Hypoxia in CBNMS and GFNMS

Results from Recent Monitoring

John Largier
in collaboration with Kate Hewett, Dani Lipski, Jaime Jahncke and others

25 August 2016
Hypoxia

Oxygen dissolves in water. Saturation or equilibrium state depends on T and S and P … in equilibrium with atmosphere

\[ [O_2] \approx 250 \text{ mmol/m}^3 \text{ or } 8 \text{ mg/L} \text{ (at } \approx 15^\circ\text{C or } 59^\circ\text{F}) \]
Hypoxia

Oxygen dissolves in water. Saturation or equilibrium state depends on $T$ and $S$ and $P$ ... in equilibrium with atmosphere

$[O_2] \sim 250 \text{ mmol/m}^3$ or 8 mg/L
(at $\sim 15^\circ\text{C}$ or 59$^\circ\text{F}$)
Hypoxia

Oxygen dissolves in water. Saturation or equilibrium state depends on $T$ and $S$ and $P$ ... in equilibrium with atmosphere

\[
[O_2] \approx 250 \text{ mmol/m}^3 \text{ or } 8 \text{ mg/L (at } \approx 15^\circ\text{C or } 59^\circ\text{F)}
\]

Oxygen levels can be above or below equilibrium ... primarily due to production and remineralization \((\text{photosynthesis} \& \text{ respiration})\)

Hypoxia typically defined as $[O_2] < 2 \text{ mg/L}$
Hypoxia

Hypoxia occurs naturally where oxygen is taken up faster than it can be replenished by photosynthesis or flux from atmosphere.
Hypoxia

Hypoxia occurs naturally where oxygen is taken up faster than it can be replenished by photosynthesis or flux from atmosphere.
Hypoxia

Hypoxia occurs naturally where oxygen is taken up faster than it can be replenished by photosynthesis or flux from atmosphere. Russian River Estuary ...

![Graph showing salinity and oxygen levels in the Russian River Estuary.](https://via.placeholder.com/150)
De-oxygenation

Concern is for “deoxygenation” – a trend towards lower oxygen (and associated ecological impacts)

Well recognized in context of local eutrophication

Chesapeake Bay
Mississippi River Plume
De-oxygenation

Concern is for “deoxygenation” – a trend towards lower oxygen (and associated ecological impacts)

New concern with global-scale deoxygenation ...

- Expansion/intensification of OMZ
  - Surface warming and lower oxygen in surface waters
  - Surface warming and less ventilation through mixing
- Enhanced upwelling – changes in wind
- Upwelling source waters
  - Local enrichment (respiration)
  - Changes in deep circulation
- Oxygen uptake over shelf – sediment/circulation
- Local eutrophication
- Local stratification (runoff)
De-oxygenation

Concern is for “deoxygenation” – a trend towards lower oxygen (and associated ecological impacts)

New concern with global-scale deoxygenation ...

*Oxygen decline in NE Pacific over last 50 years.*

**British Columbia**

1978-2010

Crawford and Pena 2013

**Oregon**

50 m

1960-2010

Pierce et al. 2012

**So. Cal. Bight**

1984-2012

Stn. 93.110 26.5 isopycnal

Bograd et al. 2015
De-oxygenation

Concern is for “deoxygenation” – a trend towards lower oxygen (and associated ecological impacts)

New concern with global-scale deoxygenation ...

*Diurnal Vertical Migration (DVM) depth set by oxygen ... habitat compression*

Seawater oxygen concentration is the best single predictor of migration depth at the global scale

Bianchi et al. 2013
De-oxygenation

Low oxygen observed over OR and WA shelf (mortality events) – upwelling plus oxygen demand of sediment and water column respiration … the longer water retained, the worse it gets.

2005 ECOHAB-PNW observations (units mL/L and bold line at 1.4 mL/L) … Siedlecki et al (2015)
Monitoring GFNMS and CBNMS

ACCESS profile data from 2010

BML surface oxygen from 2010 & sub-surface oxygen from 2013

Tomales Bay oxygen from 2014

Cordell Bank oxygen from 2014

Gulf of Farallones in 2015
Monitoring GFNMS and CBNMS

ACCESS profile oxygen data
2010-2014
Line 2 (CB)
Line 6 (GF)

Also profile data at Bodega Head and in Tomales Bay shows low DO.
Monitoring GFNMS and CBNMS

ACCESS profile oxygen data
2010-2014
Line 2 (CB)
Line 6 (GF)
Monitoring GFNMS and CBNMS

CBNMS mooring data – shallower mooring CB1 (2014-2016)
Monitoring GFNMS and CBNMS

CBNMS mooring data – deeper mooring CB2 (2014-2016)
Monitoring GFNMS and CBNMS

CBNMS mooring data – comparing sites in 2014

Mooring 1: loggers from 40m to ~80m (spaced every 10m)

Mooring 2: loggers from 40m to ~100m (spaced every 10m)

Dissolved Oxygen (mg/L)

Temperature (°C)

21Sep
14Sep
07Sep
31Aug
24Aug
17Aug
10Aug
03Aug
27Jul
20Jul
13Jul
06Jul
29Jun
22Jun
15Jun
Monitoring GFNMS and CBNMS

CBNMS mooring data compared with BML data for 2014
Monitoring GFNMS and CBNMS

CBNMS mooring data compared with BML data for 2015
Monitoring GFNMS and CBNMS

GFNMS mooring data – site near NDBC 46026 in 2015

- Temp. T °C
- Sal. psu
- DO mg/L

![Graphs showing temperature, salinity, and dissolved oxygen over time](image)
Monitoring GFNMS and CBNMS

GFNMS mooring data – site near NDBC 46026 in 2015
Looking forward –

This is just the beginning.

Key questions ...
• Has oxygen concentration changed in the Sanctuaries?
• If so, why has it changed?
• What does this change mean for the ecosystem?

Work going forward ...
• Analysis of existing data (including historical data).
• Ongoing monitoring in Sanctuaries.
• Potential for modeling of changing conditions.
• Linking to large-scale NE Pacific fluctuations.