# Estimates of Carbon Supply from Phytoplankton and Heterotrophic Bacteria to the Food Web of the Northern San Francisco Estuary and Suisun Marsh: Implications for the Pelagic Organism Decline


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## Introduction

The pelagic organism decline (POD) observed in the northern San Francisco Estuary (SFE) - Delta has become a major focus of estuarine research and management. Food availability has received some attention as phytoplankton biomass has declined in the northern SFE and may no longer be sufficient to maintain higher trophic levels within the estuary.
Heterotrophic bacteria represent a potentially important alternative source of organic carbon to estuarine foodwebs via the microbial loop. Much less is known about trends in bacterial biomass and production. This research program is designed to characterize the relative importance of bacteria and phytoplankton carbon supply for the estuarine foodweb in both Suisun Bay and the adjacent Suisun Marsh.

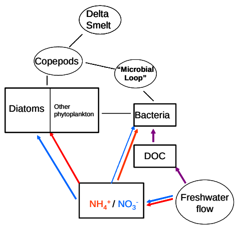


Figure 1: Conceptual model of the foodweb of the low salinity zone (LSZ) of the northern SFE.

### Pelagic Habitats of northern SFE

*Suisun Bay*

The channel habitat of the low salinity (0-5 psu) zone is characterized by low primary production and phytoplankton biomass (see poster by Lidstrom & Carpenter). Nutrients and dissolved organic matter are primarily supplied through river flow with bacterial production being roughly half of primary production. Bacterial production is supported through phytoplankton and exogenous DOM.

*Suisun Marsh*

Suisun Marsh represents a potential source of bioavailable organic carbon for Suisun Bay. Long residence times, nutrient and organic matter supply may support high phytoplankton and bacterial biomass. Sloughs adjacent to Suisun City (blue- see map) are influenced by the Fairfield - Suisun Sewer District, which discharges roughly 16 million gallons of wastewater daily to Boynton Slough. The eastern sloughs (yellow – see map) are characterized by lower nutrient concentrations but higher phytoplankton biomass.

## Materials and Methods

**Bacterial production** (BP) was determined by $^{3}$H-Leucine incubations conducted at saturating (60nM leu) concentrations. Bacterial production was converted to **carbon production** using empirical conversion factors developed for the northern San Francisco Bay (Hollibaugh & Wong, 1996)

**Bacterial abundance** was determined by direct counts after staining with DAPI. Cell counts were converted to **carbon biomass** using conversion factors of Ducklow, 2000 and Fakuda et al., 1998.

**Bacterial growth efficiency** was calculated using parallel measurements of bacterial production and **bacterial respiration**. Respiration was determined by monitoring changes in the dissolved inorganic carbon pool by the <2 µm fraction during 24- 48hr incubations.

## The Role of Bacteria in the Suisun Bay Foodweb

### Cross System Comparison of Bacterial Production in Estuaries

| Location | mg C $m^3$ $d^{-1}$ | Reference |
|---|---|---|
| Essex Estuary, USA | 100-150 | Wright & Coffin, (1984) |
| Narragansett | 336 | Hobbie & Cole,(1984) |
| Delaware Bay | 4.8-38 | Kirchman & Hoch,(1988) |
| Hudson River | 20-175 | Hudak et al., (1988) |
| San Francisco Bay | 15-76 | Hollibaugh, (1988) |
| ***LSZ, San Francisco*** | ***2-18*** | ***This Study*** |
| ***Suisun Marsh*** | ***20-128*** | ***This Study*** |

### Interannual Variation in Phytoplankton and Bacterial Production

| | | Bacteria | | Phytoplankton | |
|---|---|---|---|---|---|
| | | 2006 | 2007 | 2006 | 2007 |
| | | mg C $m^2$ $d^{-1}$ | | mg C $m^2$ $d^{-1}$ | |
| | | (n =84) | (n=40) | | |
| 0.5 psu | average | 93 | 41 | 198 | 88 |
| | range | (12-266) | (17-98) | (26-497) | (51-134) |
| 2 psu | average | 104 | 51 | 267 | 86 |
| | min | (20-138) | (24-73) | (47-1301) | (28-265) |
| 5 psu | average | 64 | 44 | 244 | 63 |
| | min | (7-142) | (7-73) | (61-989) | (19-134) |

### Comparison of Bacteria and Phytoplankton in Suisun Bay

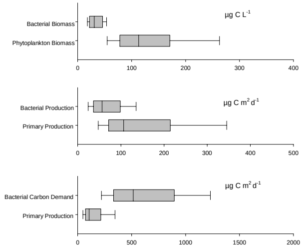


Figure 2: Average biomass and production estimates for phytoplankton and bacteria in the LSZ for 2006 and 2007.

### Estimates of Bacterial Growth Efficiency (BGE) in the LSZ

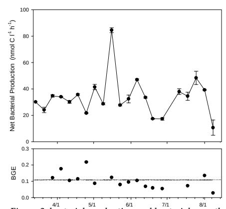


Figure 3: bacterial production and bacterial growth efficiency at 2psu for 2006

| System | | Bacterial Growth Efficiency | Reference |
|---|---|---|---|
| Estuarine | | | |
| | Florida estuaries | 0.11-0.61 | Coffin et al. (1993) |
| | Danish Fjord | 0.22-0.36 | Middelboe, et al. (1992) |
| | Hudson River | 0.18-0.61 | Findlay et al. (1992) |
| | Santa Rosa Sound | 0.60-0.61 | Kroer (1993) |
| | ***LSZ-San Francisco*** | ***0.05 - 0.22*** | ***This Study*** |
| Marine | | | |
| | Sargasso Sea | 0.04-0.09 | Hansell, et al. (1995) |
| | Peru upwelling | 0.30-0.34 | Sorokin & Mameva (1980) |

From delGiorgio & Cole 2000

Bacterial growth efficiency may be lower than previously assumed, requiring more reduced carbon to support net bacterial production.

### Summary and Foodweb Models

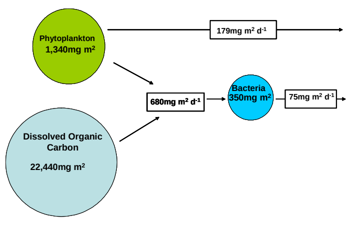


Figure 4: Average carbon budget for phytoplankton and bacteria in the LSZ of northern SFE.

Over the two-year study, bacteria contributed roughly 30% of the carbon production to the LSZ foodweb.

Bacterial growth efficiency is low in the LSZ, requiring a ca. 9-fold higher carbon subsidy to bacterial carbon demand – This subsidy must come from allochthonous DOC supply.

The decline in both phytoplankton and bacteria in 2007 suggest co-variation over broad scales and bacterial dependence on primary production.

## Bacteria in Suisun Marsh

### Station Comparisons in Suisun Marsh and Bay

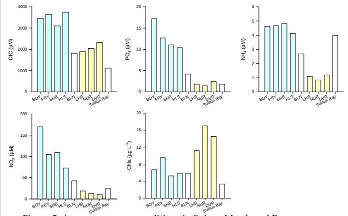

Figure 5: Average summer conditions in Suisun Marsh and Bay stations. See map right) for station locations.

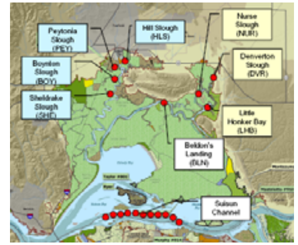


Figure 6: Station Map of Suisun Marsh and Bay stations. Map DWR

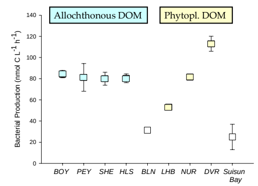


Figure 7: Bacterial production estimates in Suisun Marsh stations.

**Western Sloughs (BOY, SHE, PEY, HLS)**

- Western sloughs within Suisun Marsh support similar bacterial production with high nutrients concentrations.
- Western sloughs have similar chl-a (4-6µg $L^{-1}$).

**Eastern Sloughs (LHB, NUR, DVR)**

- Eastern sloughs within Suisun Marsh support variable bacterial production.
- Nutrients in eastern sloughs are lower.
- Phytoplankton biomass is higher in eastern sloughs.

**We hypothesize that:**

1) Nutrient supply to western sloughs is through wastewater discharge from Fairfield – Suisun Sewer District (to Boynton Slough). This input drives bacterial production.

2) Phytoplankton biomass in the eastern sloughs supports much of the bacterial production.

3) Stations in Suisun Marsh (except BLN) support 4-5-fold higher bacterial production compared to Suisun Bay and may be an important source of organic matter supply to Suisun Bay.

## Literature cited


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