■ Interagency Ecological Program for the San Francisco Estuary ■

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■

Of Interest to Managers

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This issue's Quarterly Highlights focuses on an update by Paul Buchanan on water quality monitoring for water year 2004. These data represent an important component of IEP's long-term monitoring of specific conductance and water temperatures. The monitoring network includes stations extending from Suisun Bay (Benicia Bridge) to South San Francisco Bay.

Lori Wichman and Jason Hanni's article on the recent trends in fish assemblages in the upper San Francisco estuary represents a good example of the progress that has been made in analyzing the results of IEP monitoring data. The two FWS biologists examined trawl and beach seine data to determine whether fish assemblages have been consistent since 2000. The analysis found that there has been no major change in species composition over the past six years. Note, however, that these results are not necessarily inconsistent with the recent Pelagic Organism Decline (POD) in the Delta. First, the analysis was based on relative abundance (i.e. ranks among species) rather than overall abundance. Second, the surveys focused on winter; the pelagic species are often still spawning, so their young are not yet abundant. Finally, the beach seine data are not an effective method to sample pelagic fishes; hence, the dominant species in the analysis were inshore types such as Chinook salmon, red shiners and inland silverside.

This issue of the IEP Newsletter includes Anthony Marrone's update on CALFED's Non Native Invasive Species (NIS) Program. The program is designed to provide technical assistance, guidance and coordination for the control and management of NIS. Marrone reports that the program is developing a reference collection of NIS to assist in historical documentation, teaching and research. Part of this effort includes the development of a database for the reference collection, providing a valuable resource for the identification and confirmation of new invaders.

Drs. Cath Hall and Anke Mueller-Solger report on progress in the cultivation of two locally important copepods, the primary prey for POD species: delta smelt, longfin smelt, threadfin shad and early life stages of striped bass. While information is widely available on the cultivation of other types of zooplankton (e.g. cladocerans), the present effort shows that the two key copepod species, *Pseudodiaptomus forbesi* and *Eurytemora affinis*, can be successfully grown in the laboratory. Laboratory cultivation techniques provide valuable information on the life history of zooplankton and allow us to experiment with factors (e.g. water and food quality) that may affect the abundance of these fish prey.

IEP Quarterly Highlights

Specific-Conductance and Water-Temperature Data, San Francisco Bay, California, for Water Year 2004

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Introduction

This article presents time-series graphs of specific-conductance and water-temperature data collected in San Francisco Bay during water year 2004 (October 1, 2003, through September 30, 2004). Specific-conductance and water-temperature data were recorded at 15-minute intervals at seven U.S. Geological Survey (USGS) locations (Figure 1, Table 1).

Specific-conductance and water-temperature data from Point San Pablo (PSP) and San Mateo Bridge (SMB) were recorded by the California Department of Water Resources (DWR) before 1988, by the USGS National Research Program from 1988 to 1989, and by the USGS-DWR cooperative program since 1990. Benicia Bridge (BEN), Carquinez Bridge (CARQ), and Napa River (NAP) were established in 1998 by the USGS. San Pablo Bay (SPB) was initially established in 1998 at Channel Marker 9 but was moved to Channel Marker 1 in 2003. The monitoring station at Alcatraz (ALC) was established in 2003 by the USGS to replace the discontinued monitoring station San Francisco Bay at Presidio Military Reservation.

Data Collection

Specific-conductance and water-temperature data were collected at two depths in the water column (Table 1) to help define the vertical stratification. However, at the shallow SPB and ALC sites, data were collected only at one depth.

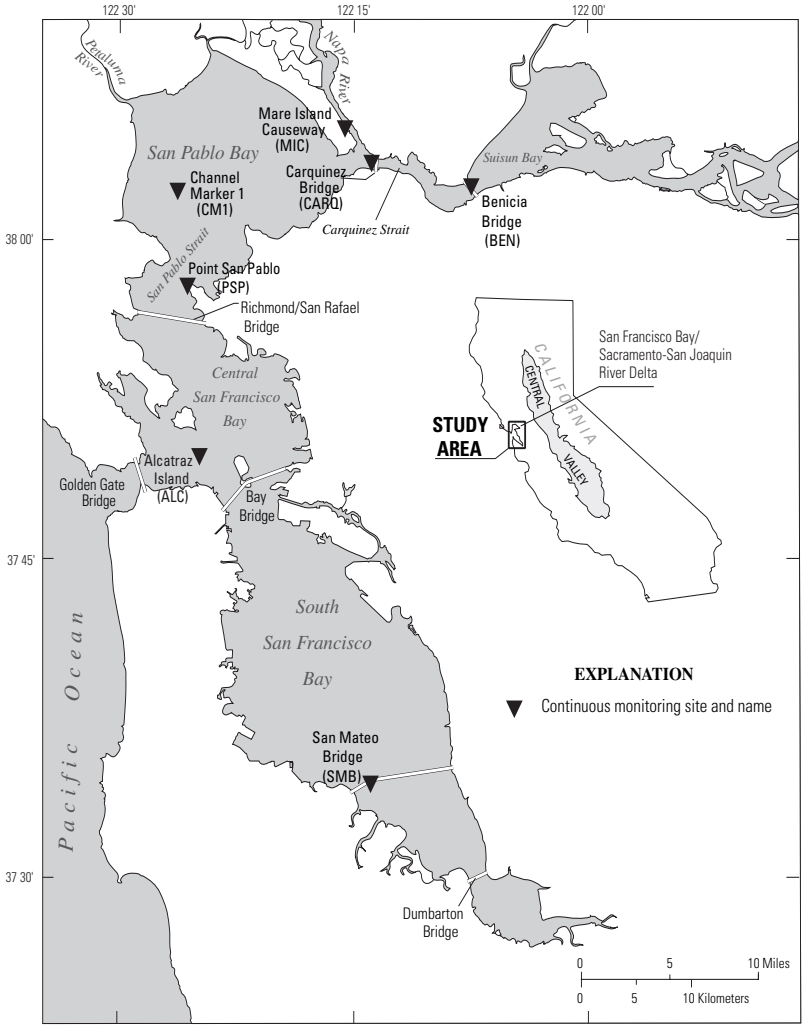

Figure 1 Specific-conductance and water-temperature data monitoring sites in San Francisco Bay, California

Several types of instrumentation were used to measure specific-conductance and water-temperature data in San Francisco Bay. Specific conductance [reported in microsiemens per centimeter at 25°Celsius (C)] was measured using either a Foxboro[1] electrochemical analyzer (calibrated accuracy ±0.5%), a Hydrolab Datasonde 4 multiprobe (conductivity cell calibrated accuracy ±0.5%) or a YSI 6920-M multi-parameter water-quality logger (conductivity cell calibrated accuracy ±0.5%). Water temperature (reported in degrees Celsius) was measured using a Campbell Scientific thermister (accuracy ±0.2°C), a Hydrolab Datasonde 4 multiprobe (temperature probe accuracy ±0.2°C) or a YSI 6920-M multi-parameter water-quality logger (temperature probe accuracy ±0.2°C). The calibrated accuracies stated here are manufacturer specifications and do not reflect the accuracy of collected data. In an environmental monitoring program, potential sources of introduced error include, but are not limited to, electronic drift, calibration standard inconsistencies, and fouling of sensors.

Monitoring instrument calibrations were checked every 2–3 weeks. Calibration of the Foxboro specific-conductance instrument was checked using an WTW model 197 conductivity meter (calibrated accuracy ±1%), which was calibrated to a known specific-conductance standard (direct checks against a known standard are not possible with the Foxboro large-bore probe because of the large volume of standard needed). Calibration of the

1. The use of firm, trade, and brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey or California Department of Water Resources.

Hydrolab and YSI specific-conductance instruments were checked using a range of known specific-conductance standards. Calibration of the water-temperature instruments were checked using a Cole Parmer thermister (accuracy ±0.2°C). Data corrections (necessary because of biological fouling or instrument electronic drift) were applied to the record following the guidelines described by Wagner and others (2000).

Table 1. Sensor depths (in feet) below mean lower low water (MLLW), Suisun Bay, San Pablo Bay, and Central and South San Francisco Bays, California, water year 2004

Site	*Abbreviation*	*Station No.*	*Latitude*	*Longitude*	*Sensor depth*	*Depth below MLLW*	*Water depth at MLLW*
Suisun Bay at Benicia Bridge, near Benicia, Ca.	BEN	11455780	38°02'42"	122°07'32"	Near-surface Near-bottom	6 55	80
Carquinez Strait at Carquinez Bridge, near Crockett, Ca.	CARQ	11455820	38°03'41"	122°13'23"	Mid-depth Near-bottom	40 83	88
Napa River at Mare Island Causeway, near Vallejo, Ca.	NAP	11458370	38°06'40"	122°16'25"	Near-surface Near-bottom	5 25	30
San Pablo Strait at Point San Pablo, Ca.	PSP	11181360	37°57'53"	122°25'42"	Mid-depth Near-bottom	13 23	26
San Pablo Bay at Petaluma River Channel Marker 1, Ca.	SPB	380240122255701	38°02'40"	122°25'57"	Mid-depth	4	8
San Francisco Bay at NE shore Alcatraz Island, Ca.	ALC	374938122251801	37°49'38"	122°25'18"	Mid-depth	6	16
South San Francisco Bay at San Mateo Bridge, near Foster City, Ca.	SMB	11162765	37°35'04"	122°14'59"	Near-surface Near-bottom	4 38	48

[a] The mean lower-low water depth is the average of the lower-low water height above bottom of each tidal day observed during the National Tidal Datum Epoch (NTDE). The NTDE is the specific 19-year period (1960-1978 for values given in this report) adopted by the National Ocean Service as the official time segment during which tidal observations are made and reduced to obtain mean values (Hicks, 1983).

Data Presentation

Figures 2 through 7 show time-series graphs of the specific-conductance and water-temperature data measured at the seven sites in San Francisco Bay. Gaps in the data primarily are caused by equipment malfunctions and fouling. Tidal variability (ebb and flood) affects specific conductance and water temperature (Cloern and others, 1989; Ruhl and Schoellhamer, 2001). Tidal variability was greater in San Pablo Bay than in South San Francisco Bay (Schoellhamer, 1997). To illustrate tidal variability, Figure 8 shows the near-surface and near-bottom specific conductance and the corresponding water-level data at BEN for the 24 hours of March 20, 2004. The water-level data are not published or referenced to a known datum and are shown only to detail how specific conductance varies with tidal change.

Daily maximum and minimum values of specific-conductance and water-temperature data for the seven sites are published annually in Volume 2 of the USGS California water data report series, which is available on the USGS website (USGS, accessed May 26, 2005). The complete data sets through October 1, 2003, also are available (USGS, accessed May 26, 2005).

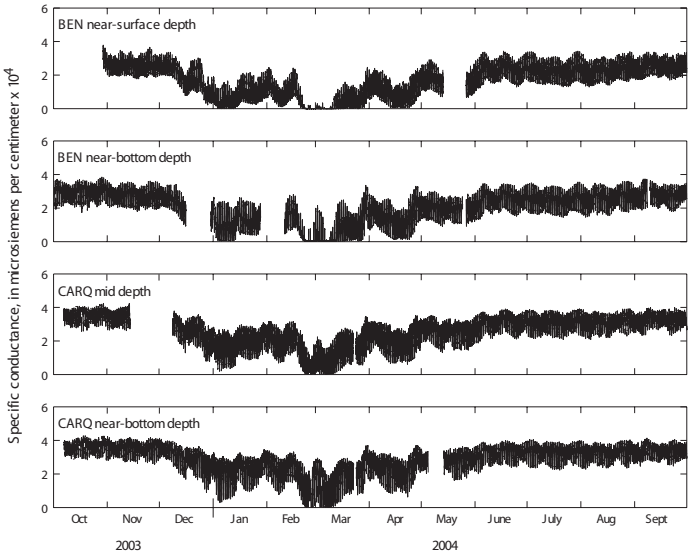

Figure 2 Measurements of specific conductance at Benicia Bridge (BEN) and Carquinez Bridge (CARQ), San Francisco Bay, water year 2004. For reference, seawater has a specific conductance of about 53,000 microsiemens per centimeter (5.3 x 10^4).

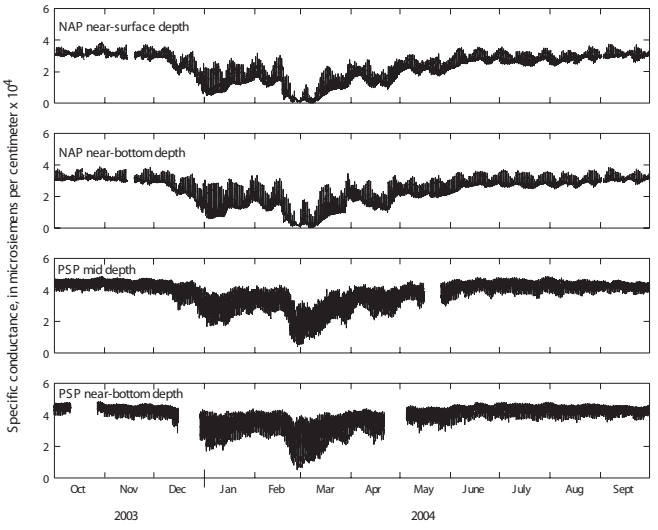

Figure 3 Measurements of specific conductance at Napa River NAP) and Point San Pablo (PSP), San Francisco Bay, water year 2004. For reference, seawater has a specific conductance of about 53,000 microsiemens per centimeter (5.3 x 10^4).

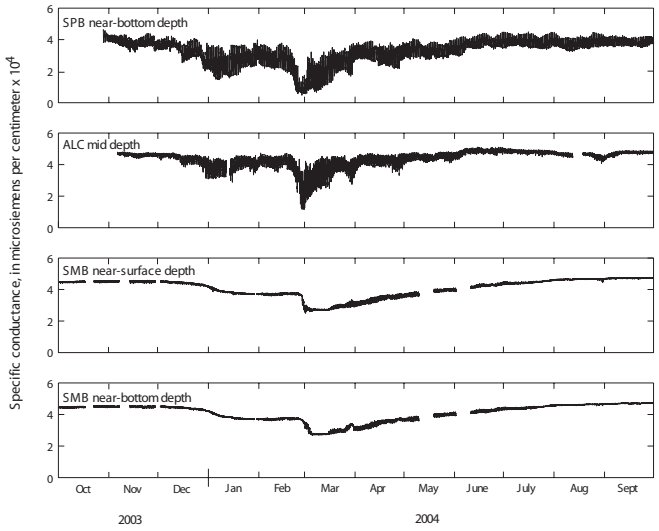

Figure 4 Measurements of specific conductance at San Pablo Bay (SPB), Alcatraz Island (ALC), and San Mateo Bridge (SMB), San Francisco Bay, water year 2004. For reference, seawater has a specific conductance of about 53,000 microsiemens per centimeter (5.3 x 10^4).

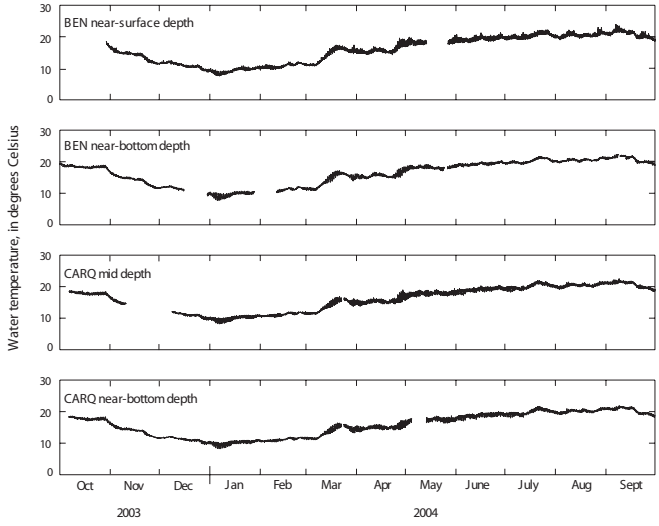

Figure 5 Measurements of water temperature at Benicia Bridge (BEN) and Carquinez Bridge (CARQ), San Francisco Bay, water year 2004.

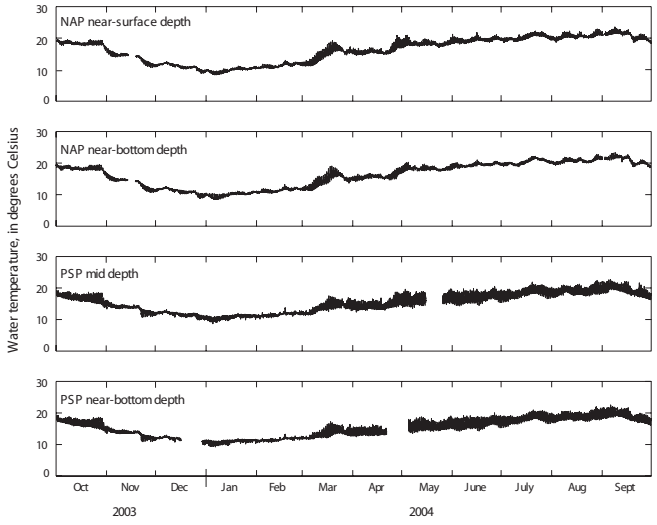

Figure 6 Measurements of water temperature at Napa River (NAP) and Point San Pablo (PSP), San Francisco Bay, water year 2004.

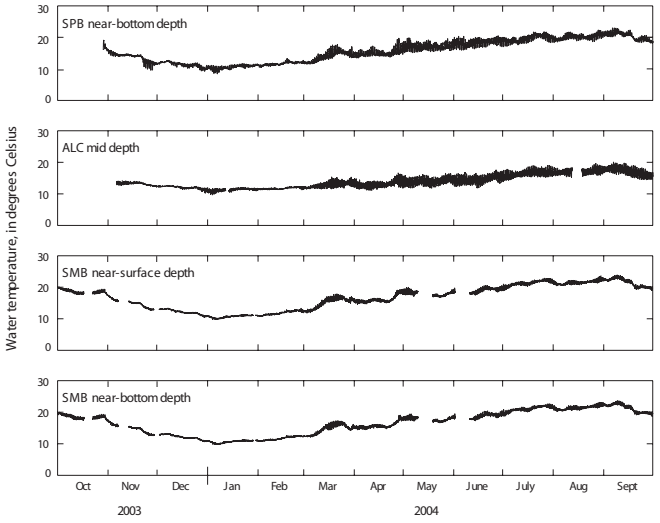

Figure 7 Measurements of water temperature at San Pablo Bay (SPB), Alcatraz Island (ALC), and San Mateo Bridge (SMB), San Francisco Bay, water year 2004.

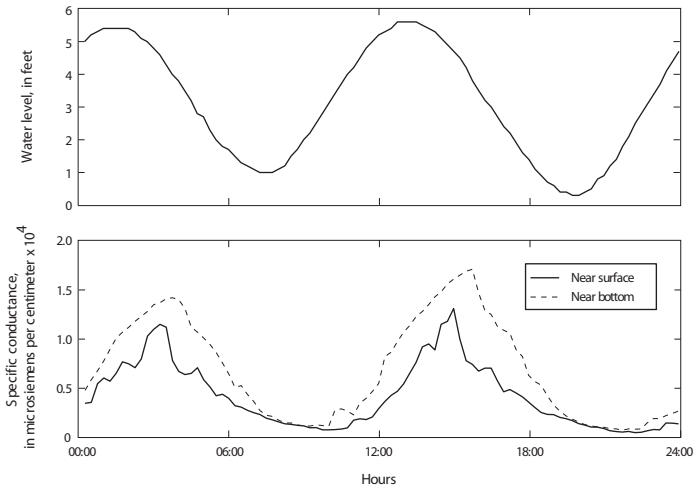

Figure 8 Near-surface and near-bottom measurements of specific conductance and water levels at Benicia Bridge, Suisun Bay, March 20, 2004. For reference, seawater has a specific conductance of about 53,000 microsiemens per centimeter (5.3×10^4).

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Contributed Papers

Chinook Salmon Catch and A Preliminary Look at Fish Assemblages in the Sacramento-San Joaquin River Delta and Bays

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Background

Historically, the Stockton Fish and Wildlife Office (STFWO) has used beach seines, Kodiak (KDTR) and mid-water (MWTR) trawls to monitor juvenile Chinook salmon *(Oncorhynchus tshawytscha)* and other juvenile fishes in the Sacramento-San Joaquin Delta and Bays. During the last 6 years, beach seine sampling has been conducted consistently and regularly at 44 sites in 5 regions located in the Sacramento-San Joaquin River Delta and 9 sites in a 6th region, San Francisco and San Pablo Bay. Trawls were conducted at three locations, Chipps Island, Sherwood Harbor, and Mossdale. Data collected by STFWO facilitates decision making and planning for water operations in the Sacramento-San Joaquin Delta and Suisun Bay, and can provide information regarding relative abundance of juvenile fishes.

Here we report the total catch for Chinook salmon and other dominant species by region and gear type for 1 January through 30 April 2005. We also compare the species catch per unit effort (CPUE) as number of individuals/m^3, to the previous 5 years of the same reporting period, to determine if an association exists for fish assemblage CPUE over the past 6 years within each sample area. We analyzed these recent data to provide initial insight into the fish assemblage in the Sacramento-San Joaquin Delta and Bays.

Methods

STFWO selected beach seines as a method for sampling near shore communities, and trawls to sample open water from the surface to a maximum depth of 10 feet. To reduce bias in catch from sampling methods, beach seining and trawling were conducted in accordance with standard operating procedures (USFWS 2005). All Chinook salmon captured in beach seine and trawling were assigned a race according to Fisher's size criteria (Fisher 1992).

The STFWO divides the Sacramento-San Joaquin Delta and Bays into 6 different regions each with specific sampling sites (Figure 1): region 1 - Lower Sacramento (7 sites), region 2 - North Delta (10 sites), region 3 - Central Delta (9 sites), region 4 - South Delta (8 sites), region 5 - San Joaquin River (10 sites), and region 6 - San Francisco and San Pablo Bays (9 sites). Between January and April seine sites are sampled once per week with the exception of Lower Sacramento River region, which is sampled twice a week from 1 January through 31 March. An additional 3 sites are sampled during January in the Lower Sacramento River region to improve detection of less abundant races of juvenile salmon, such as winter run.

Trawling is conducted at 3 different locations, Chipps Island, Mossdale, and Sherwood Harbor. STFWO uses only mid-water trawls at Chipps Island and only Kodiak trawls at Mossdale. At Sherwood Harbor, both trawling methods are used: Kodiak trawls are conducted during January through March, while mid-water trawls are conducted during April. STFWO uses Kodiak trawls to increase catch efficiency of larger sized, less abundant races of juvenile Chinook salmon (late fall, winter and spring run) during periods of peak migration (Brandes et al. 2001). Trawls are typically conducted 3 days per week, although their frequency may increase during periods of increased coded wire tag salmon recovery.

To report catch, the juvenile fish monitoring program database maintained by STFWO was queried for all fish species captured between 1 January and 30 April for 2005. All unidentified and non-fish species were excluded. In addition, experimental dyed salmon were excluded from the beach seine calculations because they were released for trawling efficiency experiments conducted by other agencies.

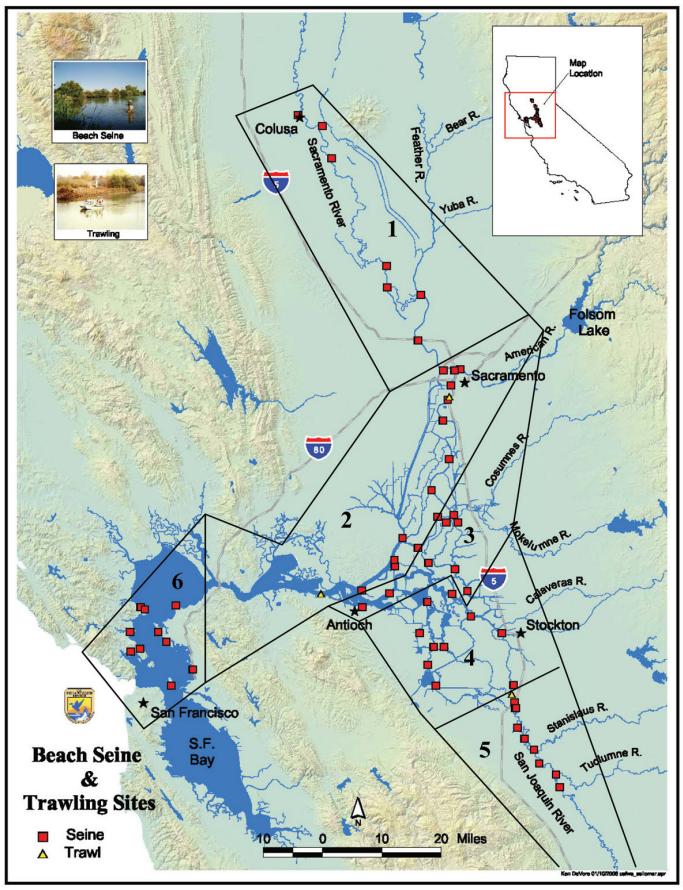

Figure 1 Stockton Fish and Wildlife Office beach seine sites and trawl locations by regions.

Kendall's coefficient of concordance with tied ranks *(W_c)* (Zar 1999) was selected to compare fish CPUE in specific areas (trawl locations or seine regions) to provide preliminary data regarding fish assemblage stability between 1 January through 30 April from 2000-2005. This test allowed us to compute a correction for tied ranks as well as consider association between several years. To calculate W_c, catch totals and volume of water sampled (effort) were queried from the juvenile fish monitoring program (JFMP) database for the reporting period for the years of 2000-2005, and CPUE were summarized for species by year. For the purposes of calculating W_c, each race of Chinook salmon and marked (adipose fin clipped, tagged, spray-dyed, etc.) salmon were treated as separate species. Marked and unmarked steelhead were also treated as separate species. Ranks from highest CPUE to the lowest were assigned, allowing for ties. Ties within CPUE were accounted for by giving each tie an equal number. Once all individual species were ranked, we used the following equation to calculate W_c:

$$W_c = \frac{\sum R_i^2 - \frac{\left(\sum R_i\right)^2}{n}}{\frac{M^2\left(n^3 - n\right) - M\sum T'}{12}}$$

where Ri = species rank
n = number of species
M = number of years

$$T = \sum_{i=1}^{m}\left(t_i^3 - t_i\right)$$

t = number of ties
m= number of groups of tied ranks

The value of W_c can range from 0, where there is no association among years within fish assemblage CPUE, and 1 where there is complete association overtime within fish assemblage CPUE.

To determine if the association is significantly different ($\alpha < 0.05$) from a random association, W_c was converted to a Friedman χ_r^2 value using the equation below (Zar 1999). Then the calculated χ^2 value was compared to the critical χ^2 distribution.

$$\left(\chi_r^2\right)_c = M(n-1)W_c$$

Results

Chinook Salmon Summary

Between 1 January and 30 April 2005, a total of 9,111 unmarked Chinook salmon were captured while beach seining. The majority of these salmon (Table 1) were fall run captured in region 1, region 2 and region 3. Region 6 (San Francisco and San Pablo Bays) yielded no Chinook salmon during the reporting period. Finally, in regions 1-3, 229 marked salmon were recovered.

STFWO captured 9,031 unmarked (raced juvenile and adult) Chinook salmon while trawling: 5,105 Chinook were captured at Chipps Island; 1,656 at Sherwood Harbor KDTR, 1,822 at Sherwood Harbor MWTR and

448 in the San Joaquin River at Mossdale (Table 2). The majority of marked fish were recovered from Mossdale (Table 2; n = 1,124) in late April and are likely from experiments conducted by Region 4, California Department of Fish Game (DFG)

Table 1. Regional catch and CPUE of unmarked (raced) and marked Chinook salmon captured from beach seining activities conducted from 1 January - 30 April 2005.

Region	Volume (m3)	Fall	CPUE	Late Fall	CPUE	Spring	CPUE	Winter	CPUE	Marked	CPUE
1. Lower Sacramento R.	6200.8	2,783	0.448813046	0	0	94	0.015159334	102	60.79215832	89	0.014352986
2. North Delta	9788.3	4,818	0.492222814	10	0.001021633	106	0.010829311	56	0.005721145	74	0.007560085
3. Central Delta	7031.9	1,033	0.146903017	8	0.001137681	50	0.007110504	7	0.000995471	55	0.007821555
4. South Delta	7198.5	21	0.002917274	0	0	0	0	0	0	2	0.000277836
5. San Joaquin R.	2817.6	22	0.007808063	0	0	1	0.000354912	0	0	9	0.003194208
Total		8,677		18		251		165		229	

Table 2. Catch and CPUE of unmarked (raced) and marked Chinook salmon captured at each trawling location from 1 January - 30 April 2005.

Location	Volume (m^3)	Adult	CPUE	Fall	CPUE	Late Fall	CPUE	Spring	CPUE	Winter	CPUE	Marked	CPUE
Chipps Island mid-water trawl	13884675	0	0	3,374	0.000243	7	5.04153E-07	1,604	0.000115523	120	8.64262E-06	426	3.06813E-05
Mossdale Kodiak trawl	6384041	0	0	139	2.1773E-05	0	0	308	4.82453E-05	1	1.56641E-07	1,124	0.000176064
Sherwood Harbor Kodiak trawl	4218535	1	2.37049E-07	1,507	0.000357233	1	2.37049E-07	98	2.32308E-05	49	1.16154E-05	248	5.87882E-05
Sherwood Harbor mid-water trawl	1009038	0	0	1,409	0.001396378	0	0	412	0.000408309	1	9.91042E-07	205	0.000203164
Totals		1		6,429		8		2,422		171		2,003	

Fish Assemblage - Beach Seining Data

For the reporting period of 1 January through 30 April 2005, 56 different species were captured for a total of 64,417 fish in 754 (est. vol. = 38,700 m^3) total beach seine samples. In the lower Sacramento River (region 1), 6,774 fish from 23 species were captured. In the North Delta (region 2), 10,133 fish from 28 species were captured. In the Central Delta (region 3), 6,870 fish from 21 species were captured. In the South Delta (region 4), 8,419 fish from 20 species were captured. In the San Joaquin River (region 5), 25,328 fish from 22 species were captured. In the San Pablo and San Francisco Bay (region 6), 6,893 fish from 17 species were caught. The most abundant fish captured overall were non-indigenous: red shiners (*Cyprinella lutrensis;* n=23,902) and inland silversides (*Menidia beryllina*; n=17,641). Alternatively, the 2 highest catches of native fishes were fall run Chinook salmon (n=8,677) and Sacramento splittail (*Pogonichthys macrolepidotus;* n=2,421). Other priority species captured were winter run Chinook salmon (n=165) from regions 1, 2, and 3; delta smelt (*Hypomesus transpacificus*; n=18) from region 2, and unmarked steelhead (*O. mykiss*; n=1) also from region 2. As mentioned previously Sacramento splittail were one of the most abundant native species and were found in all regions except 6; though the majority of the individuals were captured in region 3. In 2005, 3 or fewer fish species comprised > 75% of the total fishes captured in each region (Table 3).

Total catch data by region from 2000 and 2004 are included in Table 4. W_c was calculated to assess changes in the ranks of fish within an assemblage between1 January to 30 April from 2000 - 2005. CPUE of fish assemblages sampled by beach seines were evaluated by regions. Region 1 (Lower Sacramento River) had a high association of W_c=0.8233 (χ_r^2 = 182.8; n = 38 species) in CPUE ranks over time. Regions 2, 3, and 4 all demonstrated somewhat high associations, W_c=0.7584 (χ_r^2 = 200.2; n = 45 species), 0.7408 (χ_r^2 = 146.7; n = 34 spe-

cies), and 0.7624 (χ_r^2 = 151.0; n = 34 species), respectively. Region 5 had a value of W_c=0.7297 (χ_r^2 = 122.6; n = 29 species). Region 6 had the lowest value for W_c (0.6927) (χ_r^2 = 149.6; n = 37 species). The association of CPUE ranks over time in each region were statistically significant ($p < 0.001$).

Table 3. Species that comprise greater than 75% of the fishes captured within each beach seine region and trawl sample area from 1 January - 30 April 2005.

Beach Seine Region	*Species*	*(n)*	*% of total fish captured*	*Total Fish Captured*	*Total Species*
1. Lower Sacramento River (n = 7 sites)	TOTAL	5,109	75%	6,774	23
	Chinook Salmon (fall)	2,783	41%		
	Sacramento Sucker	1,299	19%		
	Inland Silverside	1,027	15%		
2. North Delta (n = 10 sites)	TOTAL	9,136	90%	10,133	28
	Chinook Salmon (fall)	4,818	48%		
	Inland Silverside	4,318	43%		
3. Central Delta (n = 9 sites)	TOTAL	5,337	78%	6,870	21
	Inland Silverside	3,049	44%		
	Splittail	2,288	33%		
4. South Delta (n = 8 sites)	TOTAL	8,035	95%	8,419	20
	Inland Silverside	5,961	71%		
	Red Shiner	2,074	25%		
5. San Joaquin River (n = 10 sites)	TOTAL	21,469	85%	25,328	22
	Red Shiner	21,469	85%		
6. San Francisco and San Pablo Bays (n = 9 sites)	TOTAL	6,687	97%	6,893	17
	Pacific Herring	4,035	59%		
	Topsmelt	2,652	38%		
Trawl Location					
Chipps Island	TOTAL	11,567	77%	15,039	19
	American Shad	6,589	44%		
	Chinook Salmon (fall)	3,374	22%		
	Chinook Salmon (spring)	1,604	11%		
Mossdale	TOTAL	2,011	83%	2,434	23
	Chinook Salmon (marked)	1,124	46%		
	Threadfin Shad	339	14%		
	Chinook Salmon (spring)	308	13%		
	Pacific Lamprey	240	10%		
Sherwood Harbor (mid-water)	TOTAL	1,821	89%	2,039	7
	Chinook Salmon (fall)	1,409	69%		
	Chinook Salmon (spring)	412	20%		
Sherwood Harbor (Kodiak)	TOTAL	1,851	84%	2,216	22
	Chinook Salmon (fall)	1,507	68%		
	Chinook Salmon (marked)	246	11%		
	Chinook Salmon (spring)	98	4%		

Table 4. A summary of species richness and total individuals captured while beach seining and trawling from 1 January - 30 April between 2000 and 2004.

	2000		2001		2002		2003		2004	
	Species Richness	No. Individuals	Species Richness	No. Individuals	Species Richness	No. Individuals	Species Richness	No. Individuals	Species Richness	No. Individuals
Beach Seine Region										
1. Lower Sacramento River	22	8,790	25	6,651	24	8,533	23	9,712	23	13,027
2. North Delta	28	16,057	30	8,737	21	7,281	23	8,721	20	11,241
3. Central Delta	19	4,618	23	4,149	23	4,072	23	5,118	20	5,242
4. South Delta	21	7,037	19	6,313	19	7,172	19	6,143	18	5,470
5. San Joaquin River	15	12,500	13	10,025	13	12,807	15	13,289	16	15,338
6. San Francisco and San Pablo Bays	16	1,227	23	1,470	15	1,381	18	4,645	22	3,470
Trawl Location										
Chipps Island	25	20,579	27	9,780	25	13,567	19	14,059	23	14,058
Mossdale	24	2,572	19	3,751	20	4,826	20	6,364	19	4,218
Sherwood Harbor (mid-water)	6	2,285	8	1,845	5	2,943	9	3,118	11	5,258
Sherwood Harbor (Kodiak)	15	3,635	18	5,656	18	2,545	16	2,732	17	3,249

Fish Assemblage – Trawling Data

STFWO conducted 1,932 trawls (est. vol. = 25,496,289 m^3) between 1 January and 30 April 2005 and captured 36 different species for a total of 21,740 fish. Chipps Island trawls yielded 19 different species for a total of 15,039 fish. At Mossdale, 23 different species were captured for a total of 2,434 fish. Sherwood Harbor mid-water trawls captured 7 different species for a total of 2,039 fish and Kodiak trawls captured 22 different species for a total of 2,216 fish. The most abundant species captured overall were non-native American shad (n = 6,590), 99% of which were captured at Chipps Island. Fall run Chinook salmon (n = 6,429) were the most abundant native species overall and were captured at all trawling locations, although they did not represent a large proportion of the total catch at Mossdale. Some species of concern to IEP that were captured while trawling include: Sacramento splittail (n = 345) captured at Chipps Island, Mossdale, and Sherwood Harbor (Kodiak gear); Delta smelt (n = 247) captured at all locations and gear types; and unmarked steelhead (n = 18) captured at Chipps Island and Sherwood Harbor (both gear types). Winter run Chinook salmon (n = 171) were captured at all locations and gear types; however, the one specimen detected at Mossdale is likely a large fall run Chinook salmon. In 2005, as reported for the beach seine data, 3 or fewer fish species comprised > 75% of the total fishes captured at each trawl location (Table 3).

W_c was calculated to assess changes in the ranks of the CPUE between1 January to 30 April from 2000 - 2005. Each trawling site and year combined was treated as an assemblage. The strongest association of CPUE for the fish assemblage occurred at Chipps Island ($W_c = 0.79$; $\chi_r^2 = 210.0$; n = 45 species). Mossdale ($W_c = 0.77$; $\chi_r^2 = 165.8$; n = 37 species), Sherwood Harbor MWTR ($W_c = 0.73$; $\chi_r^2 = 96.2$; n = 23 species) and Sherwood Harbor KDTR ($W_c = 0.73$; ($\chi_r^2 = 143.7$; n = 34 species) had somewhat high W_c values. A significant association for CPUE of fish species over time existed at each trawling location ($p < 0.001$).

Discussion

Using abundance ranks by species (Kendall's W_c) is a broad ecological approach and an excellent way to preliminarily examine inter-annual fish assemblage stability. The relatively high Kendall's W_c values show that if a species CPUE for 2005 had a high rank (more abundant) then it is very likely that the same species had high relative abundance in each of the previous 5 years. The same is true for mid and low ranked species (ie., ranks for species within an assemblage are not changing greatly during the study period). This lack of change in ranks indicates that, (from January to April), there is stability within the fish assemblage for each region or location over the past 6 years. All associations were found to be statistically significant indicating that the stability in the ranks is not random. The relatively high catches of Chinook salmon and rank consistency across years indicate that the standard operating procedures and current survey gear are relatively effective at capturing salmon from year to year.

Although the overall dynamics of the fish assemblage appear to be stable, it is likely that the most abundant species caught are highly influencing the analysis. For example: large numbers of Chinook salmon may influence stability in region 1 and 2 while the continued presence coupled with the high abundance of red shiners may influence stability in region 5. In future analysis, investigating the association among years without the dominant species may show different results. Also, a more in depth look at native and non-native dynamics between years may provide insight into assemblage stability. Based on this analysis, it would be worthwhile to compare assemblage changes across years, since the inception of the program, to analyze the possible affects of biological (non-native species) and physio-chemical parameters to the native fish in the assemblage.

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News from Around the Estuary

CALFED Non-Native Invasive Species Program and Reference Collection

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The purpose of the Non-Native Invasive Species (NIS) Program within the U.S. Fish and Wildlife Service is to provide technical assistance and guidance regarding prevention, control, and management of non-native invasive species. The program strives to mitigate the impacts caused by non-native invasive species on the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds. This program is also focused on preventing the establishment of supplementary non-native species in order to reduce the negative ecological, economical, social and public health impacts which result from the influx of undesirable non-native species. The U.S. Fish and Wildlife Service has been charged with developing and coordinating this program through funding from CALFED, the support of the academic community, and non-profit and stakeholder contributors.

As part of our efforts to provide technical assistance, we are developing a Non-native Invasive Species (NIS) reference collection and database. The specific intent of this collection is to catalog aquatic NIS found in the San Francisco estuary. This collection is intended to be a resource for members within IEP but is available to all organizations and interested professionals. It is not our intent to duplicate the efforts of others, therefore, our goal is to work cooperatively within partnerships to reduce redundancy and augment current information.

Along with non-native fish and invertebrates, we anticipate adding non-native plants to the collection in the future. The collection will include two types of specimens: historical documentation specimens (i.e., voucher specimens) and teaching or reference specimens. The historical documentation specimens will be kept to verify the occurrence of a species outside of its natural range and to provide evidence that can be scrutinized by the scientific community. Access to these specimens will be restricted. The teaching or reference specimens will be used to aid or confirm the identification of a species and can be manipulated for instructional purposes. For example, when area professionals need to verify the specimen identification from the field, they could access teaching specimens from the collection for comparison.

In conjunction with the specimen collection, we are developing a NIS relational database. The primary purpose of this database is for users to have web-based access to query information regarding specimens in the NIS reference collection. Information which will be available to the user will include phylogenic information, life stage, size, quantity, condition, preservation fluid, where the specimen is stored, where and when the specimen was collected including GPS coordinates, and who, or what agency, identified the specimen.

We are currently requesting specimen donations for several non-native species which are in poor condition or missing from the current collection. If you would be interested in donating to the collection, participating as a taxonomic expert, or if you have any questions regarding our program or the reference collection, please contact Anthony Marrone with the U.S. Fish and Wildlife Service.

Culturing Delta Copepods

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Successful copepod cultivation is vital for research that requires a reliable supply of healthy copepods of known ages and feeding history. Such research includes studies of ecological processes such as carbon and energy cycling and contaminants transfer. Cultured copepods can also be used as model animals to measure the effects of environmental stressors or as food in research that focuses on aquatic animals that require live prey.

Eurytemora affinis and *Pseudodiaptomus forbesi* are calanoid copepods that serve as important food organisms for pelagic fish species in the Delta, including delta smelt. Here we describe culturing procedures for these two copepod species that were developed for laboratory experi-

ments investigating food requirements of copepods in the freshwater regions of the Sacramento-San Joaquin River Delta and Suisun Marsh. Procedures described here are for relatively small-scale production of copepods, however, the basic physiological requirements will remain the same at larger scales of production. This project was supported by CalFed Project ERP-01-N50 and carried out at the University of California, Davis. Cigdem Alemdar provided valuable assistance.

To initiate cultures, copepods were captured using a 43µm-mesh plankton net pulled slowly behind a boat or vertically through the water column at several Delta sites. *P. forbesi* is generally abundant in the Delta in the summer and fall months, while *E. affinis* is more abundant through winter and spring. During this study, sites yielding high numbers of *P. forbesi* included Mildred Island and the San Joaquin River at Mossdale, while *E. affinis* was predominantly found at Hill Slough in Suisun marsh, the Sacramento River at Rio Vista, and the San Joaquin River at Mossdale. Salinity and water temperature were measured at each collection site. For transport to UC Davis, copepod samples were stored in containers filled with water from the collection site and kept at or below the ambient temperature of the collection site. Care was taken not to overcrowd the sample containers with copepods and other zooplankton to avoid density related mortality.

In the laboratory, adults and later stage copepodites of the target copepod species were separated from other zooplankton under a dissecting microscope using a narrow pipette and placed in 4L flasks with culture medium at a density of 25-50 animals per liter. This separation procedure was repeated weekly to remove accidentally transferred non-target species until there were no more non-target individuals. Inspection of cultures for contamination was continued on a monthly basis.

Cultures were maintained in a temperature controlled room at 20ºC (68ºF) under a constant light:dark cycle of 16:8 hours. Copepods were placed in 4L flasks loosely covered with aluminum foil. Flasks were cleaned with a 0.1N HCl acid solution and rinsed with deionized water. Of several culture media tested, "L-16 with vitamins" proved most successful. This is a synthetic culture medium modified with vitamin B12, biotin, thiamin, and soil extract. It has an ionic composition similar to that of many nutrient rich aquatic systems (Lindstrom 1983). This medium has also been successfully used for culturing *Daphnia magna*, a cladoceran occurring in the Delta, and their food organisms (Mueller-Solger et al 2002).

Both *E. affinis* and *P. forbesi* were found to survive and reproduce well on an exclusive diet of the flagellated cryptophyte species *Cryptomonas ovata* originally obtained from the Culture Collection of Algae at the University of Texas at Austin (http://www.bio.utexas.edu/research/utex) and cultured in L-16 with vitamins. Other tested algal food species such as the green alga *Scenedesmus acutus* and the diatom *Skeletonema sp.* were less successful, possibly indicating that these copepod species may prefer motile prey. The copepods were fed approximately 1µg carbon per animal per day. To maintain optimal copepod health, it was important not to overfeed the copepods, as excess algae resulted in substantial mats appearing in the bottom of the culture flasks which fostered bacterial growth. Copepod densities were determined as described below. The number of algal cells per mL of algal culture was ascertained using a Bright-Line Hemacytometer. To calculate the required algal culture volume, we used the relationship between algal densities and carbon concentration (Figure 1). This relationship was established by measuring organic carbon concentrations in algal cultures of known cell densities filtered onto precombusted 13mm glass fiber filters. Filters were dried at 60ºC, wrapped in tin capsules, and processed by the UC Davis stable isotope facility using a Europa Scientific Hydra 20/20 continuous flow Isotope Ratio Mass Spectrometer (IRMS).

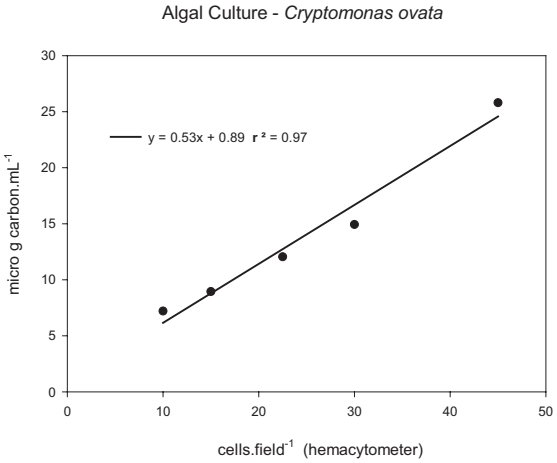

Figure 1 Laboratory cultured *Cryptomonas ovata* - carbon concentrations for cell counts obtained using a Bright-Line Hemacytometer. Culture initially obtained from UTEX algal culture facility, and grown in L-16 (with vitamins)

Culture densities of approximately 25-50 adult copepods per liter proved most successful for long-term culture maintenance. Culture densities were regularly checked by removing a small volume (250 mL) from the

well-mixed cultures and counting the number of adults. If too many adults were found, cultures were split, topped off with fresh L-16 medium, and fed.

Salinity in the culture media was initially adjusted to replicate the salinity measured at the collection site. After an initial culturing period of several weeks, the salinity of all copepod cultures was then slowly modified to a uniform level at a rate of 0.2 ppt every few weeks to standardize the copepod cultures for use in experiments. We found that adjusting the salinity by adding appropriate amounts of a 10 ppt solution of Instant Ocean synthetic sea salt dissolved in L-16 was effective. The salinity that produced the highest rates of survival and productivity was 1 ppt for both *P. forbesi* and *E. affinis*.

Copepods prefer as little handling as possible. However, in order to keep cultures healthy and free of excess debris, it is necessary to do a partial water change approximately every month. To accomplish this, we allowed the debris in the old culture flask to settle and then poured about half of the culture into a new flask. We then carefully poured the remaining volume in the old flask through a 48-µm mesh net until the debris began to flow. The contents of the net were rinsed into a Petri dish with L16 and copepods present in the Petri dish were transferred into the new culture flask. The debris at the bottom of the old culture flask was poured into a smaller beaker, allowed to settle, and remaining copepods were harvested and transferred into the new flask. The remaining debris was discarded. The total volume in the new flask was then adjusted to the appropriate salinity. Copepod mortality resulting from this process was minimal.

Copepods for experiments were obtained by gently pouring a culture through a 48-µm mesh net and immediately inverting the drained net into a Petri dish filled with culture medium avoiding exposure of the animals to air. Copepods were allowed to swim from the net into the culture medium. From this Petri dish, groups of copepods were transferred into a second, clean Petri dish with a wide-mouth pipette. Individual animals were chosen from this Petri dish using a narrow-mouth pipette and transferred into the experimental containers. Finally, the remaining animals were returned to the culture.

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