Universidad Autónoma de Baja California
Facultad de Ciencias Marinas

Relaciones de las pesquerías de camarón con las variaciones a largo termino en el Golfo de California y Áreas Adyacentes

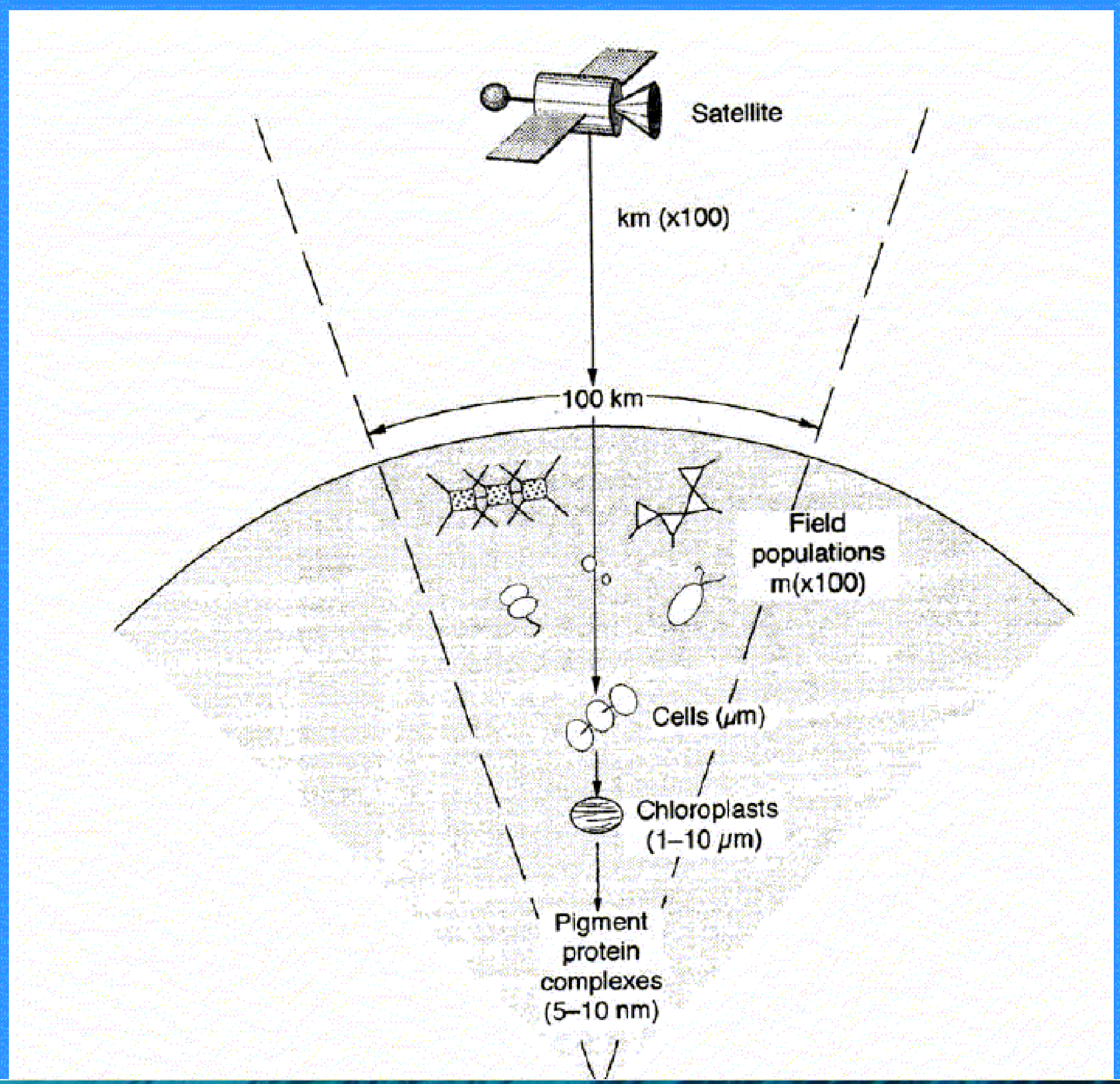
Eduardo Santamaría-del-Angel

*P*hyt*OP*lankton *E*colog*Y* t*E*am
POPEYE

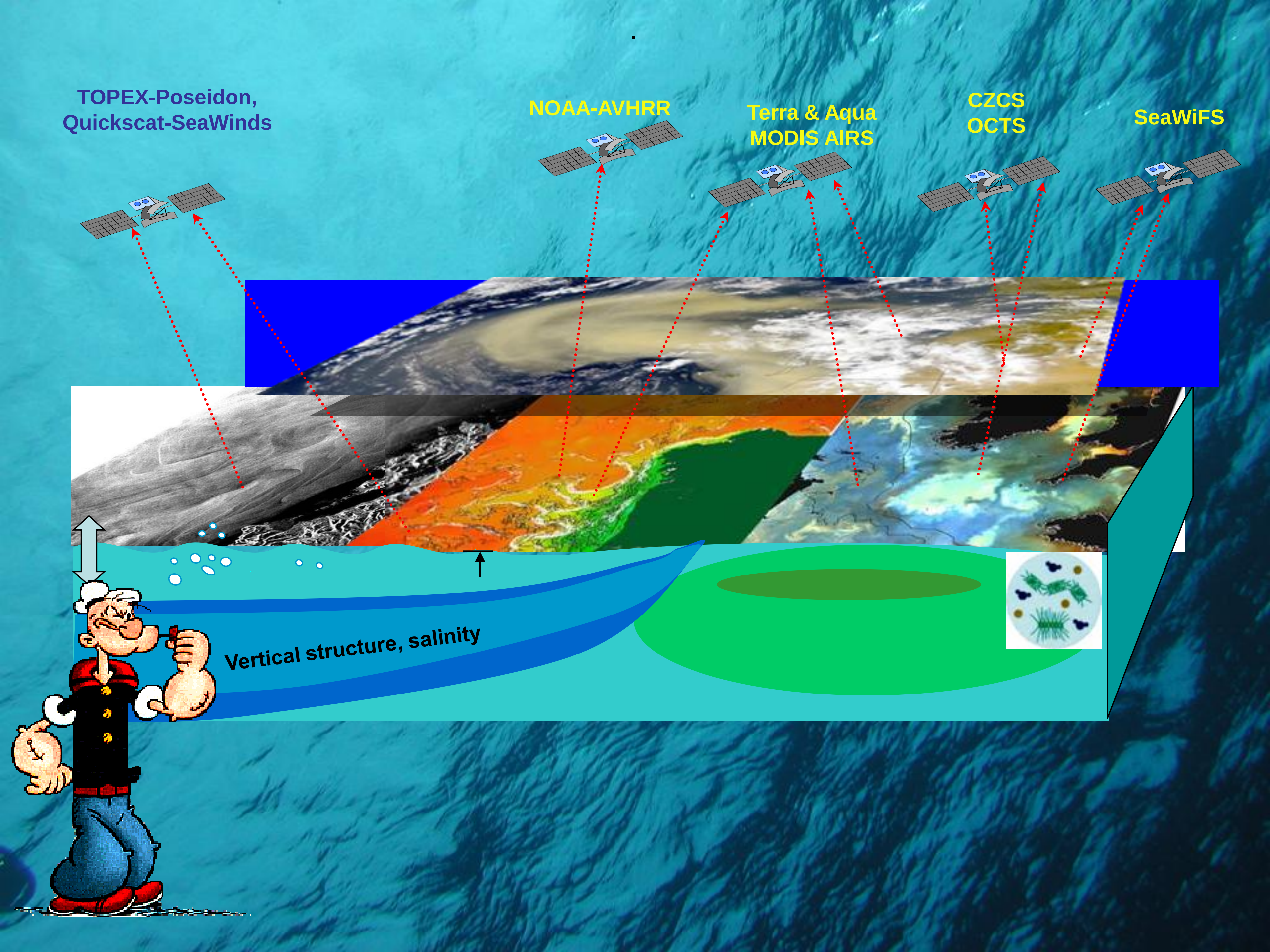
México


Ecología del Fitoplancton
Modelación de la Productividad Orgánica primaria
Flujos de Carbono
Cambio Climatico
Óptica Hidrológica
Oceanografía por sensores Remotos

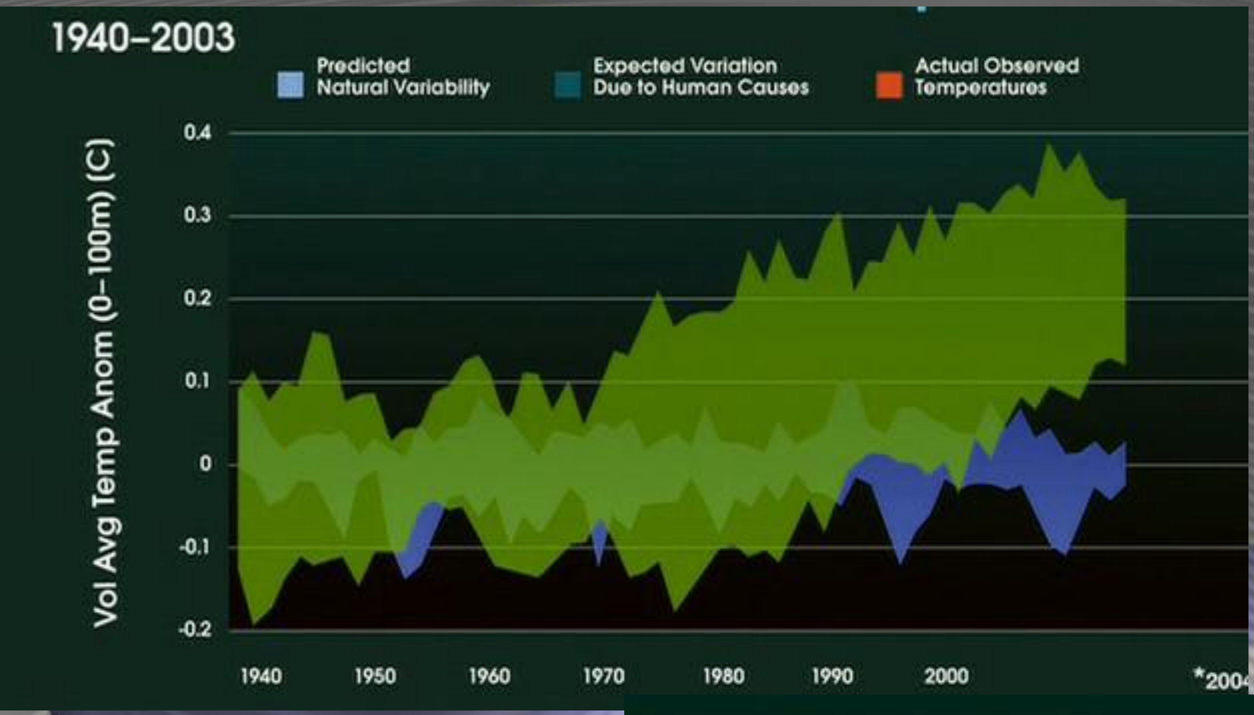
ESCALAS MOLECULAR - GLOBAL



Jeffrey & Mantoura, 1997



TOPEX-Poseidon,
Quickscat-SeaWinds
NOAA-AVHRR
Terra & Aqua
MODIS AIRS
CZCS
OCTS
SeaWiFS
Vertical structure, salinity



1940–2003
Predicted Natural Variability
Expected Variation Due to Human Causes
Actual Observed Temperatures
Vol Avg Temp Anom (0–100m) (C)
0.4
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1950
1960
1970
1980
1990
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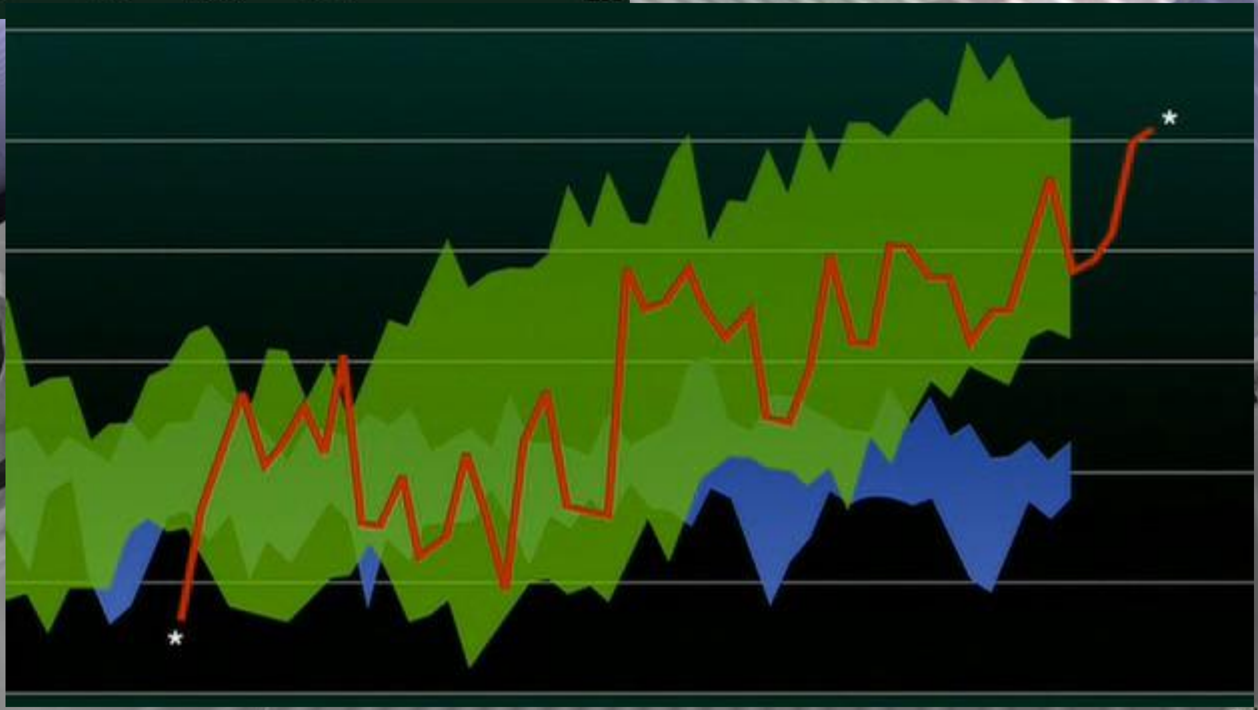
*2004



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ashu

existe o no el cambio climático global?

Serie de tiempo irrefutable sobre el cambio climático global


chloroGIN
Chlorophyll Global Integrated Network
AER IGNIS AQVA TERRA
IOCCG
International Ocean Colour Coordinating Group

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Korea Ocean Research and Development Institute

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National Oceanic and Atmospheric Administration (USA)

The IOCCG is an Affiliated Programme of SCOR (Scientific Committee on

The International Ocean-Colour Coordinating Group (IOCCG) is an international Committee of experts comprising representatives from various space agencies as well as the user community. It was established in 1996. The main objectives of the IOCCG are to develop consensus and synthesis at the world scale in the subject area of satellite ocean colour.

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Societal Issu

Climate Change

The number one proble
is truly global in scope. (
(CO_2), leading to ocean

Overpopulation

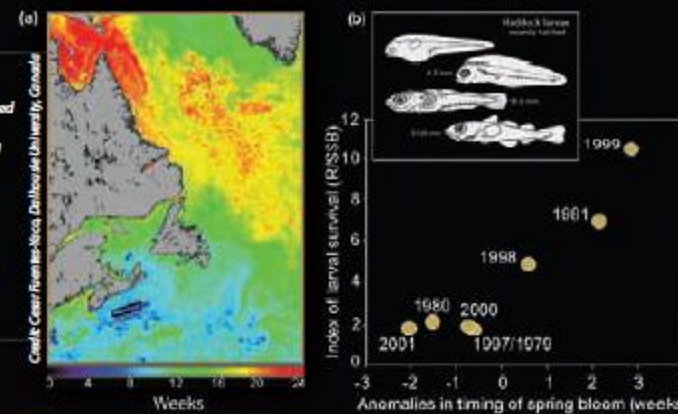
There is also a growing p
world, and the rate of po
coastal fringes of the co
impact along the coastal
river run-off). Coastal p
the sea, but there is a
fisheries and other living

Credit: Grant Pitcher, MCM, South Africa

for the world tourism industry and also for the
developing economy of aquaculture. Coastal zone

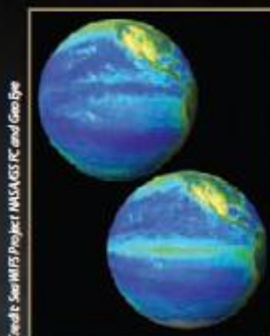
More Societal Benefits of Ocean Colour

Interannual variability in marine ecosystems can be monitored using ocean-colour data, helping to explain, for example, the effect of environmental fluctuations on the survival of larval fish.



(a) Timing of the maximum phytoplankton biomass in the NW Atlantic from February to July, derived from SeaWiFS climatology (1998-2001). Blue indicates an early spring bloom (March), red indicates a late spring bloom (July).

(b) Relationship between larval haddock survival index and local anomalies in bloom timing for the periods 1979-1981 and 1997-2001 (adapted from Platt et al., 2003, Nature, 423: 398-399).



Major perturbations at the regional level, for example El Niño, can be visualised using ocean colour, and the effect on the marine ecosystem quantified.

SeaWiFS images of the Pacific Ocean during the peak of the 1997-1998 El Niño (top), during which phytoplankton activity in the Equatorial Upwelling Zone was significantly reduced, and (bottom) during the subsequent La Niña when phytoplankton activity in the Equatorial Upwelling Zone was elevated.

Climate Change

Phytoplankton take up CO_2 during photosynthesis making them potentially important carbon sinks. The annual uptake of CO_2 on a global scale (~50 gigatonnes) can be quantified using ocean-colour data, which also provides
essential information for initialising and validating

Reports and Monographs of the International Ocean-Colour Coordinating Group

An Affiliated Program of the Scientific Committee on Oceanic Research (SCOR)
An Associate Member of the Committee on Earth Observation Satellites (CEOS)

IOCCG Report Number 8, 2009

Remote Sensing in Fisheries and Aquaculture

Edited by:
Marie-Hélène Forget, Venetia Stuart and Trevor Platt

A contribution of the SAFARI initiative (Societal Applications in Fisheries & Aquaculture using Remotely-Sensed Imagery), funded by the Canadian Space Agency (CSA) and directed by Trevor Platt. This report is based on contributions from (in alphabetical order):

Cedric Bacher, Gary Borstad, Alida Bundy, Emmanuel Chassot, Changsheng Chen, Christopher Clark, Nicholas Dulvy, Rashmin Dwivedi, Paul Fanning, Joao Ferreira, John Field, Alain Fonteneau, Marie-Hélène Forget, Kevin Friedland, César Fuentes-Yaco, Jon Grant, Steve Groom, Guoqi Han, Nick Hardman-Mountford, Johanna Heymans, Nicolas Hoepffner, Evan Howell, Chuanmin Hu, Kimberly Hyde, Hidetada Kiyofuji, Donald Kobayashi, Peter Koeller, David Kulka, Beena Kumari, Masahiro Kuno, Alan Longhurst, Vivian Lutz, Satsuki Matsumura, Bruce Monger, Jesus Morales, Shailesh Nayak, Jay O'Reilly, Daniel Pauly, Daniel Pendleton, Andrew Pershing, Trevor Platt, Jeffrey Polovina, Mini Raman, Nicholas Record, Anne Richards, Cristina Rodriguez-Benito, Sei-Ichi Saitoh, Shubha Sathyendranath, Kenneth Sherman, Himmatsinh Solanki, Venetia Stuart, Fumihiro Takahashi, Maureen Taylor, Cara Wilson and Linda Woodard.

Series Editor: Venetia Stuart

WELCOME

SAFARI aims to accelerate the assimilation of satellite Earth observation data into fisheries research and management on a global scale. This initiative, funded by the Canadian Space Agency, falls under the Group of Earth Observation (GEO) Task AG-06-02, which calls for consultation at the international level to identify opportunities for enhanced utilization of Earth Observation data in fisheries and aquaculture.

The SAFARI Initiative (Societal Applications in Fisheries and Aquaculture using Remotely-sensed Imagery) held an International Symposium on Remote Sensing and Fisheries from 15-17 February 2010 at the Abad Plaza in Kochi,

Relationship between climate change and Shrimp Fisheries in the Gulf of California (México) and adjacent areas

Response of two shrimp (*Farfantepenaeus californiensis* and *Litopenaeus stylirostris*) to long-term variability in the Upper Gulf of California (Mexico) and adjacent areas

Response of shrimp fisheries to climate change and long-term climate variability in the upper Gulf of California and along the West Coast of Southern Baja California, México.

Santamaría-del-Ángel Eduardo[1*]; Millán-Núñez Roberto[1]; González-Silvera Adriana[1]; Callejas-Jiménez Mariana[1]; Cajal-Medrano Ramón[1]; Galindo-Bect Manuel Salvador[2].

Aceptado en el Numero especial de Journal Marine Science
Para SAFARI 2010 en abril del 2011

Mexico has coastlines of 8 475 km along the Pacific and 3 294 km along the Atlantic Oceans. Shrimp fishing in Mexico takes place in the Pacific, Gulf of Mexico and Caribbean, both by artisanal and industrial fleets. A large number of small fishing vessels use many types of gear to catch shrimp. The larger offshore shrimp vessels, numbering about 2 212, trawl using either two nets (Pacific side) or four nets (Atlantic). In 2003, shrimp production in Mexico of 123 905 tonnes came from three sources: 21.26 percent from artisanal fisheries, 28.41 percent from industrial fisheries and 50.33 percent from aquaculture activities.

Shrimp is the most important fishery commodity produced in Mexico in terms of value, exports and employment. Catches of Mexican Pacific shrimp appear to have reached their maximum. There is general recognition that overcapacity is a problem in the various shrimp fleets.

On the Pacific coast, the shrimp fishing season is from September to February, with some variations for some coastal lagoons and estuaries

Although trawling for shrimp started in the late 1920s, shrimp has been captured in inshore areas since pre-Columbian times. Magallón-Barajas (1987) describes the lagoon shrimp fishery, developed in the pre-Hispanic era by natives of the southeastern Gulf of California, which used barriers built with mangrove sticks across the channels and mouths of estuaries and lagoons.

The National Fisheries Institute (INP, 2000) and Magallón-Barajas (1987) reviewed the history of shrimp fishing on the Pacific coast of Mexico. It began in 1921 at Guaymas with two United States boats. During the 1930s, 17 Californian sardine boats were modified to trawl and were incorporated into the fleet. Japanese trawlers explored the Mexican Pacific coast and located the main trawling areas in the same decade. In 1941, a fleet of 21 shrimp vessels landed 1 900 tonnes of shrimp from the area around Guaymas. During the 1940s and 1950s, the fishery expanded to the entire Gulf of California and to the Gulf of Tehuantepec.

During the late 1950s, double-rig trawls were introduced. By 1960, fishing operations extended to the southwest coast of Baja California. During the late 1960s and early 1970s, fishers gradually reduced mesh size.

Aproximación 1
Por tipos de pesca

Para inferir como afecta el cambio climático a la pesquería de camarón en el Golfo de California y áreas adyacentes.

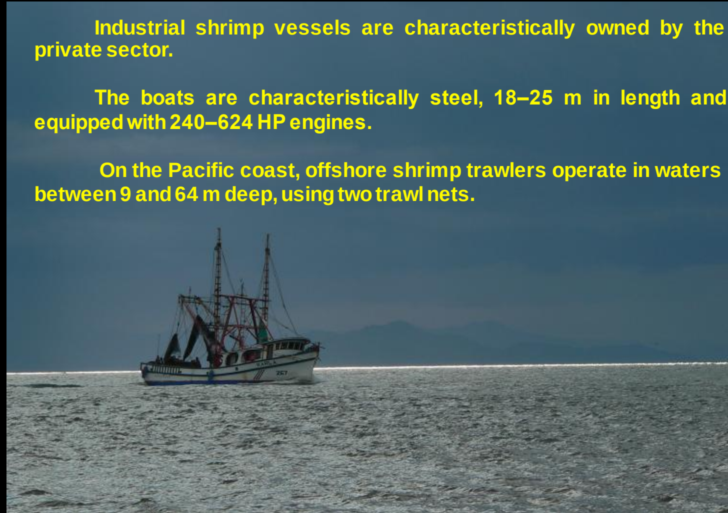
Se generaron la base de datos de las capturas totales, artesanales e industriales desde para San Felipe, Bahía Magdalena

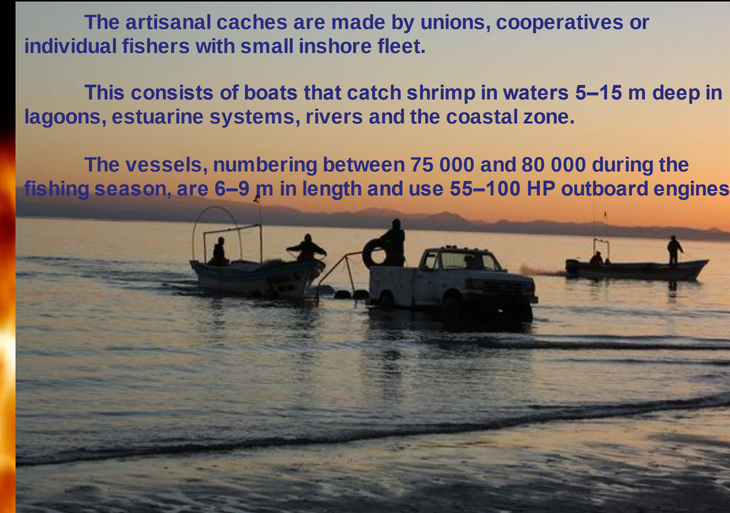
Los datos fueron obtenidos de los reportes de la Secretaria de pesca (1986, 1987, 1988, 1989) y de SAGARPA (2002, 2003, 2004a, 2004b, 2004c, 2004d, 2005, 2006a, 2006b, 2007, 2008 and 2009).

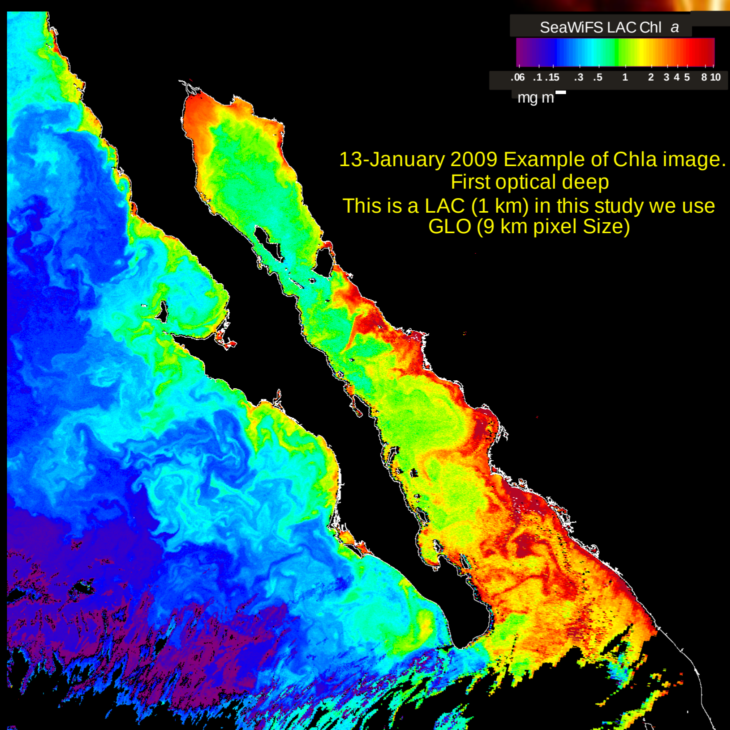
Productos espectroradiometricos fueron usados como indicadores de cambio climático:

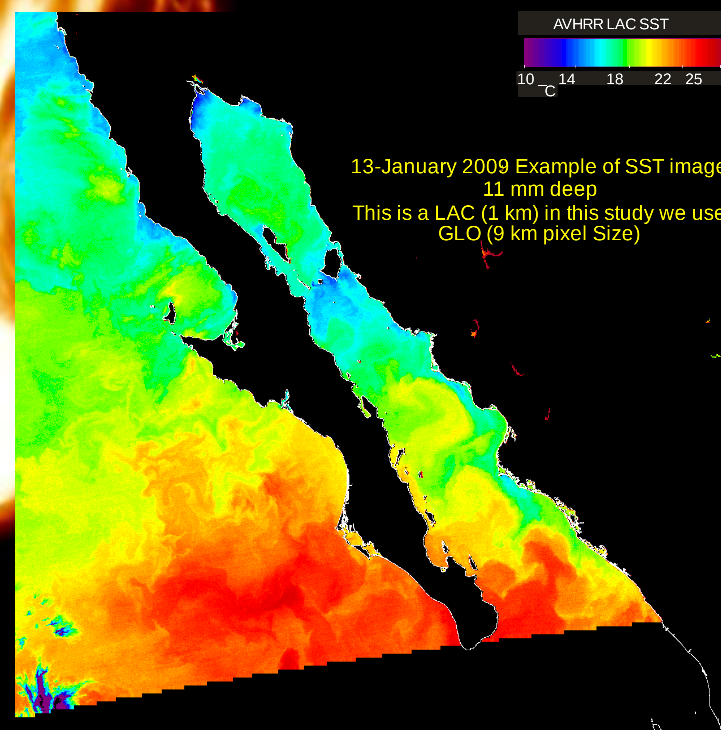
- SST derivada del AVHRR algoritmo Pathfinder versión 5
- Concentración de Clorofila a (Chl a)
- Carbón orgánico particulado (POC)
- Carbón orgánico disuelto (CDOM),
- Reflectancias satelitales a 412 nm (Rrs412) y 490 nm (Rrs490)

Todas derivadas de las observaciones del SeaWiFS usando los algoritmos estándares de cada producto.


Industrial shrimp vessels are characteristically owned by the private sector.
The boats are characteristically steel, 18–25 m in length and equipped with 240–624 HP engines.
On the Pacific coast, offshore shrimp trawlers operate in waters between 9 and 64 m deep, using two trawl nets.


The artisanal caches are made by unions, cooperatives or individual fishers with small inshore fleet.
This consists of boats that catch shrimp in waters 5–15 m deep in lagoons, estuarine systems, rivers and the coastal zone.
The vessels, numbering between 75 000 and 80 000 during the fishing season, are 6–9 m in length and use 55–100 HP outboard engines.


SeaWiFS LAC Chl a
.06 .1 .15 .3 .5 1 2 3 4 5 8 10
mg m
13-January 2009 Example of Chla image.
First optical deep
This is a LAC (1 km) in this study we use
GLO (9 km pixel Size)


AVHRR LAC SST
10 14 18 22 25
C
13-January 2009 Example of SST image.
11 mm deep
This is a LAC (1 km) in this study we use
GLO (9 km pixel Size)

Por región se calcularon promedios geométricos de las capturas y los indicadores climáticos

Para determinar la relación entre todas las variables se aplico un análisis de componente principal (PCA)de las variables estandarizadas para cada localidad. Estas relaciones fueron expresadas gráficamente con un análisis de factor, sin rotación basado en el PCA.

Para complementar se realizo análisis de Cluster usando la correlación de Pearson como medida de asociación y un método de ligamiento promedio.

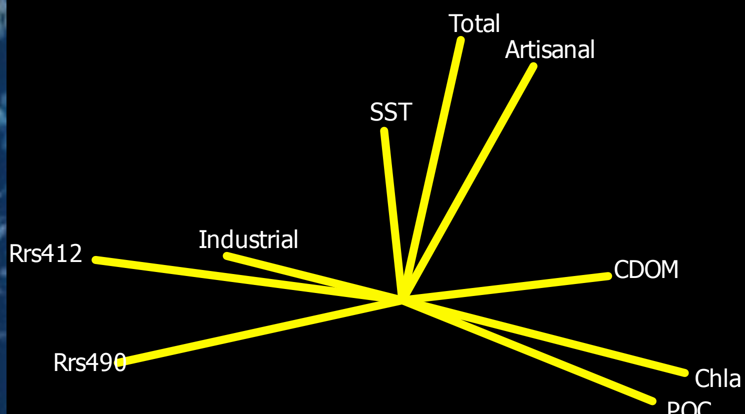
Análisis de tendencia basada en la pendiente (b1) de una simple regresión lineal usando capturas y SST como variables dependientes y los años como variables independientes de para 1994 a 2007 para San Felipe y desde 1994 a 2008 para Bahía Magdalena.

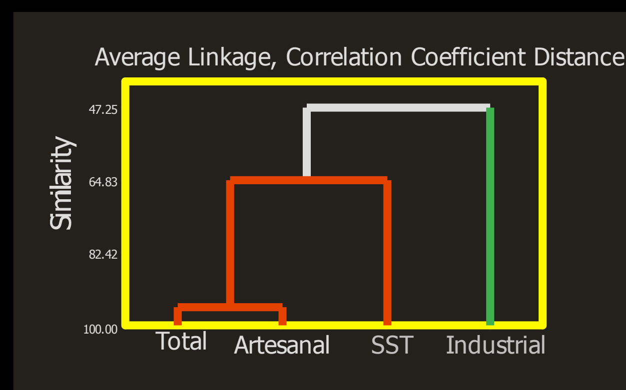
San Felipe

Eigenvalue	4.41	2.54	1.38
Proportion	0.44	0.25	0.13
Cumulative	0.44	0.69	0.83

	Comp.1	Comp.2	Comp.3
Total	0.28	0.77	0.11
Industrial	-0.49	0.41	-0.71
Artisanal	0.47	0.57	0.41
SST	0.04	0.59	0.21
CDOM	0.71	0.10	-0.65
Chla	0.84	-0.45	0.01
POC	0.69	-0.60	0.29
Rrs412	-0.95	0.31	0.06
Rrs490	-0.95	-0.09	0.10

A direct relationship was found between SST Total and Artisanal catches, (Comp. 2). The Industrial catches not show any relation with any variable (Comp.3)

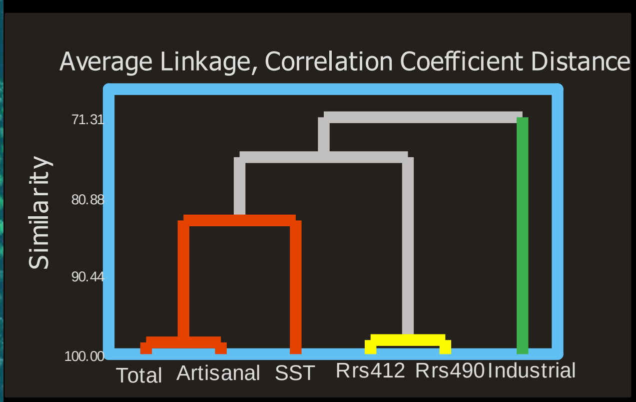


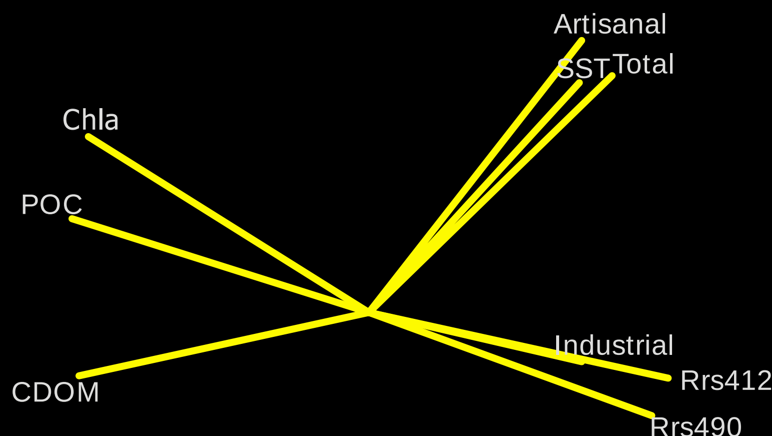


Bahía Magdalena

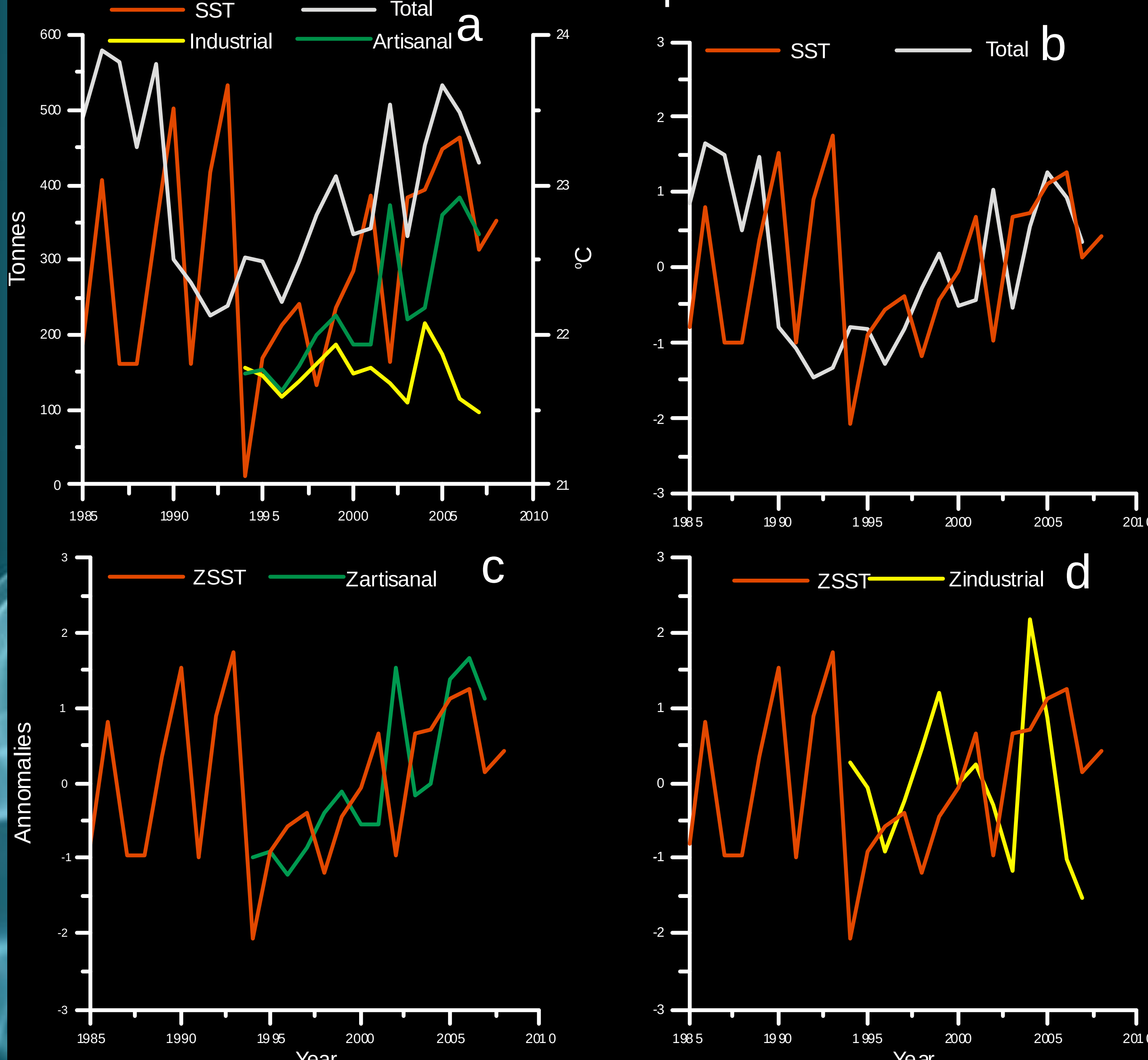
	Comp.1	Comp.2
Eigenvalue	6.84	1.57
Proportion	0.68	0.15
Cumulative	0.68	0.84
Total	-0.78	-0.60
Industrial	-0.67	0.09
Artisanal	-0.68	-0.69
SST	-0.67	-0.57
CDOM	0.92	0.18
Chla	0.89	-0.38
POC	0.94	-0.19
Rrs412	-0.95	0.11
Rrs490	-0.90	0.20

All Catches have a direct relationships with the SST and Rrs, and inversely with the CDOM, Chla and poc. (Comp. 1).



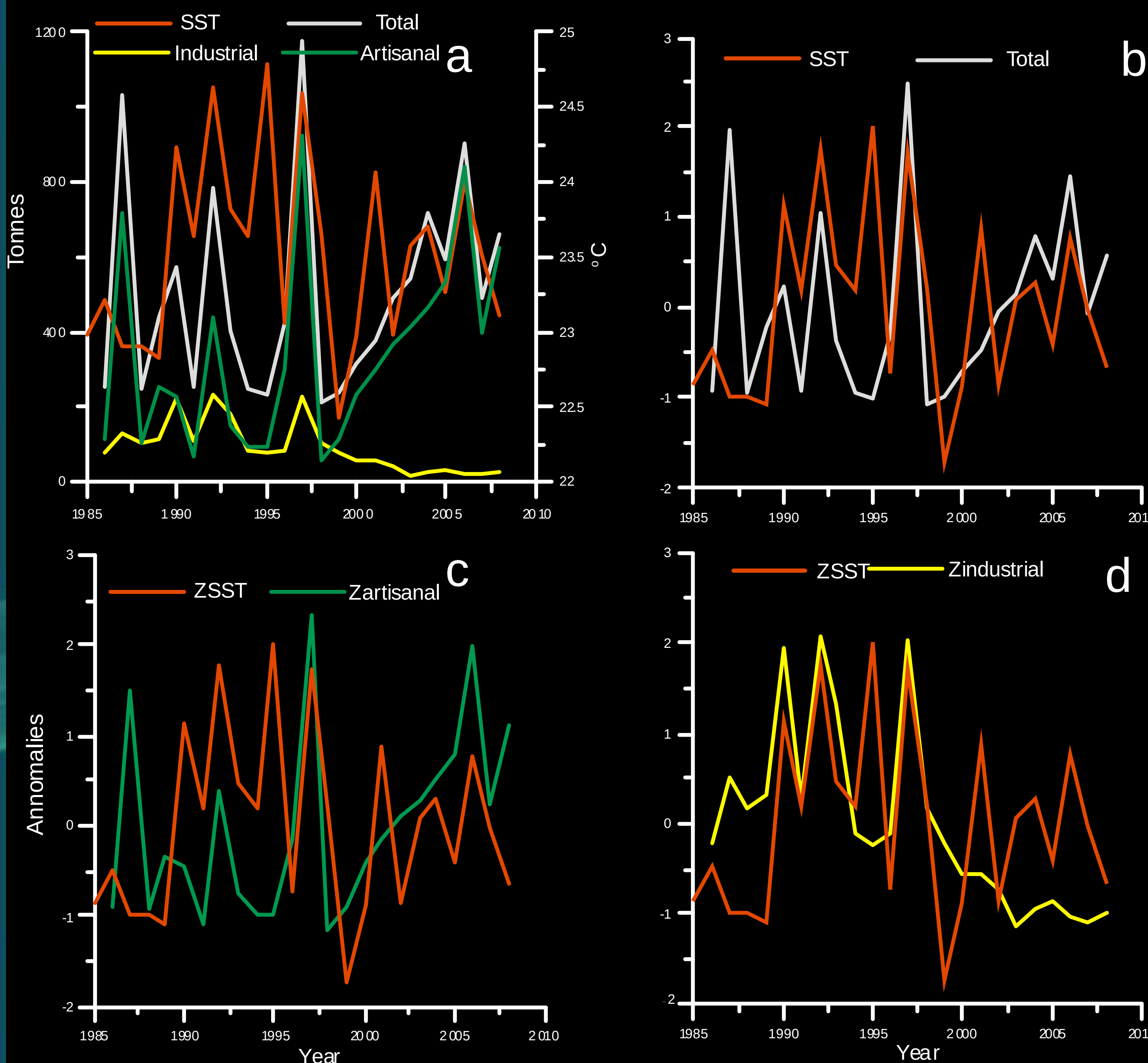


San Felipe



a
SST
Total
Industrial
Artisanal
Tonnes
°C
b
SST
Total
c
ZSST
Zartisanal
Annomalies
Year
d
ZSST
Zindustrial
Year

Bahia Magdalena



Trend Analysis (TA) based on the slope (b1) of a simple linear regression model, using the catch and SST as dependent variables and years as an independent variable for 1994 to 2007 SF and 1994 to 2008 for SBCWC. The red values show no significant slopes, being smaller than the t_{crit}.

	San Felipe Baja California		Bahia Magdalena	
g.l.	12		13	
t_{crit}	2.17881		2.16037	
Year	1994-2007		1994-2008	
Alfa 5%	b1	t_{cal}	b1	t_{cal}
Total	17	4.32	24.1	1.55
Industrial	-.094	-.043	-7.84	-3.13
Artisanal	17.9	5.27	30.8	2.21
SST	0.12	4.65	-0.03	-0.90

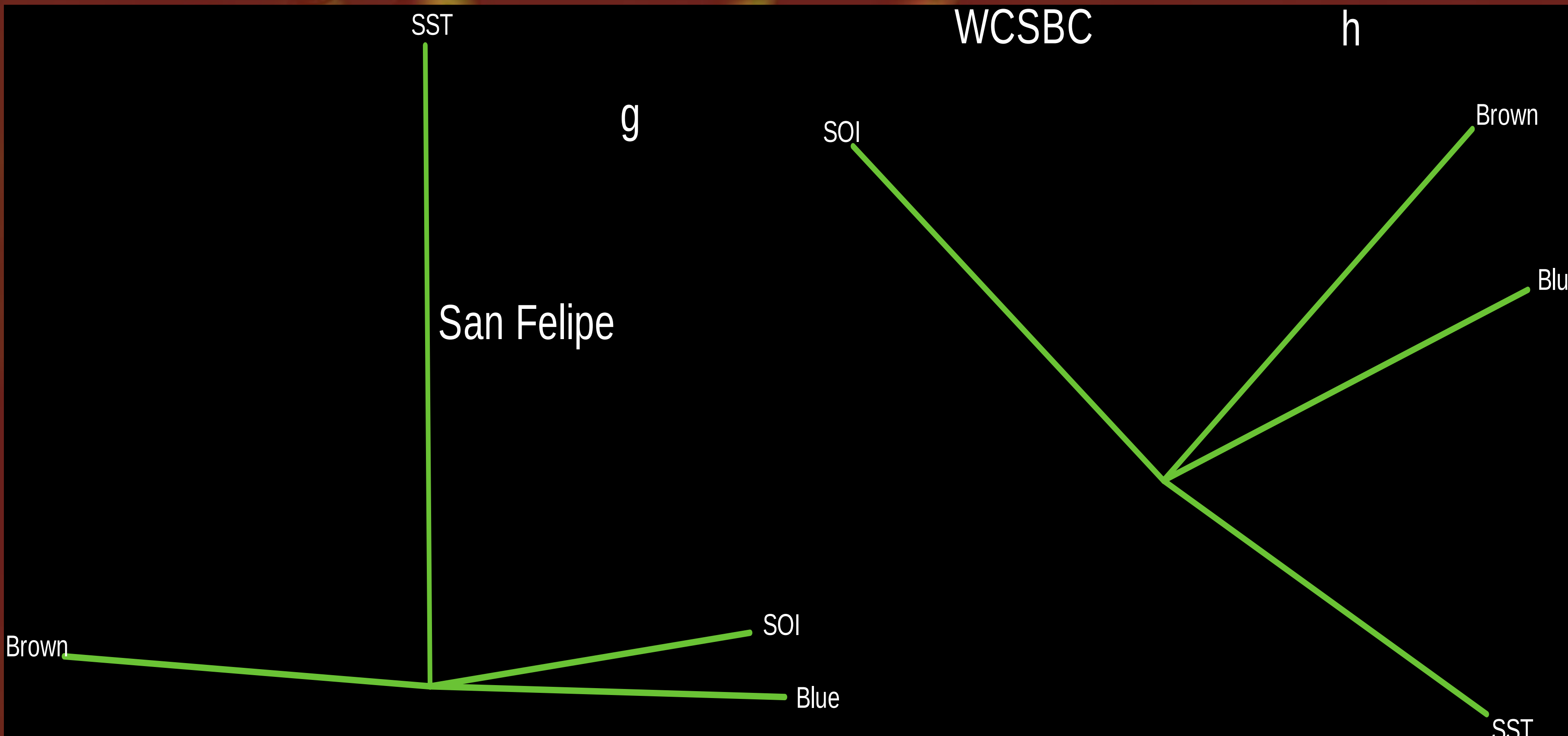
En general la relación entre las capturas de camarón y las variables ambientales (Chl a, POC, CDOM, Rrs412, Rrs490) no fueron significativas

La explicación de esto es posiblemente a que el periodo de estudio (13 años) no fuera lo suficientemente largo para calcular anomalías más representativas

Two shrimp species are catches in this area:

a) blue shrimp *Litopenaeus stylirostris*

b) brown shrimp *Farfantepenaeus californiensis*


SST
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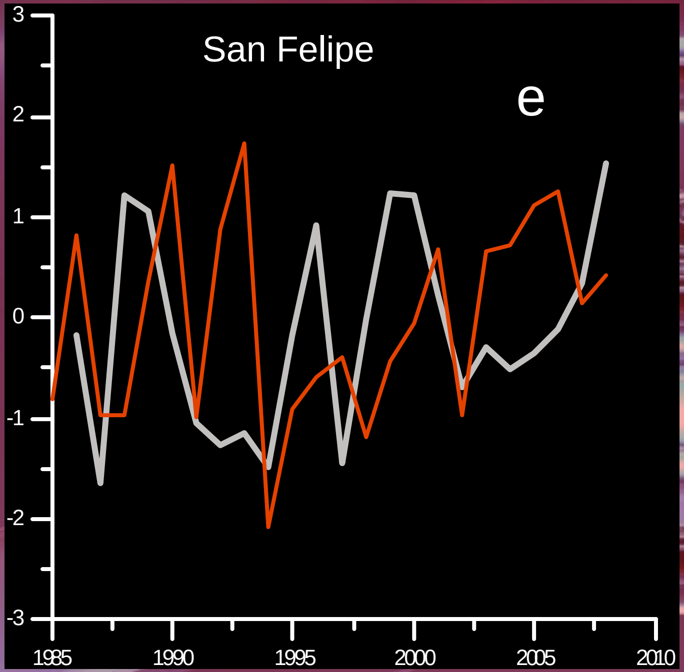
San Felipe
SOI
Brown
Blue
SST


San Felipe
e
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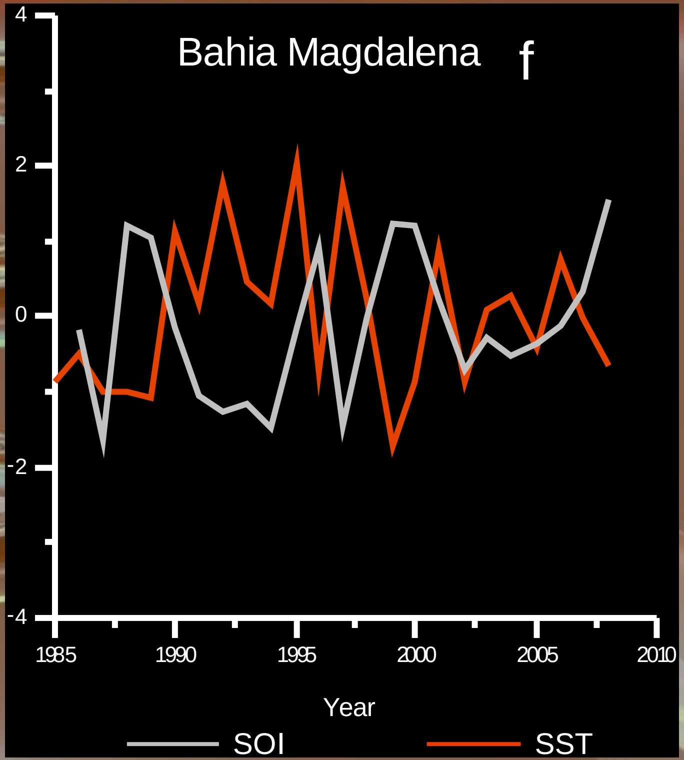
Bahia Magdalena
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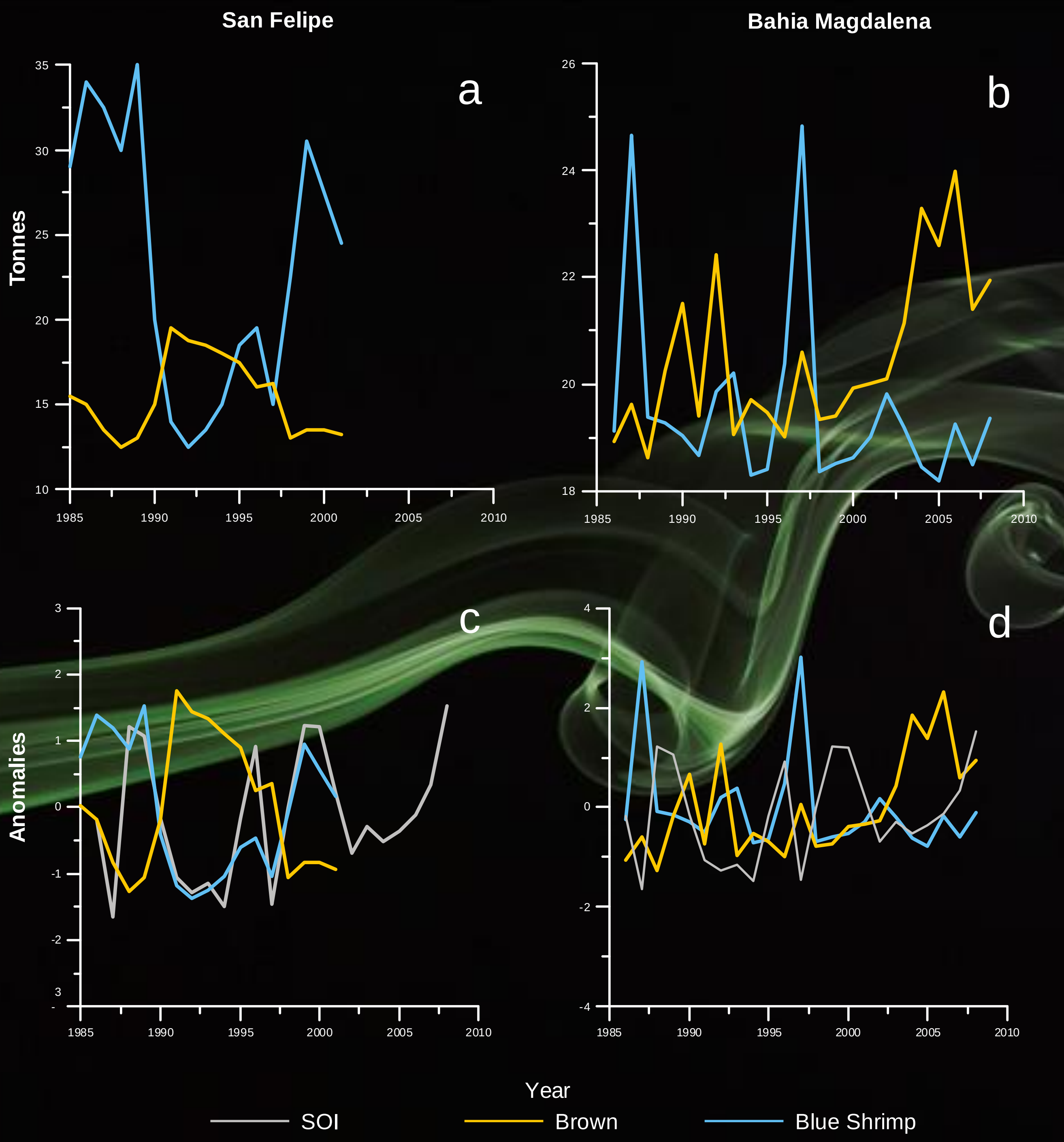

San Felipe
Bahia Magdalena
a
b
c
d
Tonnes
Anomalies
35
30
25
20
15
10
26
24
22
20
18
3
2
1
0
-1
-2
4
-2
-4
1985
1990
1995
2000
2005
2010
Year
SOI
Brown
Blue Shrimp

Resultados relevantes

- La SST fue el indicador ambiental que mejor se asoció a las capturas.

- La captura total en ambas áreas esta principalmente sustentada por la captura artesanal

- La captura del azul en SF presenta una variación similar a la del SOI, mientras que el café muestra una relación inversa.

- En ambas áreas, el incremento en las capturas de camarón café puede ser una señal de la llegada de El-Niño.

- Entretanto, sería necesaria una serie de tiempo más larga para poder calcular de manera más representativa las anomalías locales y confirmar estos patrones.

Consideraciones importantes

Aun y cuando ambas especies se pescan en las dos áreas los reportes del estado del stock pesquero menciona que el azul está deteriorado en ambas áreas, mientras que el café está considerado como deteriorado en SBCWC y en SF se reporta como al límite de la pesca sustentable (SAGARPA, 2002, 2003, 2004b).

Sin embargo, Galindo-Bect (2003) menciona que este deterioro se puede deber a factores antropogenicos como la infección de las poblaciones de camarones silvestres por virus liberados por las granjas de camarón. En 1990 se registró por primera vez la presencia del virus IHHNV (Infectious Hypodermal and Hematopoietic Necrosis Virus) en poblaciones silvestres del Alto Golfo de California (Lighter *et al*., 1992), sin embargo, el impacto producido por este virus en la cadena alimenticia del océano es desconocido.

Las capturas por especie muestran a lo largo del tiempo, una alternancia de especies, cuando hay máximas capturas en el camarón azul, las del camarón café están bajas, y viceversa.

Debido a que la alternancia entre especies se da aproximadamente en periodos de 5 años, se asoció el SOI anual con las capturas por especie. La captura estandarizada del azul presenta una variación similar a la del SOI anual, mientras que el café muestra una relación inversa.

Estas relaciones sugieren que en condiciones No-El-Niño el Alto Golfo de California presenta las condiciones adecuadas para el camarón azul. Con el cambio de las condiciones ambientales debido a El-Niño, la abundancia del camarón azul disminuye y la del café aumenta.

Esta alternancia de especies podría ser explicada por medio de las relaciones que existen entre las abundancias de cada especie y las variaciones ambientales a mediano y largo plazo.

Los efectos de El-Niño en el Alto Golfo de California pueden asociarse a aumento en las descargas del Rio Colorado o precipitación pluvial, lo cual aumenta las áreas inundadas incrementando las zonas de crianza.

Aun y cuando el Delta del Rio Colorado es un cuerpo costero con altas concentraciones de nutrientes (Hernández-Ayón *et al.,* 1993), altamente turbio (Santamaría-del-Ángel *et al.,* 1996) pero con alta POP (Millán-Núñez *et al*., 1999), el incremento de los flujos del Rio Colorado puede incrementar los nutrientes. Galindo-Bect *et al*., (2000) reportan para esta zona una estrecha relación entre las capturas de camarón y el aporte de agua dulce del Rio Colorado.

En general las relaciones de las capturas de camarón con los productos espectroradiométricos estándar (Chl *a*, POC, CDOM, Rrs412, Rrs490) no fueron significativas.

Una explicación de lo anterior puede ser que el largo de la serie (trece años) no fue suficiente para poder derivar las anomalías de una manera más representativa.

De la misma el no haber encontrado relación puede deberse a la naturaleza misma del parámetro pues por ejemplo el CDOM básicamente es un tipo de materia orgánica muy vieja y refractaria, probablemente producida por lisis y excreción de organismos, que disminuye la penetración de la luz y que al igual que el POC solo de manera indirecta afecta a la producción primaria, por lo que su efecto en la pesquería del camarón no es fácil de identificar.

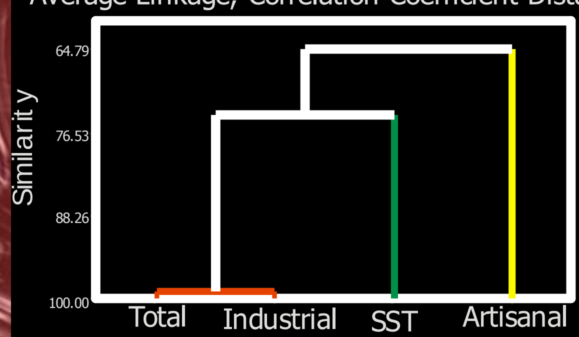
Mazatlan

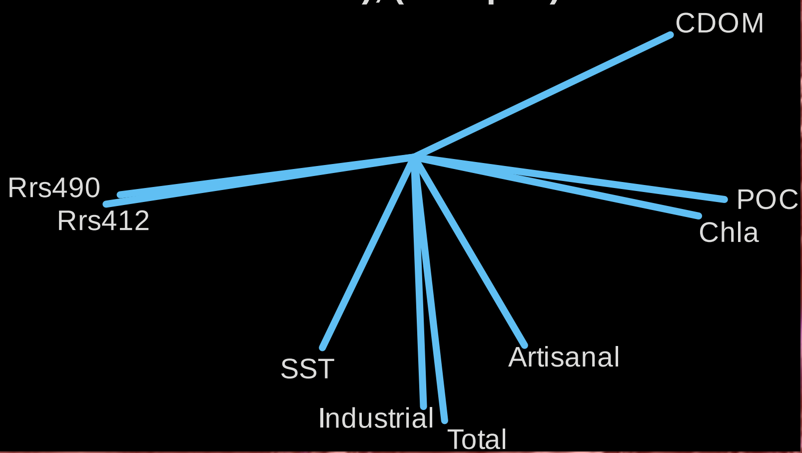
Eigenvalue	4.48	2.74	1.66
Proportion	0.44	0.27	0.16
Cumulative	0.44	0.72	0.88

	Comp.1	Comp.2	Comp.3
Total	0.08	-0.87	0.35
Industrial	0.02	-0.82	0.46
Artisanal	0.32	-0.62	-0.33
SST	-0.27	-0.67	-0.01
CDOM	0.81	0.45	0.41
Chla	0.89	-0.19	-0.34
POC	0.97	-0.13	-0.13
Rrs412	-0.96	-0.18	-0.21
Rrs490	-0.92	-0.16	-0.37

Only a direct relationship was found between SST and all catches (Total, Industrial and Artisana), (Comp. 2).

Average Linkage, Correlation Coefficient Distance





Sonora

Eigenvalue	4.54	2.36	1.48	1.05
Proportion	0.45	0.23	0.15	0.10
Cumulative	0.45	0.69	0.84	0.94

	Comp.1	Comp.2	Comp.3	Comp.4
Total	0.38	0.75	-0.02	-0.07
Industrial	0.40	0.62	0.10	-0.27
Artisanal	0.17	0.78	-0.31	0.40
SST	-0.24	0.40	0.78	0.28
CDOM	0.64	-0.25	-0.63	0.32
Chla	0.87	-0.36	0.43	0.16
POC	0.91	-0.38	0.29	-0.01
Rrs412	-0.96	0.35	0.14	-0.10
Rrs490	-0.88	0.48	-0.22	0.20

The catches not show any relation with SST or another variable