Investigating hypoxia in a climate change scenario in a region of upwelling

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Abstract

Increasing CO2 in the ocean leads to warming, reduced pH (ocean acidification), and lower oxygen content in deeper ocean waters. Warming, ocean acidification, and hypoxia in deep ocean waters can have important consequences for nearshore marine ecosystems especially for regions with seasonal upwelling such as the California Current. In these regions, seasonal upwelling combined with internal waves brings low pH, low oxygen waters into nearshore reefs where animals are exposed to intermittent stressful conditions. We compared exposure between present-day and future climate scenarios (RCP85) using ROMS coupled with a biogeochemical model.

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Abstract

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Study Site

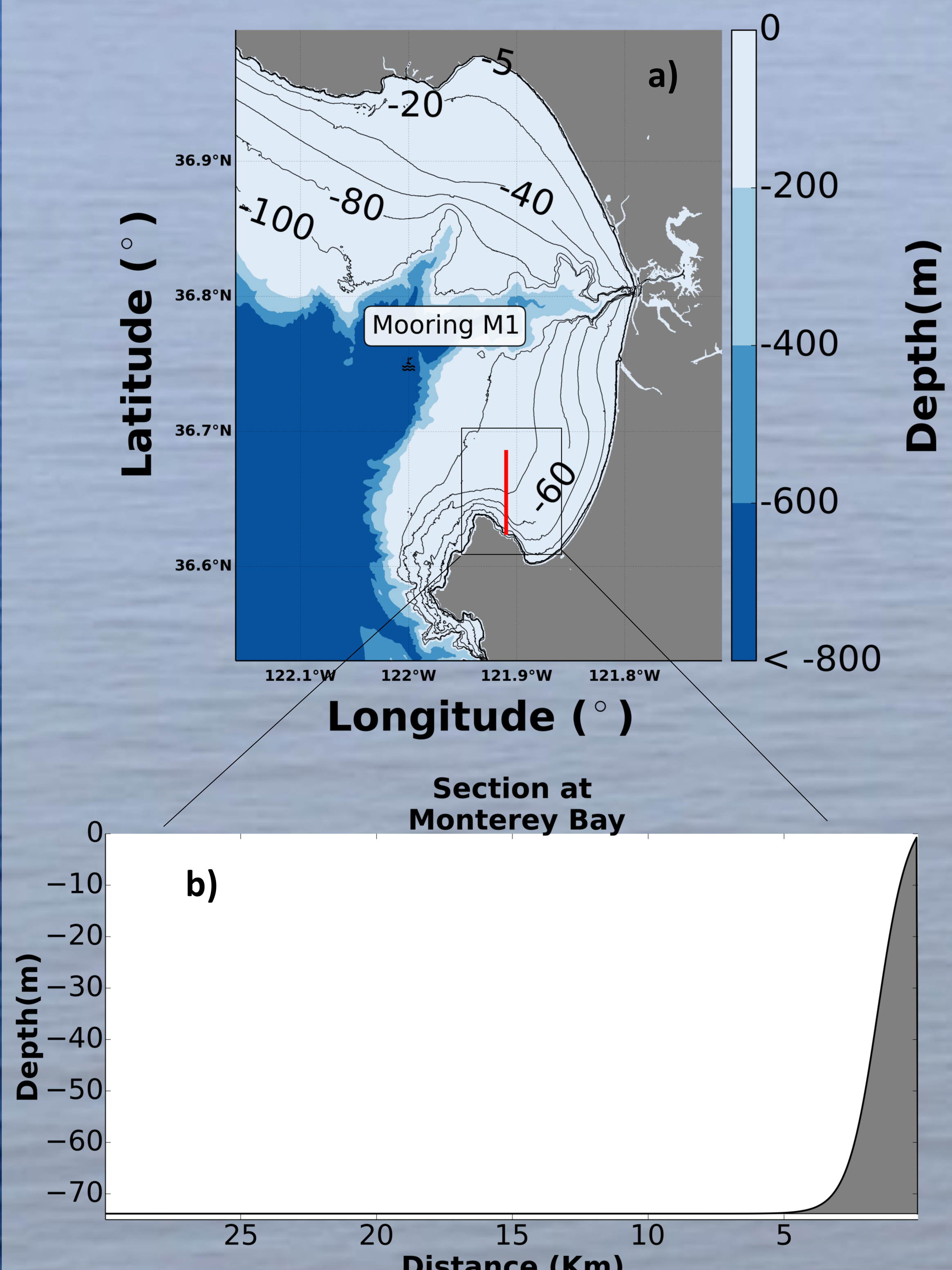

Figure 1. Model domain based on the cross shore section (red line) (a). Vertical section of the domain based on [2](b).

Present Observations

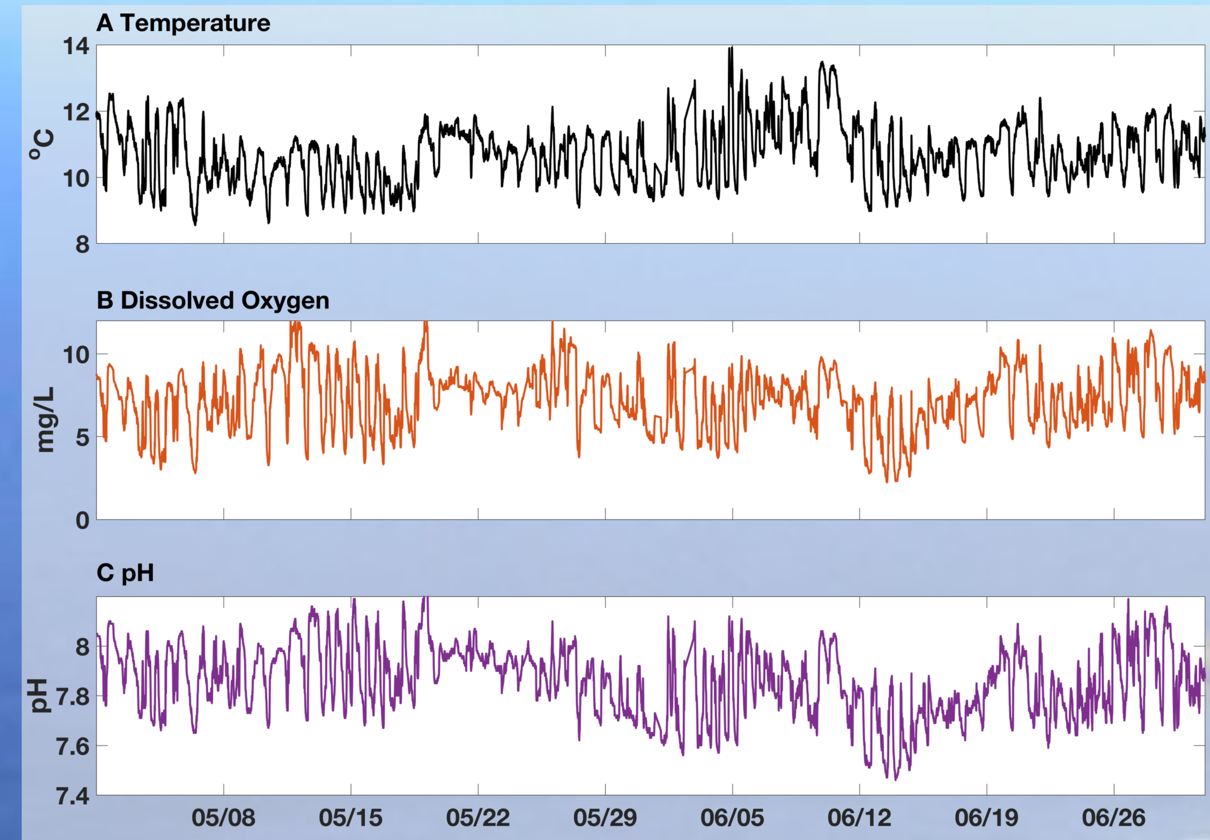

Figure 2. Time series of temperature, Dissolved Oxygen, and pH from [3] showing for a typical period of upwelling.

Model Setup

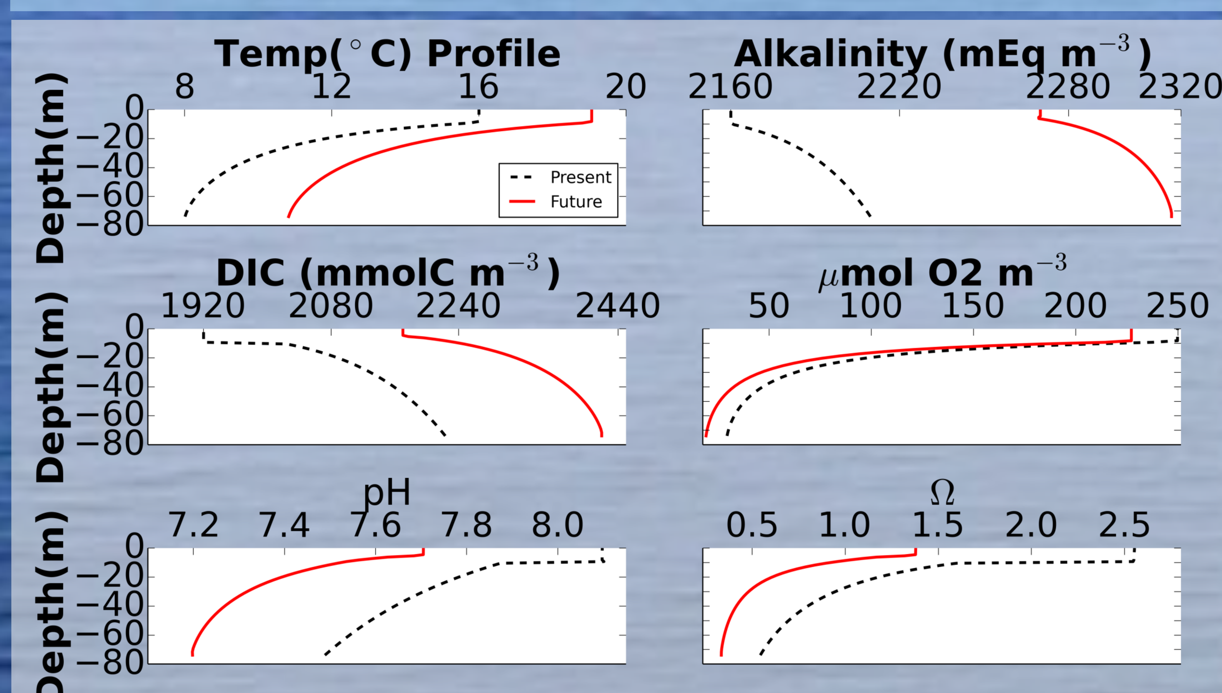

Figure 3. Initial conditions for present and future (2100) scenarios for model runs. Present conditions estimated from [4]. Future conditions extrapolated from RPC85 surface Talk and TIC. CO2SYS for calculation of pH and Aragonite.

	Model Setup
Resolution	50 m X 200 m
Δt	60 s
Sigma Layers	50
Atmospheric Forcing	no winds, radiation
Period	3 months
Temporal Resolution	Hourly
Oceanic Forcing	M2=K1=0.06 m/s

Table 2 - Initial settings for the idealized case runs. Ocean forcing estimated from cross-shore barotropic currents at M1 near model offshore boundary.

Results

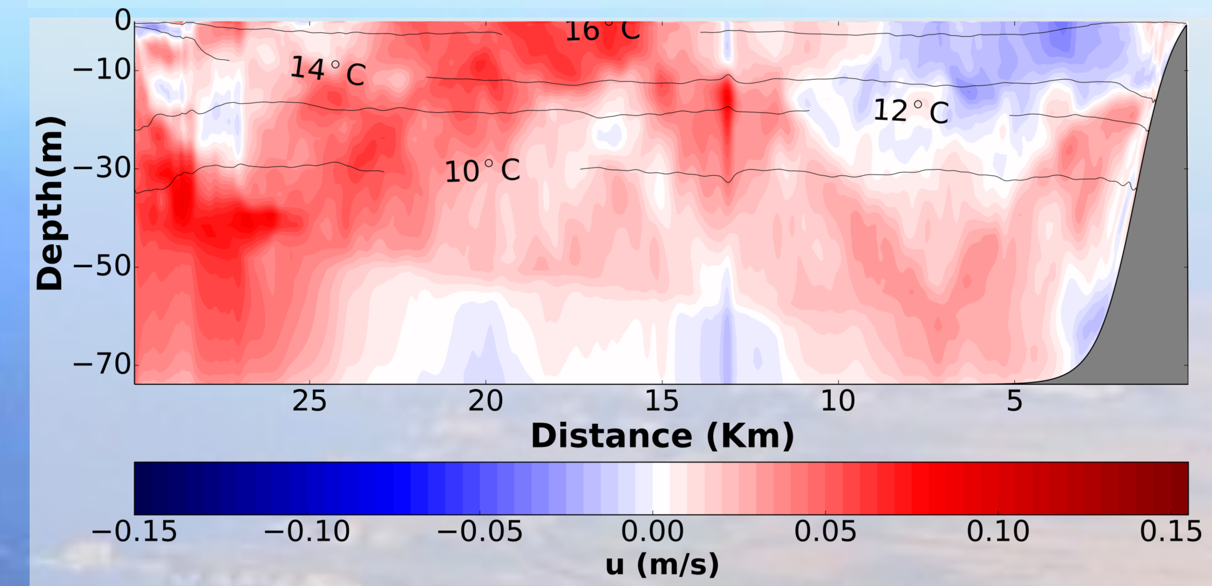

Figure 4. Snapshot of u-component of velocity and temperature on day 67 from the model.

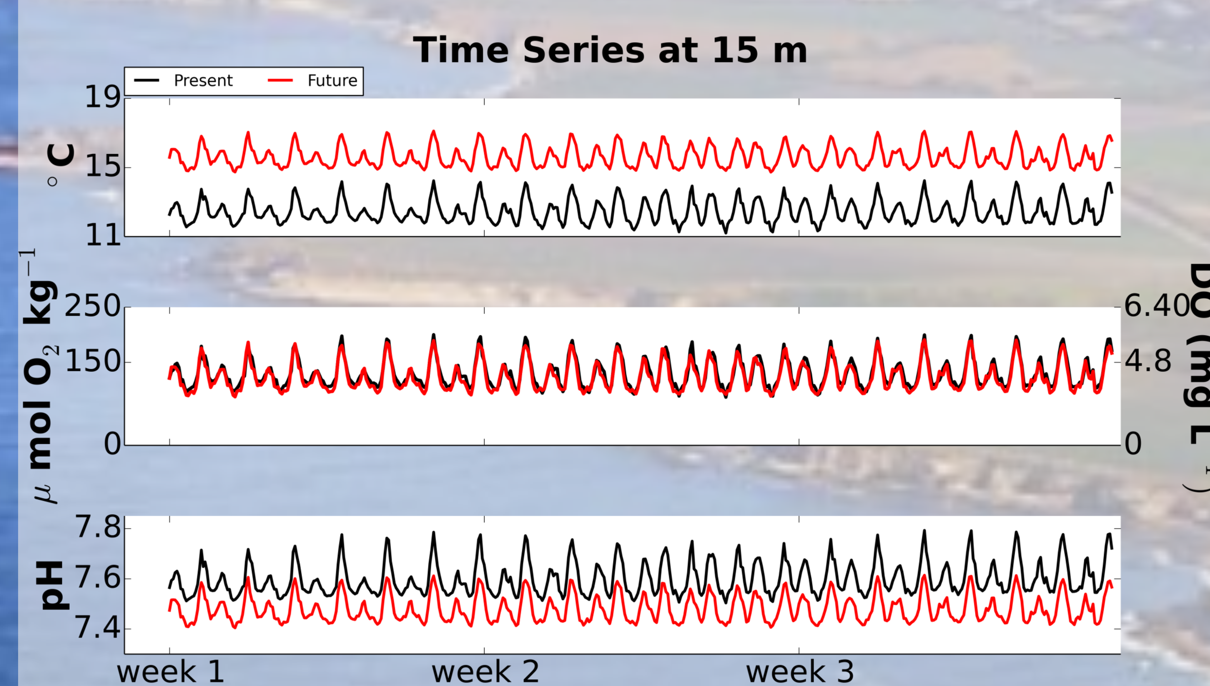

Figure 5. Modeled time series of temperature, dissolved oxygen, and pH for a one month period with idealized upwelling.

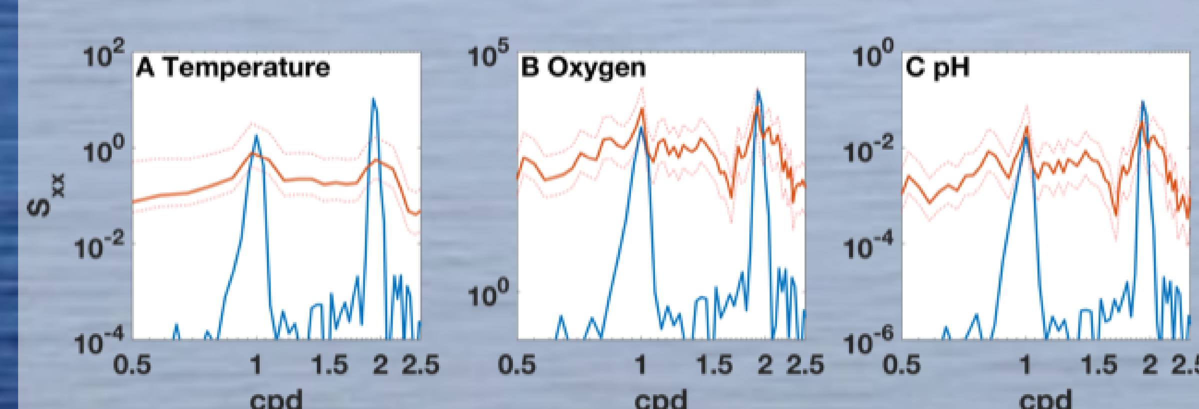

Figure 6. Power spectra of temperature, oxygen, and pH from data used in [3] and current model showing model reproduces observed semi-diurnal and diurnal variability.

$$\phi' = \phi - \phi_{th} \begin{cases} \phi' > 0 \rightarrow \phi' = 0 & \text{for pH and } O_2 \\ \phi' < 0 \rightarrow \phi' = 0 & \text{for temperature} \end{cases}$$

$$\text{Integrated Exposure} = \int_0^t |\phi'| dt$$

Equation 1- Equation for calculating integrated exposure in the model runs.

Approximate thresholds for abalone populations in the California Current.

$\Phi_{th} = 4.6$ mg L^{-1} for O_2
$\Phi_{th} = 7.6$ for pH
$\Phi_{th} = 14$ °C for temperature

Integrated Exposure

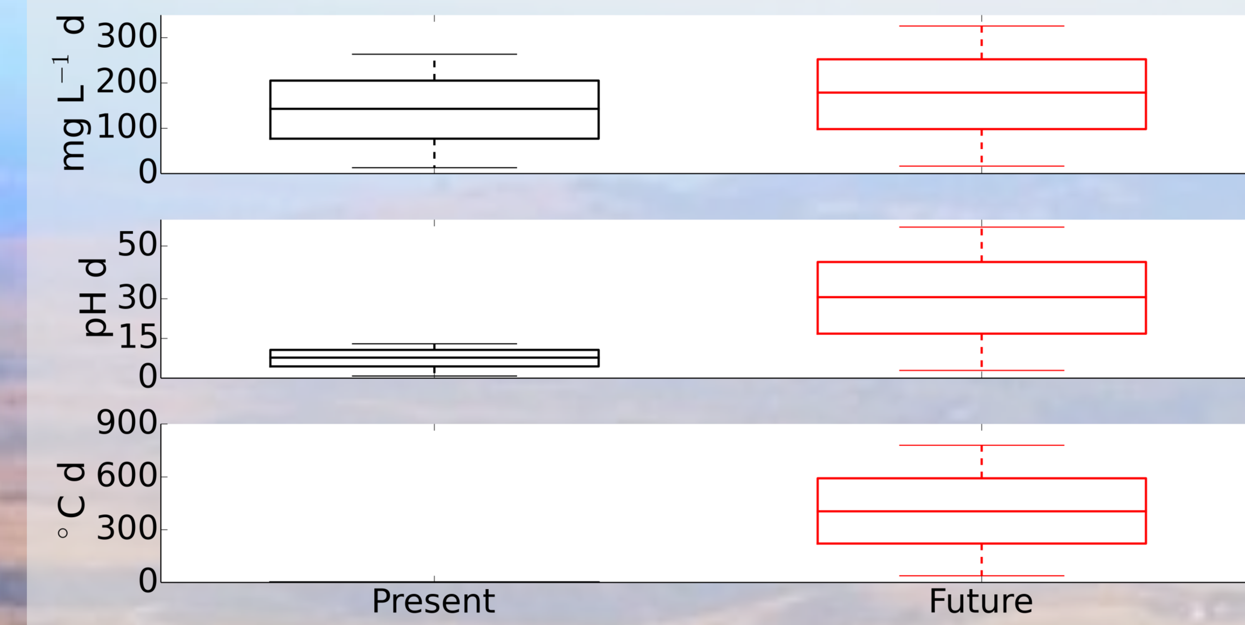

Figure 7 – Mean daily integrated exposure of present and future scenario. Box plots show mean, 25% and 75% quantiles, and data range.

Conclusions and Future work

- The idealized model reproduces variability in important stressors at semi-diurnal and diurnal periods.
- Exposure will increase for organisms sensitive to pH and temperature. However, exposure low oxygen is not significantly different in future scenario..
- Integrated exposure is species-specific (abalone populations shown here).
- Modify drag coefficient to represent kelp forests regions nearshore. Add forcing for low-frequency variability.
- Adapt bioFennel module in order to reproduce productivity in kelp forests regions.

References

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Acknowledgements

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