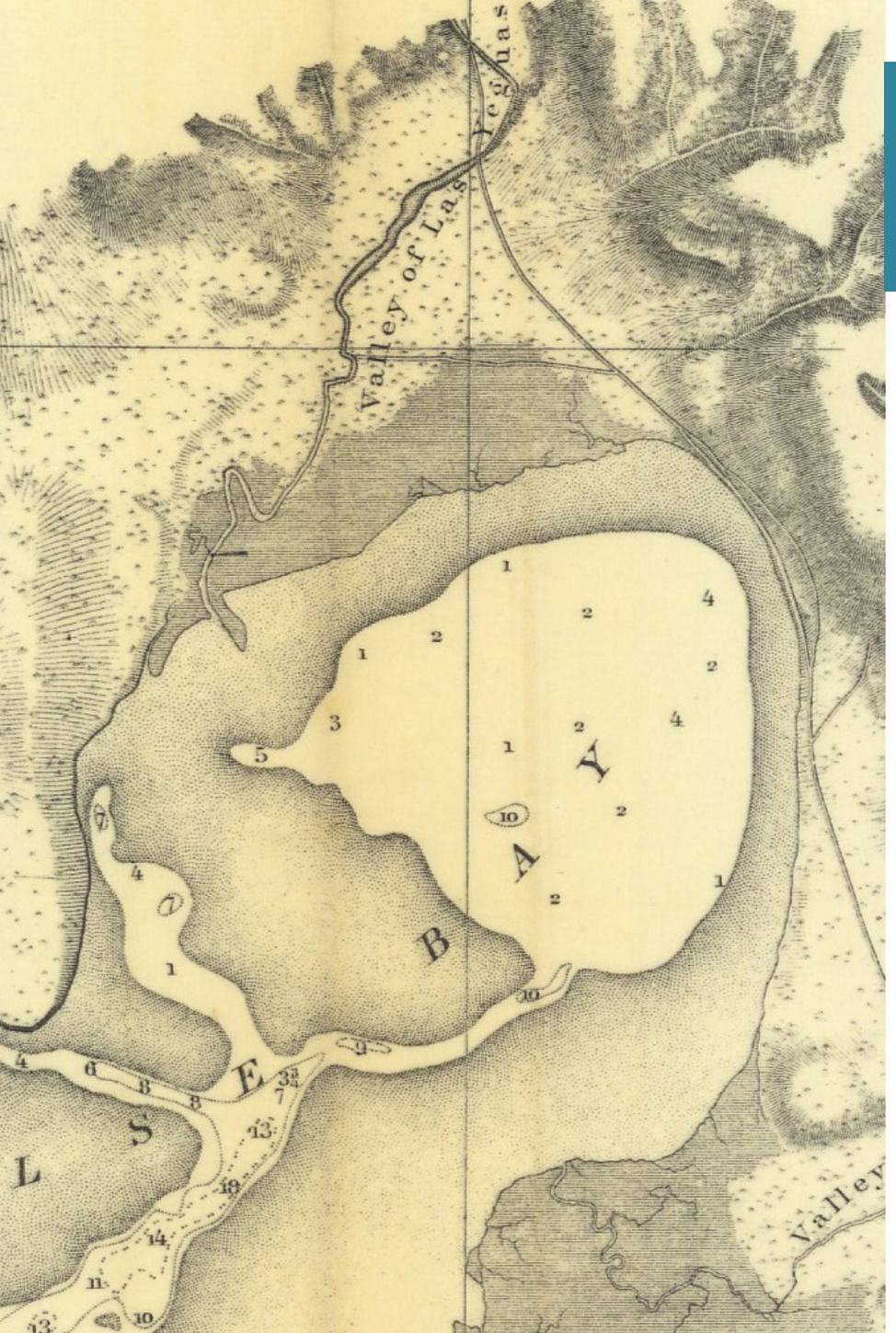


Mission Bay Historical Ecology Reconnaissance Study

Data collection summary and initial findings

March 17th, 2016 • *Presentation to*
The San Diego Audubon Society
ReWild Mission Bay Wetlands Working Group
ReWild Mission Bay Science & Technical Advisory Committee
Everest Consultants

San Francisco Estuary Institute
Resilient Landscapes Program

Sam Safran
Emily Clark
Erin Beller
Robin Grossinger

Using the past to understand the present landscape and envision its future potential

- Not just the "way things were," but the "way things work"
- Understand system pattern and process at broad temporal and spatial scales
- Not about recreating the past!

Image removed due to copyright status.
To be included at a later date.

California systems reconstructed

Sacramento-San Joaquin River Delta

Napa River

Mark West Creek

Marsh Creek

Alameda Creek

Penitencia Creek

Coyote Creek

Guadalupe River

Uvas Creek

Llagas Creek

Pajaro River

Salinas River

Ventura River

Santa Clara River

Ballona Creek

San Gabriel River

Mission Bay reconnaissance

Tijuana River

Funding: State Coastal Conservancy and San Diego Audubon Society
Start date: February 2015

Project goals

- Collect archival and geophysical data on Mission Bay that can help to characterize ecological, hydrological, and geomorphic conditions and dynamics in the recent past
- Identify possible future research directions
- Ultimately support conversations on habitat restoration and management strategies

Image removed due to copyright status.
To be included at a later date.

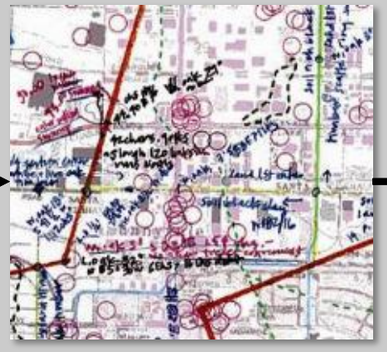
View image here:
http://www.sandiegohistory.org/photostore/product/mission-bay-aerial-c-1917/

Shows vegetated islands in western Mission Bay.

Steps in an historical ecology study

Reconnaissance study

Collection



Compilation

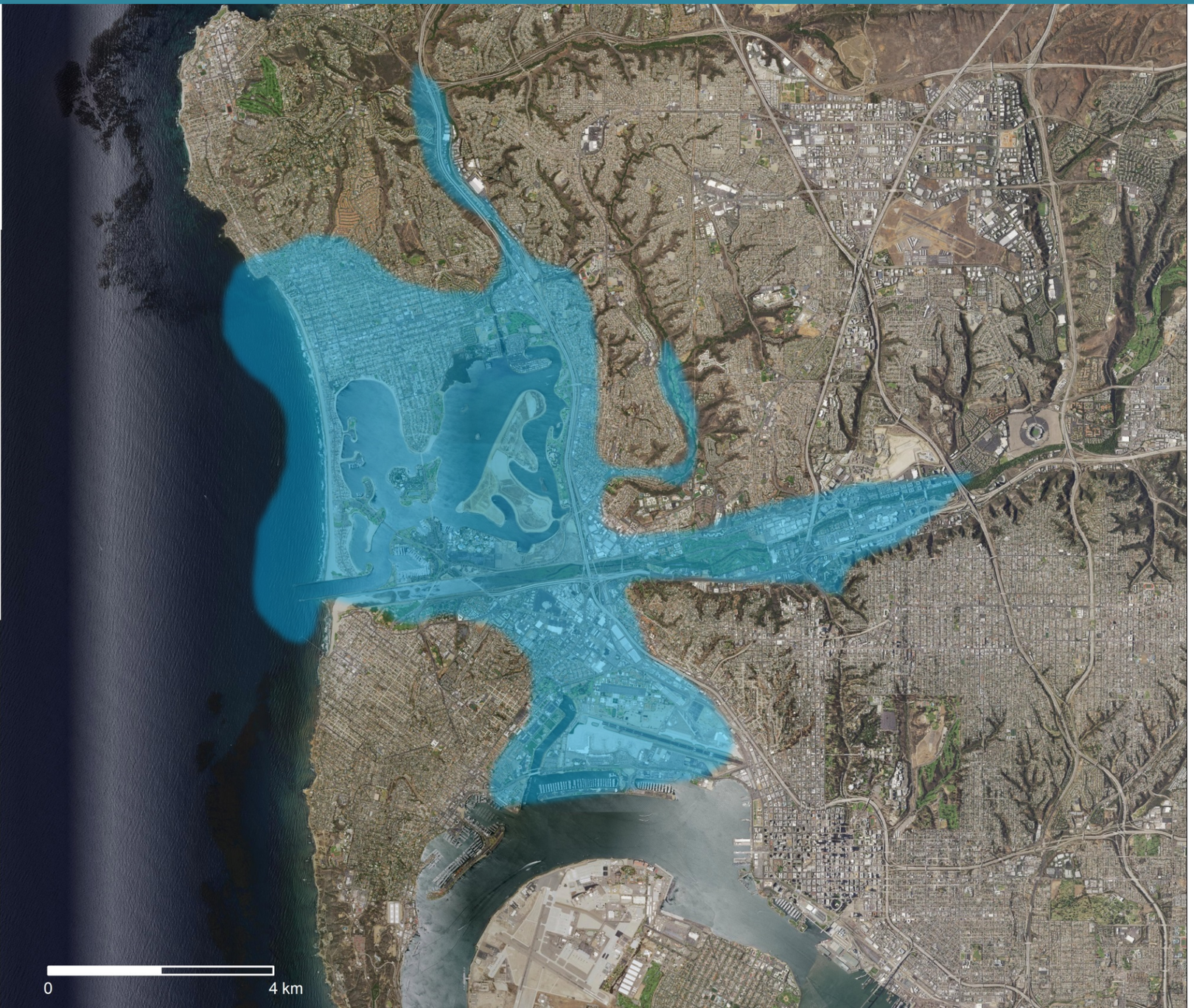
Synthesis

Analysis

Reporting

What are some of the preliminary observations, storylines?

Study extent



- Mission Bay including surrounding coastal plain and the lower reaches of its historical tributaries

Study extent

- Mission Bay including surrounding coastal plain and the lower reaches of its historical tributaries
- Priority focus area is northeast corner

courtesy ReWild Mission Bay

Goal: *pose questions relevant to current management issues to guide historical research*

Habitat Types, Distribution Extent

- Coastal/estuarine, riparian, aquatic, terrestrial
- Seasonal and inter-annual variability

Fluvial Hydrogeomorphology

- Character of freshwater inputs
- Channel planform
- Channel stability
- Head of tide
- Dry-season flow

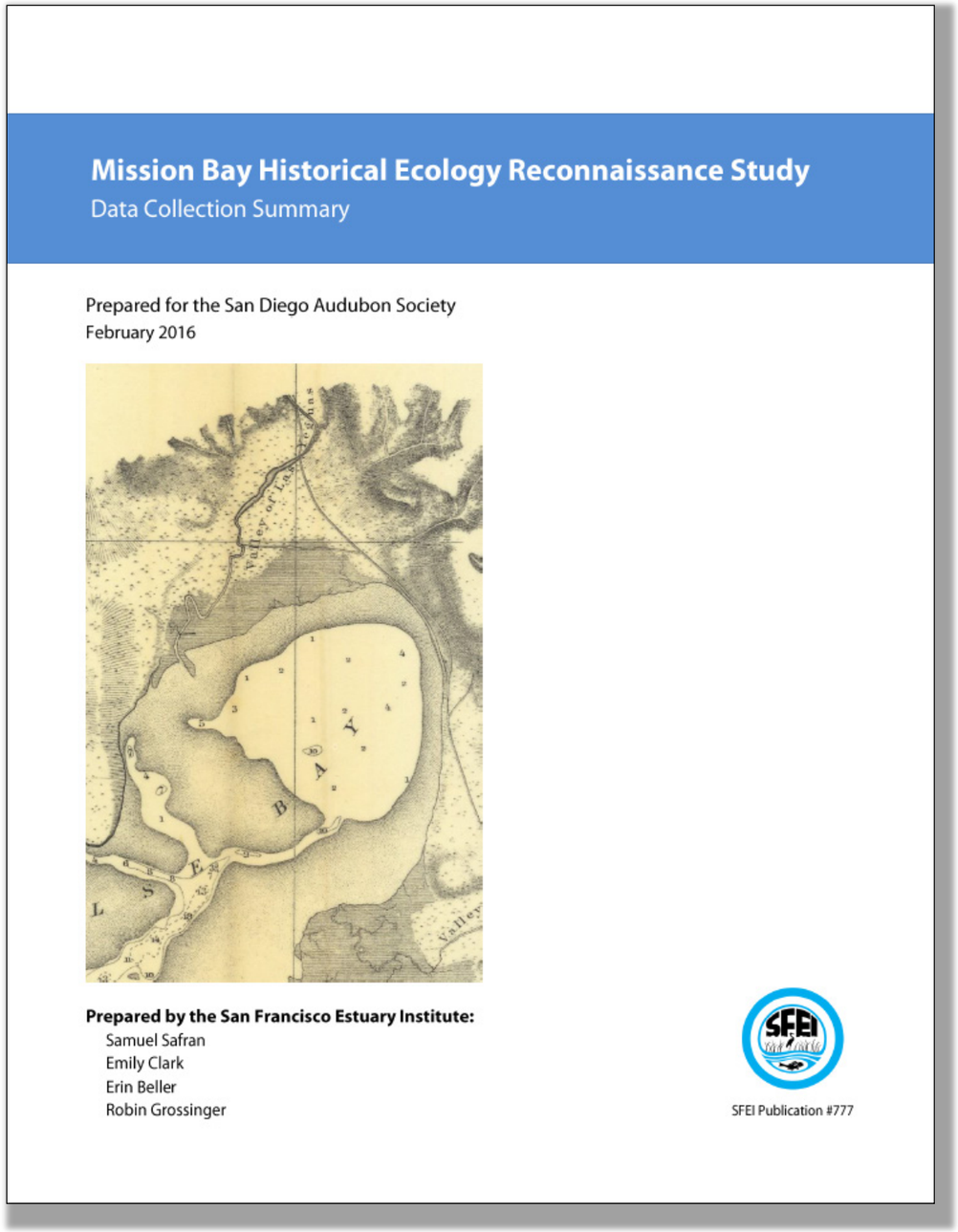
Historical Context

- Indigenous land use
- Change over time
- Contaminant sources

Other questions

- Extent of De Anza Point
- Species distribution
- Fish foraging in Rose Creek
- Earthquakes, rainfall, temperature data

Primary : *Northeast Mission Bay and lower Rose Creek*
Secondary: *remainder of Mission Bay and lower parts of tributaries*



Mission Bay Historical Ecology Reconnaissance Study

Data Collection Summary

Prepared for the San Diego Audubon Society
February 2016

Prepared by the San Francisco Estuary Institute:
Samuel Safran
Emily Clark
Erin Beller
Robin Grossinger

SFEI Publication #777

MBHE Data Collection Summary technical memo

- Delivered to SDAS in February 2016
- Summarizes data collection and compilation efforts
- Includes reproductions of priority data
- Describes other data collected
- Outlines next steps

Online data collection

- Online Archive of California
- California Digital Newspaper Collection
- Google Books
- Library of Congress
- Museum of Vertebrate Zoology Archives
- Smithsonian Archives
- Society of California Pioneers
- Huntington Digital Library
- NOAA Historical Map & Chart Collection
- USGS Photo Archive
- San Diego Public Library Digital Archive
- Edward H. Davis Collection
- David Rumsey Map Collection
- Sanborn Maps
- Barry Lawrence Ruderman Antique Maps
- Penny Postcards
- Wieslander Vegetation Type Maps & Photographs

Archival visits

- San Diego History Center
- UC San Diego Special Collections & Archives
- Scripps Institution of Oceanography Archives
- SDSU Special Collections & University Archives
- UC Riverside Water Resources Collections and Archives
- The Bancroft Library (UC Berkeley)
- UCB Earth Sciences and Map Library

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Image removed due to copyright status. To be included at a later date.

View image at:
http://www.sandiegohistory.org/photostore/product/mission-bay-aerial-looking-north-c-1935-cropped-15968/

Image removed due to copyright status. To be included at a later date.

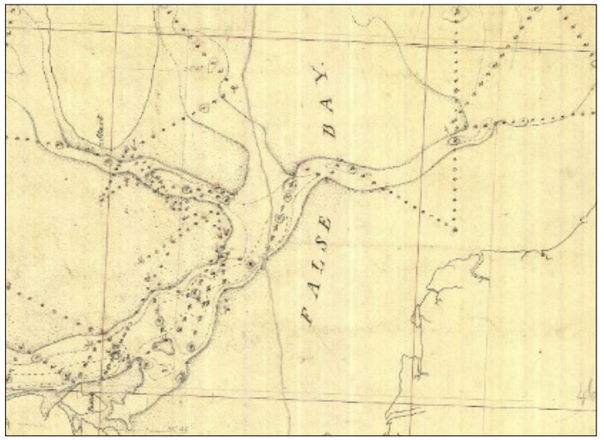
View image at:
http://www.rosecreekwatershed.org/docs/SDARC.pdf
(page 12)

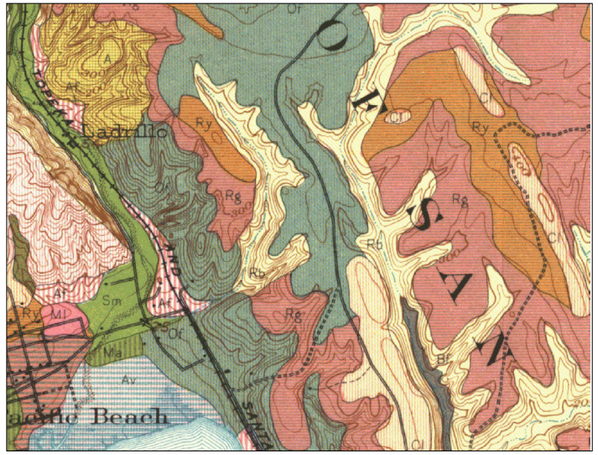
Photographs

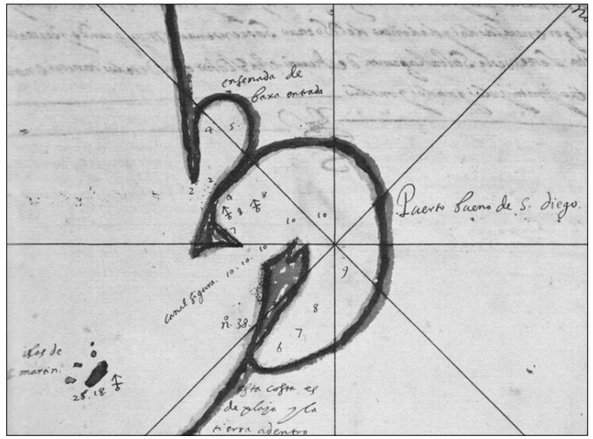
~300 landscape photos
~30 mosaicked aerials

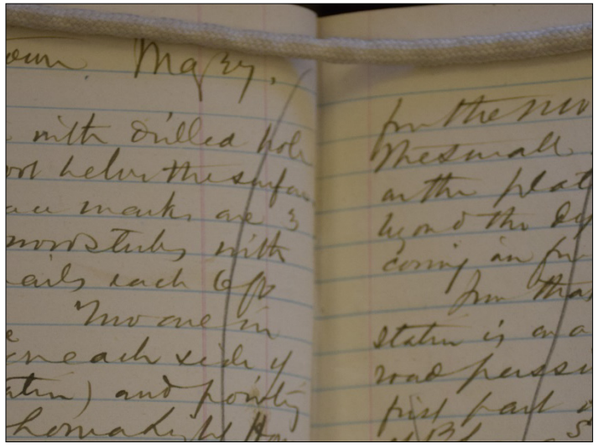
Maps

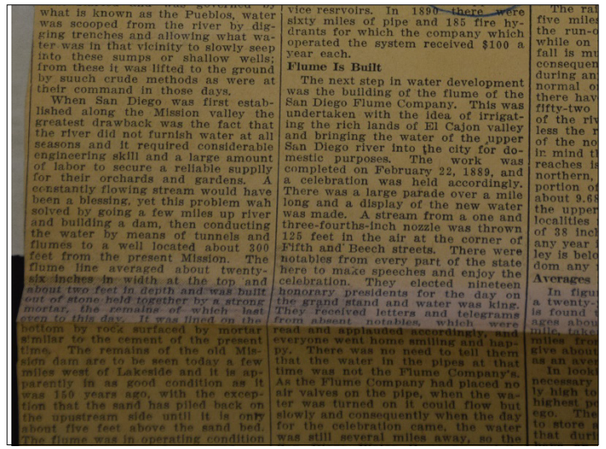
~100 maps
~10 georeferenced

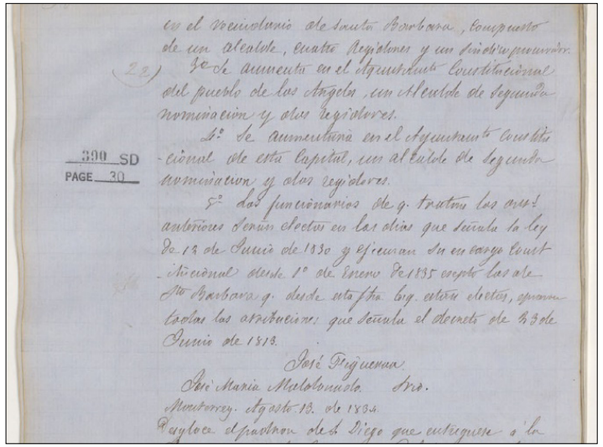












Texts

Hundreds of documents reviewed
~80 pages transcribed

T-Sheets

- Harrison 1852
- Rodgers 1889
- USCGS 1933

Soil maps and surveys

- Holmes and Pendleton 1918
- Storie and Carpenter 1930

GLO

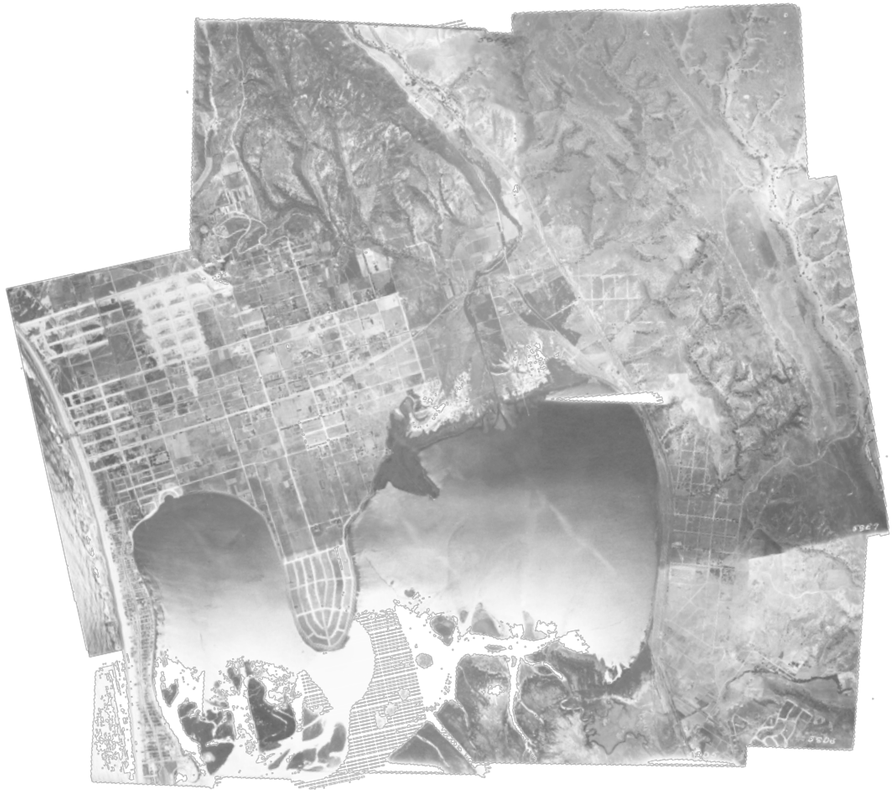
- Very little available since study extent falls within extent of Pueblo Lands of San Diego
- 1858 notes obtained

Quads

- La Jolla- 1903, 1930, 1943, 1953, 1967, 1975, 1996
- San Diego- 1904, 1930
- Point Loma- 1942, 1953, 1967, 1975, 1991, 1996

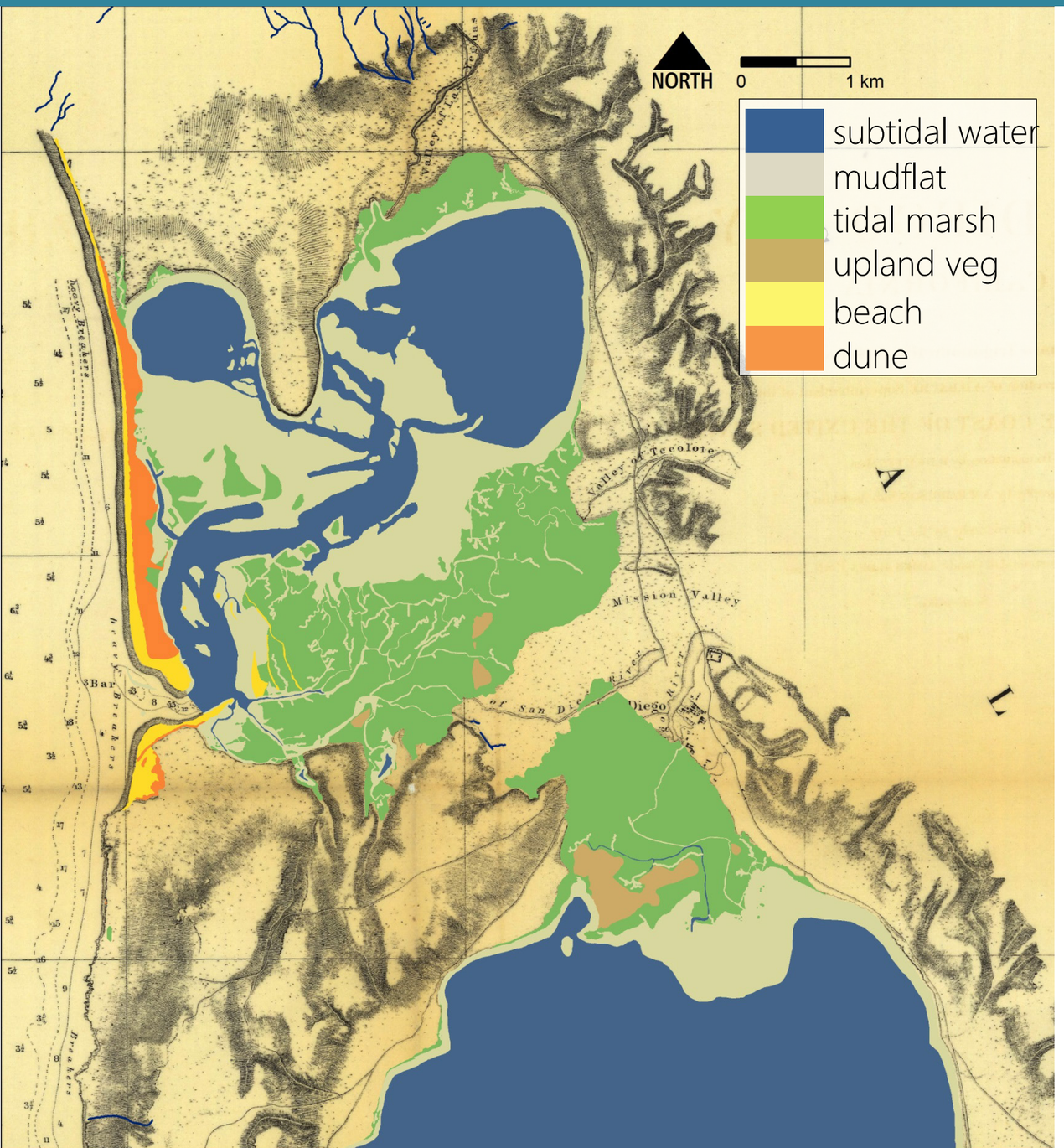
Aerial photographs

- San Diego County 1928
- Obtained 65 photos
- Of which ~40 cover study extent
- Orthorectified 12-15 photos that cover NEMB
- Mosaicked and georeferenced MB photos

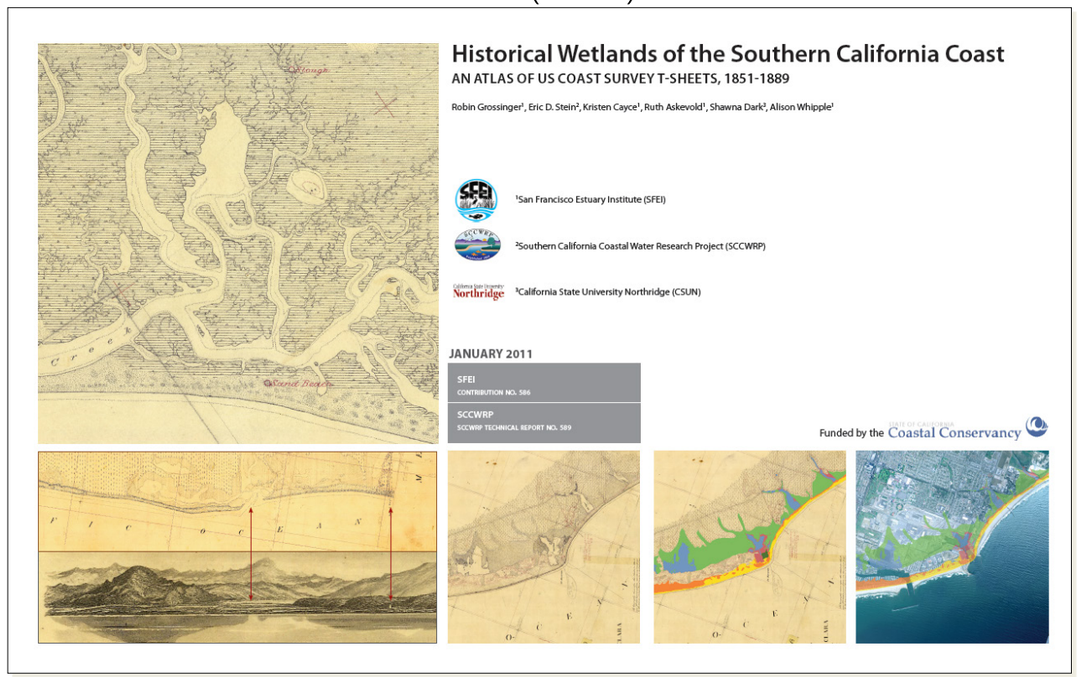


County of San Diego 1928

Data collection summary- standard sources



Previous work: T-Sheet Atlas (2011)



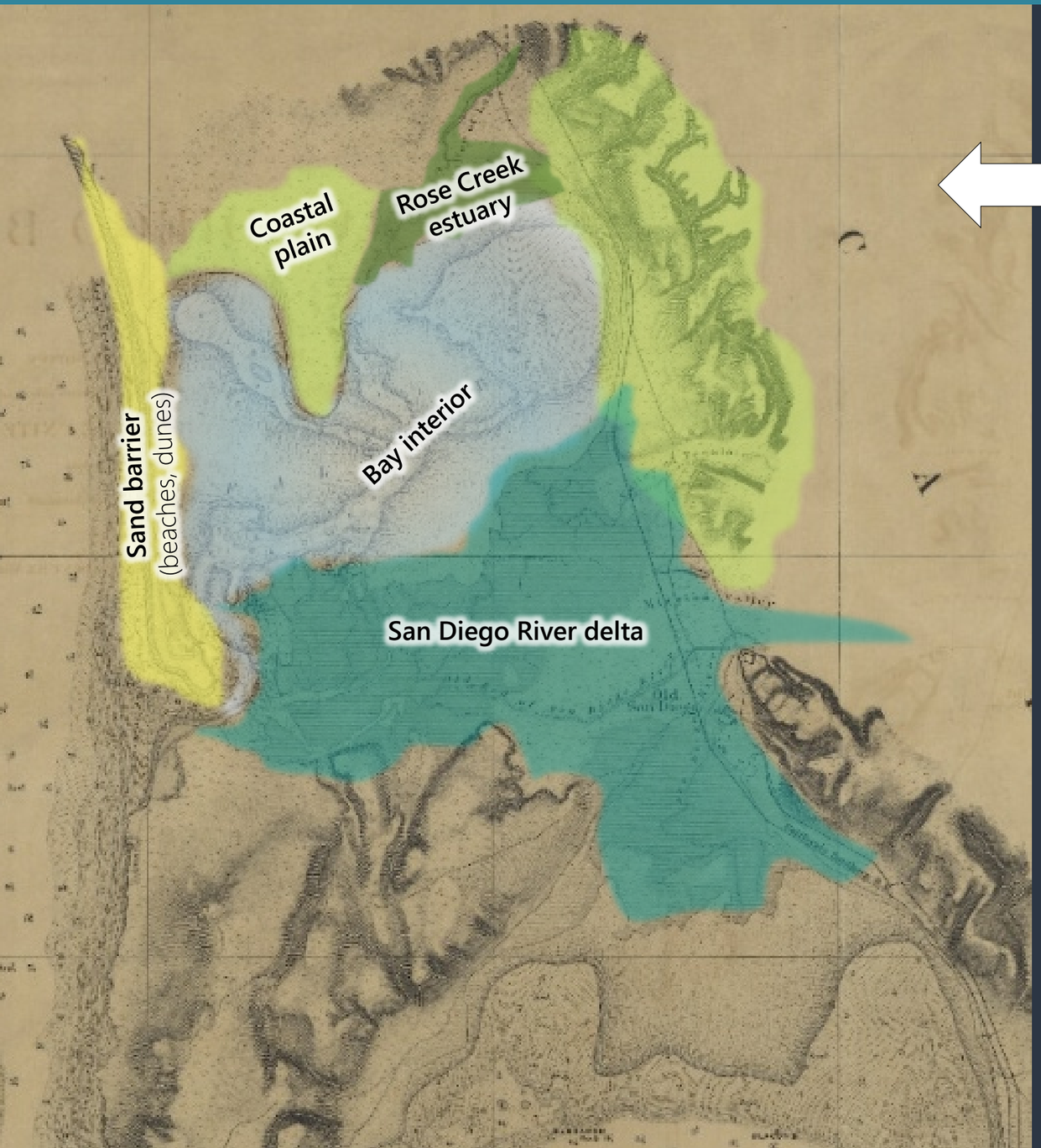
T-sheets are a great starting place!

- Mapped by experienced surveyors
- Very early look at landscape before major modifications
- Produced with high scientific standards and accuracy at an unusually large scale

(but note their limitations)

- only show one point in time
- often limited to estuarine habitats
- symbology can be ambiguous

Overview



One way you might split the historical Mission Bay into ***very*** general regions.

For each of these regions, we will spend remainder of presentation:

- showing additional historical data
- describing initial observations/findings
- discussing new questions raised by the data and possible next steps

Rose Creek estuary

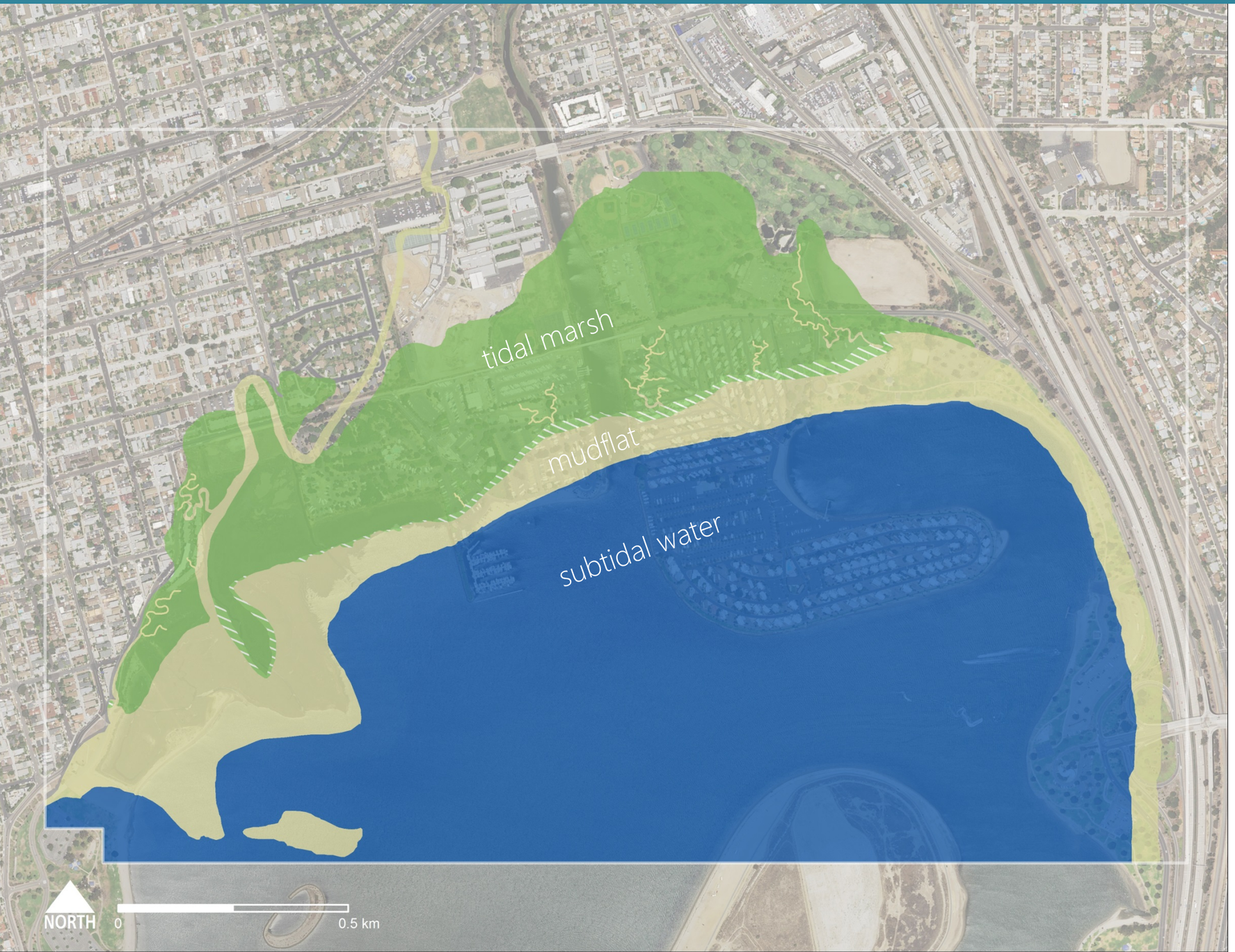
Guiding questions

- Extent and distribution of estuarine habitat types in NEMB?
- Extent of De Anza Point?
- Rose Creek planform, position, stability, head of tide, dry season flow, riparian vegetation?
- Extent of fish foraging?
- Change over time?

Preliminary observations

- Historical data document a wide range of habitat types in NEMB
- Significant changes apparent prior to 20th century, but still need to work out details
- Rose Creek outlet has shifted, tidal-fluvial interface altered
- Seems like flow was intermittent/ephemeral, but some year-round sources of freshwater
- Riparian vegetation apparently significant historically, some indication of longitudinal gradients

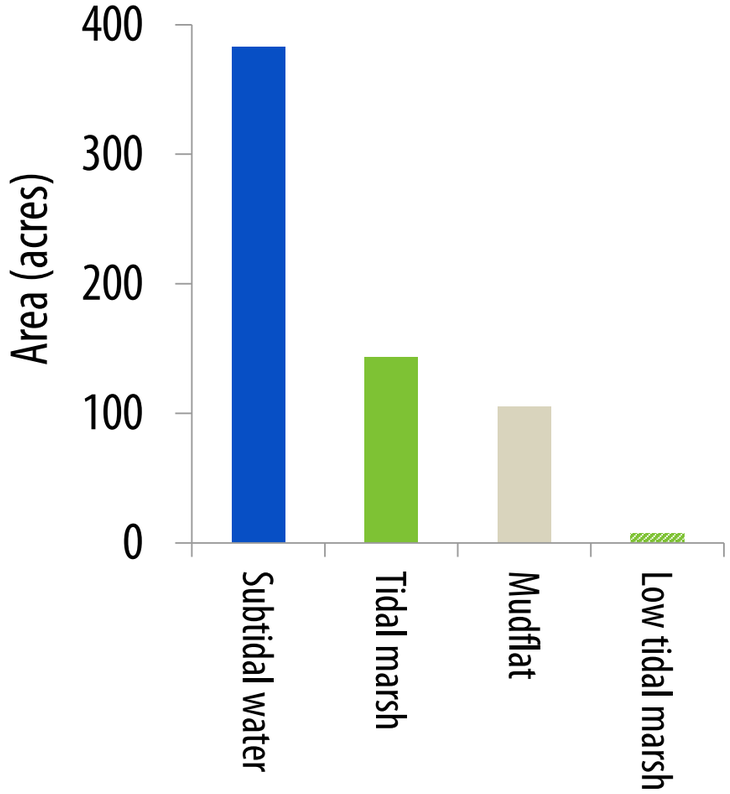
What was the extent and distribution of estuarine habitat types in NEMB?

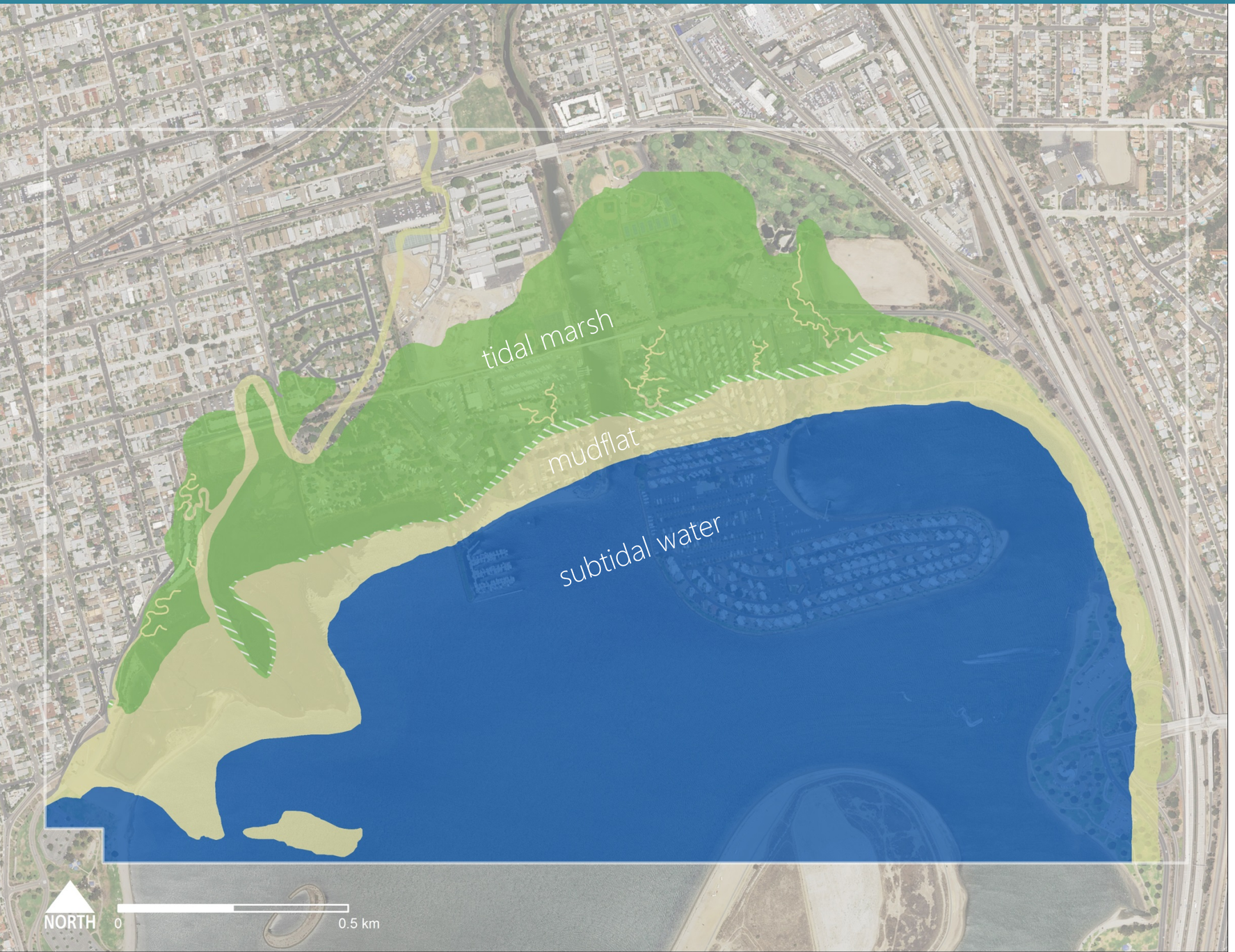


Estuarine habitats (1852)

T-sheet shows a very simple suite of habitat types:

- Tidal marsh plain: 143 acres
- Low tidal marsh: 7 acres
- Unvegetated intertidal flat: 105 acres
- Subtidal water: 383 acres





Tidal channels

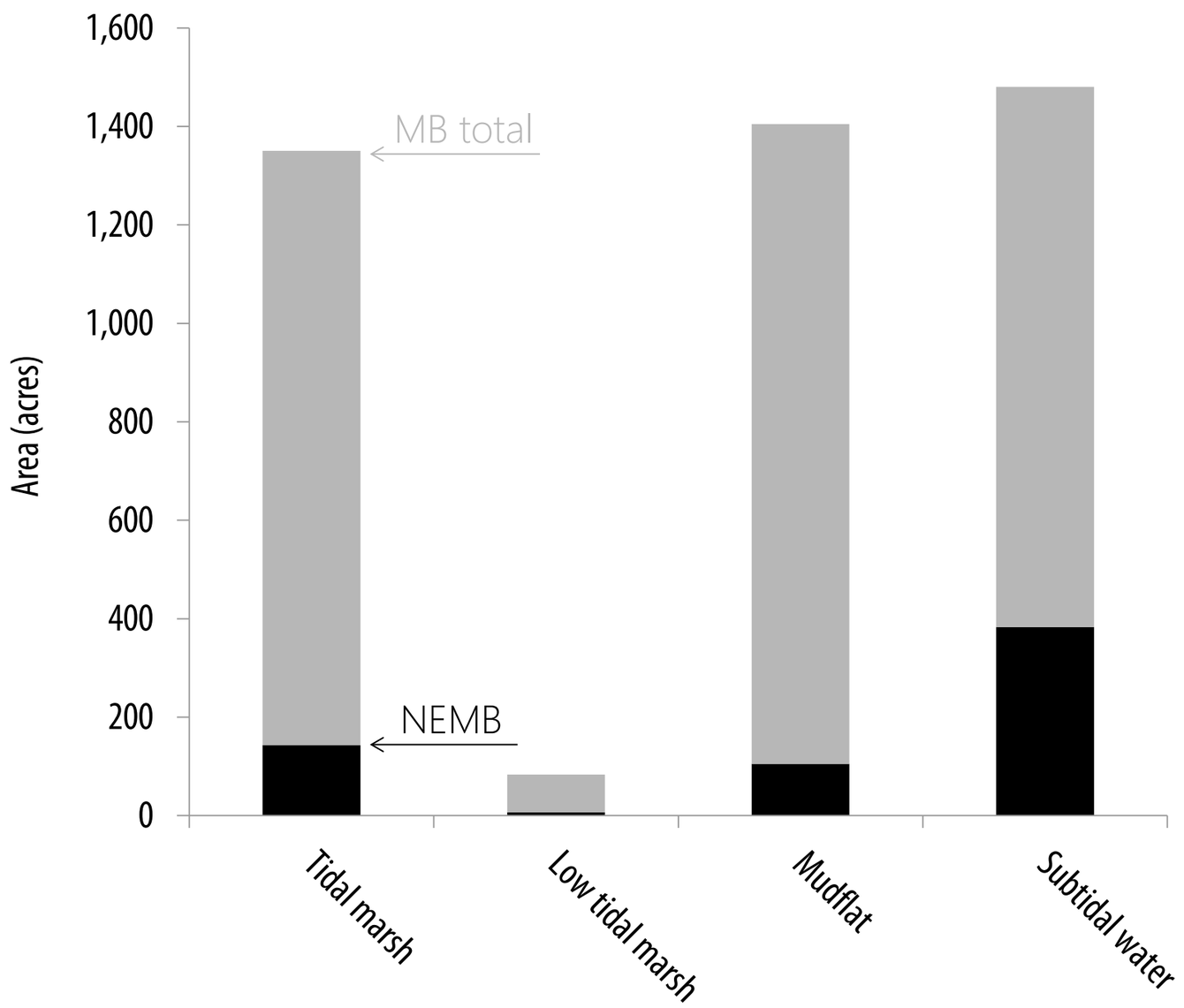
- Rose Creek = 1.7 km
- Others = 6.1 km
- Total = 7.8 km

- Density = 0.013 m/m^2

Low tidal channel density?

No former courses of Rose Creek evident?

How did the northeast portion of Mission Bay compare to other parts of the estuary?



- NEMB was home to:
  - 10% of MB's tidal marsh
  - 8% of MB's low tidal marsh
  - 7% of MB's mudflats
  - 20% of MB's subtidal habitat
- **Ratio of marsh to mudflat** in NEMB was very similar to that of MB as a whole:
  - NEMB: 1.4
  - MB: 1.0
- Note that MB had an even mix of marsh, mudflat, and open water.

Salt flats during early 20th century…

Image removed due to copyright status. To be included at a later date.

View image at:
http://www.sandiegohistory.org/sites/default/files/printroom/pacific_beach_-_view_-_1906_-_342.jpg?1371148918

Shows large salt flat above northeast Mission Bay marshes.

…was **bisected by Rose Creek** ca. 1916

County of San Diego, 1928

Image removed due to copyright status.
To be included at a later date.

Shows same salt flat still present in 1940s.

but persisted into 1940s…

Salt flats

Note that these features are not evident in earlier sources (like Harrison 1852 T-Sheet)

- Harrison did map salt flats in Tijuana Estuary…

But they are associated with Alviso very fine sandy loam soils ("Av"):

- "Those parts not under water support a cover of pickleweed and salt grass. Areas that dry out during the summer expose a white bare surface having a heavy crust of alkaline or saline salts." (Storie and Carpenter 1923)

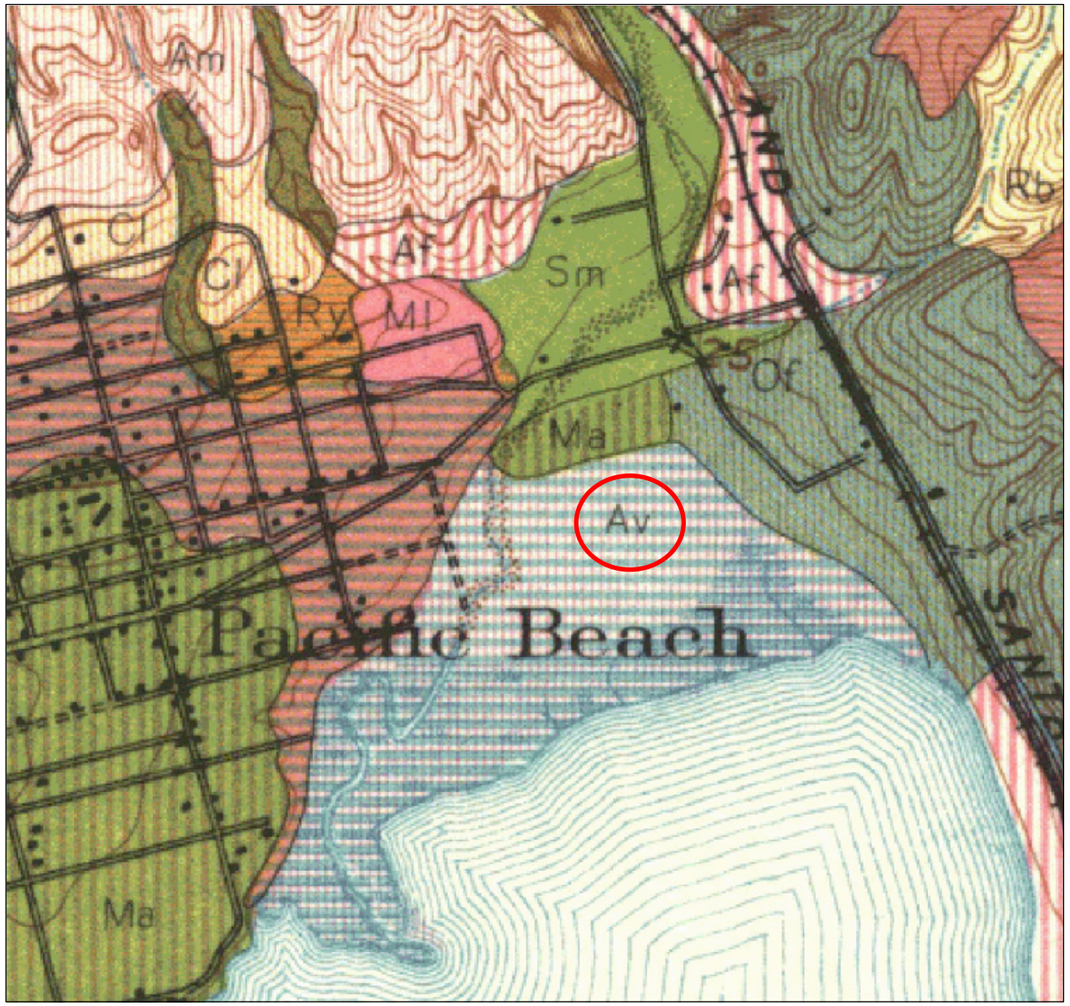
And salinas were noted early on in southern MB:

- "At an inlet here there are good-sized *salines* having very good white salt." Crespi [Brown] 1769 [2001])

When did salt flats form?

Possible formation/expansion during late 19th/early 20th century?

Could be the result of changes in the watershed?



Storie and Carpenter 1923

Early marsh expansion in Northeast Mission Bay

Date	Change (acres)
1852	n/a

Harrison 1852

Rodgers 1899

USCGS 1933

Intertidal Flat

Early marsh expansion in Northeast Mission Bay

Date	Change (acres)
1852	n/a
1899	+14

Harrison 1852

Rodgers 1899

USCGS 1933

Intertidal Flat

Early marsh expansion in Northeast Mission Bay

Date	Change (acres)
1852	n/a
1899	+14
1933	+12

Image removed due to copyright status. To be included at a later date.

View image at: http://www.sandiegohistory.org/photostore/product/pacific-beach-aerial-nd/

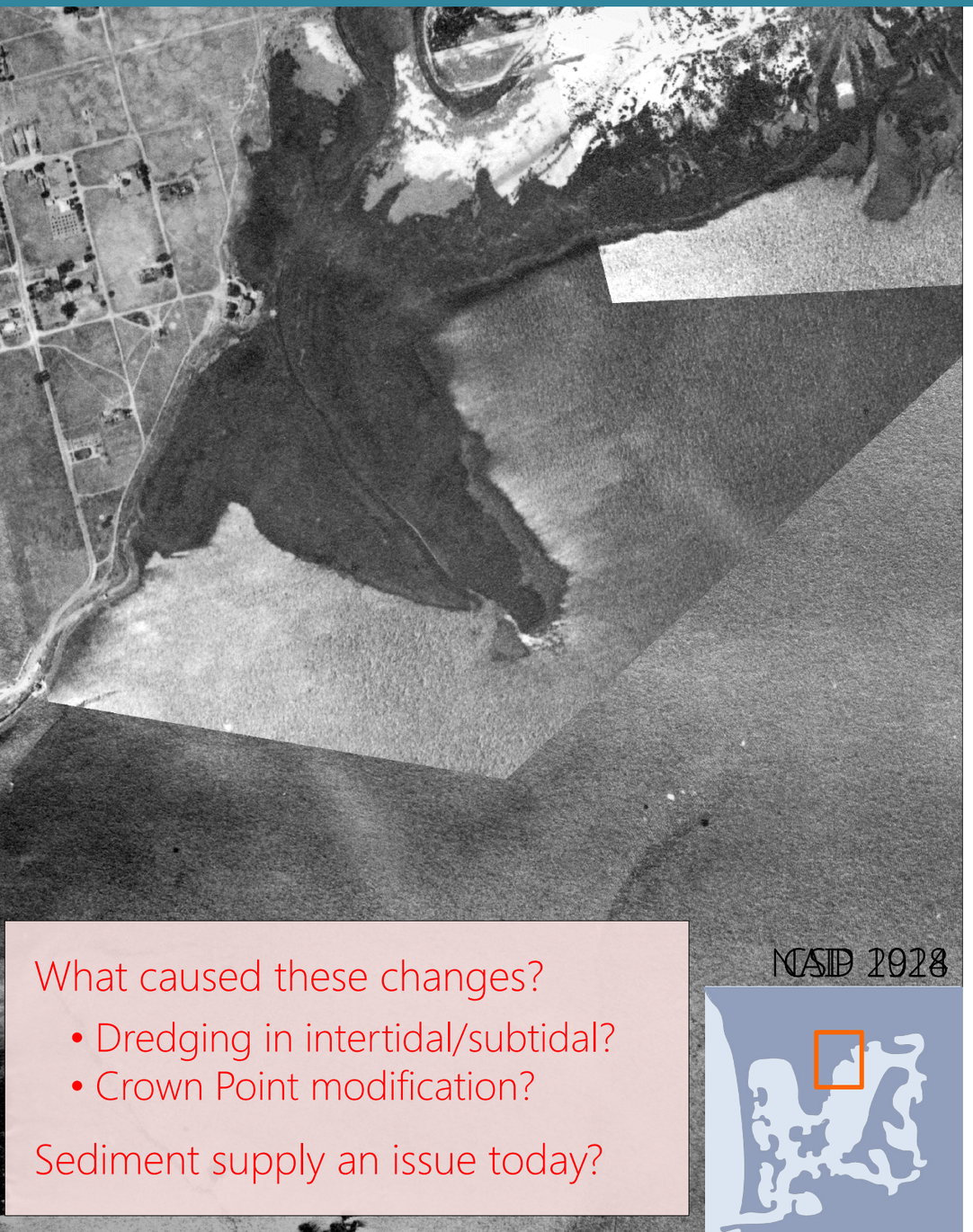
Shows new marshes expanding from shifted Rose Creek outlet.

- Harrison 1852
- Rodgers 1899
- USCGS 1933
- *Intertidal Flat*

20th century changes in Northeast Mission Bay marsh

20th century changes in Northeast Mission Bay marsh

20th century changes in Northeast Mission Bay marsh



What caused these changes?

- Dredging in intertidal/subtidal?
- Crown Point modification?

Sediment supply an issue today?


courtesy City of San Diego Digital Archives

Image removed due to copyright status.
To be included at a later date.

Shows dredger operating in Mission Bay.

What was the historical extent of De Anza Point?

1945-1965: "From 1945 to 1956…a narrow channel was dredged in the east bay to De Anza Cove, the point of which was created from dredged material. The original material pumped on to De Anza Point was a mucky silt which would not hold up equipment of any type. Although this material set for approximately three years, it never gave up its water content and nothing could be built over it. As a remedial action, it was decided to pump, by dredging, three feet of good sand over this area." (Patterson 1965:18)

Rose Creek hydrology

Intermittent/ephemeral flow indicated by 20th century sources

- 1933: "Rose Creek enters the bay through the northern marsh. This stream carries water only during the wet seasons." (Fry and Croker 1933)

Freshwater near shore in summer 1769:

- 1769: "July 14th: On going about two leagues we came upon a big heathen village lying at a corner made by this second harbor, where they have some small springs of water, and I called it The village of the small springs of water at the *rinconada de San Diego"* (Crespi 1769)

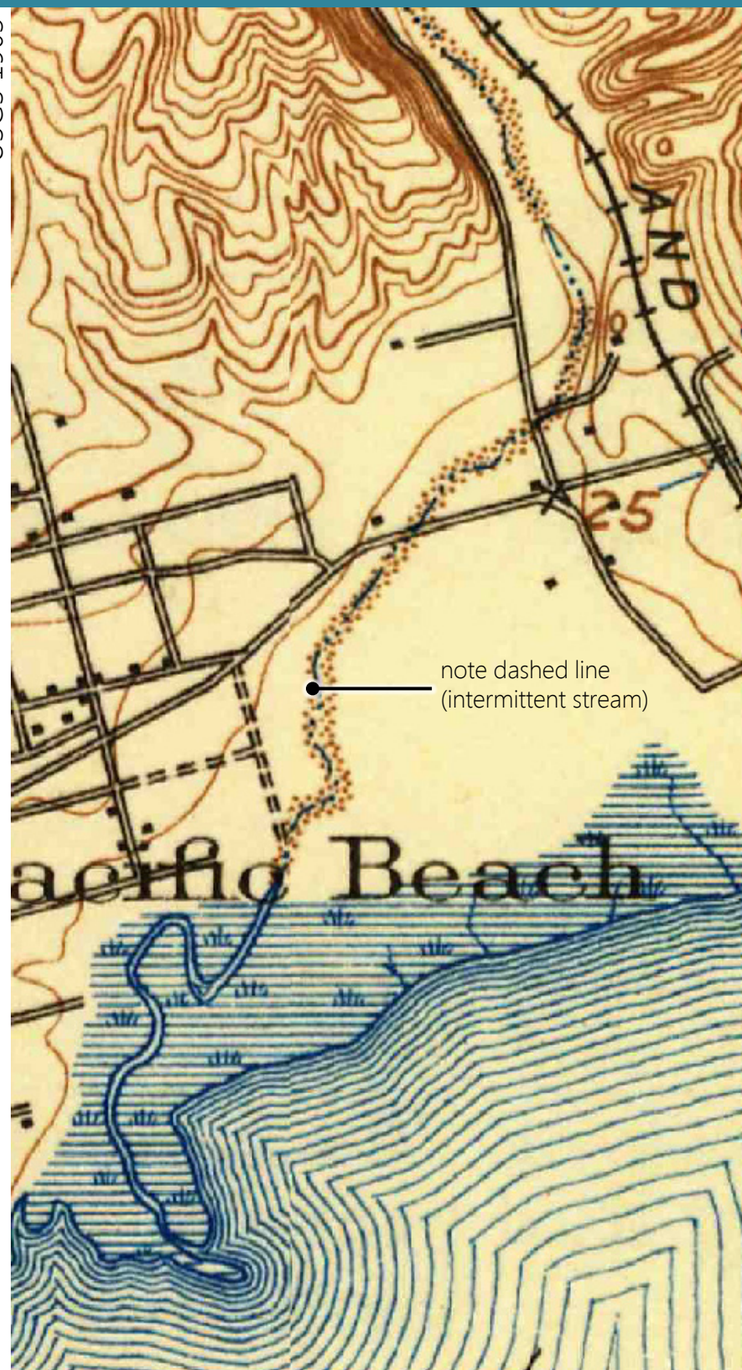
Also water at surface further up Rose Canyon:

- 1769: "July 14th: ...we understood from the heathens belonging to the village which we passed that there were some small wells of fresh water here in this hollow, which we well believed would be the case, the hollow being so green.... they yielded quite enough water for the people's use with only a very little digging" (Crespi 1769)

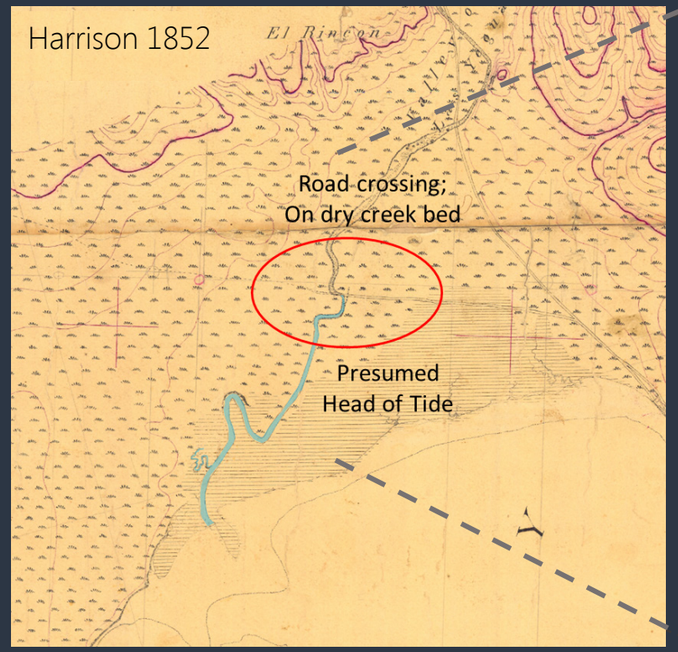
Later sources confirm presence of springs and pools:

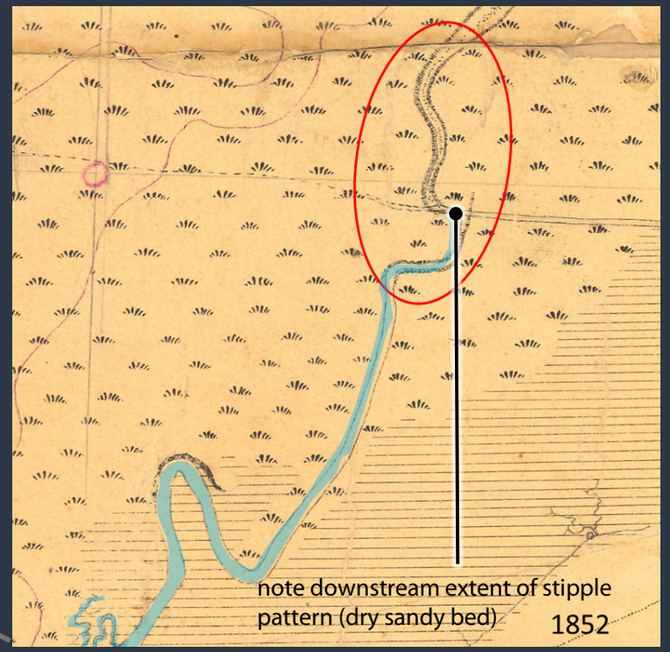
- 1856-1857: "Digging eight feet, water is plenty; on most parts of the ranch [Rose's Rancho], water is obtained in three feet or less. Two creeks flow through it during the rainy season and four months after, and many springs make large ponds from two to three feet deep, so as to supply the whole year a large number of cattle." (Hayes 1929)

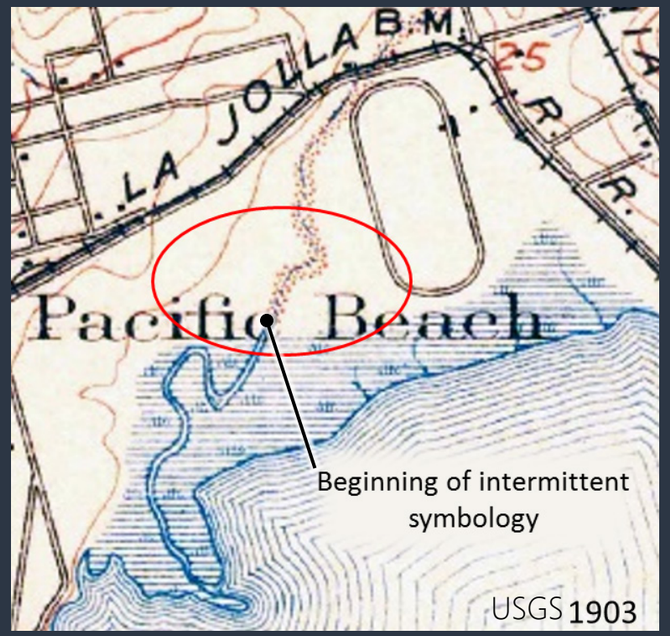
USGS 1903

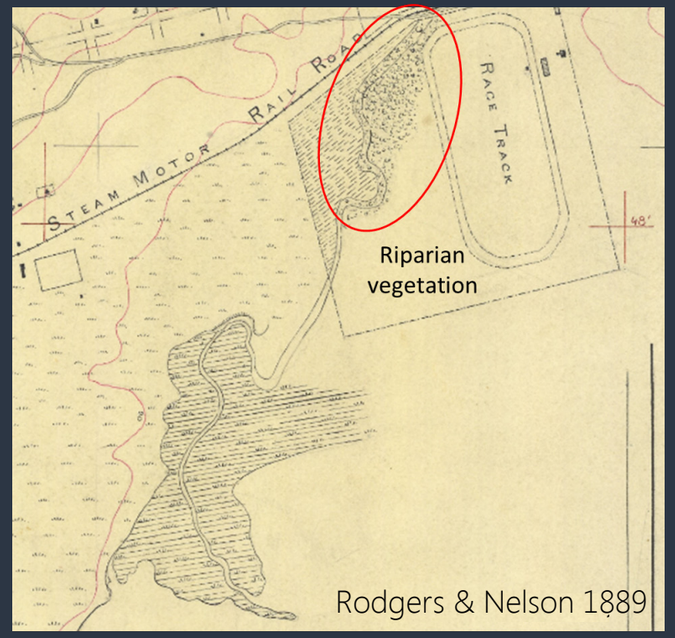


What was the extent of tidal influence in Rose Creek?









Details from early maps suggest that tidal influence extended approximately **1.5 kilometers** up Rose Creek

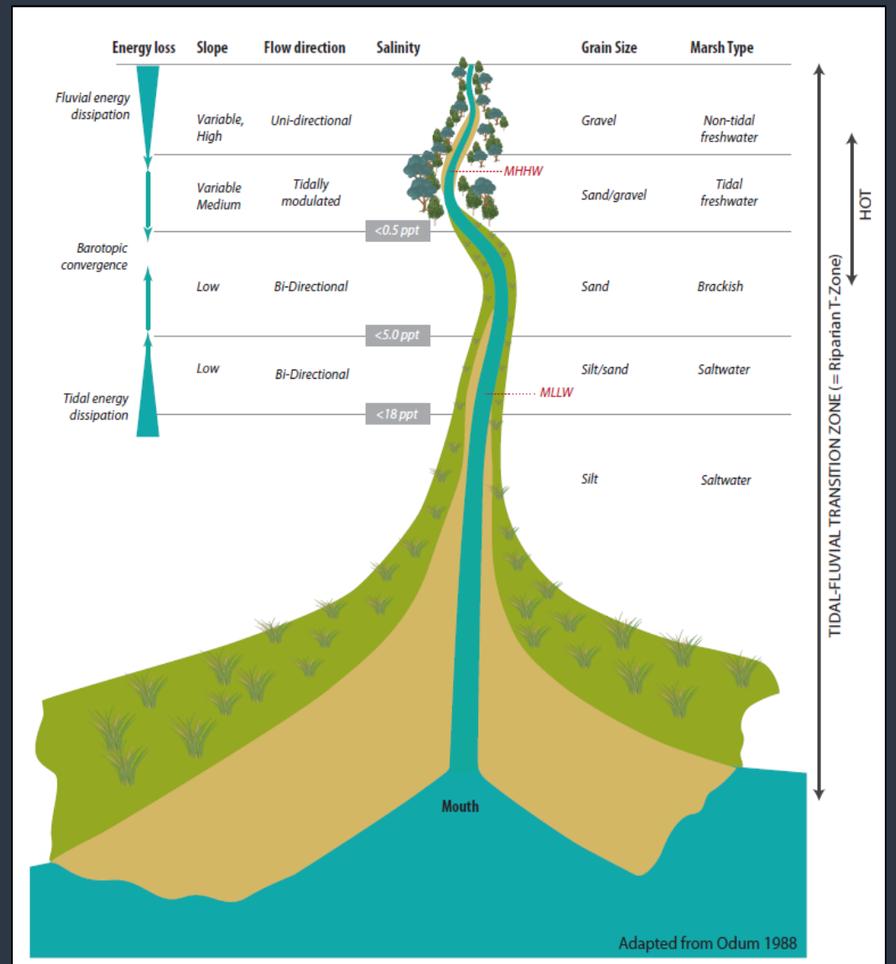


Figure 2.1. Conceptual model of the fluvial-tidal transition. This conceptual model identifies some of the physical and biological changes across the fluvial-tidal interface. Change in slope drives fluvial energy loss which impacts change in grainsize. Flow direction and tidal energy expenditure drives salinity and thus marsh type.

Protocol to Identify and Delineate the Head of Tide Zone
SFEI 2014

Rose Creek riparian vegetation

Earliest sources suggest presence of significant riparian vegetation, including willows, sycamore, and live oak

- 1769: "July 14th: …upon the same course we came into a hollow between hills. Where there are a good many willows and some sycamores ["alders," Bolton] and live oaks…the hollow [was] so green" (Crespi 1769)
- 1850: "At [MB's] northeast comes a larger stream, its banks lined with Sycamore…The now swollen stream winds through the bottom so that the road crosses it 9 times in the course of 2 miles. Towards the upper part of the stream Live Oak trees, but stunted, make their appearance mingled with the Sycamore, which is rather an unusual combination." (Parry)

Suggestions that riparian forest persisted into mid-19th century, but then decreased?

- 1856-1857: "There is enough of sycamore and willow to fence 10 miles square. Very little oak." (Hayes 1929)
- 1834, pre-1873: "His memory also goes back to the days when Rose's Canyon, clear to Captain Johnson's, at Peñasquitas, was covered with a liberal forest growth. The tanning operations of the venerable Mr. Rose are responsible for much of this disappearance of timber." (San Diego Daily World, June 12, 1873 in Smythe 1907)

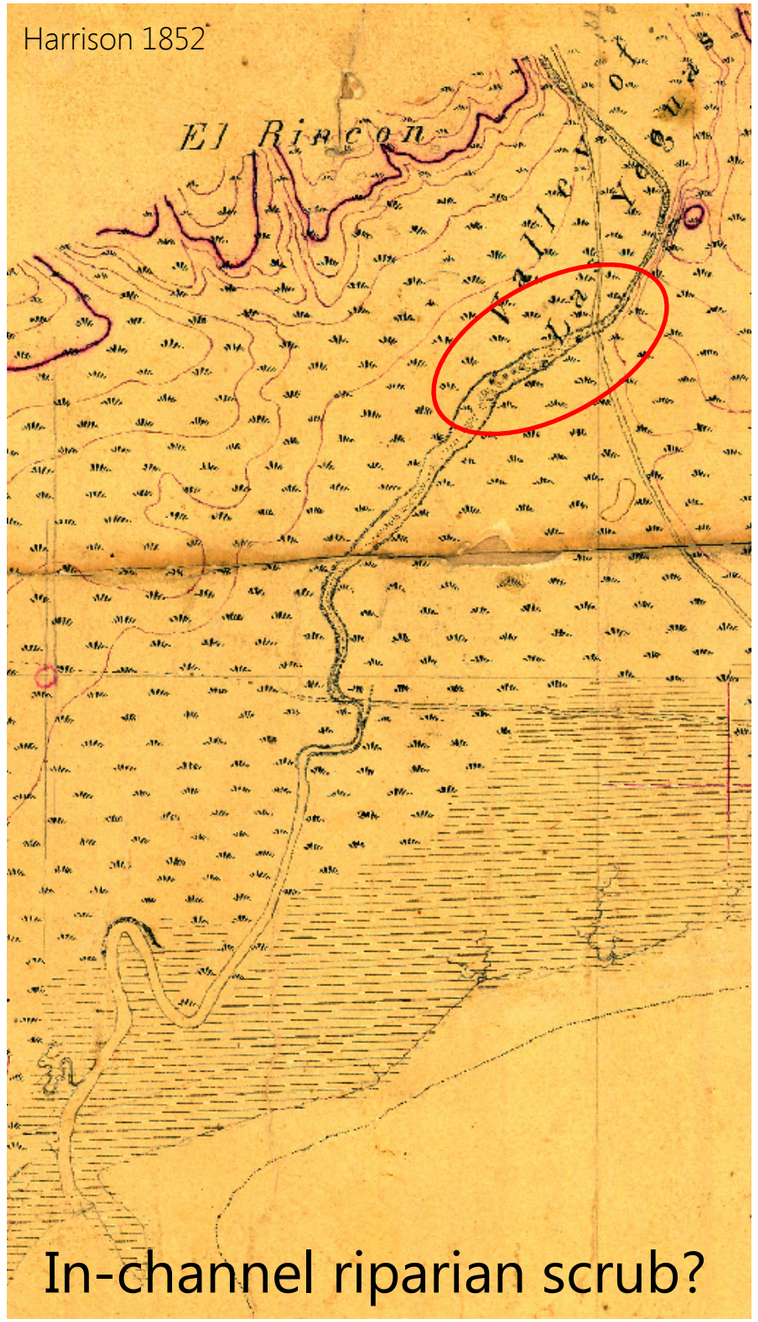
Fitch 1845

Map removed due to copyright status. To be included at a later date.

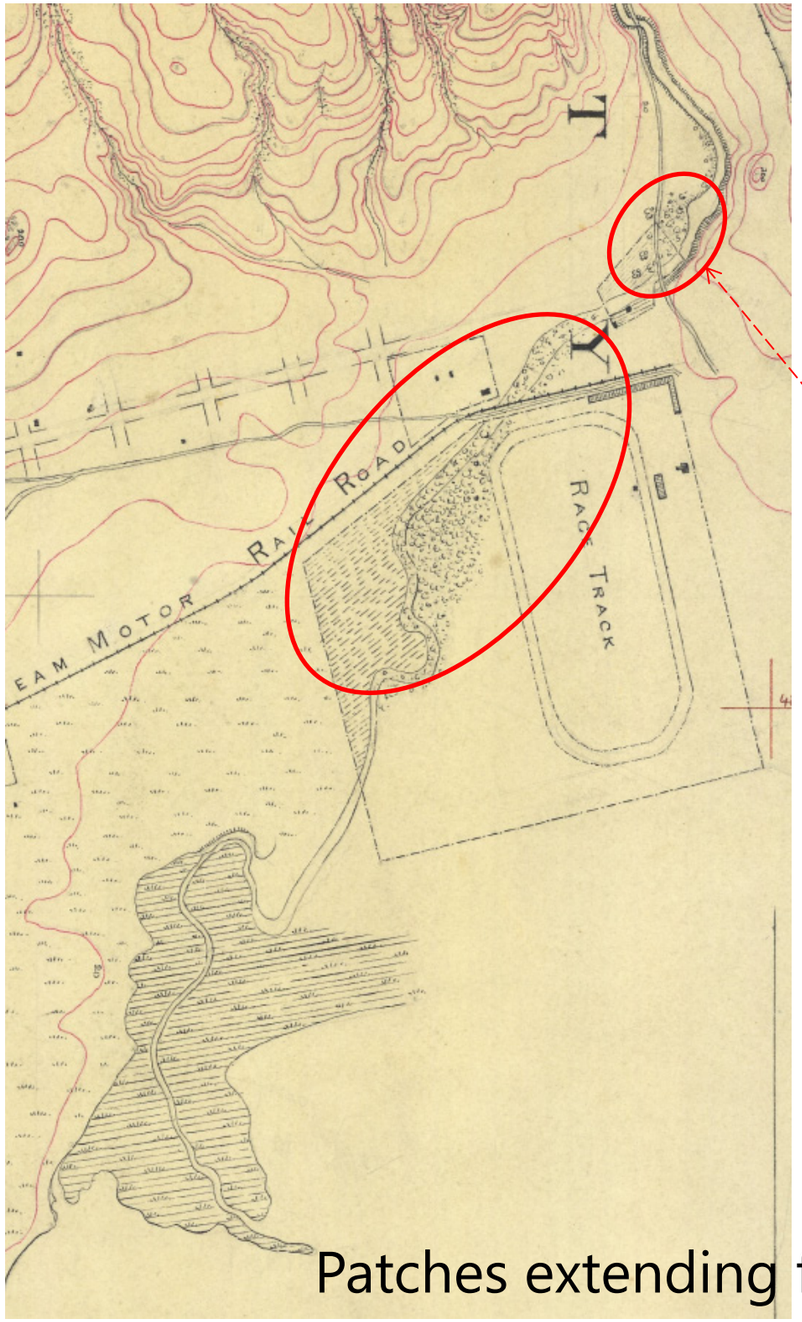
View image here: http://vm136.lib.berkeley.edu/EART/maps/fitch.jpg

Shows hand drawn trees along course of Rose Creek.

What was the extent and character of riparian vegetation along lower Rose Creek?



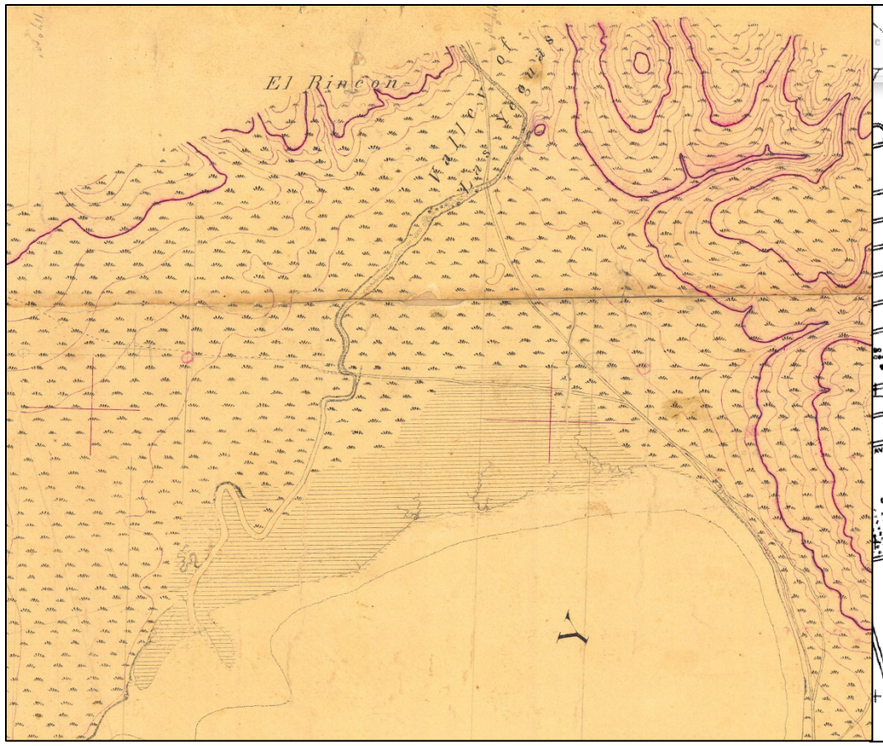
In-channel riparian scrub?



Patches extending further upstream?

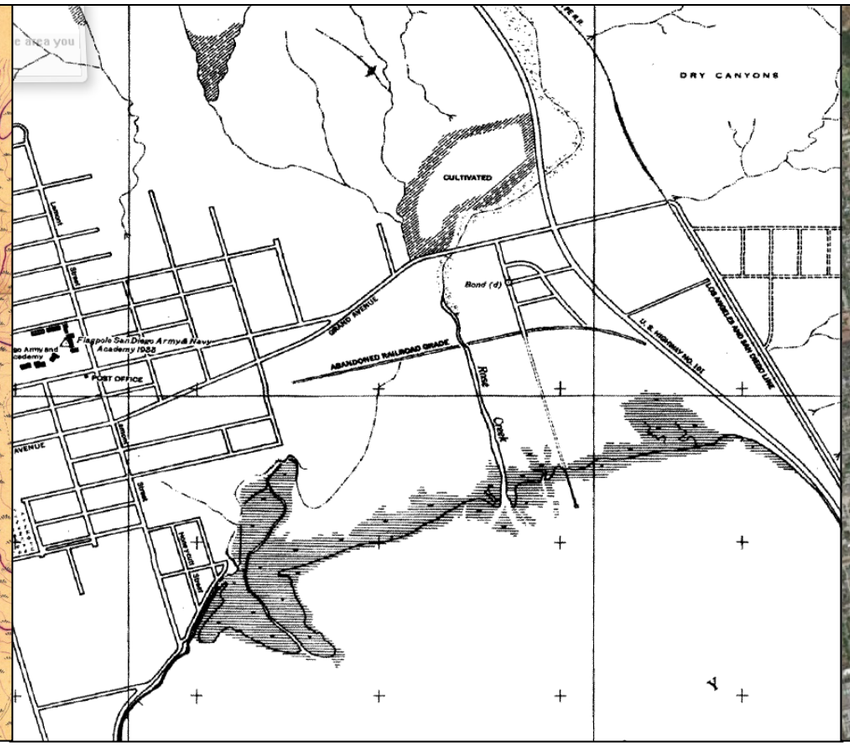
What was the character of historical freshwater inputs to Mission Bay?

Harrison 1852



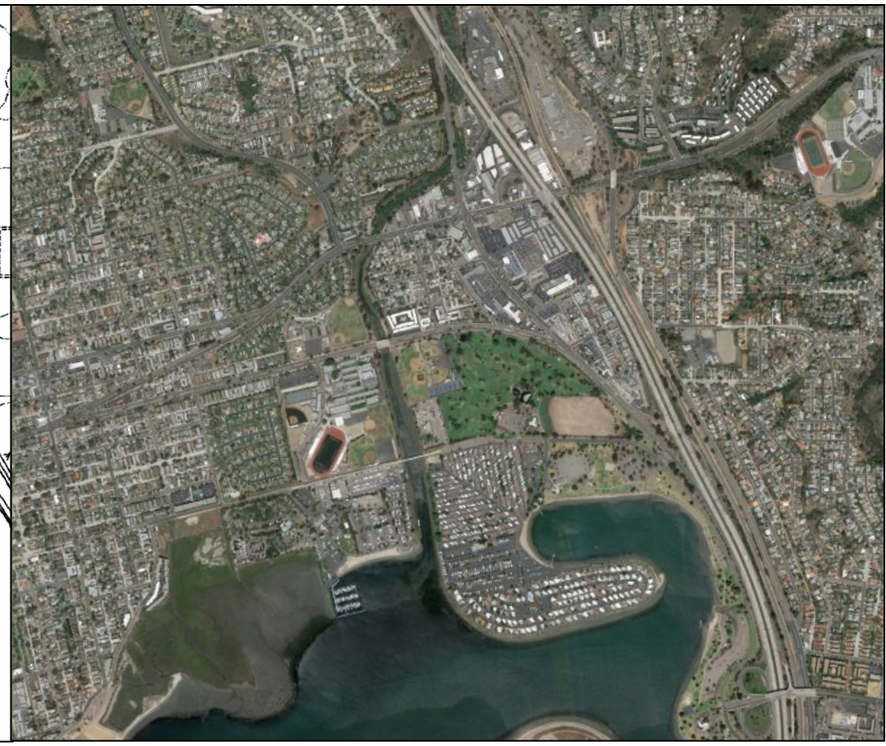
1852: Rose Creek enters MB through a tidal channel network

USCGS 1933



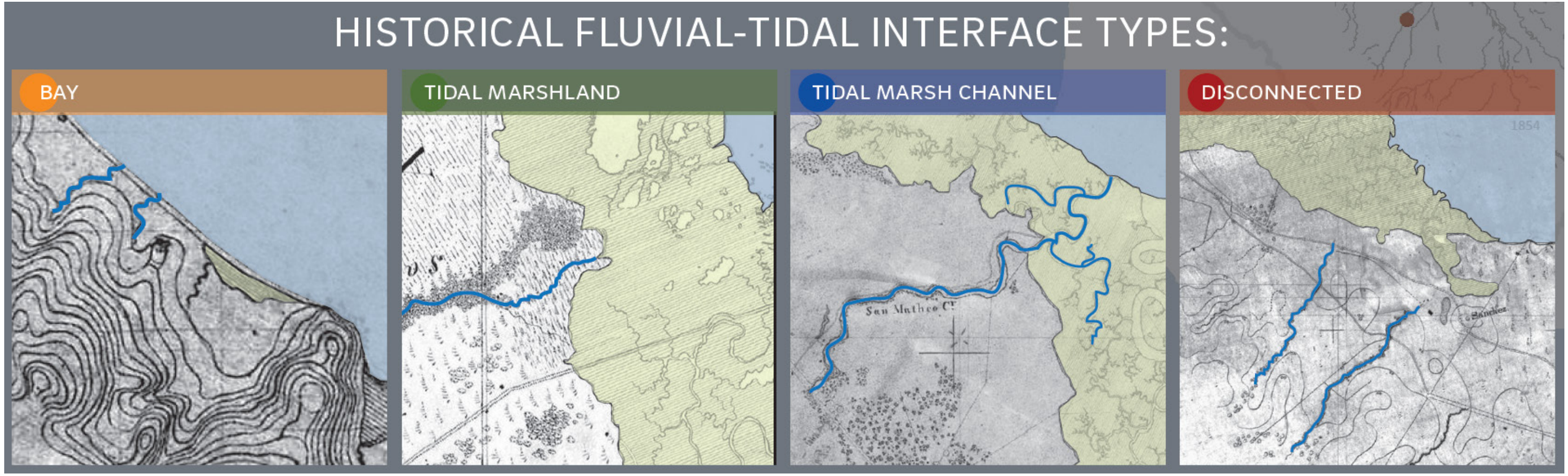
1933: Rose Creek enters MB through fringing marshes

NAIP 2014



2014: Rose Creek enters directly to MB through armored channel

Also some disconnected streams?



"How Creeks Meet the Bay" (SFEI 2014)

- Classifies fluvial-tidal interfaces of San Francisco Bay
- Useful way to think about how interfaces have changed (and resulting impacts on flooding dynamics, ecosystem functioning, and landscape resilience to climate change)
- Examples of how historical understanding has helped to develop creative ideas for reengineering interfaces

Rose Creek estuary

Preliminary observations

- Historical data document a wide range of habitat types in NEMB
- Significant changes apparent prior to 20th century, but still need to work out details
- Rose Creek outlet has shifted, tidal-fluvial interface altered
- Seems like flow was intermittent/ephemeral, but some year-round sources of freshwater
- Riparian vegetation apparently significant historically, some indication of longitudinal gradients

Questions raised, possible next steps, etc.

- Were salt flats present prior to 20th century? If not what caused their formation?
- Can core data help understand early changes in marsh extent?
- Was 1916 avulsion an outlier? Human influence? Why no evidence of former migrations in marsh planform?
- Did Rose Creek planform and flow permanence actually vary upstream? Does this relate to patterns in riparian vegetation?

San Diego River delta

Guiding questions

- Extent and distribution of habitat types?
- History and impact of San Diego River's connection to Mission Bay?
- Seasonal variability?
- Change over time?

Preliminary observations

- Historical data suggests extensive mosaic of habitats at the mouth of San Diego River (estuarine wetlands, riparian vegetation, freshwater ponds)
- San Diego River has shifted between the two bays numerous times
- Extensive historical data for connected areas (e.g. lower San Diego River, northern San Diego Bay)

Estuarine habitats at the mouth of the San Diego River

Images removed due to copyright status. To be included at a later date.

View images here:
http://www.sandiegohistory.org/photostore/product/mission-bay-beach-aerial-1937/

And here:
http://www.sandiegohistory.org/photostore/product/mission-bay-ingraham-streeet-to-crown-point-aerial-193779_741-442/

Show marshes and tidal channels in southern Mission Bay during early 20th century.

San Diego River hydrology

Early sources describe intermittent/ephemeral streamflow…

- 1769: "In the middle of this valley ran a large river, six or eight varas wide, with water half a vara in depth, but it went on diminishing from day to day, so that in three weeks after our arrival it entirely stopped flowing, and there was left only water in pools." (Crespi 1769)
- 1849: "a foamy current was seen making its way down the sandy & hitherto dry bed of this river. It moved on in a body…at the rate of a fast walk. By night the stream had worked out a deep channel."
- 1853: "At the mission (six miles from San Diego) it is usually dry from May 1 to November 1; from this time to March freshets frequently occur" (Derby 1853)
- 1887: "San Diego River, so called, is a typical stream of the southern part of the state, the winds of Summer raising billows of sand only over its dry bed, while in Winter it may be a raging torrent for a few days at a time, or in occasional years not running a drop of visible surface water to the ocean." (Rodgers 1887)

…but also suggest flows could extend well into summer during wet years

- 1888: "In seasons like 1884-85 the river is not fordable at its mouth the summer through, but ordinarily after May it shrinks up the stream day by day, until in the middle of July one must ascend its sandy bed for thirty miles to find flowing water on the surface, and nearly forty miles by September" (Hall 1888)
- 1907: "The water continued to flow visibly, in a considerable stream, to the ocean until late in the summer of 1906—a most unusual phenomenon." (Smythe 1907)

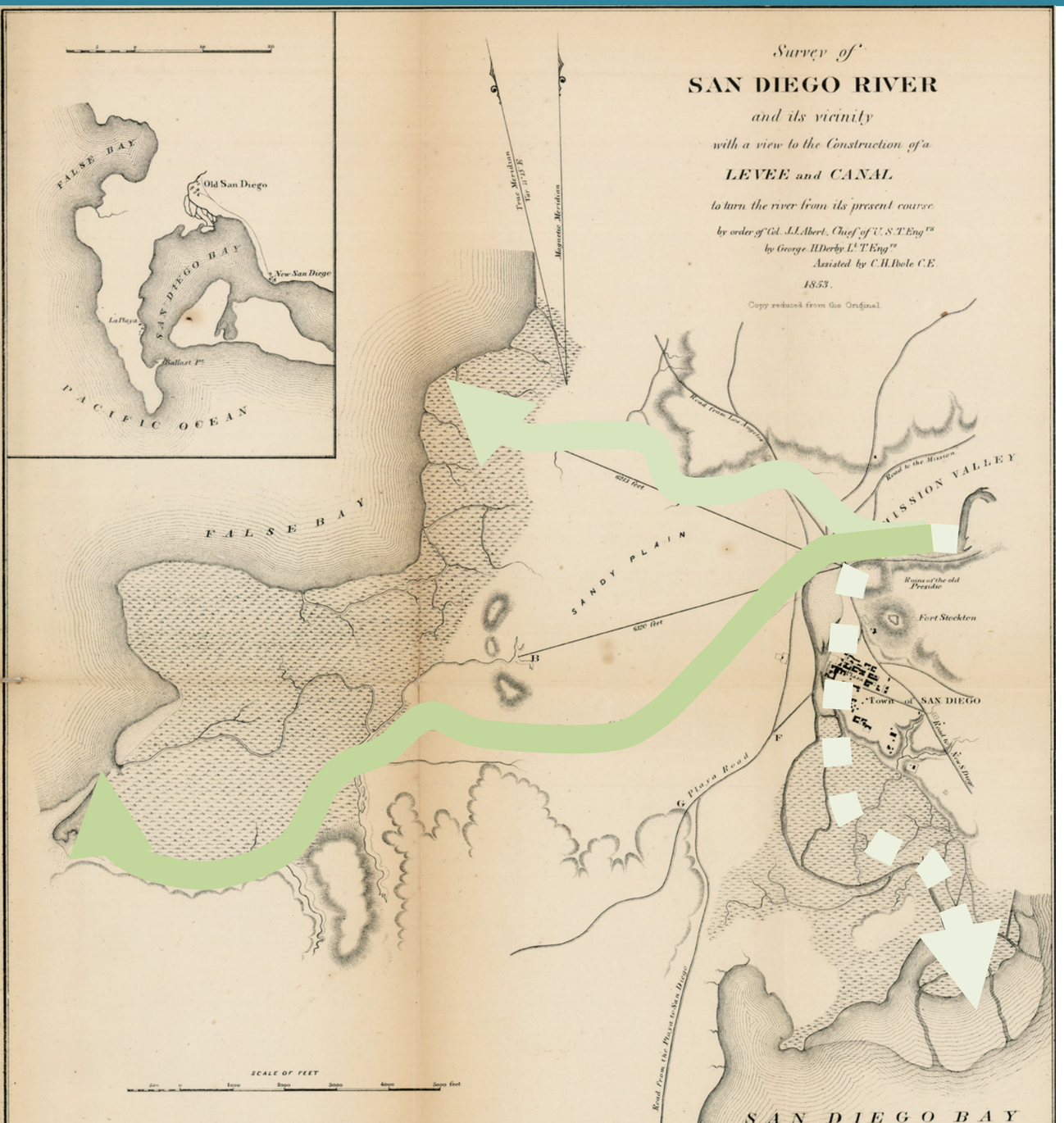
San Diego River hydrology

Subject to major floods

Image removed due to copyright status.
To be included at a later date.

Shows San Diego River flooding into Mission Bay during 1927 flood.

What was the history and impact of the San Diego River's connection to Mission Bay?



San Diego River channel movement

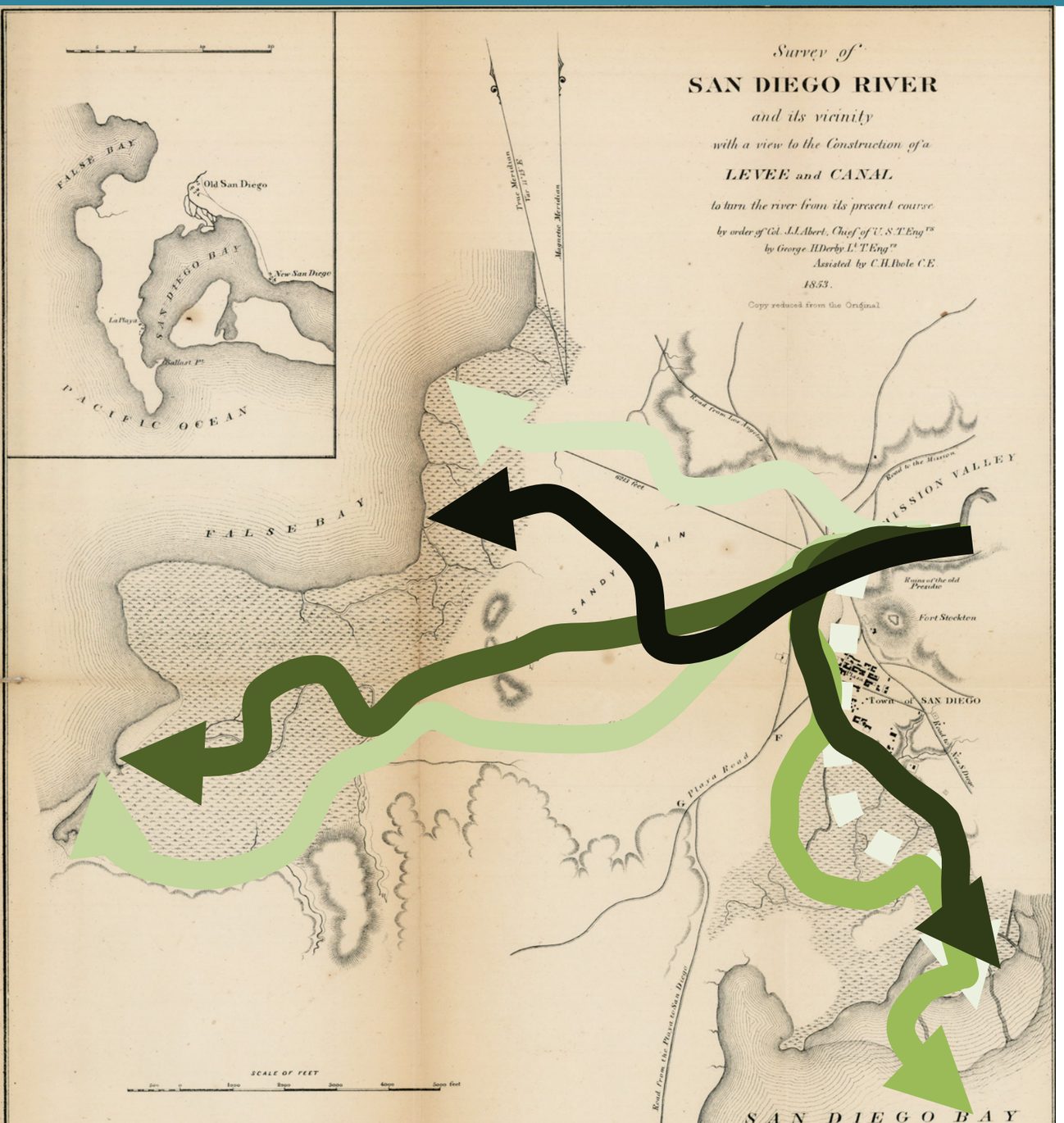
1769: flows to SDB (precise course unknown)

Pre-1811: flows to MB

1811: shifts to western MB

Derby 1853
courtesy Barry Lawrence Ruderman Antique Maps Inc.

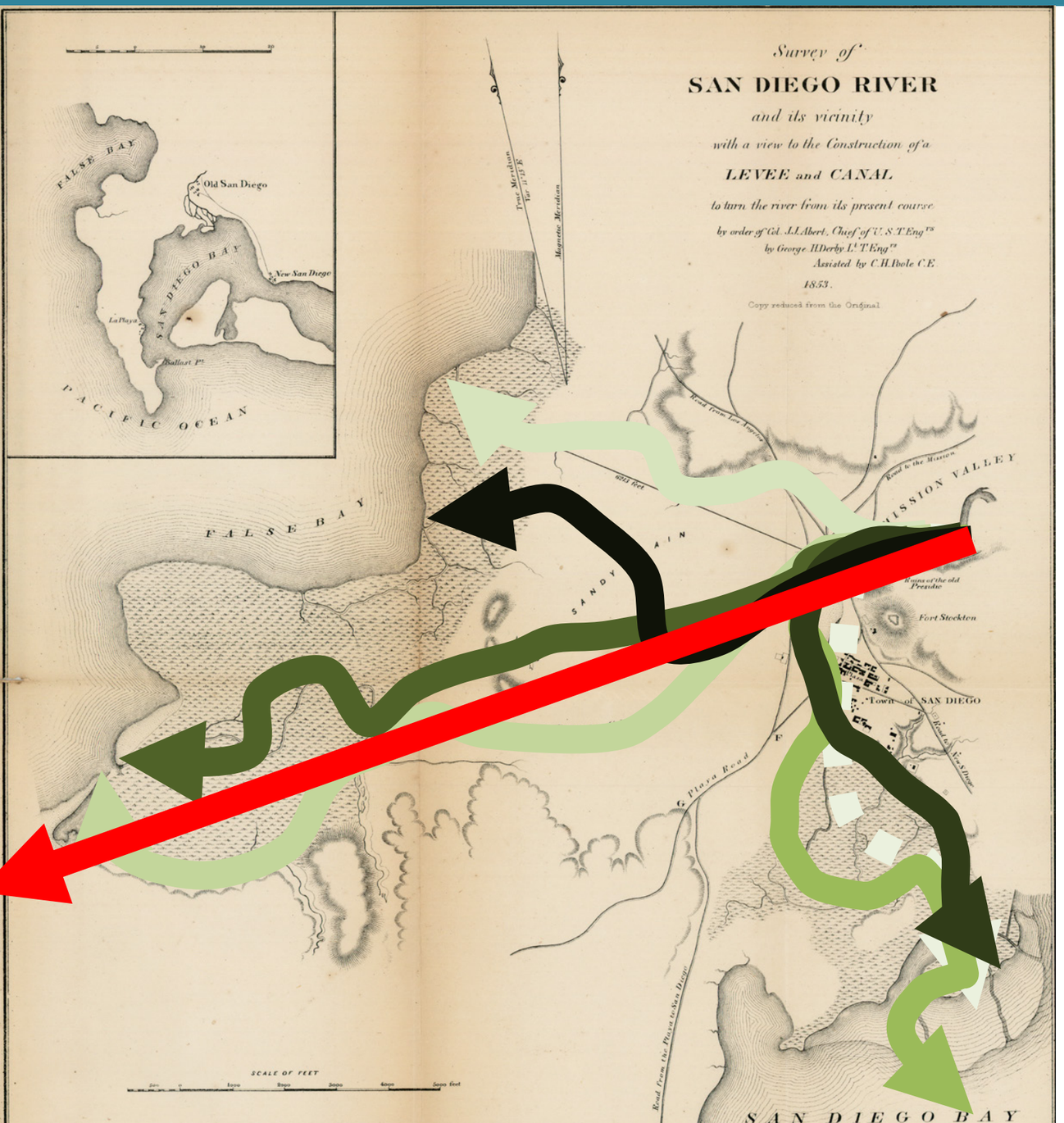
What was the history and impact of the San Diego River's connection to Mission Bay?



San Diego River channel movement

1769: flows to SDB (precise course unknown)
Pre-1811: flows to MB
1811: shifts to western MB
1821-1840: incremental shift from MB to SDB
1853: diverted to MB (Derby's Dike)
1856: breaks through dike and back to SDB
1870: diverted back to MB

Derby 1853
courtesy Barry Lawrence Ruderman Antique Maps Inc.

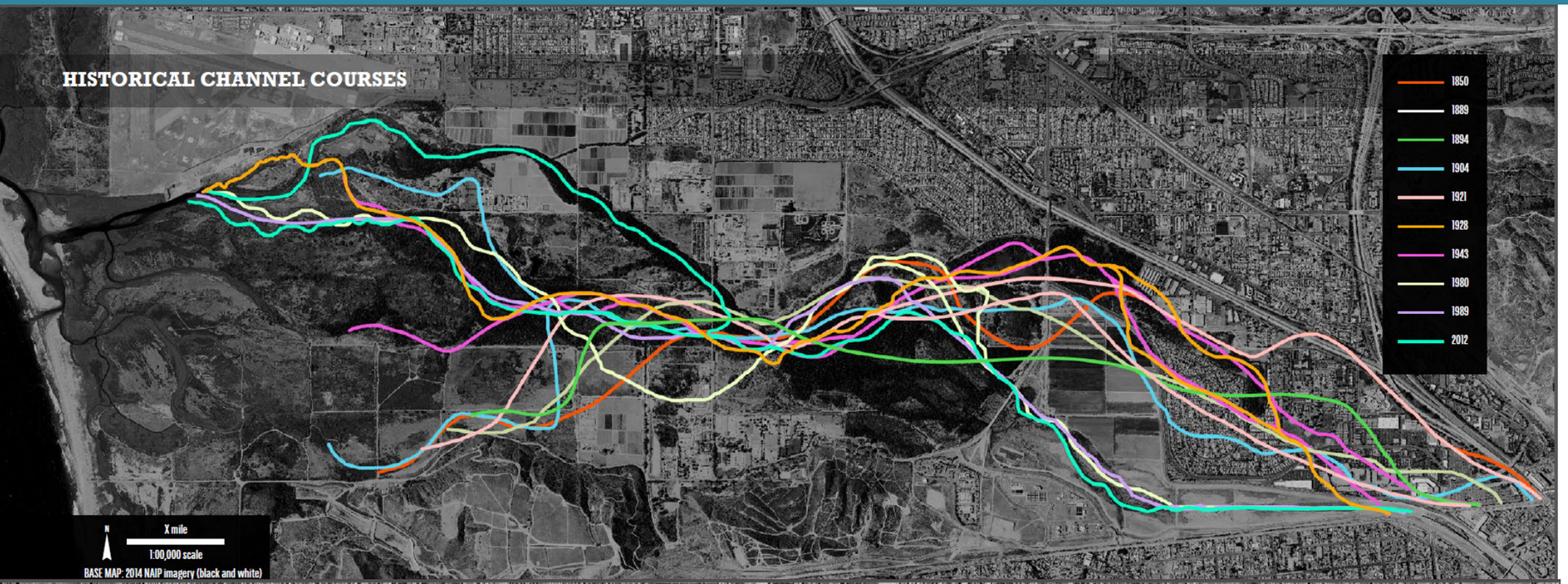


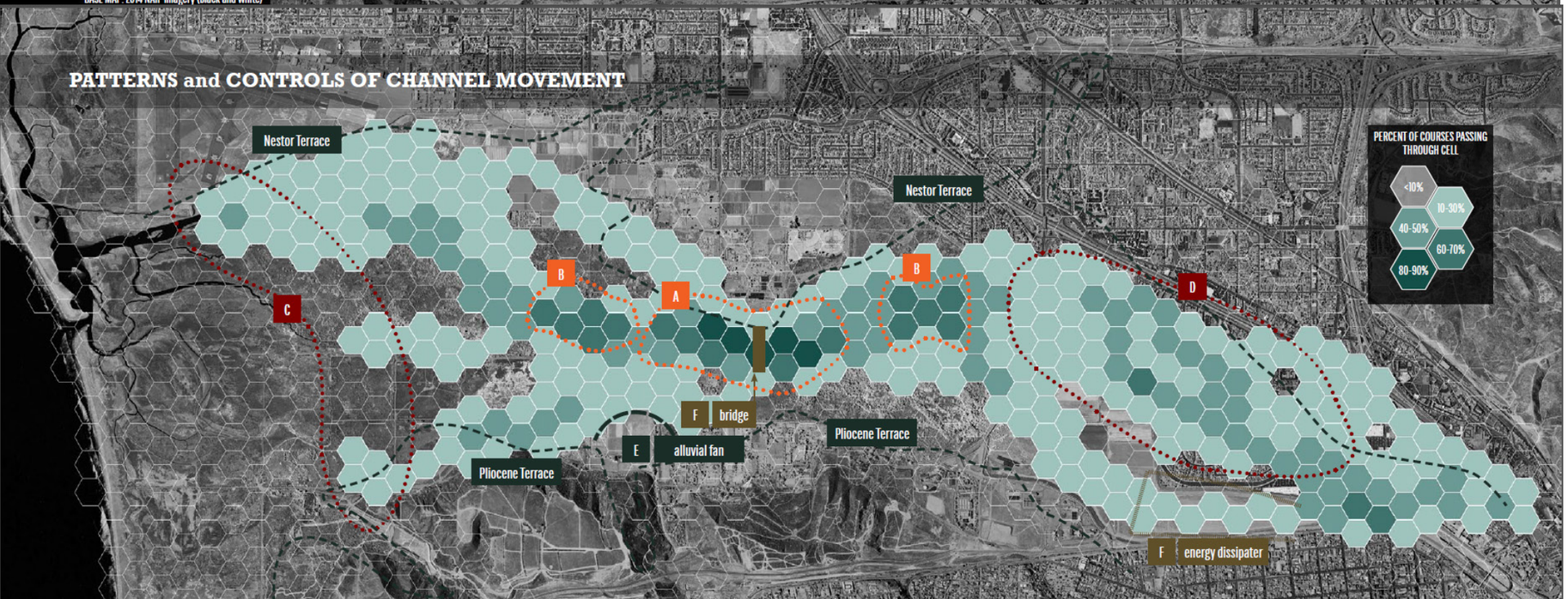
San Diego River channel movement

1769: flows to SDB (precise course unknown)
Pre-1811: flows to MB
1811: shifts to western MB
1821-1840: incremental shift from MB to SDB
1853: diverted to MB (Derby's Dike)
1856: breaks through dike and back to SDB
1870: diverted back to MB
1946: channelized to Pacific

Derby 1853
courtesy Barry Lawrence Ruderman Antique Maps Inc.

What was the history and impact of the San Diego River's connection to Mission Bay?





- History of regular channel avulsions similar to Tijuana River
- Spatial analyses can reveal controls on river movement
- River movement in Tijuana helped maintained heterogeneous floodplain. Preliminary suggestions of similar landscape at MB…

Complexity in the marsh

- Channels formed by **former courses of river**?
- Natural **levee deposits**?
- Freshwater influence:

"The sloughs emptying into False bay (into one of which I propose to turn the river) are half-filled with fresh water at low tide; and the people of San Diego inform me that water may always be had by digging four feet in the bed of the river when apparently dry in the summer." (Derby 1853)

Freshwater ponds

- 1769: “a great many large pools of fresh, very pure and delicious water” (Crespi)
- 1933: “There are a few fresh-water potholes near the point where this stream [SDR] enters the marsh.” (Fry and Croker)

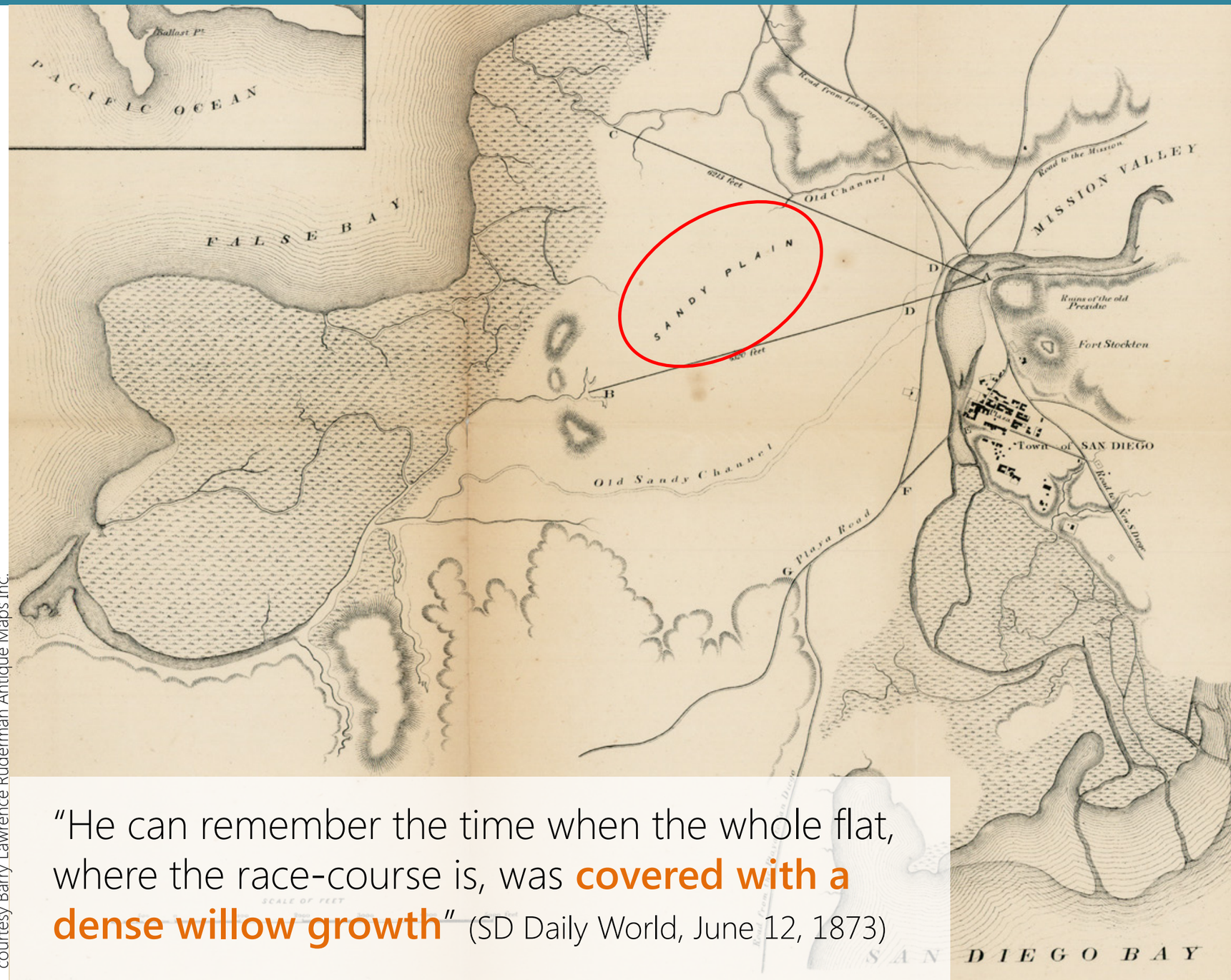
La Jolla Quadrangle
USGS 1940

Sandy floodplain with riparian vegetation

1602: "There was a very large grove at an estuary which extended into the land" (Vizcaino)

1769: "The whole river bed very much lined with willows, cottonwoods, and a few sycamores, and some large live oaks at the end of the hollow. There are…lush grapevines…rose-of-Castile bushes… some of what they call *romerillos* [sagebrush], that is very fragrant; there are prickly pear fruits, and jojobas" (Crespi)

1869: "I am told that during portions of the rainy season, when the river is high, that the whole flat is covered with water, and presents the appearance of a lake." (Heuer)



"He can remember the time when the whole flat, where the race-course is, was **covered with a dense willow growth**" (SD Daily World, June 12, 1873)

Derby 1853
courtesy Barry Lawrence Ruderman Antique Maps Inc.

Many photos of **riparian vegetation** along San Diego River

Image removed due to copyright status. To be included at a later date.

View image here:
http://www.sandiegohistory.org/photostore/product/old-town-1869-3961-a/

Shows San Diego River in 1860s at Old Town San Diego without any significant woody riparian vegetation.

courtesy UCSD

Dec. 1927- Old Town Bridge

courtesy UCSD

Flood of 1916- Old Pardre Dam


courtesy UCSD

Also great descriptions of **upstream hydrology**, including perennial reaches

courtesy UCSD

San Diego River delta

Preliminary observations

- Historical data suggests extensive mosaic of habitats at the mouth of San Diego River (estuarine wetlands, riparian vegetation, freshwater ponds)
- San Diego River has shifted between the two bays numerous times
- Extensive historical data for connected areas (e.g. lower San Diego River, northern San Diego Bay)

Questions raised, possible next steps, etc.

- How stable were tidal channels and marshes at mouth of SDR? Are all major tidal creeks former courses of SDR?
- How connected were Mission Bay and San Diego Bay marshes?
- Are potholes related to flooding?
- Temporal or spatial patterns in riparian vegetation? Species composition?

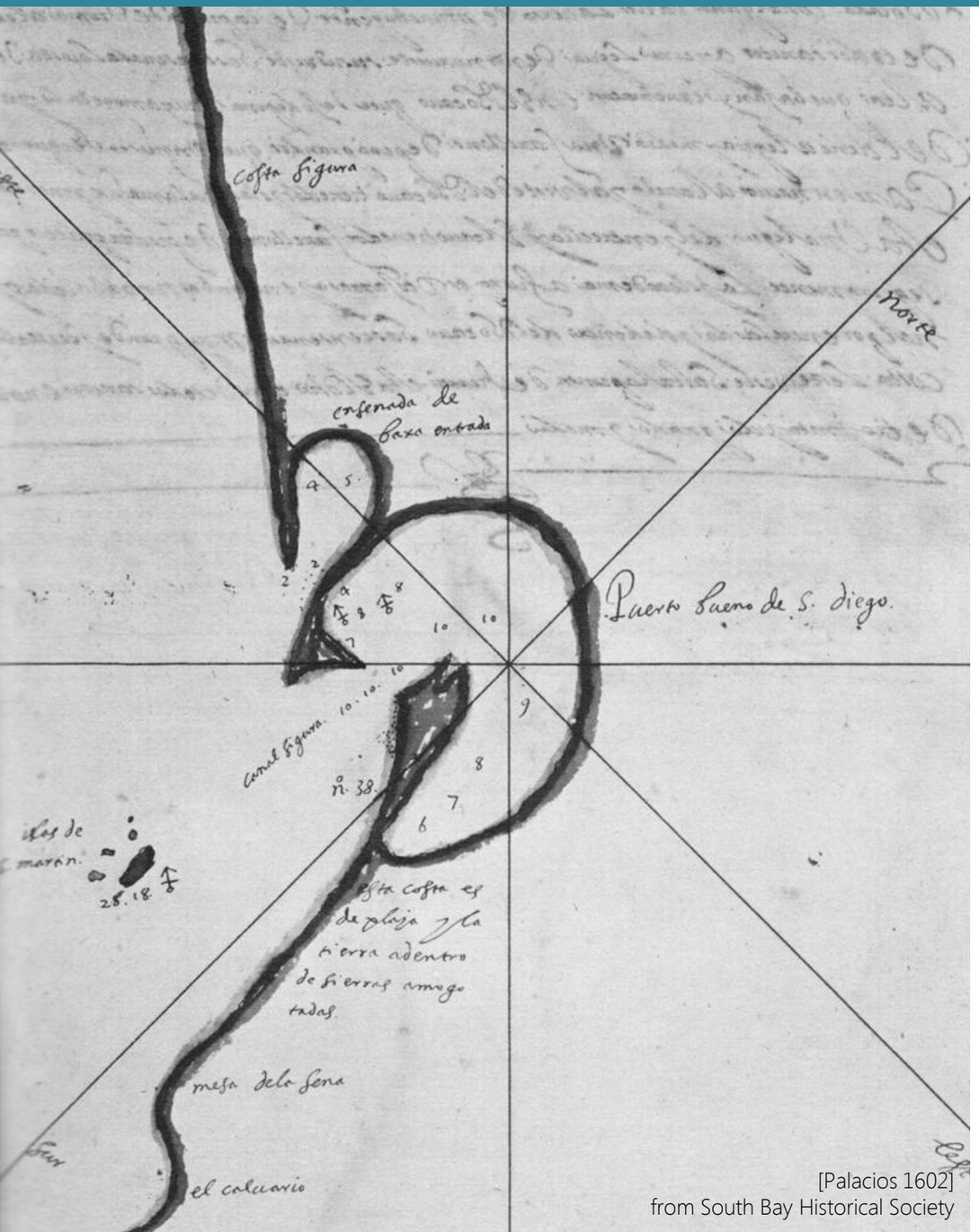
Bay interior

Guiding questions

- Extent and distribution of habitat types?
- Seasonal variability?
- Change over time?
- Wildlife?

Preliminary observations

- Intriguing stories regarding changes in Mission Bay's bathymetry and associated sub/intertidal habitats (e.g., mudflats, eelgrass, Spartina marshes)
- Relatively large amounts of data on the bay's interior (especially topics such as the fish community, benthic invertebrates, mudflats)



[Palacios 1602]
from South Bay Historical Society

Was Mission Bay deeper during Spanish period?

- *[Palacios], "Puerto bueno de S. Diego" [1602]:*
  - earliest known map of Mission Bay
  - although extremely generalized, the chart gives **soundings of 2 brazas (~11 ft.) at the mouth** of Mission Bay and soundings of 4 and 5 brazas (~22-27 ft) within the interior of the bay

- *1856 H-sheet*
  - deepest point in entire located just inside Point Meganos at 4.75 fathoms (28.5 ft)
  - deepest point in NE embayment = 10 ft
  - deepest point at narrowest part of inlet = 15 ft
  - **Bar outside of inlet < 6 ft deep**

"Before 1810 the False bay was sufficiently deep to admit of the ingress of vessels of very considerable size; at present it is filled with shoals and sand bars, and has hardly sufficient water at low tide for an ordinary sail-boat." (Derby 1853)

Mudflats, shoals, and islands

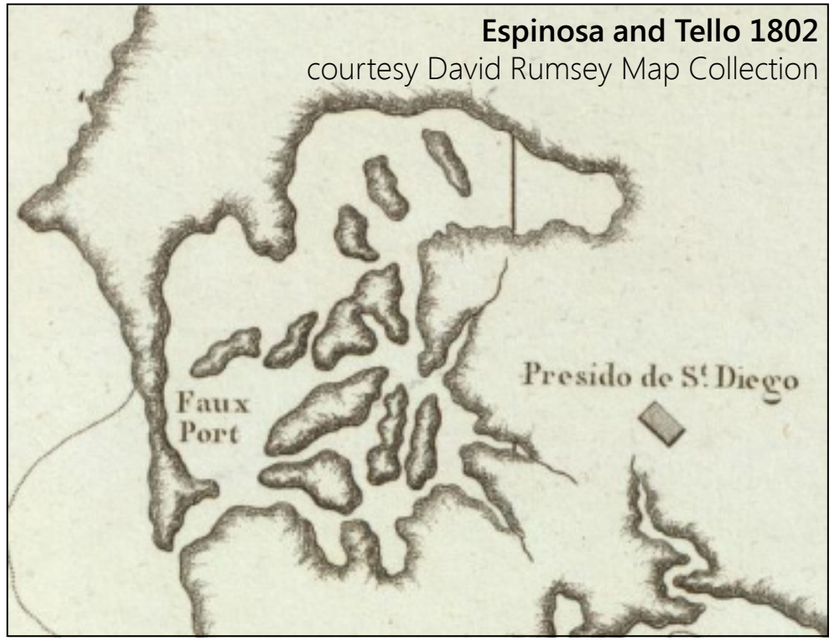


Image removed due to copyright status. To be included at a later date.

View image here: http://www.sandiegohistory.org/photostore/product/mission-bay-aerial-c-1917/

Shows western part of Mission Bay with low vegetated islands during early 20th century.

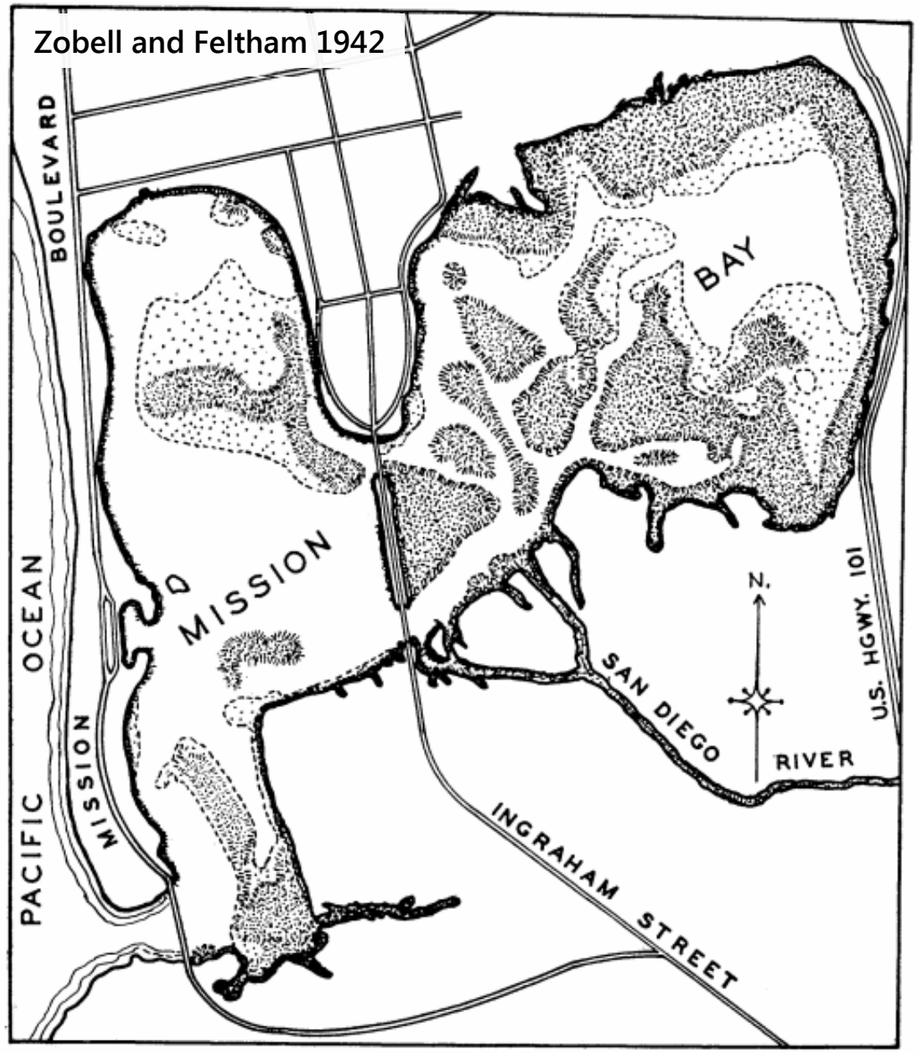
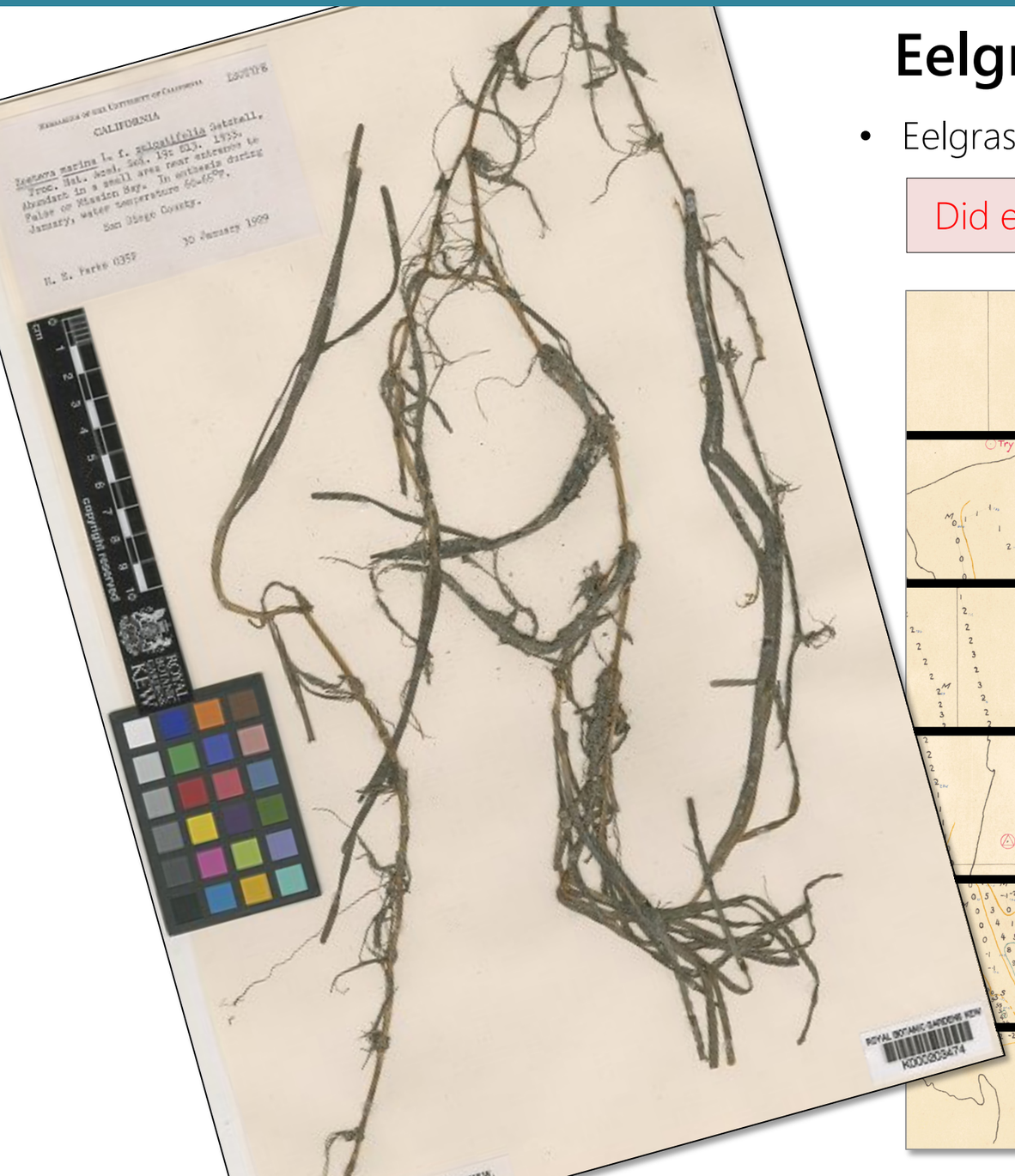


FIG. 1. Mission Bay, a shallow inlet of the ocean between San Diego and La Jolla, California. Heavily shaded areas are exposed at mean sea level and stippled areas enclosed by dotted lines are exposed when the water is 1.0 foot below mean sea level. These latter areas which are exposed for a few minutes up to three or four hours every day of the year were the ones investigated. They are flooded with water twice a day, sometimes to a depth exceeding five feet.

"In the north end of the bay are large islands of Spartina which look like great fields of wheat in the summer."

Purer 1942

- How many islands were vegetated?
- How persistent were these features over time?
- Are there any clear stories about how these features changed over time?



Eelgrass

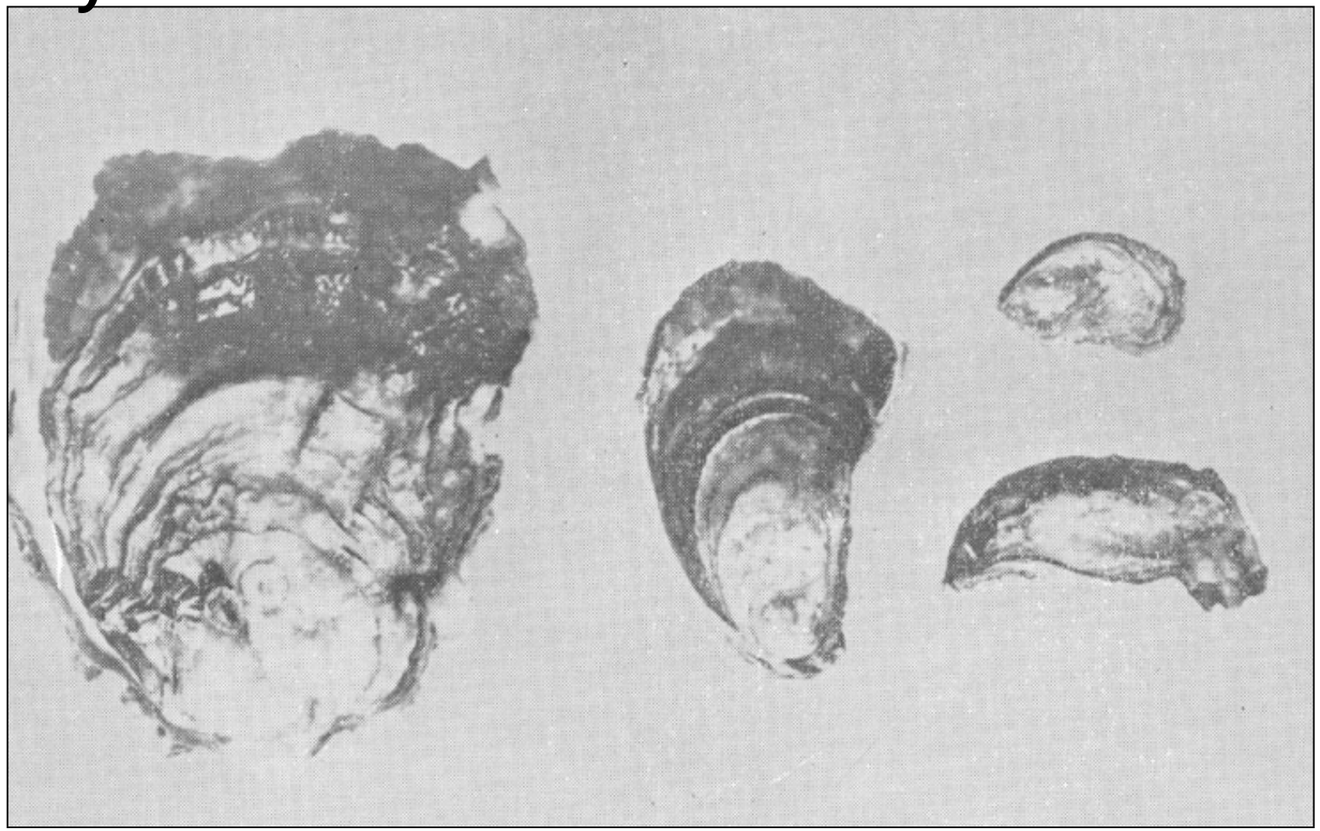
- Eelgrass present in the 1930s, but conflicting accounts on trajectory of change

Did eelgrass increase or decrease with dredging operations?

(Left) ***Zostera marina* L. f. *sulcatifolia***
Collected in False Bay by H.E. Parks, January 30th, 1929

(Right) Mcbean 1934 courtesy NOAA

Oysters



Species of oysters grown in CA, including the native species, *Oster lurida*
Barrett 1963

"Bonnet (1935) noted the presence of small quantities of oysters everywhere in Mission and San Diego Bays"
(San Diego Bay Native Oyster Restoration Plan 2015)

Naked clam

James Watanabe

"Remarkable new form of Mollusca.... Nothing of the sort, or in the least approaching it, has ever been described." (Dall 1884)

Bay interior

Preliminary observations

- Intriguing stories regarding changes in Mission Bay's bathymetry and associated sub/intertidal habitats (e.g., mudflats, eelgrass, Spartina marshes)
- Relatively large amounts of data on the bay's interior (especially topics such as the fish community, benthic invertebrates, mudflats)

Questions raised, possible next steps, etc.

- What was the landscape trajectory of Mission Bay's (natural) islands? How persistent was bathymetry over time?
- Can we learn anything interesting from species records and fisheries data?
- How does closure regime relate to tidal prism and compare to other SD County systems?
- Spatial variability in composition of bottom?

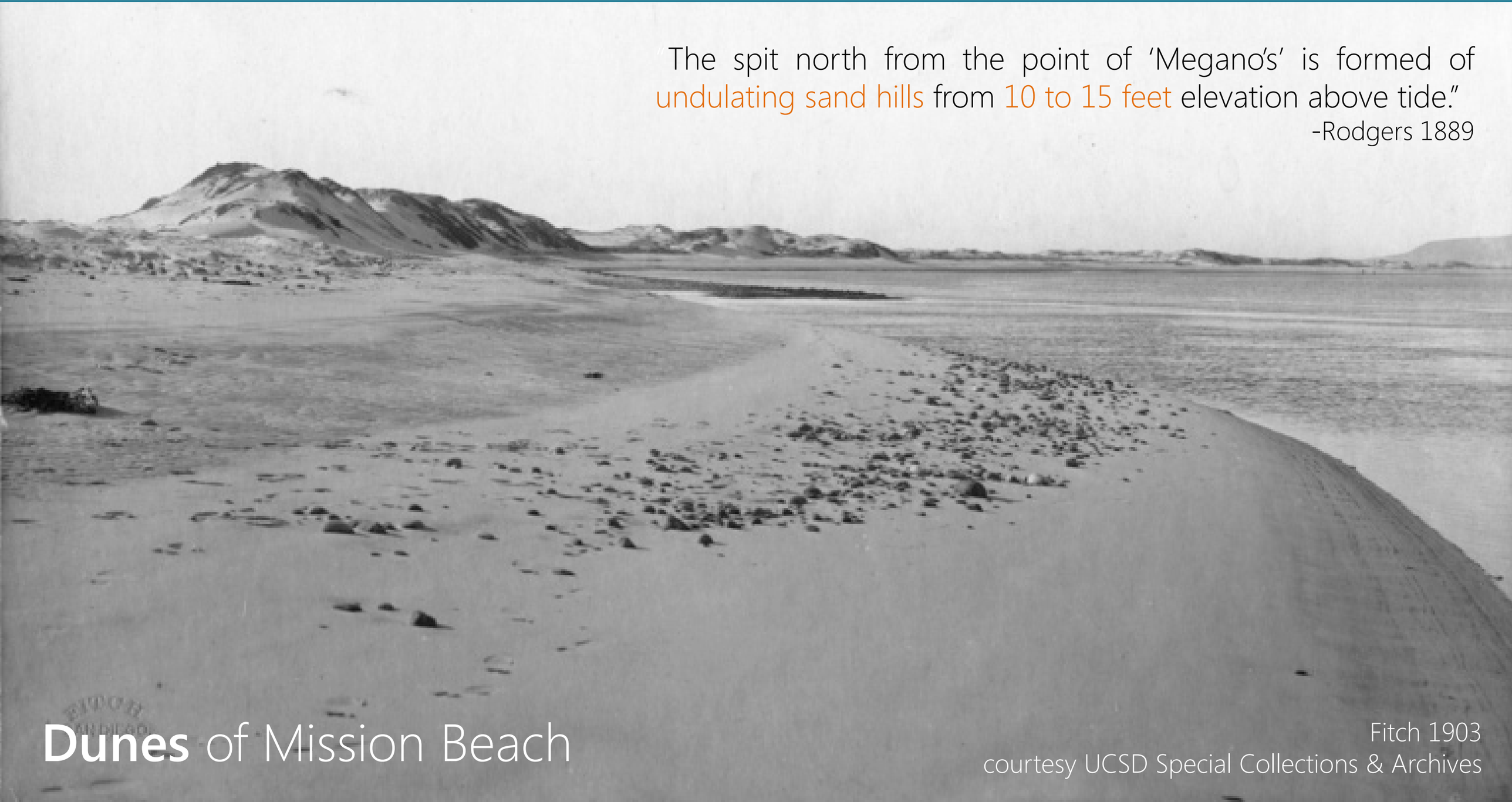
Sand barrier

Guiding questions

- Extent and distribution of habitat types?
- Change over time?
- Seasonal variability?

Preliminary observations

- Vegetated dunes along western margin of Mission Bay
- Shoreline appears predominantly sandy, though some notable stony stretches of beach



"The spit north from the point of 'Megano's' is formed of undulating sand hills from 10 to 15 feet elevation above tide."
-Rodgers 1889

Dunes of Mission Beach

Fitch 1903
courtesy UCSD Special Collections & Archives

Sand barrier

Preliminary observations

- Vegetated dunes along western margin of Mission Bay
- Shoreline appears predominantly sandy, though some notable stony stretches of beach

Questions raised, possible next steps, etc.

- What was the morphology of dune ridge?
- How stable were dunes?
- What was extent and distribution of beach/dune vegetation?

Coastal plain

Guiding questions

- Extent and distribution of habitat types?
- Seasonal variability?
- Change over time?

Preliminary observations

- Portions of MB shoreline without extensive estuarine wetlands (steep gradient)
- Indications that upland areas featured a range of habitat types, including vernal pools, scrub, herbaceous cover, springs
- Early and rapid modification of Pacific Beach—treeless and largely undeveloped in 1880 but dotted with homes, hedgerows, windbreaks, etc. by 1912

Portions of shoreline were relatively **steep and lacked estuarine wetlands**

Images removed due to copyright status. To be included at a later date.

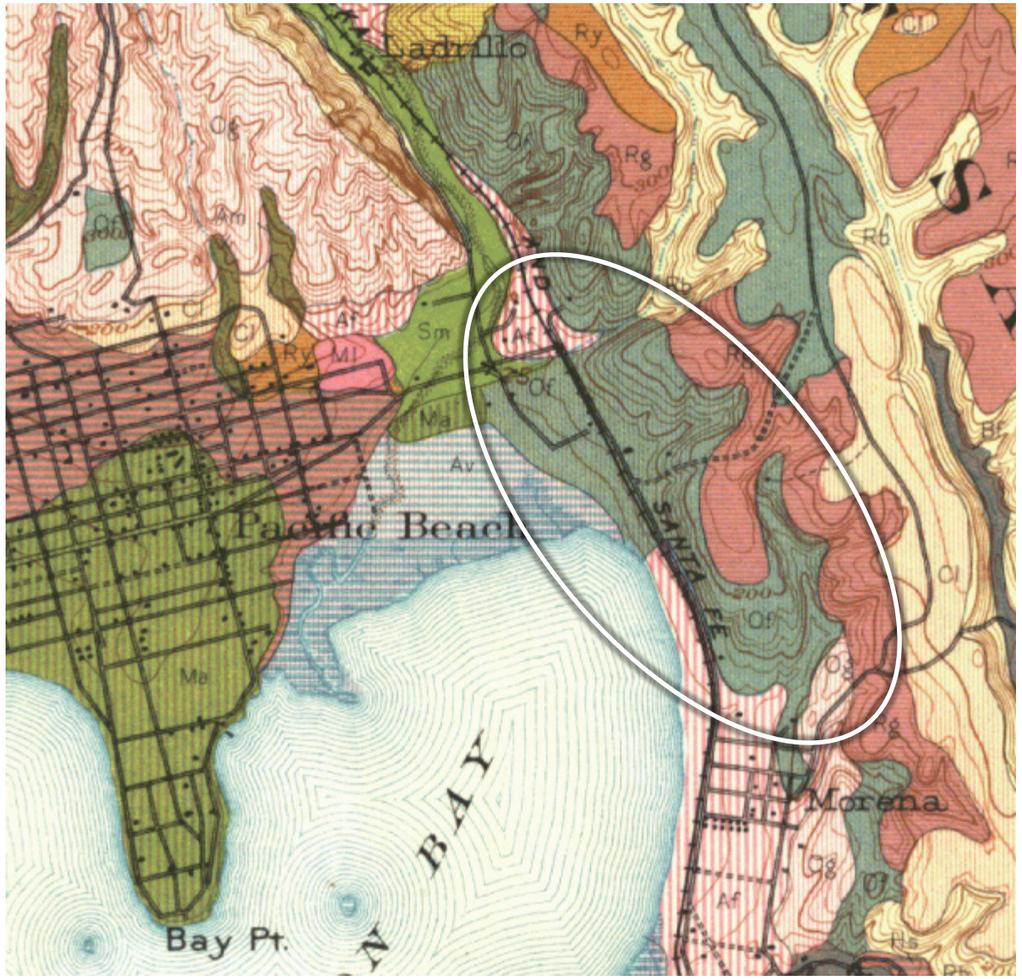
View images here:
http://www.sandiegohistory.org/photostore/product/pacific-beach-mission-bay-1906/

And here:
http://www.sandiegohistory.org/photostore/product/pacific-beach-mission-bay-view-near-crown-point-1909-264/

Shows relatively steep shorelines along Crown Point and along the eastern shore of Mission Bay.

Vernal pools

- 1923: "The surface is characterized by pronounced hog-wallow mounds and depressions.... water is held in the depressions between the knolls for a long time after heavy rains. The vegetal cover consists of light brush and native grasses." (Storie and Carpenter 1923)
- Part of the high marsh transition zone in Tijuana (still found)



"Especially on our mesas were to be found **thousands of miniature lagoons** [within] innumerable hillocks ..." (Orcutt 1887)

"Thus, the lakes were formed, their surface and bottoms grown over with plants till the water was hid from view, and gradually disappeared by evaporation, leaving only **dense jungles on a minute scale**" (Orcutt 1887)

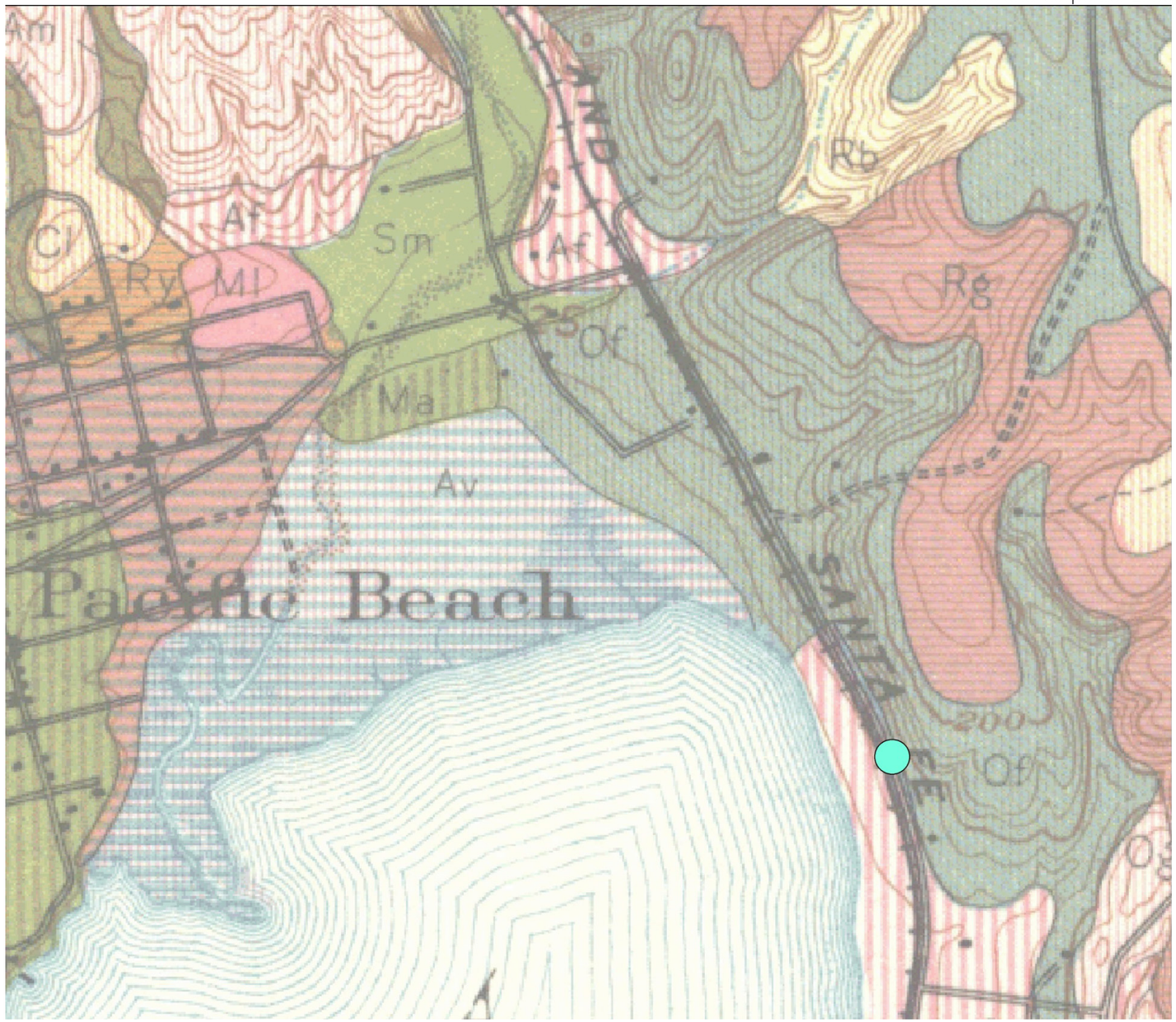
Mendenhall 1905
courtesy of USGS

Slope seep/spring wetlands

- ca. 1893: "A fault bordering the east shore of Mission Bay is suggested by… the presence of a small spring near the bay shore between Atwood and Morena" (Hertlein 1944, referring to Fairbanks 1893)
- 1944: "This spring, which is now a mere seep, is 2,376 feet north along U. S. Highway 101 from a point where joined by Jellett Street….Tufaceous material is exposed in the road embankment for about 100 yards near the spring" (Hertlein 1944)

Sanford 1880

Storie and Carpenter 1930



Terrestrial habitats

Pacific Beach devoid of trees during late 19th century—instead brushy and herbaceous cover.

Image removed due to copyright status. To be included at a later date.

Shows Pacific Beach at two points in time (ca. 1880 and ca. 1912). The earlier image shows a treeless plain with scrub in foreground; the later image show agricultural/suburban development with many planted trees.

ca. 1880 left:
http://www.sandiegohistory.org/photostore/product/pacific-beach-mission-bay-nd/

ca. 1880 right:
http://www.sandiegohistory.org/photostore/product/pacific-beach-crown-point-looking-south-to-mission-bay-c-1880-1581/

ca. 1912 left:
http://www.sandiegohistory.org/photostore/product/pacific-beach-nd-3/

ca. 1912 right:
http://www.sandiegohistory.org/photostore/product/pacific-beach-1913/

Coastal plain

Preliminary observations

- Portions of MB shoreline without extensive estuarine wetlands (steep gradient)
- Indications that upland areas featured a range of habitat types, including vernal pools, scrub, herbaceous cover, springs
- Early and rapid modification of Pacific Beach—treeless and largely undeveloped in 1880 but dotted with homes, hedgerows, windbreaks, etc. by 1912

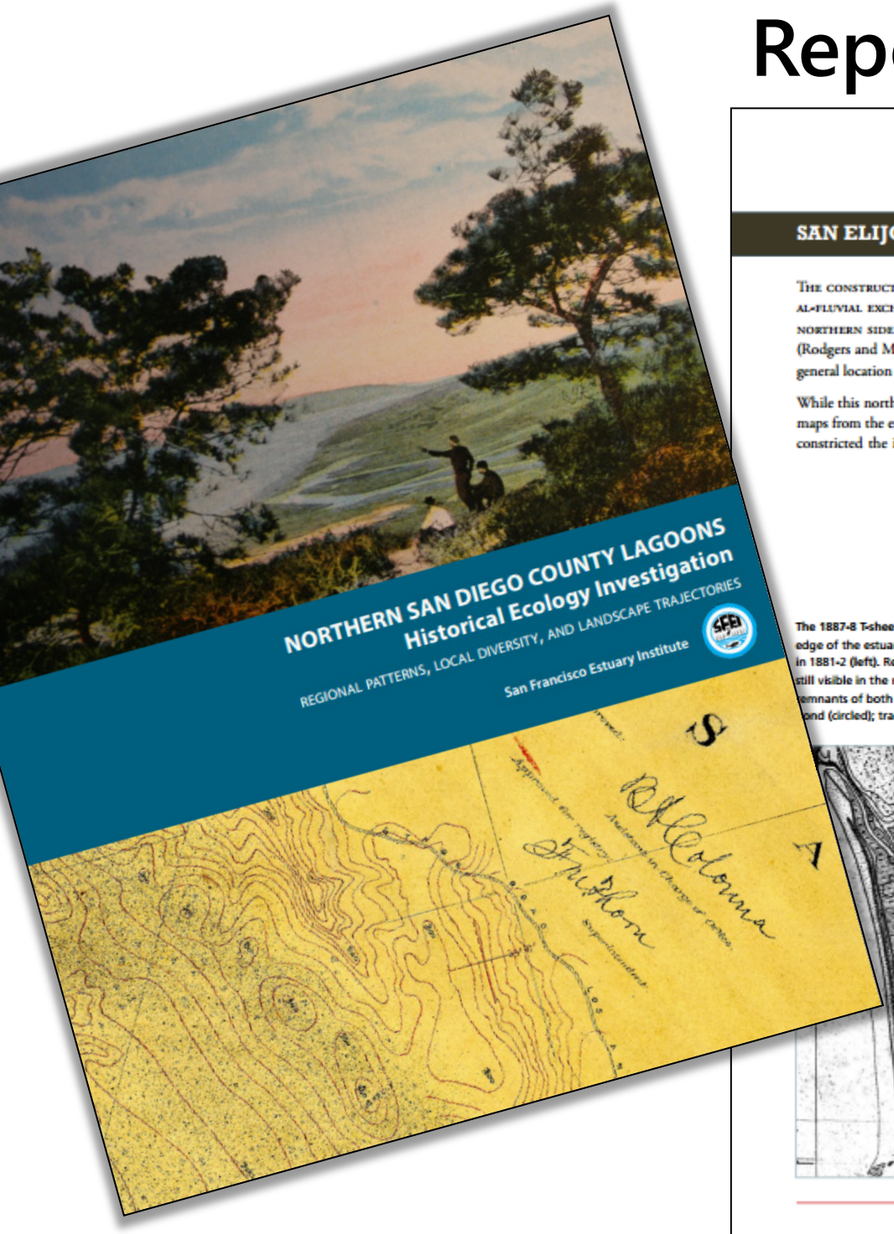
Questions raised, possible next steps, etc.

- Review species records and textual data to determine precise character of terrestrial scrub and herbaceous areas
- What was character of other adjacent upland areas, e.g. Point Loma? Controversy over whether headland was forested during Spanish period…

Reconnaissance study general findings

- Substantial historical data are available for Mission Bay…
- …but these data raise as many interesting questions as they easily answer!
- Additional synthesis and analysis to make sense of what's been collected, nail down interesting stories, etc.
- Seems to be enough material to support a detailed analytical study, historical mapping.
- Hard to consider Mission Bay in total isolation--substantial data available for connected areas too

Reports on findings



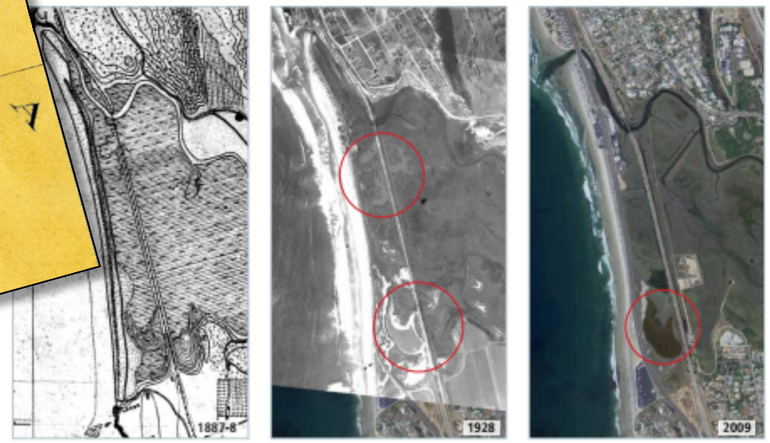
SAN ELIJO LAGOON: Spatial Variability in Inlet Location

The construction of the California Southern Railroad berm across San Elijo Lagoon in 1881-2 blocked tidal-fluvial exchange everywhere except through a single channel running under the railroad bridge on the northern side of the berm. The inlet was confined to the northwestern corner of the lagoon, as shown on the T-sheet (Rodgers and McGrath 1887-8a) and in the historical aerials (San Diego County 1928); the lagoon inlet occupies the same general location today (see images below).

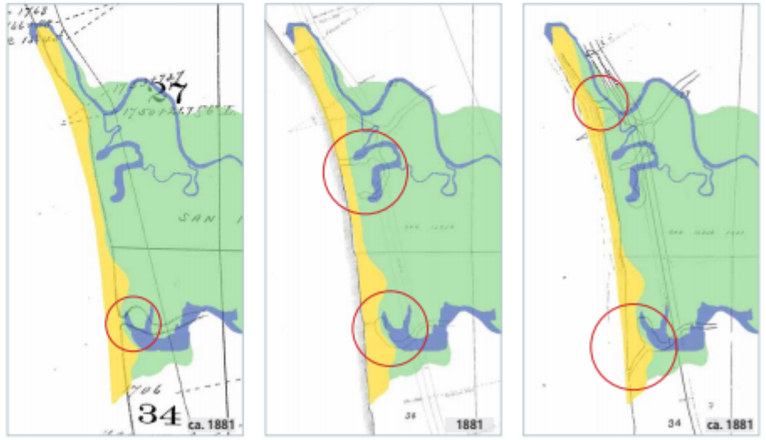
While this northern inlet marked a historically persistent inlet location, additional sources – in particular, a series of railroad maps from the early 1880s – provide evidence for the existence of multiple additional inlet locations before the railroad berm constricted the inlet (see facing page). Though these maps were created as part of the route assessment for the California Southern Railroad, they were surveyed prior to the railroad's construction. It is apparent from this suite of maps that the mouth of San Elijo Lagoon breached in different locations along the beach barrier at different times. Following large flood events, multiple inlets may have been activated simultaneously.

Although the additional inlet locations documented in the early 1880s were no longer activated after construction of the railroad berm bisected channels leading to the inlets, relicts of these features persisted as ponds and channels throughout the 20th century (see images below and photograph on pages 108-109). These "fossilized" inlet and channel remnants were some of the deepest portions of the estuary, retaining surface water in the dry season longer than other parts of the lagoon (USGS [1891]1898).

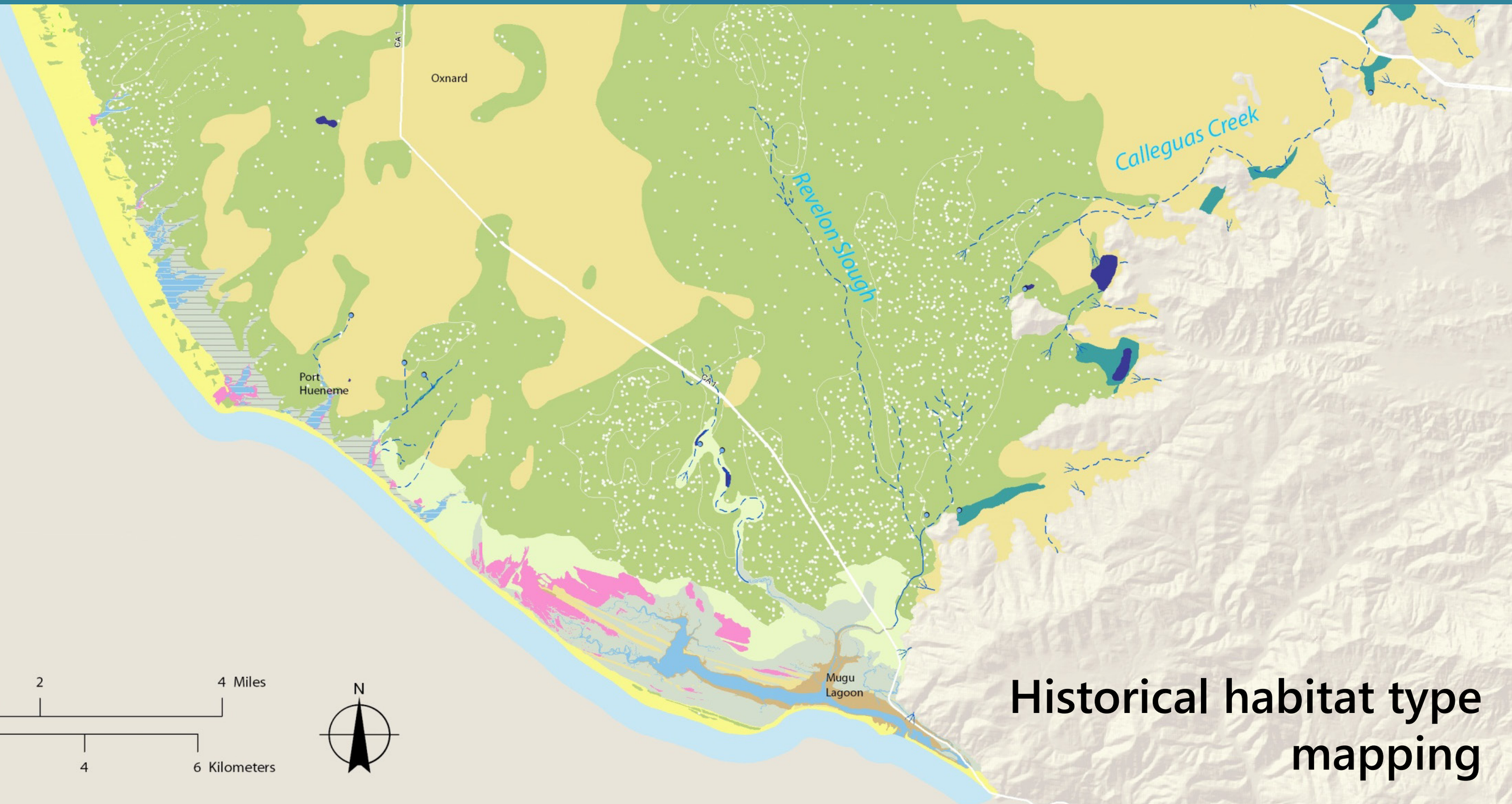
The 1887-8 T-sheet, 1928 aerial photographs, and 2009 aerial photographs of San Elijo Lagoon all show an open inlet at the northern edge of the estuary. The inlet was confined to this general location by the construction of the California Southern Railroad berm in 1881-2 (left). Remnants of several alternative inlet locations that would have been activated historically (see facing page) are still visible in the modern aerial photos in the form of ponds and channels within the marsh plain. In the 1928 photograph (center), remnants of both a central and southern inlet are visible (circled), while by 2009 (right) only the southern inlet is still marked by a pond (circled); traces of the central inlet have been removed. (Rodgers and McGrath 1887-8a, San Diego County 1928, NAIP 2009)



Three early 1880s railroad maps, overlaid with the historical synthesis mapping for context, show multiple inlet locations at San Elijo Lagoon. The map on the bottom left (ca. 1881, season unknown) offers no indication of a northern inlet, and instead shows a single open inlet at the southern edge of the lagoon corresponding to the location of the open water pond shown in the historical mapping. The map at bottom center (February 1881) also shows a southern inlet (though here shown at least partially closed), and depicts an additional middle inlet extending from the U-shaped channel shown in the synthesis mapping; the northern route (now the main inlet) is not connected to the ocean. Finally, the map at bottom right (ca. 1881, season unknown) shows a southern and northern inlet, both open (the northern inlet is slightly displaced compared to the location shown on the T-sheet and historical aerials). The precise meaning of this suite of maps is ambiguous: given the proximity in date and similarity in purpose of the maps, it is not clear if these differences represent actual changes in inlet location over time, or different surveyors or cartographers depicting similar inlet conditions in different ways. Furthermore, it is not clear whether the railroad bridge over the northern channel reinforced what was already a primary inlet, or whether an alternate channel route was more frequently occupied prior to the construction of the bridge and berm. Regardless, these maps clearly illustrate spatial variability in inlet location and highlight the dynamic nature of the inlet prior to the railroad. (Sources: Unknown ca. 1881a, Osgood 1881a, Unknown ca. 1881b)

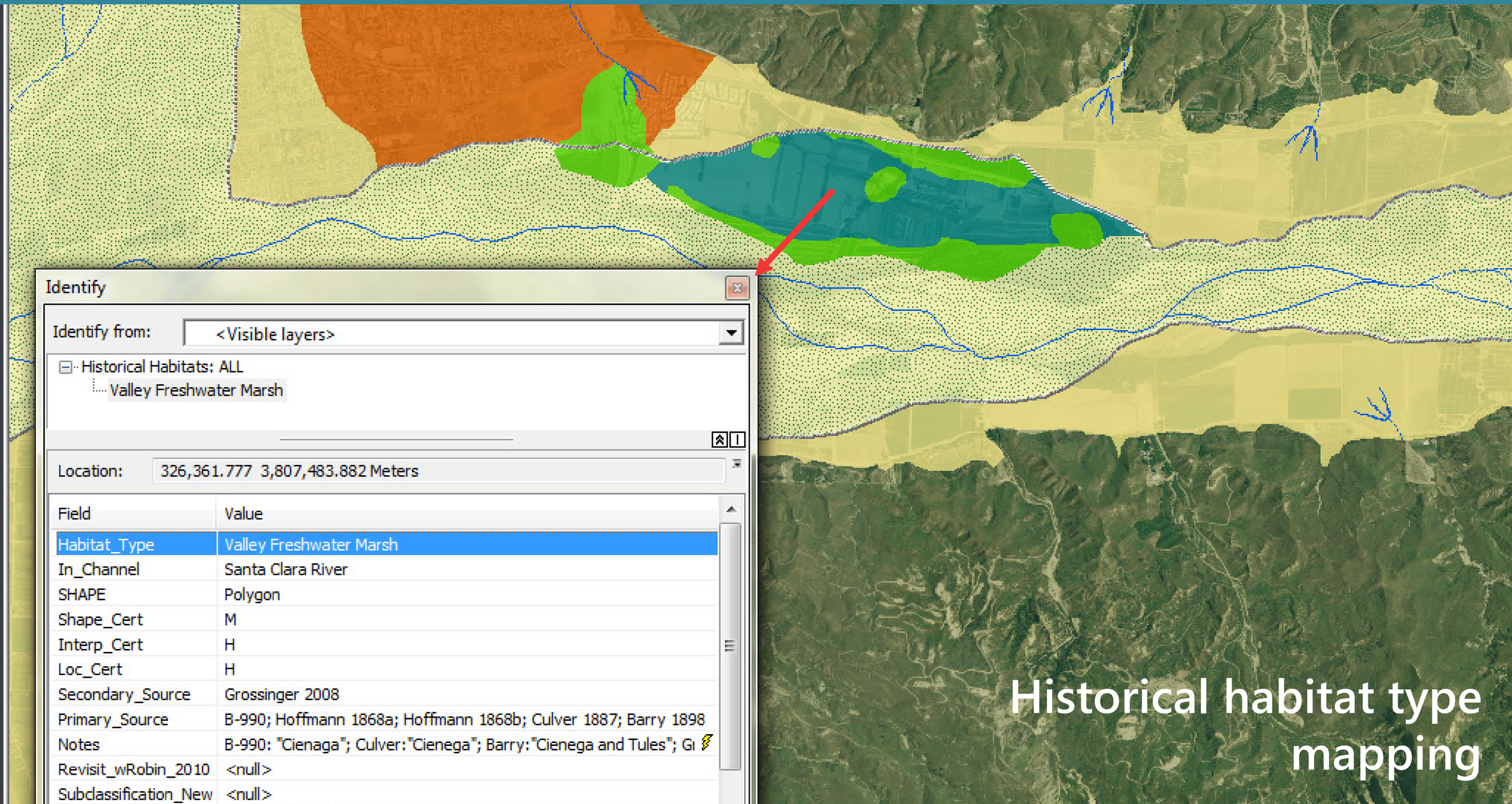


Historical ecology synthesis- future work?



Historical habitat type mapping

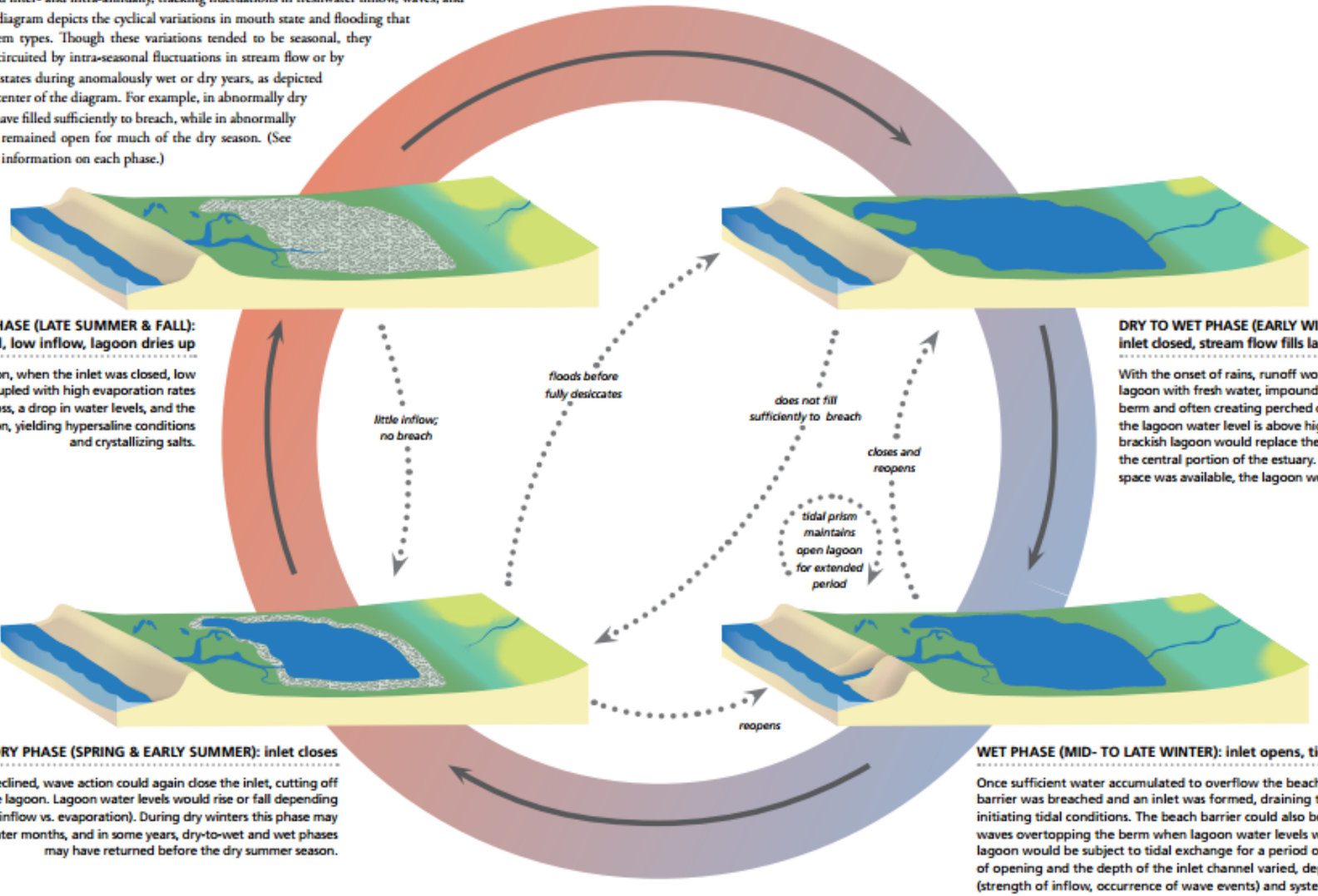
Historical ecology synthesis- future work?



Conceptual models of historical landscapes and processes…

Summary of Findings: Variability in Lagoon Character

Lagoon conditions varied inter- and intra-annually, tracking fluctuations in freshwater inflow, waves, and sediment delivery. This diagram depicts the cyclical variations in mouth state and flooding that characterized these system types. Though these variations tended to be seasonal, they would have been short-circuited by intra-seasonal fluctuations in stream flow or by unusually stable mouth states during anomalously wet or dry years, as depicted by dotted arrows in the center of the diagram. For example, in abnormally dry years a lagoon may not have filled sufficiently to breach, while in abnormally wet years it could have remained open for much of the dry season. (See pages 192-199 for more information on each phase.)



DRY PHASE (LATE SUMMER & FALL): inlet closed, low inflow, lagoon dries up

During the dry season, when the inlet was closed, low freshwater inflow coupled with high evaporation rates led to net water loss, a drop in water levels, and the drying out of the lagoon, yielding hypersaline conditions and crystallizing salts.

DRY TO WET PHASE (EARLY WINTER): inlet closed, stream flow fills lagoon

With the onset of rains, runoff would begin to fill the lagoon with fresh water, impounding behind the beach berm and often creating perched conditions (i.e., where the lagoon water level is above high tide). A freshwater/brackish lagoon would replace the hypersaline salt flat in the central portion of the estuary. Where more flooding space was available, the lagoon would persist longer.

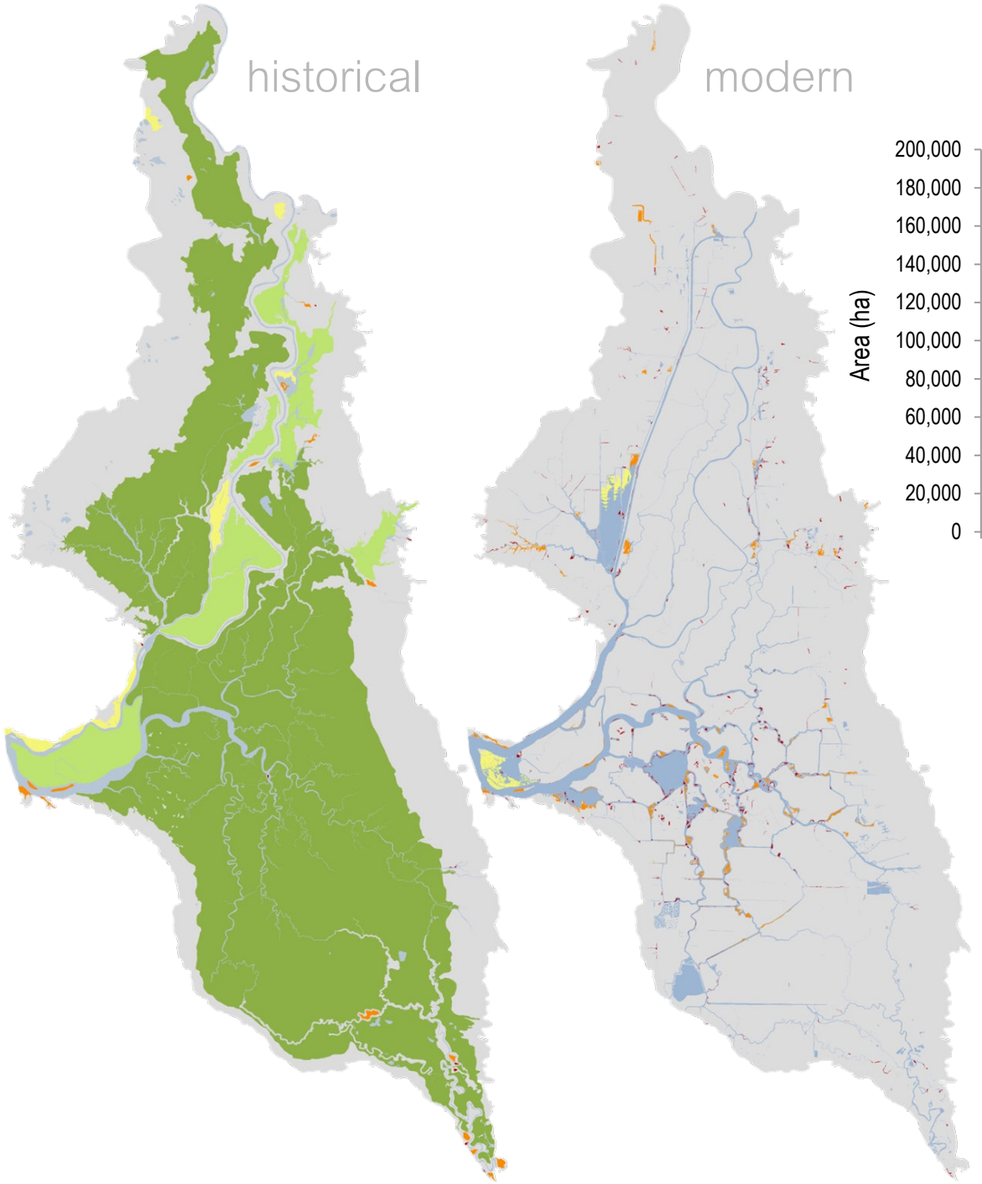
WET TO DRY PHASE (SPRING & EARLY SUMMER): inlet closes

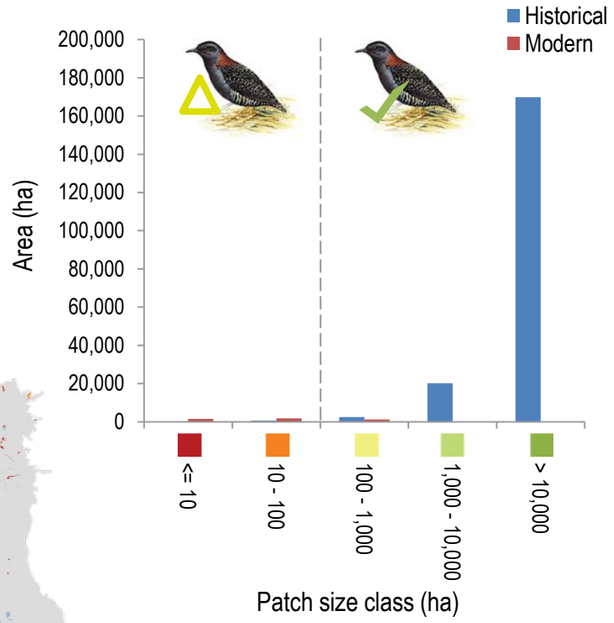
As seasonal inflow declined, wave action could again close the inlet, cutting off tidal exchange to the lagoon. Lagoon water levels would rise or fall depending on net water balance (inflow vs. evaporation). During dry winters this phase may have occurred in winter months, and in some years, dry-to-wet and wet phases may have returned before the dry summer season.

WET PHASE (MID- TO LATE WINTER): inlet opens, tidal conditions

Once sufficient water accumulated to overflow the beach berm, the beach barrier was breached and an inlet was formed, draining the lagoon and initiating tidal conditions. The beach barrier could also be breached by large waves overtopping the berm when lagoon water levels were very high. The lagoon would be subject to tidal exchange for a period of time. The duration of opening and the depth of the inlet channel varied, depending on the year (strength of inflow, occurrence of wave events) and system (available capacity to hold water, tidal prism volume, exposure to wave events).

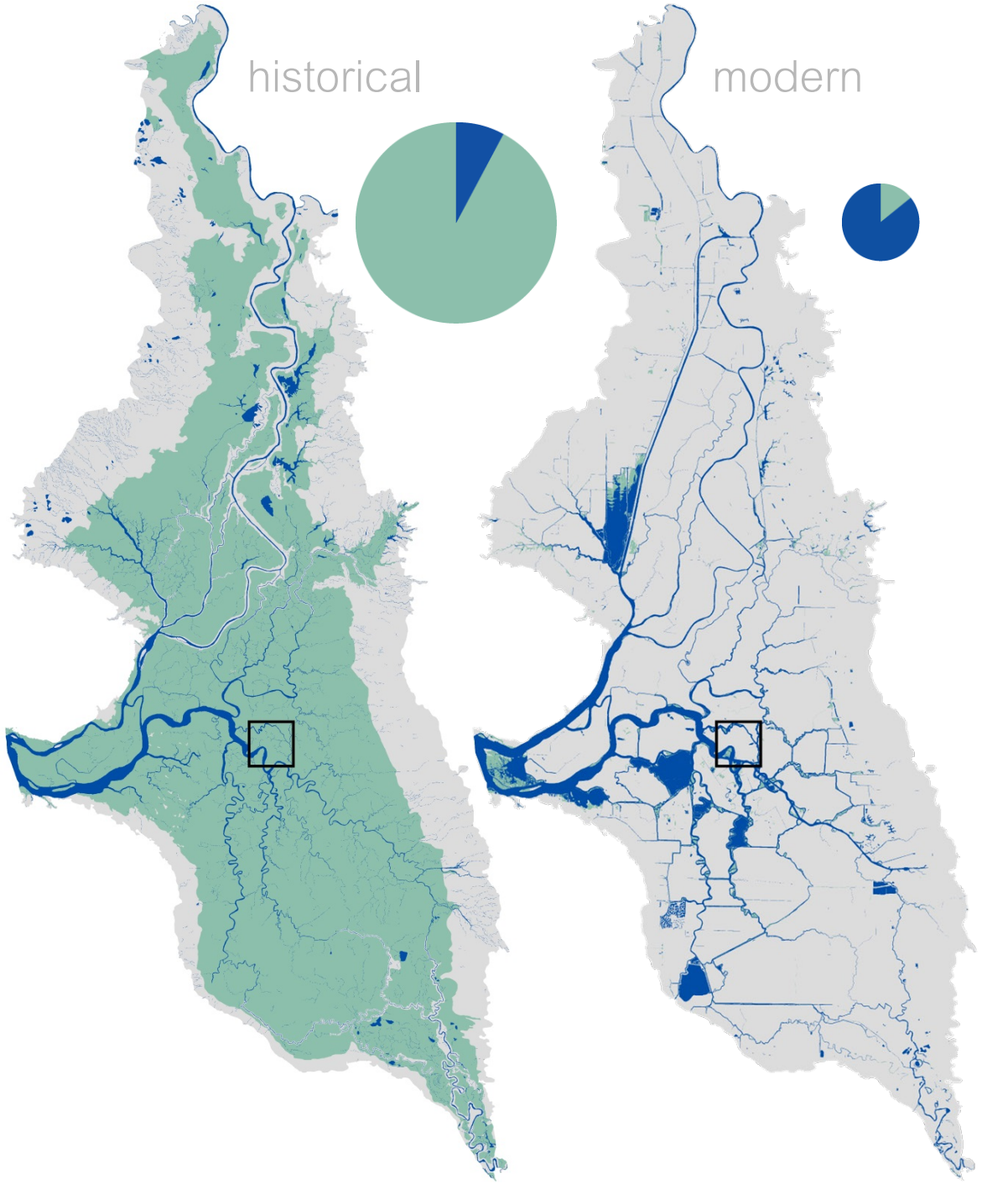
Quantifying change over time, developing landscape metrics





marsh patch size class (hectares)

- <= 10 ha
- 10 - 100
- 100 – 1,000
- 1,000 – 10,000
- > 10,000



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