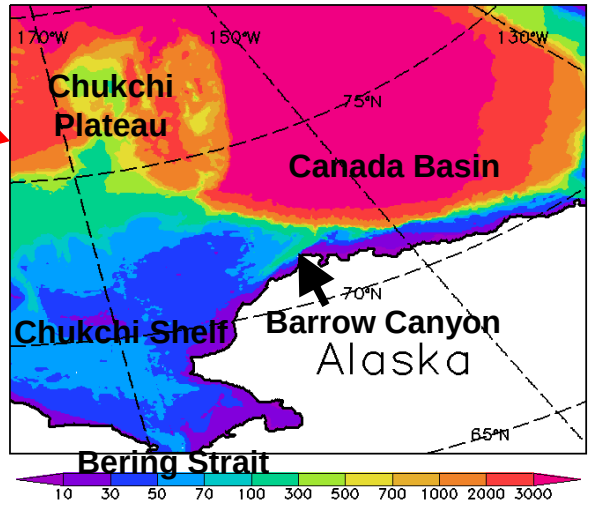
: Japanese chum salmon migrated to northern areas in the Bering Sea during summer (Sato et al., 2012).



CPUE during summer 2009 (Sato et al., 2012)

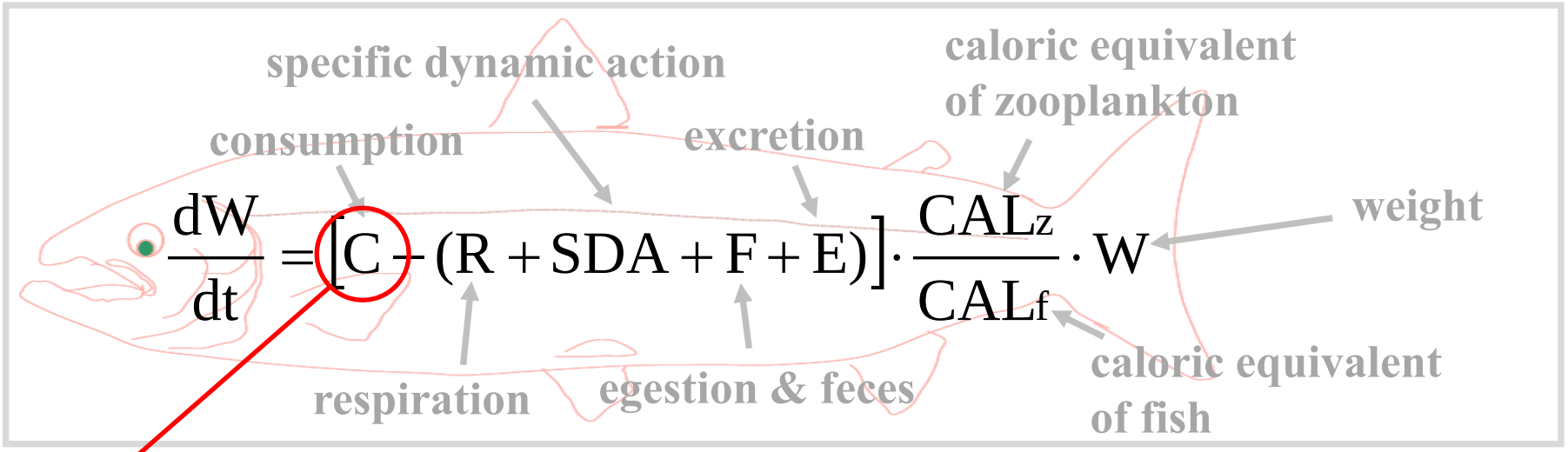


● **Focus on chum salmon migrating northward to the Western Arctic during summer**



● **To estimate the potential habitat for chum salmon in the Western Arctic using a bioenergetics model coupled 3D-NEMURO**

Bioenergetics model

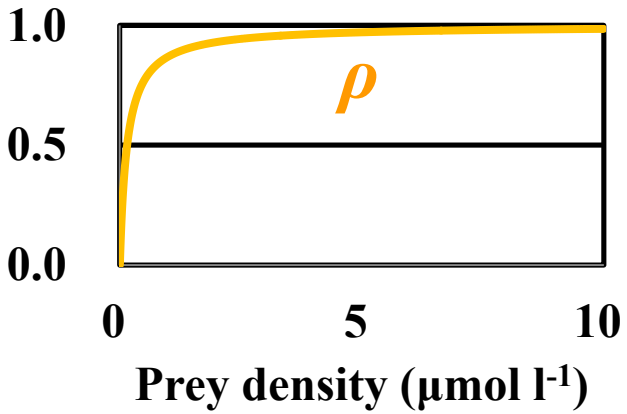


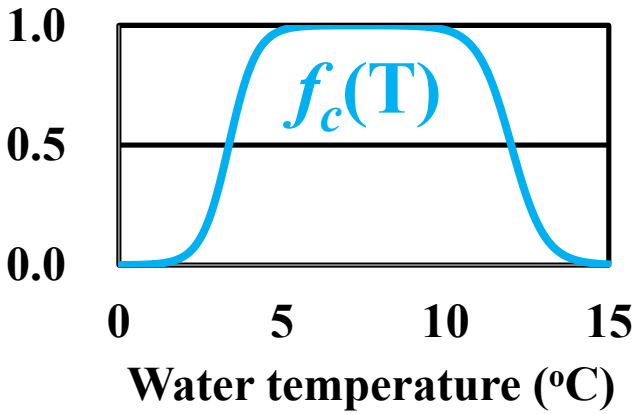
$$\frac{dW}{dt} = \left[C - (R + SDA + F + E)\right] \cdot \frac{CAL_z}{CAL_f} \cdot W$$

(Rudstam, 1988; Kamezawa et al., 2007; Kishi et al., 2010)

$$C = C_{MAX} \times \rho \times f_c(T)$$

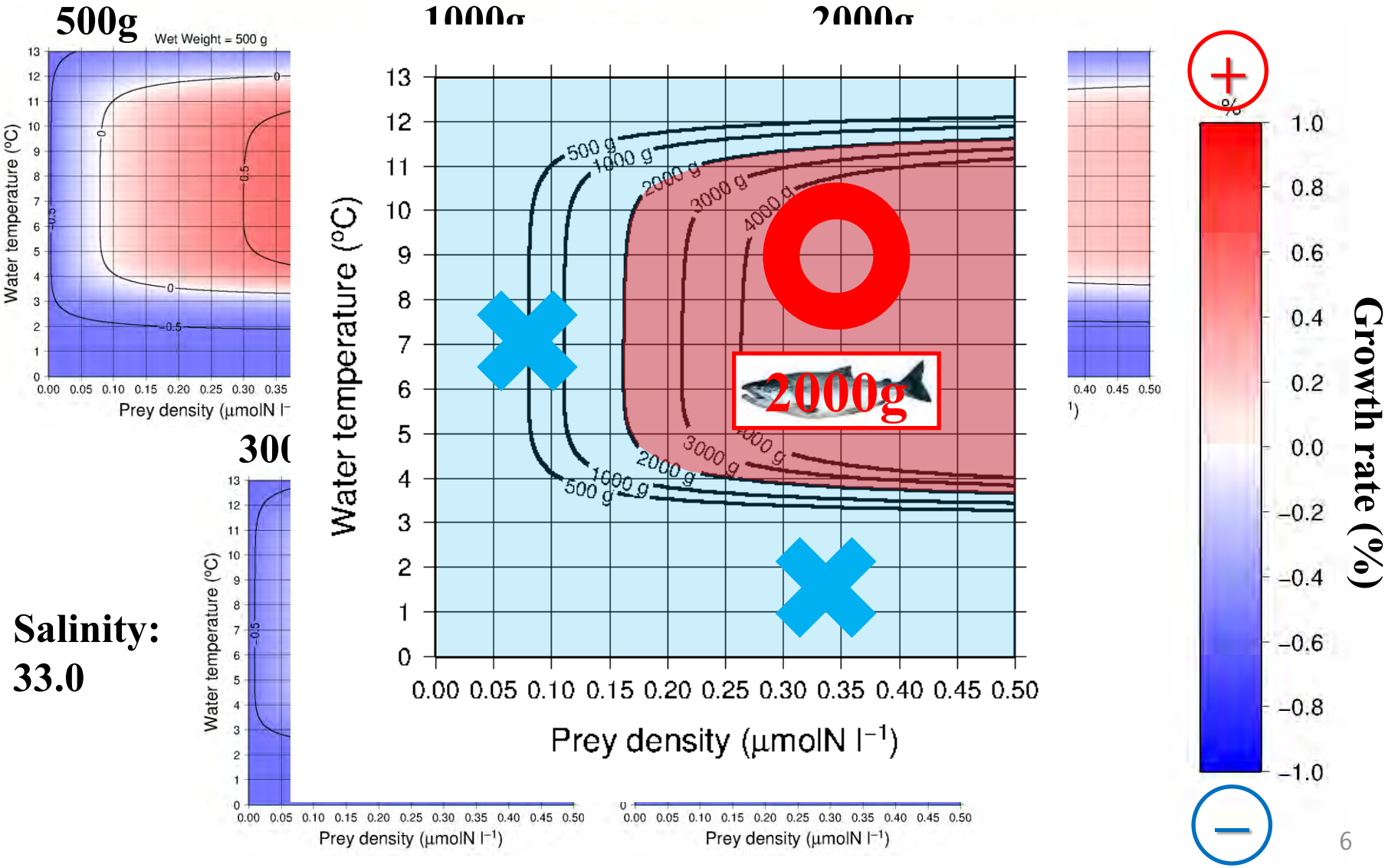
C_{MAX} : Maximum consumption rate ($C_{MAX}=ac \times W^{bc}$)





Definition of potential habitat

"an area where chum salmon can grow up (i.e., $\frac{dW}{dt} > 0$)"



● **Water temperature, salinity, and prey density in the bioenergetics model: obtained from the 3-D NEMURO results simulated by Watanabe et al. (2012)**

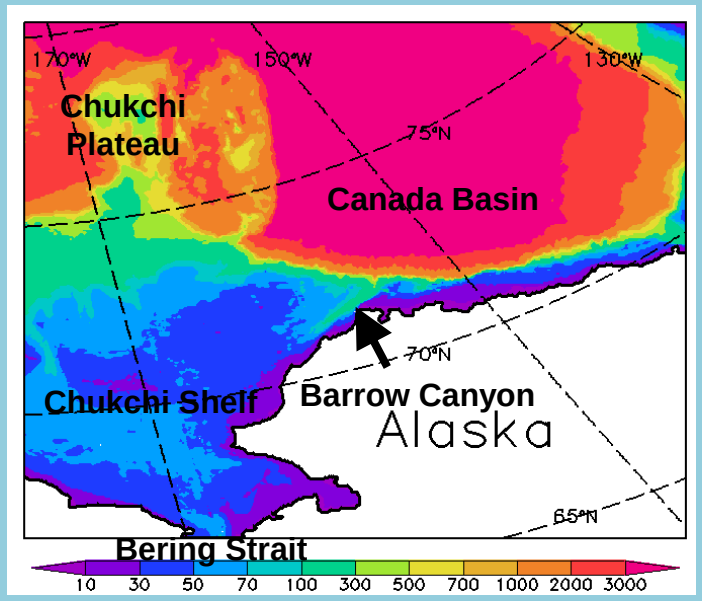
3-D NEMURO (Watanabe et al., 2012)

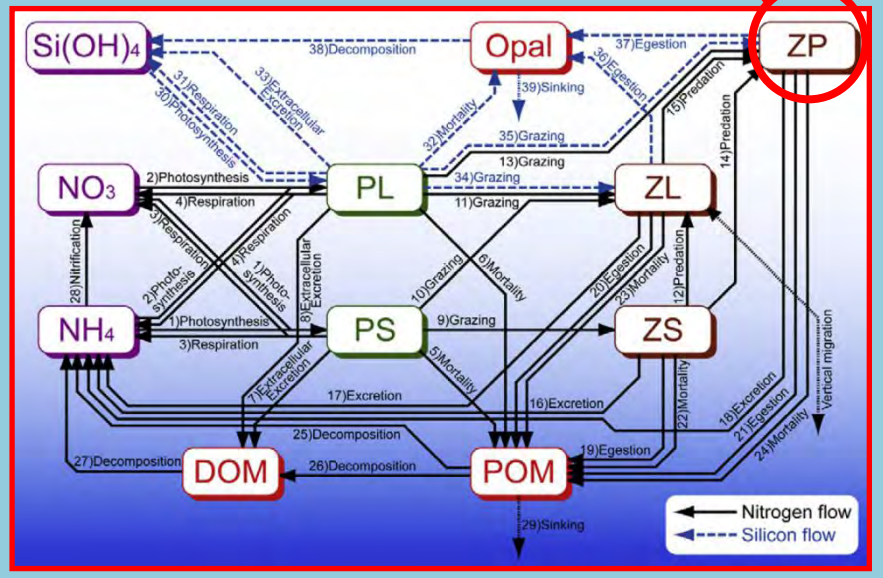
COCO 3.4 (Hasumi, 2006) + **NEMURO (Kishi et al., 2007)**

■ **Horizontal: 2.5 km, Vertical: 25 l**

■ **Run for nine months from M**

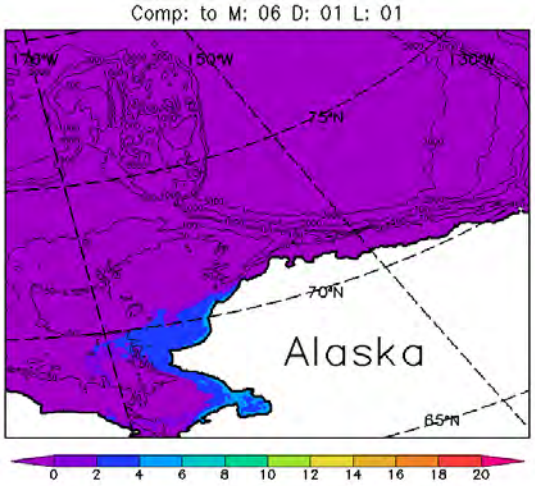
+ **Bioenergetics model**



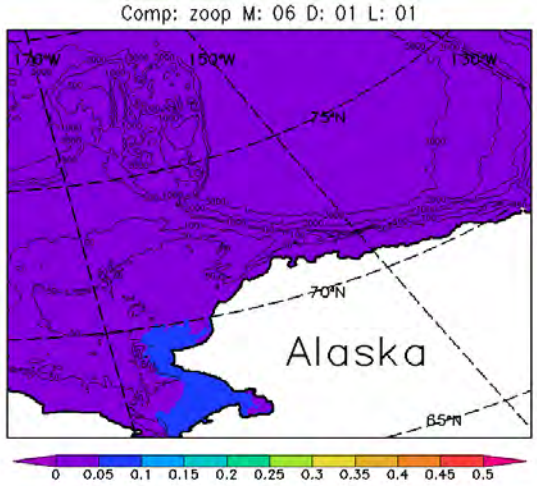


Inputs from 3-D NEMURO

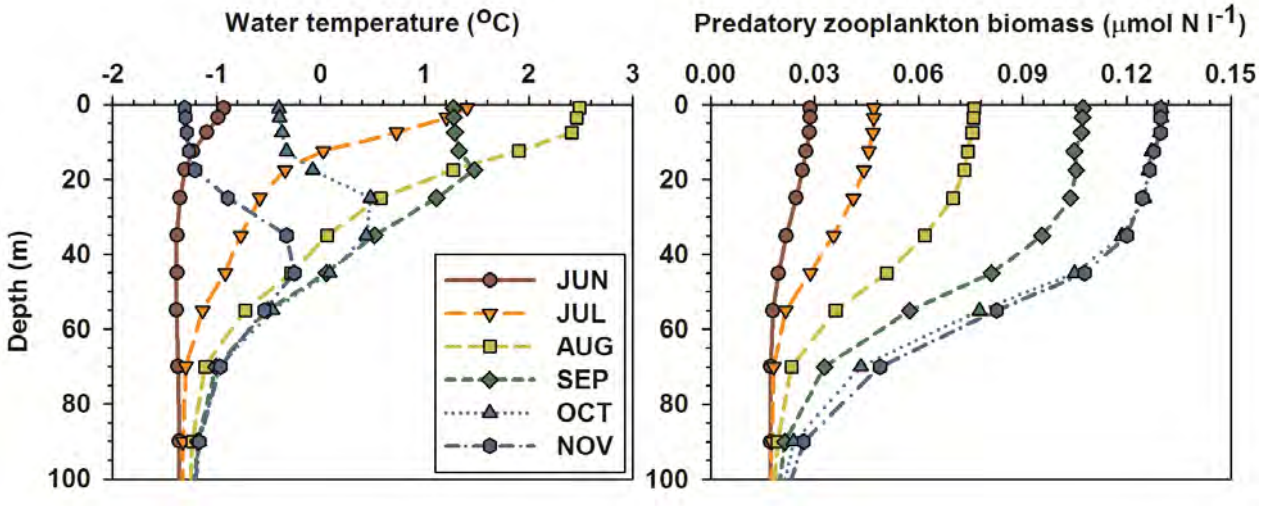
Water temperature (°C)



Prey density (μmol l^{-1})



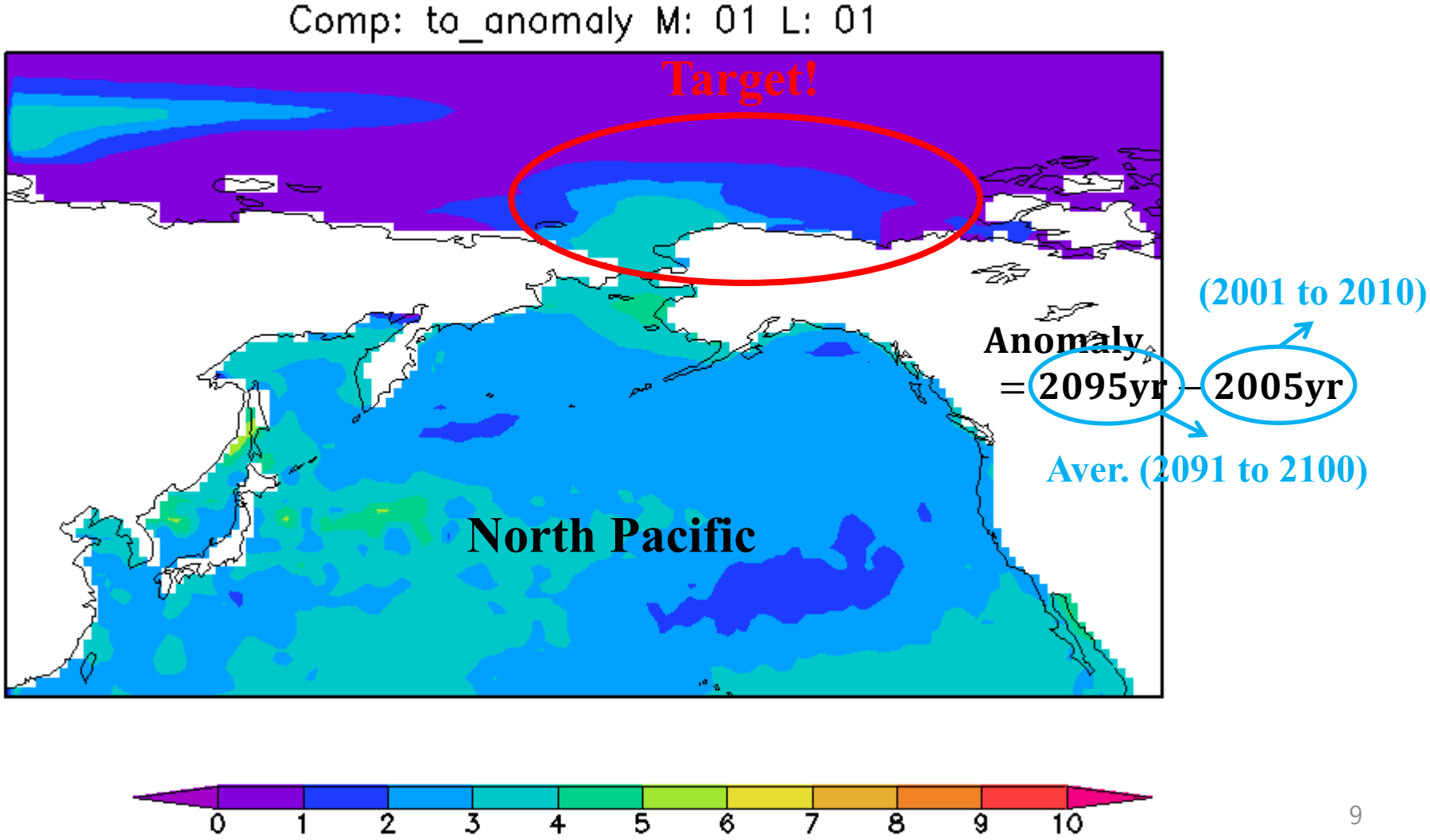
Horizontal ~
at surface
from June to November



Monthly vertical ~
from the surface to 100 m
(averaged horizontally
in the entire model domain)

Global warming scenario

● **Monthly water temperature anomaly modeled under the SRES-A1B of IPCC simulated by Kawamiya et al. (2005) using the MIROC (Hasumi and Emori, 2004).**

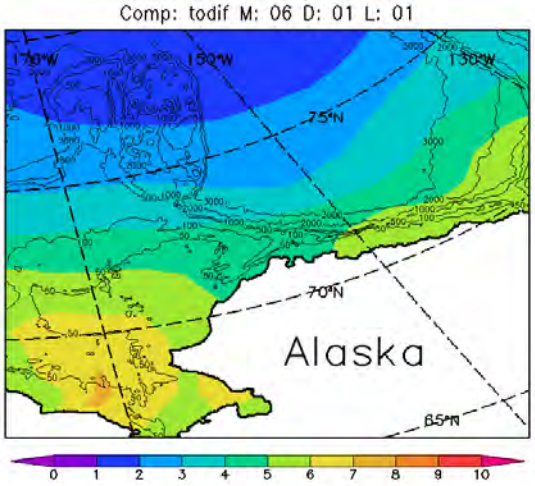


Anomaly (or normalized anomaly)

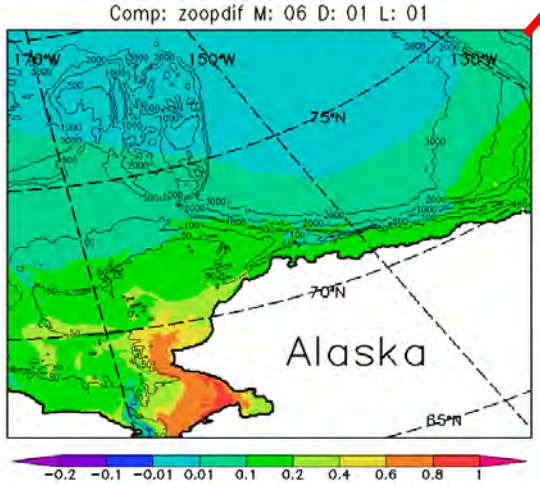
$= 2095\text{yr} - \text{present}$

$= \dfrac{2095\text{yr} - \text{present}}{\text{present}}$

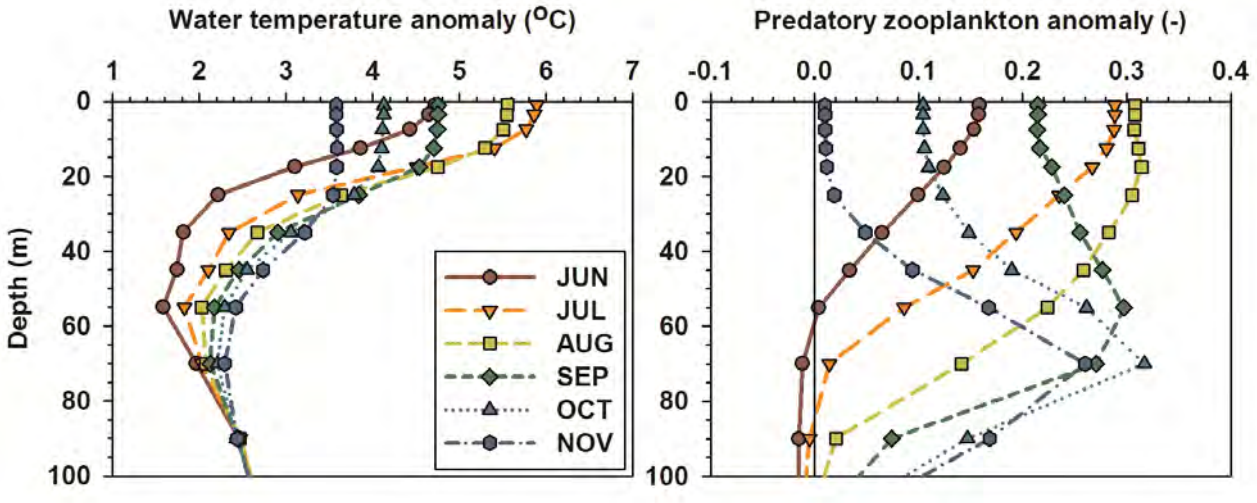
Water temperature (°C)



Prey density (μmol l^{-1})



Horizontal ~
at surface
from June to November

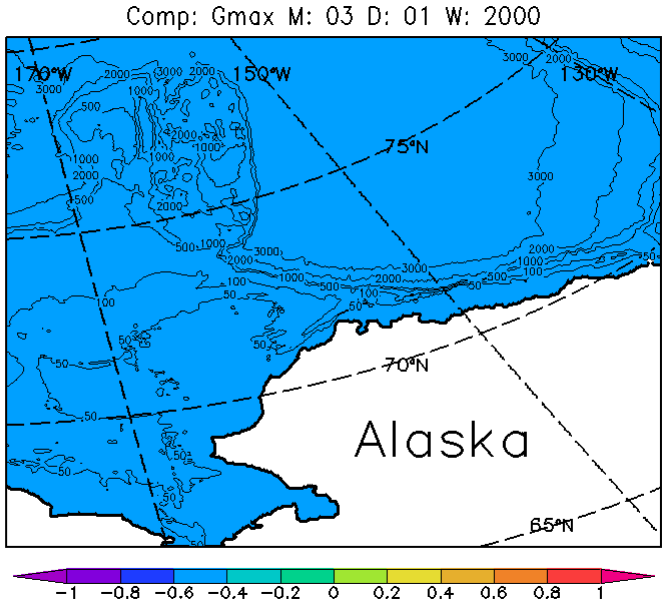


Monthly vertical ~
from the surface to 100 m
(averaged horizontally
in the entire model domain)

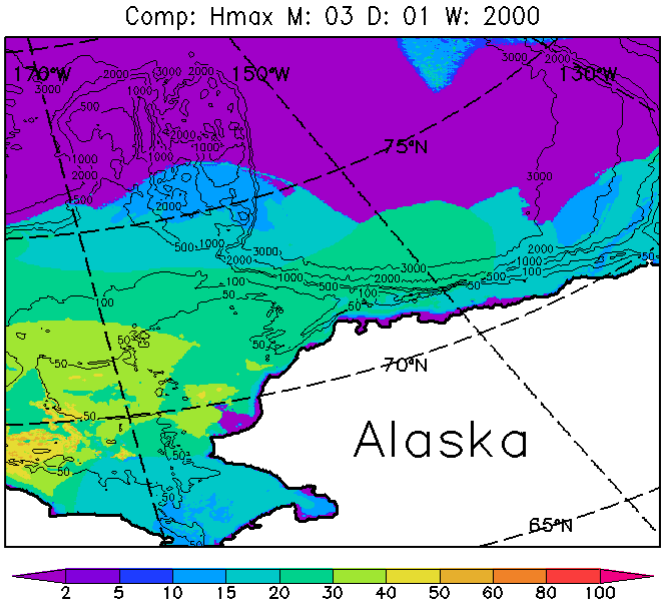
2000 gWW chum salmon under 2003 case

MODEL RESULT

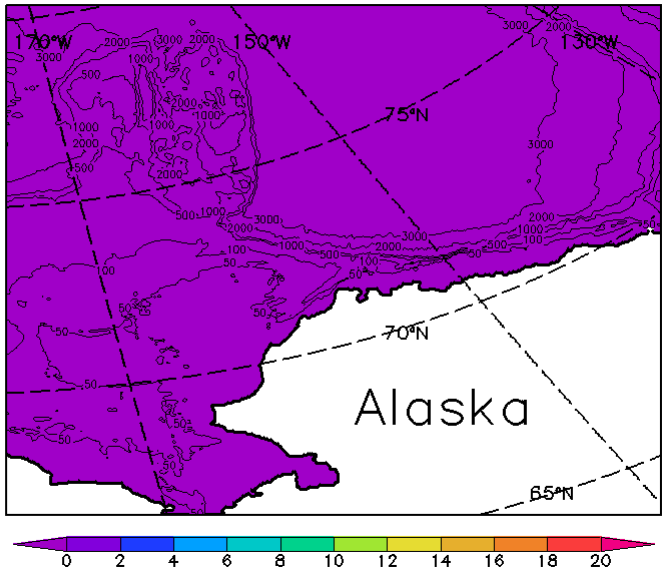
Maximum growth rate (%)



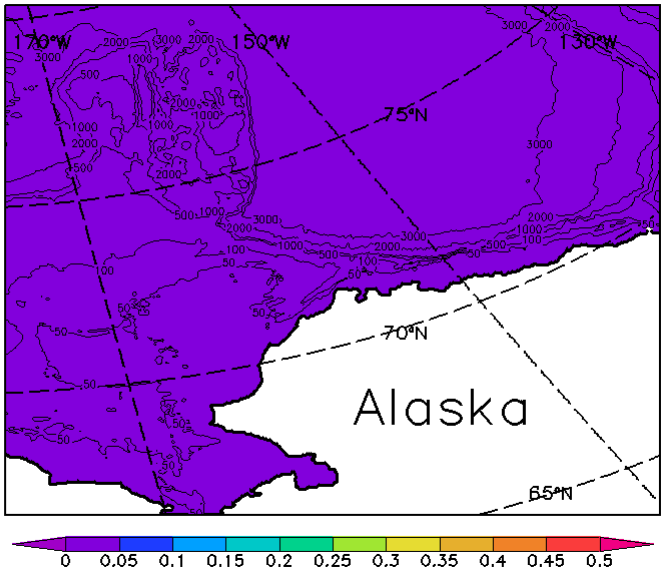
Maximum Growth Depth (m)



Water temperature at the MGD

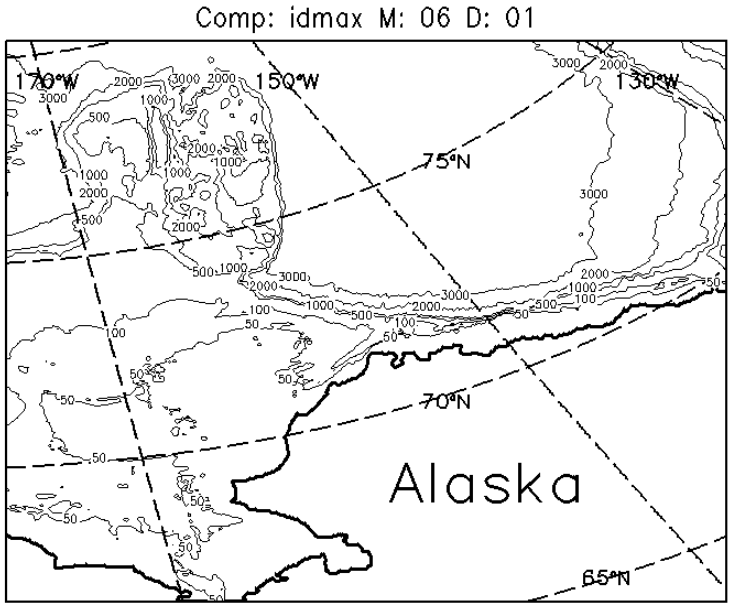


Predatory zooplankton at the MGD

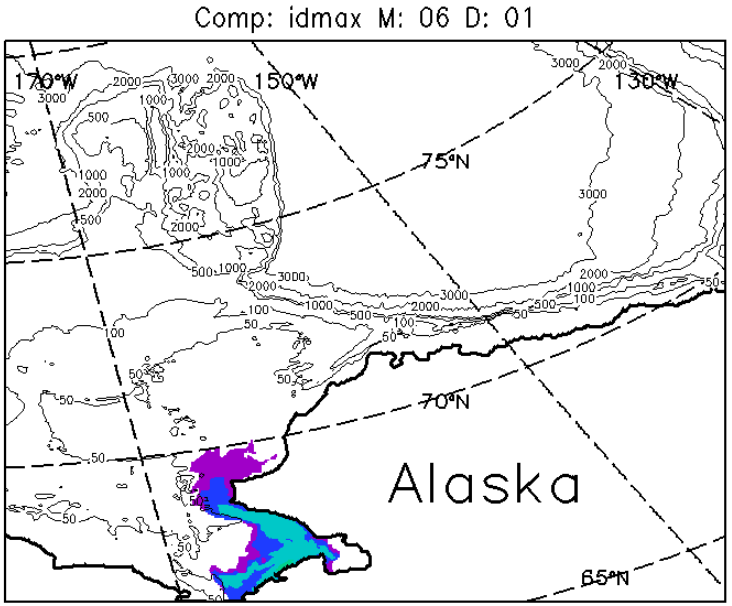


Potential habitat for chum salmon June to November

Present

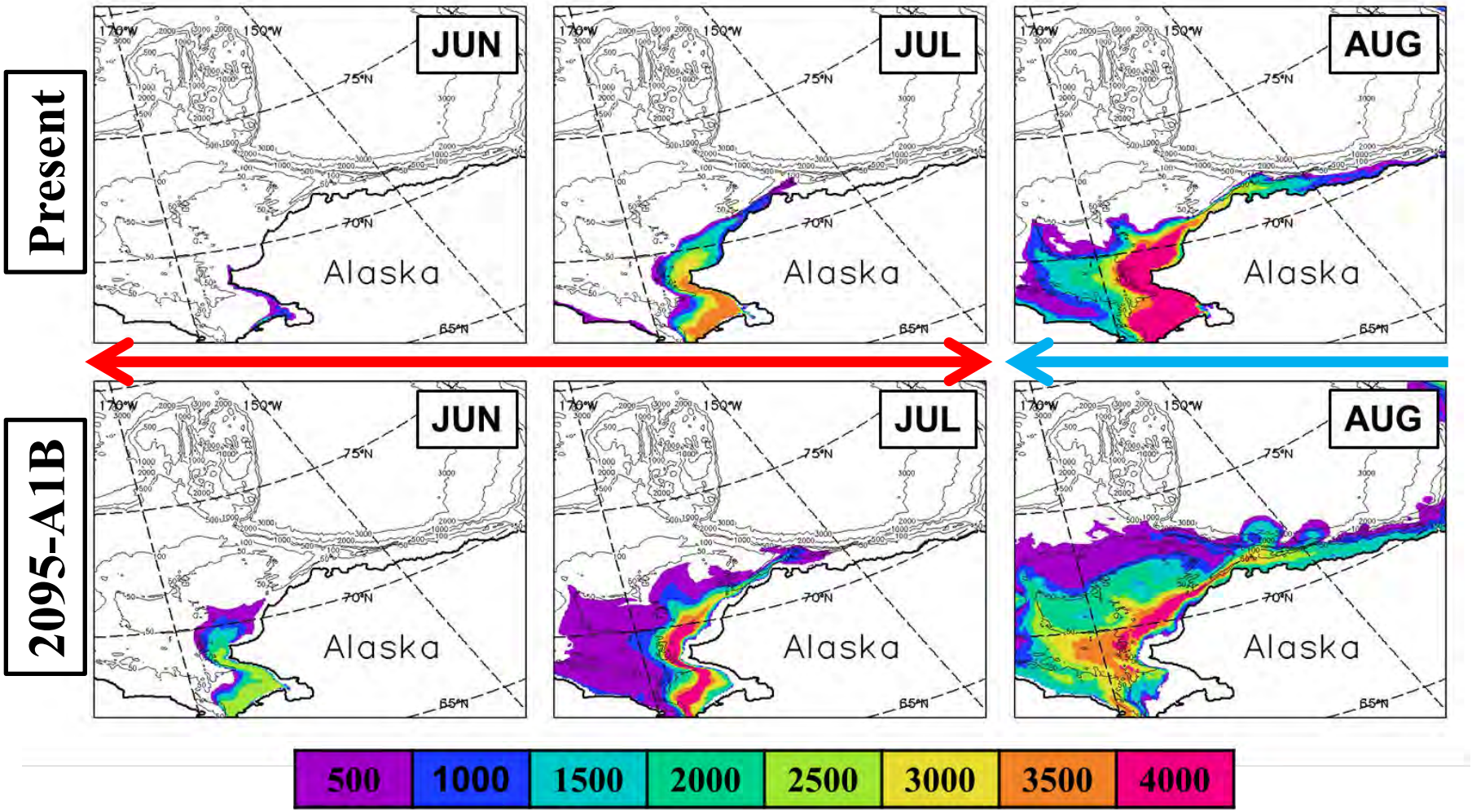


2095-A1B



● The potential habitat is restricted to the southwestern Alaskan coast on June and is expanded to the Chukchi Sea and along the Alaskan northwestern coast from July to September and is reduced from October.

Monthly potential habitat for chum salmon #1

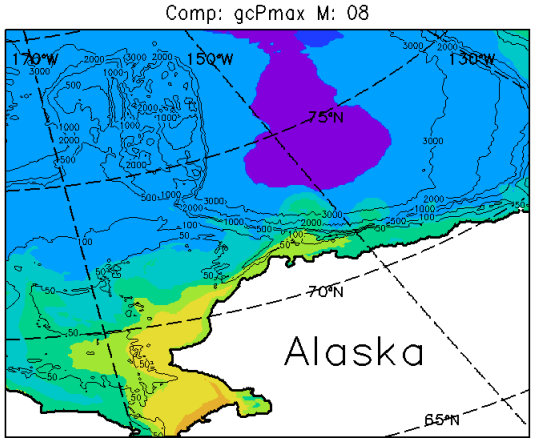


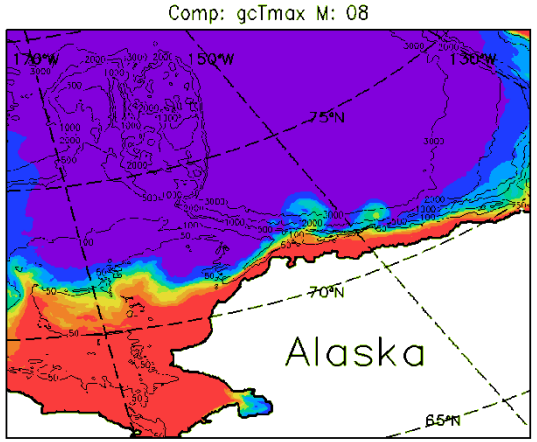
● Under the global warming scenario, the potential habitat increased for all chum salmon on June and July due to the water temperature increase,

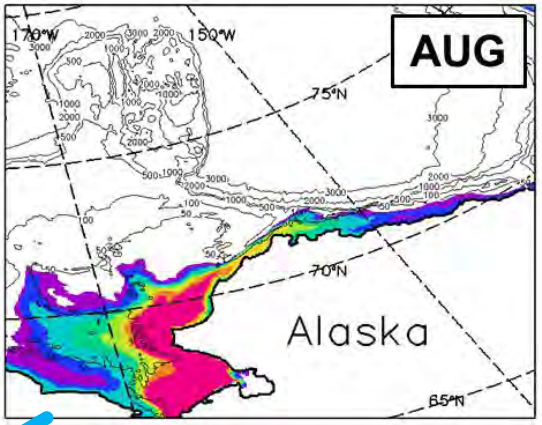
While, on August, the potential habitat increased for smaller chum salmon (~1500 g) but decreased for larger chum salmon (>2000 g). **WHY???**

ρ $f_c(T)$ **at maximum growth depth on Aug.**

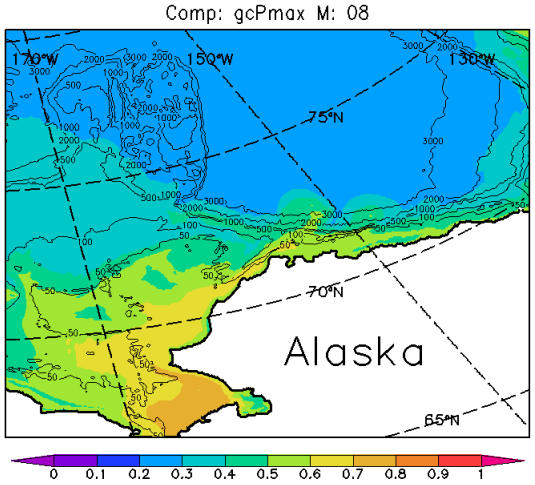
Present

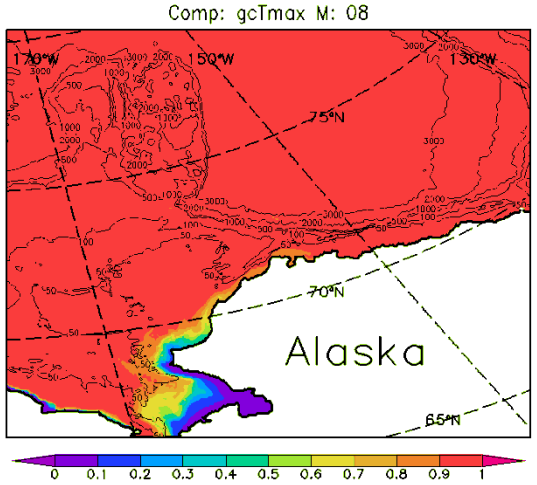


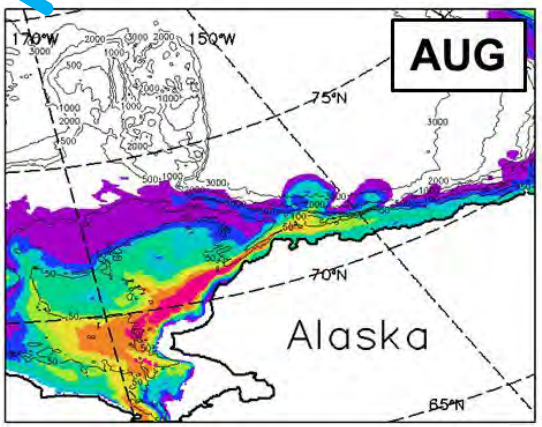


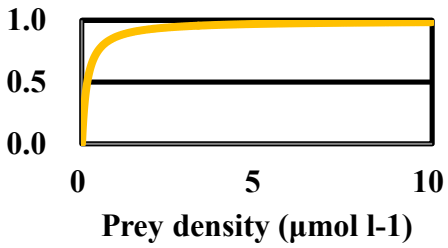


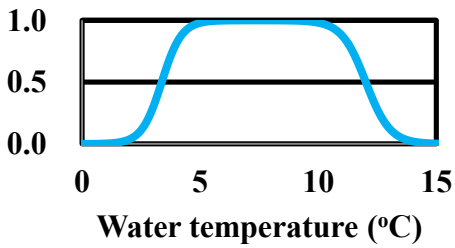
2095-A1B





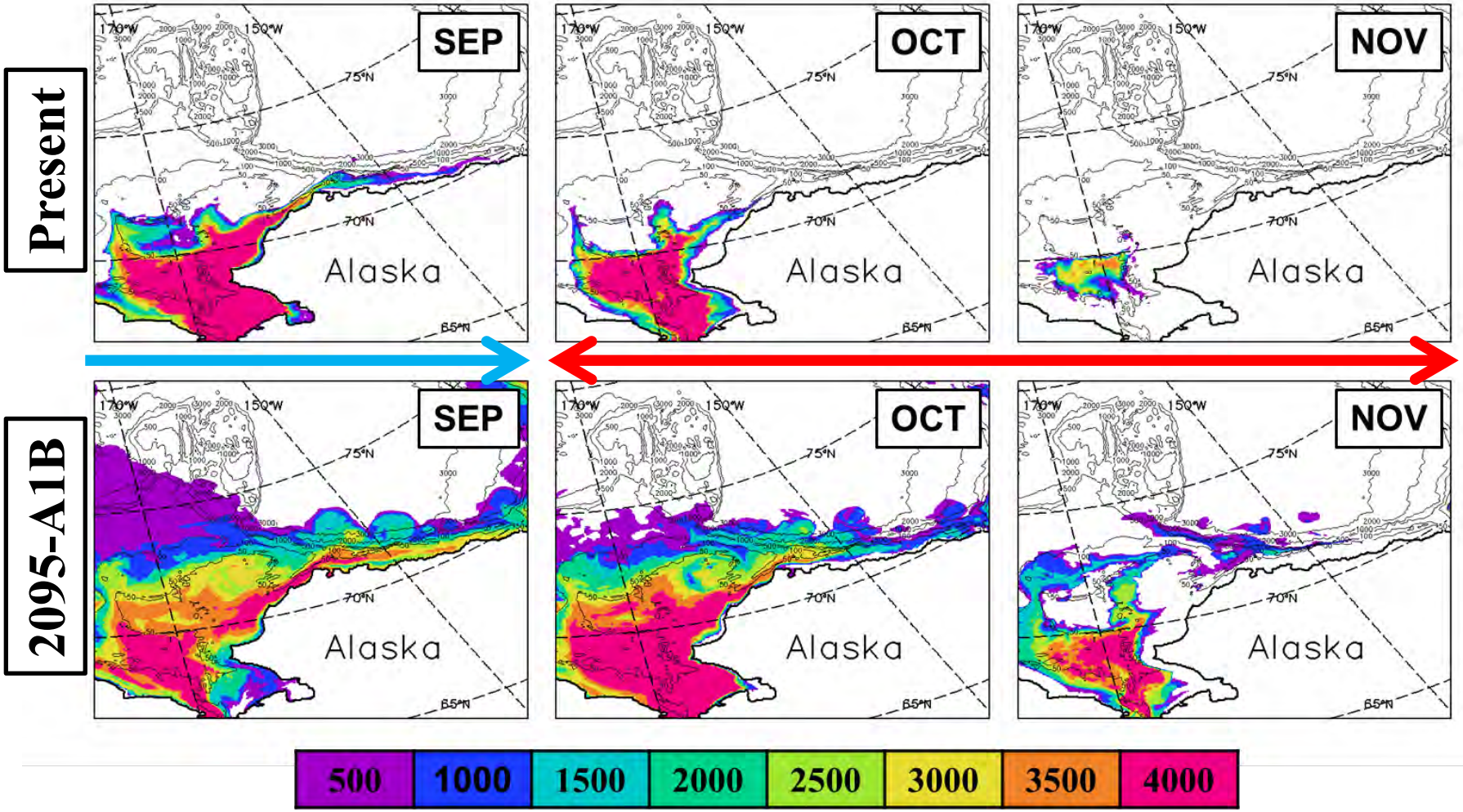






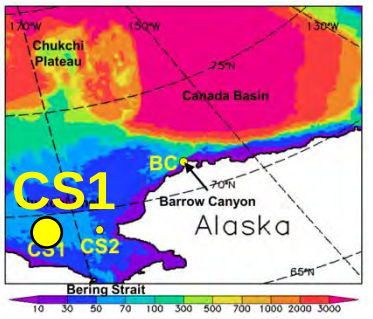
- **Water temperature exceeds the optimal temperature during summer.**

Monthly potential habitat for chum salmon #2

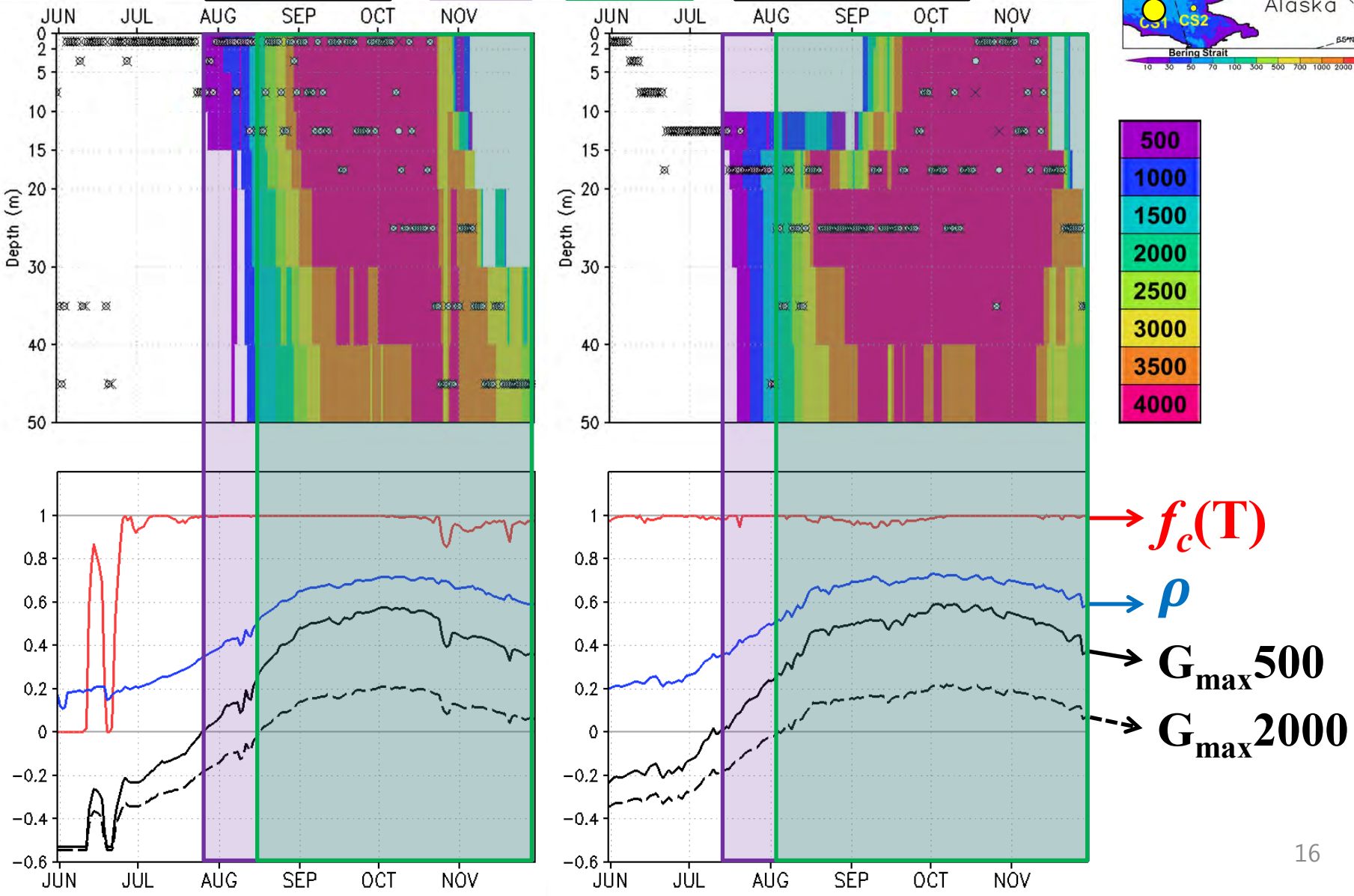


● Under the global warming scenario, the potential habitat increased for smaller chum salmon (~1500 g) but decreased for larger chum salmon (>2000 g) on September, while the potential habitat increased for all chum salmon on June and July due to the water temperature increase,

Vertical potential habitat at CS1



Present | **500** | **2000** | **2095-A1B**



500
1000
1500
2000
2500
3000
3500
4000

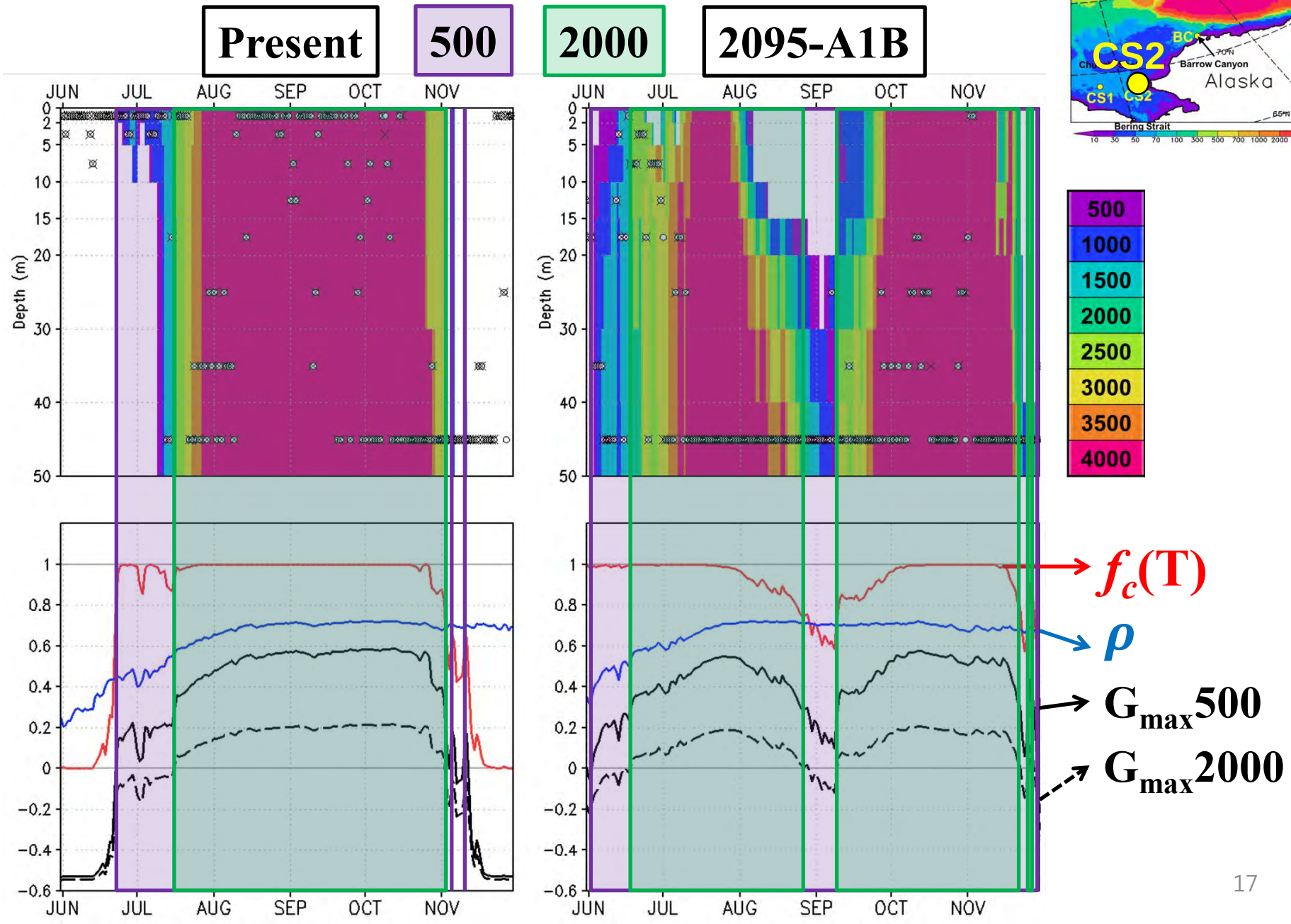
$f_c(T)$

ρ

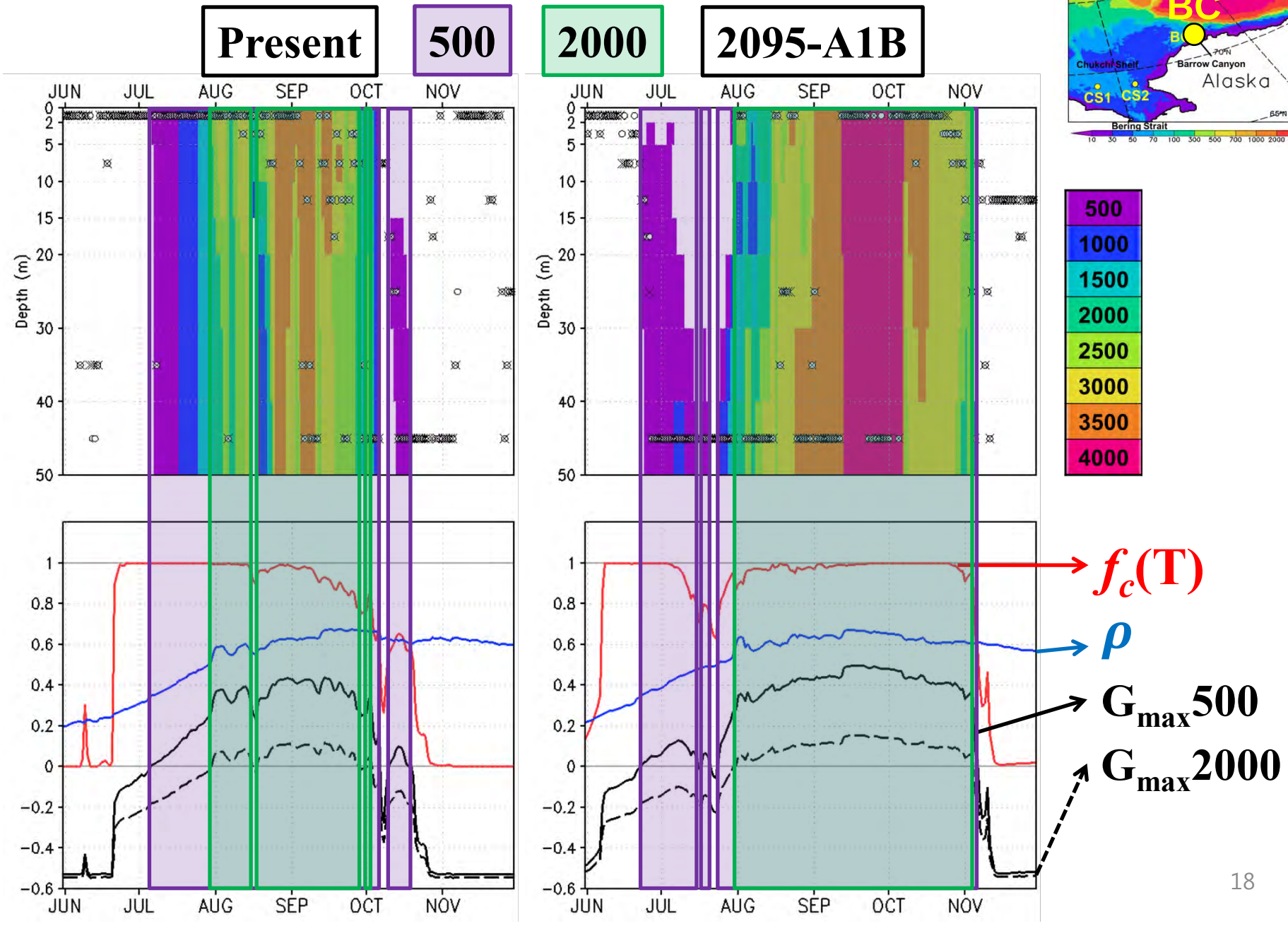
$G_{max}500$

$G_{max}2000$

Vertical potential habitat at CS2



Vertical potential habitat at BC

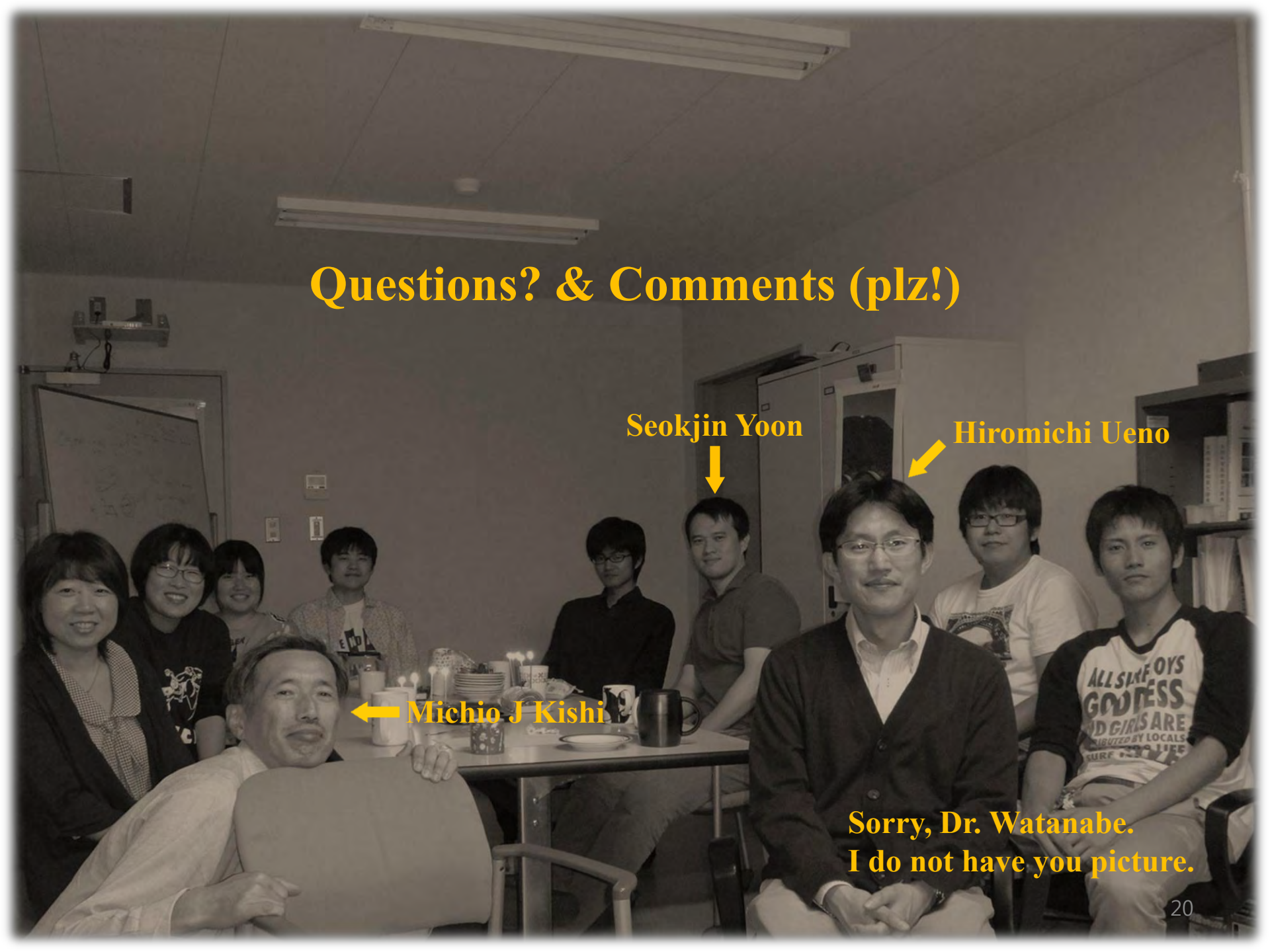


Summary

- This study is the first attempt for estimating the potential habitat for chum salmon in the Western Arctic using a bioenergetics model.

- The potential habitat was restricted to the southwestern Alaskan coast on June and expanded to the Chukchi Sea and along the Alaskan northwestern coast from July to September and reduced from October.

- Under the global warming scenario, the potential habitat increased for all chum salmon during early summer and autumn due to the water temperature increase, while, during summer, the potential habitat increased for smaller chum salmon (~1500 g) but decreased for larger chum salmon (>2000 g) because the water temperature exceeded the optimal temperature.


Questions? & Comments (plz!)
Seokjin Yoon
Hiromichi Ueno
Michio J Kishi
Sorry, Dr. Watanabe.
I do not have you picture.