Hydrography and Zooplankton off the Central Oregon Coast during the 1997–1998 El Niño Event

William T. Peterson
NOAA/NMFS/Northwest Fisheries Science Center (NWFSC)
Hatfield Marine Science Center
2030 S. Marine Science Drive
Newport, OR 97365 U.S.A.
e-mail: bpeterso@sable.nwfsc-hc.noaa.gov

I had the good fortune to initiate monitoring of hydrography and zooplankton offshore of Newport, Oregon prior to the 1997–98 El Niño event. Stations 1, 3, 5, 10 and 15 miles off Newport (44º 40'N) were sampled biweekly beginning in May 1996. The zooplankton at these same stations were sampled repeatedly from 1969–1973 and in 1978 thus providing a baseline to which modern measurements could be compared. In this brief note, I compare present observations to data from the 1970s.

In 1997, upwelling began as usual in late March indicating the onset of the spring transition. A boom in zooplankton production followed in April. In May, northerly winds weakened, upwelling relaxed, Columbia River Plume Water moved onto the shelf, and zooplankton numbers began to decline. The intrusion of warm Columbia River Plume Water was indicated by a salinity minimum in June (Figure 1). A minor upwelling event occurred in mid-June and a third (and final) upwelling event lasting

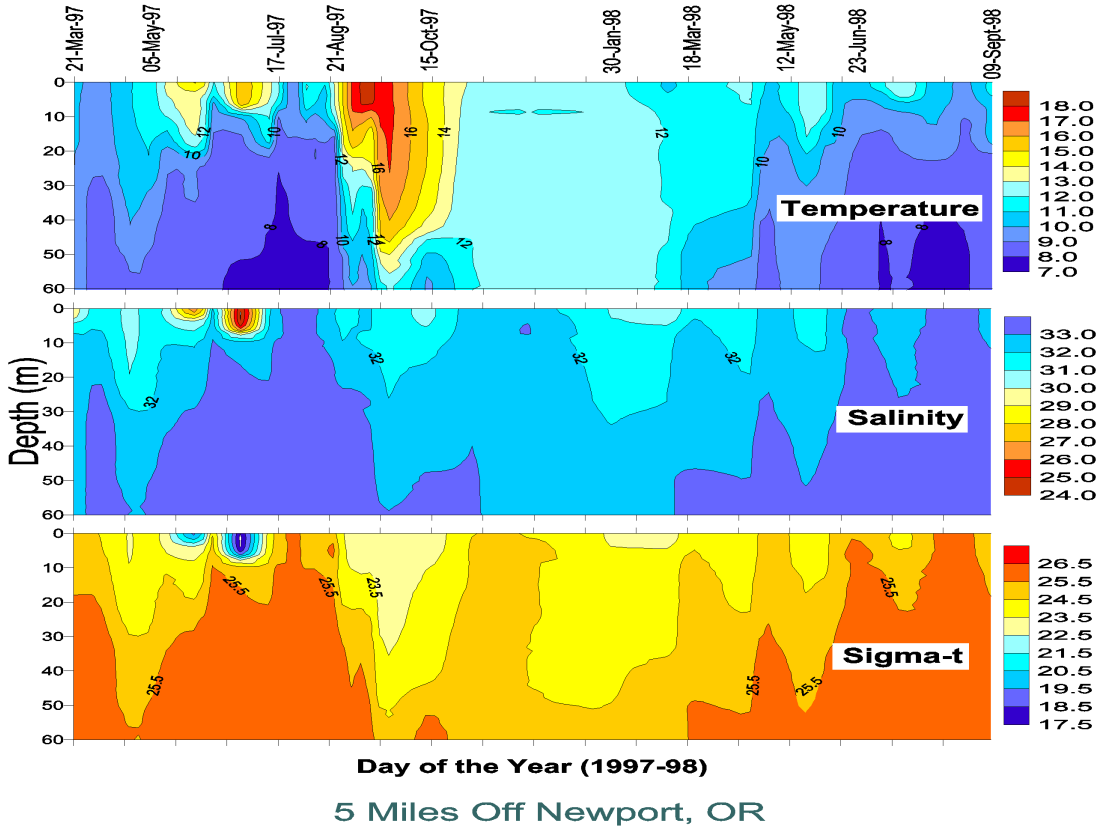

Figure 1. *Time series of temperature, salinity and sigma-t 5 miles off Newport, Oregon.*

five weeks occurred from 12 July through 19 August. The latter showed little biological response; subsequently, upwelling ceased altogether. Sea surface temperatures on the shelf warmed from 12º to 17ºC during the period of extended relaxation from May until mid-July. Surface waters cooled to 10ºC during the July/August upwelling event. From 20–26 August, a strong southwesterly storm moved north along the Oregon coast, resulting in a large downwelling event, with warm waters penetrating to near the sea floor at our baseline station at NH 5 (Figure 1). Surface waters warmed to a record temperature of 18.5ºC, warmer by 1 degree than any observation made during the 1983 El Niño event (Figure 2a, b, c), and warmer than 5ºC compared to climatological temperatures measured at this same station in the early 1970s. After the September peak, the sea surface cooled rapidly and wintertime temperatures were no warmer than 1–2ºC.

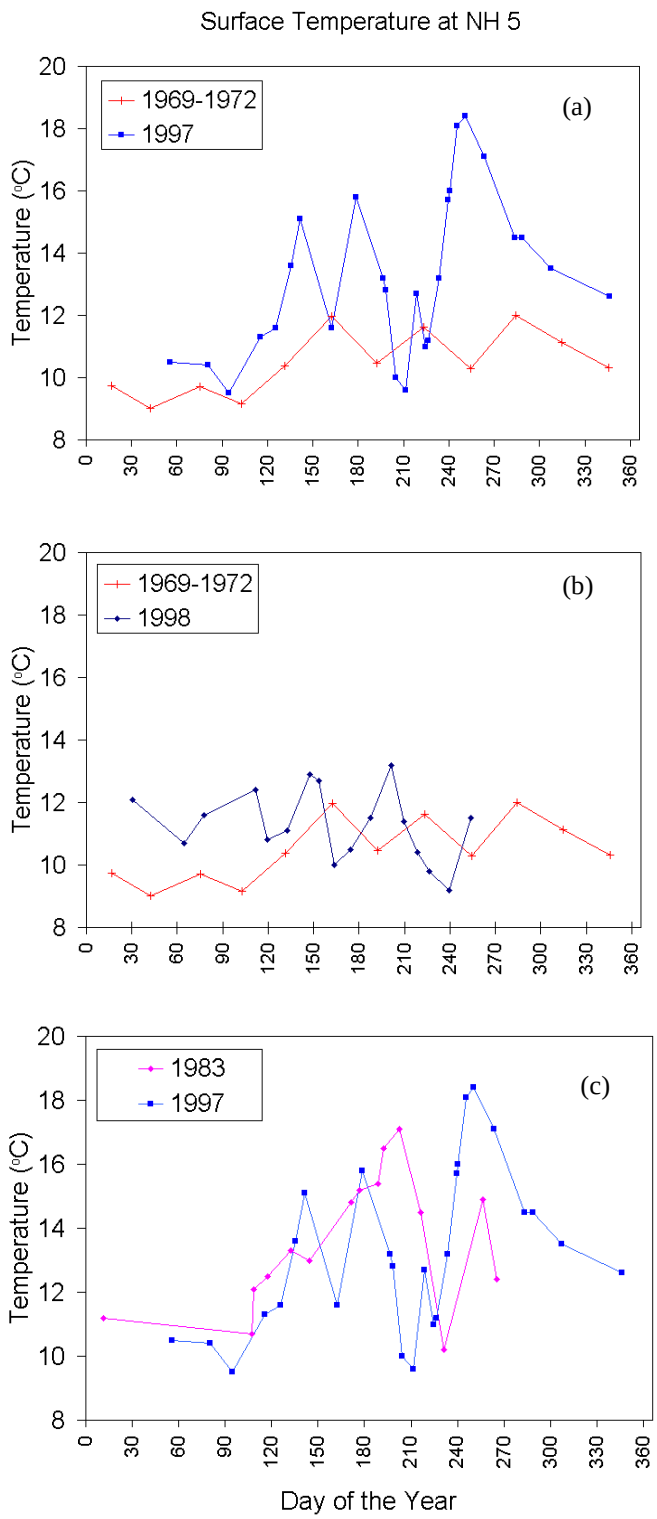

Figure 2. *Comparison of sea surface temperatures at station NH 5 for (a) 1969–1972 and 1997, (b) 1969–1972 and 1998, and (c) 1983 and 1997.*

Secchi depths were deep during both the early and late summer 1997 warm events, averaging 10 m during June/July and exceeding 15 m during the late-summer warming event. Usual secchi depths are on the order of 3–5 m during the summer upwelling season (Figure 3a, b). During the winter of 1997–98 secchi depths remained deep, then shoaled to 3–4 m in the summer of 1998.

The copepods captured in shelf waters during April/May and during the July/August upwelling events were boreal species. During relaxation of upwelling in May/June and August/September, species captured were those normally found in waters offshore of Oregon (Table 1). During the winter months of 1997/98, the zooplankton were typical of those expected with the Davidson Current — i.e., species with southern and offshore affinities. In spring 1998, these same southern and offshore species continued to dominant the zooplankton through at least mid-June, chiefly because southwesterly storms were frequent and upwelling had not become firmly established.

In contrast to the 1982–83 El Niño, very few unusual zooplankton, fish or bird species were seen in Oregon's coastal waters. Thus, the greatest effect of the 1997/98 El Niño on the zooplankton community was firstly, a reduction in biomass and production of local zooplankton species due to a shortened upwelling season in 1997, a delayed start of upwelling in 1998, and secondly, changes in community structure due to advection onshore of species which are normally found off Northern California and/or in waters well offshore of Oregon. The "usual" boreal coastal zooplankton species did not begin to increase in numbers until late July 1998; by September, the most common and abundant species, *Pseudocalanus mimus*, *Acartia clausii*, *A. longiremis*, and *Centropages abdominalis*, had population sizes only 10 to 20% of normal.

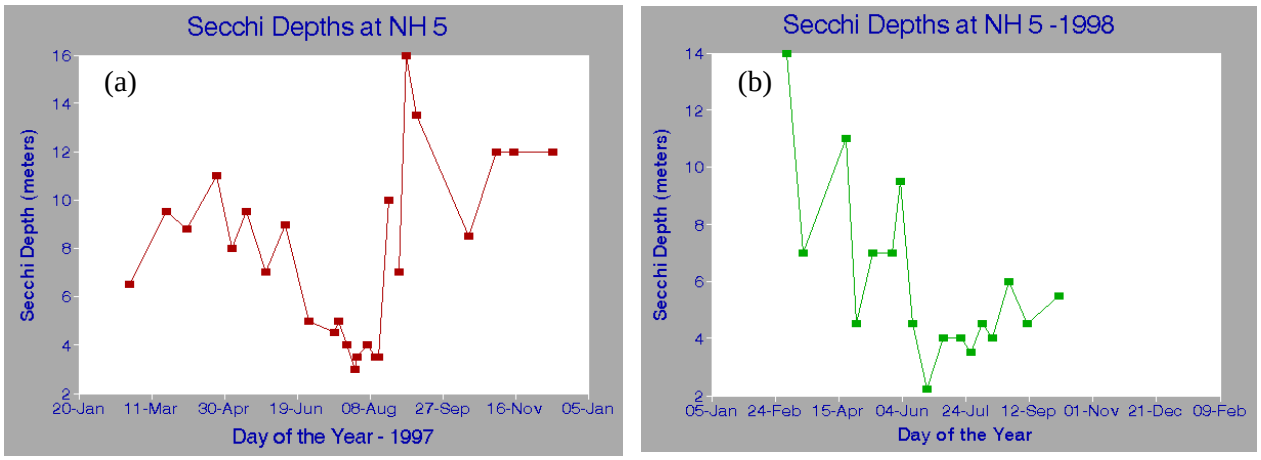

Figure 3. *Comparison of secchi depths at station NH 5 for (a) 1997 and (b) 1998.*

Table 1. *Density (number per cubic meter) of zooplankton species collected at a station five miles off Newport OR (water depth 60 m) during the summer of 1997 from June through September. The "warm event" began on 20 August and reached a maximum in mid-September, bringing with it warm water copepod species to the Oregon shelf.*

	Date (June through September)									
	6/27	7/15	7/23	7/30	8/6	8/14	8/21	8/28	9/2	9/9
Cool Water Species										
Calanus marshallae	17	49	125	31	46	553	559	61	5	0
Pseudocalanus mimus	461	1470	1719	678	207	796	987	173	184	22
Paracalanus parvus	159	219	1218	130	84	103	102	555	495	710
Centropages abdominalis	168	1138	72	157	103	73	17	17	0	0
Acartia longiremis	0	0	54	104	65	225	204	113	25	4
Oithona similis	537	601	1737	574	245	474	493	113	709	372
Warm Water Species										
Calanus pacificus	0	4	0	0	0	0	0	17	36	32
Calanus tenuicornis	0	0	0	10	4	0	0	9	5	2
Eucalanus californicus	0	0	0	0	4	0	0	52	15	0
Ctenocalanus vanus	0	0	0	0	0	0	17	9	15	10
Acartia danae	0	0	0	0	0	0	0	0	15	6
Corycaeus anglicus	0	0	0	0	0	0	0	26	76	64
Dolioletta gegenbaurii	0	0	0	0	0	0	0	130	71	22

A possible long-term trend may be evident: as compared to the summers of the 1970s when sampling was carried out at the same stations as those which I am currently sampling (Peterson and Miller, 1975), during the summers of 1996–1998, numbers of the copepod *Paracalanus parvus* are at least 100-fold higher; numbers of *Calanus marshallae* are lower by a factor of 2–3 (Figures 4 and 5). A similar result has been found for the two *Acartia* species listed above as well as for *Centropages* (not shown). *Pseudocalanus mimus* numbers (Figure 6) showed little change when 1996 and 1997 were compared to the early 1970s; however, as noted above, the population off Oregon collapsed in August 1997 and has not yet become re-established.

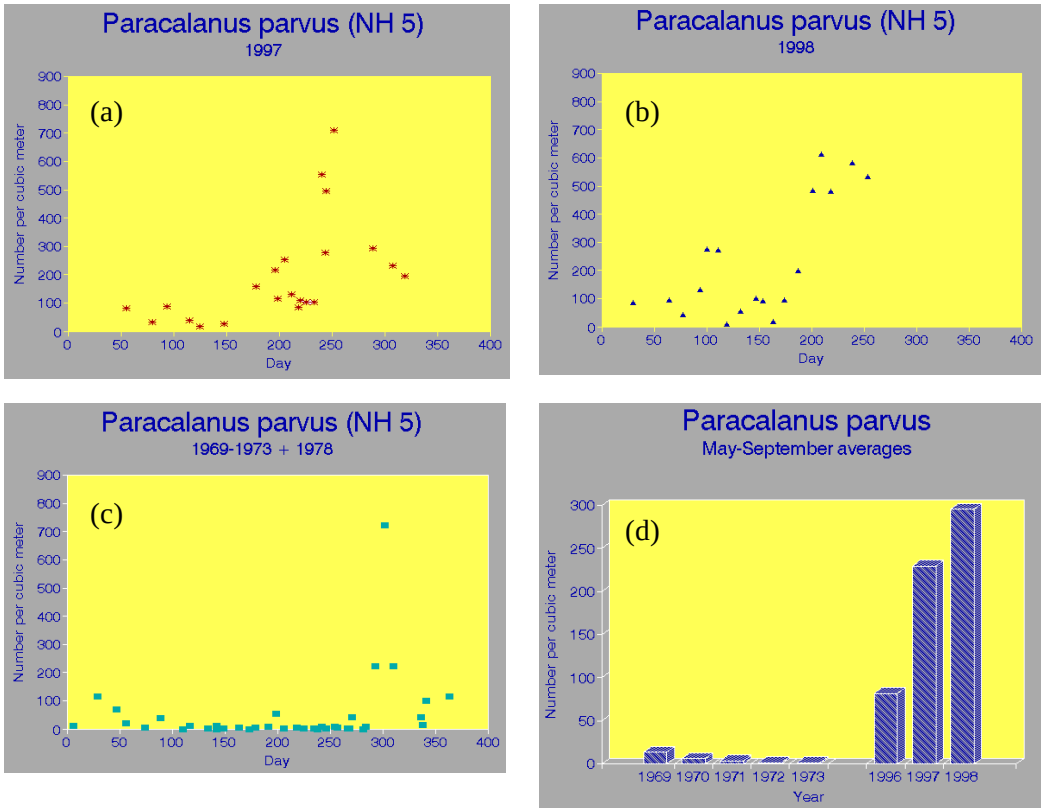

Figure 4. *Comparison of* *<u>Parcalanus parvus</u>* *populations for (a) 1997, (b) 1998, (c) 1969–1973 and 1978, and (d) histogram comparing data from 1969–1973 with 1996, 1997, and 1998.*

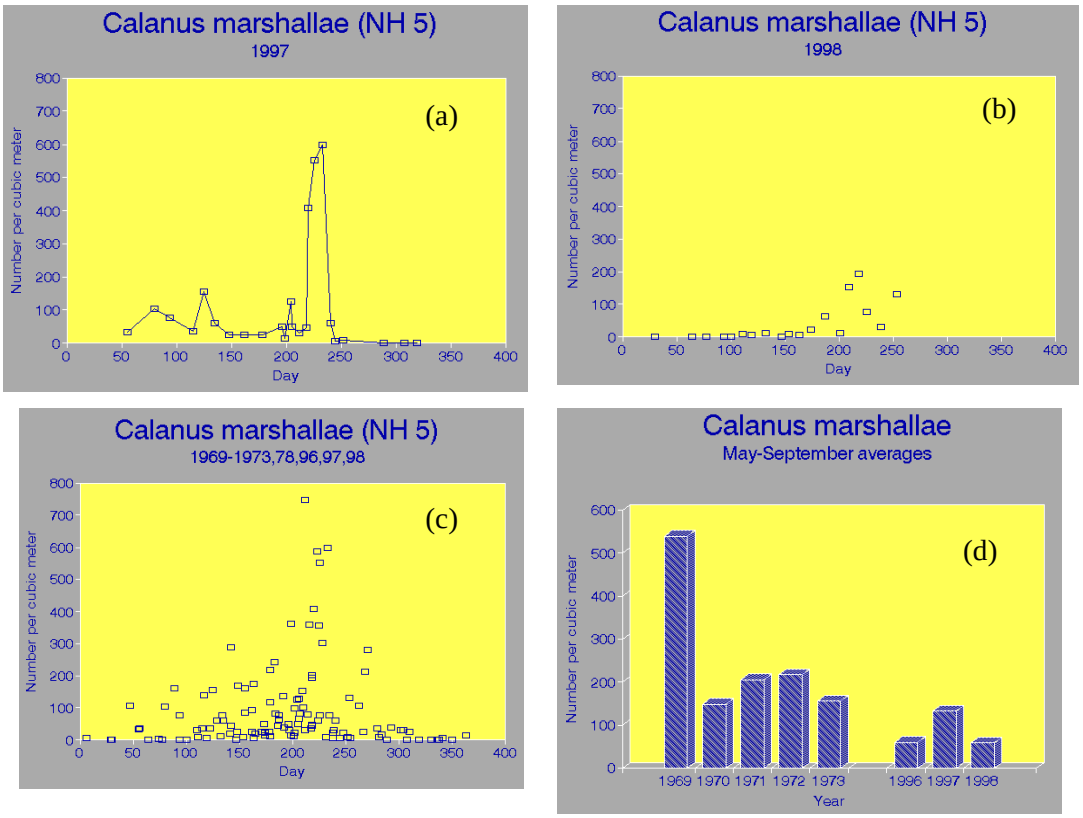

Figure 5. *Comparison of* *<u>Calanus marshallae</u>* *populations for (a) 1997, (b) 1998, (c) 1969–1973, 1978, and 1996–1973, and (d) histogram comparing data from 1969–1973 with 1996, 1997, and 1998.*

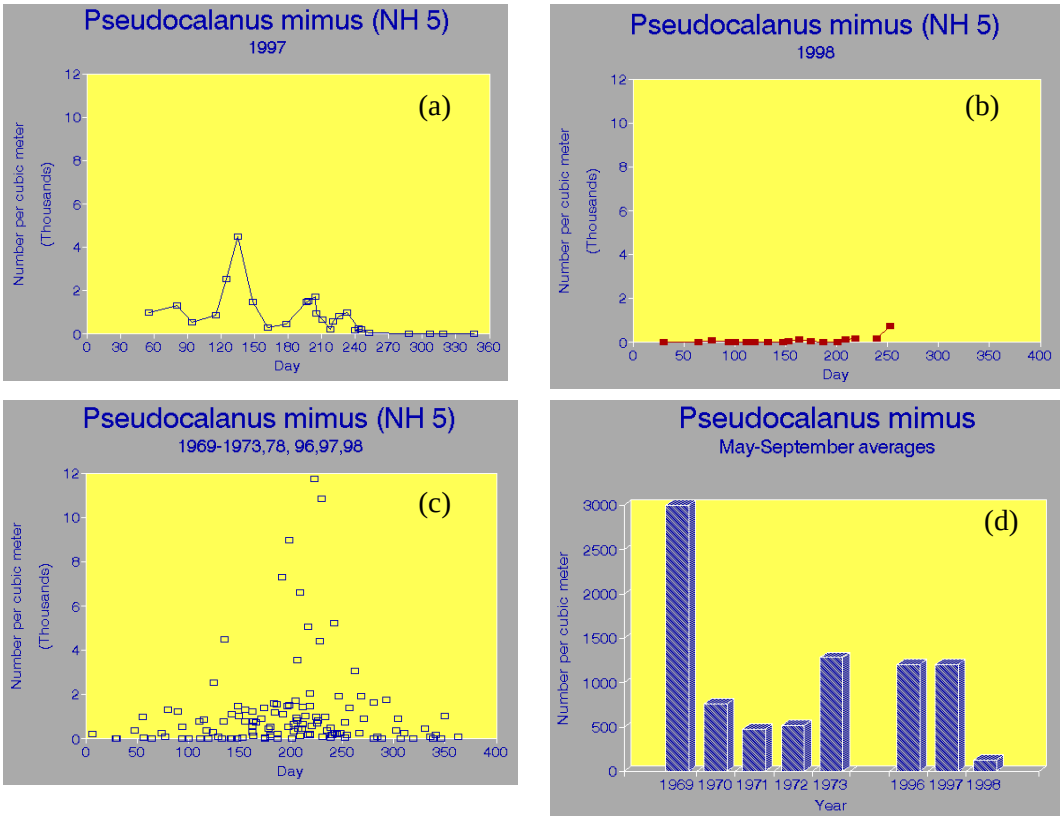

Figure 6. *Comparison of* *Pseudocalanus mimus* *populations for (a) 1997, (b) 1998, (c) 1969–1973, 1978, and 1996–1998, and (d) histogram comparing data from 1969–1973 with 1996, 1997, and 1998.*

The degree to which the warm water event of late-summer 1997 is linked to the equatorial El Niño event remains an open question — there is evidence, presented in the PICES/El Niño session by Jim Overland, that the warming was due to anomalous atmospheric patterns off the west coast of the U.S. that may have been teleconnected to the equatorial weather patterns associated with the movement of the "warm pool" from the western Pacific to near the dateline.

The effects of the "warm event" of the summer of 1997 on chlorophyll and copepod egg production rates are discussed in Gomez-Gutiérrez and W. T. Peterson (in press).

A listing of the key events observed during the "warm event" is shown below:

Key Events observed during the 1997–1998 "warm event"

1997	
Last week of March	Spring transition initiated
April	El Niño begins at equator
15 May	Warming trend begins in N. Pacific
early June	Brief upwelling event off Oregon (ca. 5 days duration)
mid-June	Warming trend resumes
14 July	Upwelling begins off Oregon
19 August	Upwelling ends off Oregon
21 August	Offshore and southern copepod species appear on shelf; remain dominant through winter and spring/summer 1998
18 September	Maximum temperature observed, 18.4ºC
22 September	Autumn cooling begins
October–March	Winter cooling to 12ºC (approx. 1–2ºC warmer than normal)

1998	
mid-March	Spring transition begins
late April	End of el Niño; first big coastal upwelling event
12 May	Some boreal coastal copepod species begin to re-appear on shelf
12 June	First large phytoplankton bloom
28 July	Boreal coastal copepod species first begin to increase in numbers
16 September	First southwesterly storm

References

Gomez-Gutiérrez, J. and Peterson, W. 1999. Egg production rates of eight copepod species during the summer of 1997 off Newport, Oregon, USA. *J. Plankton Res.* In press

Peterson, W.T. and Miller, C.B. 1975. Year-to-year variations in the planktology of the Oregon upwelling zone. *Fish. Bull. U.S. 73*, 642–653.