# SEAGRASS BEDS IN LAGUNA SAN IGNACIO, B.C. S. AND ADJACENT AREAS: AN ASSESSMENT OF CRITICAL HABITATS AND PROTECTED SPECIES CONSERVATION

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Time frame of the report: September to April 2009, additional field trip in October 2009.

Objective: Determine the critical areas of seagrasses and seaweeds distribution in Laguna San Ignacio and in Gilmore's Lagoon (Estero La Pitahaya) to the south as habitats for conservation of protected and endangered species, and the conservation of other marine species and their associated biodiversity.

Content of the report:

a. A GIS map of seagrasses meadows and seaweeds showing their present distribution.
b. A spatial evaluation of the density and distribution of the main species in relation to different areas of the lagoon.
c. A spatial evaluation of the associated biodiversity that may indicate changes along the interior of the lagoon.
d. A temporal and spatial distribution of invasive species *Gracilaria vermicullophyla* and an evaluation of its potential threat to *Zostera marina* distribution.
e. A comparison of the feeding habits of the green turtle between the main foraging areas in the Pacific Coast of BCS.

<u>Future goals of the Laguna San Ignacio research (between October 2010 and April 2012):</u>

f. Develop a comparative analysis of the seagrass distribution over different temporal scales (years, decades).
g. Evaluate alternatives for restoring the depleted seagrass meadows and their ecological settings.
h. Identify to the lowest taxonomic level the invertebrate fauna in sediments.
i. Determine the changes in sedimentation and invertebrate composition before and following restoration activities.
j. Evaluate the disturbance to the seagrass and invertebrate communities resulting from the recent hurricanes over the region (Oct. 2009).

## ABSTRACT

San Ignacio Lagoon is part of the Vizcaino Marine Biosphere; a wetland considered as part of the Convention on Wetlands of International Importance or RAMSAR convention and is consider a critical area for bird and marine species conservation in North America. In this lagoon several economic activities are present (e.g. eco-tourism, fisheries and aquaculture), and other activities (i.e., mineral mining or seaweed aquaculture) could potentially occur in the lagoon. San Ignacio is well known for the extensive seagrasses and seaweeds beds that provide habitat and food for marine fish, invertebrates, gray whales (*Eschrichtius robustus*), brant (*Branta bernicla*) geese, and green sea turtles (*Chelonia mydas*) (Mexican NOM 059). However, little is known about the importance of the role these critical habitats provide for conservation (such as seagrasses and seaweeds), and there is an urgent need to develop an understanding of their historical distribution to evaluate which areas would be critical for conservation and supporting the species diversity in the lagoon. Another need is to understand the role of these plant habitats in relation to associated biodiversity and recruitment of fisheries species.

Seasonal visits (summer, fall 2008, spring 2009) were made to the Laguna San Ignacio to observe and to evaluate the density, cover and area of seagrass meadows to establish baseline information for comparison with satellite imagines. To document associated biodiversity, cores of the bottom sediments were taken in representative sites around the lagoon and density and richness of macrofauna were evaluated. Seagrasses beds are dominated by *Gracilaria vermicullophyla* (an introduce species) and were evaluated similar to the seagrasses from observations made during visits from 2006 to 2008. Evaluations of the volume and richness of feeding items of the green turtle were

undertaken at least for one season and samples for isotope analysis were gathered for comparative analysis between the main four coastal lagoons of Baja California (i.e., Guerrero Negro, Ojo de Liebre, Bahia Magdalena, and San Ignacio).

The results of this study in Laguna San Ignacio indicate that seagrass distribution is highly variable around the lagoon based on size and density of the beds, also the size of the seagrass beds were different between the December 2008 and the April 2009 samples. The observed seagrass densities were similar to the values obtained in our previous study (1999) and other recent publications (Cabello Pasini *et al.* 2002). However, there was a noticeable presence of *Ruppia marina* populations along the western side of the lagoon and very low seed numbers in the cores. The associated fauna was found to exhibit spatial heterogeneity related to the sediment type and the presence of seagrass or seaweeds. Small rhodolith beds were detected south of the islands at the middle of the lagoon. The *Gracilaria* beds were highly variable among years and sites. This variability may be dependent on the water temperature and also might be relative to consumption by herbivores (such as turtles and nudibranchs). This is evident when stomach contents of the green turtle were analyzed and found to contain a high proportion of red seaweed in their diet and the noticeable amount of *Ruppia marina*.

We will continue to investigate the feeding ecology of green turtle around Pacific Baja California Sur by monitoring the invertebrate diversity by species (to the lowest possible level), and by evaluating the temporal and spatial trends of the invertebrates in relation to the substrate composition. We will continue sampling the diet of the sea turtles by analyzing the esophagic contents of dead turtles, and by conducting isotopic analyses of blood and skin tissue samples in relation to prey items.

Project staff include the Doctorate student Jorge Manuel Calderon (Historical trends of seagrasses in Coastal Lagoons in Northwestern Mexico) CIMACO UABCS, and Master´s students Mario Vergara (Population and Chemical variations of *Gracilaria vermicullophyla* in Laguna de San Ignacio) and Juan Manuel Rodriguez (Green turtle feeding ecology) CICIMAR IPN.

## BACKGROUND

Coastal lagoons are well known marine systems in where key biological processes (i.e. high primary production, reproduction, recruitment, feeding grounds etc.) occur in the nearshore areas (Vailiela 1989). In Mexico, the Pacific side of the Baja California Peninsula has five coastal lagoons: San Quintín, Punta Banda, Ojo de Liebre, San Ignacio y Bahía Magdalena that are critical areas for the marine and coastal biological interactions (CONABIO 2000). These lagoons are a relevant habitats for the feeding and nursery areas for black (green) turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*), olive ridley turtles (*Lepidochelys olivacea*) and hawksbill turtles (*Eretmochelys imbricata*) (Gardner & Nichols 2000; Seminoff *et al*. 2002; Koch *et al.* 2006). They are also known nursery and probably feeding sites for the gray whale (*Eschrichtius robustus*) during the winter months (Urban *et al*. 2003, Caraveo and Soto 2005), and for migratory birds (Sedinger *et al*. 2004; Ward 1983; Ward *et al* 2005) like brant geese (*Branta bernicla*). The Green turtle (*Chelonia mydas*), has a diet composed mainly of red seaweeds belonging to the family Gracilariaceae in Bahía de Los Angeles (Seminoff *et al*. 2002). A combination of several species of green, red seaweed and seagrasses are found in Bahía Magdalena (López-Mendilaharsu *et al*. 2005, López-Mendilaharsu *et al*. 2008) and in San Ignacio Lagoon seagrasses are predominant (i.e., *Zostera marina*) (Santos-Baca 2008). All of the vertebrate species that feed in these areas on these marine plants are included in the Mexican endanger species list (NOM ECOL 059) and in the UICN endangered species on red list (www.uicnredlist.org). While not endangered or threatened, marine seagrasses in wetland areas are noted in the NOM-022.

All the coastal lagoons of Baja California are biologically important areas because of their biodiversity and economical values. These lagoons are listed as a Priority Marine Areas and an Important Bird Conservation Areas (AICA) by the National Commission for Knowledge and Use of Biodiversity (CONABIO) in Mexico (www.conabio.gob.mx). Laguna San Ignacio is one of the least developed of the coastal lagoons along the Pacific Baja California Peninsula (www.pronatura.org) and is under the continuous threat from unplanned coastal development. San Ignacio Lagoon is also economically relevant because of its high productivity for commercially important fish and shellfish species (i.e. fish, scallops, clams, shrimp, etc.) (CONABIO 2000, Carta Nacional Pesquera 2006), and for the aquaculture of oysters.

Laguna San Ignacio is part of the wetland convention or RAMSAR convention site for wetland conservation no. 1341, and it is Part of Biosphere Reserve and World Heritage Site (UNESCO, http://whc.unesco.org/en/list/554). Overfishing, un-regulated growth, and inadequate waste disposal are regarded as the main problems facing development in the area. There have been several efforts to buy or lease the lagoon's interior land by several companies wishing to develop the area. While the lagoon remains relatively undeveloped, there is the opportunity to understand the natural condition of the area and, to develop the proper management plan. In this regards, there are several non-government agencies (PRONATURA, TNC,SFS, Nichols *et al*. 2000) who are developing efforts to protect the San Ignacio Wetlands Complex as an entire ecosystem by developing a a management plan (Wildcoast http://www.wildcoast.net/sitio/index.php?option=com_content&task=view&id=218&Itemid=147). However, knowledge is limited for of the marine critical areas and their importance for conservation.

Without adequate information on the biological importance of these areas, the potential economic development of many of these lagoons represents a threat for the species and habitat conservation in general for the region.

In Laguna San Ignacio there are several habitats dominated by plants or algae that should be conserved: seagrasses meadows, rhodolith beds, seaweed communities, and mangrove forest. The green turtle feeds mainly on seaweeds (8 species) and seagrasses (3 species) in open coast and in estuaries (Hilbert *et al*. 2000; López-Mendilaharsu *et al*. 2005, 2008). North eastern Pacific gray whales have been observed feeding within *Zostera marina* meadows in the lagoons presumably to obtain a species of amphipod and other invertebrate fauna associated with the seagrass (Jones and Swartz 1984; Caraveo & Soto 2005). The brant geese feed extensively within *Zostera marina* meadows along estuaries in the Baja California Peninsula (Davison & Hughes, 1998; Sedinger *et al*. 2004). There is little information on the biological the impact of the cumulative interactions of these herbivores and commercial fisheries on the seagrass meadows and seaweed beds in the lagoon, or the impact of these activities on the associated biodiversity of the lagoons.

The feeding of these marine species in the coastal lagoons along the Pacific coast of Baja California is probably driven by the natural seasonal fluctuation in *Zostera marina* population over time. Comparative studies of the population dynamics and physiological status of *Zostera marina* near its southern limit (Cabello-Pasini *et al*. 2002; 2003, 2004; Santamaria-Gallegos *et al*.2001, 2007), suggest that most of the coastal lagoons have a perennial populations of marine species because of the ecological similarities of the water bodies and their oceanographic dynamics (Obeso *et al* 2004). This very structured spatial organization along the lagoons is reflected in the genetic structure of the populations (Muñiz *et al* 2005) where the gene flow is north to south. However, one would suspect that the species' spatial variations would be more related to seaweed abundance, rather than north to south geographical influence.

There is very little known about the natural distribution or changes in space and time of species of the seaweeds in the lagoons (like Bahía de Los Angeles--Ruíz & Zertuche-González 1996a, 1996b, 2002 or Bahía Magdalena González-Ramos & Santos-Baca 2005). Especially, there is limited information about the dynamics of seaweeds in Laguna San Ignacio (Nuñez-López & Casas-Valdez 1998a, 1998b; Riosmena-Rodríguez 1999). Some information is known about main components of the sea turtle diet. The best available studies were conducted by Pacheco-Ruíz *et al* (1999) on *Gracilariopsis lameneifornis* and the research on the temporal variation of *Codium amplivesiculatum* by Riosmena-Rodríguez and Olguin-Acosta (2008) in Bahía de La Paz.

Seagrasses and seaweeds are important key species in terms of biomass and their contribution in the food web (Coleman and Williams 2002), and for their ability for nutrient recycling (McRoy & McMillan, 1977; Short, 1987; Hemminga *et al*. 1991; McRoy & Goering, 1974). The leaves of seagrasses attenuate the currents and the roots are relevant for sediment stabilization (Rasmussen, 1977). These physical characteristics of seagrass meadows support many more species of invertebrates and fish than in adjacent areas with less seagrasses. The physical structure of the meadows and seaweed beds are good substrate for a wide range of organisms that increase the local biodiversity (Harlin, 1980; Siqueiros-Beltrones *et al.,* 1985; Sánchez-Lizaso & Riosmena-Rodríguez 1997;

Schneider & Mann, 1991a, 1991b; Harrison, 1987; Heck *et al*. 1989). At the same time the meadows or the seaweed beds function as refuges and food for many larvae of the local invertebrate and fish species and their interactions (Blaber *et al*. 1992; Perkins-Visser *et al*. 1996; Pohle *et al*. 1991; García-Esquivel & Bricelj, 1993).

Coastal development such as eco-tourism, industrial development, or fishing activities have the potential to damage seagrass meadows or seaweeds beds by the changes in sediment quality and cause them to disappear from extensive areas (Wyllie-Echeverria et al.2003) ranging from local to regional extinction. The impact of the loss of these seagrass beds may be intense, and active restoration techniques have been developed to recover damaged seagrass areas. These techniques range from regular transplants of adult plants based on typical gardening techniques to the active plant of seeds in new areas for "natural" development. Seagrasses may also be planted in small containers and transplant the young plants into the field.

The Mexican government recently changed the NOM 022 (Diario oficial de la Federacion 2004) for wetlands suggesting restoration and mitigation activities be used to recover lost areas in relation to coastal development, but the regulation did not specify methods or provide recommendations for any form of restoration or mitigation leaving. Developing an appropriate conservation strategy requires the understanding of critical areas in where the seagrass and seaweeds are distributed over time and space. Because of that the use of modern scientific tools like GIS are critical for establishing the limits of the distribution of the main species of the seagrass and seaweed.

## SCIENTIFIC APPROACH:

The following activities will be used to determine the distribution of seagrasses and seaweeds and those habitats that require conservation to support endanger and other marine species:

1. Use Geographic Information System (GIS) methods and technology to determine the variation and distribution of the primary habitats for seagrasses within San Ignacio Lagoon and Gilmore's Lagoon to the south to identify specific areas for conservation activities.
2. Determine ecological important seagrass associated species, their distribution, and biomass by taken cores of sediment in the meadows.
3. Determine distribution of protected species within the lagoon.
4. Estimate the distribution of other relevant seaweed with in the lagoon.
5. Determine the primary diet species of the green turtle in Laguna San Ignacio and compare to green sea turtle diets in other Pacific coast lagoons of Baja California.

## MATERIAL AND METHODS

The maps of the current and historical distribution of the seagrasses meadows are being developed based on field work, archive data and satellite photographs. All the maps that are in development will show the peak of the seagrass season (February to April) and when the the eel grass is not present (October to December). The maps will represent the actual condition and, if possible, will be compared with historical data from Riosmena 1999 collections in relation to INEGI photograph database. At the same time, evaluation of the spatial variation in associated flora and fauna are in development based on NAGISA methodology (Rigby *et al*. 2007), and these evaluations will contribute to the understanding the major components of the community and its structure. The range of the sampling will include replicate samples areas from intertidal down to sub-tidal populations around 10 m.

Field sampling will utilize vessel surveys in each lagoon looking for sites with seagrass meadows and seaweed beds; the location of each meadow/bed is marked with a Juno ST™ GPS unit to estimate the area covered by the seagrass beds. SCUBA divers will sample each meadow/bed by taking sea grass/algae density measurements and sediment core samples. Density measurements are estimated from the average number of individual plants that are found within a 0.25m PVC quadrant measuring device from four randomly places replicates along a 40m transect line within each meadow/bed.

Sediment cores are extracted with a 15cm diameter PVC corer, and three replicates per transect are taken to a depth of approximately 10cm (standard measurements in NAGISA methodology). Sediment cores will be sieved onboard with a set of three sieves with the following mesh opening sizes:

3300 µm – to discard larger material (leaves, shells, rocks),

840µm – to collect seagrass seeds and macro-invertebrates.

420µm – to collect micro-invertebrates.

Sieved materials are preserved in individual containers (840ml and 420ml) with enough isopropyl alcohol (70%) to cover all sampled material. In addition, plant material collected for each sampled site is preserved in plastic bags with silica gel for DNA analysis in the laboratory.

All the materials are deposited in the Natural History Museum of UABCS and will be identified using classical and modern keys for the species. Sea weeds are identified using the keys compiled by Riosmena-Rodriguez (1999), Amphipods using keys by Barnard (1965), Echinoderms from keys by Cintra et al. (2001), Polychaetes from keys by Salazar-Vallejo *et al*. (1989) and Mollusks are identified by Keen (1980) Also reference benthic survey in Laguna San Ignacio by Kurth et al. 2008 – on LSI Website). Benthic macro-invertebrates are identified by staining them with Bengala Pink in seawater which is applied to each sample in a dissection tray. Labeled crystal vials are used to separate each taxonomic group found in the sample. Specimens are identified, and counted with the naked eye first and then verified with the aid of a stereoscope and species keys for each taxa. A photographic catalog is created for each of the major taxa observed (polychaetes, echinoderms, crustaceans, ascidians, and seagrass seeds).Significant and important materials are prepared and shipped to specialists for formal identification and for depositing in other collections.

The relative abundance of each species will be evaluated based on percent of cover and density, depending on the specimen. The basic sampling design will include the three ( 3) main areas of the lagoon (the northern most interior, the middle area, and lower area nearest the lagoon entrance to the ocean), and sampling at three (3) depths (intertidal, 1m and 4m) with an orthogonal design. In all cases mean and standard deviation will be calculated and tested for normality/homoscedasticity. Multivariate analysis will be performed to evaluate which areas are the most significant in species distribution or abundance. Sampling areas will be selected in relation to the feeding and reproduction areas of importance for the conservation of rare and endangered species and for important fisheries species. This will allow the identification of specific areas that should be proposed for potential conservation and protection because of their importance to these species .

## PRELIMINARY RESULTS

I. A Global Information System (GIS) map of seagrasses seed density and possible meadows and main seaweeds showing their present distribution within Laguna San Ignacio.

The present report includes data and observations from all visits completed to date (i.e., September, December 2008 and April 2009), in which *Zostera marina* & *Ruppia maritima* distribution area cover were determined (Fig. 1A). Estimates of shoot density and associated biodiversity and seed density from sediment cores were obtained (Fig. 1B) for 67 sampling sites around the lagoon between intertidal zones down to 6 m depth (Fig. 1C combining seagrass and sediment cores).

The GIS maps for San Ignacio Lagoon and Gilmore's Lagoon to the south (December 2008) clearly show the wide distribution of *Zostera marina* (green circle, Fig. 1A), a significant distribution of *Ruppia maritima* (green square and flag, Fig. 1A), and areas in where *Z. marina* with *R. maritima* were found combined (blue circle, Fig. 1A). Based on our spatial distribution we were able to calculate the total area cover of *Zostera marina* (green circles, Fig. 1D, Fig. 2) and compare between seasons. As part of our sampling we have found extensive areas cover with *Ruppia maritima* (López-Calderon *et al.* in press) that were not found in the area in previous studies (Santamaria Gallegos *et al*.2001; Cabello Pasini *et al.* 2003).

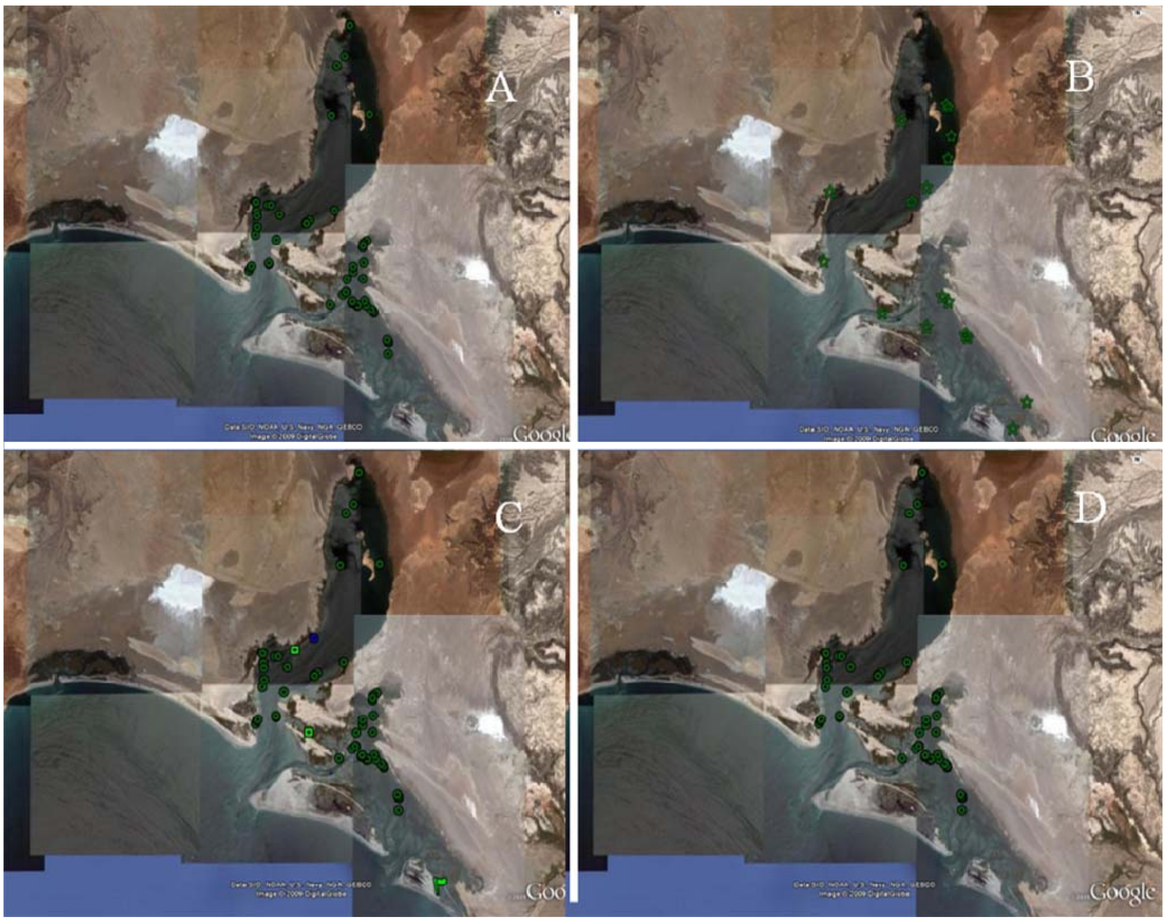


**Figure 1**. GIS maps for San Ignacio Lagoon (December 2008) showing: A) spatial distribution of *Zostera marina* (green circle), *Ruppia maritima* (green square and flag) and *Z. marina* with *R. maritima* (blue circle); b) sites of sediment cores (green stars); c) all sampled sites (blue circles); D) spatial distribution of Zostera marina (green circles).

The areas covered by *Zostera marina* in December and April are shown in Figures 2A-B. In December 29 seagrass beds were identified that represented 3,012 hectares (Fig. 2A); while in April 23 seagrass beds representing an area of 1,114 hectares were observed. This represents a decrease in 1,899 hectares between the winter and spring seasons.

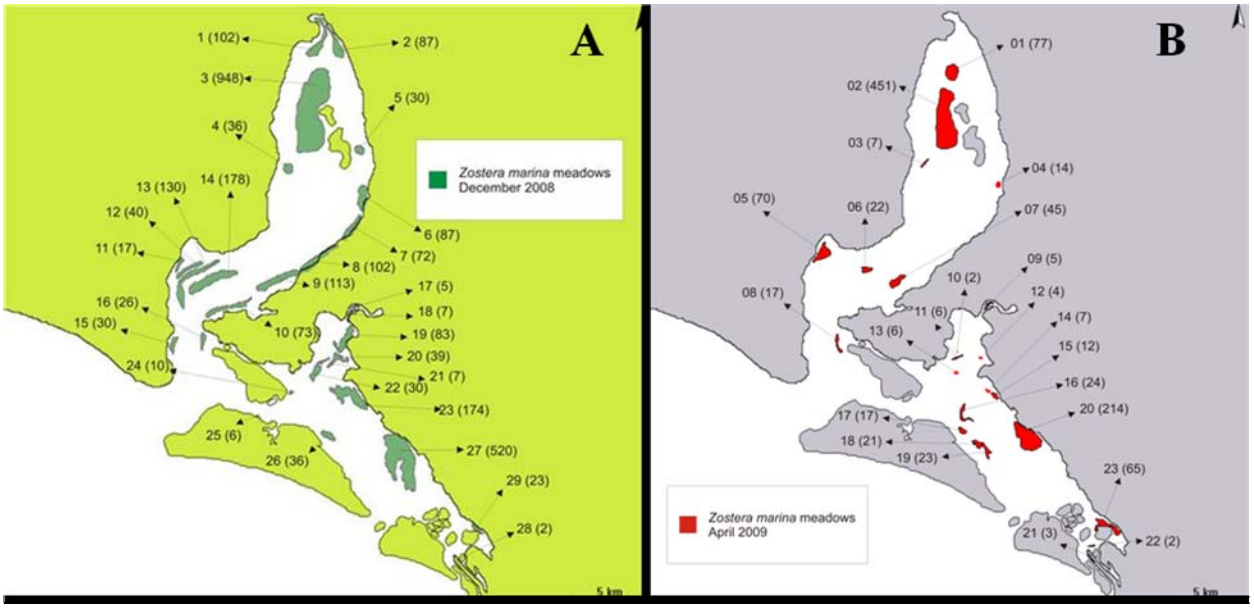

Figure 2. Core number for the sampling developed in September (A) and December 2008 (B).

II. <u>A spatial evaluation of the density and cover of the primary sea grass and algae species in different areas of the lagoon.</u>

The density of *Zostera marina was* variable around the sites sampled within the Lagoon (Fig. 3A, B, C: 18 sites in September *vs* 10 sites in December), in relation to Ruppia maritima (3D) and in Gilmore's lagoon south of the main Laguna San Ignacio (Fig. 3E). In particular, in September 2008 many sites with seagrass had densities ranging from 100 shoots per square meter to areas with up to 800 shoots per square meter (Fig.3A, B, C). The variation in the number of shoots in September ranged from lower mean densities of 50 shoots per square meter to a higher density of 450 shoots per square meter (Fig. 3B). The trend in the head of the lagoon (Fig. 3C) in relation to Gilmore's lagoon (Fig. 3E) is similar between seasons.

The sea grass *Ruppia* was present in fewer sites around the lagoon during both sampling periods (Fig. D); however, the shoot density in September (2 sites) was highest with an average between 1,200 shoots per square meter (Fig. 3D). In December the density of *Ruppia* ranged from a low (one with100 and the other with 400 shoots per square meter) to a high mean densities of over 1000 shoots per square meter (Fig. 3D).

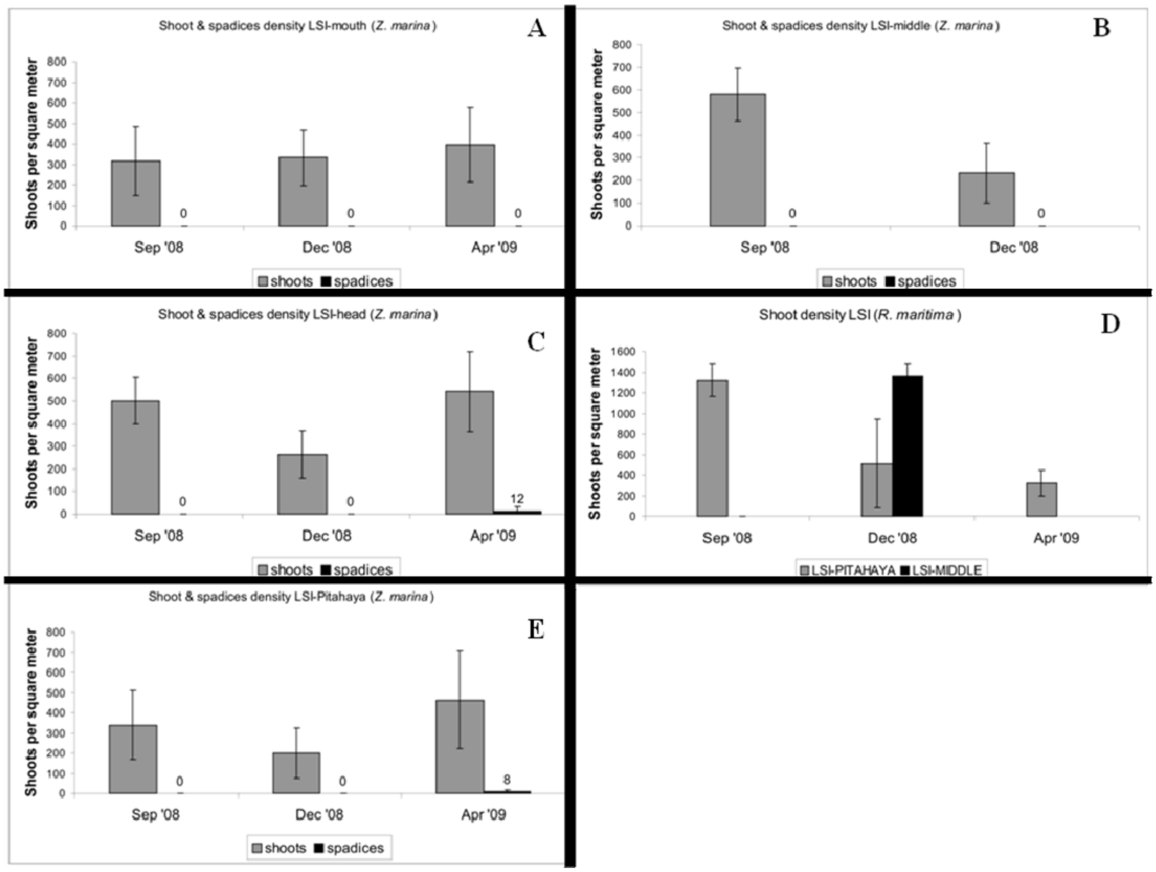


Figure 3. Mean (std) of shoot density per square meter of Zostera marina in mouth (A), middle (B), head (C), and Ruppia marina in September (D) and data from Gilmore's lagoon (Estero La Pitahaya) (E) showing temporal and spatial differences.

III. A spatial evaluation of the associated biodiversity of the primary infauna within the lagoon.

Five (5) primary invertebrate taxa were documented within the seagrass meadows: ascidians, crustaceans, anomurans, mollusk and polychaetes along with *Zostera* seeds (Fig. 4). A strong spatial and temporal variation in the abundance was observed for all these groups. It was particular significant that sea grass seeds were observed in only three (3) of the benthic sediment cores taken in the middle portion of the lagoon, and the seeds were in extremely low density . The density of invertebrates was also low with variations between sampling season (in most cases) and in relation to spatial scales (in all cases).

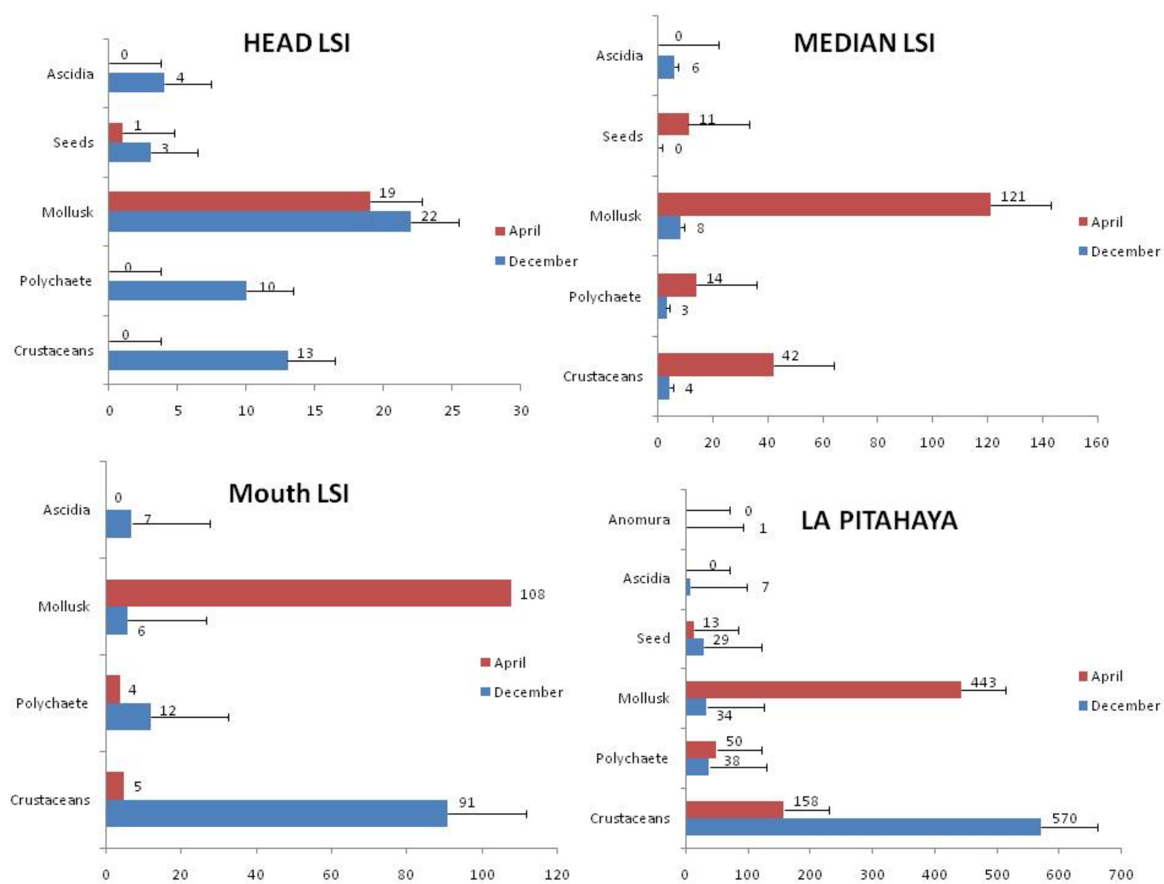


Figure 4. Associated biodiversity of macrofauna and seeds in seagrass beds in San Ignacio.

IV. Determination of the distribution of other biomass seaweed producers.

The biomass (wet weight) of G. vermicullophyla was significantly different for each sampling area ($p < 0.05$) during 2007 and 2008. Similar variation was documented with the appearance and disappearance of the beds in the same site the same year (Fig. 5). This change was similar to that observed in the 2004-2005 samples from this lagoon (Unpublished data). In autumn 2007, a single sea grass bed was found in the lagoon at the southern end of Estero La Pitahaya (Gilmore's Lagoon) (Fig. 5), with a total area of 44,500 m2 and biomass of 135 ± 34 wet tons. This sea grass bed represents an undocumented area without any information on the specific sea grass species, and suggests that this area will comprise increased biomass for the future seasons.

In winter 2008 the sea grass biomass decrease significantly to 12 ± 6.6 wet tons found in two small beds at different sites (Fig. 5). The beds examined in autumn were visited again in winter but they had deteriorated significantly, and contained an abundance of *Aplysia* with densities of 1 individual per m2 and with some individuals measuring over 30 cm in length. These *Aplysia* were grazing actively on *Gracilaria* thallus in this seagrass bed.

Finally the summer sampling revealed a significant decrease in sea grass density compared to the same areas in 2005 and 2008. Contrary to our expectations, only 228 ±52 wt were estimated in these beds. The absence of the *G. vermicullophyla* beds at the mouth of Laguna San Ignacio compared to those observed in the 2006 samples was unexpected. Instead of Gracilaria, small patches of the seagrass *Zostera marina* were found in sites where previously beds of *G. vermicullophyla* were in 2004-2005.

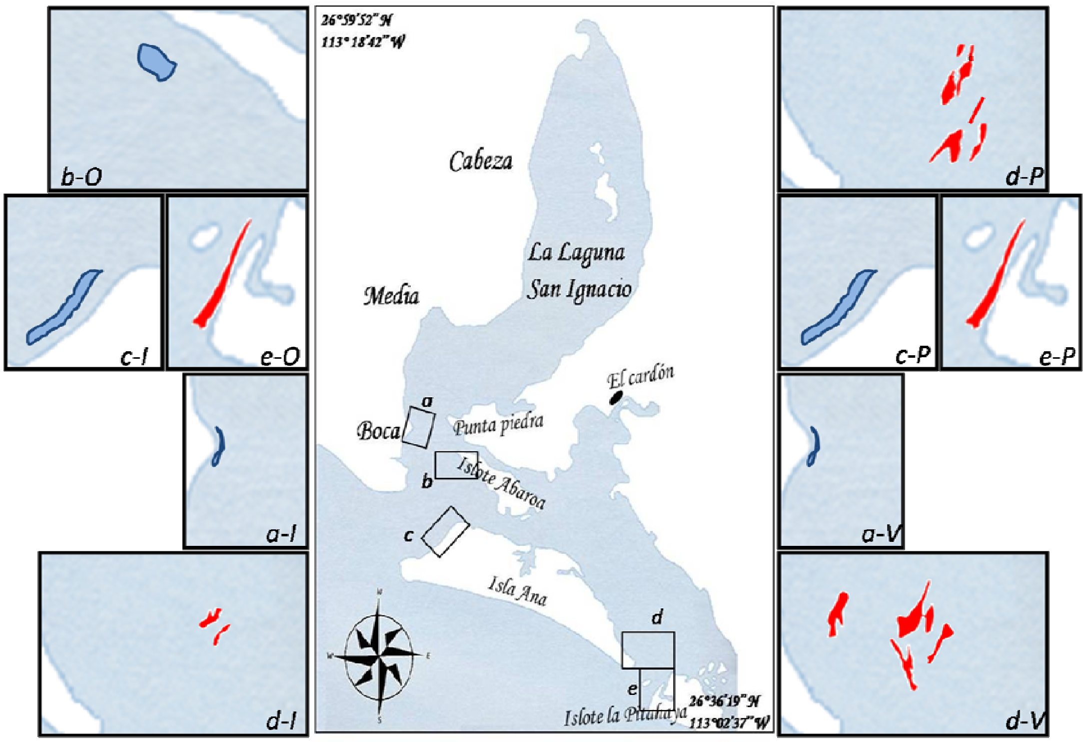


Figure 5. Biomass distribution of Gracilaria vermicullophyla in San Ignacio Lagoon between 2006 (blue beds) and 2008 (red beds).

No difference in the interannual comparison of sea surface water temperature was observed between sampling years (Fig.6). The lowest observed temperature was in 15°C and the highest was 26.5°C, representing a 10 degree seasonal difference between in the years. The historical trend is not sufficiently long enough to demonstrate any consistent historical differences (Calderon-López *et al.* in press).

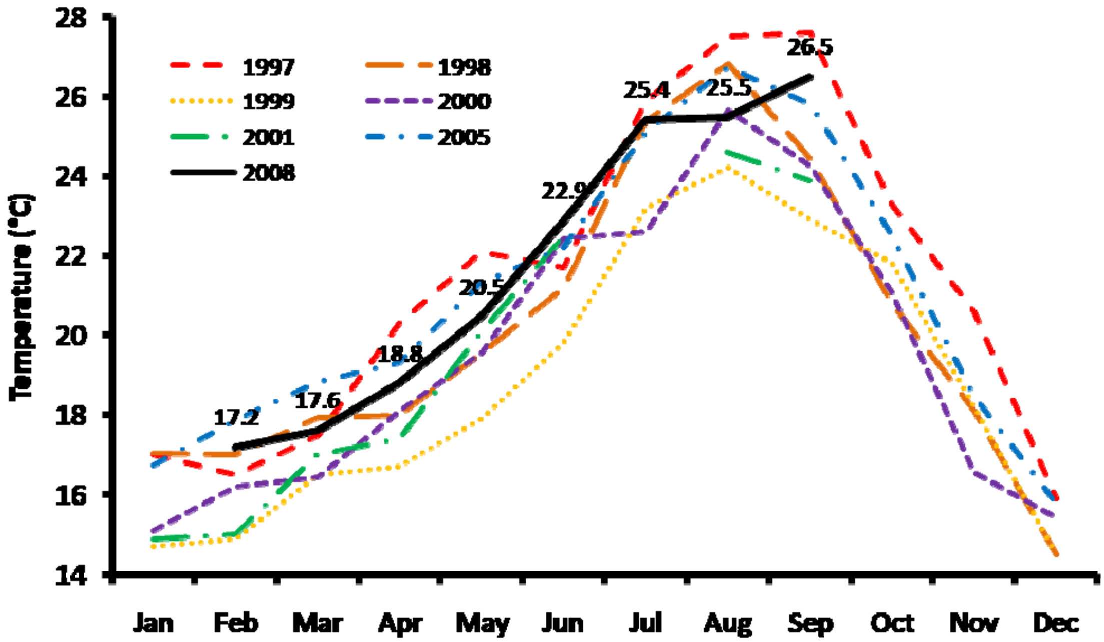


Fig. 6. Interannual variation in seawater temperature in shallow areas of San Ignacio.

V. Comparison of the feeding habits of the green turtle among the main foraging areas in the Pacific Coast of Baja California Sur, Mexico.

The feeding habits of the green turtle were compared among the major foraging grounds of Bahia Magdalena, Laguna San Ignacio, Punta Abreojos and Laguna Ojo de Liebre). Significant differences in the composition and amounts of prey items in the diet of the green sea turtle were observed among these areas (Fig. 6). In particular, there was a noticeable shift in the diet of the turtle in relation to the amount of *Ruppia maritima* eaten in different areas compared to previous reports (Santos Baca 2008), strongly suggesting changes in the relative abundance and availability of the prey species among foraging areas.

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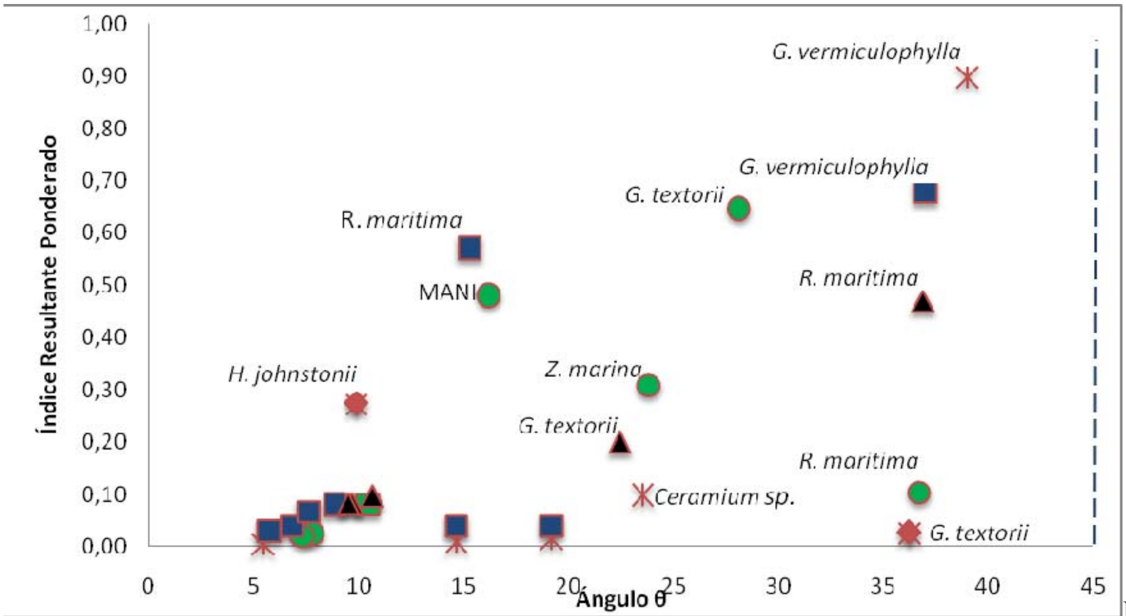


Fig.

Fig. 7. Spatial comparison of the feeding preferences of the green turtle between Magdalena bay (stars), Laguna San Ignacion (green circle), Punta Abreojos (blue square) and Scammon Lagoon (triangle black).

## VI. Future directions of the Research in Laguna San Ignacio (Oct 2009 to 2012).

1. Additional sampling in October 2010 to evaluate size of seed banks.
2. Evaluate potential effects of hurricane Jimena (2009) over previously documented sea grass beds.
3. Develop the historical maps of seagrass distribution based on INEGI aerial photos and old satellite photos.

4. Develop a proposed sea grass loss mitigation project (submitted to CONABIO) to restore lost sea grass beds and to enhance their recovery.
5. Conduct additional sea grass bed mapping efforts in the deeper areas of the Lagoon.
6. Determine to lowest possible taxonomic level the invertebrates collected in 2008 and 2009.

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