Climate-Driven Geomorphic Alteration of Intertidal and Subtidal Shoal Habitats for Foraging Migratory Birds in the San Francisco Bay Estuary

DATA SUMMARY PROGRESS REPORT

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Products:

1. Conduct a comprehensive review on foraging of migratory birds on shoal habitats
2. Host a modeling workshop with partners to identify what parameters are needed to model effects of sea level rise on the ecology of shoals and migratory birds
3. Use existing shoals modeling grids (Ganju and Schoellhamer 2010) to develop methodology of quantifying key metrics for habitat change
4. Complete a report on the findings of the workshop and proposed habitat change metrics from the grid approach

Preliminary Results:

1. Conduct a comprehensive review on foraging of migratory birds on shoal habitats

With the prospect of changing climatic conditions affecting the future dynamics and distribution of critical mud flat and shallow shoal habitats, we conducted a comprehensive overview of the suitability of these habitats for foraging birds to help guide future directions for research and management. An extensive review of over 300 scientific journal articles was conducted from August through October 2010, and information is currently being incorporated into a literature review paper. The review document discusses biotic and abiotic influences on foraging suitability for avian species utilizing tidal flats and shallow shoals, explores community dynamics, species requirements, and foraging strategies, discusses various influences on bird carrying capacity, outlines the threats to mud flat and shoal ecosystems, discusses the role of restoration and alternative or artificial habitats, and prioritizes research and management activities. The general

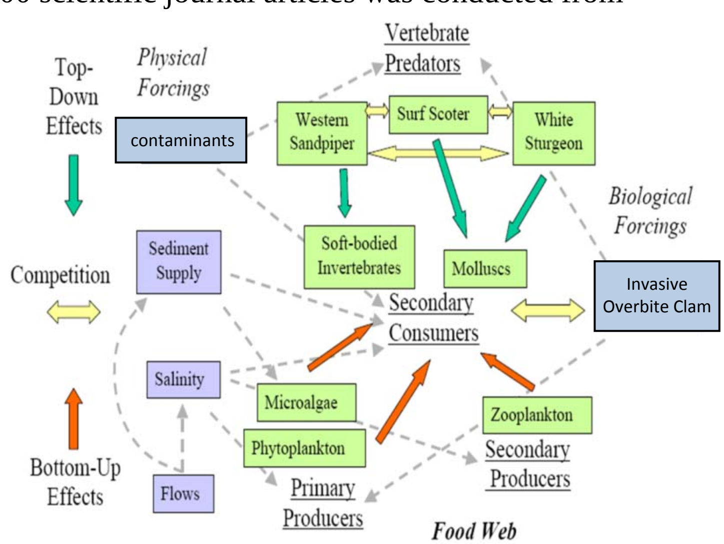

Figure 1. Ecology of shoals conceptual model

discussion relates to physical processes and birds in the estuarine shoals and mud flats of the San Francisco Bay.

2. Host a modeling workshop with partners to identify what parameters are needed to model effects of sea level rise on the ecology of shoals and migratory birds

In October 2010, a workshop was held with partners to identify the parameters needed to model effects of sea level rise on the ecology of shoals and migratory birds. This is the first workshop addressing climate change effects on shoals. Participants of the workshop discussed approaches for modeling the influence of climate change on shoal geomorphology, ecosystem and community dynamics, and habitat suitability to generate spatially explicit predictions of avian response to sea level rise through: a) downscaled climate change models, (b) three-dimensional geomorphic modeling, (c) benthic invertebrate response to geomorphic change, and (d) avian response to geomorphic and invertebrate change. Key discussions of the workshop included: avian ecology of shoal environments, the biophysical interface, the shoal to marsh continuum, the effects of sea level rise, key model parameters, modeling approaches for geomorphic change, modeling approaches for avian ecology, spatial scales, temporal scales, extreme events, and necessary steps for model integration. This workshop was supported by the U. S. Fish and Wildlife Service, California Landscape Conservation Cooperative (LCC) and the U. S. Geological Survey. The main ideas and model parameters identified in the workshop are briefly summarized in this document and are presented relative to the LCC Project goals. A detailed final report of workshop findings is currently being prepared for release in January 2011. Next steps will involve the development of a complete conceptual model integrating the inputs and outputs of the different model types and scales.

Figure 2. Workshop Participants and Affiliation, *left to right:* Neil Ganju (USGS), Janet K. Thompson (USGS), L. Arriana Brand (USGS), Brenda Goeden (SF BCDC), Rebecca Fris (USFWS-LCC), Dano Roelvink (UNESCO-IHE, Deltares), Wendy Goodfriend (SF BCDC), Marilyn Latta (Subtidal Habitat Goals), John Y. Takekawa (USGS), Isa Woo (USGS), Bruce Jaffe (USGS), Amy Foxgrover (USGS), Sam Veloz (PRBO Conservation Science), Noah Knowles (USGS), Laura Shaskey (USGS), Christina Sloop; *not pictured:* Tsewang Namgail (USGS), Aariel Rowan (SFSU), Matt Gerhart (SCC)

Partners: The USGS Pacific Science Center (Jaffe) and UNESCO-IHE (van der Wegen, Roelvink) will provide geomorphic modeling expertise. The USGS Western Ecological Research Center (Takekawa, Woo, Brand, and De La Cruz) will provide invertebrate, bird, and water depth relations and ecological modeling, while the USGS California Water Science Center (Schoellhamer) will provide geomorphic modeling expertise and watershed boundary conditions, primarily sediment supply, to inform geomorphic modeling efforts.

3. Use existing shoals modeling grids (Ganju and Schoellhamer 2010) to develop methodology of quantifying key metrics for habitat change

In conjunction with hosting his visit to the workshop, Ganju provided modeling grids with geomorphic change determined from the ROMS model for the scenarios of global warming, sea level rise, and decreased sediment supply explored in the Ganju and Schoellhamer (2010) paper. We have begun developing methods for working with these data. A series of metrics for habitat change will be created by analyzing geomorphic change from these scenarios, and it is expected that model grid cell size will determine the spatial scale of the metrics. The limitations of using output from hydrodynamic/sediment transport/geomorphic models on habitat metrics will be part of the analysis.

4. Complete a report on the findings of the workshop and proposed habitat change metrics from the grid approach

a) Use of downscaled climate change models to translate climatic predictions into habitat quantity predictions through three-dimensional geomorphic modeling

The CASCaDE project has developed data on the cascading effects of changes under different climate scenarios as they propagate from the climate system to watersheds to river networks to the Delta and San Francisco Bay (Cayan et al. 2008a, 2008b, 2008c, Ganju et al. 2008, Ganju and Schoellhamer 2009). Global climate models are run under selected scenarios of future greenhouse gas emissions, and resulting precipitation and temperature projections are downscaled for use in the hydrologic model, which provides input for the estuarine models. This model output, which is available now, is the input for the geomorphic model. The proposal for CASCaDE II involves the Delft-UNSTRUC, incorporates hydrodynamic effects from ocean to river, and also includes the fate of wetlands.

Initial steps of hydrological modeling will use current bathymetry and topography to explore the effects of sea level rise. The goal is to determine the overall availability of suitable depth ranges as sea level rises and intertidal habitat disappears as it moves landward and potentially into hard structures. However, increasing wave reflection from hard structures would eventually increase erosion of the flats. Modeled shoal changes for Suisun Bay (Ganju and Schoellhamer 2010) will also be used to develop methodologies for quantifying intertidal habitat change resulting from climate change and sea level rise. These simulations showed an increase in erosion of intertidal areas when a base-case scenario was compared with a scenario of warming, sea level rise, and decreased watershed sediment supply. Intertidal areas can be delineated from historic surveys, and change in tidal flats can then be quantified using recent light detection and ranging (LiDAR) surveys. Parameters that affect tidal flat change will be identified and spatial distribution of wave energy, tidal currents, and sediment availability will be determined. Mud flat change over time will be used to determine estuarine geomorphic numbers for San Pablo Bay and the South Bay. Numbers can be refined by hydrodynamic and sediment transport models.

Stratification of modeling scales and complexity are essential because the time to run the large scale, fully 3D models prohibits a large number of long-term simulations. The influence of sediment size, tidal range, and wave exposure will first be assessed at locations with characteristic profile shapes from around San Francisco Bay. Distilling to 1-D profiles where wave attenuation will be assessed is very informative for determining how sea level rise affects the wave and the marsh. The approach focuses on type localities, how much habitat is there, and how it will be altered by changes in wave energy associated with sea level rise. Looking at simplified models of profile behavior will be helpful in determining the key driving processes. It is important to capture different topologies, shoreline types, and the full transition from tidal flat to vegetated marsh, and then assess how these will be affected by sea level rise. Developing a tool to look at cross-shore behavior and marsh response will be useful in parameterizing the larger model. We will run sensitivity analyses involving waves, sediment types, tides, upwelling, and vegetation response. Furthermore, by looking at probabilistic depth-distribution by cell, we can have a representation of more complex small-scale topography. Variation in microtopography within a cell influences the movement of the tide line, water depths, and fine-scale prey and predator distributions. Because shorebirds are more refined in the habitat that they use, subgrid modeling will focus on near-shore areas. Shoreline extrapolation will be refined with new lidar data.

Ultimately, the Delft3D modeling system will be used to investigate sediment transport, hydrodynamics, and morphological change. We will use a combination of the Delft 2DH (Roelvink et al. 2001) and 3D (Lesser et al. 2004, Winterwerp 2001) coupled hydrodynamic, sand and mud transport models and morphology models within the Delft3D system (http://delftsoftware.wldelft.nl/index.php?option=com_content&task=view&id=109 and http://www.wldelft.nl.soft/d3d/intro/) to assess likely changes to the intertidal, and because of its influence on the intertidal, the subtidal. Changes in depth, due to sediment redistribution, and sea level rise, alter the distribution of available habitat. Freshwater inflows and sediment supply are simulated from GCCM output and combined with sea level rise and estuarine hydrodynamics to estimate likely future geomorphic change (Ganju et al. 2009; van der Wegen et al., in review). These models are informed by research on historical intertidal changes in the northern San Francisco Estuary (Jaffe et al. 2007, Jaffe et al. 1998, Capiella et al. 1999). The same data also allow calibration and validation of the geomorphic models. GIS tools will be developed that integrate with the avian foraging model.

Linkage between subtidal shoal, intertidal flat, and marsh, the modeling of the shoals will be connected to modeling in the marsh. There is an integral linkage between the protection of the marsh and the mudflat, because of the equilibrium between the destruction and formation of both flats and marsh. A continual cycle between sedimentation and erosion is important for a healthy system, as it is necessary for wave energy to attack the marsh in order to build shoals and mud flats. The ability of the marsh to erode will determine the amount of sediment in the system. Furthermore, the potential levels of marsh protection and the ability of storms to redistribute sediment to shoal habitats will need to be included in models. Estimating the sediment demand of salt ponds being converted to marsh will be a part of the modeling.

The ultimate goal is to determine the key driving processes for mud flat change as sea level rise rates accelerate in the future. A key step is the identification of the tipping point or threshold for system change and determining when this might occur. In scenario modeling, this would involve an identification of areas that would allow for natural processes to keep occurring. The scenario approach is useful in determining the effect of human inhabitation, such the incorporation of water conveyance systems in CASCaDE I. Hydrodynamic models will need to incorporate the future location, height, and condition of levees. Potential impacts of deepened shipping channels, increased tidal prism, and salinity intrusion should also be included in models. Ultimately, color-coded hazard maps can be developed depicting sea level rise effects.

b) Simulate response of benthic invertebrates to changes in intertidal geomorphology

Major effects on invertebrates include predation pressure, sediment characteristics, tidal inundation and exposure, salinity, and temperature. Predation pressure is dependent on foraging time and water depth. Water inundation and exposure is driven by slope and elevation relative to the tidal cycle. Annual depletion of prey stocks is common, due to annual avian predation, the influence of non-avian predators (i.e. fish, crustaceans, rays, and sharks), and potential predator invasion of the estuary due to upwelling. The separation of inundation and exposure from predation pressure is difficult, but it can be accomplished using predator exclusion experiments. Invertebrates are also strongly influenced by salinity, so the effects of potential increase in salinity stratification due to sea level rise need to be taken into account.

Phytoplankton dynamics are a key aspect in predicting invertebrate abundance and distribution. Suspended sediment concentrations and water depths will influence the light available to phytoplankton, and it is possible to model how decreased sediment concentrations could offset the increase in water depth. Phytoplankton blooms are generally initiated in the shallow shoal environments, as cells have increased opportunity for light.

Spatially-explicit geographic information system-based analysis (ArcGIS, ESRI Systems, Redlands, CA) will be used to map expected macroinvertebrate densities in response to changing physical conditions. We will use model simulations to determine how sediment and morphological changes may affect community composition and availability of their macroinvertebrate food resources. We will use CANOCO 4 (ter Braak and Smilauer 1998) to perform canonical correspondence analyses (CCA; ter Braak 1986, ter Braak 1988) to reveal gradients in species composition and relate log-transformed macroinvertebrate abundance values to environmental variables (i.e., salinity, bed elevation, sediment grain size).

There are some difficulties in discerning seasonal and spatial variability in invertebrates, because many influential factors are not locally determined. Larger scale landscape factors have an influential role on invertebrate distribution and abundance in shoal habitats. Invertebrate dynamics are driven by phytoplankton, however predation influences the crash of benthic populations. Large spatial scales will be necessary to model hydrology, phytoplankton, and annual changes in benthic communities. In addition, oceanic upwelling events will drive nutrient availability, and the more food availability, the increased influence of predator migration into the bay. Models of ocean systems and data on upwelling can be used to assess changes on productivity. Larger-scale fluctuations, such as El Nino and NPGO, will need to be accounted for as well. As mentioned previously, shoals and wetlands are connected as part of a continuous system, therefore modeling of invertebrates must also involve wetland dynamics. Wetlands act as nurseries for biota, such as amphipods, isopods, and fish.

c) Model shorebirds and waterfowl response to geomorphic and invertebrate change

Shorebirds and waterfowl generally use different areas of shoals, intertidal and subtidal respectively, however habitat area overlaps somewhat in the intertidal zone. Suitability of avian habitat will be defined by both prey and physical characteristics (i.e. water depth, sediments, slope, salinity, inundation regime). All of these factors interact to determine the area suitable for foraging. Water depth and the movement of the tidal line influence the available foraging time and accessibility of prey, while inundation/exposure and salinity are the biggest factors in determining invertebrate distribution. Prey quality, abundance, distribution, and accessibility will determine bird carrying capacity and population health. Predictions of sea level rise relative to geomorphic change will be used to model the change in fine-scale tidal flat habitat for foraging shorebirds and the amount of shoal habitats at suitable water depths for foraging waterfowl. For diving ducks, both the energy cost of diving and the thresholds for diving depth are variable by species and will need to be considered.

We have conducted studies on the foraging ecology of migratory birds in San Francisco Bay for over 20 years. We will apply our extensive existing datasets on foraging behavior, as well as the results of detailed shorebird and invertebrate prey surveys from the USGS Shoals Project and our knowledge of current and past baywide distribution of migratory waterbirds (Takekawa et al. 2001, Takekawa et al. 2002, Warnock et al. 2002, Takekawa et al. 2006, Hickey et al. 2007, Takekawa et al. 2009). Presence-absence and density of surf scoters have also been modeled relative to habitat distribution. Next steps are to add details to models, such as the factors of disturbance and management, and then incorporate them into larger-scale models.

We will use geographic information system-based analysis (ArcGIS, ESRI Systems, Redlands, CA) to compare the current and projected extent of shoal habitats through the next half century with our knowledge of foraging ecology of migratory birds to estimate likely functional and numerical responses to alteration of their foraging resources. Spatially-explicit habitat suitability models or indices (HSI) involve factors influencing different groups of birds in order to determine degrees of suitability of specific areas. The percentage of shoals that are available and accessible for specific periods of time will be modeled. The number of acres at certain elevations and how moving water lines will change according to profile shape, slope, and tide will be determined. Landscape influences on the suitability of foraging sites, such as proximity to suitable roosting and nesting habitat, will also be assessed using spatial analyses.

Carrying capacity modeling will assist in determining the current baseline resource value in the estuary, which will aid in estimating how bird populations will be affected by changing conditions. Models of carrying capacity can be parameterized with information from habitat-based models, and they will eventually determine the maximum number of bird days that can be supported by the supply available at a particular site. Threshold prey densities for species or guilds can be determined through carrying capacity models, and modeling also accounts for the effects of competitors on their shared prey base. Next steps will involve fish biologists in order to assess how climate will affect fish communities and predator-competitor interactions. Models of carrying capacity have recently been developed for diving ducks of San Pablo Bay Shoals (Lovvorn 2010, Lovvorn etal. *in prep.*), as well as small sandpipers on the Dumbarton Shoals (Rowan 2010, Rowan et al., *in prep.*). A structured equation model would also be created based on invertebrate and bird data currently available for the Dumbarton Shoals.

Another important consideration is that habitat provided by former salt ponds growing new marsh is providing valuable transitional habitat that may be lost if fully restored to marsh. Steps are currently being made to determine the energetic value of salt ponds. The availability of salt pond habitats is currently supplementing the carrying capacity of the flats for shorebirds, therefore future carrying capacity predictions will need to account for decreased habitat availability as these ponds transition into mature marshes.

Although we need a better understanding of historic benthic conditions, it can be possible to hindcast causes of bird decline and changing habitat use patterns by analyzing more recent bird and invertebrate data over the last decade. Reproducing the past can help to determine what is driving trends and will assist in modeling future scenarios. Bird habitat utilization can be predicted based on benthic conditions, by modeling the influences on spatial variability of food sources from the Benthic Atlas (Rowan et al., *in prep*.). Due to seasonal variability in birds and invertebrates, the scope of analyses can be narrowed down to be season-specific. Modeling will assess correlations with seasonal variation in hydrodynamics, while sediment dynamics will be incorporated cumulatively over time.

d) Integrate predictive changes in habitat quantity and prey abundance to generate spatially-explicit predictions of avian response to changes from climate change and sea level rise

Our ultimate goal is a spatially explicit evaluation of: a) quantitative change in habitat availability for key waterbird species, incorporating both climate change-driven changes in sediment distribution and increased sea level rise; and b) change in distribution and relative abundance of waterbird species, incorporating changes in habitat quantity and quality (i.e., invertebrate food resource changes due to changes in salinity or sediment grain size).

In the San Francisco Bay estuary, biological forcing factors are at the scale of embayment. Different prey densities and species compositions influence bird responses, therefore spatial predictions of avian responses to habitat change will be assessed by sub-bay. There are currently more ducks in San Pablo Bay and more shorebirds in the South Bay. In San Pablo Bay, the shoals and flats are wider and hydrological models are well developed. The South Bay has a smaller shoal area, however the USGS Shoals Project is underway and baseline waterbird and invertebrate data has been collected over the last couple years.

The scenarios approach to modeling will be essential in this process, and will need to include both climate scenarios and management scenarios. Because of uncertainty of future events, models must allow for a range of sea level rise projections and potential land management decisions (i.e. levee removal). Early outputs from initial models will be important in influencing land management in the near future. For modeling at larger temporal scales, 30-year timescales are feasible and will help in predicting effects of current management practices, as well as guiding management decisions down the line. The largest predicted climate change effects are in terms of sea level rise, as there is no consensus on how storminess will change with climate change. Increased frequency of severe storms could result increased burying loss of food availability. The event scale should be focused on what is of greatest concern to birds. In looking at scenarios, the model of the mean can be compared to models of extremes.

References Cited

Cappiella, K, Malzone, C, Smith, R. E., and Jaffe, B.E., 1999, Sedimentation and bathymetry changes in Suisun Bay, 1867-1990: U.S. Geological Survey Open-File Report 99-563 [URL: http://geopubs.wr.usgs.gov/open-file/of99-563/].

Cayan, D., A. Luers, G. Franco, M. Hanemann, B. Croes, and E. Vine. 2008a. Overview of the California climate change scenarios project. Climate Change 87: 1-6.

Cayan, D., E. Maurer, M. Dettinger, M. Tyree, and K. Hayhoe. 2008b. Climate change scenarios for the California region. Climate Change 87: 21-42.

Cayan, D., P. Bromirski, K. Hayhoe, M. Tyree, M. Dettinger, and R. Flick. 2008c. Climate change projections of sea level extremes along the California coast. Climate Change 87: 57-73.

Ganju, N.K., and D. H. Schoellhamer. 2010. Decadal-timescale estuarine geomorphic change under future scenarios of climate and sediment supply. Estuaries and Coasts 33:15-29.

Ganju, N.K., N. Knowles, and D.H. Schoellhamer. 2008. Temporal downscaling of decadal sediment load estimates to a daily interval for use in hindcast simulations. Journal of Hydrology 349: 512-523.

Ganju, N.K., Schoellhamer, D.H., and Jaffe, B.E., 2009, Simulation of decadal-timescale estuarine geomorphic change with a tidal-timescale model, Journal of Geophysical Research-Earth Surface, doi:10.1029/2008JF001191.

Hickey, C., N. Warnock, J.Y. Takekawa, and N. D. Athearn. 2007. Space use by black-necked stilts in the San Francisco Bay estuary. Ardea 95: 275-288.

Jaffe, B.E., Smith, R. E., and Torresan, L. Z., 1998, Sedimentation and bathymetric change in San Pablo Bay: 1856 to 1983: U.S. Geological Survey Open-File Report 98-759 [URL: http://wrgis.wr.usgs.gov/open-file/of98-759/].

Jaffe, B.E., Smith, R.E., and Foxgrover, A.C., 2007, Anthropogenic influence on sedimentation and intertidal mudflat change in San Pablo Bay, California: 1856 to 1893. Estuarine. Coastal and Shelf Science 73 (1-2), 175-187, doi:10.1016/j.ecss.2007.02.17.

Lesser, G. R., J. A. Roelvink, J. A. T. M. van Kester, and G. S. Stelling, 2004, Development and validation of a three-dimensional morphological model, Coastal Eng., 51, 883 – 915, doi:10.1016/j.coastaleng.2004.07.014.

Lovvorn, J.R. 2010. Modeling habitat dependencies of diving ducks in San Francisco Bay. Unpubl. Final Report to Oikonos. Santa Cruz, CA.

Roelvink, J.A., Jeuken, M.C.J.L., van Holland, G., Aarninkhof, S.G.L. and Stam, J.M.T., 2001. Long-term, process based modelling of complex areas. Proceedings 4th Coastal Dynamics Conference, Lund, Sweden, pp 383-392.

Rowan, A. 2010. Effects of the South Bay Salt Pond Restoration Project on mud flats and their carrying capacity for small shorebirds. Unpubl. Rep., Quarterly Update, RLF contract #2009-0210. Sacramento, CA.

Takekawa, J. Y., C. T. Lu, and R. Pratt. 2001. Avian communities in salt evaporation ponds and baylands of the northern San Francisco Bay estuary. Hydrobiologica 466: 317-328.

Takekawa, J. Y., N. Warnock, G. M. Martinelli, A. K. Miles, and D. C. Tsao. 2002. Waterbird use of bayland wetlands in the San Francisco Bay estuary: movements of long-billed dowitchers during the winter. Waterbirds 25: 93-105.

Takekawa, J. Y., A. K. Miles, D. H. Schoellhamer, N. D. Athearn, C. Jannusch, M. K. Saiki, W. D. Duffy, and S. Kleinschmidt. 2006. Trophic structure and avian communities across a salinity gradient in evaporation ponds of the San Francisco Bay estuary. Hydrobiologia 567: 307-327.

Takekawa, J. Y., A. K. Miles, D. C. Tsao-Melcer, D. H. Schoellhamer, S. Fregien, and N. D. Athearn. 2009. Dietary flexibility in three representative waterbirds across salinity and depth gradients in salt ponds of San Francisco Bay. Hydrobiologia 626:155–168.

ter Braak, C.J.F.,1986. Canonical correspondence analyses: a new eigenvector method for multivariate direct gradient analysis. Ecology 67: 1167-1179.

ter Braak, C.J.F., 1988. Partial canonical correspondence analysis. In Classification and Related Methods of Data Analysis (H.H. Bock, ed.), North-Holland, Amsterdam pp. 551-558.

ter Braak, C.J.F. & P. Smilauer, 1998. CANOCO Reference Manual and User's Guide to CANOCO for Windows: Software for Canonical Community Ordination, version 4, Microcomputer Power, Ithaca, NY.

USGS. 2007. CASCaDE: Computational Assessments of Scenarios of Change for the Delta Ecosystem: URL http://sfbay.wr.usgs.gov/cascade/

van der Wegen, M., Jaffe, B.E., and Roelvink, D., in review, Process-based, morphodynamic hindcast of decadal deposition patterns in San Pablo Bay, California, 1856-1887, Journal of Geophysical Research-Earth Surface.

van der Wegen, M., Roelvink, D., Jaffe, B.E., Ganju, N., Schoellhamer, D., 2008, CASCaDE research on hindcasting bathymetric change in San Pablo Bay, 1856-1983: A step towards assessing likely geomorphic change in response to climate change (abs.) Fifth Biennial CALFED Science Conference, p. 207. 567: 307-327.

Warnock, N., G.W. Page, T.D. Ruhlen, N. Nur, J.Y. Takekawa, and J.T. Hanson, 2002. Management and conservation of San Francisco Bay salt ponds: effects of pond salinity, area, tide, and season on Pacific Flyway waterbirds. Waterbirds 25: 79-92.

Winterwerp, J.C. 2001. Stratification effects by cohesive and non-cohesive sediment, 2001, Journal of Geophysical Res., Vol. 106, No. C10, pp 22,559-22,574.