INTERNATIONAL OCEAN COLOUR SCIENCE MEETING 2023

OCEAN COLOR IN LATIN AMERICA

ECOSYSTEM FUNCTION, CITIZEN SCIENCE, AND COMMUNITY DEVELOPMENT

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FECOP - COSTA RICA

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Ocean Color in Latin America

Leatherback turtles nest in Costa Rica and rely on ETP for prey before reproduction. Nesting success related to high PP of La Niña and blooms following El Niño (Fe+) (Saba et al., 2008).

Whale sharks tagged in Galapagos benefit from high PP in Equatorial and Central America upwelling, move from Eq. to coastal upwelling in winter (Ryan, 2017).

Significant shift in giant squid fishing grounds off Peru in response to changes in SST & chl-a (Yu et al. 2017).

Variability in chl-a in spawning areas of anchovy and Argentine hake and recruitment success (Marrari *et al* 2013; 2016)

Evaluation of hyperspectral chl-a algorithms in Rio de la Plata during Cyanobacteria bloom (Ana Dogliotti).

Merged chl-a data in Gulf of CA to examine variability in 24 Priority Marine Regions and support conservation and management (Robles-Tamayo et al., 2022)

Timeseries programs:

- CARIACO Basin timeseries (Muller Karger et al.)
- ANTARES network in Brazil (Kampel et al.)
- EPEA station in Argentine Sea (Lutz et al.)

Ocean Color in Latin America

Changes of marine ecosystems have large **socio-economic impacts** on **marine goods** (e.g. fisheries) and **services** (e.g. tourism, recreation, health).

VOCES (Variability of Ocean Ecosystems around South America, IAI): goal to assess effect of climate variability on **(1) HLME**, **(2) PLME** and **(3) SBLME**, included **(4) PCACLME**.

Used 20-year timeseries of merged data from SeaWiFS and MODIS Aqua for the period 1997-2017 to examine trends in chl-a at 4 Large Marine Ecosystems.

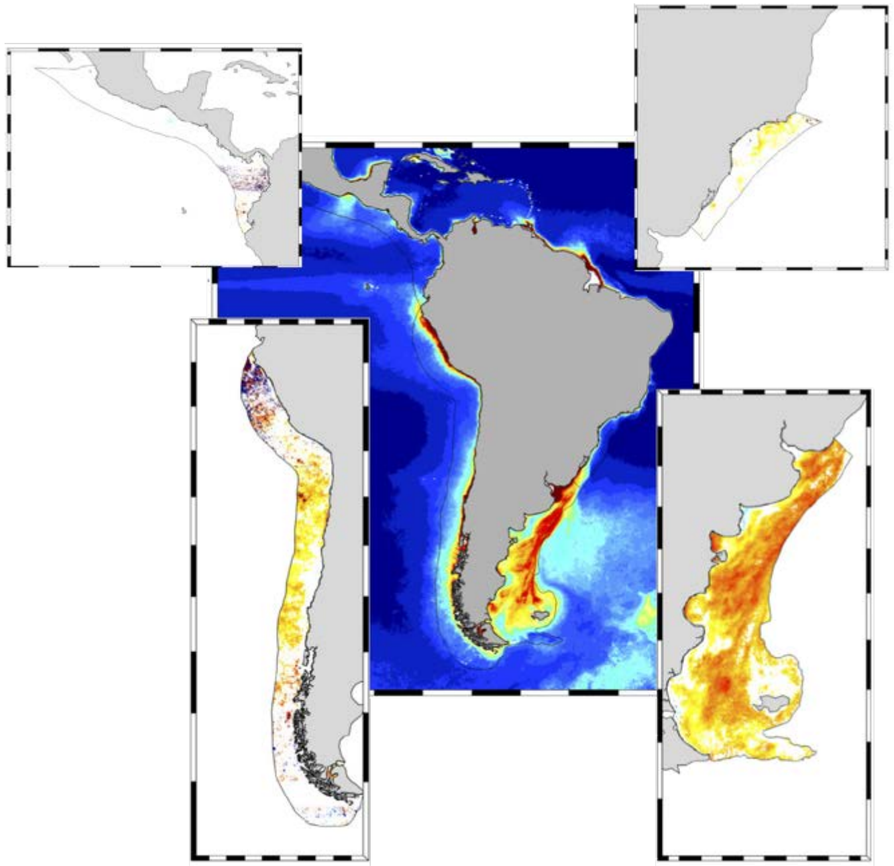
Chlorophyll trends around South America

PLME: **78.23%** (99% ++). Largest and most widespread increases in chl-a, mostly at shelf-break and mid-shelf frontal areas.

Large implications for ecosystem dynamics, fisheries and management: evidence of shifts and expansion of distribution range. Could these areas buffer the effects of climate change?

HMLE: **43.03%** (89% +): Increasing trends in the central area, decreasing, reduced trends in northern and southern sectors.

For SBLME and PCACLME trends were less evident from this large-scale perspective.



Significant trends in chlorophyll concentration between 1997-2017 (Marrari et al., 2017)

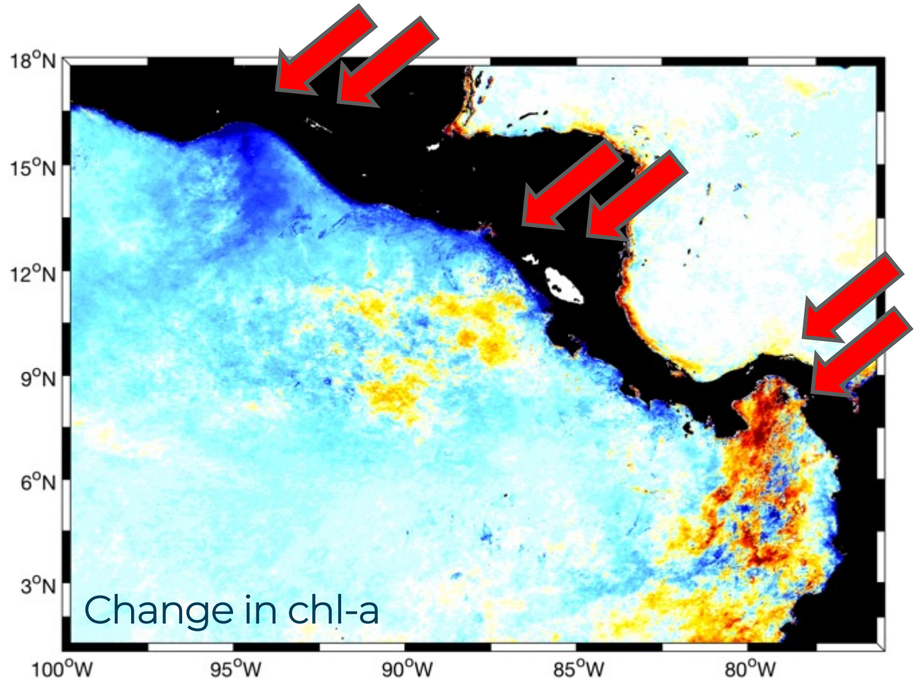
PCACLME: Pacific Central America

Changes less widespread and consistent, but **areas of increasing chl-a** emerged.

Region permanently stratified, nutrient limitation, low chl-a. ENSO main source of variability, phytoplankton controlled by mixing and upwelling.

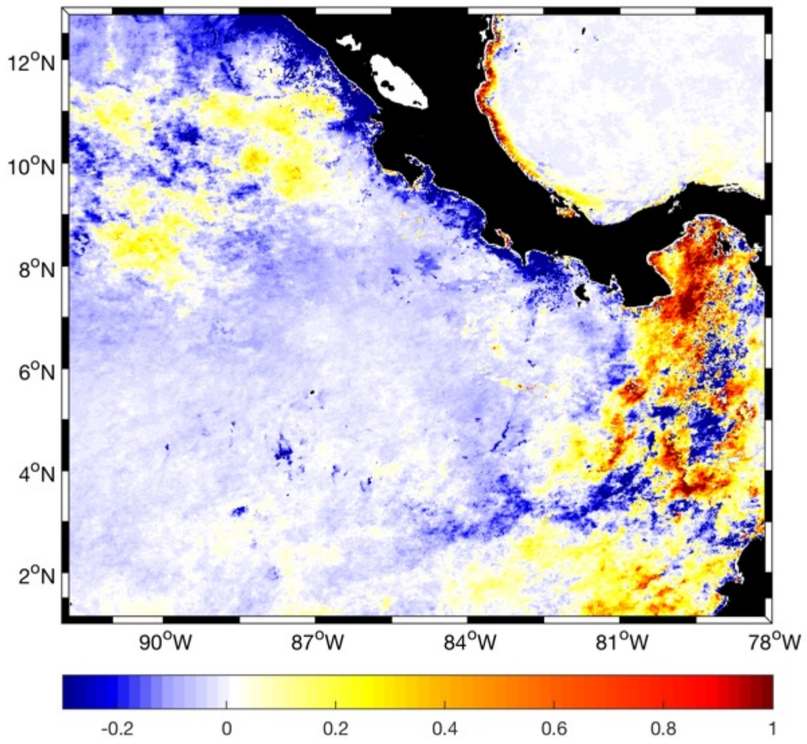
Seasonal intensification of easterlies as ITCZ moves south results in 3 strong wind jets in gulfs of Panama, Papagayo, Tehuantepec and **seasonal upwelling**.

SST values usually <20°C, and high chl-a, zooplankton, small fish, large pelagic predators like sharks, billfishes, mammals.

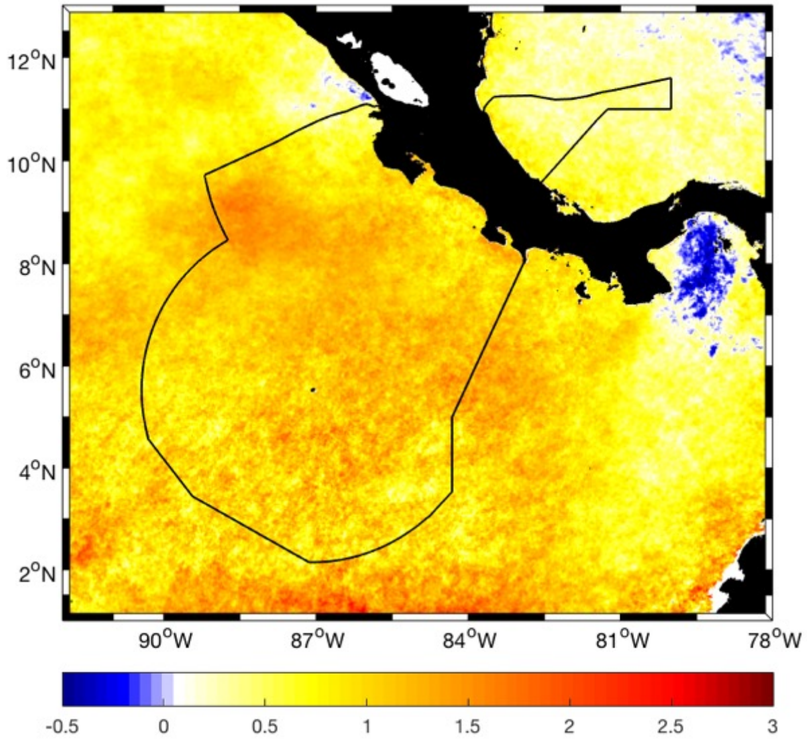


Result: high production in otherwise warming oligotrophic waters: Gulf of Papagayo supports **45% fisheries** in Costa Rica.

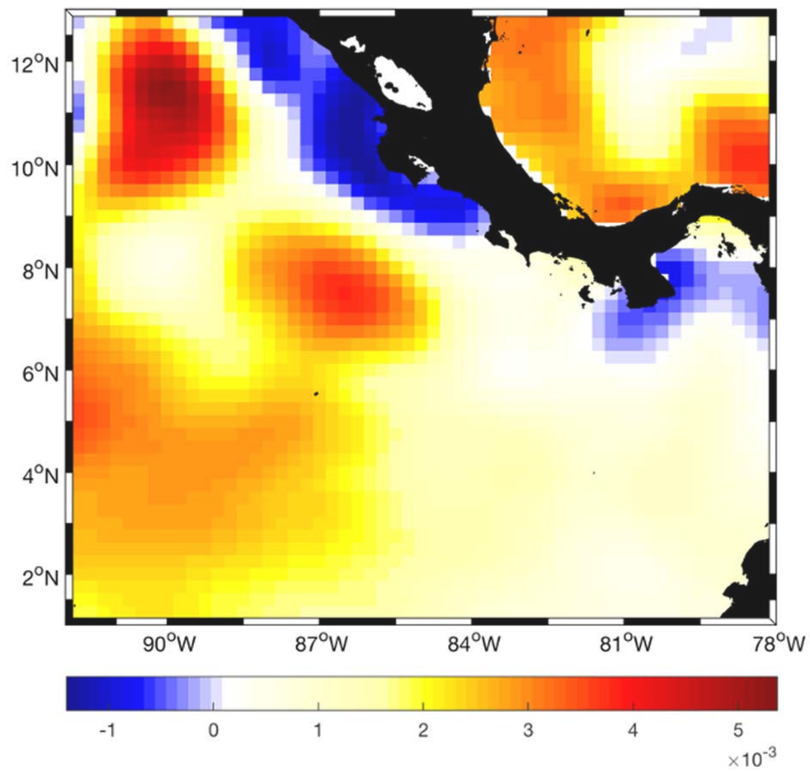
Total change in chl-a



Total change in SST



Trends in SLA Feb



Increased upwelling → Colder SST & shallower nutricline → Increased chlorophyll concentrations → Milder more favorable conditions

Can the upwelling areas in the gulfs of Panama and Papagayo be considered Climate Refugia?

How can we use ocean color information among other satellite data tools to assist decision-makers in the design and implementation of management and conservation measures?

Climate Refugia

"*Areas* ***buffered from climate change*** *over time that enable the persistence of valued resources.*"

"*Offer the best chances for survival for many taxa, making their identification important for conservation under anthropogenic climate change*" (Keppel et al, 2012)

Provide conditions that favor **species persistence** in regions threatened by environmental change, contributing to maintaining biodiversity & biomass.

3 main types identified in marine areas:

- High latitudes
- Deep areas
- Upwelling

Climate Refugia

Upwelling areas have been identified as playing an important role as refugia (Lourenco et al., 2016; Salois et al., 2022).

Defined as vital in decision-making processes for climate adaptation and conservation.

ETP: Opportunities to include ocean color and other tools in initiatives that will define, monitor and manage these areas.

In Costa Rica, these areas of milder conditions have large implications for **ecosystem services**:

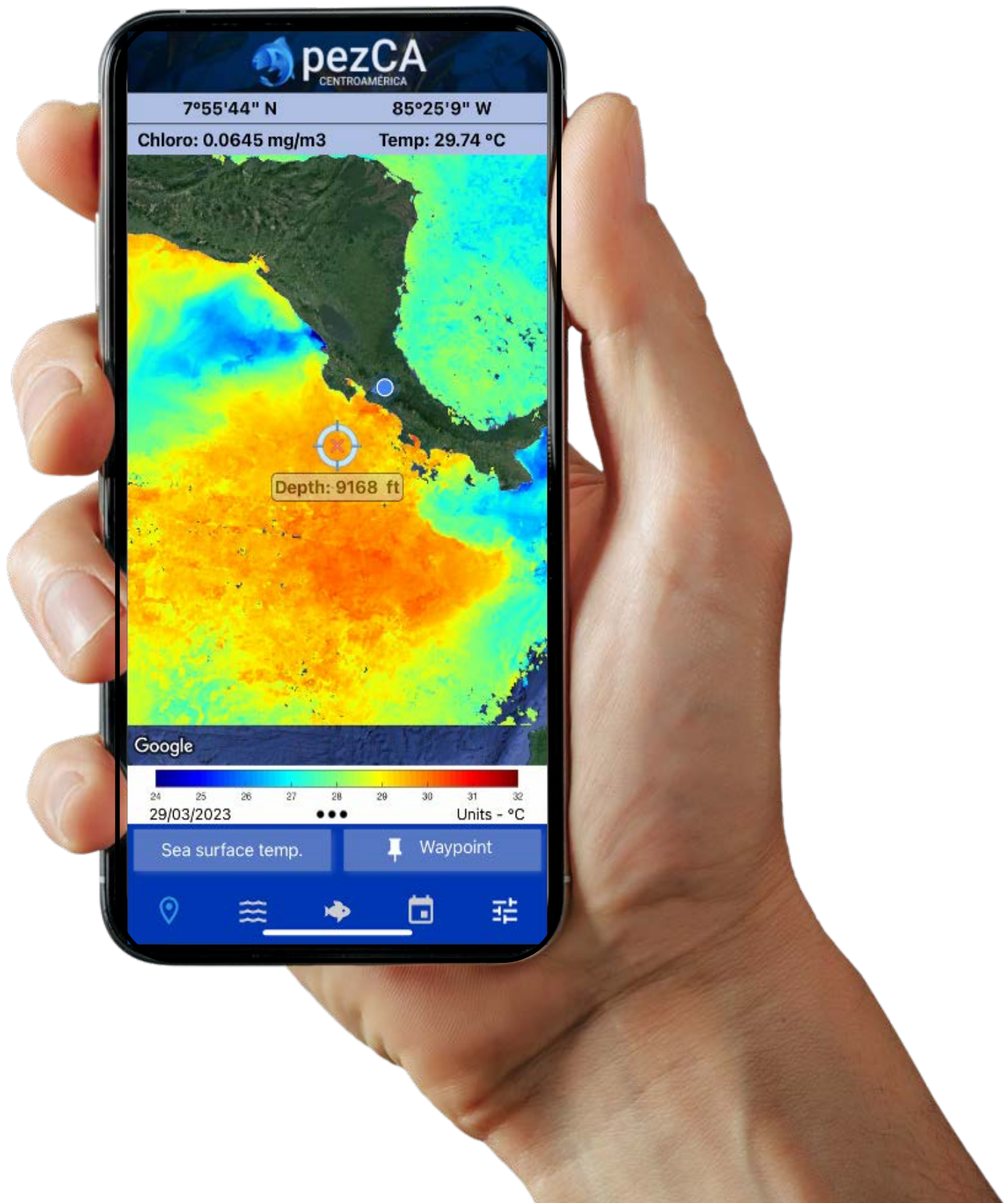
- Tourism
- Conservation and management
- Commercial fisheries
- Recreational fisheries

Implications for Coastal Communities

MARINE RECREATIONAL FISHERIES

- FECOP - Costa Rica Fishing Federation.
- Steady growth, main source of income for coastal communities. Sustainable, low impact on marine populations: catch and release.
- Costa Rica: most developed infrastructure 6 marinas, **US$ 520 million/year** (2.13% GDP), **150.000** tourists, **33.000** jobs. Premium billfishing destination.
- Fishing tourism is linked to **coastal community development** (Cascante & Marin, 2019):
  - Income 45% higher than average for coastal communities
  - Higher quality of life linked to infrastructure and education opportunities.

Tools for better management

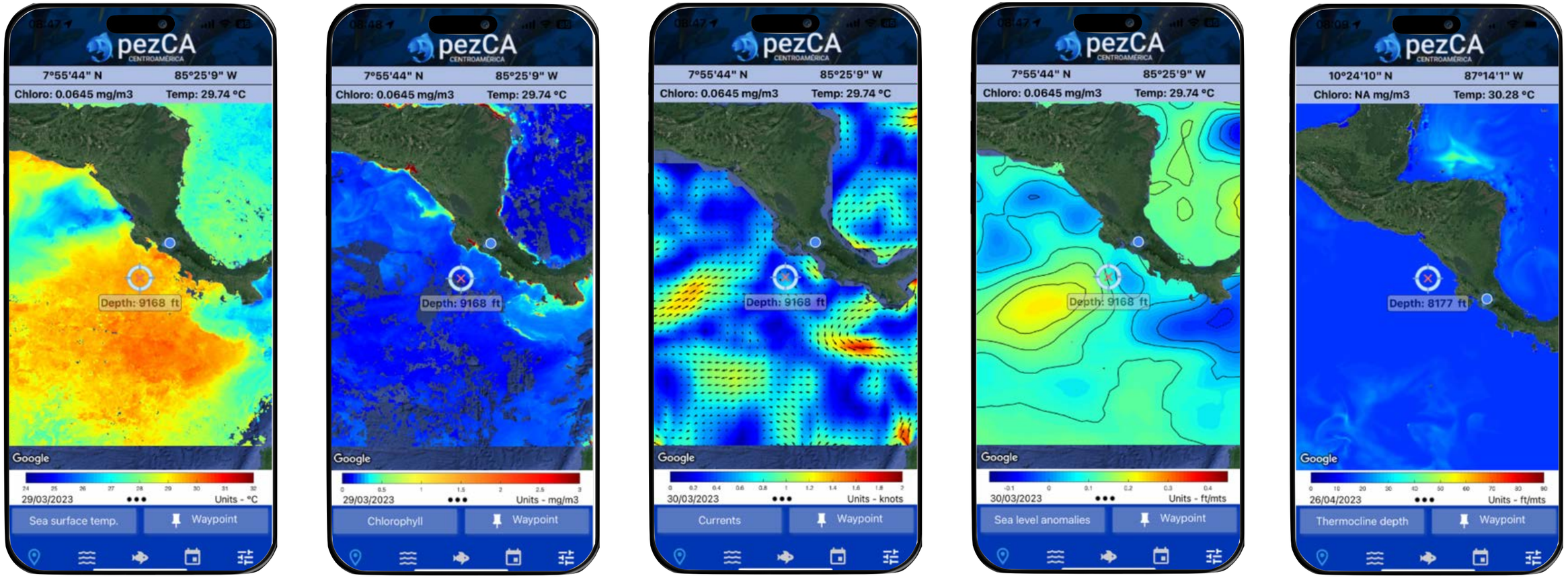


CHARACTERISTICS

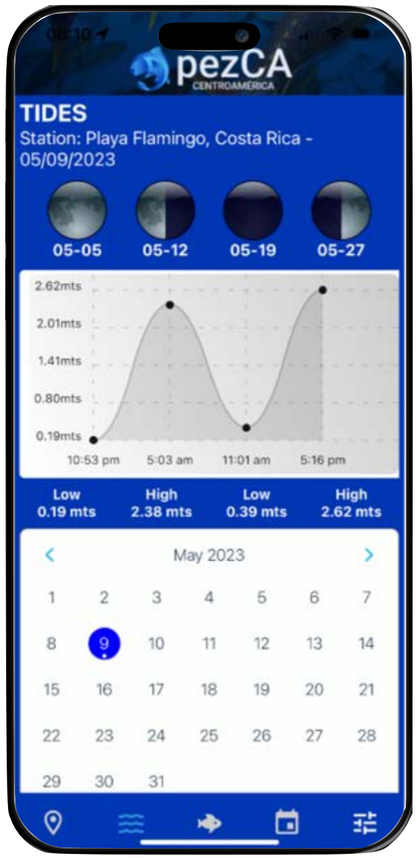
- Need for tool specific to region. Developed in-house.
- Free mobile application compatible with iPhone and Android, web version. English/Spanish.
- Domain: Central America.
- Maps and data of different oceanographic products, complementary information.

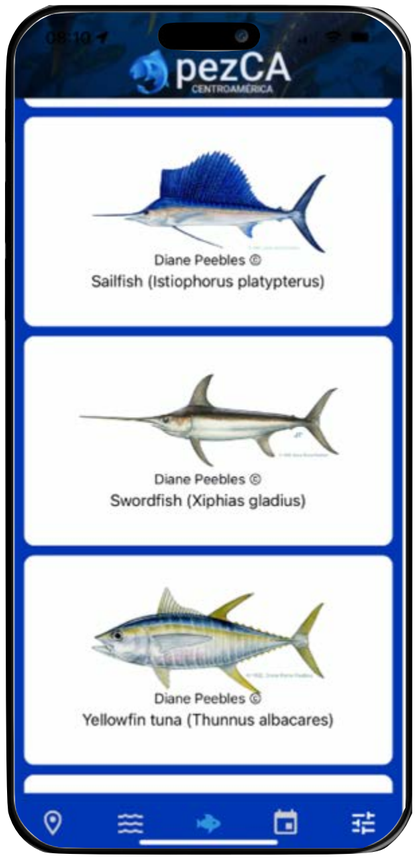
GOALS

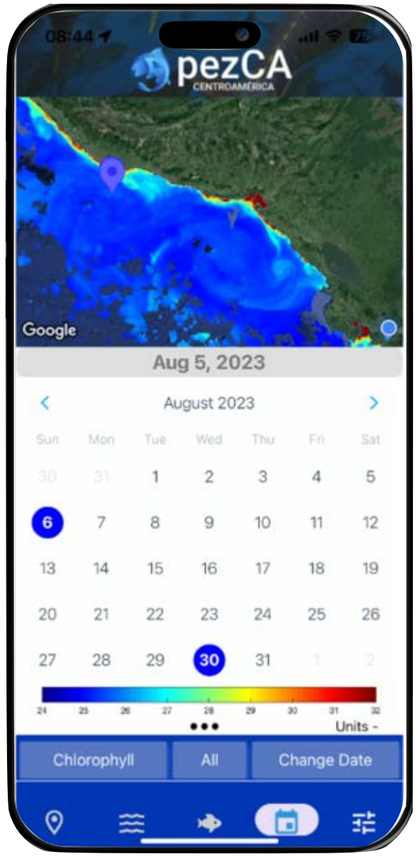
- Distribute NRT oceanographic data to monitor ocean conditions, useful to anglers and commercial fishermen, government, research, etc.
- Provide tools for identification of favorable areas.
- Promote responsible fishing practices through up-to-date information.
- Citizen Science: Collect user-contributed data.

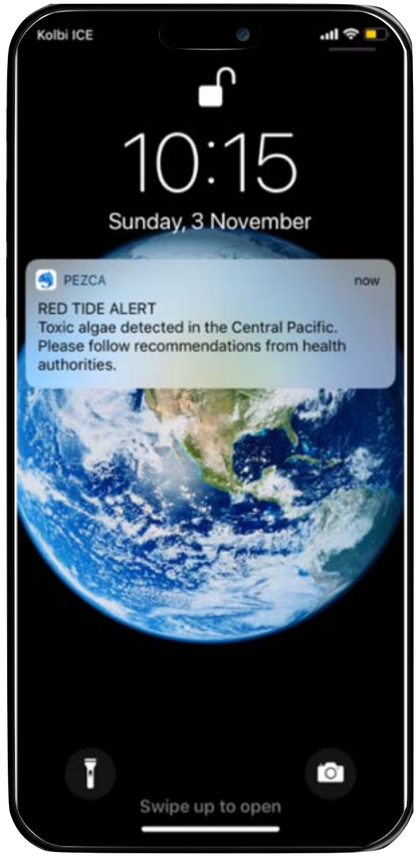


- Temperature and chlorophyll: MODIS Aqua/Terra, 2 km/pixel, 5-day rolling means.
- Currents: NASA OSCAR model, 37 km/pixel, updates every 5 days.
- Sea level anomalies from altimeters. Copernicus, 25 km/pixel, 1 day.
- Thermocline depth: Copernicus, Mercator model, 9 km/pixel, 1 day.





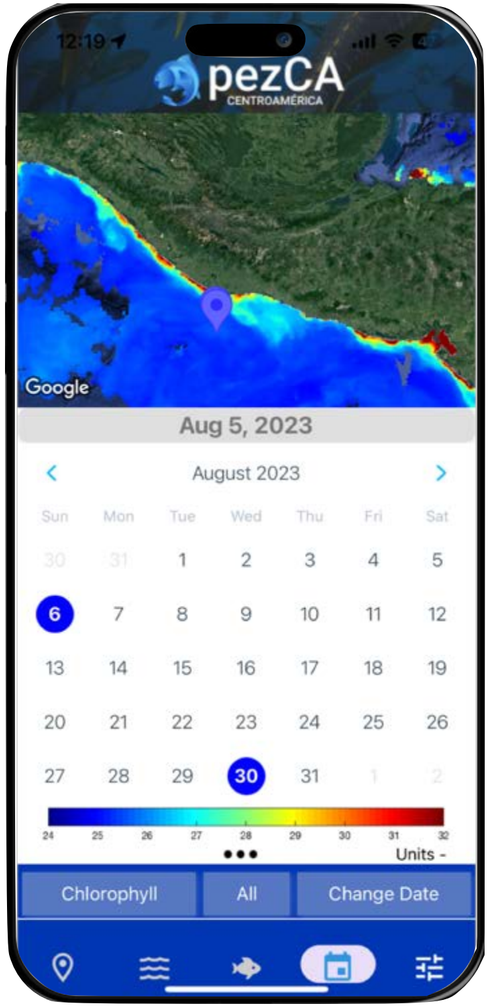


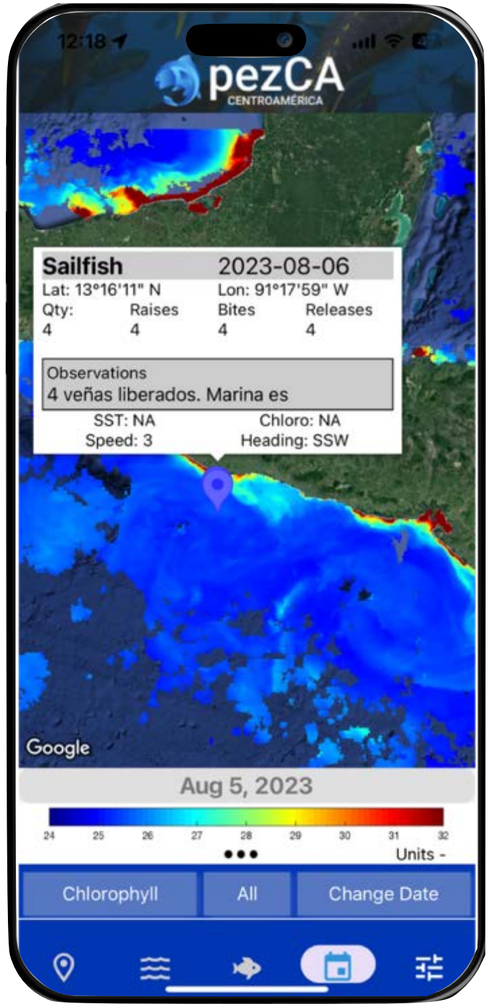


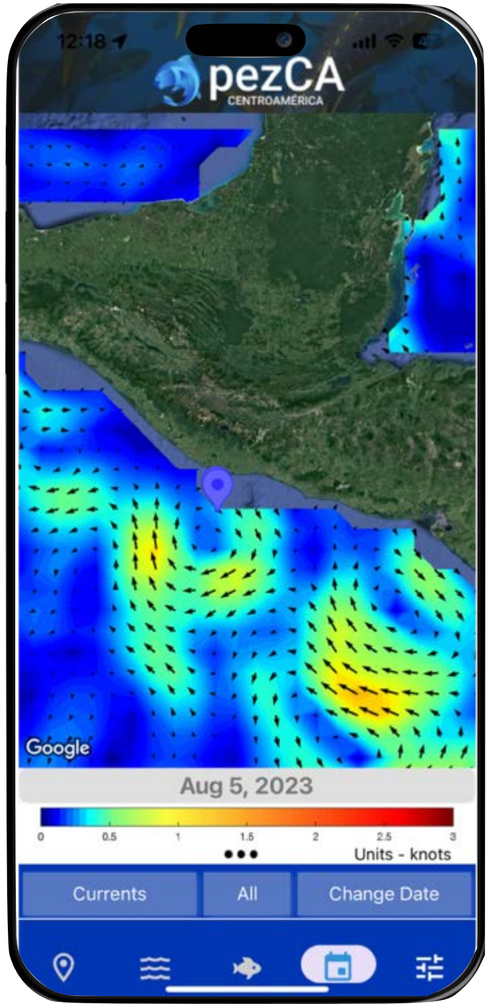
- Tides and moons: Tide forecasts +2 months in multiple stations, and moon phases.
- Fishing Zones: Regulations and limits for Tuna zoning, EEZ, National Parks).
- Fish: Biology, morphology, types of fishing, regulations.
- Waypoints: Historical user database.

Capacity building for fishing sector

User contribution

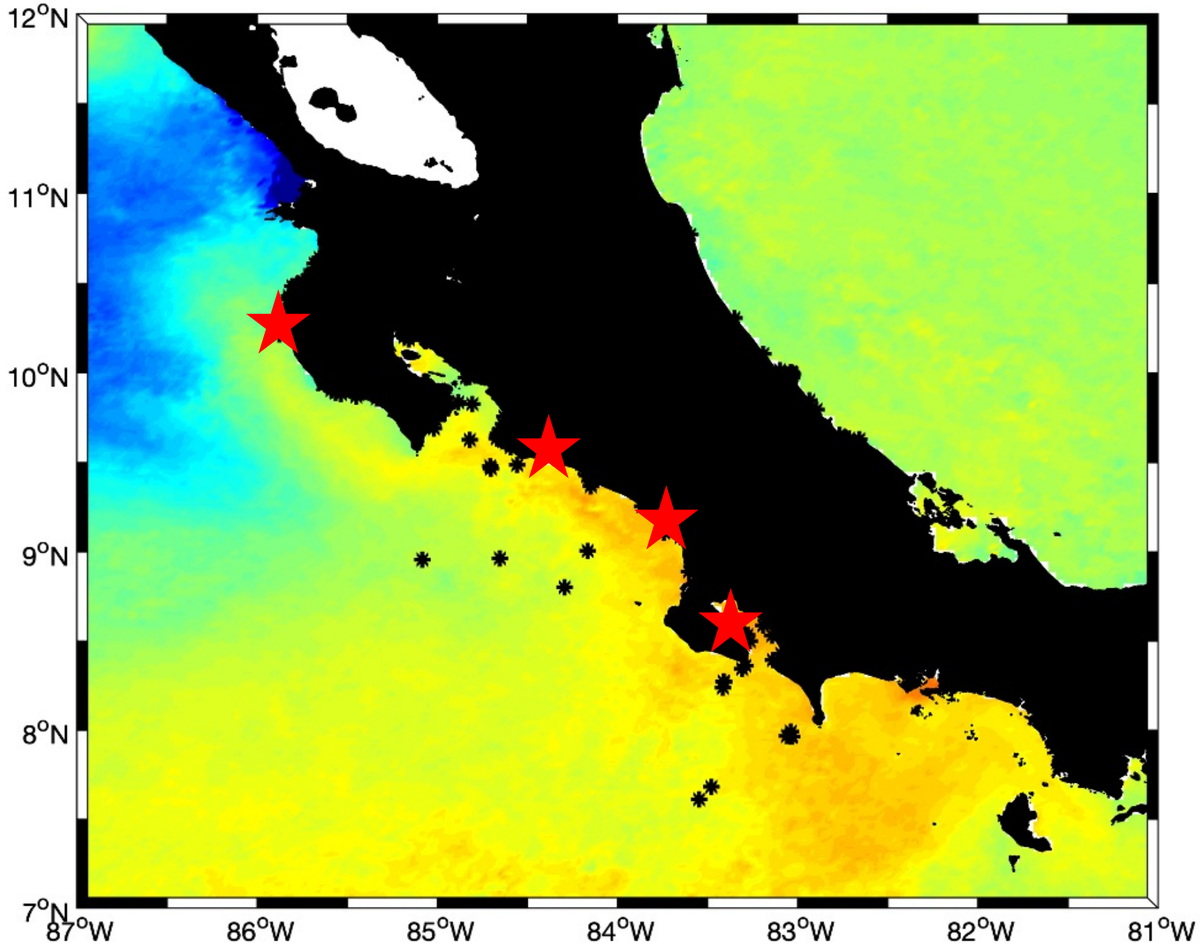






- User-specific historic data, including fishing information and satellite imagery.
- Shared to contribute to regional database

User contribution



Ongoing and Next Steps

- Suggestions: add new products: cloud-free SST, anomalies, frontal areas.
- User interaction.
- Implement as tool to collect data in tournaments, scientific tournaments, regional initiatives, management (e.g. Cocos Island).
- Develop product to monitor HABs.
- Training and capacity building in coastal communities.

Citizen Science and Capacity building: Women Nautical School

MISSION

Training for women to become mates and captains on sportfishing boats and incorporate them to the fishing tourism workforce.

APPROACH

60 hours of practice, 40 hours class:

- Navigation, safety, mechanics
- Knots, ropes, bait rigging, lures
- Fishing
- Handling of marine species
- Regulations
- Tourist Services
- Oceanography, satellite data interpretation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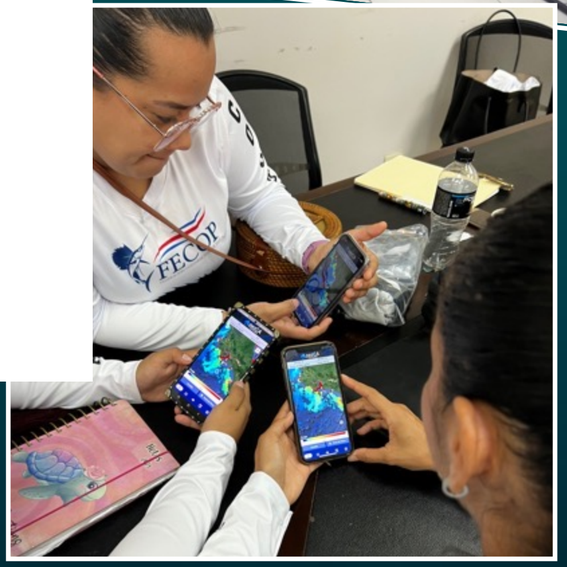
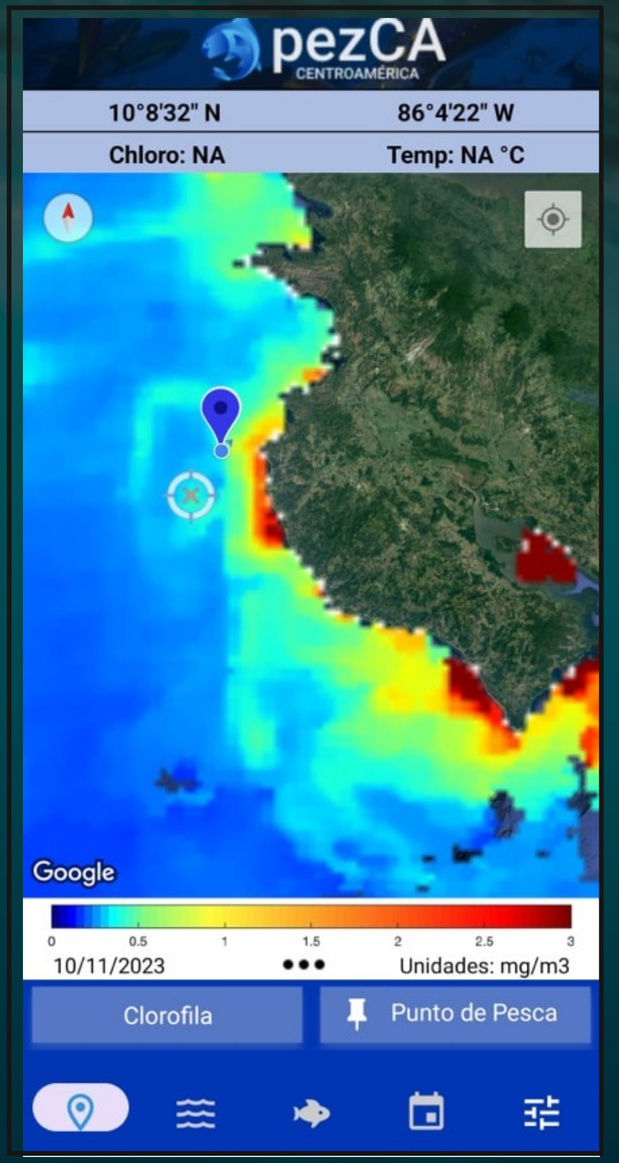
pesCA


WE ARE HIRING


FECOP
MARINA PESCA


FECOP

SUCCESS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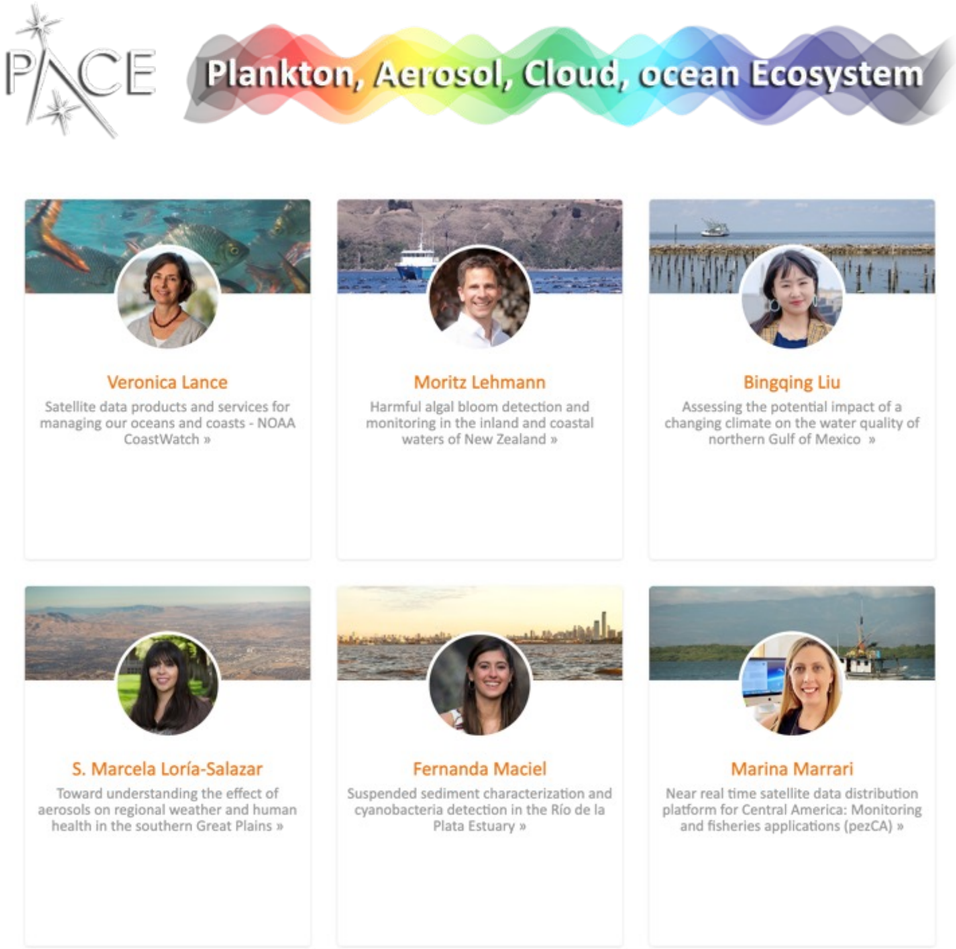
Punto de Pesca

PACE Early Adopter Program

Current functionality of PezCA and interest of stakeholders to develop further, opportunity in the **PACE EAP**.

“Promotes applied science and applications research designed to scale and integrate PACE data into policy, business, and management activities that benefit society and inform decision making”.

Participants have need for PACE, have an application or idea for a new PACE-related application that directly benefits society, and is involved with stakeholders, decision-makers, or other end users.



PACE Early Adopter Program

RED TIDE MONITORING FOR CENTRAL AMERICA

Increased frequency and magnitude of HABs in ETP, important implications for ecosystem function, tourism, health, fisheries. Need to identify main species.

OBJECTIVES: develop a harmful algal bloom monitoring program for the region.

APPROACH: Use PACE data to develop algorithm and operational product to distribute in NRT through PezCA.

Collaboration: FECOP, NASA, USF (Brian, Chuanmin, Jen), UNA, Citizen Science (Pelagos)

Agro

Senasa mantiene veda para extracción de moluscos en costa pacífica por marea roja

Análisis de laboratorio evidenció la presencia de toxinas paralizantes en las muestras de carne de moluscos bivalvos de las costas del Pacífico Central y Norte.

NACIONAL

Comerciantes de Caldera aseguran que marea roja baja ventas hasta un 60%

Según los comerciantes, esta condición del mar en Caldera ha sido más frecuente este año. Para este jueves ya era menos lo que se apreciaba.

SUCESOS

Cientos de erizos de mar aparecen muertos en playas de Guanacaste

Un equipo del CIMAR se está desplazando a la zona para investigar este fenómeno.

Salud

Alerta para bañistas: Salud reporta marea roja en playas del golfo de Nicoya y Guanacaste

Autoridades piden a turistas abstenerse de ingresar al mar si observan mancha oscura y de mal olor; contacto con microalga podría afectar vías respiratorias, ojos y piel de personas

PACE Early Adopter Program

RED TIDE MONITORING FOR CENTRAL AMERICA

INITIAL ACTIVITIES

Identified capacities and needs, developed sampling and processing protocol, field tests.

Sampled HAB along Pacific coast of CR: *Margalefidinium polykrikoides*, (~2.800.000 cell/l). Other species present in lower concentrations

M. polykrikoides: common worldwide, previously observed in Pacific CR. It is icthiotoxic (fish kills). Associated with eutrophication and fish farming.

2022 event lasted 14 mo, had a big impact on marine tourism and coastal communities affecting fisheries, aquaculture, sportfishing, beach tourism.

a. M. p *sus*, d. *Odonte* *mense*

PACE Early Adopter Program

RED TIDE MONITORING FOR CENTRAL AMERICA

NEXT STEPS

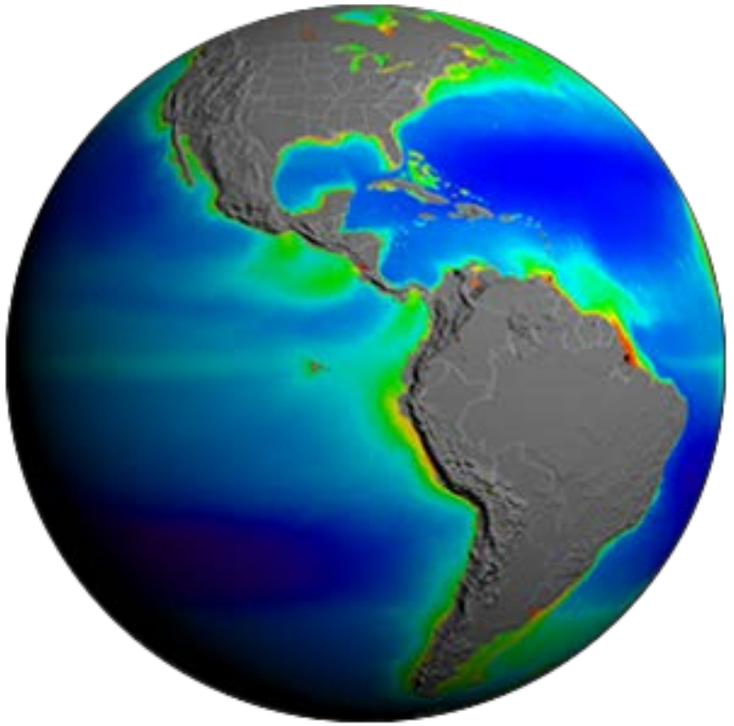
Sample events, collect *in situ* samples for taxonomy and pigment composition (HPLC), radiometry data. Identify dominant HAB producing taxa.

Use PACE data to develop algorithm to identify HAB-forming species.

Characterize dynamics of HABs.

Incorporate into PezCA as an operational product available to all users.

Include in government action plans: National Red Tide Commission, SENASA, Fisheries Authority, Health and Tourism Ministers, Academics.



Final Remarks

The application of ocean color tools has greatly contributed to our understanding of ecosystem function and dynamics in Latin America.

Understanding the impact of environmental change on marine ecosystems is essential for developing adaptation and mitigation strategies.

Ocean color tools are essential in the identification of priority areas for conservation and management

Coastal communities are involved and interested in sharing their traditional knowledge and data to science. These are especially valuable when other resources are not available.

Ocean color tools contribute to the development of coastal communities supporting sustainable blue economy activities and the creation of high quality jobs.

The work we do has a large and direct impact, far beyond the research and academic environments. This work creates opportunities for a better quality of life for people in coastal communities around the world.

THANK YOU