This is a proposal that redirects sedimentation and dredging operations in coastal areas and ports to provide a material stream that addresses challenges associated with sea level rise. These infrastructures have the capacity to create new commodity markets, build and support industries, preserve ecologies, and create new programmatic realms for urban waterfronts. San Francisco Bay serves as a case study to explore this concept.

In this century sea levels are projected to rise as much as 55" due to global climate change. In the United States this trend threatens the most populated coastal areas, economies, ecologies, and cultures.

This epic disaster will unfold slowly. In dense metropolitan areas surrounding estuaries and ports, the response is likely to be slow, late, and resource intensive. The sheer magnitude of the issue promises uncoordinated efforts among governments, agencies, and the private sector.
Sea levels are projected to rise 55" in this century. This trend threatens our most productive economies, critical infrastructures, cultures, and coastal ecologies. Occurring incrementally over generations, it will be a catastrophe in slow motion.

The tendency of governments, agencies, and the private sector will be to act slowly in an ad hoc fashion. Acting in a coordinated large-scale force that leverages all available resources can engage the available time to offer efficiencies, less disturbance, and lower costs.
Supply

Estuaries where there are larger populations will employ time-tested technologies such as dikes, bulkheads, and raising land and marshes above sea level. These are resource-intensive endeavors that require large-scale resource (sand, soil, gravel, rock) extraction and transport. In the past century land reclamation projects used the closest source of material to make land. Today these resources are not available in urban areas. Furthermore, extracting resources remotely and transporting them on the scale of an estuary would be a destructive and carbon-intensive process.

Estuaries themselves can provide a material stream through dredging operations that are routine to ports, ship channels, and marinas. Applying this material stream to sea rise projects offers an alternative to ports for handling contaminated sediments, lowers transport costs, and diverts material to projects that would typically be dumped at sea.

400 million cubic yards of dredged material is removed from US ports each year - enough to fill a four lane highway, 20 feet deep, from New York City to Los Angeles. 60% of the material is dumped at sea.
The events of September 11, 2001 and Hurricane Katrina are our most recent examples of large scale events that threaten cities. With the support of voters and governments, both tragedies have lead to preemptive practices to limit the possibility of similar events in the future, aggressive rebuilding efforts, and staunch resistance to fundamental change from what was lost.

Sea rise threatens profound losses on a greater scale. While there will certainly be losses of land and compromises, these examples suggest that the prevailing collective demand will be to invest, protect, and if necessary rebuild.
SITUATION: The Bay Area is over-invested in the areas threatened by the uncertain change of sea rise with cities, economies, and a way of life. Urbanism and industry, the same forces that have filled and transformed the Bay to half its pre-development size in the past century, will vigorously resist this change in the century to come. Environmentalists and regulatory agencies as well will apply forces to keep bay habitats functioning. The technology for this feat is not the issue. In addition the Bay is accident prone, maintenance heavy, and threatened by environmental issues on a tremendous scale that will continue or be compounded by sea rise.

CASE STUDY: SAN FRANCISCO BAY

FACTS
- Every year 6 million cubic yards of sediment is dredged from the San Francisco Bay—enough to fill the TransAmerica Building 27 times.
- Hydraulic gold mining before the turn of the century deposited 8 times the volume of sand, rock, and gravel than was excavated from the Panama Canal into the delta.
- There have been more than 10 major oil spills in the Bay since 1970. In 2008 Cosco Busan spill released 53,000 gallons of toxic bunker fuel.
- There are over 70 sites regulated by the Environmental Protection Agency at the Bay edge.
- There are potentially over 100,000 acres that could be restored to tidal marsh, but costs, lack of sediments, and high salinity prevent progress.

This is a proposal for a regional scale infrastructure, a pipeline, for adapting to sea level rise and climate change. Rather than settling into a pattern of piecemeal solutions over the next century, this proposal envisions a coordinated effort to leverage collective resources and modify San Francisco Bay over time. With a machine designed to distribute material streams to re-make and maintain the Bay landscape, we will be able to build coastal defenses, support industries, create a new economy, and cope with the known and unknown challenges that sea level rise and global climate change will present.
**PRIMARY FUNCTION: SEDIMENT**

The system would be a circuit comprised of large diameter pipes designed for the **primary purpose of distributing sediments** to provide the basic materials of sand, silt, and gravel needed to **supply coastal defense and habitat projects**. At the water surface, mobile pontoons equipped with wind and solar power facilities would provide energy and pumping equipment to circulate the materials. The pontoons would also serve as manifolds for distribution to various projects and operations.

**SOURCES**

Sediments would come from a variety of sources: off-shore deposits, dredging operations from ports and harbors, new deposits of sediments introduced by stronger currents, and the bay floor.

There are sediment deposits and sites in the Bay that are contaminated. The pipeline would be capable of evacuating contaminated sediments much more safely and efficiently than conventional dredging methods. As potential building materials, these sediments could be directed to projects capable of **encapsulating** them. In other cases, **entire contaminated sites** threatened by tides could be evacuated and mitigated by treatment wetlands before being used for construction.

**SECOND FUNCTION: THERMAL**

To cope with climate change influences, a second function of the pipeline would be **thermal exchange loops for mediating water temperature**. Shallow areas in the north and south bay would support industrial ecologies that would include uses such as algal biofuels, aquaculture, remediation wetlands, waste water treatment, and native oyster beds. Thermal loops would supply the needs of these industries by exchanging warm water in shallow areas with cool water from deep trenches. Cool water would also augment stream flows to facilitate fish migrations back to spawning grounds.

**THIRD FUNCTION: TOXIC**

A third function of the pipeline would be for **disaster response**. In times where quick action on a large scale is needed the pipeline would be converted to a conduit for evacuating spills and moving them to **settling ponds and remediation wetlands**.
MINERAL PARCELS

After establishing a parcel system that would protect habitats and hydrologic functions of the Bay, parcels would be sold, traded, and harvested for their sediments to supply projects.

Creating a market for “mineral rights” to mining parts of the bay floor would yield a stream of capital to finance the pipeline.
1. **PROJECT:** algal biofuel facility  
   **CONSTRUCTION TIME:** 20 years  
   **NOTE:** thermal loop diverts warm water from shallow cells to aquaculture farms

2. **PROJECT:** raised tide marsh  
   **CONSTRUCTION TIME:** 25 years

3. **PROJECT:** aquaculture  
   **CONSTRUCTION TIME:** 25 years  
   **NOTE:** former big box shopping center

4. **PROJECT:** Menlo Park Levee  
   **CONSTRUCTION TIME:** 12 years  
   **NOTE:** 6 mile levee. Levee core encapsulates 6 million yards of contaminated sediment

5. **PROJECT:** raised tide marsh  
   **CONSTRUCTION TIME:** 25 years  
   **NOTE:** sediments delivered from delta to raise pond bottom elevation

6. **PROJECT:** Foster City Levee  
   **CONSTRUCTION TIME:** 25 years in 2 phases  
   **NOTE:** 12 mile levee protecting 20,000 residents

7. **PROJECT:** Seal Slough Restoration  
   **CONSTRUCTION TIME:** 43 years  
   **NOTE:** 5,000 residents and businesses moved to create slough, ponds, and tide marsh at higher elevation

8. **PROJECT:** Burlingame Levee and Marsh  
   **CONSTRUCTION TIME:** 22 years  
   **NOTE:** light industrial and residential area evacuated to create marsh and 6-mile levee

9. **PROJECT:** SFO International Airport Runway Elevation  
   **CONSTRUCTION TIME:** 4 years  
   **NOTE:** raised runway elevations in existing configuration

   **PROJECT:** SFO International Airport Runway Expansion  
   **CONSTRUCTION TIME:** 15 years  
   **NOTE:** expand runways to accommodate larger planes and increased frequency weather events disrupting service

10. **PROJECT:** San Bruno Levee, Marsh Creation, and I-380 Protection as Mitigation for SFO Runway Projects  
    **CONSTRUCTION TIME:** 35 years  
    **NOTE:** light industrial businesses evacuated in 2 areas and construction of 12 miles of levee
SURFACE PROGRAMS

Pumps, energy production facilities, operations, maintenance, and supplies would be stationed on a fleet of pontoons on the surface to support the functions of the pipeline. The pontoons are large-scale marine infrastructure intended for medium to long term installations.

The forms are intentionally simple to allow for periodic relocation, maximum stability, and modular construction. The pontoons would be moored to weights placed on the sea floor.

In addition to support functions, the pontoons and moorings would be used to host other civic scale programs and income producing uses. Accessed by boardwalks mounted to floating pipelines, pontoons can be used to provide large-scale programs that are difficult to locate in urban areas such as street tree nurseries or food production. Pontoons would also substitute for waterfront programs displaced by coastal projects with long construction periods such as sports fields and beaches. Pontoons for both pipeline support, and programs would form flotillas that serve as new programmatic realms in a time of adaptation to rising sea levels.
FLOTILLA

1. Pipeline
2. Lift Station & Manifold
3. Operations & Maintenance
4. Energy Production
5. Floating Pipeline/ Boardwalk
6. Land Elevation Project
7. Greenhouse/ Market Plaza
8. Treatment Wetland
9. Pool / Beach / Marina
10. Aquaculture
11. Street Tree Nursery