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Knowledge Infrastructure for Coastal Infrastructure: The Y02A Patent Initiative and Site-Based Climate Adaption Strategies

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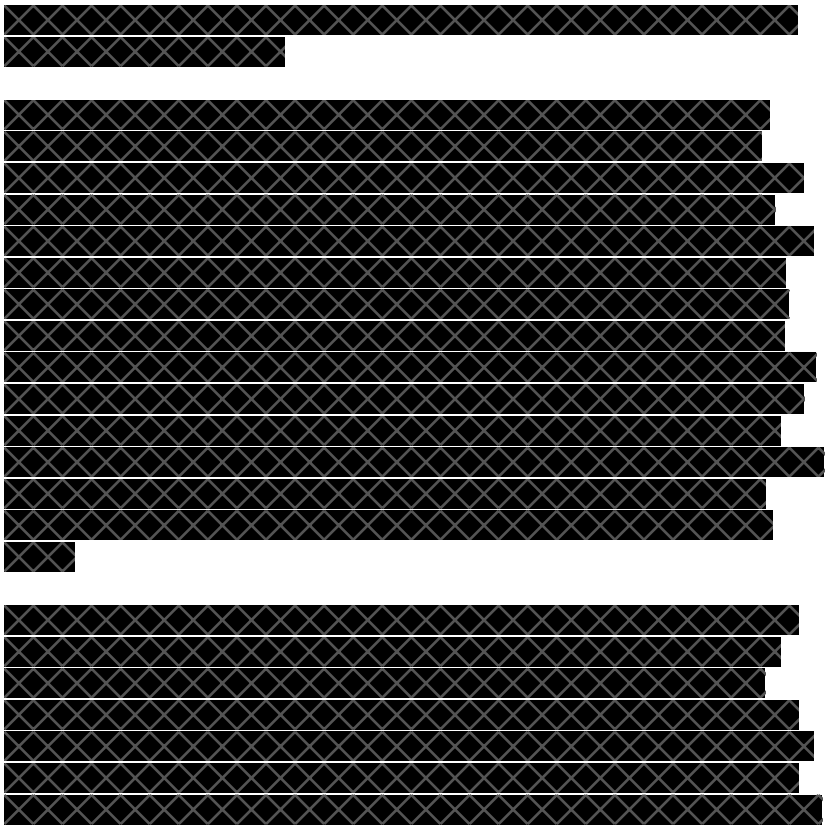
LANDSCAPE URBANISM

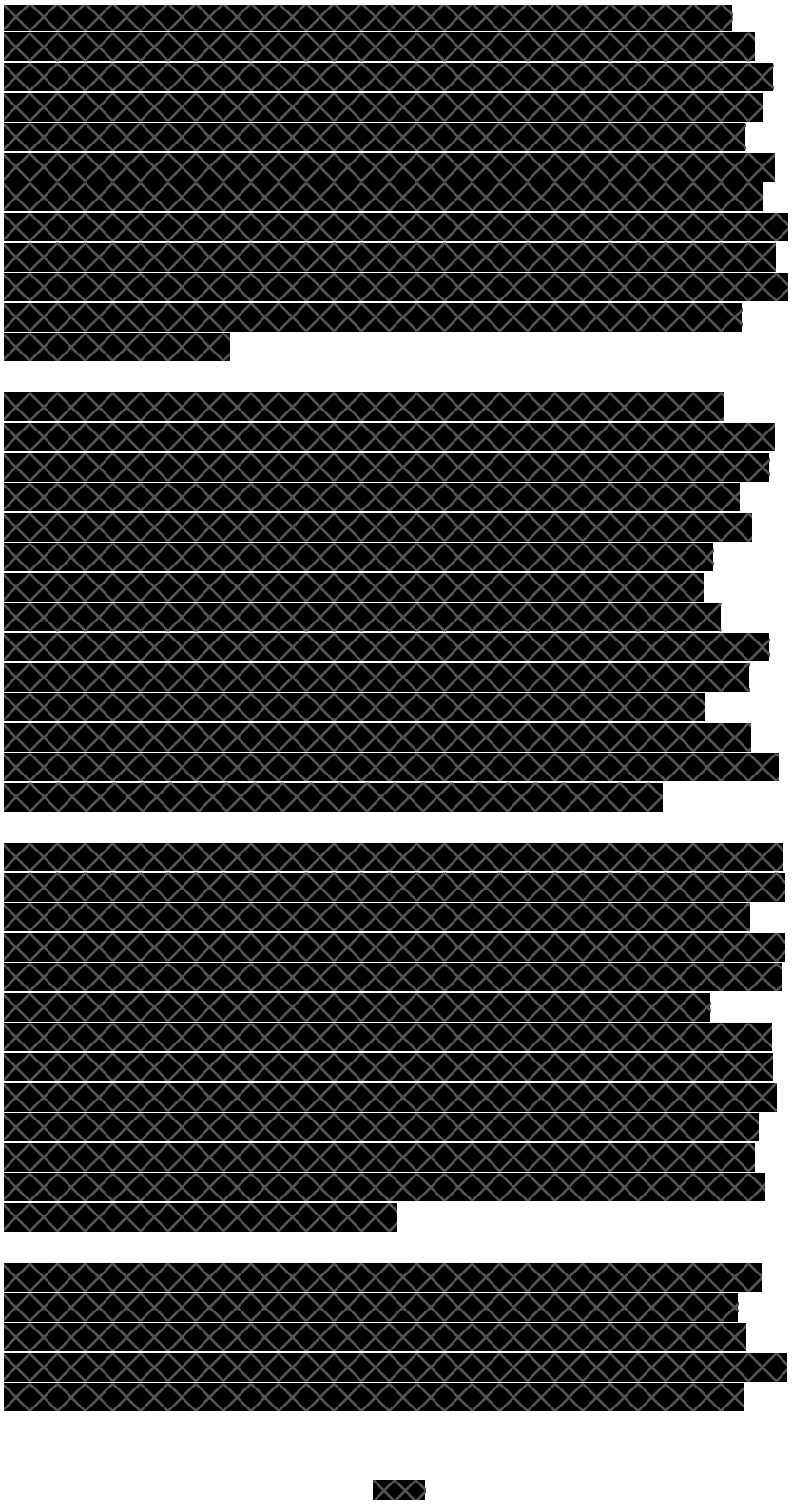
ABSTRACT - *Innovation in climate adaptation and resilience practices is among the most critical issues in architecture, design, and planning. This essay explores how coastal adaptation and resilience planning processes may be informed by the Y02A patent classification scheme to design advanced forms of site-specific coastal infrastructure. The Y02A scheme covers the "technologies for adaptation to climate change," organizing coastal, riverine, and urban climate adaptation innovations into distinct sub-classes, with the aim of building technical capacity and coordinating discovery in related sectors. The mechanisms and processes through which these novel technologies are invented, tested, translated, and implemented within environmental design and planning praxis remain largely unknown, creating opportunities for new methods of knowledge exchange to be developed. To address the unique, and potentially transformative relationship, important aspects of the Y02A classification scheme are introduced in conjunction with a case study analysis from 2017/18 Resilience by Design Bay Area Challenge in California, during which the Common Ground Team utilized patent innovation studies to conceptualize site-based adaptation and resilience strategies for the San Pablo Baylands.*

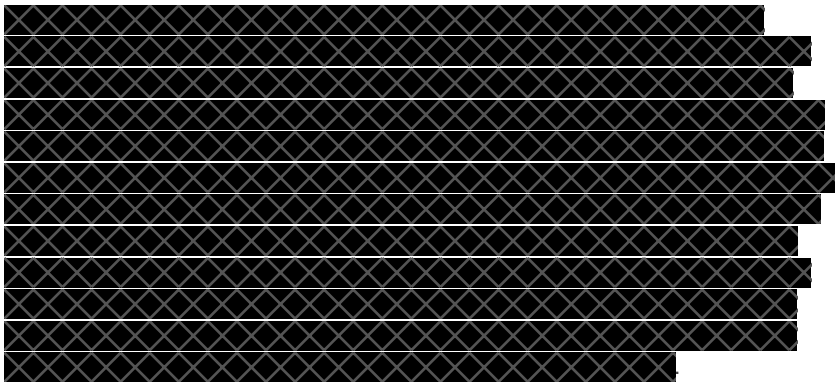
Keywords: coastal adaptation, design heuristics, innovation, research methods, resilience

During the Resilience by Design Bay Area Challenge in California (2017-18), the Common Ground Team, led by TLS Landscape Architecture (Berkeley

CA, USA), developed innovative site-specific climate adaptation strategies through the integration of patent data and technical specifications into the design process, attempting to bridge between inventors, patent data, and landscape systems. This exchange of technical information contributed to the development of site planning strategies for deltaic restoration, ecological enhancement, and transportation infrastructure, through a heuristic method. Today, this case study serves as a precedent for the integration of technologies, and data, covered by the Y02A patent classification scheme, covering “technologies for climate adaptation” into landscape planning and design praxis. The Y02A patent classification scheme was created to track technologies for adaptation to climate change, including broadly interconnected sectors related to the management and planning of urbanized coastal anthromes, including technologies for mapping, sensing, human health, and infrastructure adaptation, water management, etc. The initiative aims to build climate adaptive capacity through coordinated innovation and facilitate the rapid diffusion of technical information, presenting the allied disciplines of environmental design and planning with the opportunity to integrate datasets and novel technologies chronicled by the scheme into praxis – helping to ground novel technologies in real world sites and engage global innovation networks.







ORIGINS AND SCOPE OF THE Y02A CLASSIFICATION SCHEME

The Y02 classification scheme, and its eight subclasses of technology (Y02A, Y02B, Y02C Y02D, Y02E, Y02P, Y02T, Y02W), were born out of the need to understand trends in emergent climate technologies. Scope of this cross sectoral technology space is apparent in the class definition, which states: “This class covers selected technologies, which control, reduce or prevent anthropogenic emissions of greenhouse gases [GhG], in the framework of the Kyoto Protocol and the Paris Agreement, and also technologies which allow adapting to the adverse effects of climate change.” [2] In essence the Y02 aims to build technological pathways outline by global climate policy, manage innovation in emergent climate sectors, and disseminate information through increased accessibility to a range of end users, constituents, and researchers.

Origins of the initiative are interesting to consider. In 2009/2010, the European Patent Office created a novel computer algorithm to automatically identify, track, and organize all low-carbon technologies in a searchable database accessible to patent examiners as a reference for emergent technologies which was documented in Raphael Calel’s 2020 article “Adopt or Innovate: Understanding Technological Responses to Cap-and-Trade.” The algorithm created real-time technical dossiers and provided insights regarding emerging low-carbon and climate change mitigation technologies (CCMTs). Essential functions and scope of the Y02 were made public in June 2010 at the United Nations Framework Convention on Climate Change (UNFCC), Subsidiary Bodies Session, in Bonn, Germany, and have been in use within the European Patent Office since this time. The initiative has received ongoing support from the UNFCC as a mechanism to link innovation in climate mitigation technologies to global policy and funding initiatives as documented in the 2012 article by Victor Veefkind et al. entitled “A New EPO Classification Scheme for Climate Change Mitigation Technologies.” Organizationally, this new patent data is organized using the special “Y” designation assigned to monitor new technological developments and to tag cross-sectional technologies that do not fit in a

single other section of the International Patent Classification (IPC) and Cooperative Patent Classification (CPC) or have been classified elsewhere.

The Y02A classification scheme, and the seven other subclasses of the Y02 (Y02B, Y02C Y02D, Y02E, Y02P, Y02T, Y02W), were refined and implemented from 2010-2018 and were made fully accessible through international patent offices, including the United States Patent and Trademark Office (USPTO) circa 2018 as the Resilient by Design Bay Area Challenge design phase was initiated (Table 1). These data sets and documents are now readily available to researchers and planners through robust search tools designed to increase the rate of discovery and diffusion of innovation that "allows for non-patent experts to search for climate change-related technologies in a more user-friendly fashion." [3] Provisions for user friendly searches mean that technological information can be searched and collated easily, facilitating the diffusion of innovation and helping inventors, governments, and end users to find relevant technologies. These datasets can now, provide technical, legal, and business information to support strategic decision-making in the field of climate adaptation. Public accessibility is most clearly accomplished through web-based searches hosted by the EPO's Espacenet Patent Search, where users can develop detailed searches, apply filters, and build technical dossiers with limited prior knowledge.

Among the subclasses the Y02A is unique for its focus on the cross-sectoral technologies of the built environment, including and the emergent context of coastal adaptation and resilience (Table 2). Subclasses cover technologies at coastal zones, river basins, infrastructure adaptation, mapping and sensing technology, human health, artificial reefs, green infrastructure, and a range of interconnected sectors with relevance to the future of coastal, landscape, and urban planning (Table 3). For example, as new mapping and sensing technology are integrated with green infrastructural systems, the linkages between storm water management, flooding, and artificial intelligence, will build likely build smarter climate adaptive cities – a sector that will only expand as climate change continues and at are now covered by the Y02A.

With the implementation of the Y02A, a distinct opportunity has existed since establishment of the new climate adaptation categories to link this robust knowledge infrastructure to the practices of urban and landscape planning. Linking the Y02A initiative to real-world projects is an important step in operationalizing the adaptive capacities of technology, and grounding policy and funding initiatives for coastal adaptation and resilience, including the rapidly expanding national, regional, and urban level plans currently in development. The allied professions of environmental design and planning are therefore integral to the implementation, and operationalization, of Y02A innovation and translation of technological advancements into coastal adaptation and resilience

Y02A - Technologies for Adaptation to Climate Change
Y02B - Climate Change Mitigation Technologies Related to Buildings, e.g., Housing, House Appliances or Related End-User Applications
Y02C - Capture, Storage, Sequestration or Disposal of Greenhouse Gases [GhG]
Y02D - Climate Change Mitigation Technologies in Information and Communication Technologies [ICT], i.e., Information and Communication Technologies Aiming at the Reduction of Their Energy Use
Y02E - Reduction of Greenhouse Gas [GhG] Emissions Related to Energy Generation, Transmission, or Distribution
Y02P - Climate Change Mitigation Technologies in the Production or Processing of Goods
Y02T - Climate Change Mitigation Technologies Related to Transportation
Y02W - Climate Change Mitigation Technologies Related to Wastewater Treatment or Waste Management

Table 1. Y02 classification scheme – technologies or applications for mitigation or adaptations against climate change.

10/00 At Coastal Zones; At River Basins
20/00 Water Conservation; Efficient Water Supply; Efficient Water Use
30/00 Adapting or Protecting Infrastructure or Their Operation
40/00 Adaptation Technologies in Agriculture, Forestry, Livestock or Agro Alimentary Production
50/00 In Human Health Protection, e.g., Against Extreme Weather
90/00 Technologies Having an Indirect Contribution to Adaptation to Climate Change

Table 2. Y02A subclass – technologies for adaptation to climate change.

Y02A 10/00 AT COASTAL ZONES; AT RIVER BASINS
10/11 Hard Structures, e.g., Dams, Dykes or Breakwaters
10/23 Dune Restoration or Creation; Cliff Stabilization
10/26 Artificial Reefs or Seaweed; Restoration or Protection of Coral Reefs
10/30 Flood Prevention; Flood or Stormwater Management, e.g., Using Flood Barriers
10/40 Controlling or Monitoring, e.g., Of Flood or Hurricane; Forecasting, e.g., Risk Assessment or Mapping
Y02A 20/00 WATER CONSERVATION; EFFICIENT WATER SUPPLY; EFFICIENT WATER USE
20/108 Rainwater Harvesting
20/124 Water Desalination
20/131 Reverse-Osmosis
20/138 Using Renewable Energy
20/141 Wind Power
20/142 Solar Thermal; Photovoltaics
20/144 Wave Energy
20/146 Using Grey Water
20/148 Using Household Water from Wash Basins or Showers
20/15 Leakage Reduction or Detection in Water Storage or Distribution

Table 3. Categories of the Y02A classification scheme.

20/152 Water Filtration
20/20 Controlling Water Pollution; Waste Water Treatment
20/204 Keeping Clear the Surface of Open Water from Oil Spills
20/208 Off-Grid Powered Water Treatment
20/211 Solar-Powered Water Purification
20/212 Solar-Powered Wastewater Sewage Treatment, e.g. Spray Evaporation
20/30 Relating to Industrial Water Supply, e.g., Used for Cooling
20/40 Protecting Water Resources
20/402 River Restoration
20/404 Saltwater Intrusion Barriers
20/406 Aquifer Recharge
20/411 Water Saving Techniques at User Level
Y02A 30/00 ADAPTING OR PROTECTING INFRASTRUCTURE OR THEIR OPERATION
30/14 Extreme Weather-Resilient Electric Power Supply Systems, e.g., Strengthening Power Lines or Underground Power Cables
30/24 Structural Elements or Technologies for Improving Thermal Insulation
30/242 Slab Shaped Vacuum Insulation
30/244 Using Natural or Recycled Building Materials, e.g., Straw, Wool, Clay, or Used Tires
30/249 Glazing, e.g., Vacuum Glazing
30/254 Roof Garden Systems; Roof Coverings with High Solar Reflectance
30/27 Relating to Heating, Ventilation, or Air Conditioning [HVAC] Technologies
30/272 Solar Heating or Cooling
30/274 Using Waste Energy, e.g., From Internal Combustion Engine
30/30 In Transportation, e.g., on Roads, Waterways, or Railways
30/60 Planning or Developing Urban Green Infrastructure
Y02A 40/00 ADAPTATION TECHNOLOGIES IN AGRICULTURE, FORESTRY, LIVESTOCK, OR AGROALIMENTARY PRODUCTION
40/10 In Agriculture
40/13 Abiotic Stress
40/132 Plants Tolerant to Drought
40/135 Plants Tolerant to Salinity
40/138 Plants Susceptible to Heat
40/146 Genetically Modified [GMO] Plants, e.g., Transgenic Plants
40/20 Fertilizers of Biological Origin, e.g., Guano or Fertilizers Made from Animal Corpses
40/22 Improving Land Use; Improving Water Use or Availability; Controlling Erosion
40/25 Greenhouse Technology, e.g., Cooling Systems, Therefore
40/28 Specially Adapted for Farming
40/51 Specially Adapted for Storing Agricultural or Horticultural Products
40/58 Using Renewable Energies
40/60 Ecological Corridors or Buffer Zones
40/70 In Livestock or Poultry
40/76 Using Renewable Energy
40/80 In Fisheries Management
40/81 Aquaculture, e.g., of Fish
40/818 Alternative Feeds for Fish, e.g., in Aquacultures
40/90 In Food Processing or Handling, e.g., Food Conservation

Table 3 (continued...).

40/924 Using Renewable Energies
40/926 Cooking Stoves or Furnaces Using Solar Heat
40/928 Cooking Stoves Using Biomass
40/963 Off-Grid Food Refrigeration
40/966 Powered by Renewable Energy Sources
Y02A 50/00 IN HUMAN HEALTH PROTECTION, E.G., AGAINST EXTREME WEATHER
50/20 Air Quality Improvement or Preservation, e.g., Vehicle Emission Control or Emission Reduction by Using Catalytic Converters
50/2351 Atmospheric Particulate Matter [PM], e.g., Carbon Smoke Microparticles, Smog, Aerosol Particles, Dust
50/30 Against Vector-Borne Diseases, e.g., Mosquito-Borne, Fly-Borne, Tick-Borne, or Waterborne Diseases Whose Impact Is Exacerbated by Climate Change
Y02A 90/00 TECHNOLOGIES HAVING AN INDIRECT CONTRIBUTION TO ADAPTATION TO CLIMATE CHANGE
90/10 Information and Communication Technologies [ICT] Supporting Adaptation to Climate Change, e.g., For Weather Forecasting or Climate Simulation
90/30 Assessment of Water Resources
90/40 Monitoring or Fighting Invasive Species

Table 3 (continued).

plans. This “grounding” of climate policy through technical pathways has enormous co-benefits, including forging of new partnerships and green-lighting of innovative adaptation technology with positive environmental outcomes. A schema for integration in coastal planning posits that patent data and new technology can inform workflows and also establish a feedback loop between innovation and tangible real-world sites integrated with novel technology. (Fig. 1)

Tangible benefits of this information exchange and workflow are easy to identify. For example, datasets from the Y02A have the potential to inform practical projects common in planning such as budgeting for a seawall replacement, developing technical specifications for storm water management, or even the forecasting of technological trends. Briefly consider the processes of coastal seawall and breakwater upgrades occurring globally to improve biodiversity and coastal defense. Technological innovation can inform new material and design standards, helping to align advanced technologies with the pragmatics of local planning. Novel concrete mixtures like ecological concrete, by ECOncrete Tech Ltd. (US9538732B2 & AU2014217435B2 “Methods and Matrices for Promoting Fauna and Flora Growth”) are engineered to meet international construction standards. They can integrate into marine construction projects. Importantly, by tracking innovation in ecological concrete or a range of other applicable technologies, planners, and designers can develop an understanding of leading-edge technology. Similar observations can be made across sectors germane to coastal adaptation and resilience depending on site requirements and environmental contingencies. For example, for coastal sites threated by invasive species, innovation studies in the subject area may reveal exciting new technologies in patent subclass

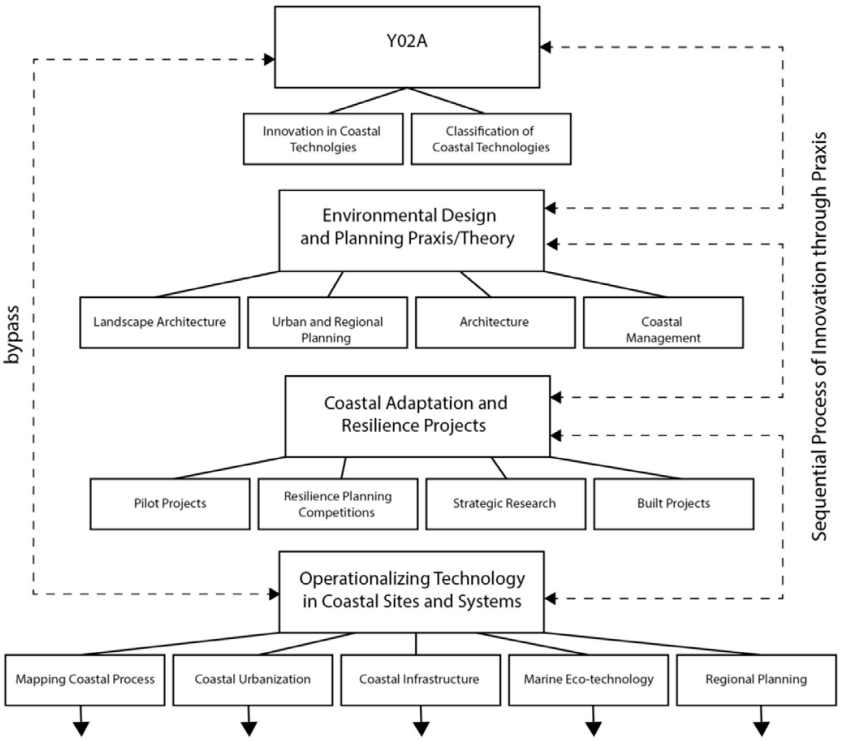


Figure 1. A schematic diagram linking the practices of design and planning to the Y02A classification scheme.

Y02A 90/40 covers the “Monitoring or Fighting Invasive Species” which includes a range of related technologies such as rovers to collect invasive lionfish or devices for the filtering of algae blooms.[4] (Fig. 2)

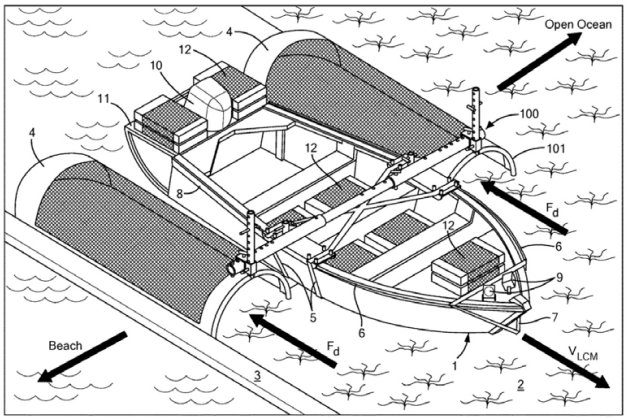
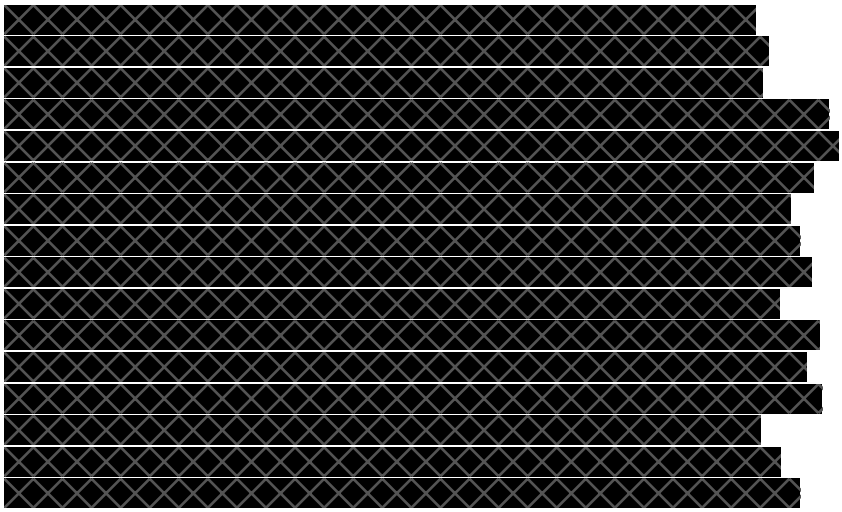


Figure 2. US20230082558A1 “Retrofitting Small Watercraft as Collection Boats for Sargassum Seaweed” a module for retrofitting a boat for collection of floating biomass has a telescoping beam that spans the width of the boat and connects to aft-ends of levers that rest on the gunwales.

METHODS OF KNOWLEDGE EXCHANGE: SITE STRATEGIES AND INNOVATION STUDIES FOR DESIGN OF THE “GRAND BAYWAY”



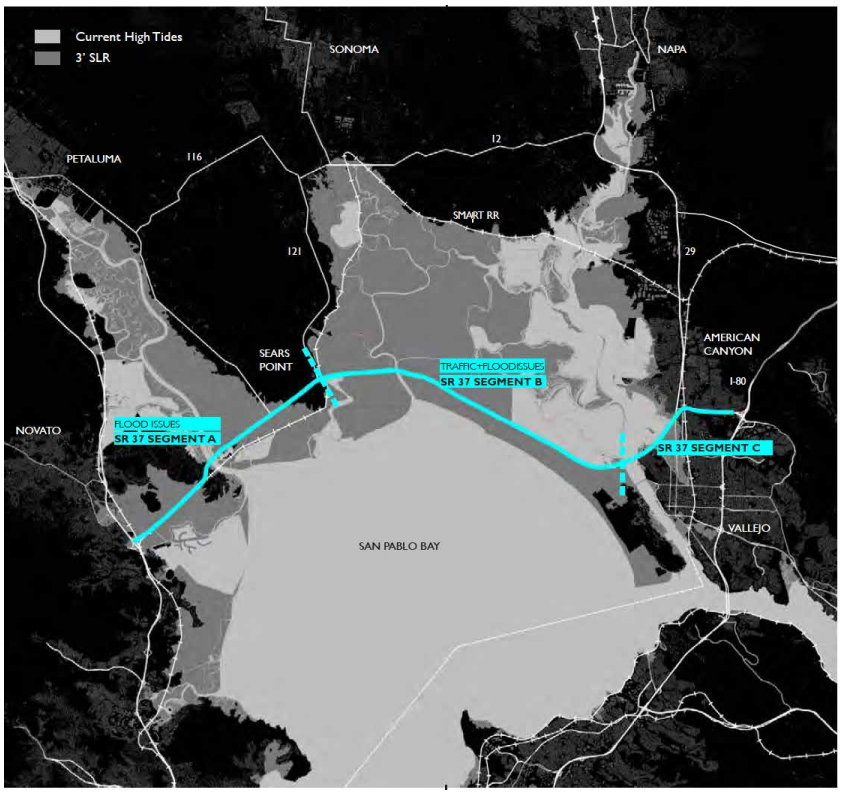


Figure 3. Site location and context – San Pablo Baylands, State Route 37, and sea level rise.

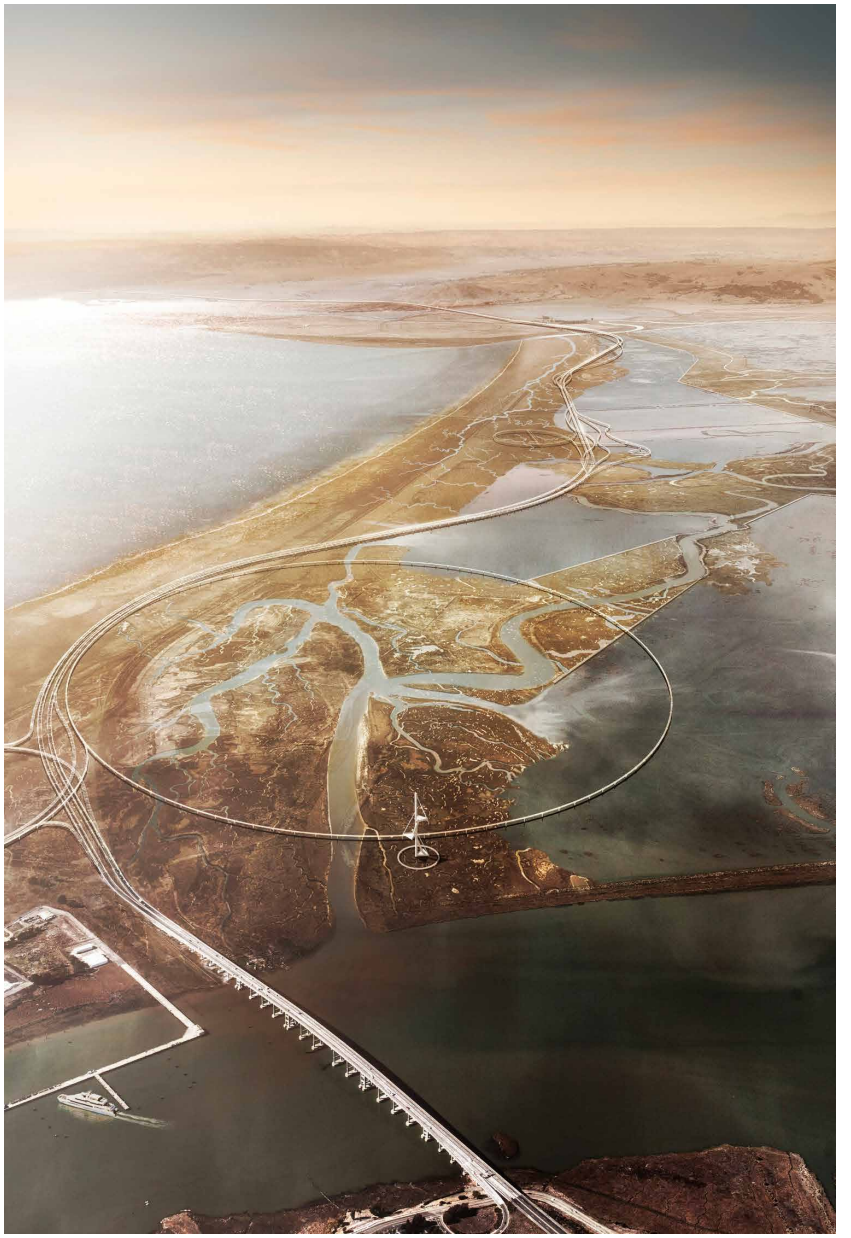


Figure 4. Design vision for the “Grand Bayway,” replacing State Route 37.

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METHODS FOR BUILDING A TECHNICAL DOSSIER – THE PATENT SYSTEM AS KNOWLEDGE INFRASTRUCTURE FOR SITE DESIGN TECHNOLOGIES

The Common Ground Team utilized technical information from individual patents, and analysis of larger classifications, to develop a coastal adaptation and resilience strategy. Three types of publicly accessible searches were used during this process, including classification searches, citation searches, and keyword searches. This allowed the team to rapidly gain knowledge about the innovation landscapes related to the project and build upon established technologies – providing a rich heuristic and also a technical repository for subsequent design phases. Importantly, searches were conducted primarily through the public accessible web-searches of European Patent Office which area readily available to others and free of charge.

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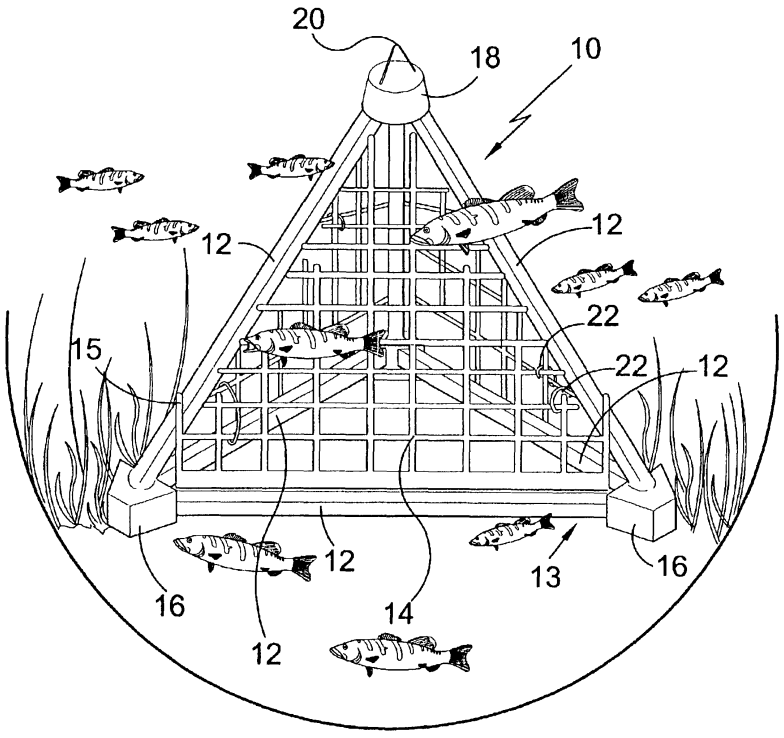

Figure 5. US6824327 for an “Artificial Barrier Reef.”

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(Fig. 6)

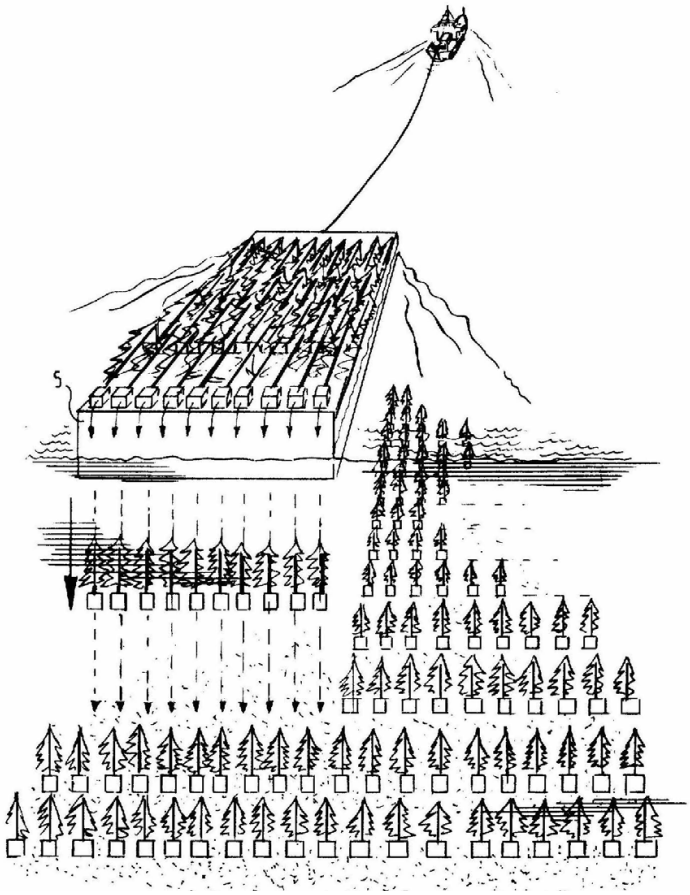
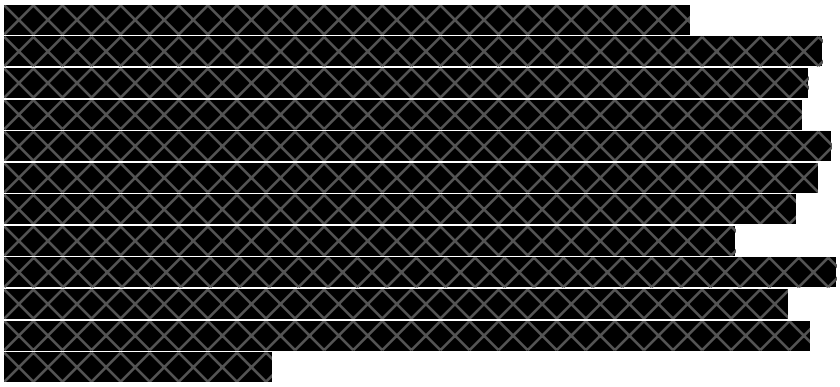
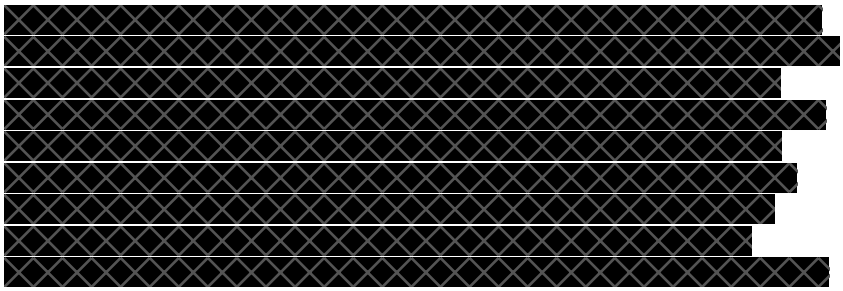


Figure 6. US4397587 “Method of Constructing an Artificial Island and Island Constructed by the Same” (1980) showing the process of arraying trees to form and island.



Of course, it is important to note that the existence of a patent does not mean a technology works or has found an application in the real world. Technical information is communicated in patent documents through text and image. Representation therefore facilitates the envisioning of new technology and calls into question the nature of invention as often the representation of technology precedes its tangible existence. This epistemological loophole in the inventive process is important to consider as it simultaneously hastens the rate of invention but may lead to issues, including misinterpretation and manipulation of the process. Irrespective of abuses, modern patent rights are founded on the theory that drawings, and text, can be sufficient to describe the scope and functioning of an invention. Central to this issue is the term “reduction to practice” which is a step in the inventive process in beyond the initial conception when either an invention is shown to work or a patent application with sufficient disclosure is submitted. In essence this means that the drawings, models, and textual description are akin to invention as they should describe the proper functioning of the invention. In the case of site-based climate adaptation technology, the testing, grounding, and evaluation may follow the existence of the patent – a fact that may ultimately heighten the role of environmental designers and planners in the implementation of technology as well as the critical translation of novel technologies into site-specific works.

DESIGN METHODS – HEURISTICS AND TECHNICAL SPECIFICATIONS FROM PATENTS



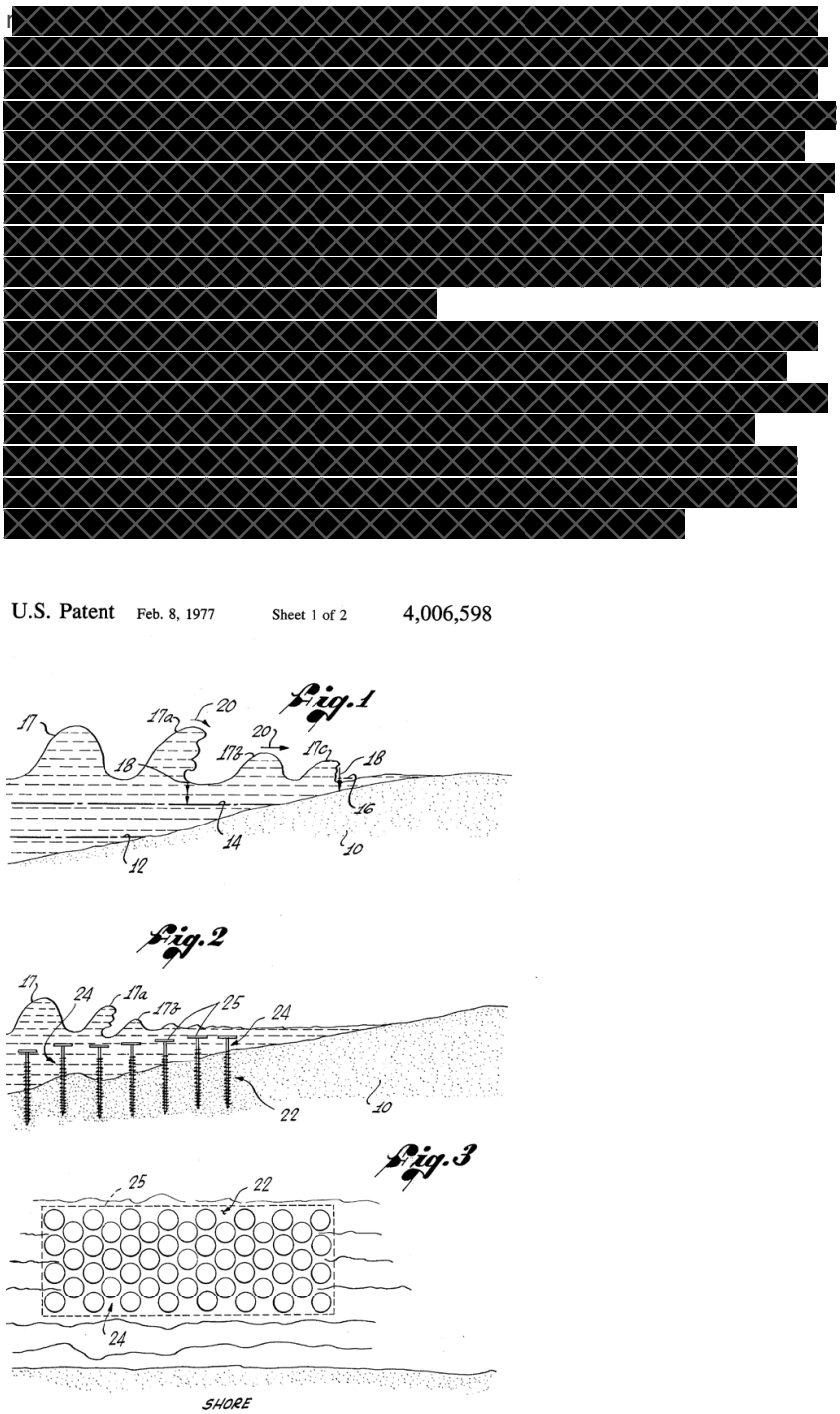
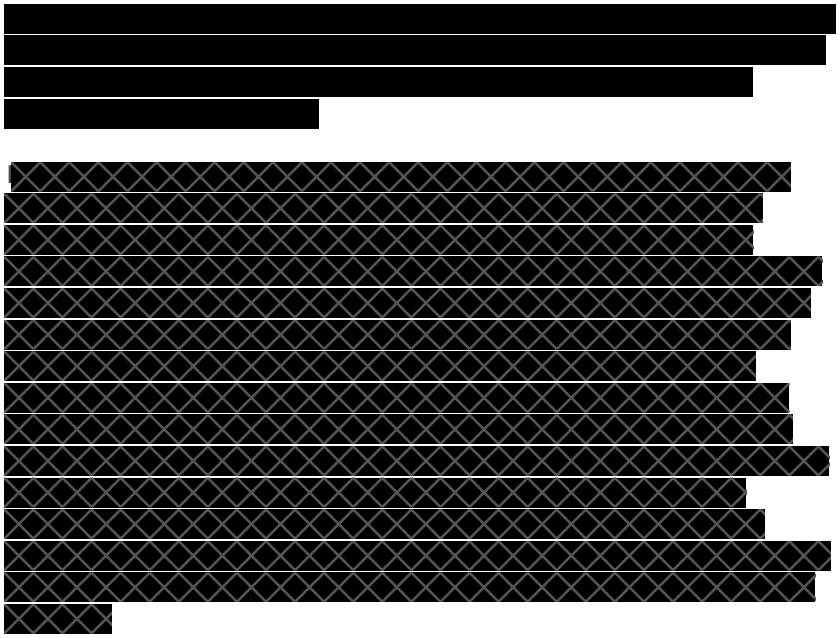


Figure 7. US4006598 “Breakwater System” – an example of patents included in the technical dossier for specific site technologies.



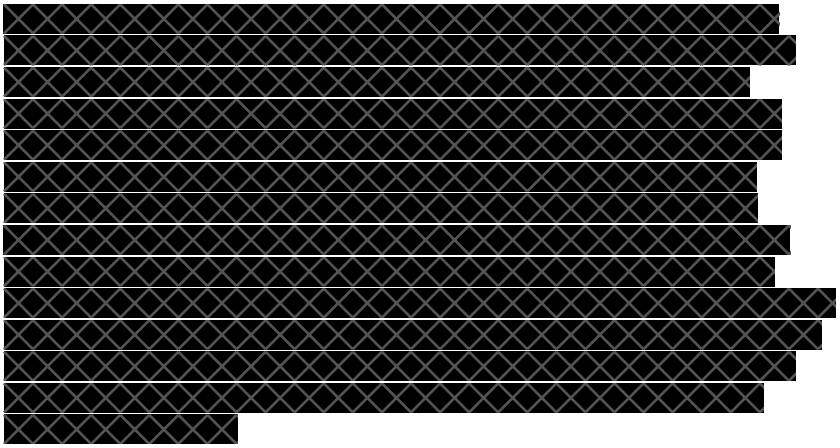
01 Channel Chamfers, 02 Mechanical Reclamation, 03 Plashed Hedgerows, 04 Structural Sediment Accumulators, 05 Sediment Diversion, 06 Water Gates, 07 One Percent Terraforming, 08 Bioengineering Sediment Capture, 09 Biomass Farming, 010 Carbon Sequestration & Soils, 011 Forestation, 012 Passive Irrigation and Waterworks, 013 Micro-topographies, 014 Reclamation Enclosures, 015 Sediment Train, 016 Wetland Terraces, 017 Artificial Seaweeds, 018 Benthic Habitat / Artificial Reefs, 019 Imported Organics (Hay Structures, etc.), 020 Floating Breakwaters, 021 Floating Wetlands, 022 Artificial Islands, 023 Permeable Dikes / Breakwaters, 024 Channel Sediment Collectors, 025 Groundwater Recharge, 026 Mollusk Habitat

Table 4. Initial “net-casting” categories used to initiate prior-art searches and build a patent dossier.

The patents related to each category functioned as carriers of innovation that create context for innovation and help define technical domains during the design process. In this context patent archiving and collating creates a heuristic from which inventors may borrow, adapt, and innovate.[11] Heuristics can become an essential method to defining new technologies or for strategic design thinking. In the field of engineering design heuristics are often used to help generate new concepts through sketching and other forms of ideation.[12] Similarly, in the fields of industrial and product design heuristic methods utilizing existing product knowledge and datasets facilitate the creation of innovative new solutions to fundamental design problems.[13] Beyond the envisioning and net-casting heuristic process, the patent innovation studies also provided technical specifications and details associated with specific coastal infrastructure, such as artificial benthic

ecology and floating wetlands. These technical specifications reveal the value of patent knowledge infrastructure for the diffusion of innovation, as complementary to standard mode of design and planning praxis which rely on extensive list of consultants and bespoke design solutions.

SAN PABLO BAYLANDS: SITE-STRATEGIES FOR BUILDING GROUND



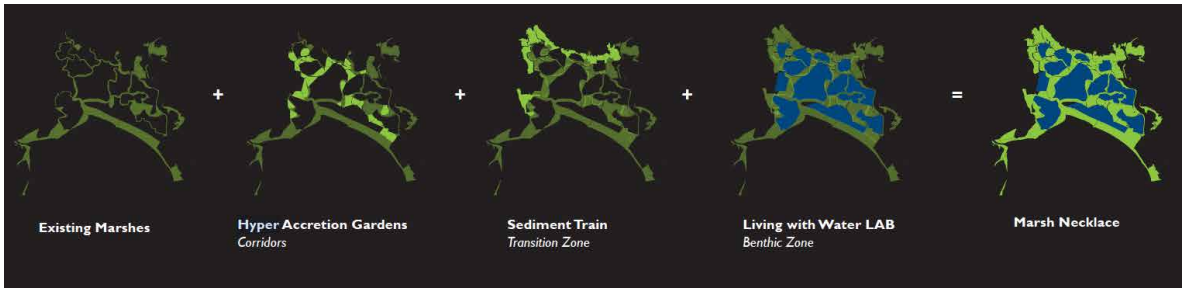


Figure 8. Site diagram showing areas of hyperaccretion, and open water based on site topography and hydrology.

Hyper-Accretion Gardens

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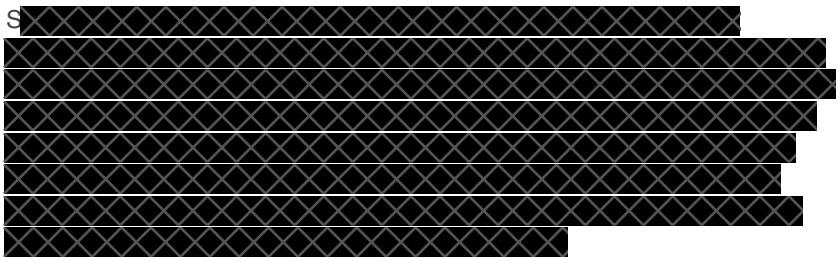


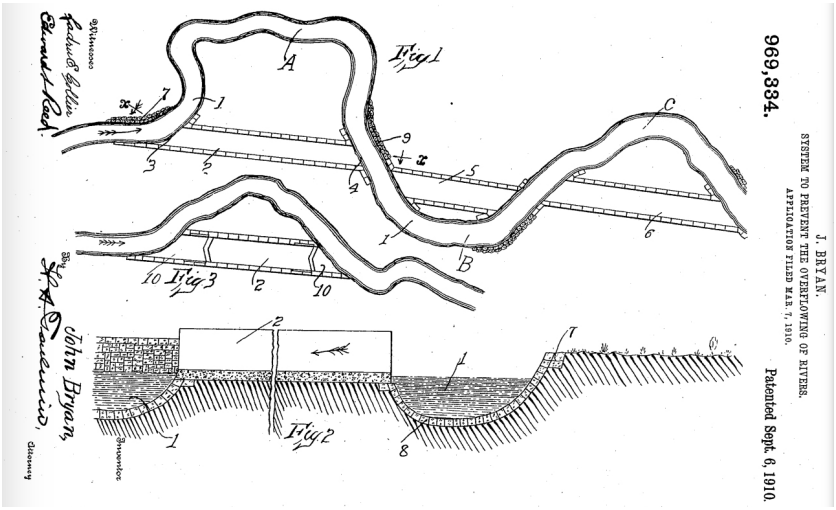
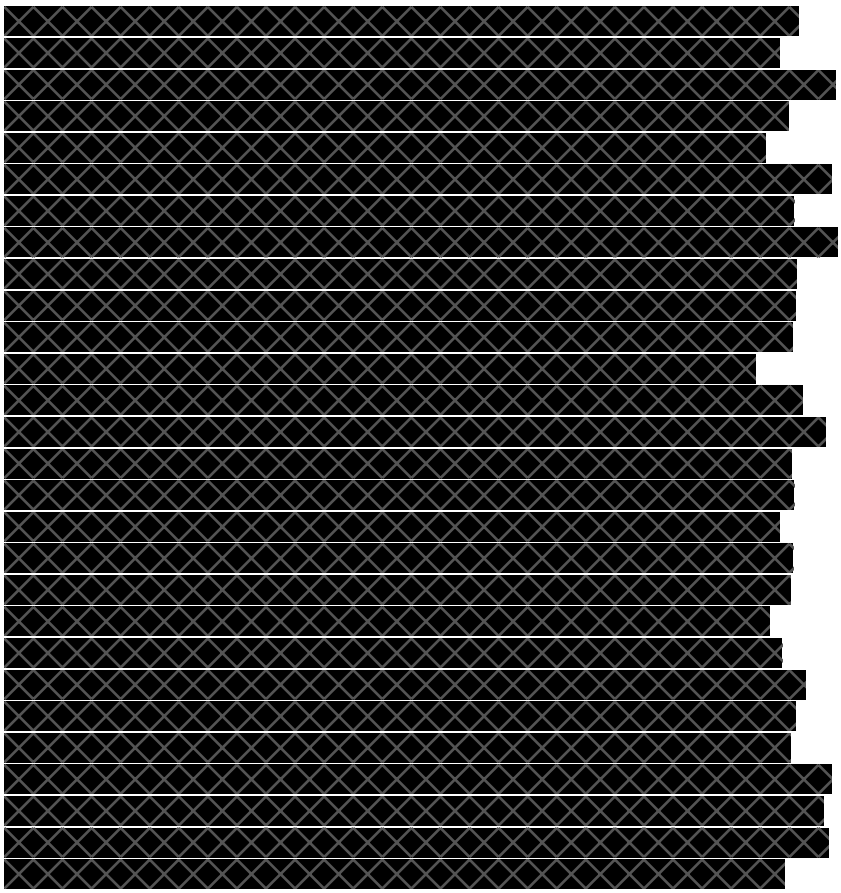


Figure 9. US969334 “System to Prevent the Overflowing of Rivers” (1910) a conceptual and technical precedent for channel chamfers.



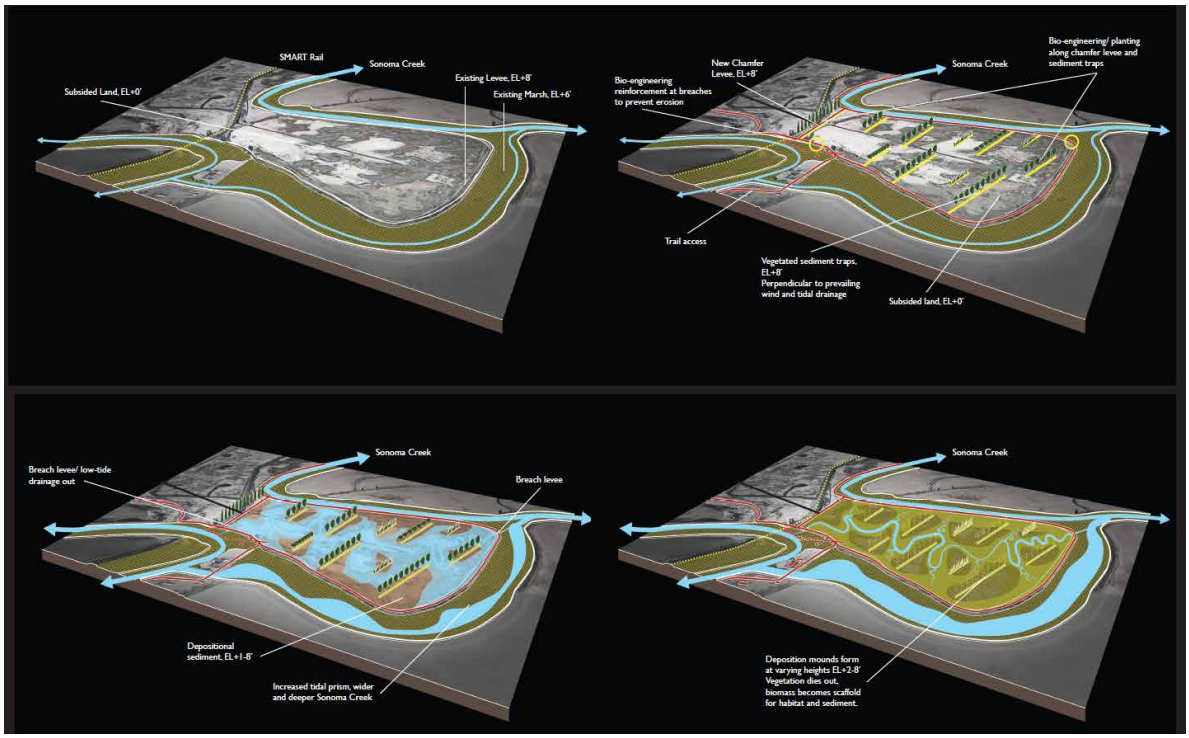


Figure 10. Rendering of hyperaccretion garden showing the landscape configuration and embedded technologies.

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Sediment Train

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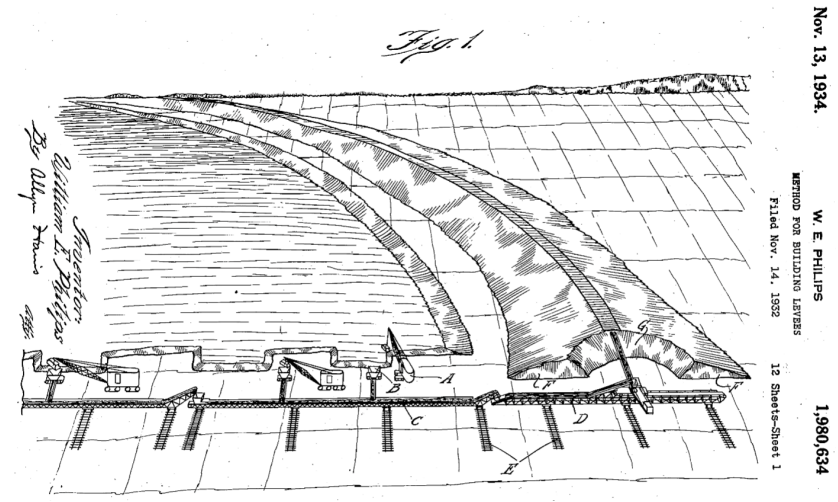

Figure 11. Drawing from US1980634 “Method for Building Levees” which provided technical information and conceptual precedent for the “sediment train” proposed by the Common Ground Team for use in deltaic restoration.

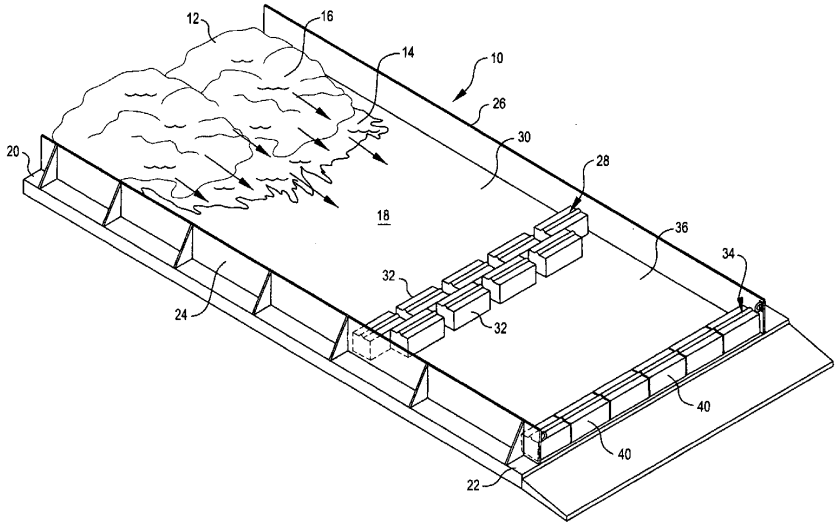

Figure 12. US20060162195A1 “System and Method of Dewatering Dredge Spoils Using Sloping Drain Barge” (2006) – part of the project technology portfolio.

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Artificial Marine Ecology and Integrated Structural Systems

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Figure 13. Open water benthic ecology rendering, showing the landscape morphology and technologies to be used.

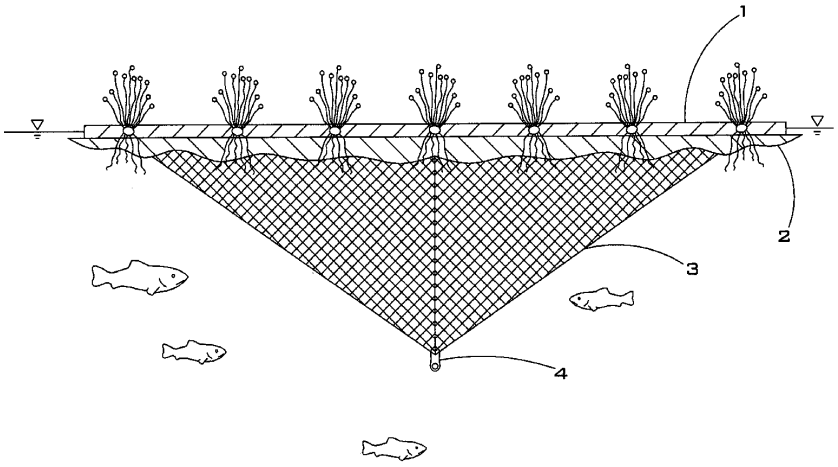

Figure 14. US20050183331A1 “Super-Enhanced Aquatic Floating Island Plant Habitat” – one of the many floating systems incorporated into the newly formed bodies of open water on the site.

DISCUSSION

Given the close relationship between technological innovation and the development of coastal regions the patent archive serves as a valuable dossier of visual and textual information, both historical and current, that may be interpreted and applied in the context of coastal adaptation and resilience works. Translation between the technological knowledge infrastructure of the global patent archive and the applied works planning and design presents distinct opportunities to link the sociotechnical processes of innovation to real-world project sites. The recent establishment of the Y02A has the potential to streamline this process, making knowledge about coastal innovations readily accessible and available for integration into praxis. This knowledge infrastructure can serve both heuristically to help problem solve and as a technological database to develop frameworks for innovation. During the 2017 Resilience by Design Bay Area Challenge, the Common Ground Team coupled patent-innovation studies with a heuristic process to develop innovative strategies for coastal resilience. Each landscape condition was linked to an innovation citation network of patented technologies that might structure the site. In certain instances, specific site assemblies were suggested and integrated into the design, showing how each technology would impact the site and future scenarios for the region. As a form of innovation-knowledge infrastructure, the Y02A classification scheme is an essential mechanism to track progress adaptation technologies. It chronicles developments and establishes a precedent of prior art, archiving specifications, claims, and drawings while providing metadata for research, interpretation, and discovery. In emergent sectors such as coastal adaptation and resilience, this combinatory process is precious, contributing technical specifications, visual references, and future imaginaries to complex problems with planetary scope.

Notes

1. See “Bay Area: Resilient by Design Challenge,” n.d. Bay Area: Resilient by Design Challenge, accessed June 21, 2021 – http://www.resilientbayarea.org.
2. See http://worldwide.espacement.com/patent/cpc-browser#!/CPC=Y02.
3. See Stefano F. Angelucci, et al., “Supporting Global Initiatives on Climate Change: The EPO’s ‘Y02-Y04S’ Tagging Scheme,” 54, (September 2018): S85-S92.
4. See Alan Martin Darius et al, Method apparatus and system for controlling fish, GB2567452A, filed October 12, 2017, and issued April 17, 2019.
5. See Joy E. Altwies and Gregory F. Nemet, “Innovation in the US Building Sector: An Assessment of Patent Citations in Building Energy Control Technology,” *Energy Policy* 52, (2013): 819-31.
6. See David M. Walter, Artificial barrier reef, US6824327B1, filed May 27, 2003, and issued November 30, 2004 – https://patents.google.com/patent/US6824327B1/en.
7. See Sungjoo Lee, et al., “An Approach to Discovering New Technology Opportunities: Keyword-Based Patent Map Approach,” *Technovation* 29, no. 6-7 (2009): 481-97.
8. See Jan op den Velde et al., Method of constructing an artificial island and island constructed by the same, US4397587A, filed October 6, 1980, and issued August 9, 1983.
9. See Mitchell James, Hedge, US380450, filed January 5, 1888, and issued April 3, 1888.

10. See Jobst Hulsemann, Breakwater system, US4006598A, filed November 24, 1975, and issued February 8, 1977.
11. See Stefan Bechtold, et al. “Innovation Heuristics: Experiments on Sequential Creativity in Intellectual Property,” *Indiana Law Journal* (2016), Forthcoming Cardozo Legal Studies Research Paper No. 475 – https://ssrn.com/abstract=2704107.
12. See Shanna R. Daly, et al. “Design Heuristics in Engineering Concept Generation,” *Journal of Engineering Education* 101, no. 4 (2012): 601-29.
13. See Seda Yilmaz, et al. “Design Heuristics in Innovative Products,” *Journal of Mechanical Design* 138, no. 7 (2016).
14. See John Bryan, System to prevent the overflowing of rivers, US969334A, filed March 7, 1910, and issued September 6, 1910.
15. See Brian B. Langdon et al., System and method of dewatering dredge spoils using sloping drain barge, US2006162195A1, filed January 26, 2005, and issued July 27, 2006.
16. See Bruce G. Kania et al., Super-enhanced aquatic floating island plant habitat, US2005183331A1, filed July 1, 2004, and issued August 25, 2005.

Credits

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Tables 1-4: sourced from TLS & “Common Ground” Team, 2017-2018.

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