Gulf of California 
(Sea of Cortez)

Field trip to Desert Museum this Saturday
• Required field trip (you lose a total of 30 out of 100 course points if you do not go)
• Meet at 7:45 AM on SE corner of Bioscience West (NW corner of 6th St. Parking Garage)
• We have vans – no self driving allowed.
• We will be gone all day (guaranteed return by 5PM).
• Go to bed early on Friday night!
• Bring good walking/hiking shoes, hat, water.
• It may be chilly at 8AM – dress accordingly.
• Wear sunscreen.

Field trip to Desert Museum this Saturday
• If you are doing a plant collection bring your plant collection spiral notebook, tape and clippers/scissors.
• If you are doing an insect collection bring Tupperware and maybe an insect net.
• Reread instructions for plant an insect collections.
• Lunch can be purchased for ~$10 or bring your own.
• If you own binoculars, bring them.

The Sea of Cortez
• 60% of the land of the Sonoran Desert is in Mexico
• 50% of the Sonoran Desert is marine
Land = 240,000 sq km (~93,000 sq mi)
Sea of Cortez = 280,000 sq km
• High biodiversity of Sonoran Desert due to bi-seasonal rainfall
• Summer monsoons derive principally from Gulf of California
• Sonoran Desert is only maritime desert in North America

The Sea of Cortez
• 800 miles long
• 260,000 sq km surface area
(100,000 sq mi)
• Length & basin shape create some of the world’s largest tides (tidal range is 10 m in upper Gulf)
The Sea of Cortez from Space

- Baja is the 3rd longest peninsula on earth (after Malay & Kamchatka Peninsulas)

VISIBLE FROM SPACE:
- Colorado River
- U.S. - Mexico border
- Rain shadow effect of coastal range
- Gran Desierto sand dunes (2,200 sq mi)
- El Pinacate

Low tide in the Northern Gulf

The tide comes up, the tide goes down

Shrimp boat, low tide in Northern Gulf
The abundance of life gives one an exuberance, a feeling of fullness and richness… where the sea swarms with life complete from plankton to porpoise” – Steinbeck and Ricketts 1941.

- Rich oceanic waters support huge numbers of fish & invertebrates.
- 50% of Mexico’s fisheries (60% by economic value).

Southern Gulf
- Modest tides
- Open access to the Pacific Ocean
- Warm saline waters exit the Gulf on the surface.
- Cold bottom waters enter Gulf on bottom, carrying oxygen and nutrients that upwell in Gulf.

MEXICO

-more than a third of the world’s cetacean diversity
- 891 fish species

Faunal Biodiversity in the Sea of Cortez
- ~5,000 named species of invertebrates recorded from Gulf (~12,000 species predicted)
- 1,115 species of vertebrates
- 36 marine mammals, including 31 cetaceans (whales & porpoises) --
Gulf of California

“The world’s aquarium” (J. Cousteau)
“Mini-Galapagos”

Isolated sea, many coves, islands, islets, desert subtropical/tropical habitats

800 islands and islets

Diversity

.008% of world’s seas = Gulf of California

Diversity of fish rivals that of Bermuda and Hawaii
Biodiversity “hot spot”

Diversity

<table>
<thead>
<tr>
<th>Type</th>
<th>Numbers</th>
<th>endemics</th>
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<tbody>
<tr>
<td>Marine invertebrates</td>
<td>4839</td>
<td>749</td>
</tr>
<tr>
<td>Marine mammals</td>
<td>36</td>
<td>1</td>
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<tr>
<td>Marine turtles</td>
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<td></td>
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<tr>
<td>Fish</td>
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<td>75</td>
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<td>Birds, sea and shore</td>
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<td></td>
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<tr>
<td>Birds</td>
<td>626</td>
<td>62</td>
</tr>
<tr>
<td>Macroalgae</td>
<td>530</td>
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</tr>
</tbody>
</table>

~ 10% endemics

Island land animals
many reptiles, birds, mammals (50% endemics)

Endemic = originated in and found only in a certain region

Marine invertebrates (almost 5000 species, 749 endemics)
CNIDARIA - Sea Anemones and their kin

- 259 species of Cnidaria known from Gulf
- 21% endemic
- 526 species predicted to occur in Gulf

Mud tube anemones

CNIDARIA

- Jellyfishes (Scyphozoa)
- Only 5 species of jellyfish reported from Gulf - but at least 25 occur there.

CNIDARIA True corals - 40 species in Gulf

Dendrophyllia oldroydi
PLATHELMINthes

- 22 species of flatworms described from Gulf, 40% endemic.
- 110 species predicted to occur in Gulf.

NEMERTEA  Ribbon worms

- 17 species in Gulf; 12% endemic.
- 30 species predicted to occur in Gulf.

ECHIURA (Spoon worms)

- 4 species of Echiura in Gulf, 1 endemic.
- 7 species predicted to occur in Gulf.
POLYCHAETA (Segmented worms)
7 species of Chaetopteridae - parchment worms

CRUSTACEA
- 1,026 species of Crustacea in Gulf, 12% endemic.
- 1,477 species predicted to occur in Gulf.

CRUSTACEA
- 300 species of true crabs in the Gulf
- 54 species of hermit crabs occur in the Gulf
CHELICERATA  Pycnogonids (sea spiders)
15 species reported, 45 species predicted to occur in Gulf

MOLLUSCA
- 2,193 species of molluscs in Gulf (most diverse phylum in Sea of Cortez)
- 21% endemic (460 species)
- 2,590 species predicted to occur in Gulf

MOLLUSCA, GASTROPODA
All of the large attractive snails have disappeared from shallow waters due to over-collecting.

MOLLUSCA, CEPHALOPODA
- 20 species of cephalopods (octopuses & squids) in Gulf, 4 endemic

Crown sea slug, Chromodoris morris

MOLLUSCA, GASTROPODA -- SEA SLUGS
- 144 species of sea slugs ("nudibranchs") described from Gulf

Octopus bimaculatus, two-spotted octopus

Clypeola resplendens

Tent olive, one of 35 olive snails in the Gulf
Heliaster, the sunstar, crash in 1978, now returning

*Endemic* to Gulf of California

Lives in intertidal zone

“Keystone” predator on the reef

Pre-1978

one individual/m² on the reef

“keystone predator” top predator

that eats many other species

1978

population crashed

extremely rare for almost 20 yrs

still not common

endemic = where originated and currently found

Heliaster kubinjii

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Heliaster, the sunstar, crash in 1978, now returning
31 species of cetaceans (whales & dolphins) inhabit the Gulf -- 34% of all the world’s marine cetacean species!

Some migratory have given up migrating due to the abundance of food in Gulf (e.g., fin whales, sperm whales).

- Fin whale
- Common dolphin
- Gray whale

Long-beaked common dolphin (Delphinus capensis) and bottlenose dolphin (Tursiops truncatus)

Gulf of California, Bahia de los Angeles,

http://www-cs-students.stanford.edu/~robles/bc/bajacalif.html
California sea lion (*Zalophus californianus*)

http://www.oceanoasis.org/fieldguide/zalo-cal.html

Fin whale (*Balaenoptera physalus*)

http://www.exzooberance.com/virtual%20zoo/they%20swim/fin%20whale/Fin%20Whale%20314040.jpg

Gray whale (*Eschrichtius robustus*)

Baja, Loreto, Gray whale calving ground

http://www.exzooberance.com/virtual%20zoo/they%20swim/fin%20whale/Fin%20Whale%20314040.jpg

Gray whale migration, 10,000 miles rt

http://www.arkive.org/species/GES/mammals/Eschrichtius_robustus/more_moving_images.html

Gray whale movies
**Vaquita**

*Phocoena sinus*

The marine mammal with the "most-est"

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**Smallest**  
**Most restricted range**  
**Most secretive**  
**Most endangered**  
“critically endangered”  
250 left

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**Vaquita**  
*Phocoena sinus*

Size: 120 lbs (55 kg), less than 5 feet long (1.5m)  
Color: gray back, pale belly, dark eye ring and lips in adults, babies uniformly gray  
Shape: relatively tall dorsal fin and long pectoral fins for a porpoise  
Behavior: alone or small groups (2, 4, or 10 max). Shy.  
Endemic to Northern Gulf of California

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**Vaquita**  
*Phocoena sinus*

Threats:  
• 40-60 killed each year in gillnets (fishing boats) and trawling nets (shrimp boats)  
• habitat loss due to damming of Colorado River

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WWF-Mexico proposes the following milestone to save the vaquita:  
By 2009, bycatch of vaquita in the Gulf of California be reduced to no more than one animal per year. To achieve this, they suggest:  
• a wildlife refuge covering the distribution area of the vaquita that falls outside of the Upper Gulf of California Biosphere Reserve  
• Eliminate the use of gillnets and shrimp trawls in vaquita habitat  
• Make progress on alternative gears and other sustainable economic alternatives for local fishermen and communities
Blue whale, minke whale, humpback whale...

34 species of marine mammal in the Gulf of California

• 181 aquatic bird species in Gulf.
  • Entire breeding populations of some sea birds (e.g. Elegant Tern, Heermans’s Gull, Yellow-footed Gull) occur within the Sea of Cortez.

• Isla Raza protected in 1964 through efforts of the Desert Museum

Isla Raza

http://www.oceanoasis.org/fieldguide/islaraza.html

Isla Raza

Heermans’s Gull
Nest on Isla Raza & Little Cardenoza, summer
150,000-300,000 pairs
Migrate to B.C.

http://www.oceanoasis.org/fieldguide/islaraza.html
Heerman’s gulls and Elegant terns breed on Isla Raza

Isla Raza
Sterna elegans, Elegant tern
90% of world population nest on Isla Raza

http://www.oceanoasis.org/fieldguide/islarasa.html

videos

Isla Raza
Sterna elegans, Elegant tern
22,500 pairs on Isla Raza, 2000
Other nests elsewhere (eg, San Diego)
1940, 1 million birds on Raza
1960s, 25,000 birds
1973, 5000 birds
1963/4, rat eradication program
1993, 350,000 heermann’s gulls
1994, 45,000 elegant terns
1964, declared a legal bird sanctuary
Threats: egg collecting, rats, fishing camps, 300 ecotourists per year
More noisy than royal tern

http://www.oceanoasis.org/fieldguide/islarasa.html

Pair of black sea turtles

Sea turtles of Baja
Green turtle (aka black turtle)
Loggerhead
Olive Ridley
Hawksbill
Leatherback
New shark species from the Gulf of California, 2003

Mustelus hacat, 1 m long, lives at 250 m

Pacific Seahorse

Eels and seahorses are fish.

Garden Eel:

- Eels and seahorses are fish.
- Garden eel:

Threats to Biodiversity

Death of the Colorado River

- 20 dams & thousands of kilometers of canals have converted the Colorado River into a totally controlled plumbing system.
- Prior to Hoover Dam (1935), ~15 maf/year of river water reached the upper Gulf annually.
- 100 years ago, river boats steamed from the Gulf into the Colorado/Gila River system -- major steamship port in Yuma.

Today:

- Almost no river water reaches the Gulf, except during “flood years.”
- The Delta has switched from a depositional basin to an erosional basin, as tides now remove ancient sediments.
- The Delta and its marshes are disappearing into the deep basins of the Gulf
- Spawning & nursery grounds for commercial species of fish and shrimp are being lost.
• Flow of Colorado River created brackish habitats (less salty than sea water).
• Now the tides have made this area hypersaline.
• The many plants and animals that lived in the fresh or brackish waters of the delta are gone.
• Was an incredible area for native and migrating birds, spawning grounds for fish and invertebrates.

Cienega de Santa Clara

• Drain water has been siphoned into a concrete canal and dumped at the Mexican border for the last 30 years.
• This has created a highly productive wetland which is the last surviving remnant of the vast Delta wetlands!
• Many species are being maintained here.
• Home to thousands of birds and a critical link in the Pacific Flyway.
The Gulf Shrimp that we eat start their lives as free-floating larvae out in the sea.
They move into shallow marshes and estuaries with brackish water
When they reach a subadult stage they go back out in the sea.
Loss of the Colorado delta and other estuaries has reduced shrimp numbers.

The fabled Totoaba
- Found in the northern Sea of Cortez.
- Formerly abundant and intensely fished.
- Now rare and endangered.
- Predatory fish, lives up to 15 years, matures at 6-7 years.
- Spawn in Colorado delta, where the larval and juvenile stages live in brackish water.
- Adults live out in the open sea only returning to the delta once a year in springtime to spawn.

The fabled Totoaba
- It could be a big fish!
- Fishing started in the 1920’s reaching 2,000 metric tons in 1943.
- By 1975 down to only 50 tons.
- Mexico banned fishing.
- Now stabilized at a low level.
- Bladders - a Chinese soup – Seen Kow
- still worth about $100 each on the black market.

The fabled Totoaba
- Double trouble:
  - Requires the old Colorado River delta conditions for reproduction.
  - Recovers slowly from fishing, due to long life and delayed maturity.

Threats to Biodiversity
- Extraction of sea life for tourist trade.
Threats to Biodiversity: Over Fishing
Nearly every fishery in the Gulf is over-fished.

- Bottom trawlers (shrimp boats)
- Purse seiners (anchovy/sardine boats)
- Gill nets
- Long lines
- Artisanal (family) fishing (~25,000 pangas in Gulf)

- More than 1,000 shrimp trawlers operate in the Gulf.

- A bottom area of sea floor equivalent to 2X the total size of the Gulf is dragged annually.

Bycatch
Non-target fishes caught accidentally in fishing gear

Damage by Bottom Trawling
*equivalent of clear cutting forests

- Trawlers continually disrupt bottom communities.
- Completely remove seafloor life — then rain dead animals ("by-catch") back to the sea floor, creating "dead zones" of hypoxia.
- Capture up to 40 kg of by-catch for every 1 kg of shrimp caught — most inefficient fishery on earth ~ 95% waste
- Catch per unit effort has been declining since the 1970s.
- Federal government subsidizes over-harvesting and over-capacity of fishing fleets (cheap diesel fuel, prop up fishing cooperatives, etc.)
Is Aquaculture the Answer?

95% of the mangrove lagoons in Sonora have been developed as shrimp ponds.

Threats to Biodiversity:
Aquaculture

- Conversion of estuaries to shrimp farms.
- Destruction of mangroves.
- No government regulation of runoff (food, wastes, drugs, exotic disease organisms, etc).

Former mangrove lagoon in Gulf

Destruction of coastal mangrove lagoons eliminate habitat for hundreds of species, including critical nursery grounds for nearly all commercially important shellfish and finfish in the Gulf.
"The abundance of life gives one an exuberance, a feeling of fullness and richness... where the sea swarms with life... complete from plankton to porpoise" – Steinbeck and Ricketts 1941.
The Sea of Cortez is “exhausted but not yet dead”. NYTimes 2002.