Effects of the 1997-1998 ENSO event in the eastern tropical Pacific coastal ecosystem

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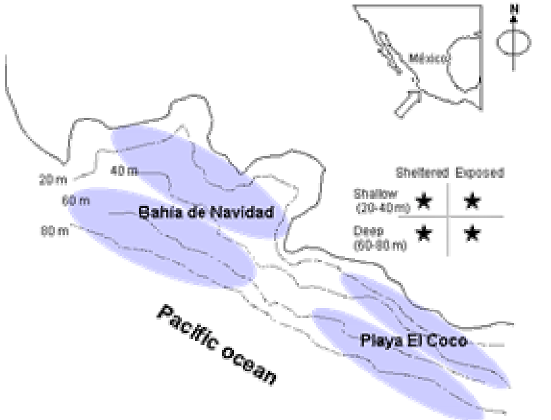
Introduction

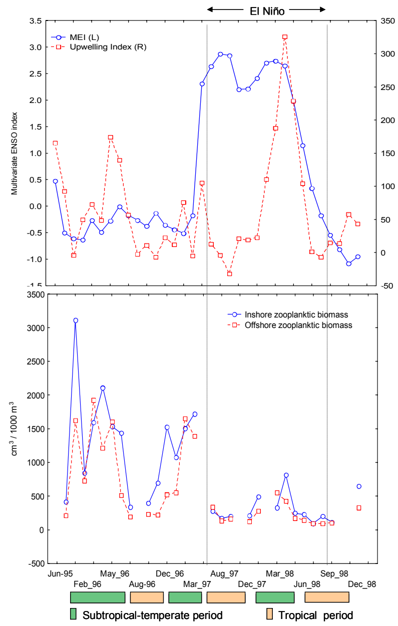
The ENSO phenomenon is an irregular fluctuation that involves the entire tropical Pacific Ocean and global atmosphere (Philander 1999). ENSO itself consist of an unstable interaction between sea surface temperature (SST) and atmospheric pressure. It results in variations in winds, rainfall, thermocline depth, circulation, and ultimately in biological productivity, and in the feeding and reproduction of fish, birds and mammals (Fiedler 2002). The 1997-1998 El Niño was by some measures; the strongest of the 20th century (McPhaden, 1999; Kerr, 1998) and their consequences still are being surveyed.

The knowledge about the El Niño and La Niña events has increased recently and the related environmental variability in the Pacific Ocean begins to be well understood in global and regional scales, while the knowledge about ecological impacts in the coastal marine ecosystems remain partial and spatially fragmented



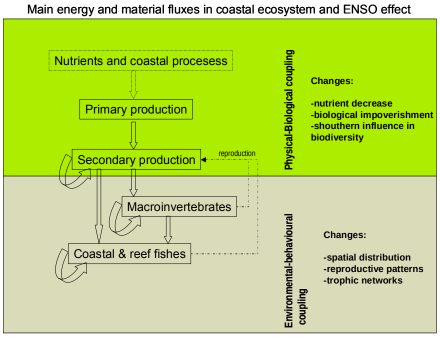
GLM results (x = parameter included in the most parsimonious model)

Multivariate parameters CA 1st Axis	Season	MEI	Upwelling index	d.f.	AIC	L.Ratio	p
Inshore larval fish assemblages	x			2	135,6	8,3	0,016
Offshore larval fish assemblages	x	x	x	4	67,0	52,6	<0.001
Shallow-sheltered invertebrate assemblages	x			2	78,2	3,3	0,196
Deep-sheltered invertebrate assemblages		x	x	2	48,9	17,1	<0.001
Shallow-exposed invertebrate assemblages	x	x		3	36,3	15,4	0,001
Deep-exposed invertebrate assemblages	x	x		3	51,5	20,3	<0.001
Coastal and reef fish assemblages	x	x	x	4	125,9	7,3	0,123
percentage	85,7	71,4	42,9				
CA 2nd Axis	**MEI**	**Upwelling index**	**Season**	**d.f.**	**AIC**	**L.Ratio**	**p**
Inshore larval fish assemblages	x	x		2	134,8	15,1	0,001
Offshore larval fish assemblages	x			1	129,1	2,0	0,156
Shallow-sheltered invertebrate assemblages	x	x		2	82,8	13,9	0,001
Deep-sheltered invertebrate assemblages	x			1	57,8	1,7	0,199
Shallow-exposed invertebrate assemblages		x		1	57,6	0,4	0,550
Deep-exposed invertebrate assemblages	x			1	63,0	3,9	0,049
Coastal and reef fish assemblages	x			1	119,1	4,7	0,031
percentage	85,7	42,9	0				
Univariate parameters	**Season**	**MEI**	**Upwelling index**	**d.f.**	**AIC**	**L.Ratio**	**p**
Inshore zooplankton biomass	x	x	x	4	419,7	23,7	<0.001
Offshore zooplankton biomass	x	x		3	400,5	26,1	<0.001
Inshore larval fish abundance	x	x		3	466,8	17,1	0,001
Offshore larval fish abundance	x	x		3	443,8	12,8	0,005
Shallow-sheltered invertebrate abundance			x	1	442,6	1,8	0,177
Deep-sheltered invertebrate abundance	x			2	464,7	3,0	0,223
Shallow-exposed invertebrate abundance		x		1	286,8	5,7	0,017
Deep-exposed invertebrate abundance	x	x		3	310,9	8,6	0,035
Coastal and rocky fish	x		x	3	176,8	7,3	0,064
percentage	77,8	66,7	33,3				



The decline of the zooplankton biomass during the El Niño event evidence the physical-biological coupling, which affect with no lag to larval fish abundance. The seasonal signal in biomass and larval abundance remain during the El Niño event.

Main energy and material fluxes in coastal ecosystem and ENSO effect



Source of ecosystem data

Variables	Sampling design				Methods	Biodiversity
	Inshore		Offshore			
Zooplankton biomass	X		X		Oblique tows in a 12 station net 500 microns mesh size bongo net	
Ictioplankton assemblages	X		X			137 taxa
Macroinvertebrate	Shallow (20-40 m)		Deep (60-80 m)		Tows on soft bottoms with shrimp trawl gear. 1 ha sampled per tow	
	sheltered	exposed	sheltered	exposed		
Biomass	X	X	X	X		
Assemblages	X	X	X	X		230 species
Coastal and reef fishes	Sand, and hard bottoms (rocky and reef)				Gillneting with several mesh size nets (7.62, 8.89, 10.16 and 11.43 cm mesh size)	
Biomass	X					
Assemblages	X					188 species

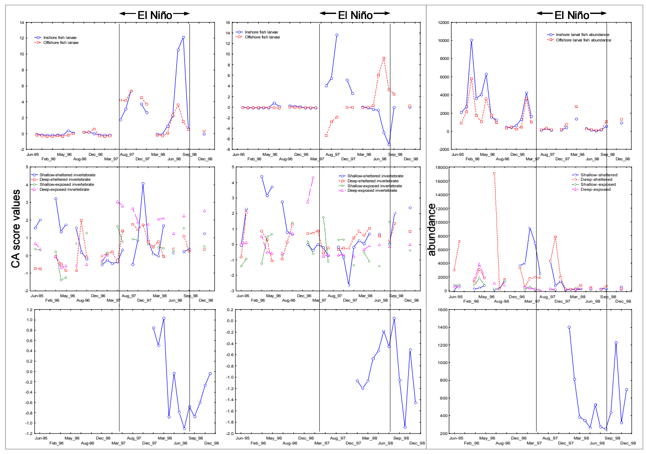
Analysis

Dimensionality of species matrices was reduced using the scores values of the first two axis of a correspondence analysis CA. A generalized linear model was employed to determine the most influent environmental variables during the previous El Niño 1997-1998 and during El Niño event. The environmental variables considered were: normal seasonality, upwelling index UI (21° N) and the multivariate ENSO index MEI. The model was constructed using the best subset procedure approached based in the Akaike information criterion AIC.

Results and discussion

The GLM analysis in both uni- and multivariate (first axis of CAs) ecosystem parameters shows that the main source of temporal variability is related to normal seasonality, which is maintained in our data as a attenuated signal during El Niño event. The second CA axes are related clearly to the ENSO event. Besides CA axes 2 could explain the assemblage variability associated to El Niño, no significant cross-correlations were found between fish and invertebrates at any lag indicating that there were no cascading effects. The species recomposition caused by the ENSO can be related with the specific response of the different ecosystem components to environmental changes. In fishes, changes in their movements patterns associated to food searching, are the most frequently observed. Reports abouth the response of the soft-bottom invertebrates are scarce, however the observed shift to more coastal and sheltered areas could indicate a response similar to fishes.

The physical-biological coupling has been reported as the main initial effect of El Niño, represented by a reduction of nutrient availability, and a subsequent decline of secondary production.The strongest and the most rapid effects appeared at lower trophic levels, although responses could be observed at several levels. A clear cascade effect with no lag can be observed with the start of the El Niño event and the drastic decrease of the zooplanktic biomass and larval fish abundance.



The variability of the species composition (CA Axis 1 and 2) of larval fish assemblages evidence the effects of the El Niño event, while that of the invertebrate and fish could reflect the consequences of changes in spatial distribution that affect their catchability.

The main changes in the invertebrate and fish abundance support the environmental-behavioural coupling. In the exposed site (both shallow and deep areas) abundance decreace strongly during El Niño, while in the sheltered, shallow area the abundance increase previous to the start of El Niño, and decrease sharply in the first phase of El Niño. In the deep, sheltered area invertebrate abundance decrease aproximately at the half of the El Niño period.

References

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