Upwelling-Driven Inner-Shelf Hypoxia and its Connection to Oceanographic Changes in the Northeast Pacific

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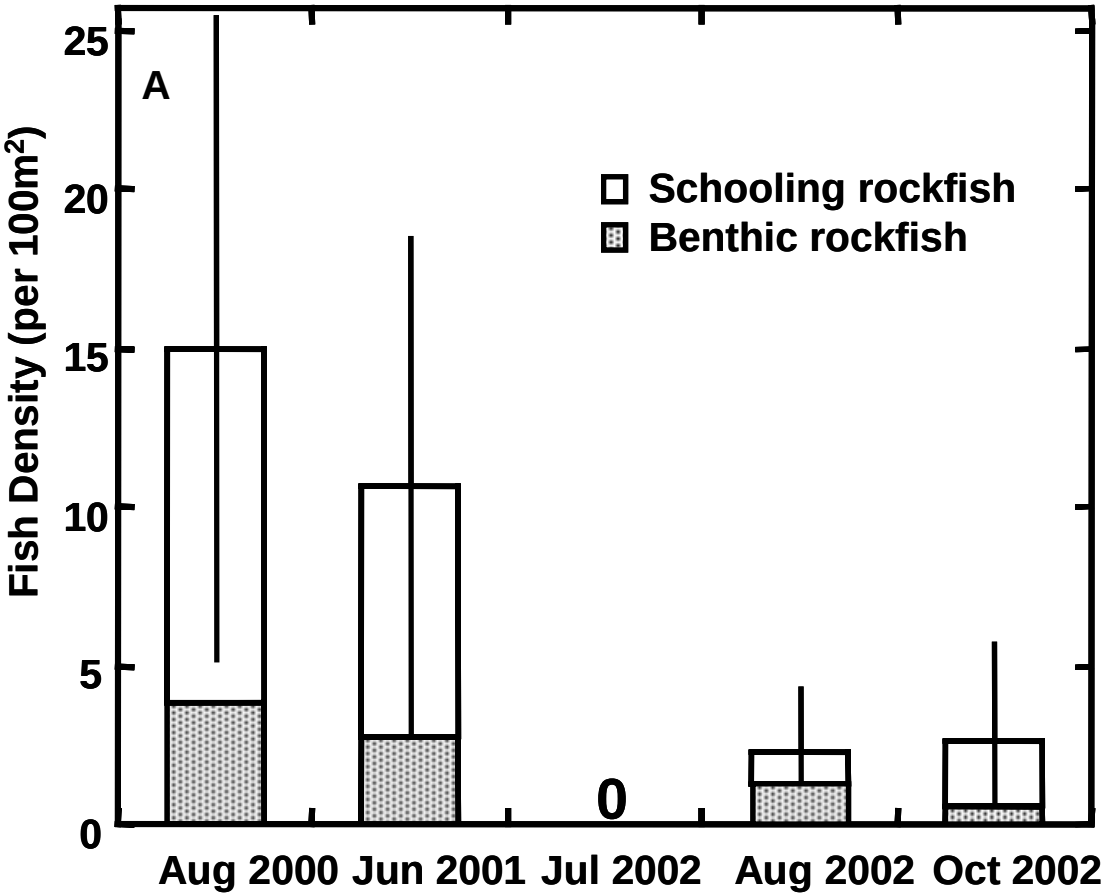
Hypoxia off the central Oregon coast

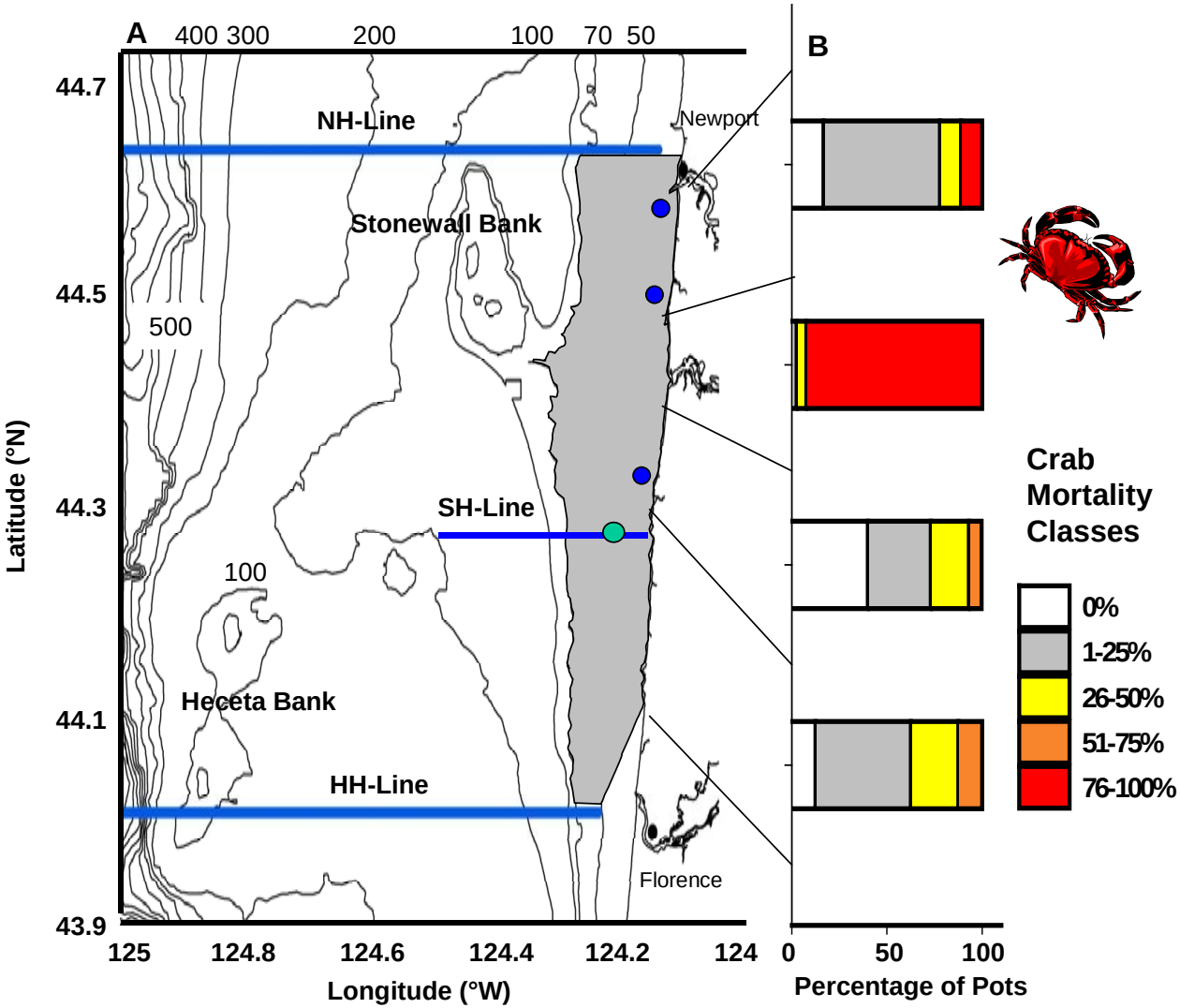


Normal Inner-Shelf
Rockfish Community

July 2002

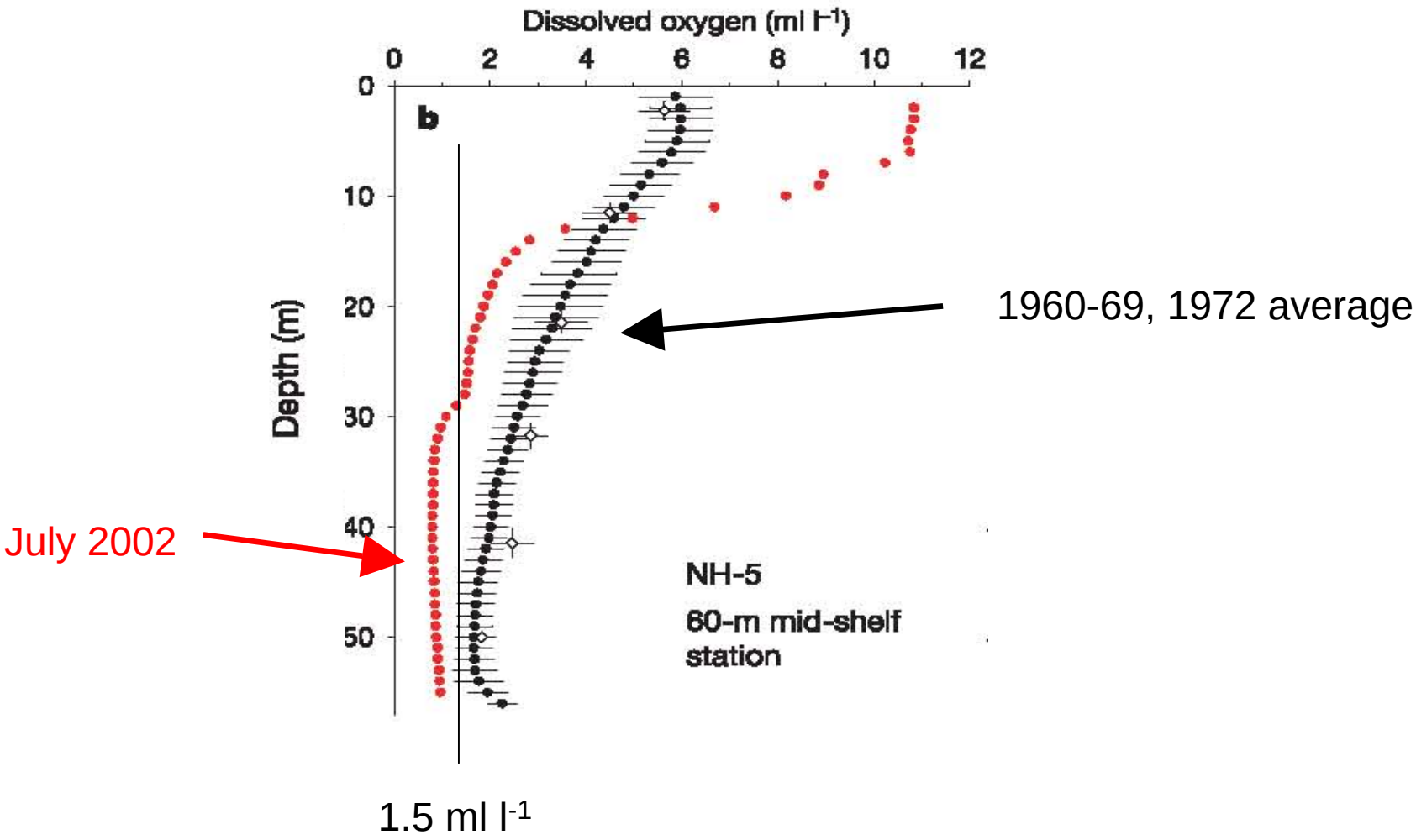
Grantham et al. (2004)

Significant Dungeness crab die-offs



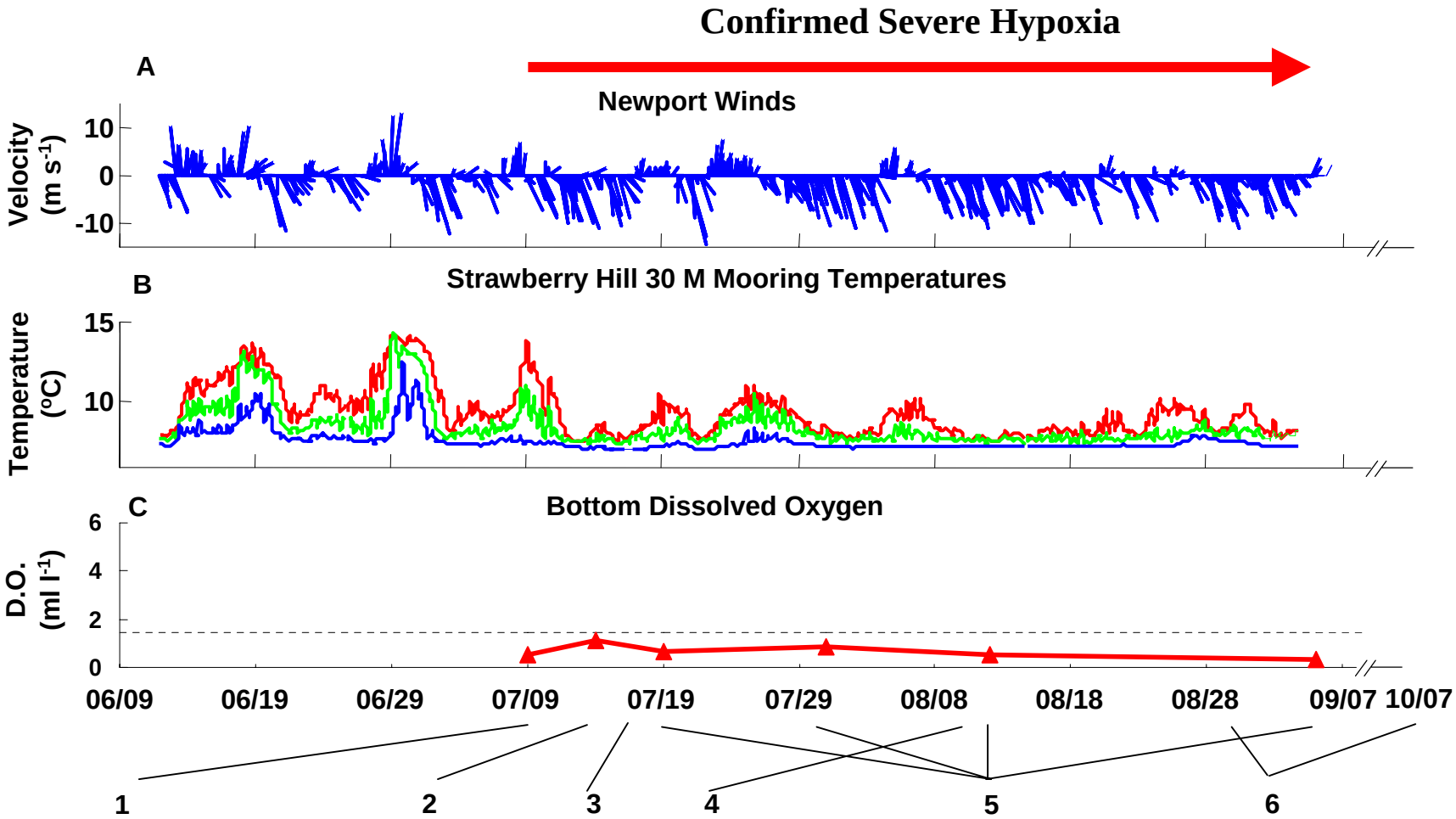
Grantham et al. (2004)

Low-oxygen shelf water



Grantham et al. (2004)

Low-oxygen bottom water persisted for ~2 months

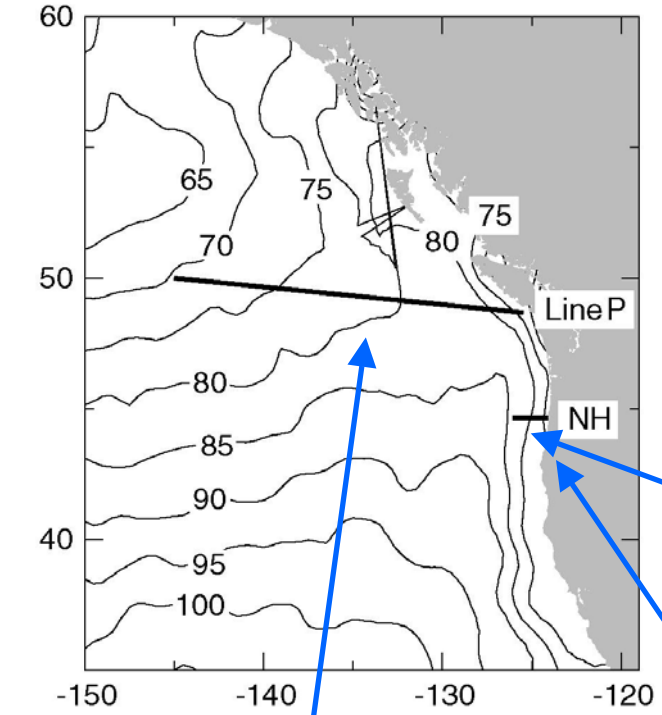


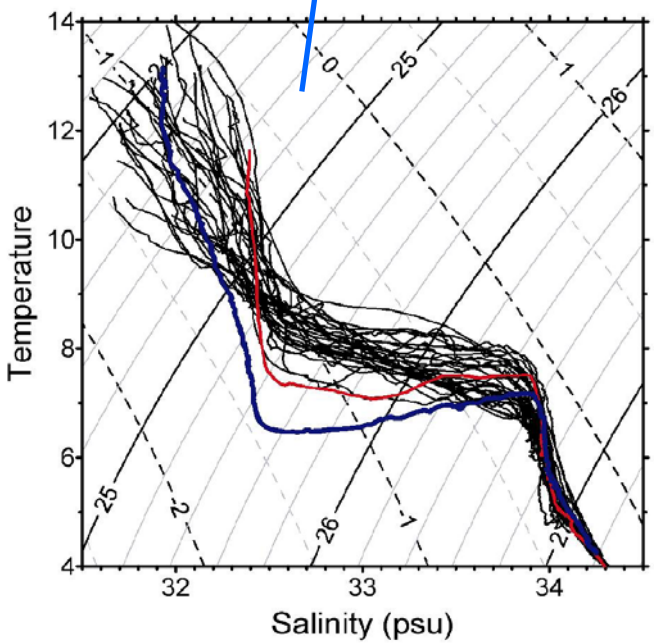
2002

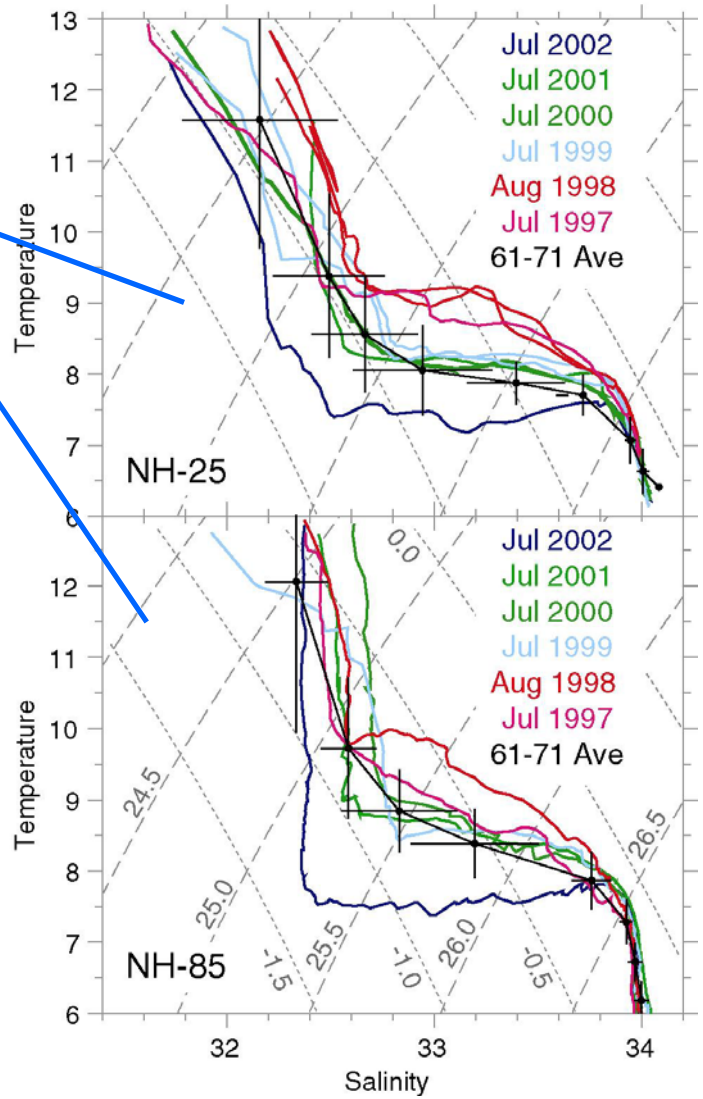
Grantham et al. (2004)

Subarctic Invasion in 2002

caused extreme anomalies in T, S, nutrients, chlorophyll & oxygen

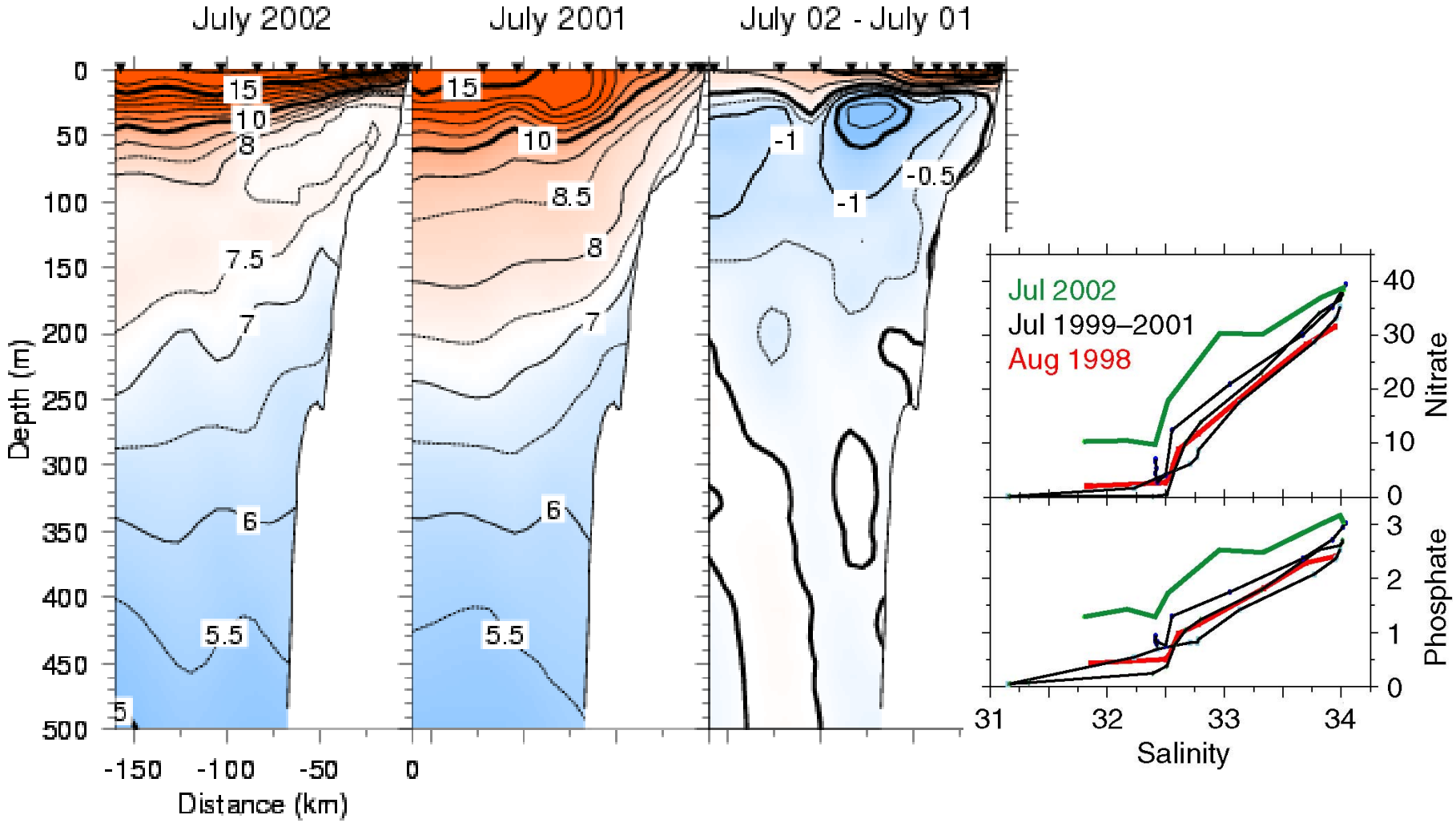






Freeland et al. (2003)

Cold halocline during 2002

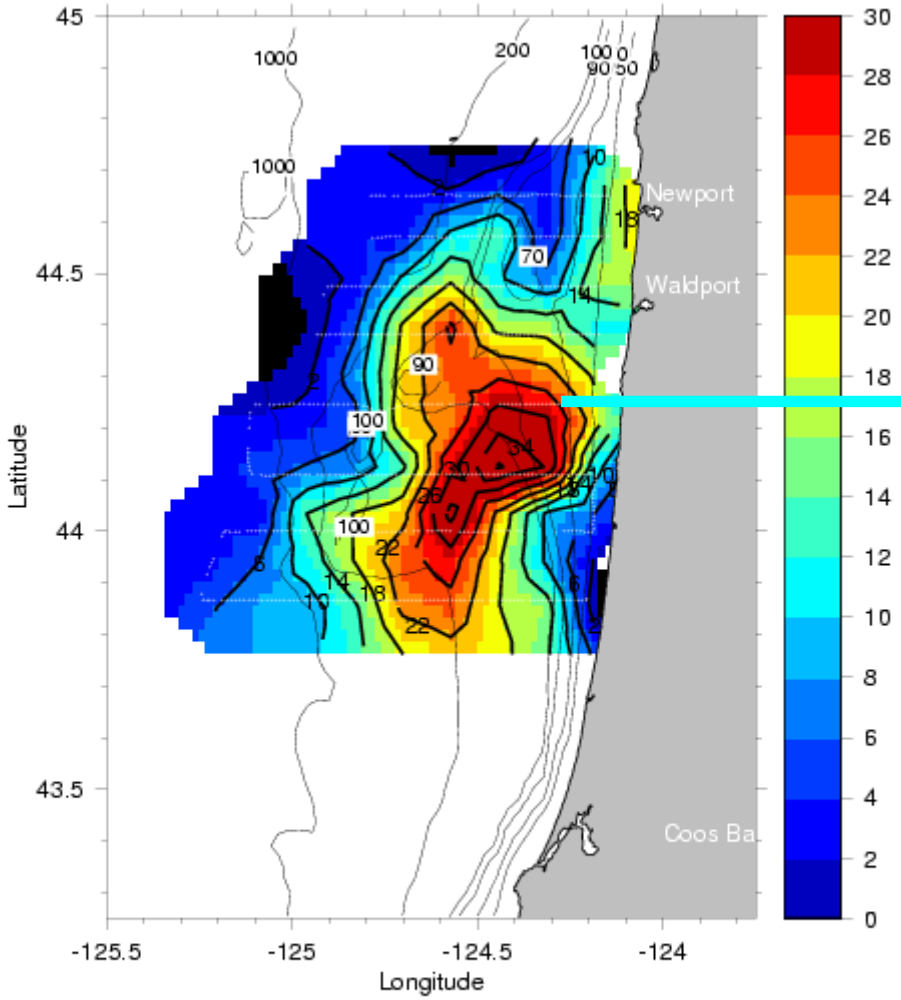


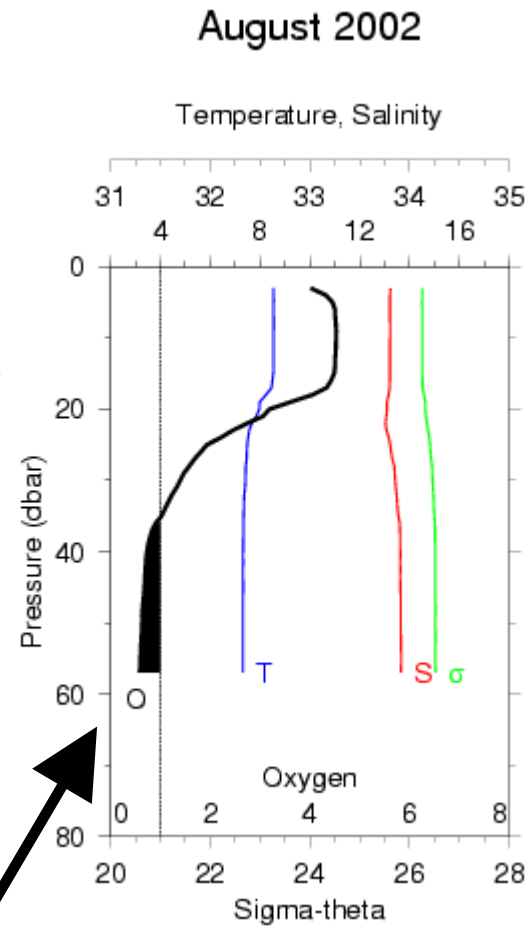
Freeland, Gatien, Huyer and Smith (2003)

Wheeler et al. (2003)

Ecosystem Response

GLOBEC NEP, 9-11 August 2002
5-m chlorophyll (mg/m³)

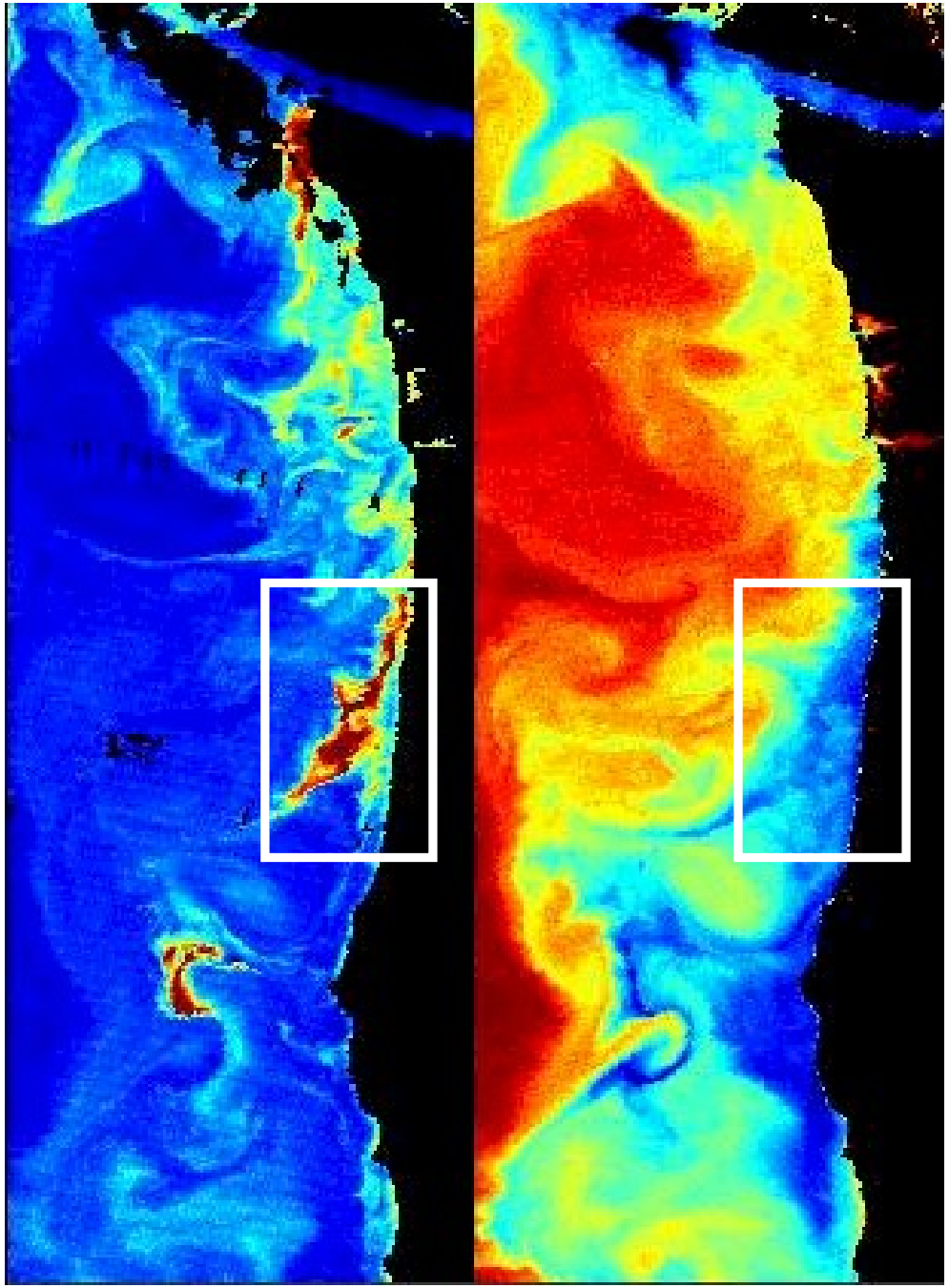




hypoxic

Grantham et al. (2004)

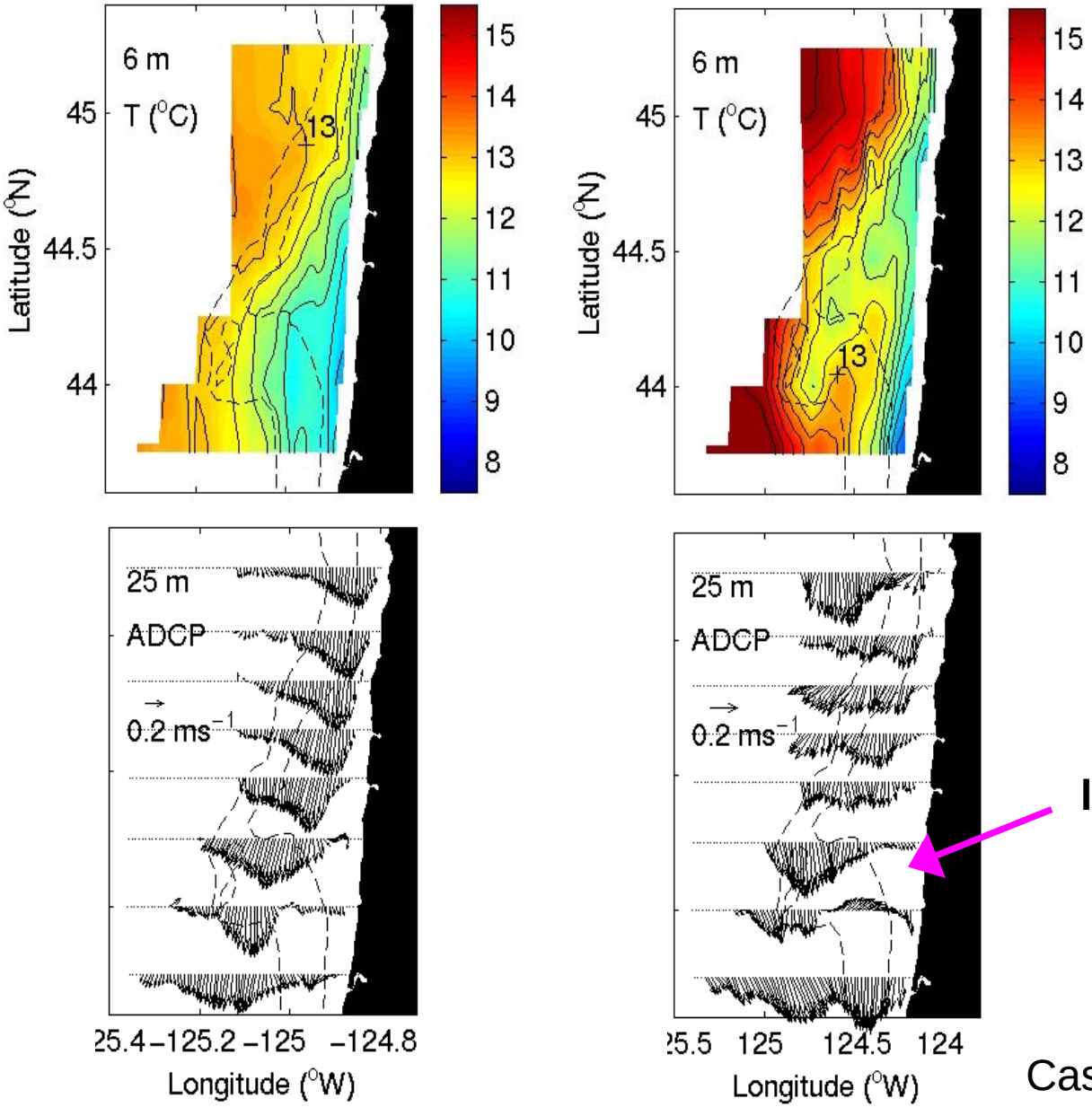
chlorophyll SST



Is Heceta Bank special?

September 2002

Heceta Bank deflects coastal upwelling jet offshore

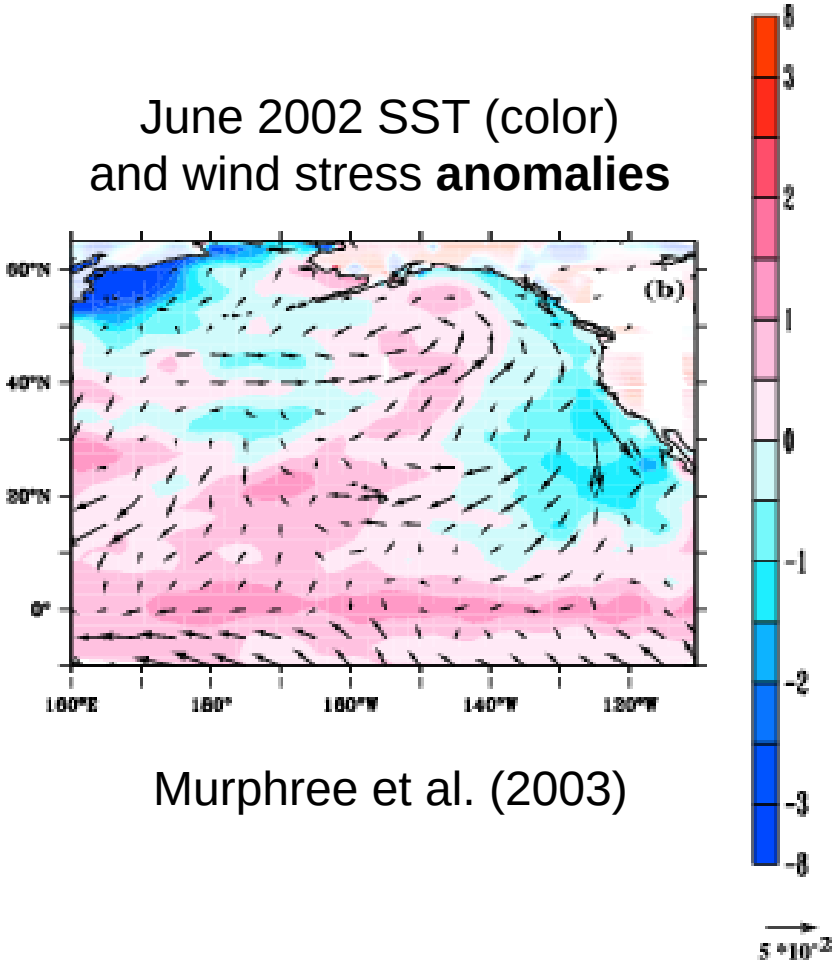


low-velocity inshore

Castelao and Barth (2004)

Possible mechanisms for cold-water anomaly in CCS

June 2002 SST (color)
and wind stress **anomalies**



Murphree et al. (2003)

anomalously strong:

• southward transport of Subarctic waters into the North Pacific Current (NPC)

• eastward flow in the eastern part of the NPC

• equatorward flow in the CCS

Freeland et al. (2003)

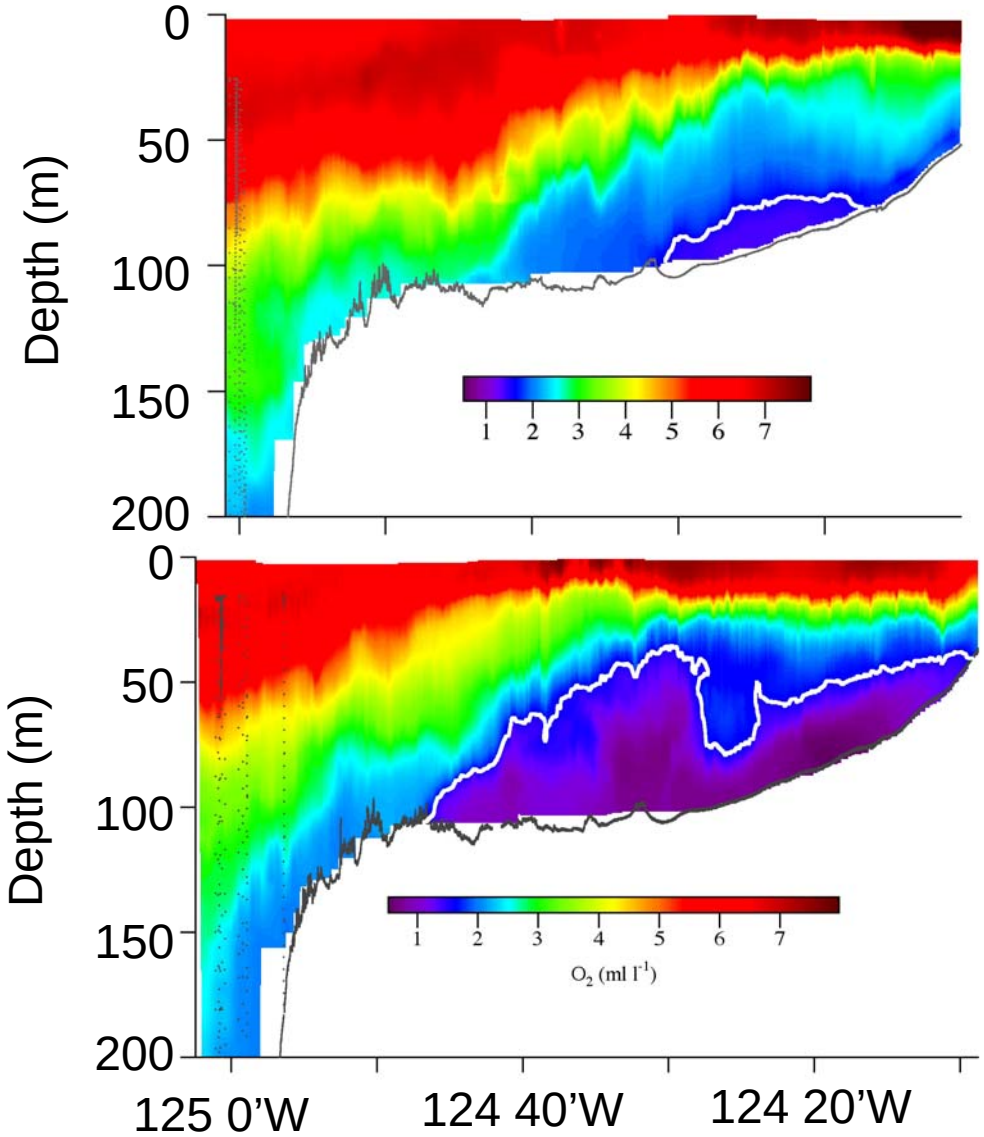
See also:

• Freeland (PICES XIII: S1-1818)

• Crawford et al. (PICES XIII: S7-2160)

• Bograd et al. (PICES XIII: S9-2084)

Was low-oxygen deep water present in previous years?



28-29 May 2001

11-12 August 2001

Vertical sections of oxygen (ml/l) at 44 13'W

B. Hales (OSU)

Hypoxia and invertebrate die-offs in summer 2004

Grant McOmie/katu.com

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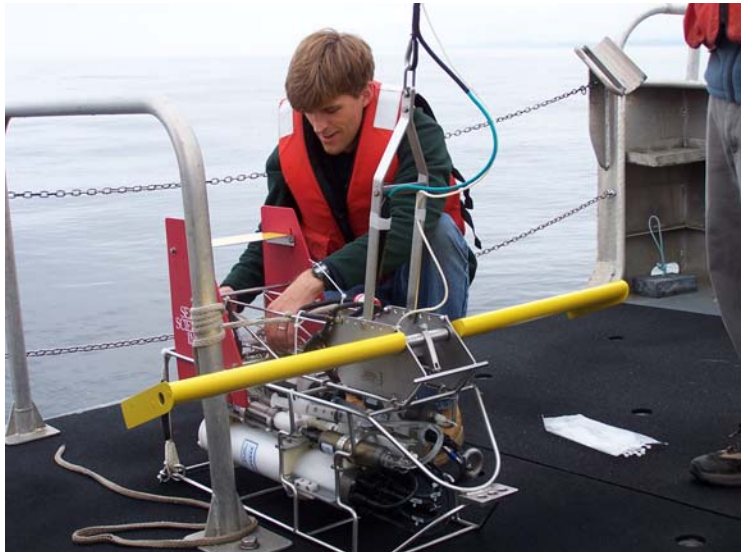
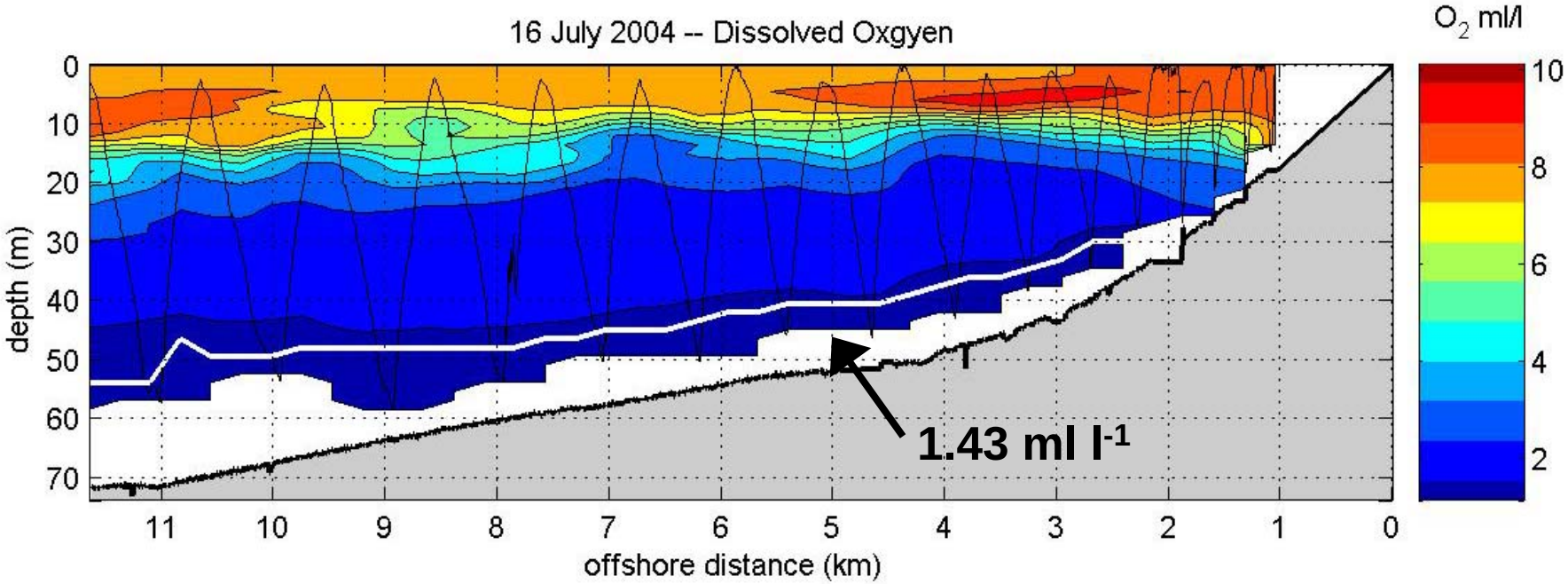
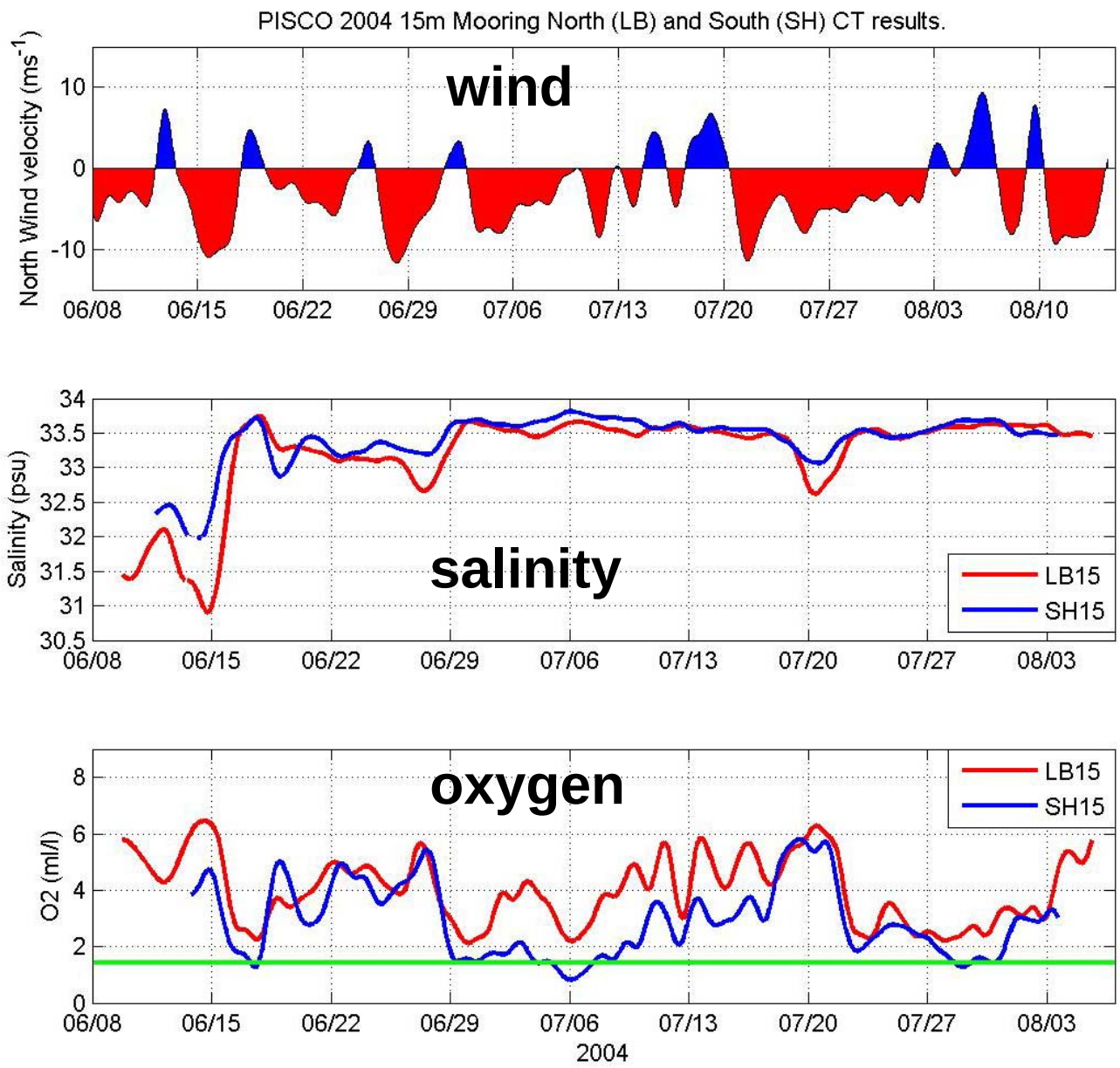
Cross-shelf section sampled with a towed, undulating Vehicle (Acrobat)

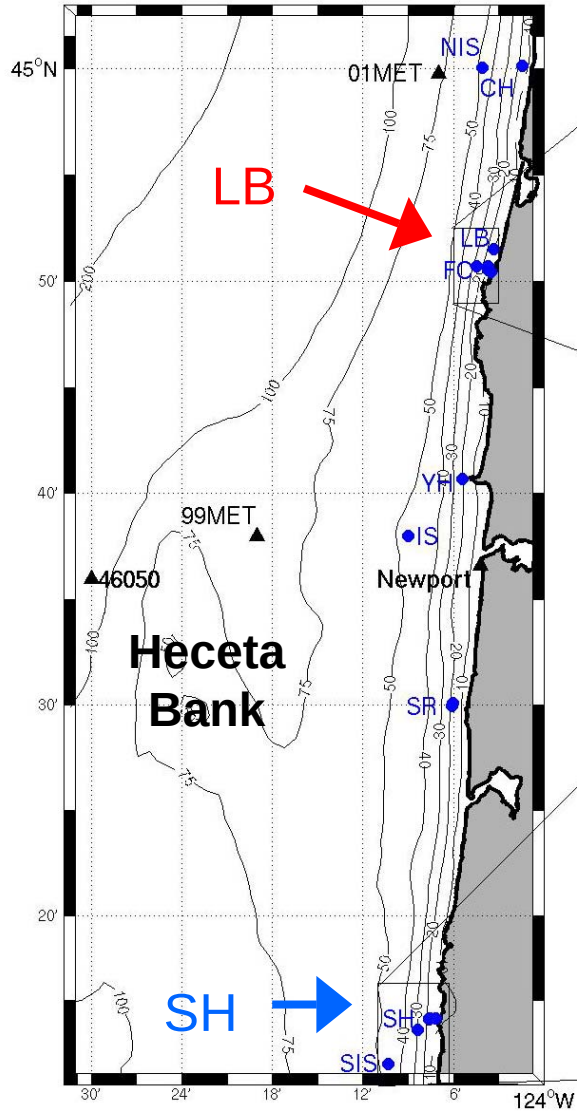




A. Kirincich/J. Barth (OSU)

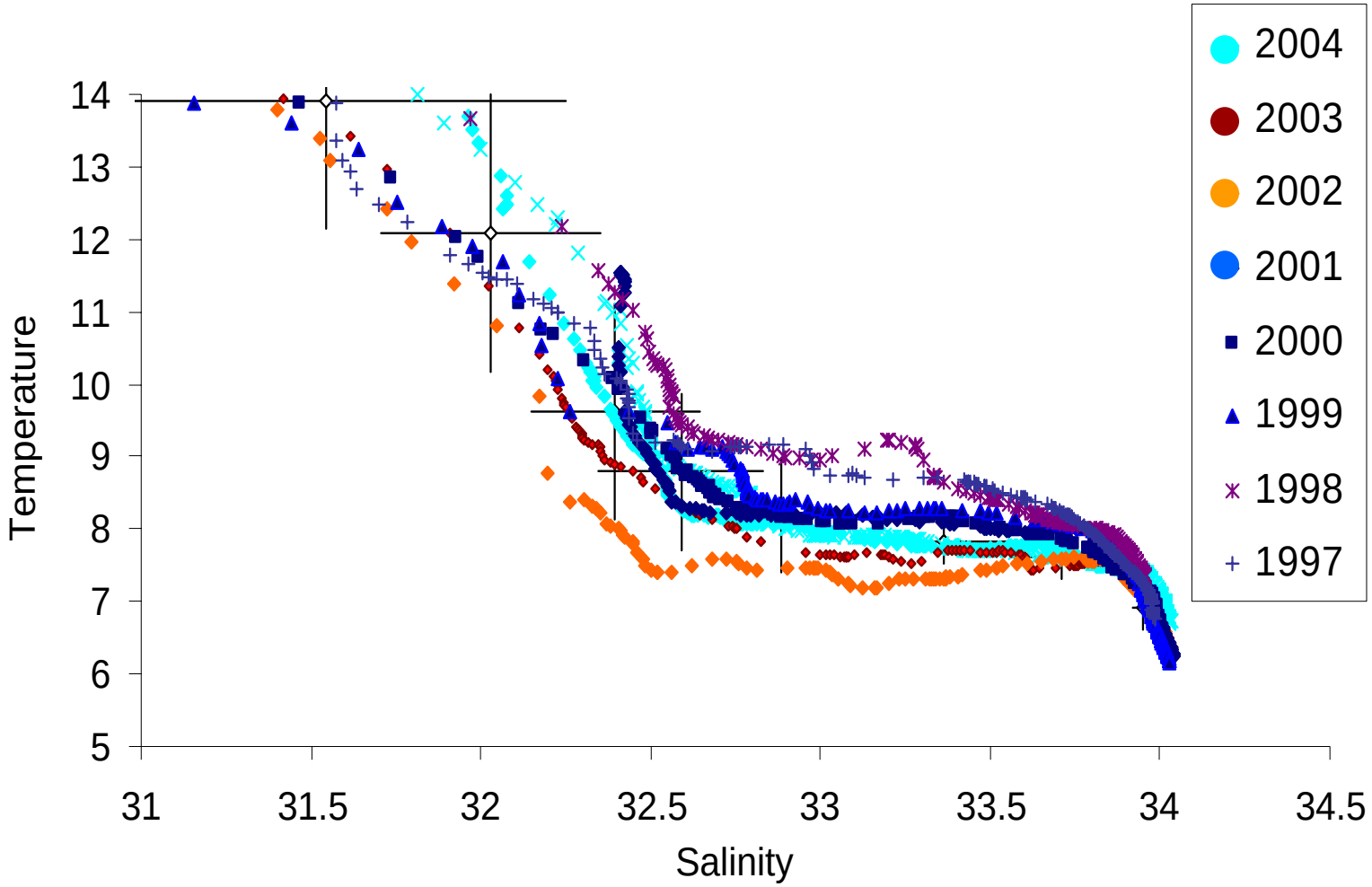


instrument depth was 11.5 m below surface 1.43 ml/l hypoxia threshold shown in green



PISCO-OSU

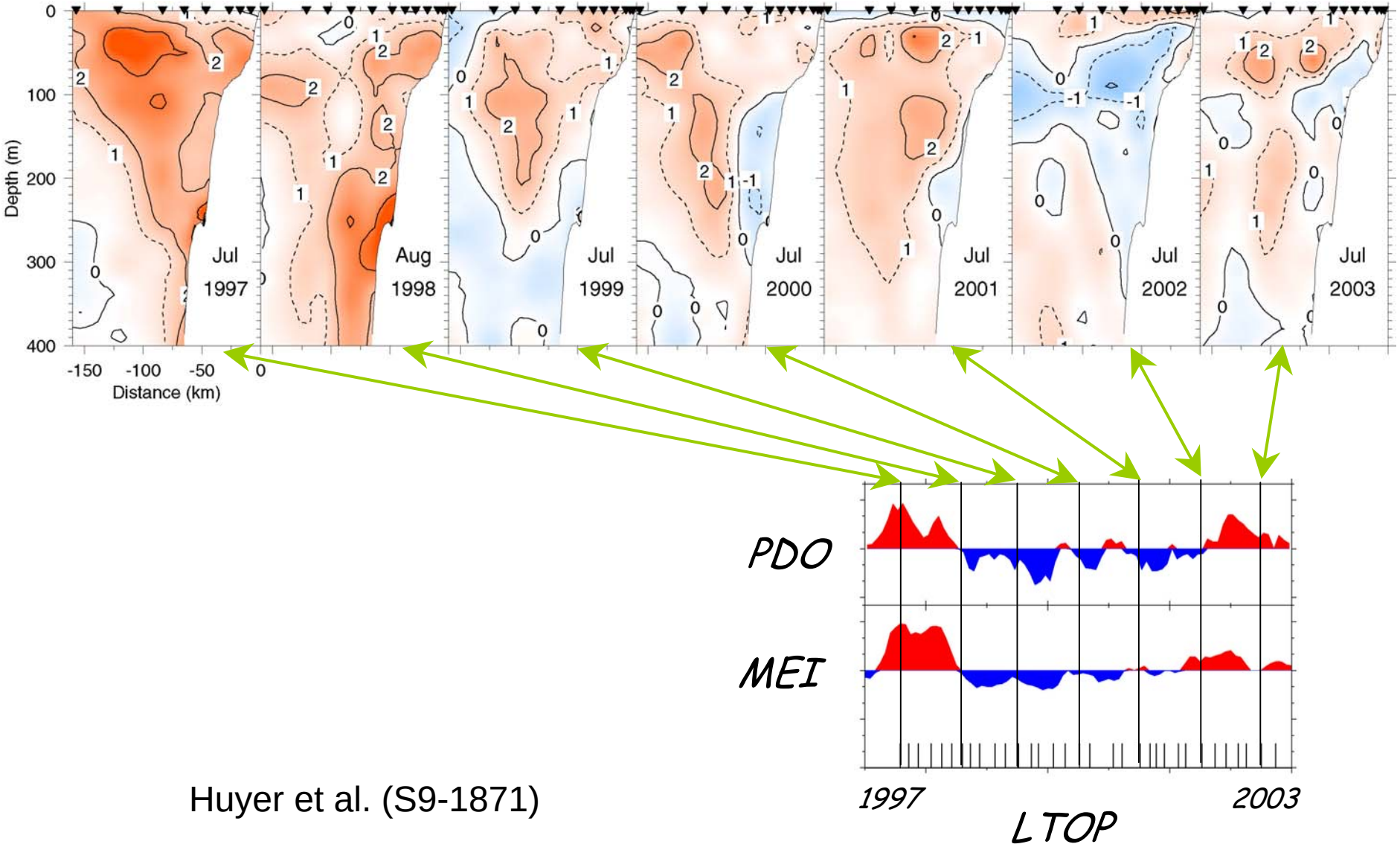
T/S properties of 2004 source water were not anomalous



PISCO-OSU

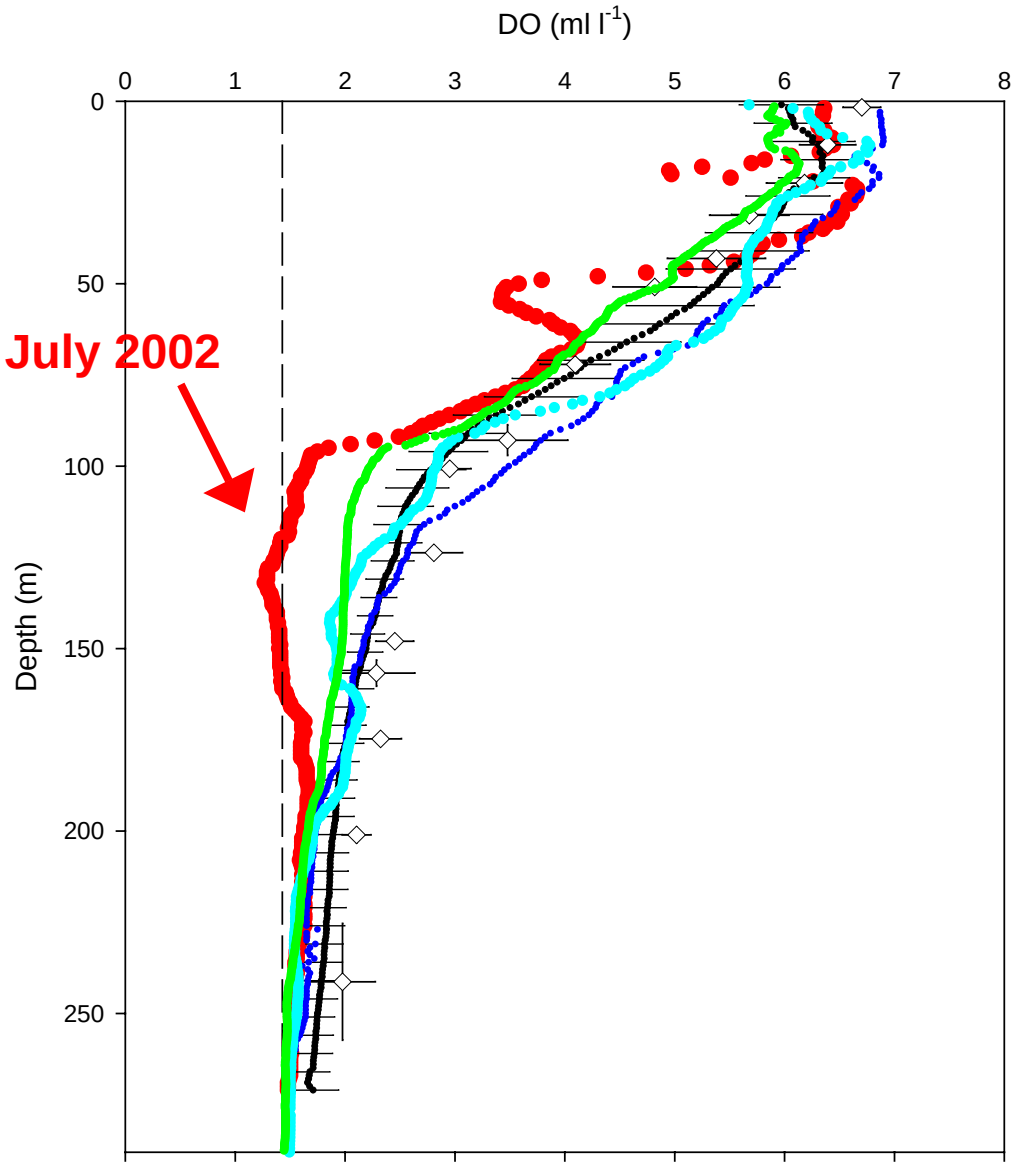
Summer Temperature Anomalies

(normalized by 1961-71 summer std dev)



Huyer et al. (S9-1871)

Oxygen in 2004 source water was not anomalously low



NH-25

◇ 1960-69, 1970

• 1999 to 2001 LTOP mean

2002 July LTOP

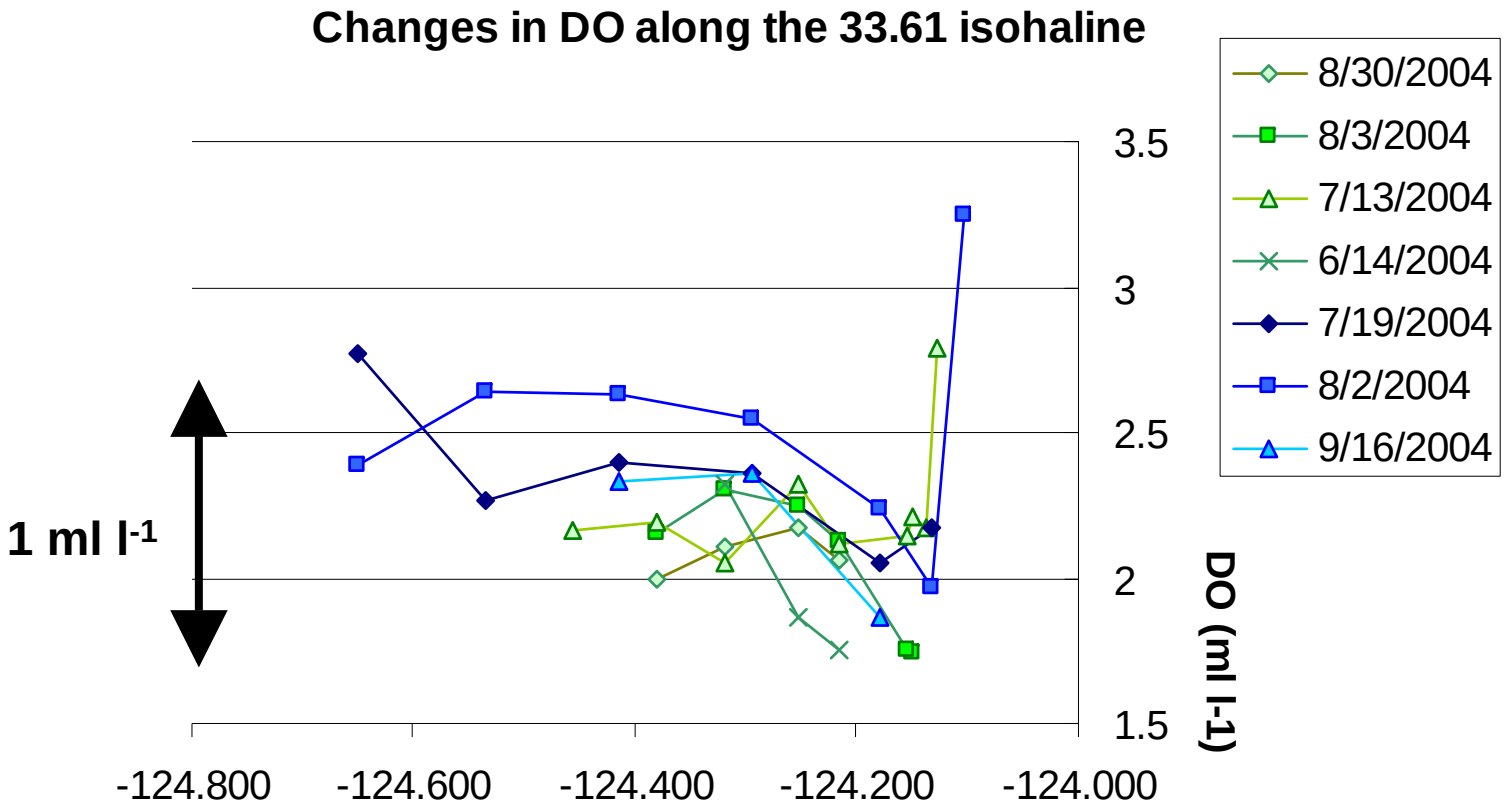
2003 July LTOP

2004 July Peterson/PISCO

2004 Aug Peterson/PISCO

Error bars = 95% C.I.

Shelf respiration signal during summer 2004



Sufficient near-bottom organic carbon to fuel consumption of 1 ml l^{-1} of DO

PISCO-OSU

Upwelling-Driven Inner-Shelf Hypoxia: Summary

Deep low-oxygen water upwelled onto continental shelf (this is normal)

Shelf bottom water can become hypoxic from a combination of low-oxygen source waters and respiration

Flow-topography interaction at Heceta Bank creates low-velocity lee region with high surface chlorophyll

Location and duration of hypoxic water in inner-shelf habitats controlled by event-scale wind forcing

Low-oxygen source water in 2002 from Subarctic invasion

Relatively normal source water properties in 2004: respiration more important

Future events?

- Hypothesis testing with models
- Observing systems