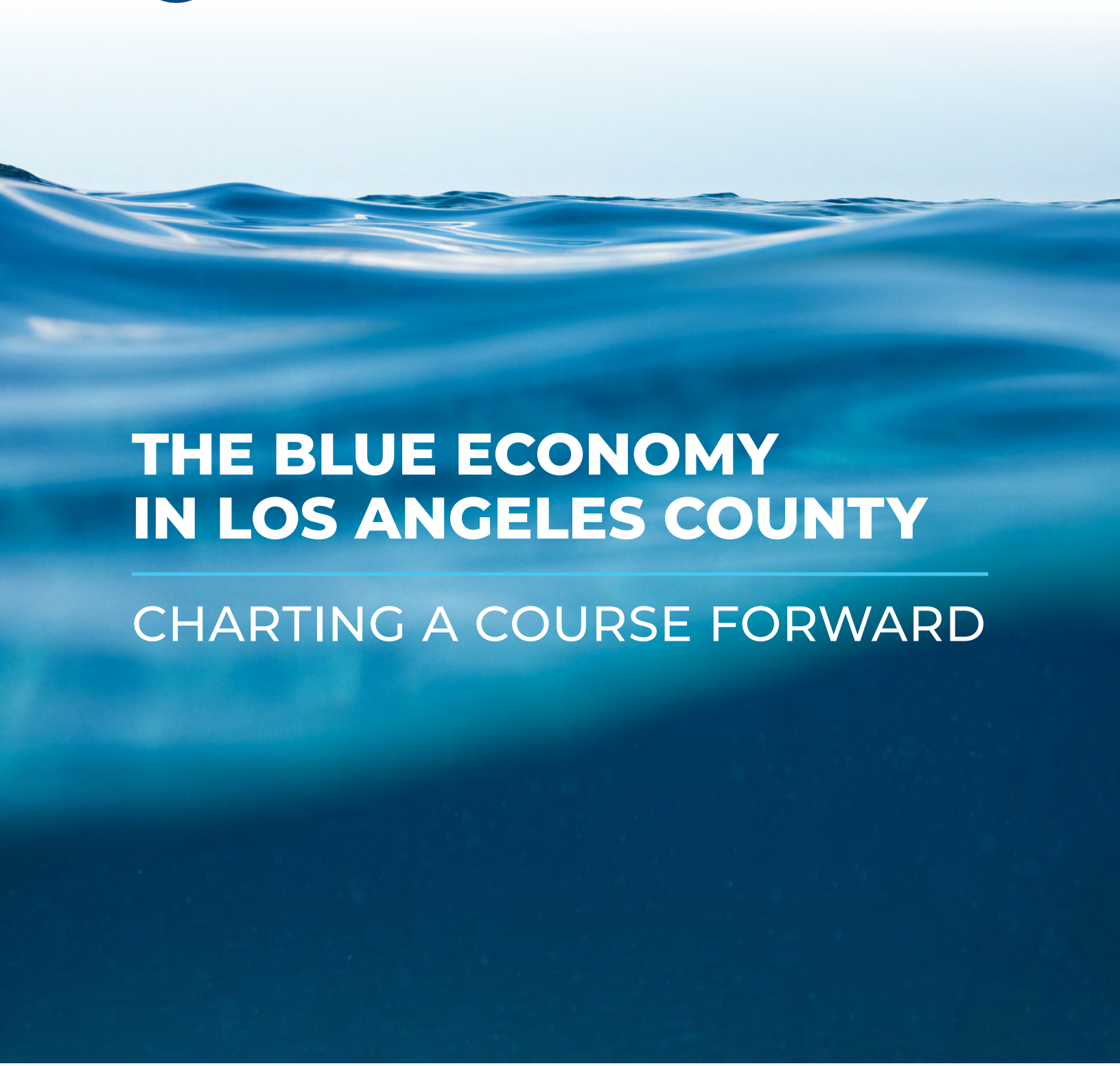
BECAP | BLUE ECONOMY CLIMATE ACTION PATHWAYS



THE BLUE ECONOMY IN LOS ANGELES COUNTY

CHARTING A COURSE FORWARD

LAEDC

LARC LOS ANGELES REGIONAL CONSORTIUM

California Community Colleges

THE BLUE ECONOMY IN LOS ANGELES COUNTY

CHARTING A COURSE FORWARD

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EXECUTIVE SUMMARY

This report provides an overview of the blue economy in Los Angeles County, including its relationship to the broader ocean economy, relevant economic and occupational metrics, industries & businesses at the forefront of this emerging economic sector, and programs supporting workforce development. This information is intended to support community college stakeholders and partners as they engage with industry collaborators and develop curricula as part of the Blue Economy and Climate Action Paths (BECAP) programs.

What is the Blue Economy?

Broadly speaking, the blue economy can be thought of as a subset of ocean-based industries and economy activities that are more environmentally sustainable and socially equitable than "conventional" ocean economy activities. Examples of these industries include renewable ocean energy, sustainable port operations, regenerative aquaculture, marine research and development, blue technology (blue tech), ecosystem conservation, marine professional services, ecotourism and recreation, and others.

L.A. County's Ocean and Blue Economies

Measuring the Ocean Economy

Since 2005, the National Oceanic and Atmospheric Administration (NOAA) has published the annual ENOW[1] ocean economy data set for industries in six sectors whose economic activities rely upon proximity to the oceans or Great Lakes. While this dataset does not distinguish between sustainable and conventional economic activities and does not include certain industries that are relevant to the emerging blue economy, it is the most relevant starting point for understanding ocean economy employment and GDP in the U.S. In 2021 (the most recent year available), the ocean economy in L.A. County provided 105,074 jobs across 3,896 establishments and contributed over $14 billion to county real GDP.

1 "Economics: National Ocean Watch (ENOW)" *The National Oceanic & Atmospheric Administration (NOAA),* https://coast.noaa.gov/digitalcoast/data/enow.html.

Status of the Blue Economy

Currently, blue (sustainable ocean) economy activities account for a small percentage of total ocean economy activities in L.A. County (and the U.S. more broadly). However, this is changing, as heightened awareness of the risks posed by climate change, pollution, and aquatic ecosystem degradation are driving increased attention to, and investment in, more sustainable ocean-based industries and resources.

Los Angeles' nascent yet rapidly growing blue economy benefits from unparalleled regional assets, including the largest port complex in the western hemisphere, home to AltaSea at the Port of Los Angeles (a 35-acre ocean institute driving blue economy development); world-class universities and colleges for research, higher education, and career training; national leaders in blue economy industries; state and local governments firmly committed to equity, sustainability, and addressing climate change; and a diverse labor force exceeding 5 million in L.A. County alone.

L.A.'s blue economy is also getting a boost from the Blue Economy and Climate Action Pathways (BECAP) Consortium, an alliance of 15 Los Angeles community colleges, AltaSea at the Port of Los Angeles, and the Los Angeles Economic Development Corporation (LAEDC). The Consortium is developing a novel workforce training and placement program to prepare students for the next generation of ocean economy occupations. Embracing the principles of regional collaboration, equity, and enduring capacity, the BECAP Consortium is leveraging existing resources and innovative workforce opportunities to establish post-secondary certificate and degree programs in blue economy industries, including renewable energy and wave energy technologies. Through BECAP, students are gaining access to experiential learning opportunities and blue economy jobs across Southern California. BECAP's flagship certificate in Sustainable Aquaculture launched its first cohort at Santa Monica College in 2024, and certificates are being developed for Green Hydrogen (LA Harbor College), Underwater Robotics (El Camino College), and Nature Based Solutions (West LA College).

Workforce Development

Organizations in Los Angeles County are developing programs to support the growth of the blue economy workforce. Youth programs (such as Los Angeles County Office of Education's Marine Science Floating Laboratory) and high school programs (such as the career technical education program at Port of Los Angeles High School) are generating interest in marine issues.

Currently, the only explicitly blue economy-related community college-level program is Santa Monica College's Aquaculture program (certificate). However, the area's community colleges offer a wide range of coursework to provide foundational skills and knowledge for ocean/blue economy occupations. Some courses (e.g., oceanography, biology, geography, earth sciences, and environmental studies) are directly applicable to blue economy occupations, whereas other courses (e.g., skilled trades) may lack instruction for specific marine applications.

To address these gaps, BECAP is updating/"climatizing" existing curricula and developing new offerings in the four BECAP focus areas (Regenerative Aquaculture, Renewable Energy, Bluetech & Underwater Robotics, and Ecosystems Conservation and Restoration). Taking this approach leverages course content already in place while addressing curriculum gaps, providing students with the sector-specific knowledge and skills needed by ocean/blue economy employers.

At the four-year university level, the California State University system has a robust assortment of blue economy-focused institutions and partnerships, such as the Ocean Studies Institute, Council on Ocean Affairs, Science, and Technology, and the Sustainable Ocean Economies Initiative. Partnerships between these institutions, as well as with other postsecondary institutions such as UCLA, USC, LMU, and Occidental College, are essential for developing a robust educational ecosystem for the development of the blue economy workforce.

Blue Economy Workforce Development: Case Studies and Best Practices

The final section of the report looks beyond Los Angeles County to understand macro-level trends in blue economy workforce development.

First, governmental initiatives to support the emergence of a blue economy and a trained workforce are described, including those led by the National Oceanic and Atmospheric Administration (NOAA), the Department of Transportation's Maritime Administration, the National Science Foundation (NSF), the Department of Labor (DOL), the Economic Development Administration (EDA), the Small Business Administration (SBA), and the State of California Ocean Protection Council.

Second, academic research into blue economy workforce education program design is discussed. Recommendations include increasing access to STEM education through more flexible learning modalities (e.g., hybrid and online coursework), expanding access to experiential learning experiences, and developing shorter-term credential programs to help workers fill skill gaps or focus on blue economy issues.

Third, case studies are presented describing blue economy workforce development initiatives in five different regions (Delaware, Massachusetts, Mississippi, North Carolina, and Washington). These initiatives provide roadmaps for curriculum development and information on applying best practices for supporting the growth of the blue economy workforce.

Key findings regarding blue economy workforce development best practices include:

- Partnerships in curriculum development and hands-on learning opportunities among educational institutions (to building pathways), local governments, community organizations, and industry partners
- Paid experiential learning opportunities (internships, fellowships, research, apprenticeships)
- Cross-disciplinary curricula that focus on marine issues through scientific and social lenses
- Flexible curricula, such as shorter-term credentials and online/hybrid learning modalities
- Equity-focused programming for underrepresented groups and those from impacted areas
- Industrial specialization in certain subsectors, such as autonomous vehicles in Delaware, marine research and development in Mississippi, and ship building in North Carolina, among others
- Youth and high school programming to generate early interest in marine issues
- Regional conveners and events to bring together educational, governmental, and industry stakeholders, facilitate networking for young professionals, and inspire curiosity

Los Angeles County is well-positioned to grow its blue economy, with many of the above best practices already being implemented in the county, such as AltaSea's partnership with Santa Monica College, Santa Monica College's aquaculture certificate, Port of Los Angeles High School's career technical education program, and the activity of the Southern California Marine Institute. However, there is more work to be done to provide a larger range of blue economy workforce development programming, centering equity efforts in workforce development, and deepening partnerships among educational institutions and with government and industry partners.

OVERVIEW OF THE OCEAN ECONOMY

Terminology: Ocean, Marine, and Blue Economies

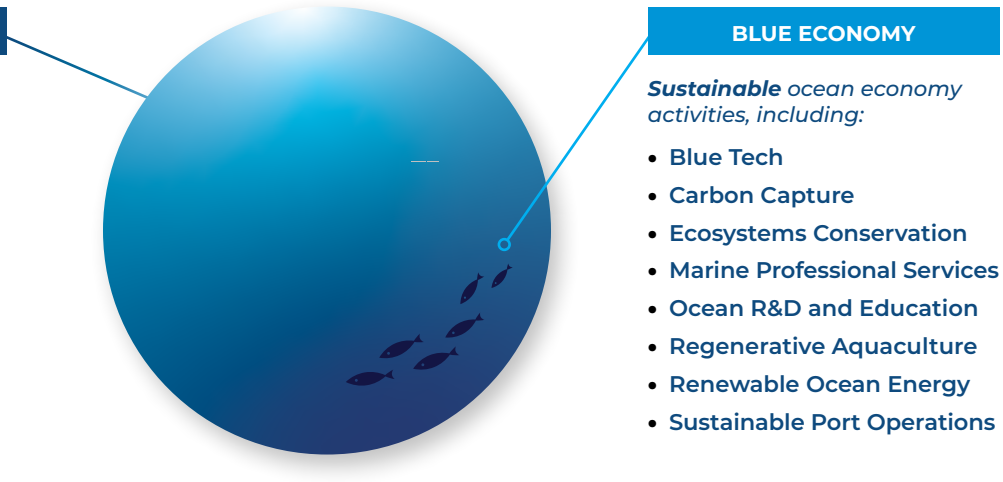
Economic activities deriving from proximity to water bodies are variously referred to as the "ocean economy," "blue economy," and "marine economy." The terms are often used interchangeably, but they have specific meanings:

- *Ocean economy* is generally used to refer to all economic activities based on ocean resources or proximity to the ocean
- *Marine economy* (the term used by the National Oceanic and Atmospheric Administration—NOAA) generally refers to all economic activities that depend on proximity to oceans or other very large bodies of water (e.g., the Great Lakes)[1]
- *Blue economy* is generally used to describe the sustainable use of ocean resources[2]; a widely cited definition from the World Bank is "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."[3]

These distinctions are important. In this report, the term "blue economy" is used to refer to those activities that are more environmentally sustainable and socially equitable, whereas the terms "marine economy" and "ocean economy" are used to refer to all marine economic activities, whether sustainable or not. The graphic below may be helpful in conceptualizing the relationship between the ocean and blue economies.

Currently, many blue economy activities are not captured in NOAA's ENOW dataset at all; furthermore, for the sectors that are included in ENOW, the data does not distinguish between sustainable and conventional ocean economy activities. However, as time goes on, the thin crescent will grow broader as sustainability becomes more established in day-to-day operations.

FIGURE 1: RELATIONSHIP BETWEEN CONVENTIONAL AND SUSTAINABLE MARINE ECONOMIC ACTIVITIES



1 National Oceanic and Atmospheric Administration (NOAA). "Economics: National Ocean Watch (ENOW) Data". Based on data from the Bureau of Labor Statistics and the Bureau of Economic Analysis. Charleston, SC: NOAA Office for Coastal Management. https://coast.noaa.gov/digitalcoast/data/enow.html.

2 World Bank, *Riding the Blue Wave: Applying the Blue Economy Approach to World Bank Operations*, 2021. https://openknowledge.worldbank.org/server/api/core/bitstreams/fbeffb8d-77bb-5192-a4ab-f315b1798299/content

3 World Bank, "What is the blue economy?", 2017. www.worldbank.org/en/news/infographic/ 2017/06/06/blue-economy.

Global Economic Value of Ocean-Based Industries

The United Nations Conference on Trade and Development (UNCTAD) reported in its *Trade and Environment Review 2023* that the ocean economy is estimated to be worth between $3 trillion to $6 trillion a year, providing at least 150 million *direct* jobs across a wide range of sectors, including shipping, tourism, aquaculture, offshore wind energy, oil & gas, mining, and marine biotechnology.[1]

Of course, the official tally of the value of ocean-based goods and services is only part of the story. Over 3 billion people rely on ocean and coastal biodiversity for their livelihoods—for employment, for sustenance, or both.

- According to the United Nations (UN) Food and Agriculture Organization (FAO), approximately 600 million people, including subsistence and secondary sector workers, depend at least partially on fisheries and aquaculture for their livelihoods.[2]
- Similarly, tourism and recreation support the livelihoods of hundreds of millions of people around the world; clean, functioning ecosystems are a critical element for a thriving coastal tourism industry.
- Aquatic foods provide sustenance for billions of people. The United Nations (UN) Food and Agriculture Organization (FAO) estimates that aquatic foods represent the primary sources of animal protein for approximately 3.3 billion people provide approximately 17% of animal protein to the global population (7.7 billion in 2019).[3]

1 United Nations Trade & Development (UNCTAD). Trade and Environment Review 2023 - Building a sustainable and resilient ocean economy beyond 2030 (UNCTAD/DITC/TED/2023/1) 8 May 2023. https://unctad.org/publication/trade-and-environment-review-2023

2 United Nations (UN) Food and Agriculture Organization (FAO). *The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation*, 2022. p. xvi. Rome, FAO. https://doi.org/10.4060/cc0461en

3 FAO, *The State of World Fisheries and Aquaculture 2022*, p. 8.

Quantifying U.S., California, and L.A. County Ocean Economies

Given the relatively recent focus on the blue economy, it is perhaps not surprising that the U.S. does not yet have an official comprehensive blue economy data set. Thus, the starting point for any analysis of the blue economy is to use established ocean/marine economy data sets.

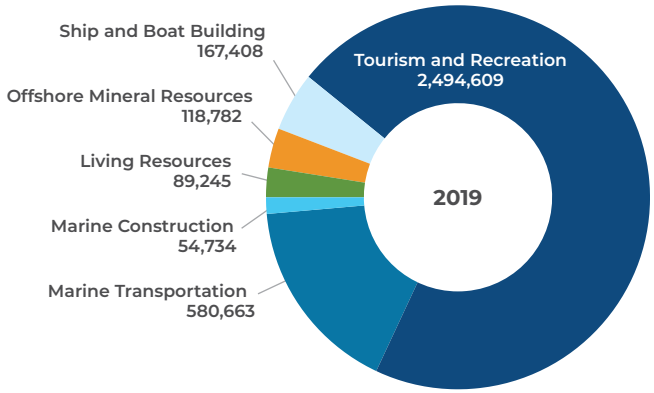
In the U.S., NOAA's ENOW (Economics: National Ocean Watch) data set tracks GDP, employment, and wages for 48 industries in six industrial sectors: Marine Construction, Offshore Mineral Extraction, Tourism and Recreation, Living Resources, Ship and Boat Building, and Marine Transportation.[1] These datasets have been published for many years using a standardized methodology that allows for comparisons across time and regions.

Employment and GDP in the U.S. Marine Economy

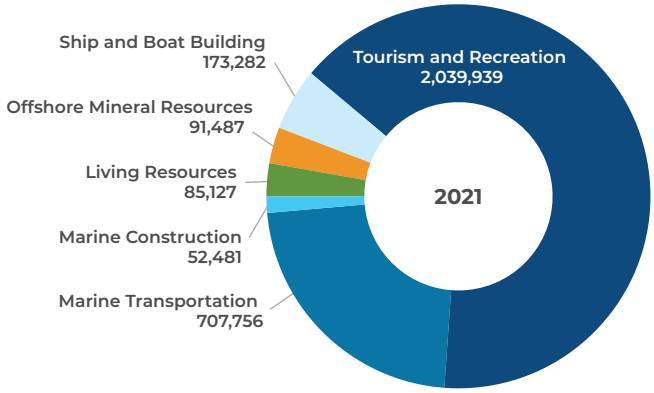
In 2021 (the most recent year for which data is available), the U.S. marine economy employed 3.15 million people, provided $147.8 billion in wages, and accounted for $368 billion in goods and services (1.8% of U.S. GDP). In 2019, prior to the pandemic, the U.S. marine economy employed 3.5 million people, provided $149 billion in wages, and accounted for $338 billion in goods and services (1.9% of U.S. GDP).[2] The following figure shows the change in employment by U.S. marine economy sector in 2019, before the pandemic, through 2021.

FIGURE 2: U.S. MARINE ECONOMY EMPLOYMENT BY SECTOR, 2019 TO 2021

2019 Total U.S. Marine Economy Employment: 3,505,443



2021 Total U.S. Marine Economy Employment: 3,150,072



The Tourism and Recreation ENOW sector experienced the greatest job losses (almost 656,000 jobs, or 26.3% from 2019 to 2020). This sector gained back over 201,000 jobs in 2021, but was still short of 2019 levels by about 455,000. In contrast, the Marine Transportation sector grew from 580,663 in 2019 to 635,265 in 2020; the sector added another 72,491 jobs in 2021 to bring total Marine Transportation sector employment to 707,756.

1 NOAA, *ENOW Data*.

2 Ibid.

Employment and GDP in California's Marine Economy

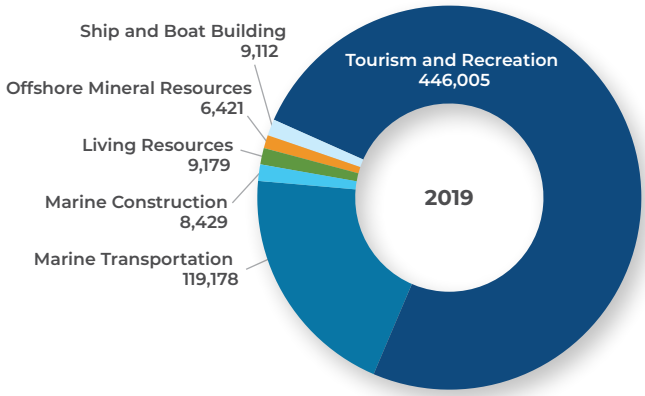
In 2021, California's marine economy employed 511,325 workers, provided over $26.6 billion in wages, and accounted for $51.3 billion in goods and services. In 2019, prior to the pandemic, California's marine economy employed 598,324 workers, provided $26.4 billion in wages, and accounted for $52.4 billion in goods and services.[1] The figure below shows the change in employment by sector from before the pandemic through 2021.

Employment and GDP in Los Angeles County's Marine Economy

In 2021, Los Angeles County's marine economy employed 105,074 workers, provided $8.35 billion in wages, and accounted for $15.7 billion in goods and services (over 30% of California's marine economy GDP). In 2019, prior to the pandemic, the County's marine economy employed 116,246 workers, provided over $7.6 billion in wages, and accounted for almost $14.3 billion in goods and services (27.3% of California's marine economy GDP).[2] The figure below shows the change in employment by sector from before the pandemic through 2021.

FIGURE 3: CALIFORNIA'S MARINE ECONOMY EMPLOYMENT, 2019 TO 2021

2019 Total California Marine Economy Employment: 598,324



2021 Total California Marine Economy Employment: 511,325

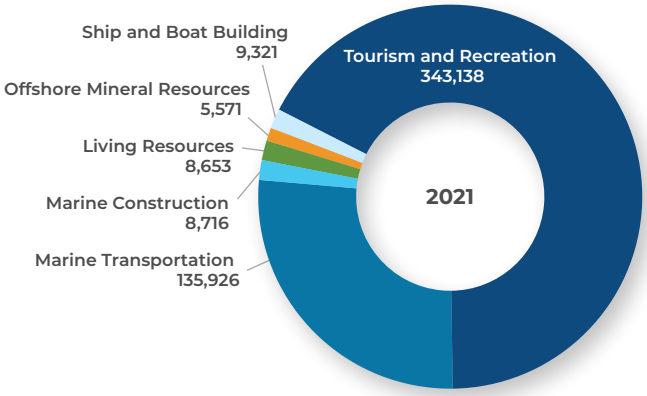
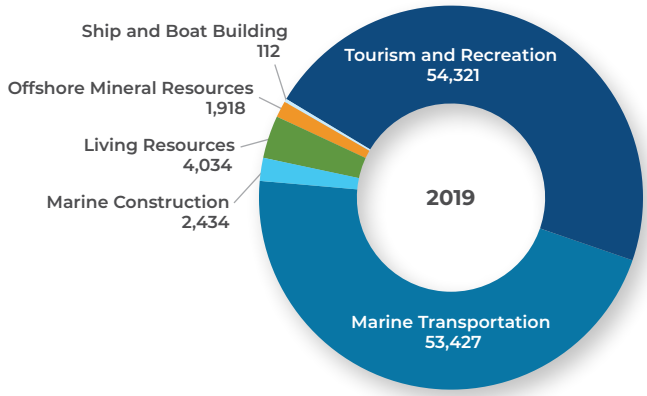
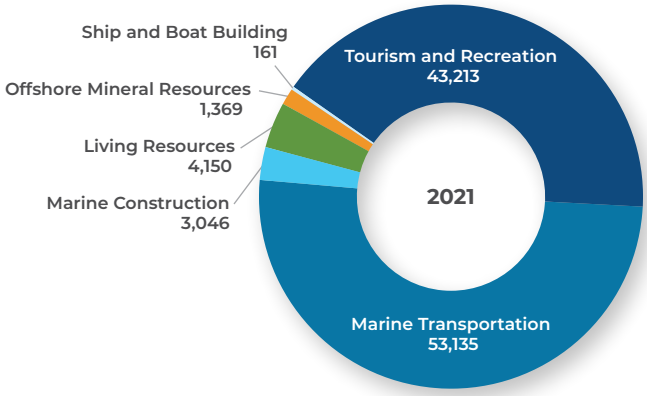


FIGURE 4: LOS ANGELES COUNTY'S MARINE ECONOMY EMPLOYMENT, 2019 TO 2021

2019 Total L.A. County Marine Economy Employment: 116,246



2021 Total L.A. County Marine Economy Employment: 105,074



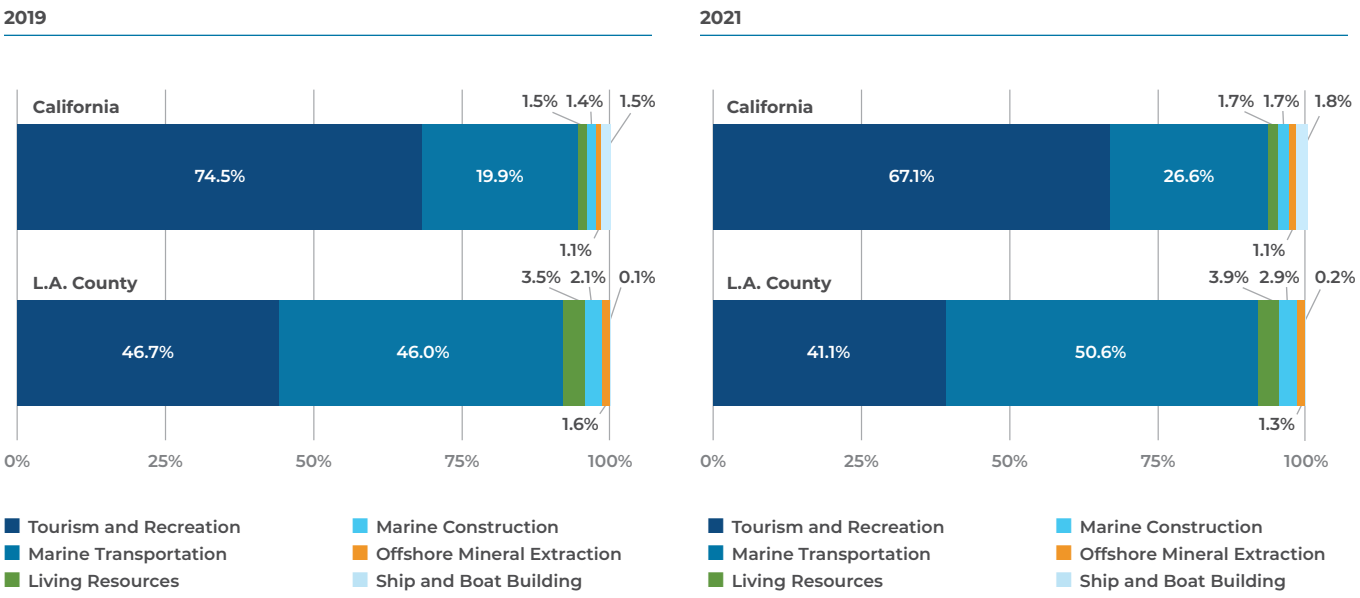
1 ENOW dataset, 2021, NOAA. Nominal GDP.

2 Ibid.

Relative to other coastal counties in California, L.A. County derives a substantially higher percentage of employment from the Marine Transportation sector, and most Marine Transportation employment is due to cargo movement and freight logistics. In 2022, the ports of Los Angeles and Long Beach together handled just over 19 million TEUs per year—almost exactly double what the second largest US port, the Port of New York and New Jersey, handled in 2022 (9.5 million TEUs).[1] L.A. County's ports comprise the largest gateway to international trade of any port complex on the West Coast.

The second largest employment sector is in the Tourism and Recreation sector, which in 2021 provided 41% of L.A. County marine economy employment, compared to 67% of marine economy employment for the State of California as a whole. The figure below compares California and L.A. County marine economy sector employment between 2019 and 2021.

FIGURE 5: CALIFORNIA AND L.A. COUNTY MARINE EMPLOYMENT, 2019 - 2021

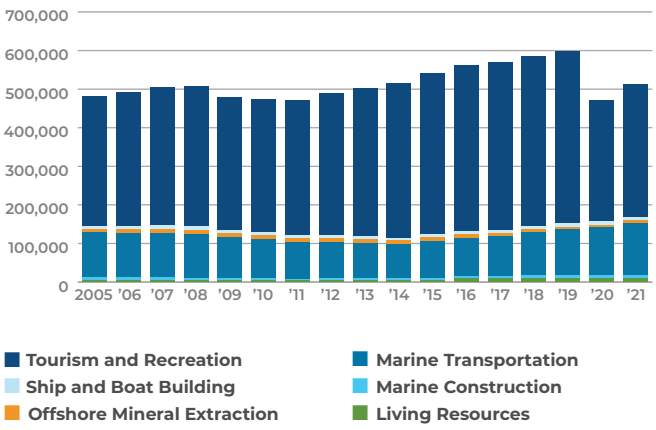


Comparing proportions of marine sector employment between California and L.A. County shows the relatively greater significance of Marine Transportation in L.A. County versus California. The larger proportion of jobs in the Tourism and Recreation in 2019 relative to 2021 reflects effects of the pandemic on Tourism and Recreation employment.

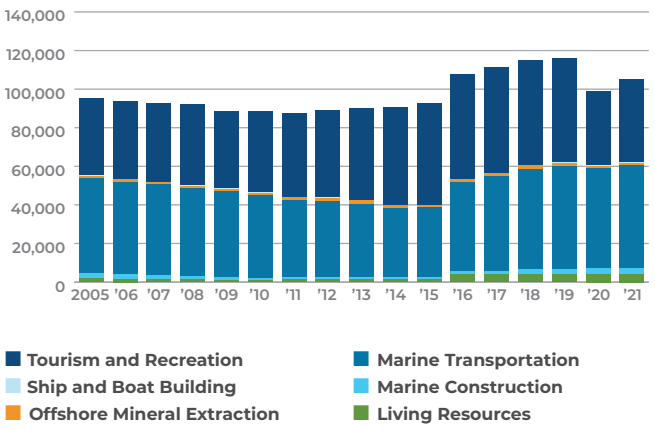
1 Carl Verdon, "10 Busiest U.S. Ports in 2024 (and How to Choose One)", ATS International. https://www.atsinc.com/blog/busiest-us-ports-how-to-choose-one.

FIGURE 6: EMPLOYMENT BY MARINE ECONOMY SECTOR, CALIFORNIA AND L.A. COUNTY, 2005 - 2021

California



Los Angeles County

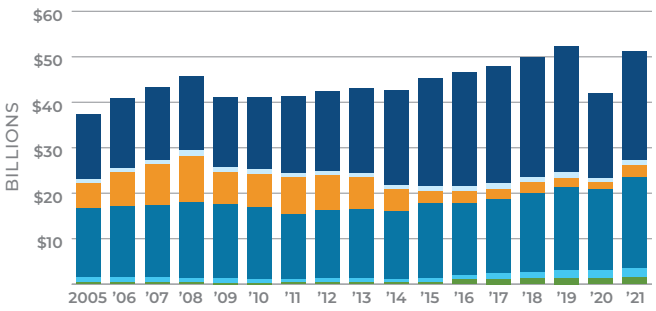


- Tourism and Recreation
- Ship and Boat Building
- Offshore Mineral Extraction
- Marine Transportation
- Marine Construction
- Living Resources

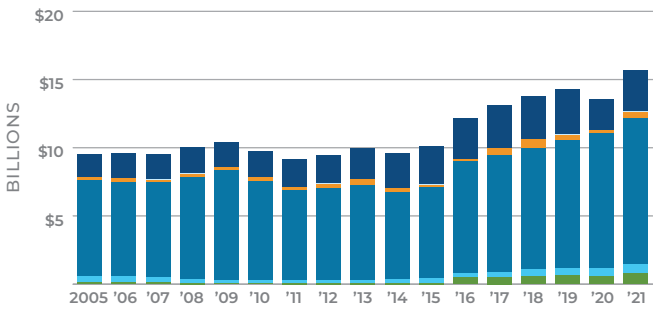
Comparing employment by marine economy sector for California and L.A. County shows the large role that Tourism and Recreation sector employment plays in California's marine economy as a whole, versus that of the Marine Transportation sector in L.A. County.

FIGURE 7: GDP BY MARINE ECONOMY SECTOR, CALIFORNIA AND L.A. COUNTY, 2005 – 2021

California



Los Angeles County



- Tourism and Recreation
- Ship and Boat Building
- Offshore Mineral Extraction
- Marine Transportation
- Marine Construction
- Living Resources

Comparing GDP by marine economy sector for California and L.A. County reveals that a large percentage of GDP in L.A. County's marine economy is generated by the Marine Transportation sector.

Ocean Economy Employment by Occupation in L.A. County

A review of employment in middle- and high-skill occupations tied most directly to the ocean economy reveals that the majority fall under the category of marine transportation and logistics. This is unsurprising, given the large volume of goods from overseas that move through the Ports of Long Beach and Los Angeles every year. The figure below shows the fifteen largest occupations in the marine economy in 2022, sorted by number of jobs.

When Tourism and Recreation is excluded[1], the dominant sector by employment is Marine Transportation. In addition to the diversity of occupations represented in the top employment categories, there are over 200 additional occupations employed in the county's ENOW sectors, spanning a wide range of activities, educational requirements, and experience levels.

The transition to the blue economy will require these occupations, plus many more in fields such as marine biology, biotechnology, robotics engineering, software development, ecological restoration, data science and analytics, regenerative aquaculture, renewable energy, advanced materials development, education, research and development (R&D), and more. Workforce development efforts (including those encompassed by the BECAP programs) are already underway to provide the skilled workforce needed to fulfill these needs. These activities are described further in the sections that follow.

FIGURE 8: TOP 15 OCCUPATION CATEGORIES, ENOW OCEAN ECONOMY SECTORS, L.A. COUNTY, 2022[2,3]

OCCUPATION	SOC CODE	L.A. COUNTY EMPLOYMENT 2023	PERCENTAGE OF TOTAL, 2023
Laborers and Freight, Stock, and Material Movers, Hand	53-7062	7,142	11.6%
Stockers and Order Fillers	53-7065	4,807	7.8%
Industrial Truck and Tractor Operators	53-7051	3,601	5.9%
Heavy and Tractor-Trailer Truck Drivers	53-3032	1,542	2.5%
First-Line Supervisors of Transportation and Material Moving Workers*	53-1047	1,536	2.5%
Captains, Mates, and Pilots of Water Vessels	53-5021	1,513	2.5%
Packers and Packagers, Hand	53-7064	1,430	2.3%
Electrical, Electronic, and Electromechanical Assemblers**	51-2028	1,342	2.2%
Shipping, Receiving, and Inventory Clerks	43-5071	1,317	2.1%
Software Developers	15-1252	1,304	2.1%
Crane and Tower Operators	53-7021	1,230	2.0%
General and Operations Managers	11-1021	1,186	1.9%
Sailors and Marine Oilers	53-5011	1,118	1.8%
Transportation, Storage, and Distribution Managers	11-3071	920	1.5%
Sales Representatives, Wholesale and Manufacturing***	41-4012	802	1.3%

** Except Aircraft Cargo Handling Supervisors*
*** Except Coil Winders, Tapers, and Finishers*
**** Except Technical and Scientific Products*

1 As described in the previous section, the two largest sectors in L.A. County's ocean economy are Marine Transportation and Tourism and Recreation. While the latter employs a substantial number of people, the majority of those jobs are low-wage positions and many require little, if any, formal education. Given BECAP's focus on developing curricula to support students interested in middle-skill/high-road jobs in the blue economy, the Tourism and Recreation sector is excluded for the purposes of this section.

2 Excludes the Tourism and Recreation ENOW sector

3 Occupation categories are at the 4-digit SOC Code level

TOWARD THE BLUE ECONOMY

The Blue Economy Imperative

As mentioned previously, a substantial portion of the world's population lives in coastal zones and relies on ocean and coastal ecosystems for their livelihoods. As world population continues to grow, greater numbers of people will rely on the oceans for their livelihoods, communities, and recreation. Yet, ocean resources and ecosystems are experiencing unprecedented levels of strain as economic demands increase.

The idea that human activity could affect the oceans on a large scale was once unimaginable. Now, however, climate change, habitat destruction, overfishing, and widespread pollution in the form of plastics, chemicals, and agricultural runoff pose threats to the ability of ocean ecosystems to provide the goods and services upon which billions of people depend.

Small Island Development States (SIDS) in particular are experiencing outsized negative impacts of ecosystem degradation (e.g., plastics pollution, fishery overexploitation, habitat destruction) and climate change. Some are facing the prospect of relocating entire societies to new lands as their ancestral homes are overtaken by rising sea levels.[1] Unsurprisingly, SIDS (or "Large Ocean States", as some, such as Seychelles, prefer to be called) have been among the earliest and most vocal advocates for sustainable ocean resource management and climate change mitigation, with many developing blue economy frameworks to steward resources and facilitate the emergence of more environmentally sustainable and socially equitable economies.[2]

Solving these problems and achieving economic growth, social equity, and sustainability will require a broad range of initiatives, from the greening of traditional marine economic activities to the development of knowledge about ocean ecosystems to inform the development of policies, technologies, and incentives to sustainably manage marine resources. It will also require action and collaboration across the public and private sectors, and at local, national, and international levels[3].

All coastal nations and states have an important role to play in improving the sustainability of marine economy activities. When implemented effectively, these efforts can help mitigate economic risks, enhance ecosystem and human health, and provide occupational and entrepreneurial opportunities to diverse populations.

1 Jet Propulsion Lab. "NASA Analysis Shows Irreversible Sea Level Rise for Pacific Islands." *NASA*, September 25, 2024. https://www.nasa.gov/science-research/earth-science/nasa-analysis-shows-irreversible-sea-level-rise-for-pacific-islands/

2 Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). "Shades of blue: what do competing interpretations of the Blue Economy mean for oceans governance?" *Journal of Environmental Policy & Planning,* 20(5), 595–616. https://doi.org/10.1080/1523908X.2018.1473153

3 As stated by the World Bank, "sustainable management of oceans will require collaboration across nation-states and the public and private sectors on a scale that has not been achieved before."

Defining the Blue Economy

Since the term "blue economy" first emerged in 2009[1,2], many definitions have been put forward. A succinct and widely cited definition of provided by World Bank in 2017 states that the blue economy is "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."[3] Another definition given in 2021 by the OECD and the United Nations Conference on Trade and Development (UNCTAD) describes the "sustainable ocean economy" (blue economy) as "...[encompassing] economic sectors that sustainably utilize and contribute to the conservation of oceans, seas and coastal resources for the benefit of humanity in a manner that sustains all ocean resources over time."[4] The figure below summarizes these sectors.[5]

One thing to note in this broader characterization of the ocean economy is the inclusion of high-tech products and services, coastal and marine environmental services, marine research and development and related services, and ocean and renewable energy.

Researchers, organizations, and governments continue to better define and measure both the ocean and blue economies. In the U.S., NOAA has outlined plans to help spur the "new blue economy", with a particular emphasis on new technologies and data collection and analysis.[6] There have also been a few examples in the U.S. to better define and characterize the blue economy at the state (e.g., Rhode Island[7], Hawaii[8]). Such efforts are likely to grow as states and localities seek to better understand the regional benefits provided by ocean economy activities.

FIGURE 9: CLASSIFICATION OF THE OCEAN ECONOMY BY SECTOR

GOODS	SERVICES	ENERGY
• Marine fisheries • Aquaculture and hatcheries • Seafood processing • Sea minerals • Ships, port equipment and parts thereof • High-technology and other manufactures not elsewhere classified (NEC)	• Marine and coastal tourism • Trade in fisheries services • Maritime transport and related services • Port services, related infrastructure services and logistical services • Coastal and marine environmental services • Marine research and development and related services	• Ocean energy and renewable energy • Carbon capture

1 Martínez-Vázquez, R.M., Milán-García, J. & de Pablo Valenciano, J. *Challenges of the Blue Economy: evidence and research trends. Environ Sci Eur* 33, 61, 2021. https://doi.org/10.1186/s12302-021-00502-1

2 U.S. Senate Committee on Commerce, Science, & Transportation. *Hearing Summary: The Blue Economy: The Role of the Oceans in Our Nation's Economic Future, June 9, 2009. U.S. Senate Committee on Commerce, Science, and Transportation,* https://www.commerce.senate.gov/2009/6/hearing-summary-the-blue-economy-the-role-of-the-oceans-in-our-nation%E2%80%99s-economic-future

3 World Bank, "What is the blue economy?", 2017.

4 The United Nations Conference on Trade and Development (UNCTAD) and The United Nations Food and Agriculture Organization (FAO). *Background Note for the 4th Oceans Forum on Trade-related Aspects of SDG 14,* Geneva, Switzerland, 6–8 April 2022, page 6. https://unctad.org/system/files/non-official-document/ditc-ted-06042022-Oceans4-BackgroundNote-v3.pdf.

5 UNCTAD. *Towards a harmonized international trade classification for the development of sustainable ocean-based economies* (UNCTAD/DITC/TED/2020/4) 16 Mar 2021, p. 28. https://unctad.org/system/files/official-document/ditcted2020d4_en.pdf

6 "New Blue Economy", NOAA, June 20, 2023. https://www.noaa.gov/blue-economy

7 Jennifer McCann, Sam Poli, Sue Kennedy, Erin O'Neill, Don Robadue and Dawn Kotowicz. Monica Allard Cox, Ed. *The Value of Rhode Island's Blue Economy, March 2020.* Coastal Resources Center and Rhode Island Sea Grant College Program and Graduate School of Oceanography, University of Rhode Island. https://web.uri.edu/gso/research/blue-economy/.

8 Eastern Research Group and NOAA. *ENOW Hawaii: Exploring the Hawaii Ocean Economy through a Deeper Dive into the ENOW Dataset,* July 2018. https://coast.noaa.gov/data/digitalcoast/pdf/econ-hawaii.pdf

Additional Industries to Include in the Blue Economy Definition

As mentioned in the previous section, various governments, academics, and organizations have explored more expansive definitions of the ocean economy. Many of these definitions include industries such as "blue tech" (e.g., marine robotics, autonomous vehicles), marine biotechnology, coastal and offshore renewable energy, marine sensing, data science and analytics, and conservation and research.

Based on an extensive review of the academic literature and the governmental / multilateral efforts to define and measure the blue economy, LAEDC recommends including the following industry sectors when evaluating the blue economy, in addition to NOAA's ENOW sectors.

FIGURE 10: PROPOSED BLUE ECONOMY INDUSTRY SECTORS IN ADDITION TO NOAA'S ENOW INDUSTRIES

ADDITIONAL BLUE ECONOMY INDUSTRY SECTORS (LAEDC, 2024)
Marine research & development (R&D)
Renewable ocean energy
Marine conservation and restoration
Marine education, training, and outreach
Marine environmental services (e.g., regulatory compliance/pollution control)
Marine robotics/autonomous vehicles
Marine biotechnology
Marine carbon dioxide removal (mCDR)
Marine business and technical services
Marine monitoring, data analytics, and security (e.g., sensors & related equipment; software)

Los Angeles' Growing Blue Economy[1]

When managed responsibly, coastal waters can provide economic benefits and good-paying jobs, while making progress to heal the damage done to the ocean and atmosphere. The blue economy provides a path forward to address multiple societal challenges, including climate change and resilience; food security; environmental justice and restoration; and diverse, equitable, and inclusive economic development.

Companies and Organizations at the Forefront

While the blue economy currently accounts for a relatively small proportion of jobs in the region, success stories can be found in multiple sectors, from technology to education to policy, pointing to the potential for significant growth in the next decade. Many organizations across these sectors are flourishing with Los Angeles as a base for their operations, bringing attention and resources to the region's blue economy.

MARINE CARBON DIOXIDE REMOVAL (MCDR)

Los Angeles (specifically, AltaSea) is home to the largest concentration of mCDR research, development, and commercial operations in North America. The capture and sequestration of carbon has a growing footprint as a critical solution to reducing the impact of fossil fuel emissions; it can also produce 'green hydrogen,' a clean fuel that is increasing in demand. The mCDR university-associated organizations at AltaSea are scaling up their proprietary technologies, from the direct removal of carbon from the ocean by **Equatic** (UCLA School of Carbon Management) and **Captura** (Cal Tech), to the sustainable permanent storage of carbon in the ocean by **Calcarea** (Cal Tech).[2] Their investments in this commercial translation of innovative technologies will lead to economic and job growth in the region.

1 Information in this section was provided by Meredith Brooks on behalf of AltaSea.

2 Lori Dajose. "Carbon Capture Goes Out to Sea." *CalTech Magazine*, Spring 2023. https://magazine.caltech.edu/post/carbon-capture-ocean-caltech-startups-calcarea-captura.

ROBOTICS AND MATERIALS

One company that is demonstrating the potential for scaling up jobs in the blue economy is **Blue Robotics,** an underwater robotics company that has grown over the last decade from two employees working out of a garage to over 60 employees working in 32,000 square feet of space at AltaSea. Another AltaSea onsite partner that is growing fast is **Sperra**, which utilizes 3-D concrete printing for coastal resiliency—including fabrication of low cost, durable, offshore wind, solar, and wave energy components; 3-D printing of artificial reefs and coastal infrastructure; and anchors for aquaculture and other applications. The company will be expanding operations and staff soon to manufacture their products at a larger scale on the AltaSea campus.

REGENERATIVE AQUACULTURE

Regenerative aquaculture is projected to grow significantly to address food insecurity, create biofuels and other products, restore ecosystems, sequester carbon, and stimulate economic growth in California. Organizations in Los Angeles and Southern California are helping drive this effort. San Pedro-based **Holdfast** produces California-native seaweed and shellfish seeds for purchase by seaweed farmers and also develops novel aquaculture techniques for mussels to optimize taste. **Kelp Ark** and the USC Seaweed Lab on the AltaSea Campus are staging breeding programs to enable sustainable and highly efficient offshore aquafarming for the entire west coast. They are leading a community of practice of over 40 researchers and companies focused on aquaculture farming, including **Ocean Rainforest,** an innovator in sustainable seaweed aquaculture that recently secured a $4.5M 'Technology to Market Plus Up' award from ARPA-E. The efforts of these organizations and more mark the regional commitment to advancing offshore aquaculture technologies in California.

RENEWABLE MARINE ENERGY

Technologies to produce renewable energy using marine resources are available and increasing in regional commercial application. **Eco Wave Power,** for example, is a global leader in onshore wave energy that is in the process of establishing an operation in Los Angeles. The company developed a patented, cost-efficient technology for turning ocean and sea waves into renewable electricity, and recently secured the final federal permit for its newest pilot at AltaSea, with installation scheduled for 2025. Eco Wave Power has a total project pipeline of 404.7 MW, and has received the "Global Climate Action Award" from the United Nations.

BLUE ECONOMY AND CLIMATE ACTION PATHWAYS (BECAP) PROGRAM

An important ingredient to promote the growth of the blue economy in the region is the availability of a trained workforce with the knowledge and skills to fill blue economy positions. The Blue Economy and Climate Action Pathways (BECAP) Consortium, an innovative alliance of 15 Los Angeles community colleges, AltaSea at the Port of Los Angeles, and the Los Angeles Economic Development Corporation (LAEDC), is developing a novel workforce training and placement program to prepare students for the next generation of ocean economy occupations.[1] The Consortium is leveraging existing resources and innovative workforce opportunities to establish post-secondary certificate and degree programs focused on four blue economy industry sectors: Regenerative Aquaculture, Renewable Energy, Bluetech & Underwater Robotics, and Ecosystems Conservation and Restoration.

More information about Los Angeles community college programs and course offerings can be found in the "Ocean/Blue Economy Programs at Community Colleges" section.

1 https://www.smc.edu/academics/workforce-economic-development/becap/

GREEN HYDROGEN IMPLEMENTATION

In July 2024, California's Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES) and the U.S. Department of Energy's (DOE) Regional Clean Hydrogen Hubs (H2Hubs) program announced a $12.6 billion agreement ($1.2 billion from DOE; $11.4 billion in public and private matching funds) to build and expand clean hydrogen energy infrastructure in California.[1] H2Hubs is focused on hard-to-decarbonize industrial sectors (representing 30% of total U.S. carbon emissions)[2], including public transportation, heavy-duty trucking, and port operations.[3] Cargo-handling equipment at marine terminals, along with drayage trucks, are a key focus of the program.[4]

These programs represent a large-scale investment in state and local hydrogen fueling infrastructure, requiring trained workers to build and operate it. As part of its renewable energy pillar, BECAP has formed the BECAP Hydrogen Advisory Council, which seeks to address the workforce needs to implement green hydrogen programs. The Hydrogen Advisory Council is currently comprised of the following companies and organizations:

- Air Products and Chemicals, Inc.
- APM Terminals (Maersk)
- Curtin Maritime, Corp.
- Fenix Marine Services
- ILWU Local 13 (tentative)
- Jozen Power LLC
- Pasha Stevedoring & Terminals L.P.
- Port of Los Angeles
- SoCal Gas
- Toyota Motors
- TraPac Los Angeles
- Vopak Terminal Los Angeles (Vopak USA)
- YTI (Yusen Terminals)
- 7th Generation Advisors

PUBLIC-PRIVATE PARTNERSHIP: ALTASEA

A major driver of blue economy growth in Los Angeles—and a unique asset to position the region as a global leader—is **AltaSea at the Port of Los Angeles**, a public-private blue economy institute founded in 2014 to expand science-based understanding of the ocean, incubate blue economy business, and pioneer new blue economy-focused education and workforce training programs. Located at the western hemisphere's biggest port, the AltaSea campus offers unparalleled commercial and research access to the Port, Southern California's urban coastline, and the Pacific Ocean.

Set on 35 acres of repurposed dockland, AltaSea encompasses a cluster of historic warehouses on Pier 1, with four buildings of 50,000-60,000 square feet each, comprising the core of the campus. Three of these buildings are home to the newly renovated 'Center of Innovation,' providing 180,000 square feet of usable research, education, and commercial space to support Los Angeles' blue economy. The Center abuts 2,000 linear feet of developed waterfront. Onsite partners can rent space in these facilities for periods from a few days to a few decades.

In the longer term, 15 acres of undeveloped land along 2,000 feet of the main channel in the Port of Los Angeles—as well as 500,000 square feet of additional warehouse space—are available for future expansion to support the blue economy. While shorter-term uses are accommodated with facilities managed by AltaSea, longer-term users develop their own infrastructure designed specifically to their unique needs. All share a developing mixture of common-use capacities.

AltaSea has created an innovative hybrid model of collaboration that strategically engages the research, business, and education communities and requires onsite partners actively to participate in education and workforce development programming. Further, the organization supports economic and business development through its business services as well as legislative advocacy.

1 https://archesh2.org/arches-officially-launches/
2 https://archesh2.org/arches-named-regional-h2hub/
3 https://www.energy.gov/oced/articles/award-wednesdays-july-17-2024
4 https://www.energy.gov/sites/default/files/2024-07/H2Hubs%20ARCHES_Award%20Fact%20Sheet.pdf

Policy Landscape

There is growing momentum in the California state legislature to support blue economy industries. In October 2023, California Governor Gavin Newsom signed SB 605 into law, marking a significant step forward in bringing a new renewable energy resource to the state and further solidifying California's commitment to a sustainable and clean energy future. The bill—introduced by Senator Steve Padilla (D-San Diego) and sponsored by AltaSea at the Port of Los Angeles—directs the California Energy Commission to work with various state agencies and stakeholders to assess the feasibility, costs, and potential of deploying wave and tidal energy technology across California's coastline. The bill unanimously passed in both the California State Senate and Assembly.

Legislation for sustainable aquaculture and other forms of marine renewable energy and carbon capture are in the works in conjunction with the California 'Sustainable Blue Economy' and 'Coastal' Caucuses, which bring together members of the California House delegation to share and discuss federal policy to address matters of importance to the 840-mile California coast, including paving the way for blue economy growth in the region and across the state.

The regional blue economy is years behind the green economy when it comes to government investments, workforce development, and job training. This is both a challenge and a strength: the challenge is that concerted effort and investment will be required to close the gap; the strength is that the region can learn from the evolution of the green economy and center equity and climate justice in the development of the blue economy.

Blue Economy Alignment with Regional and Statewide Strategic Plans

The blue economy provides unique opportunities to meet climate resilience, economic development, and workforce development goals at the local, regional, state, and national levels. In Los Angeles County, blue economy industries align with the Ports of Los Angeles and Long Beach 2017 Clean Air Action Plan (CAAP) Update. The CAAP is a landmark air quality plan that establishes a comprehensive, far-reaching strategy for reducing port-related air pollution and related health risks, while allowing port development, job creation and economic activity associated with that development to continue. The CAAP 2017 update focuses on zero-emissions infrastructure, freight efficiency, and sustainable energy resources. It contains 14 strategies to reduce emissions from sources in and around the Ports, including accelerating the deployment of cleaner engines and operational strategies to reduce emissions. Blue economy sectors such as marine energy technologies and carbon capture directly support the goals of the CAAP.

The blue economy will also help Los Angeles achieve the goals of L.A.'s Green New Deal. The Green New Deal is an expanded vision of the 2015 Sustainable City Plan—securing clean air and water and a stable climate, improving community resilience, expanding access to healthy food and open space, and promoting justice for all. Goals for increased renewable energy, new jobs, water resources, and other climate change mitigation strategies will all be met by blue economy business.

Similarly—and with a statewide focus—the California Air Resources Board Climate Scoping Plan (2022)[1] proposes an unprecedented shift away from petroleum in every sector of the economy and a rapid transition to renewable energy resources and zero-emission vehicles. The plan aims to slash greenhouse gas emissions, reduce air pollution, reduce fossil fuel consumption, and create new jobs, all of which will be supported by the growing blue economy. The California Climate Commitment also champions climate resiliency that will enable the state to reach carbon neutrality by 2045.[2] The initiatives of the commitment are divided into various subsections, including prosperous communities' goals of hiring and training a clean energy workforce. The blue economy also meets goals of the California Ocean Protection Council's *Strategic Plan to Protect California's Coast and Ocean*. The plan delineates four goals: 1) safeguarding coastal and marine ecosystems and communities in the face of climate change; 2) advancing equity across ocean and coastal policies and actions; 3) supporting ocean health through a sustainable blue economy; and 4) enhancing coastal and marine biodiversity.[3]

The sustainable blue economy is already advancing energy and industrial efficiency technologies and creating solutions for natural and anthropogenic disaster prevention and stands to do much more in the future. Blue economy industries are uniquely positioned to simultaneously provide economic mobility to underserved populations, revitalize ocean environments, and mitigate the effects of climate change.

1 https://ww2.arb.ca.gov/news/california-releases-final-2022-climate-scoping-plan-proposal

2 https://www.gov.ca.gov/wp-content/uploads/2022/09/Fact-Sheet-California-Climate-Commitment.pdf

3 http://www.opc.ca.gov/webmaster/ftp/pdf/2020-2025-strategic-plan/OPC-2020-2025-Strategic-Plan-FINAL-20200228.pdf

FIGURE 11: BLUE ECONOMY-SPECIFIC OCCUPATIONS AND DEMOGRAPHICS

DEMOGRAPHIC		Water Transportation Workers (53-5000)	Electricians (47-2111)	Industrial Machinery Mechanics (49-9041)	Welders, Cutters, Solderers, and Brazers (51-4121)
Sex	Male	94.0%	97.3%	96.6%	93.0%
	Female	6.0%	2.7%	3.4%	7.0%
Education	Less than High School	7.5%	7.7%	9.1%	18.3%
	High School (or Equivalent)	42.1%	37.8%	40.2%	47.7%
	Some College/Associate's	29.6%	45.6%	43.2%	30.8%
	Bachelor's	16.7%	7.3%	6.6%	2.6%
	Master's or Higher	4.0%	1.4%	0.9%	0.5%
Age	< 25	7.0%	7.5%	3.1%	7.9%
	25 - 44	38.0%	49.7%	36.3%	46.9%
	45 - 64	48.0%	37.8%	52.2%	39.6%
	65+	7.0%	4.9%	8.4%	6.0%
Race/Ethnicity	American Indian / Alaska Native	1.3%	0.3%	0.3%	0.5%
	Asian	4.6%	4.9%	8.2%	5.6%
	Black	8.5%	4.2%	3.8%	3.5%
	Hispanic or Latino	24.1%	51.8%	51.0%	64.7%
	Native Hawaiian / Other Pac. Islander	2.0%	0.3%	0.3%	0.3%
	Two or More Races	3.6%	1.6%	1.4%	1.1%
	White	55.9%	36.9%	35.1%	24.8%

DEMOGRAPHIC		Farmworkers, Farm, Ranch, and Aquacultural Animals (45-2093)	Environmental Science & Protection Technicians (19-4042)	Data Scientists (15-2051)	Electrical & Electronic Engineering Technologists and Technicians (17-3024)
Sex	Male	68.5%	51.5%	55.0%	80.0%
	Female	31.5%	48.5%	45.0%	20.0%
Education	Less than High School	46.7%	3.2%	0.4%	3.5%
	High School (or Equivalent)	29.0%	16.5%	2.7%	23.3%
	Some College/Associate's	15.2%	34.7%	9.7%	48.5%
	Bachelor's	7.4%	36.0%	39.9%	19.5%
	Master's or Higher	1.7%	9.7%	47.4%	5.3%
Age	< 25	12.9%	19.9%	6.0%	5.0%
	25 - 44	50.2%	47.0%	64.6%	41.0%
	45 - 64	29.3%	27.6%	25.4%	45.7%
	65+	7.9%	5.5%	4.0%	8.4%
Race/Ethnicity	American Indian / Alaska Native	0.3%	0.4%	0.1%	0.6%
	Asian	3.8%	22.3%	46.1%	19.8%
	Black	3.3%	4.9%	3.9%	5.7%
	Hispanic or Latino	75.0%	32.1%	16.2%	38.0%
	Native Hawaiian / Other Pac.Islander	0.3%	0.4%	0.3%	0.3%
	Two or More Races	0.5%	3.9%	3.0%	0.6%
	White	16.8%	36.0%	30.4%	35.1%

Educational Asset Mapping

This section explores the educational programming and institutions that are supporting the growth of the blue economy in the region.

Ocean / Blue Economy K-12 and Youth Education

Los Angeles County is home to several programs and organizations helping students to explore fields within the ocean economy.

AltaSea at the Port of Los Angeles has several programs to support younger students, hosting hands-on field trips and an Ocean STEM educational hub, providing sample lesson plans, and conducting a summer mentorship program for seniors.[1] The organization has a bicoastal Ocean Pathways Mentorship Program with Hugo Beu and NY/NJ Baykeeper for high school students, and hosts interns and fellows through its Ocean Career Pathways Program for students over 18.

Another resource, the Marine Science Floating Laboratory (MSFL), was created by the Los Angeles County Office of Education. The MSFL offers 3-hour cruises through Long Beach or Los Angeles harbor that provide students with hands-on learning activities including sediment sample collection, otter net trawling observation, a plankton tow and plankton observation under a microscope, water quality studies, and more.[2] Students are exposed to the harbor economy and learn about shipping vessels, breakwater functionality, and environmental engineering, helping to foster interest in related occupations from an early age.

Also serving youth is the Los Angeles Maritime Institute, which offers a TopSail youth program, STEM program, summer camps, and a Sea Scouts program.[3] For younger students, visits to facilities such as the Aquarium of the Pacific and the Heal the Bay Aquarium can also inspire an interest in marine issues; these aquariums host school visits, put on science camps, and provide educational materials to inspire a passion for topics related to the ocean.[4,5]

At the high school level, the Port of Long Beach has partnered with Long Beach Unified School District to create a curriculum that combines academic topics with industry-relevant training.[6] Its Academy of Global Logistics (AGL), hosted at Cabrillo High School, focuses on global logistics and supply chain management careers, giving students exposure to these topics through partnerships with the Port of Long Beach, Center for International Trade and Transportation, Long Beach City College, and California State University, Long Beach.

There are also two Department of Transportation Maritime Administration (MARAD)-sponsored educational programs in L.A. County.[7] First, the Port of Los Angeles High School (POLAHS) in San Pedro provides specialized Career Technical Education (CTE) programs focused on preparing students for careers in marine transportation and welding.[8] The marine transportation program uses hands-on training to help students master sailing, navigation, boat-building, and seamanship; students are able to get certifications in CPR, first-aid, and Coast Guard Standards of Training, Certification, and Watchkeeping. The welding CTE program added in 2019 largely focuses on marine welding for shipbuilding and other marine applications, though it also welcomes students interested in automotive, manufacturing, construction, and building industries.

Second, Lawndale High School, located in the South Bay, hosts the Marine Science Academy (MSA), which prepares students for four-year degrees in the marine sciences.[9] Over the four-year curriculum, students study marine biology and introduction to oceanography in year one, environmental chemistry and water quality in year two, California coastal oceanography in year three, and more advanced marine biology coursework in year four as high-school seniors dual-enrolled at El Camino College. The MSA also leverages local partners to provide work-based learning and internship opportunities, tutoring, guest speakers, and experiential learning opportunities with industry-standard equipment.

1 "Ocean STEM: Inspiring the next generation for a sustainable blue future," *AltaSea,* https://altasea.org/education/, accessed February 1, 2025.
2 https://www.outdoorscienceschool.org/msfl
3 https://lamitopsail.org/
4 https://www.aquariumofpacific.org/education/yourfieldtrip
5 https://healthebay.org/camps/
6 https://cabrillo.lbschools.net/pathway/agl
7 https://www.maritime.dot.gov/maritime-workforce/maritime-training
8 https://www.polahs.net/apps/pages/index.jsp?uREC_ID=1202818&type=d&pREC_ID=1281866
9 https://www.lawndalehs.org/apps/pages/index.jsp?uREC_ID=203235&type=d&pREC_ID=442083

Ocean / Blue Economy Programs at Community Colleges

EXISTING LOS ANGELES COUNTY COMMUNITY COLLEGE PROGRAMS

Los Angeles County community colleges provide a range of academic coursework related to the blue economy. One of the most directly blue economy-related programs is Santa Monica College's (SMC) aquaculture certificate program.[1] Launched in 2023 in partnership with AltaSea, the aquaculture certificate program will prepare students through a mix of academic and laboratory hands-on coursework, as well as internships through collaborators such as Holdfast Aquaculture (located at AltaSea).[2] As SMC continues to grow the program, they can look to the curriculum at the College of the Redwoods in northern California, where a certificate of achievement and an A.S. are offered in aquaculture technology.[3]

Other than the SMC program, there are no certificate or degree programs that focus explicitly on the blue economy.[4] However, several schools offer introductory oceanography and marine biology courses, and a few have a curriculum that feature more advanced courses.[5] Glendale City College (GCC) has several blue economy-oriented courses, including marine biology (with a laboratory), oceanography (with a laboratory), marine ecology, marine mammals, and an honors marine biology course. In addition to SMC and GCC, several colleges, including East Los Angeles College, El Camino College, and Los Angeles Pierce College, offer courses that form a solid basis for expanding their marine sciences programs.

More generally, there are multiple opportunities at Los Angeles County community colleges to develop in-demand skills for the blue economy (listed in the academic literature section of this report)—especially engineering basics, computer programming, network programming, algebra or advanced mathematics, geographic information systems, and process technology and improvement:

- Seventeen programs offer engineering degrees that result in an A.S. and allow transfer into four-year programs; CTE engineering technology programs are also widely available.
- Eighteen schools offer a CTE certificate in computer information systems, CTE in computer programming, or an A.A./A.S./A.S.T. in computer science that enables transfer to a four-year program.
- Twelve schools offer programs in network programming, with both certificates and A.A./A.S. degrees available.
- Nineteen schools offer a two-year degree in mathematics that enable students to transfer to four-year institutions; Los Angeles City College and Los Angeles Southwest College also offer mathematics/computer science degrees, which combine the two disciplines into an A.S. degree.
- Six schools offer educational programs in geographic information systems; of these, five offer two-year degrees.
- Ten schools have programs in manufacturing and industrial technology, an equivalent for process technology and improvement, offering a range of noncredit, certificate, and A.S. degree programs.

A full list of these programs is included as Appendix A at the end of the report. Note that there are other programs related to these disciplines available; however, inclusion in the tabulation was dependent upon taxonomy of programs (TOP) codes.

There are many trade fields that have applications in the blue economy. Perhaps the broadest example is welding: twelve different Los Angeles County community colleges offer welding programs, including specialty courses in shielded metal arc welding, gas tungsten arc welding, and aerospace welding (though none of them focuses on boat construction or marine welding). There are three colleges with surveying programs—East Los Angeles College, College of the Canyons, and Los Angeles Mission College—but none have ocean mapping courses. Other examples include environmental technology programs, global trade and logistics programs, Mt. San Antonio College's unmanned aircraft systems program, and Antelope Valley College's meteorology sciences for aerospace manufacturing program.

1 https://www.smc.edu/academics/areas-of-interest/stem/life-sciences/aquaculture.php
2 https://www.smc.edu/news/in-focus/2022/vol-viii-issue-5/2022-10-02.php
3 https://www.redwoods.edu/academics/aqua.php
4 https://coci2.ccctechcenter.org/programs
5 https://coci2.ccctechcenter.org/courses

COMMUNITY COLLEGE BLUE ECONOMY PROGRAM ANALYSIS

1920.00 – Ocean Technology: Procedures and techniques used to measure and analyze ocean currents, seas, and other major bodies of water and ocean life, including the operation and/or maintenance and repair of related equipment and instruments. Includes aquarium technology and aquaculture.

0959.00 – Marine Technology: Operation and maintenance of ships systems and marine equipment.

0959.10 – Diving and Underwater Safety: Professional diving, diving instructors or diving support personnel.

1919.00 – Oceanography (non-CTE): The physical and chemical properties of water, the topography and composition of the ocean bottom, waves, currents, tides, the formation of islands, and related subjects.

0303.00 – Environmental Technology: Environmental management, monitoring, assessment, and restoration, including environmental pollution control systems and the management of hazardous materials and hazardous waste, and related government regulations.

0935.00 – Electro-Mechanical Technology: Design, development, testing, and maintenance of electro-mechanical and servo-mechanical devices and systems.

0506.40 – Small Business and Entrepreneurship: Principles, practices, and strategies of small business wholesale, retail, or service operations for owners/managers, and marketing principles and methods applicable to developing businesses.

0956.50 – Welding Technology: Welding techniques, processes, and equipment applied in accordance with diagrams, blueprints, or other specifications.

0946.10 – Energy Systems Technology: Theory and methods of energy conservation applied to heating, cooling, and related systems, including the measurement and assessment of energy consumption, diagnosis, and prescription. Includes alternative energy systems.

0948.40 – Alternative Fuels and Advanced Transportation Technology: Conversion to, installation of, and maintenance of electric vehicles, liquefied petroleum gas, compressed natural gas, hybrid fuel technologies, and related systems.

2206.10 – Geographic Information Systems: Computer-based tools for acquiring, editing, storing, analyzing, and visualizing geographically referenced information, with applications in research, education, management, and planning. Includes Global Positioning System (GPS).

FIGURE 12: LA REGION COMMUNITY COLLEGE PROGRAMS RELATED TO THE BLUE ECONOMY

COMMUNITY COLLEGE	PROGRAM NAME	RELEVANCE TO BLUE ECONOMY
Santa Monica	· Aquaculture	The Aquaculture Program is a new, interdisciplinary CTE program at Santa Monica College (Business, Earth Science, & Life Science Departments) that seeks to train students for employment in the emerging field of aquaculture.
LA Mission **LA Valley** **LA Southwest** **Long Beach City**	· Robotics · Robotics and PLCs · Fundamentals of Robotics · Robotics Welding Automation	Underwater robotics is a rapidly-growing field. These existing robotics programs provide the necessary knowledge, skills, and abilities for students pursuing careers as robotics technicians, electro-mechanical and mechatronics technologists. With additional experience and education, program completers set themselves on a path towards employment as a robotics engineer.
LA Pierce **LA Trade-Tech** **Pasadena City** **Rio Hondo** **Santa Monica**	· Geographic Information Systems	Mapping the ocean floor is critical to understanding ocean ecosystem as a whole. These GIS programs provide students with the skills necessary for ongoing ocean exploration and mapping.
Long Beach City **LA Harbor** **East LA** **Mt. San Antonio**	· Oceanography · Earth Science	Knowledge of plate tectonics, coastlines, tides, marine resources and the pollution sources that threaten these are essential to the ocean economy.

Blue Economy Programs at CSUs, UCs, and Private Universities

CALIFORNIA STATE UNIVERSITY (CSU) SYSTEM

There are five universities in the California State University (CSU) system located within in Los Angeles County: CSU Dominguez Hills (CSUDH), CSU Long Beach (CSULB), CSU Los Angeles (CSULA), CSU Northridge (CSUN), and California State Polytechnic University Pomona (Cal Poly Pomona). The CSU system has an Ocean Studies Institute (OSI)[1], which was a founding member of the Southern California Marine Institute.[2] Additionally, the CSU system has the Council on Ocean Affairs, Science, and Technology (COAST), which works across all of the 23 CSU campuses to advance knowledge and research around coastal and marine resources.[3]

At CSULB, there is a B.S. program in marine biology and M.S. program in biology for students doing original research in marine biology. Students in the marine biology program have access to a semester-long immersion focusing on marine research at the Wrigley Marine Science Center (WMSC) on Catalina Island through the CSU OSI program. There are few other courses of study at CSULB or CSUDH to study issues around the blue economy: at CSULB, there are degrees in international business, supply chain management, and environmental science and policy, while students at CSUDH can take an interdisciplinary minor in environmental studies.[4,5]

There is a blue economy-focused degree at CSUN in the B.S. in biology with a marine biology concentration, as well as several related degrees, such as the B.S. in computer science, B.S. in engineering management technology, B.S. in geography and environmental studies, B.S. in geographic information science, B.S. manufacturing systems engineering, and B.S. in tourism, hospitality, and recreation management.[6]

Additionally, CSUN is home to the Sustainable Ocean Economies Initiative (SOEI), founded through a partnership with AltaSea, at its Institute for Sustainability.[7] SOEI has worked to build connections with other educational institutions and industry partners; the initiative is currently focused on sustainable seaweed, kelp, and algae and integrated multitrophic aquaculture. One of its partners in the last focus area is the Southern California Marine Institute (SCMI). SCMI is a strategic alliance of the CSU schools, University of California, Los Angeles (UCLA), University of Southern California (USC), Occidental College, Pasadena City College, the Los Angeles Community College District, and philanthropic and governmental partners. SCMI is a marine research institute located in the Los Angeles Harbor that hosts several research projects, including Palos Verdes Reef Restoration, NOAA Ship of Opportunity Program, Ecology of Harmful Algal Blooms, and others. SCMI allows faculty at universities from around the region to execute research projects at their facility, with professors from CSULB, CSUN, and CSUDH currently in residence.[8]

1 The OSI spans nine campuses—the four Los Angeles County universities, as well as Fullerton, San Bernardino, San Marcos, and Channel Islands.

2 https://www.calstate.edu/impact-of-the-csu/research/highlights/Pages/ocean-studies.aspx

3 https://www.calstate.edu/impact-of-the-csu/research/highlights/Pages/coast-ocean.aspx

4 http://catalog.csulb.edu/content.php?catoid=6&navoid=643

5 https://www.csudh.edu/university-catalog/

6 https://catalog.csun.edu/programs/major/

7 https://www.csun.edu/node/341356/soei

8 https://www.scmi.net/research/

Cal Poly Pomona does not offer programs specifically focused on ocean engineering or marine sciences, but does have tangentially related programs in engineering and hospitality management.[1,2] CSULA does not have any programs that are centered around blue economy issues. In neighboring Ventura County, CSU Channel Islands offers a B.S. in environmental science and resource management with an emphasis in marine and coastal systems for transfer and four-year students.[3]

UNIVERSITY OF CALIFORNIA

University of California, Los Angeles (UCLA) offers many programs with a blue economy focus. UCLA has a department of atmospheric and oceanic sciences within its Division of Physical Sciences, offering a minor, B.S., M.S., and Ph.D. programs in atmospheric and oceanic sciences, as well as a B.S. in atmospheric and oceanic sciences/mathematics.[4] The Division of Life Sciences hosts UCLA's marine biology program that requires a quarter of field work for a B.S. degree.[5] There are several minors with applications in the blue economy, such as Geographic Information Systems and Technologies, Environmental Engineering, and Environmental Systems and Society. UCLA is also home to the Institute of Environment and Sustainability, an interdisciplinary research center that has been working on blue economy issues as they pertain to developing island nations, (seeking subindustries in the blue economy that can support their economic growth), and gender representation, (identifying the role of women in the international blue economy).[6]

PRIVATE COLLEGES AND UNIVERSITIES

The University of Southern California (USC) also has several avenues through which students can explore blue economy issues. At USC's campus, undergraduates can explore the marine biology minor, a B.S. in Biological Sciences with an emphasis in marine biology, an M.S. in Marine and Environmental Geography, and an interdisciplinary Ph.D. in Ocean Sciences. The university also offers related programs, such as the GIS and Sustainability Science minor, a B.S. in Industrial and Systems Engineering, and a B.A. in International Relations with an emphasis in global business, among others.[7] USC's Wrigley Institute for Environment and Sustainability hosts the Catalina Residential College at the WMSC, USC's scientific diving certification program, and undergraduate internships.[8] USC also hosts the Blue Economy Program @ USC-AltaSea, offering a training program to give students knowledge and experience about aquaculture and the wider blue economy.[9] Other marine research activities at USC include the San Pedro Ocean Time-Series and Caron Lab, both of which are executing projects out of the SCMI.

The two other private educational institutions affiliated with the SCMI—Occidental College and Loyola Marymount University—offer B.S. degrees in biology, with Occidental offering a concentration in marine biology.[10,11] Occidental is home to the Vantuna Research Group (VRG), which focuses on reef and kelp forest restoration projects and long-term fish and ichthyoplankton monitoring.[12] Loyola Marymount University (LMU) hosts the Coastal Research Institute, which focuses on restoring and enhancing Santa Monica Bay and the local coastal waters of Los Angeles. The institute works with the Bay Foundation and also has a summer student research assistant program, supplying an avenue for LMU students interested in learning more about coastal ecosystems.[13]

1 https://ecatalog.calstatela.edu/content.php?catoid=54&navoid=6231
2 https://www.cpp.edu/academic-programs/about/programs.shtml
3 https://www.csuci.edu/academics/esrm.htm
4 https://atmos.ucla.edu/
5 https://www.eeb.ucla.edu/undergraduate/marine-major/
6 https://www.ioes.ucla.edu/projects/page/6/?ioestype=practicum-project
7 https://www.usc.edu/majors-minors/
8 https://dornsife.usc.edu/wrigley/
9 https://dornsife.usc.edu/reeu-usc-altasea-blue-economy-program/
10 https://www.oxy.edu/academics/areas-study/marine-biology
11 https://cse.lmu.edu/department/biology/
12 https://www.oxy.edu/academics/vantuna-research-group
13 https://cse.lmu.edu/research/coastalresearchinstitutecri/

WORKFORCE DEVELOPMENT STRATEGIES FOR THE BLUE ECONOMY

Because of the relatively recent emergence of the blue economy as an organizing principle for education and workforce development, there are few educational and training programs specifically focused on blue economy topics and occupations. However, educators, workforce development professionals, and employers can leverage existing education and training programs for occupations in the ocean economy, sustainability, or other occupations with transferable skills of value in the blue economy.

The first part of this section summarizes academic research on blue economy workforce development, as well as federal, state, and regional or local programs to prepare workers for ocean and blue economy occupations. The second part of this section maps blue economy educational assets in Los Angeles County. Finally, the third part will include a brief discussion about non-degree programs where participants earn skills to contribute to the blue economy.

Academic Research: Blue Economy Workforce Development

This section describes academic research regarding workforce development for the ocean economy / blue economy. Given the blue economy's status as a nascent sector, the academic literature specifically focusing on blue economy workforce development is limited. However, some industries and occupations directly relevant to the blue economy (e.g., aquaculture) have been examined more extensively.

A study on the proliferation of aquaculture workforce development initiatives in the 21st century was initiated by the U.S. Department of Agriculture (USDA) in 2007, with data collected from 88 universities about their programs around aquaculture in 2000 (retrospectively), 2010, and 2015 (prospectively).[1] The number of both undergraduate and graduate students studying aquaculture increased between 2000 and 2010, with the number of undergraduates more than doubling. While advanced degrees in the field were projected to continue increasing, the universities projected a decrease in the number of undergraduates in 2015.

While the research paper was not prescriptive, it did identify trends within the educational landscape: 1) online classes were a common mode of education delivery for aquaculture-related courses, 2) undergraduate research was widely considered a key element of training, 3) formal mentoring and internship programs were prioritized in the curriculum, and 4) courses in the economics of aquaculture (in addition to the scientific and engineering elements) were being offered.

1 Gary Jensen, Michael Schwarz, Sandra Shumway, Jesse Trushenski, L. Curry Woods III, Thomas Broyles and Maxwell Mayeaux. "National Assessment of Aquaculture Education at Postsecondary Institutions in the United States." *World Aquaculture,* September 2015. https://www.researchgate.net/publication/283356470_National_Assessment_of_Aquaculture_Education_at_Postsecondary_Institutions_in_the_United_States.

A more recent study from 2024 was published in the *International Journal of Fisheries and Aquatic Studies* and examined the availability of courses on the blue economy and the subindustry of marine spatial planning.[1] From the global survey of course offerings conducted using the key words "blue economy" and "marine spatial planning," North America represented only 12 percent of course offerings identified, lagging behind Europe (51 percent) and Africa (25 percent). Another takeaway was the high percentage of the programs in these geographies that were training courses, either designed for professionals or able to be taken on-demand, as opposed to a part of degree conferring programs. These programs focus on providing the blue economy context to professionals with transferable skills, a route to quickly expanding the workforce of the blue economy using the talent pool of other industries.

A smaller-scale study was performed in 2018 that surveyed the blue economy employers in the Lower Mississippi region.[2] Though the study focused on STEM careers, zeroing in on the portions of the blue economy workforce most likely to have advanced degrees, it did also highlight many roles within the blue economy where a certification or associate's degree were sufficient. The study noted that employers are most interested in candidates with practical experience (either through internships or job-shadowing), but very few employers offered programs to facilitate access to these opportunities. Those companies with internship programs acknowledged the costs associated with internships but highlighted the advantages gained from creating a pool of trained employees to hire for new roles. Most employers in the survey did facilitate access to continuing education for their employees, with 65 percent providing some sort of benefits. The study also touched on the need for cross-training in different technical skill sets for the immediate growth of the industry, with a ranked table provided. More information on programs being successfully implemented in this region will be featured later in this section.

FIGURE 13: STUDENTS IN AQUACULTURE DEGREE/ CERTIFICATE PROGRAMS

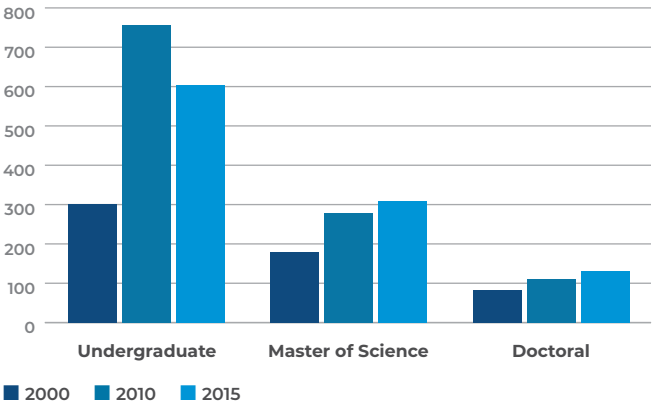


FIGURE 14: IN-DEMAND STEM SKILLS FOR THE BLUE ECONOMY

IN-DEMAND STEM SKILLS FOR THE BLUE ECONOMY
Basics of engineering (electrical, mechanical, chemical, drafting)
Computer programming
Marine science basics (oceanography, hydrography)
Network programming
Algebra or advanced mathematics
Geographic information systems (GIS)
Process technology and improvement

1 Mutia, Grace & Arori, Maurine. "Availability of educational materials and training courses on blue economy and marine spatial planning (MSP): A global review", *International Journal of Fisheries and Aquatic Studies* 2024; 12(3): 51-56. DOI:10.22271/fish.2024.v12.i3a.2934.

2 Jugan, Laurie. "Blue Economy Workforce Needs." *Marine Technology Society Journal,* Volume 52, Number 1, 15 January/February 2018, pp. 7-11(5). DOI:https://doi.org/10.4031/MTSJ.52.1.11

A major obstacle in training a workforce for the blue economy is creating opportunities to study across the multiple disciplines needed in maritime industries.[1] Siloed degree programs and those with strict accreditation guidelines, such as engineering programs, provide little flexibility to students eager to take marine-related classes outside of their main departments. To address this, administrations must promote the development of these cross-disciplinary curricula across their institutions, using interdepartmental linkages to develop new degree programs. There are also extracurricular methods to generate interest in the blue economy from students and contribute to the field through the creation of research centers that focus on the blue economy and include faculty across a range of academic specialties.

Non-degree certificate programs are an alternative approach that might better suit the needs of many blue economy employers. Micro-credentials—certificates that are smaller in scale and scope but targeted exactly to employer needs—are one way to address smaller skills gaps.[2] This micro-credential approach borrows from the field of computer programming, where credentials that demonstrate aptitude in certain domains (e.g., full-stack development) are common. Micro-credentials may also facilitate the development of a more equitable blue economy workforce, as they are accessible to a broader range of people than are more formal degree programs. It's important, however, that they be created with an emphasis on job placement to ensure they provide value. The figure below provides hypothetical examples of potential micro-credential programs.

Technical and community colleges are well-positioned to lead the field in the development of these blue economy initiatives, as they have additional adaptability due to their size and offer more courses across their institutions.[3] Furthermore, alternative course delivery mechanisms like online or hybrid learning modalities may facilitate these linkages. Beyond the learning institution, school and college administrators might create advisory boards or other programs to engage with local blue economy industries, building relationships between educational and private or governmental institutions to develop the local talent pool.

FIGURE 15: SAMPLE MICRO-CREDENTIAL PROGRAMS FOR THE BLUE ECONOMY[4]

SECTOR	JOB TITLES	POSITION REQUIREMENTS	MICRO-CREDENTIAL / COMPETENCY
Hydrographic Surveying Companies: Michels Corp, Fugro, JF Brennan, Oceaneering	Survey Technician; Hydrographic Technician; Field Hydrographer; Research Tech	Experience with multibeam and side scan sonar; experience with QPS and Hypack data processing software; GIS	Managing mapping data; sonar data acquisition; data processing; data management; project management
Infrastructure Companies: Subcom; Alpine Ocean; GL Dredge and Dock; Bollar Marine	ROV Technician; Hydrographic Surveyor; Field Engineer	ROV ops experience; engineering tech background; experience with sonar systems, experience with data processing software	System problem solving; ROV piloting; ROV maintenance hydrography; data processing

1 S. Bradley Moran. Workforce development and leadership training for the new blue economy. In Liesl Hotaling and Richard W. Spinrad (Eds.), *Preparing a Workforce for the New Blue Economy: People, Products and Policies* (Elsevier, 2021), pp. 407-416. https://www.sciencedirect.com/science/article/pii/B9780128214312000020

2 Liesl Hotaling and Hans Van Sumeren. "The Case for Microcredentials for Workforce Preparation." *Marine Technology Society Journal,* Vol. 56, No. 1, January/February 2022. DOI:https://doi.org/10.4031/MTSJ.56.1.5

3 Moran, 2021.

4 Hotaling and Van Sumeren, 2022

Federal Workforce Development Initiatives for the Blue Economy

The federal government has a key role in directing attention and funding to the development of America's blue economy workforce. NOAA has led much of the federal government's efforts around the blue economy, as it oversees managing and conserving America's coastal and marine resources, managing its fisheries, and supporting maritime commerce.[1] NOAA's *2021-2025 Blue Economy Strategic Plan*[2,3] outlines the federal government's vision for blue economy industry sectors and provides a roadmap for other organizations and government agencies with programs touching upon the blue economy. Such agencies include the Department of Transportation (DOT), National Science Foundation (NSF), Economic Development Administration (EDA), and Small Business Administration (SBA), which have each invested in research and initiatives related to the blue economy.

NOAA Programs

NATIONAL SEA GRANT COLLEGE PROGRAM

One of the longest standing workforce development initiatives around the ocean economy began in 1966 with formation of the National Sea Grant College Program. The network of 34 Sea Grant Colleges partners with NOAA to "expand knowledge and answer critical questions, train a coastal and marine workforce, and connect science to those who can use it."[4]

Sea Grant has a long history of funding workforce development initiatives. One recent example is the Climate-Ready Workforce initiative, announced in 2023 and funded with $60 million from the Inflation Reduction Act. The initiative was established to help workers in communities that are most likely to be affected by climate change to gain skills and placements in existing and emerging high-quality occupations that enhance climate resilience.[5] Long Beach City College was one of nine national award recipients; LBCC will receive $9.5 million to establish the Los Angeles County Climate Ready Employment Council,[6] which will focus on climate resilience job training in the solar and water management industries.

Two other Sea Grant programs provide funding for workforce development in both caught and farmed fish industries: the Young Fishermen's Career Development Projects and Aquaculture Workforce Development Support Projects. In 2023, $3.3 million in funding was awarded to ten projects through these competitions. One of these awards went to MiraCosta College in San Diego County to design a community college aquaculture workforce development program.[7]

Sea Grant remains a crucial source of funding for marine-focused education around the country, focused on training a workforce to promote healthy coastal ecosystems, resilient communities and economies, and sustainable fisheries and aquaculture.

1 https://www.noaa.gov/our-mission-and-vision

2 "NOAA finalizes strategy to enhance growth of American Blue Economy." *NOAA*, January 19, 2021. https://www.noaa.gov/stories/noaa-finalizes-strategy-to-enhance-growth-of-american-blue-economy.

3 *NOAA Blue Economy Strategic Plan 2021–2025,* NOAA, January 19, 2021. https://cdn.oceanservice.noaa.gov/oceanserviceprod/economy/Blue-Economy%20Strategic-Plan.pdf

4 "Our Story." *NOAA Sea Grant*. https://seagrant.noaa.gov/our-story/. Accessed February 10, 2025.

5 https://seagrant.noaa.gov/how-we-work/topics/crw/

6 https://www.dailyclimate.org/california-receives-federal-funds-to-train-climate-resilient-workforce-2668526212.html

7 https://seagrant.noaa.gov/sea-grant-projects-provide-33m-in-support-of-seafood-industry-workforce-development/

INDUSTRY-UNIVERSITY COOPERATIVE RESEARCH CENTER (IUCRC)

The NSF and NOAA have partnered to create a new Industry-University Cooperative Research Center (IUCRC) that will focus on climate change modeling and risk assessment, with special attention paid to coastal areas, targeting the needs of the financial and insurance sectors of the economy.[1] The creation of the IUCRC comes after a series of webinars which the NSF and NOAA co-hosted that focused on understanding the research and workforce capacity needs of the blue economy for both the private and public sectors.[2] IUCRCs allow university faculty and students to collaborate with industry consortia in order to provide innovative, operationalized research, with this center serving dual purposes of training a professional workforce for the blue economy and providing information to better insure businesses operating in the blue economy.

AQUACULTURE PROGRAMS

NOAA's *2021-2025 Blue Economy Strategic Plan* described its intent to establish two Regional Aquaculture Training Centers with a mix of federal, academic, and industry stakeholders to support regional aquaculture workforce development needs around the nation.[3] In August of 2020, NOAA Fisheries Department announced that an Aquaculture Opportunity Area (AOA) would be established in Southern California to expand economic opportunity in the blue economy and pioneer scientific innovations, with one of the potential sites being around 4.5 nautical miles offshore in the Santa Monica Bay.[4]

POST-SECONDARY EDUCATION PROGRAMS

NOAA's post-secondary programs include internships, fellowships, and scholarships.[5] Internship programs include the Chesapeake Bay Summer Internship, Educational Partnership Program with Minority-Serving Institutions, and the NSF Graduate Research NOAA Internship. Fellowships include the Coastal Management, Coral Reef Management, Knauss Marine Policy, and Population Dynamics and Marine Resources Economic Graduate fellowships. Additionally, NOAA offers three scholarships: the Dr. Nancy Foster Scholarship, the Ernest F. Hollings Scholarship, and the Graduate Research and Training Scholarship Program. These opportunities focus on attracting promising students to do research and explore roles in the blue economy, with many programs also emphasizing the importance of cultivating a diverse blue economy workforce through centering equity in their application criteria.

LIVING MARINE RESOURCES COOPERATIVE SCIENCE CENTER (LMRCSC)

The Living Marine Resources Cooperative Science Center (LMRCSC) is a cross-sectoral program aligned with NOAA's Fisheries department that aims to promote equitable workforce development in the marine and fisheries sciences.[6] The LMRCSC consortium was initially created in collaboration with four historically black colleges and universities (HBCUs) – University of Maryland Easter Shore, Hampton University, Savannah State University, and Delaware State University – and two other universities, University of Maryland and University of Miami. Since its inception, Oregon State University has joined as a West Coast partner. While the LMRCSC focuses on training undergraduate and graduate students, outreach and training for K-12 students is also incorporated.

1 https://www.nsf.gov/pubs/2023/nsf23106/nsf23106.jsp

2 "NSF-NOAA partner to promote the creation of centers for modeling catastrophic impacts and risk assessment of climate change." *U.S. National Science Foundation*, May 16, 2023. https://new.nsf.gov/news/nsf-noaa-partner-promote-creation-centers-modeling.

3 https://cdn.oceanservice.noaa.gov/oceanserviceprod/economy/Blue-Economy%20Strategic-Plan.pdf

4 https://www.fisheries.noaa.gov/west-coast/aquaculture/west-coast-region-southern-california-aquaculture-opportunity-area#west-coast-region-overview

5 https://www.fisheries.noaa.gov/s3//dam-migration/internships_and_scholarships.pdf

6 Chigbu, P., E.A. Babcock, D.M. Gibson, D. Hoskins-Brown, R. Jagus, J.A. Miller, M.A. Sexton, S.L. Smith, B. Stevens, D.J. Die, E. Schott, and V. Young. *Preparing a diverse future workforce in marine and fisheries science: The NOAA Living Marine Resources Cooperative Science Center.* Oceanography 36(4):88–93. 2023. https://doi.org/10.5670/ oceanog.2024.139 https://tos.org/oceanography/assets/docs/36-4-chigbu.pdf

Students supported by the LMRCSC are mandated to participate in certain professional development programs and complete coursework that aligns with the *NOAA Educational Strategic Plan 2015-2035*. The training in core competencies focus on courses in marine and fisheries science; many of these courses are taught online, which allows students across the multiple institutions affiliated with the center to access offerings. Additionally, students can attend an annual organization-wide workshop, which creates opportunities for cross-disciplinary training in other NOAA relevant science and for networking within the blue economy. Another benefit of the LMRCSC is the research mentoring and internships available to students: students are required to work at least twelve weeks in a NOAA Experimental Research and Training Opportunity in addition to the opportunities to work with LMRCSC faculty and NOAA scientists. The LMRCSC faculty and staff are trained about how to mentor students, ensuring that these connections help students grow both during their research experiences and beyond.

Between 2001 and 2022, the LMRCSC trained around 1,100 students – over 500 bachelor's students, nearly 250 master's students, almost 100 Ph.D.s, and an additional 250 non-degree students (mostly via internships). In that time, 77 percent of the 630 students (roughly 400 bachelor's, 175 master's, and 50 PhD students) who ultimately graduated from the program were a part of underserved groups, highlighting the equity focus of the LMRCSC. Keys to the success of the program over this period were its sustained funding, the evolving collaboration between NOAA and the colleges, cohort-building and networking, mentoring that is long-term and influenced by best practices, and developing center-wide operating procedures that were sensitive to the different collegiate environments and provided equal opportunity to NOAA mentors and internships.

SBA'S REGIONAL INNOVATION CLUSTER (RIC)

SBA's Regional Innovation Cluster (RIC) program focuses on creating "geographically concentrated groups of organization that will work together to support the growth of small business and their related industry." In Los Angeles County, the Larta Institute, which focuses on issues around bioscience and health, serves as a RIC.[1] In southern Mississippi, SBA has funded two different programs to nurture the growth of the blue economy: the Marine Industries Science and Technology (MIST) Cluster, hosted by the University of Southern Mississippi; and the Unmanned Coast program, an industry-led group. Both included workforce development components to support the growing blue economy.

DEPARTMENT OF TRANSPORTATION MARITIME ADMINISTRATION (MARAD)

Another major provider of maritime education is the Department of Transportation Maritime Administration (MARAD), which focuses on supporting the technical aspects of the country's maritime transportation infrastructure, such as ships and shipping and port and vessel operations.[2] In addition to being responsible for the U.S. Merchant Marine, the agency provides information for current mariners, support for future mariners, and programs to generate youth interest in maritime activities. In this last category are programs such as the Centers of Excellence for Domestic Maritime Workforce Training and Education (CoE), its K-12 maritime education programs, and its maritime academies, which have sites throughout the country, including in Los Angeles County.

1 Hotaling & Van Sumeren, "The Case for Microcredentials for Workforce Preparation."

2 https://www.maritime.dot.gov/about-us

State-Level Workforce Development Initiatives for the Blue Economy

Several states have workforce development initiatives related to the blue economy. Different states have different approaches, from state agencies funding local workforce initiatives to the creation of new state initiatives designed to foster the blue economy's workforce.

An example of state funding of local workforce initiatives can be found on the southern coast of Mississippi, where University of Southern Mississippi (USM) anchors the marine economy industrial network. To support a series of workforce training workshops from USM's Roger F. Wicker Center for Ocean Enterprise, AccelerateMS, Mississippi's statewide workforce development department, provided almost a million dollars' worth of scholarships, allowing qualified individuals to participate for free.[1] The program, the Maritime Autonomy Operational Seminar, was designed to train federal workers on "state-of-the-art, commercial, off-the-shelf autonomous technologies." The program was designed to be inclusive of transitioning military personnel, providing them an opportunity to upskill and enter the uncrewed systems industry.[2]

Funding can also come through the legislature, as shown in the case of the $8 million that University of Massachusetts, Dartmouth received after working with Massachusetts State Senator Michael Rodrigues and local legislators.[3] While a portion of the funding will focus on funding innovation in the blue economy through the purchase of new equipment, a significant focus of the funding is to create important research opportunities to support student curricular activities and development of career-relevant skills through access to these technologies. Investments include the expansion of the Biodegradability Lab, purchase of trawl monitoring equipment, founding of the Blue SWELL lab, and establishment of the University Pier Instrumentation Site, among others.

In 2019, Washington's Governor Jay Inslee launched the Washington Maritime Blue 2050 initiative to encourage more innovation and workforce development within the state's sustainable maritime industry.[4] The program was the first of its kind in the

1 https://siteselection.com/cc/mississippi/2023/capitalizing-on-coastlines.cfm#:~:text=F%20rom%20fishing%20to%20shipbuilding,Aero%2C%20in%20a%20company%20video.

2 https://www.usm.edu/news/2022/release/maritime-autonomy-seminar.php

3 https://www.umassd.edu/news/2024/deploy-state-funding--support-blue-economy-initiatives.html

4 https://medium.com/wagovernor/leading-in-the-maritime-sector-washington-launches-maritime-blue-2050-initiative-d54f7d5730cc

United States and leveraged the EDA's i6 Challenge Grant, Build to Scale Industry Challenge Grant, and Regional Innovation Strategies (RIS) program to establish itself as a nonprofit.[1] Maritime Blue has several innovation accelerators, many public-private joint innovation projects, and a Youth Maritime Collaborative (YMC) to support workforce development. The YMC centers an equity lens in its promotion

of maritime industry careers through paid internships, experiential learning opportunities, and career counseling.[2] The YMC focuses on high school age students, supporting interest in maritime careers through summer internships and interactions with companies and professionals working in the blue economy. The Maritime Blue 2050 initiative served as a model for the creation of a blue economy industry cluster, and its focus on cultivating an interest in the blue economy among Washington youth is an important approach to attracting students into programs focused on the blue economy.

In California, the Ocean Protection Council (OPC), created pursuant to the California Ocean Protection Act (COPA) of 2015, is "...charged with safeguarding coastal and ocean ecosystems for the benefit of all Californians..."[3] One of the Council's four strategic goals is "Support ocean health through a sustainable blue economy." Currently, the OPC focuses on the aquaculture and offshore wind industries within the blue economy, with programming focused mostly on driving innovation, providing access to marine data, and streamlining the regulatory landscape. Addressing this last point will be particularly important for the aquaculture industry: In its "Guiding Principles for Sustainable Marine Aquaculture in California", for example, the OPC listed ten California state governmental stakeholders that have some involvement in aquaculture (see figure at right).

FIGURE 16: STATE AGENCY STAKEHOLDERS IN CALIFORNIA'S AQUACULTURE ECONOMY

STATE AGENCY STAKEHOLDERS IN CALIFORNIA'S AQUACULTURE ECONOMY
California Coastal Commission
California Department of Fish and Wildlife
California Department of Food and Agriculture
California Department of Public Health
California Natural Resources Agency
California Ocean Protection Council
California State Coastal Conservancy
California State Lands Commission
California Fish and Game Commission
State Water Resources Control Board

1 https://www.eda.gov/funding/programs/build-to-scale/past-grantees/2023-venture-challenge/Washington-Maritime-Blue

2 https://youthmaritimecollaborative.org/

3 "About Us." *California Ocean Protection Council.* https://opc.ca.gov/about The council consists of the Secretary of the Natural Resources Agency, the Secretary for Environmental Protection, the Chair of the State Lands Commission, and two members of the public appointed by the Governor.

Regional Workforce Development Initiatives for the Blue Economy

Regional consortia of academic institutions, industry partners, and governments are one of the most effective ways to support the growth of the blue economy. This section will examine a sample of workforce development initiatives happening at the local level in five different states that are at the forefront of developing the blue economy in the United States.

Delaware

SECTORS:
Autonomous systems, aquaculture, and offshore wind

PRACTICES:
Inter-academic partnerships, industry partnerships, government partnerships, paid internship and research opportunities, micro-credential programming, upskilling, and youth outreach

Delaware is pursuing ambitious plans for its blue economy: in 2023, University of Delaware was awarded a $1.3 million grant from NOAA to help advance the state's blue economy through an initiative called "Project Align, Build, Leverage, and Expand (Project ABLE)."[1] Project ABLE, a collaboration between Delaware State University and the University of Delaware (UD) Center for Autonomous and Robotic Systems, aims to make Delaware a national leader in the application and development of autonomous systems, artificial intelligence, and workforce development for the blue economy. The program focuses on training students to use autonomous and robotic systems, fields in which the University of Delaware is innovating. In the summer of 2024, Project ABLE conducted its 2024 Autonomous Systems Bootcamp, a training and education program bringing together marine and ocean science experts with roboticists across academic, government, and industry to discuss opportunities and challenges in the field.[2] Partnerships with companies active in the local blue economy have been key to Project ABLE's success, as commercial companies work with academic researchers, communities, and government agencies to develop a talent pipeline and expand the use of autonomous systems.

1 https://www.udel.edu/udaily/2023/january/project-able-delaware-blue-technology-water-exploration/
2 https://sites.udel.edu/ceoe-able/able-summer-bootcamp/

Project ABLE is housed with the UD College of Earth, Ocean, and Environment and has been supplemented by other blue economy initiatives at the school, such as the UD Blue Tech Initiatives within UD's Center for Autonomous and Robotic Systems. In addition to the Project ABLE funding, the initiative was able to receive two awards from the NSF, an Industry-University Cooperative Research Center (IUCRC) planning grant and an NSF Engineering Research Center planning grant (alongside University of Pennsylvania, University of Rhode Island, University of South Carolina, and Delaware State University) that facilitated the establishment of the Center for Robotic Oceanic and Coastal Systems (CROCS). CROCS focuses on driving innovation in the blue economy through supporting faculty research, which can provide students with learning opportunities and valuable experience.

Beyond autonomous systems innovations, Delaware is seeking to train workers for the aquaculture and offshore wind industries.[1] Delaware's Sea Grant College Program is a leading workforce development organization for the blue economy in the state and is also home to several exciting oyster industry aquaculture initiatives. The Sea Grant, which is hosted at University of Delaware, has created resources around sustainable aquaculture, including aquaculture workshops for farmers, a directory of sustainable seafood suppliers, partnerships with local shellfish farmers and suppliers, a summary of shellfish aquaculture regulations, and an interactive map of shellfish aquaculture sites.

Outside of shellfish aquaculture, Sea Grant has workforce development projects throughout the blue economy at all learning levels.[2] Its Coastal Resilience Design Studio, in partnership with the UD Sustainable Coastal Communities Initiative and Landscape Architecture Program, provides undergraduate and graduate students opportunities to respond to problems in their communities with design-based innovations, created in concert with faculty oversight, community input, and professional consultation.[3] Additionally, the Sea Grant's Green Infrastructure Partnership with Delaware Technical and Community College creates a paid internship opportunity for students interested in learning about professional design and construction skills for coastal green infrastructure projects.[4] The class was taught in a hybrid mode, beginning with a virtual classroom and progressing to site visits later in the semester to learn about projects in their community.[5] Sea Grant also has programs focused on K-12 students, with participation in the Wilmington Green Jobs program and Lewes Field Workshops, and educator development, as well as being a hub for resources related to the blue economy in the state.

Partnerships across academic institutions are also being explored as a means of developing a workforce for the growing offshore wind industry. Delaware Technical Community College (DTCC), partnering with UD, launched a Department of Labor-funded program in January 2024 to run short-term workshops to support job opportunities in the offshore wind industry.[6] DTCC worked closely with Maersk Training to develop a training site and curriculum for students, creating a five day program for individuals seeking their Global Wind Organization Basic Safety Training certification, an example of a micro-credential program that can improve job prospects and facilitate career growth for participants.

1 https://www.choosedelaware.com/blog/explore-delawares-coastal-economy-and-maritime-opportunities/#:~:text=For%20example%2C%20University%20of%20Delaware's,assembly%20of%20offshore%20wind%20turbines

2 https://www.deseagrant.org/workforce-development

3 https://www.deseagrant.org/crds

4 https://www.deseagrant.org/workforce-development

5 https://www.udel.edu/udaily/2022/june/delaware-environment-green-infrastructure/

6 https://www.dtcc.edu/news/delaware-tech-partners-with-ud-to-provide-offshore-wind-training/

Massachusetts

SECTORS:
Aquaculture, living resources, offshore wind, and tourism and hospitality

PRACTICES:
Blue economy degree program, equity focus, paid apprenticeship and internship opportunities, industry partnerships, government partnerships, convenings and networking opportunities

While blue economy workforce development efforts in Delaware are mostly managed by the University of Delaware system, initiatives in Massachusetts are distributed among a selection of community, public, and private institutions.

Cape Cod Community College offers an A.S. in Blue Economy, an interdisciplinary two-year degree program, and one of the few of its kind in the United States.[1] The program is meant to provide students with a holistic understanding of economic and environment theories as they pertain to sustainable practices for water and coastal resource activities, emphasizing experiential learning opportunities and engaging with industry professionals. The degree allows for individual specialization, with concentrations in sustainability, entrepreneurship/business, technology, and media/communication.[2] The blue economy is woven into the coursework of other degrees as well, requiring those pursuing an A.S. in Business Administration with a hospitality and tourism management concentration to take a speaker series course featuring talks from leaders in the tourism and hospitality sector of the state's blue economy.

Within the University of Massachusetts (UMass) system, blue economy initiatives extend beyond UMass Dartmouth, with UMass Amherst's School of Earth and Sustainability and its Gloucester Marine Station working closely with the Essex County Community Foundation to launch the North Shore Blue Economy (NSBE) initiative.[3] The NSBE initiative focuses on growing the blue economy on the state's North Shore. In 2021, the NSBE initiative published a Phase I report that evaluated the state of the blue economy in Massachusetts and drafted a vision for the path forward.[4] The report shared the initiative's intent to promote an evolving living resources sector, develop a marine science and technology cluster, take advantage of offshore wind opportunities, and increase investment in coastal resilience science, planning, and preparation.

To leverage these opportunities, the NSBE initiative called for the development of workforce training and education programs designed to drive blue economy job creation as a key part of their Phase II work. One such program in the region is the MassHire North Shore Workforce Board's Clean Energy and Offshore Wind Program and Training Initiative, which will work with partners and serve residents from areas identified as environmental justice population neighborhoods throughout the North Shore.[5] The program is designed to meet the hiring needs of the Salem Wind Port, with the goal of developing direct pathways to these jobs through the Clean Energy and Offshore Wind building trades pre-apprenticeship program. This equity-focused apprenticeship program is an excellent model for employer-driven, government-coordinated workforce development in the blue economy.

1 This degree is also referred to as the A.S. in Applied Economics of Coastal and Ocean Environments https://www.capecod.edu/blueeconomy/

2 https://live-capecod.cleancatalog.io/science/associate-in-science/applied-economics-of-coastal-and-ocean-environments-blue-economy

3 https://www.umass.edu/gloucester-marine-station/focus-areas/blue-economy

4 https://www.umass.edu/identity/northshore/NSBE-ExecSummary_ADA2.pdf

5 https://masshire-nscareers.org/programs/clean-energy-offshore-wind/

Community organizations are also increasing attention on the blue economy, with the Plymouth Foundation hosting a Blue Future Conference in 2022, 2023, and 2024.[1] These conferences gave high school and undergraduate students an opportunity to learn about and engage with issues around the region's blue economy. They also brought together local businesses in the blue economy with local and state officials to increase awareness of efforts and provide networking opportunities. Blue Future 2024 featured initiatives in the fields of aquaculture, robotics, artificial intelligence, and marine technology R&D. The keynote speakers for the 2024 conference included Massachusetts' Secretary of Economic Development and Undersecretary for the Executive Office of Labor and Workforce Development, highlighting the emphasis on creating a skilled, inspired workforce for the new blue economy.

The NOAA Sea Grant programs are also directing funding to nascent workforce development efforts around aquaculture and fisheries in the region, with two projects being awarded funding from NOAA's Young Fishermen's Career Development Project and Aquaculture Workforce Development Support Project.[2] The first project focuses on providing vocational training, with a curriculum informed by the fishing industry professionals, to young fishermen entering the industry to facilitate their ascendance into skilled deckhands and eventually ship captains. These programs currently exist across New England, but the funding will be used to align and expand the programs to facilitate access to training throughout the region. The other program, which focuses on aquaculture workforce development, is administered through the Sea Grant Colleges in Massachusetts, the Massachusetts Institute of Technology (MIT) and Woods Hole Oceanographic Institution (WHOI), alongside the Barnstable County Cooperative Extension. This program will recruit a cohort of interns from a range of local communities, train interns using a hybrid learning model, and use site visits to explore aquaculture business operations. Following the students' completion of curriculum, participating businesses can hire the interns, creating paid internship opportunities for students in the aquaculture industry.[3]

Massachusetts is also home to one of the six maritime academies funded by the U.S. Department of Transportation Maritime Administration (MARAD), Massachusetts Maritime Academy (MMA).[4] The MMA and other MARAD academies educate youth for service as officers in the U.S. Merchant Marine, U.S. Armed Forces, and the U.S. intermodal transportation system; thus a four-year degree also involves the training to become a commissioned officer and a merchant marine. The MMA offers a range of disciplines through which students can study marine issues, including international maritime business; marine engineering; marine transportation; and marine science, safety, and environmental protection.[5] Students in these undergraduate majors are well-prepared to earn professional licenses after completing their programs. The school also offers an online M.S. in Maritime Business Management that prepares students for leadership roles in the maritime and goods movement industries; the program is similar to Blue MBAs, degrees that combine business administration with a focus on blue economy issues.[6]

1 https://www.plymouth-ma.biz/conference-2024/about-blue-future-24/
2 https://seagrant.noaa.gov/sea-grant-projects-provide-33m-in-support-of-seafood-industry-workforce-development/
3 https://seagrant.whoi.edu/mass-aquaculture-internships/
4 https://www.maritime.dot.gov/maritime-workforce/maritime-education
5 https://www.maritime.edu/undergraduate-programs
6 https://www.maritime.edu/graduate-programs/maritime-business-management

Mississippi

SECTORS:
Uncrewed maritime systems, marine technology research and development, oceanography, hydrography

PRACTICES:
Student research opportunities, industry-informed workforce development, micro-credential program, educational pathways, opportunities for high schoolers

FIGURE 17: USM MARINE RESEARCH FACILITIES

USM MARINE RESEARCH FACILITIES
Center for Fisheries Research and Development
Gulf Coast Research Laboratory
Gulf Blue
Marine Education Center
Marine Research Center
Roger F Wicker Center for Ocean Enterprise
Stennis Space Center, Hydrographic Center
USM Gulf Park Campus
Thad Cochran Marine Aquaculture Center

The University of Southern Mississippi (USM) has several research institutes dedicated to issues around the blue economy, providing opportunities for students to get involved with faculty and center research.[1] At the USM Gulf Park Campus, students have access to the state's only degree in ocean engineering, as well as degrees in marine biology, marine science, marine science hydrography, and sustainability sciences (coastal system dynamics).[2,3] The School of Ocean Science and Engineering (SOSE), which hosts these undergraduate degree programs, also offers a summer field research program; graduate degrees in coastal sciences (M.S. and PhD), hydrographic science (M.S.), and marine science (M.S. and PhD); and a certificate in uncrewed maritime systems.[4] SOSE supports undergraduate and graduate research opportunities and internships, improving the job prospects of students by providing an education tailored to the blue economy and experiential learning opportunities.

USM is successful in large part because it is integrated with both blue economy industry and community needs, soliciting input from these parties and co-designing programs to serve them. A key example is in the development of the uncrewed maritime systems (UMS) certificate program, a two-tiered micro-credential program that provides an guide for upskilling workers interested in the blue economy.[5] The first tier of the program is a five-week intensive course designed to teach the foundations of oceanography and ocean engineering as it pertains to uncrewed and non-vehicular systems and imbue students with hands-on experience using the relevant technologies, while the second tier (UMS operator certificate) uses an additional five week curriculum to provide students with the knowledge necessary to conduct missions with UMS through classroom teaching and experiential learning. The program was designed in 2017 to extend the school's collaboration with the U.S. Navy; its initial cohort was made up exclusively of civilian and military personnel from federal agencies, but it has since expanded to other populations.[6]

1 https://www.usm.edu/news/2023/release/coastalusm-blue-economy.php
2 https://www.usm.edu/university/gulf-park-campus.php
3 https://www.usm.edu/undergraduate-programs/?availability=Gulf%20Park
4 https://www.usm.edu/ocean-science-engineering/#our-programs-list
5 https://www.usm.edu/ocean-science-engineering/uncrewed-maritime-systems-ums-certification.php
6 https://www.navy.mil/Press-Office/News-Stories/Article/2253739/navy-unmanned-certification-begins/

USM's leadership in blue economy education has helped create an ecosystem around workforce development of blue economy workers in the region. In 2021, nearby Pearl River Community College (PRCC) began partnering with a local non-profit, the National Oceans and Applications Research Center (NOARC), to offer an autonomous coastal mapping course as a part of its unmanned aerial systems program.[1] In 2023, PRCC became the nation's first community college to offer an A.A.T. of Applied Technology in Hydrography; the program was developed with industry partners (including NVision Solutions, the organizing partner for the SBA Unmanned Coast RIC) and feeds directly into the USM marine science hydrography bachelor's and master's degree programs.[2] This type of curricular development, which centers industry needs and provides a pathway to additional educational attainment, is precisely the approach that community colleges are best positioned to navigate and represents best practices for workforce development.

The pathway to hydrography can begin as early as high school at nearby Hancock High School.[3] In 2024, hydrography was added to the Hancock High Career Technical Center, with curriculum development assistance from NVision Solutions. The program informs students about high-quality jobs that require high school and associate's degrees, with site visits and classroom learning leveraged to motivate students to pursue careers in the blue economy. This partnership serves as a model for early interventions in workforce development, giving high school students an understanding of the complex blue economy sector and the needs of businesses operating within it.

The educational environment in southern Mississippi has even spilled over into western Louisiana. Nearby Northshore Community College (NTCC) now offers a maritime technology program with a certificate of technical studies in general marine transportation technology, a technical diploma in maritime technology, and an A.A.S. in applied science in maritime technology.[4] The program, which focuses on recruiting high school graduates and transitioning military personnel, consists primarily of evening courses, making it more accessible to working students. A shift to asynchronous online classes is being considered to allow those currently working aboard marine vessels to participate in the program.

The academic institutions in southern Mississippi are able to successfully develop these programs and attract students in part due to the high concentration of federal agencies in the region. This, in turn, entices private industry to the region, as there is an able workforce and willing partners. Ocean Aero, a company that relocated from San Diego, CA to Gulfport, MS in 2021, cited industrial agglomeration, its partnership with USM, the defense industry ecosystem, and congressional support for the blue economy in the region as the four keys drivers of their relocation.[5]

1 https://prcc.edu/pearl-river-adds-unique-autonomous-coastal-mapping-course/

2 https://prcc.edu/prcc-students-have-two-new-opportunities-to-join-high-paying-and-high-demand-careers-in-cybersecurity-and-hydrography-programs/

3 https://www.wlox.com/2024/09/04/hancock-high-ctc-introduces-students-career-opportunities-hydrography/

4 https://www.waterwaysjournal.net/2023/08/25/northshore-community-college-offers-maritime-technology-program/

5 https://siteselection.com/cc/mississippi/2023/digital.html#page=58

One of the institutions that fuel this collaboration is the Mississippi Enterprise for Technology (MSET) at NASA's Stennis Space Center. MSET operates as a public-private partnership between the Mississippi Development Authority, NASA, and USM and other institutions to leverage federal assets and state/regional resources to promote economic development, with a particular focus on the blue economy.[1] The blue economy ecosystem, which also includes Mississippi State University, NOAA, Teledyne Marine, The Northern Gulf Institute, NOARC, Gulf Blue, various blue economy business accelerators, and multiple economic development agencies, is shown in the asset map created by the Hancock County Port and Harbor Commission (Figure 18).

Through the pioneering curriculum development of USM, willing partnership of federal agencies, mobilization of state and local economic development resources, and communication among academic institutions and between academia and industry, Mississippi has been able to grow one of the most dynamic innovation ecosystem for marine research and development in the U.S. Talent development begins at the high school level (providing students with an understanding of the local industry and potential occupations) and continues up to doctoral-level study, where researchers contribute key innovations that will shape what is possible and create additional blue economy opportunities.

FIGURE 18: SOUTHERN MISSISSIPPI BLUE ECONOMY ASSET MAPPING

1 https://mset.org/

North Carolina

SECTORS:
Aquaculture, marine technology, marine research and development, ship building

PRACTICES:
Robust educational ecosystem, experiential learning, internship and fellowship opportunities, cross-disciplinary academic institutions, K-12 and youth initiatives

In contrast to Mississippi, where the blue economy cluster is led principally by the USM and focuses on marine research and development, North Carolina has many academic institutions supporting the growth of the blue economy in the region, with more areas of specializations. Community colleges, private universities, and public university systems all contribute to a community of scholars and students focused on the blue economy; key actors in the space include Carteret Community College, Cape Fear Community College, Duke University, North Carolina State University (NC State), and the University of North Carolina Wilmington. With multiple educational institutions, a more diverse range of specialization is possible, with different schools focusing on boat building, aquaculture, marine technology, ocean policy, marine research and development, and marine science. These educational institutions frequently partner with each other on blue economy initiatives, a cooperative endeavor that has massive benefits for the growth of the blue economy workforce in the region.

Carteret Community College (CCC) is a coastal school that sits roughly halfway down North Carolina's coast on the Atlantic Intercoastal Waterway's Bogue Sound. At CCC, students have access to the North Carolina Marine Training and Education Center (NC MARTEC), the only comprehensive marine technology training facility in the Mid-Atlantic.[1] NC MARTEC is a 23,000 square foot facility where students are provided with classroom learning and hands-on workshops to prepare them for careers in marine manufacturing and service industries. The program in marine trades includes coursework in boat building, boat mechanics (such as engine maintenance), and captain licensing.[2] CCC offers 13- to 18-unit certificates in boat manufacturing and service, with specialties in boat building, composite boat, and marine service, as well as yearlong diplomas in composite boat and marine service. Additional educational pathways include a 15-unit, one semester marine propulsion systems certification and a 15-unit certificate in marine diesel as a part of the diesel and heavy equipment program, in which students can receive a two-year A.A.S. degree.

NC MARTEC is also home to the Commercial Fishing Academy, which focuses on training commercial fishermen in safety, legal frameworks, and sustainability through a 48-hour classroom course and 100-hour apprenticeship program. CCC also has an aquaculture program,[3] and offers three certificates (aquaculture online certificate, aquaculture technology, aquaponics), a yearlong diploma in aquaculture technology, and two-year A.A.S. degrees in aquaculture technology, with separate tracks for those continuing their education and those entering the workforce.

Cape Fear Community College (CFCC), located in Wilmington, has three main degree and certificate options relating to the blue economy: Boat Manufacturing and Service, Wooden Boat Building, and Marine Technology. CFCC offers certificates (12 units) and one-year diplomas in the first two, and a CTE pathway and a two-year A.A.S. degree for the last one. The Marine Technology program emphasizes a blend of academic and practical learning through an inter-disciplinary curriculum and a series of five training cruises, with graduates gaining proficiency in using seismic and hydrographic instruments, and specializing in areas such as fisheries science, hydrography, marine GIS, and network programming.

1 https://carteret.edu/workforce-continuing-education/non-degree-programs/marine-trades/
2 https://catalog.carteret.edu/degrees
3 https://catalog.carteret.edu/aquaculture-technology

These community colleges are a crucial component in the workforce development pathway of the blue economy in the region. NC State's Center for Marine Sciences and Technology (CMAST) is located directly on the CCC campus.[1] The CMAST facility hosts the NOAA NC Sea Grant faculty; in addition, 45 marine science faculty from twelve different departments are affiliated with the center. CMAST is home to more than a dozen marine science initiatives. Some are focused primarily on research while others are focused on workforce development, but all programs support workforce development by providing opportunities for undergraduate and graduate students to gain hands-on experience.[2]

The North Carolina Sea Grant program is an active participant in the regional blue economy, both as a provider of industry information and as a workforce development organization. NC Sea Grant published the North Carolina Blue Economy Information Series, describing research and extension activities around the blue economy in the state.[3] Sea Grant in the state has been instrumental to the proliferation of aquaculture, using a NOAA funding opportunity to expand knowledge of and implement trainings around aquaculture for high school students.[4] The workforce development initiatives of Sea Grant provide producer resources to fishers and create marine agriculture learning materials in the state.[5] Sea Grant also offers student fellowships, internships, and research opportunities.

CMAST also hosts undergraduate-focused programs, such as the Dr. Patricia McClellan-Green Summer Fellows, Bob Simpson Scholars Program, and Semester at CMAST, which help less experienced students participate in research on blue economy issues. The McClellan-Green Summer Fellows Program is open to all North Carolina college students, while the Bob Simpson Scholars Program has an equity focus and is open to all who identify as belonging to a group typically underrepresented in marine science. Students in the programs work with faculty advisors to design a summer research project on current issues in marine/coastal science, implement and analyze the findings of their research project, and come to a better understanding of the challenges and rewards around environmental research.[6] The Semester at CMAST program, beginning Spring 2025, will allow 15 undergraduates to take a full semester of marine and coastal science coursework and assist a professor or graduate student with their research.[7]

The Seafood Laboratory, an example of a more external facing organization, provides extension education and training programs in hazard analysis critical control points, good manufacturing practices, and sanitation standard procedures to help fishers, processors, and others in the seafood value chain to support business growth.[8] Targeting a younger audience, CMAST's Educational Outreach program provides experiences for students and teachers through workshops at CMAST or on schools' campuses.[9] These efforts are informed by collaborating with educational partners, school systems, and community organizations through grants and professional development agreements to provide local schools with professional development opportunities and classroom support. The program also supports teachers educating students in blue economy subjects by loaning out scientific equipment, sharing educational materials, and designing programs and activities for the classroom and beyond. While CMAST does not have a strict blue economy focus, much of the work there does focus on industries in the blue economy, such as fisheries and marine conservation.

1 https://cmast.ncsu.edu/about/
2 https://cmast.ncsu.edu/programs-at-cmast/
3 https://ncseagrant.ncsu.edu/solutions-for-coastal-nc/strengthening-the-blue-economy/
4 https://ncseagrant.ncsu.edu/nc-sea-grant-to-enhance-aquaculture-career-pipeline/
5 https://ncseagrant.ncsu.edu/lessons-in-mariculture/
6 https://cmast.ncsu.edu/programs-at-cmast/summer-fellows-program/
7 https://cmast.ncsu.edu/2024/01/welcome-to-the-spring-2024-semester-at-cmast-cohort/
8 https://seafoodscience.ces.ncsu.edu/training/
9 https://cmast.ncsu.edu/programs-at-cmast/education-outreach/

NC State also hosts the Blue Economy Innovation Program (BEIP),[1] part of the Coastal Resilience and Sustainability Initiative at the Office of University Interdisciplinary Programs. This program encourages collaboration across traditionally siloed departments. BEIP has two main initiatives: the Blue Economy Annual Workshop and the "Interdisciplinary Innovation in the Blue Economy" course. The Annual Workshop brings together the BEIP with CCC and CMAST to discuss pressing issues in the blue economy (e.g., building a climate-ready coastal workforce). Meanwhile, the course, which is offered to all undergraduate and graduate students, expands upon the annual workshop, with students working in groups to apply interdisciplinary entrepreneurial frameworks to solve challenges in the blue economy.

At NC State, students interested in blue economy issues can pursue a B.S. in marine science, specializing in biological oceanography, chemistry, geology, meteorology, or physics, or a B.S. in Natural Resources with a concentration in Marine and Coastal Resources.[2] A marine science minor is also available. An M.S. and PhD degrees are also offered in Atmospheric Science, Earth Science, and Marine Science, with a Physical Oceanography specialization available.[3] NC State does not offer blue economy or marine/coastal science-focused certificates or online/distance education programs, other than watershed assessment and restoration. This is one area where micro-credential programs or alternative learning modalities could fill a gap in blue economy program offerings.[4]

The school most typically associated with blue economy coursework is University of North Carolina Wilmington (UNCW). A list of blue economy-related studies available at the university is featured in Figure 19. In addition, UNCW also offers educational programs focused on writing for advocacy around coastal issues, coastal and ocean policy, and coastal engineering. UNCW is also home to the UNCW Center for Marine Science and the Alliance for the Blue Economy (All Blue).

FIGURE 19: UNCW BLUE ECONOMY PROGRAMS

UNCW BLUE ECONOMY PROGRAMS
Applied Coastal and Ocean Sciences (PhD)
Coastal and Environmental Writing (minor)
Coastal and Ocean Policy (M.S.)
Coastal Engineering (B.S.)
Integrative, Comparative, and Marine Biology (PhD)
Marine Biology (minor, B.S., M.S.)
Marine Science (M.S.)
Oceanography (minor, B.S.)
Sustainability (minor)

1 https://entrepreneurship.ncsu.edu/news/2024/06/10/nc-states-blue-economy-innovation-program/
2 https://catalog.ncsu.edu/undergraduate/sciences/marine-earth-atmospheric-sciences/
3 https://catalog.ncsu.edu/graduate/sciences/marine-earth-atmospheric-sciences/
4 https://online-distance.ncsu.edu/browse-programs/?show=all

The UNCW Center for Marine Science allows faculty from across UNCW to work on coastal and marine issues, with faculty from accounting and business law, health and applied human sciences, and public and international affairs departments represented alongside those in the hard sciences.[1] UNCW also hosts events for the community, such as the Planet Ocean Seminar, CMS Open House, and the Global Marine Science Summit, as well as MarineQuest, an initiative to provide academic opportunities for exploration of the marine sciences by K-12 students through classroom, field, and lab learning, and experiences like summer camps and other academic year programming.[2]

The All Blue is an interdisciplinary initiative from the UNCW Center for Innovation and Entrepreneurship that is completely focused on promoting Wilmington as a hub for the blue economy. It aims to support entrepreneurs and innovators, attract investment capital, and champion diversity, equity, inclusion, and sustainability.[3] All Blue provides information about the blue economy in the region through its asset mapping, blue economy index, and blue economy report. The Shellfish Mariculture (marine aquaculture) Propel program hosted by All Blue uses best practices in developing the aquaculture workforce: the program is an online asynchronous course aimed at new entrepreneurs in shellfish mariculture that features a business accelerator curriculum and business guidance.[4]

Other universities are also involved in blue economy efforts in the state, such as Eastern Carolina University's Coastal Studies Institute and Duke University's Oceans@Duke project. The Coastal Studies Institute provides K-12, undergraduate, and graduate activities to get students excited about coastal issues.[5] It also provides internships for high school and undergraduate students interested in coastal sciences, an excellent opportunity to gain practical experience, as well as public, family, and teacher-oriented programming.[6] Oceans@Duke is a community of practice around blue economy issues, with faculty from the school of the environment, business school, law school, public policy school, and Duke's Institute for Energy, Environment, and Sustainability coming together to "train the next generation of ocean sustainability leaders."[7]

Beyond secondary education, such as industry cluster networks such as NC East Alliance and entrepreneur support organizations such as Marine Biotechnology NC provide some support for businesses and entrepreneurs; however, the workforce development in North Carolina is principally led by colleges and universities. As a result, the city has two major blue economy hubs, one in Carteret County by CCC and CMAST and another in Wilmington's New Hanover County with CFCC, UNCW, and the Coastal Studies Institute. These hubs have spun off a number of innovative startups in the blue economy space and continue to benefit from the talent pool being created through the community college and university systems.

1 https://uncw.edu/research/centers/marine-science/education
2 https://uncw.edu/research/centers/marine-science/outreach-events/
3 https://uncw.edu/research/centers/innovation-entrepreneurship/events-programs/programs/all-blue
4 https://uncw.edu/research/centers/innovation-entrepreneurship/events-programs/programs/propel
5 https://www.coastalstudiesinstitute.org/
6 https://www.coastalstudiesinstitute.org/internships/
7 https://nicholasinstitute.duke.edu/project/oceans-at-duke

Washington

SECTORS:
Marine welding, boat building, marine engine/ electrical systems, aquaculture, oceanography

PRACTICES:
K-12 and youth programming, education ecosystem diversification, equity lens, internship/fellowship/ apprenticeship opportunities, licensure, online education, micro-credentialing, educational pathways

While the academic institutions lead in North Carolina, Washington's state leadership and business environment have been instrumental in making Washington home to one of the most successful blue economy hubs in the nation. As described in the state-level initiatives section previously, Washington Governor Jay Inslee began drawing attention to growing the state's blue economy in 2017 with the foundation of Washington Maritime Blue, which has come to anchor the innovation ecosystem for the blue economy around Seattle and Tacoma. Given the large number of programs with an ocean/blue economy focus, they are presented here by education level.

YOUTH / K-12 PROGRAMS

The organization's Youth Maritime Collaborative (YMC) focuses an equity lens in its promotion of maritime industry careers through paid internships, experiential learning opportunities, and career counseling for high school students. There are also programs for high school-aged students, such as the Ballard High School Maritime Academy (BMA), where students can explore a maritime career in the context of their overall education.[1] The BMA is for students who are looking enter the trades or 4-year universities after high school, with a curriculum grounded in the hard sciences while also exploring maritime surveying, maritime history, and oceanography.[2] Internships are also encouraged in the BMA, with students typically working between their junior and senior years, and scholarships are available for those seeking to complete coursework at University of Washington while in high school. There are also organizations like the Youth Maritime Training Association, which seeks to inspire and facilitate careers in the blue economy through career fairs, educator resources, scholarships.[3]

COMMUNITY COLLEGE PROGRAMS

At Everett Community College, just north of Seattle, the Ocean Research College Academy (ORCA) provides a marine sciences curriculum for high school students.[4] At ORCA, student cohorts have access to college faculty and can earn free college credit through a mix of classroom learning and laboratory research, while completing their high school graduation requirements. Over the course of two years, students have ample opportunity to work with faculty on research projects, better preparing them to continue their education or enter the blue economy workforce.

There is a robust ecosystem of community colleges in the state that trains much of the blue economy workforce in trades from aquaculture to welding. One innovative approach is South Seattle College's Harbor Island Training Center (HITC), which was created through a partnership with Vigor Industrial Shipyards to quickly prepare students for immediate employment in vessel fabrication.[5] The HITC maritime shipyard welding certificate is a six month "classroom-in-a-shipyard," with classes taught by industry professionals that focus on skills to increase employability.[6] The wider South Seattle Campus also offers A.A.S. degrees and a certificate in welding fabrication, but the blue economy focus, abbreviated time scale, and workforce development emphasis are what make the HITC program truly unique.[7]

1 https://ballardmaritimeacademy.wordpress.com/about-ballard-maritime-academy/
2 https://ballardmaritimeacademy.wordpress.com/about/curriculum/
3 https://ymta.net/about-us/
4 https://www.everettcc.edu/programs/stem-health-prof/orca
5 https://vigor.net/workforce-development
6 https://southseattle.edu/programs/maritime-shipyard-welding
7 https://southseattle.edu/programs/welding

Across town at Seattle Central College, students have access to the Seattle Maritime Academy (SMA), a center for undergraduate and continuing education for marine and coastal issues. SMA offers two Coast Guard-approved certificate programs in marine engineering technology and marine deck technology, with the 33-unit curriculum spread over the course of a year and followed by an at-sea internship.[1] The marine engineering technology program aligns with the Qualified Member of the Engine Department (QMED) certificate, and the marine deck technology certificate satisfies the Able Seamen (AB) Special certificate. Tying program completion to an industry-relevant certification increases graduate employability. SMA also has continuing education programs for recreational boaters, as well as professional development training, to help mariners upskill with new technologies or complete license renewal requirements. In addition to the SMA, Seattle Central College offers an A.A.S. degree in boat building and repair, with a curriculum that focuses on wooden and modern boats, preparing students to work in Washington's shipyards.[2]

Skagit Valley College (SVC), a community college in Mount Vernon, offers a marine maintenance technology program that focuses on marine mechanics and marine electrical systems.[3] Students can choose to earn a one-year certificate in either area or complete both years to receive an A.A.S. degree. Throughout the program, students can earn credentials with the American Boat & Yacht Council, National Marine Electronics Association, OSHA, EPA, and a forklift certification. Both programs focus on developing problem-solving capacity through hands-on experiences learning how to install, repair, and maintain boat engines and electrical systems, enabling students to work as motorboat mechanics or service technicians.

At Bellingham Technical College (BTC), which sits in the northwest corner of Washington, a robust fisheries and Aquaculture Sciences program has been developed alongside the Washington Department of Fish and Wildlife.[4] The curriculum emphasizes intensive field experiences and hands-on training. BTC divides its programs into three categories: *Aquaculture Science, Aquatic Science, and Fisheries Science:*

- The *Aquaculture Science* program is the most robust of the three, offering a two 2-year A.A.S. degrees in aquaculture with either a fish or shellfish specialization, two 1-year certificates (salmon and trout culturing techniques and seaweed and mollusk culturing techniques), and a 15-credit online micro-credential in aquaculture theory.
- In *Aquatic Sciences,* students can pursue a one-year certificate in the fundamentals of aquatic science or a two-year A.A.S.-T. degree in Aquatic Sciences.
- The *Fisheries Science* program has a similar offering, with a one-year fisheries and field lab techniques certificate and a Fisheries Science A.A.S. available.

While certificates are designed to upskill workers, the two-year degrees (which come with some certifications as well) aim for placement with government agencies or producers in the industry: the A.A.S. in Fisheries Science has a 90% placement rate.[5] At BTC, students operate the Whatcom Creek and Bellingham Hatcheries alongside the Washington Department of Fish and Wildlife, raising more than two million salmon and trout that support fish stocking across the state.

1 https://maritime.seattlecentral.edu/programs
2 https://woodtech.seattlecentral.edu/programs/boat-building-and-repair
3 https://catalog.skagit.edu/preview_program.php?catoid=33&poid=8630
4 https://www.btc.edu/Academics/AreasofStudy/FisheriesandAquacultureSciences.html
5 https://www.btc.edu/files/Documents/Publications/Brochures/Fisheries.pdf

Finally, Tacoma Community College (TCC) and Shoreline Community College (SCC) both offer programs for those interested in oceanography. At TCC, students can receive a two-year A.A. degree in oceanography, specially designed to facilitate transfer into the four-year program with the University of Washington School of Oceanography.[1] SCC offers an A.S.-T. degree called the "Oceanography and Marine Sciences pre-major" for students interested in transferring to a four-year university to complete a marine science education.[2]

FOUR-YEAR POST-SECONDARY EDUCATIONAL INSTITUTION PROGRAMS

The premier university to study blue economy in Washington is the University of Washington (UW), with two schools operating in the space: the School of Marine and Environmental Affairs (SMEA) and the School of Aquatic and Fishery Science (SAFS). SMEA offers a Master of Marine Affairs (M.M.A.) that enables students to work at the intersection of science and public policy.[3] The M.M.A. degree has a professional track for those interested only in coursework, or a capstone and a thesis track for those interested in research or academia. The SMEA embraces an interdisciplinary approach, bringing together faculty from across campus to teach classes in their discipline oriented towards issues in the blue economy. Students are encouraged to pursue research opportunities with faculty during their degree, with options ranging from coastal resource management to ocean acidification.

SAFS is one of the larger schools within UW's College of the Environment, hosting both undergraduate and graduate programs.[4] For undergraduates, students can matriculate into the Aquatic and Fishery Science major or add a minor in Aquatic and Fishery Science or Freshwater Science and Management.[5] For graduate students, both an M.S. and a PhD in Aquatic and Fishery Science is offered, with an additional data science specialization for those looking for experience in using complex data systems or designing software programs.[6] SAFS also organizes internships and research opportunities with NOAA and other UW departments for their students, enabling them to gain the practical experience that employers value.[7] Also within UW's College of the Environment, students can receive a minor, B.S., M.S., or PhD in Oceanography and a minor or B.S. in Marine Biology. UW releases employment statistics from each program, with the figure below comparing the employment results from 2023.

FIGURE 20: OUTCOMES BY MARINE-FOCUSED DEGREE AT UNIVERSITY OF WASHINGTON

	AQUATIC AND FISHERY SCIENCE	MARINE BIOLOGY	OCEANOGRAPHY
Collegiate Internship	67.9%	60.2%	59.7%
Employed Full Time	63.4%	57.6%	59.1%
Employed Part Time	14.6%	6.7%	8.6%
Continuing Education	7.3%	16.4%	19.4%
Top Employer	Wash. State Dept. of Fish & Wildlife	University of Washington	University of Washington
Top Job Title	Lab Technician	Lab Technician	Lab Technician

1 https://www.tacomacc.edu/academics-programs/programs/oceanography
2 https://www.shoreline.edu/programs/natural-sciences-transfer/oceanography-and-marine-sciences-pre-major.aspx
3 https://smea.uw.edu/program/
4 https://fish.uw.edu/students/
5 https://fish.uw.edu/students/undergraduate-program/
6 https://fish.uw.edu/students/graduate-program/
7 https://fish.uw.edu/students/student-and-career-opportunities/internships/

UW College of the Environment also hosts the Sea Grant College in Washington state, a center for research, outreach, and funding in the region.[1] Washington Sea Grant (WSG) has programming in aquaculture, boating, fisheries, marine and coastal planning, sustainable seafood, and shoreline restoration. In addition to NOAA-wide fellowships, Sea Grant Washington provides the Keystone Fellowship, which focuses on supporting individuals from historically underrepresented groups in marine science and policy, Hershman Fellowship, Science Communications Fellowship, and Applied Sustainability Internship programs. WSG also hosts workshops for adult learners and commercial fishermen, teaching everything from sea safety to marine wiring. To engage youth, WSG hosts the Orca Bowl, a one-day knowledge bowl competition, puts on science camps, provides a clearinghouse of educator resources, hosts a kids' day, and more.

There are additional opportunities to study the blue economy at other schools, such as at Seattle University (offering a B.S. in Marine and Conservation Biology) or Western Washington University (offering a B.S. in Marine and Coastal Science).[2,3] The region is also home to many adult-oriented educational organizations focus on helping people build useful skills for the blue economy. Some examples of organizations active in continuing education and credentialing include Northwest School of Wooden Boat Building, Maritime Institute of Technology and Graduate Studies (MITAGS), U.S. Maritime Academy, Crawford Nautical Training, Flagship Marine, Ocean Technologies Group Maritime Training Services, and North Pacific Fishing Vessel Owners' Association. These institutions help learners gain necessary certifications and explore new technologies, with activities ranging from captain's licensing to personalized marine engineering training. MITAGS even provides a registered maritime apprenticeship program, allowing participants to receive a U.S. Coast Guard-issued Mate's license in just over two years.

Coordinators are an important element in building this comprehensive workforce development ecosystem, with Washington Maritime Careers being a leader in this regard. They centralize information around registered apprenticeships in the blue economy, share career pathways for maritime occupations, host a library of research resources, equip educators and industry with education and professional development tools, and administer workforce development programs as a Career Connect Washington Maritime Sector Intermediary.

Blue Master of Business Administration (MBA) Degrees

In 2001, Copenhagen Business School started the first ever Blue MBA program, combining graduate level coursework in business administration with marine-oriented scientific concepts to embrace the cross-disciplinary nature of the blue economy. Over the last couple of decades, programs have begun to sprout up across the U.S., with a list of domestic programs provided below:

- **University of Rhode Island — Blue MBA**
- **University of Alaska Fairbanks — Blue MBA**
- **University of Central Florida — MBA with a blue economy concentration**
- **University of Maine — MaineMBA in Blue Economy**
- **University of California, San Diego — concurrent PhD in oceanography or marine biology and an MBA**

1 https://careers.uw.edu/outcomes/

2 https://www.seattleu.edu/academics/all-programs/marine-conservation-biology-bs/

3 https://www.wwu.edu/majors/marine-coastal-science

Blue Economy Workforce Development Organizations

Organizations such as Washington Maritime Careers are crucial for the success of the blue economy in the region. As a successful workforce development organization, it attracts funding and administers programming around the blue economy, while also facilitating conversation between education partners and industry representatives.

Another influential example is The Maritime Alliance (TMA) from San Diego, which was founded in 2007 to support the marine technology sector in San Diego.[1] TMA administers a blue technology incubator, coordinates workforce development initiatives such as convenings, immersion programs, and internships, and hosts a job board for the region. Creating a model for the industry, TMA worked with the San Diego Unified School District and MiraCosta College Technology Career Institute to develop the BlueSTEM Career Technical Education (CTE) Pathway program, a CTE pathway focusing on marine industries with internships, site visits, and industry speakers. TMA's willingness to innovate as a regional blue economy organization has helped propel the San Diego blue economy.

While there are few organizations similarly dedicated to blue economy workforce development at the national level, two organizations have been involved in this area for many years: the Marine Technology Society and the Maritime Primary and Secondary Education Coalition.

The Marine Technology Society (MTS) promotes awareness around and the understanding of marine technology.[2] Since 1963, it has advocated for the advancement and application of marine technology. MTS convenes industry, professionals, academia, policymakers, and students from a various disciplines at conferences; publishes a peer-reviewed journal; and supports geographic and thematic "Sections" (groups within the MTS membership focused on particular geographies or topics). One notable Section is the Early Career Ocean Professional (ECOP), which is designed to help professionals who received their last educational degree within the past ten years to network into sustainable marine technology applications.[3] MTS also creates a podcast on the blue economy, hosts a blue economy webinar series, and awards funding for students innovating around blue economy issues. Filling a hole in the workforce development ecosystem, MTS also hosts a job board, with openings ranging from entry-level positions like a QMED-certified oiler to senior positions, such as the Director of Great Lakes Water Studies Institute at Northwestern Michigan College.[4]

Another organization is the Maritime Primary and Secondary Education Coalition (MPSEC), which promotes the advancement of maritime education within primary and secondary schools.[5] MPSEC works as a network, bringing together government agencies from all levels with industry partners, maritime associations, educational institutions, and others to augment outreach about and impact of maritime education programs. In addition to developing pathways for students and connecting actors in maritime industries, MPSEC disseminates educational materials, hosts webinars and gatherings, and maintains a member community.

1 https://www.tmabluetech.org/about
2 https://www.mtsociety.org/about-us
3 https://www.mtsociety.org/sections
4 https://mtsociety.careerwebsite.com/jobseeker/search/results/. Accessed September 2024.
5 https://mpsecoalition.net/about-us/

CONCLUSION

With the blue economy set to continue growing, it is essential that blue economy stakeholders understand the current state of the county and, even more importantly, collaborate to implement best practices that have been observed in other regions.

Moving towards a more sustainable ocean economy will require not only including "new" industries (such as sustainable port operations, regenerative aquaculture, and offshore wind), but also increasing the sustainability of existing businesses and industries.

Regarding blue economy workforce needs, STEM careers in engineering and physical sciences will be in demand, in addition to traditional maritime occupations. Both categories are projected to grow over the next five years and should be embraced when developing workforce programming for the region.

Los Angeles County has many institutions operating in the blue economy that can aid in workforce development, from youth-focused activities to regional conveners. The four innovative maritime-focused high school programs in the county provide great models; insights to improve them further can be gleaned from regional case studies. The community college ecosystem in Los Angeles County is growing its blue economy offerings in the region—including a pioneering aquaculture certificate program through Santa Monica College, and STEM education training at several other schools in the system.

The California State University system has a few marine-focused institutions that can serve as partners, while UCLA, USC, LMU, and Occidental College all have programming related to the blue economy, either directly or indirectly. Furthermore, the Southern California Marine Institute is well-positioned as a convening organization for marine issues, and other organizations such as LAEDC are eager to contribute to the growth of the sector. In addition, the California Ocean Protection Council can be an important partner in Los Angeles County's efforts to grow the relevant sectors.

The academic literature on blue economy workforce development emphasizes training on in-demand STEM skills, experiential learning opportunities, and flexible curriculum design. The five case studies provide examples of models for institutions and programs to support the growth of the blue economy, from Mississippi's university-led ecosystem to Washington industry-driven landscape. Best practices from the case studies include using partnerships to develop training curricula and educational pipelines, providing paid hands-on learning opportunities, building cross-disciplinary programming, providing flexible curricula and shorter-term credentials, centering equity in workforce development, focusing on a regional industrial specialization, curating an array of youth and high school outreach and education programs, and supporting regional conveners. Many examples of these best practices are present in the case studies, which provide an inventory of innovative programs, curricula, and collaborations to guide the Los Angeles County blue economy workforce development.

Los Angeles County's ocean economy will continue to develop to meet new economic and policy demands. However, the emergence of more sustainable marine industries will depend in part on the workforce development ecosystem's ability to collaborate and build educational and experiential pathways for all Angelenos who wish to participate in the blue economy.

APPENDICES

Appendix A: Community College Programs focusing on In-Demand Skills for the Blue Economy

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	ANTELOPE VALLEY	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	ANTELOPE VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	CANYONS	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	CERRITOS	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	CITRUS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	CITRUS	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	EL CAMINO	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	GLENDALE	Certificate of Achievement requiring 60 or more semester units or 90 or more quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	GLENDALE	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	GLENDALE	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. CITY	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. HARBOR	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. MISSION	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. PIERCE	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. TRADE-TECH	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	L.A. VALLEY	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	LONG BEACH CITY	A.A. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	LONG BEACH CITY	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	PASADENA CITY	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	RIO HONDO	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	SANTA MONICA	A.S. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	SANTA MONICA	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	SANTA MONICA	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	WEST L.A.	A.A. Degree
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	WEST L.A.	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	WEST L.A.	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Engineering	0901.00 Engineering, General (requires Calculus) (Transfer)	WEST L.A.	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	ANTELOPE VALLEY	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	ANTELOPE VALLEY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	CERRITOS	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	CERRITOS	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	CERRITOS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	CERRITOS	A.A. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	COMPTON	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	EAST L.A.	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	EAST L.A.	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	EL CAMINO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	EL CAMINO	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	L.A. CITY	A.A. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	L.A. CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	L.A. HARBOR	A.S. Degree

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	L.A. MISSION	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	L.A. MISSION	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	LONG BEACH CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	LONG BEACH CITY	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	LONG BEACH CITY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	MT. SAN ANTONIO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	MT. SAN ANTONIO	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	MT. SAN ANTONIO	A.S. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	PASADENA CITY	A.A. Degree
Engineering	0924.00* Engineering Technology, General (requires Trigonometry)	PASADENA CITY	Certificate of Achievement: 12 to fewer than 18 semester(or 18 to fewer than 27 quarter) units
Computer Programming	0706.00 Computer Science (Transfer)	ANTELOPE VALLEY	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	ANTELOPE VALLEY	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	ANTELOPE VALLEY	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0706.00 Computer Science (Transfer)	CANYONS	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	CANYONS	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	CERRITOS	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	CERRITOS	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	CITRUS	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	EL CAMINO	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	GLENDALE	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0706.00 Computer Science (Transfer)	GLENDALE	A.S. Degree

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Computer Programming	0706.00 Computer Science (Transfer)	L.A. CITY	A.A. Degree
Computer Programming	0706.00 Computer Science (Transfer)	L.A. CITY	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	L.A. HARBOR	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	L.A. SOUTHWEST	A.A. Degree
Computer Programming	0706.00 Computer Science (Transfer)	L.A. VALLEY	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	LONG BEACH CITY	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	LONG BEACH CITY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0706.00 Computer Science (Transfer)	RIO HONDO	A.S.T Degree
Computer Programming	0706.00 Computer Science (Transfer)	SANTA MONICA	A.S. Degree
Computer Programming	0706.00 Computer Science (Transfer)	SANTA MONICA	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0706.00 Computer Science (Transfer)	WEST L.A.	A.S.T Degree
Computer Programming	0702.00* Computer Information Systems	ANTELOPE VALLEY	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	ANTELOPE VALLEY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	ANTELOPE VALLEY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0702.00* Computer Information Systems	CITRUS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	COMPTON	Noncredit program
Computer Programming	0702.00* Computer Information Systems	COMPTON	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	COMPTON	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	EAST L.A.	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	EAST L.A.	A.A. Degree
Computer Programming	0702.00* Computer Information Systems	EAST L.A.	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	EL CAMINO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	EL CAMINO	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	EL CAMINO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	GLENDALE	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Computer Programming	0702.00* Computer Information Systems	GLENDALE	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	L.A. CITY	A.A. Degree
Computer Programming	0702.00* Computer Information Systems	L.A. CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	L.A. CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. HARBOR	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	L.A. HARBOR	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. HARBOR	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	L.A. MISSION	A.A. Degree
Computer Programming	0702.00* Computer Information Systems	L.A. MISSION	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. MISSION	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. SOUTHWEST	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. SOUTHWEST	Noncredit program
Computer Programming	0702.00* Computer Information Systems	L.A. TRADE-TECH	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0702.00* Computer Information Systems	L.A. TRADE-TECH	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	L.A. VALLEY	Noncredit program
Computer Programming	0702.00* Computer Information Systems	L.A. VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	LONG BEACH CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	LONG BEACH CITY	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	LONG BEACH CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	LONG BEACH CITY	A.A. Degree
Computer Programming	0702.00* Computer Information Systems	MT. SAN ANTONIO	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0702.00* Computer Information Systems	MT. SAN ANTONIO	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	PASADENA CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0702.00* Computer Information Systems	PASADENA CITY	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	PASADENA CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Computer Programming	0702.00* Computer Information Systems	RIO HONDO	A.S. Degree
Computer Programming	0702.00* Computer Information Systems	RIO HONDO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	SANTA MONICA	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0702.00* Computer Information Systems	WEST L.A.	Noncredit program
Computer Programming	0702.00* Computer Information Systems	WEST L.A.	A.A. Degree
Computer Programming	0702.00* Computer Information Systems	WEST L.A.	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0702.00* Computer Information Systems	WEST L.A.	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0702.00* Computer Information Systems	WEST L.A.	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0707.10* Computer Programming	ANTELOPE VALLEY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0707.10* Computer Programming	ANTELOPE VALLEY	A.S. Degree
Computer Programming	0707.10* Computer Programming	CERRITOS	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0707.10* Computer Programming	CERRITOS	A.A. Degree
Computer Programming	0707.10* Computer Programming	CERRITOS	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	CERRITOS	A.S. Degree
Computer Programming	0707.10* Computer Programming	CITRUS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	EAST L.A.	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	EL CAMINO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	GLENDALE	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	L.A. CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	L.A. CITY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0707.10* Computer Programming	L.A. HARBOR	A.S. Degree
Computer Programming	0707.10* Computer Programming	L.A. MISSION	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	L.A. MISSION	A.S. Degree
Computer Programming	0707.10* Computer Programming	L.A. MISSION	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	L.A. PIERCE	A.A. Degree
Computer Programming	0707.10* Computer Programming	L.A. PIERCE	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	L.A. PIERCE	A.S. Degree
Computer Programming	0707.10* Computer Programming	L.A. SOUTHWEST	A.S. Degree

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Computer Programming	0707.10* Computer Programming	L.A. VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	L.A. VALLEY	A.S. Degree
Computer Programming	0707.10* Computer Programming	L.A. VALLEY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Computer Programming	0707.10* Computer Programming	LONG BEACH CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	MT. SAN ANTONIO	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Computer Programming	0707.10* Computer Programming	MT. SAN ANTONIO	A.S. Degree
Computer Programming	0707.10* Computer Programming	MT. SAN ANTONIO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	PASADENA CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	PASADENA CITY	A.S. Degree
Computer Programming	0707.10* Computer Programming	PASADENA CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	SANTA MONICA	A.S. Degree
Computer Programming	0707.10* Computer Programming	SANTA MONICA	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Computer Programming	0707.10* Computer Programming	SANTA MONICA	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Computer Programming	0707.10* Computer Programming	WEST L.A.	Certificate of Achievement: 12 to fewer than 18 semester(or 18 to fewer than 27 quarter) units
Network Programming	0708.10* Computer Networking	ANTELOPE VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	ANTELOPE VALLEY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Network Programming	0708.10* Computer Networking	ANTELOPE VALLEY	A.S. Degree
Network Programming	0708.10* Computer Networking	CANYONS	A.S. Degree
Network Programming	0708.10* Computer Networking	CANYONS	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Network Programming	0708.10* Computer Networking	CERRITOS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	CERRITOS	A.S. Degree
Network Programming	0708.10* Computer Networking	EL CAMINO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	GLENDALE	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	GLENDALE	Certificate of Achievement: 12 to fewer than 18 semester(or 18 to fewer than 27 quarter) units
Network Programming	0708.10* Computer Networking	L.A. CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Network Programming	0708.10* Computer Networking	L.A. PIERCE	A.S. Degree
Network Programming	0708.10* Computer Networking	L.A. PIERCE	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	L.A. PIERCE	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Network Programming	0708.10* Computer Networking	LONG BEACH CITY	A.S. Degree

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Network Programming	0708.10* Computer Networking	LONG BEACH CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	LONG BEACH CITY	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Network Programming	0708.10* Computer Networking	LONG BEACH CITY	Noncredit program
Network Programming	0708.10* Computer Networking	MT. SAN ANTONIO	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Network Programming	0708.10* Computer Networking	MT. SAN ANTONIO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Network Programming	0708.10* Computer Networking	RIO HONDO	A.S. Degree
Network Programming	0708.10* Computer Networking	RIO HONDO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	RIO HONDO	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Network Programming	0708.10* Computer Networking	SANTA MONICA	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Network Programming	0708.10* Computer Networking	WEST L.A.	A.S. Degree
Network Programming	0708.10* Computer Networking	WEST L.A.	A.A. Degree
Network Programming	0708.10* Computer Networking	WEST L.A.	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Network Programming	0708.10* Computer Networking	WEST L.A.	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Network Programming	0708.10* Computer Networking	WEST L.A.	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Mathematics	1701.00 Mathematics, General	ANTELOPE VALLEY	A.S. Degree
Mathematics	1701.00 Mathematics, General	ANTELOPE VALLEY	A.S.T Degree
Mathematics	1701.00 Mathematics, General	CANYONS	A.S.T Degree
Mathematics	1701.00 Mathematics, General	CANYONS	A.S. Degree
Mathematics	1701.00 Mathematics, General	CERRITOS	A.A. Degree
Mathematics	1701.00 Mathematics, General	CERRITOS	A.S.T Degree
Mathematics	1701.00 Mathematics, General	CITRUS	A.S. Degree
Mathematics	1701.00 Mathematics, General	CITRUS	A.S.T Degree
Mathematics	1701.00 Mathematics, General	COMPTON	A.S.T Degree
Mathematics	1701.00 Mathematics, General	EAST L.A.	A.A. Degree
Mathematics	1701.00 Mathematics, General	EAST L.A.	A.S. Degree
Mathematics	1701.00 Mathematics, General	EAST L.A.	A.S.T Degree
Mathematics	1701.00 Mathematics, General	EL CAMINO	A.S. Degree
Mathematics	1701.00 Mathematics, General	EL CAMINO	A.S.T Degree
Mathematics	1701.00 Mathematics, General	GLENDALE	A.A. Degree
Mathematics	1701.00 Mathematics, General	GLENDALE	A.S.T Degree
Mathematics	1701.00 Mathematics, General	GLENDALE	A.S. Degree
Mathematics	1701.00 Mathematics, General	L.A. CITY	A.S. Degree
Mathematics	1701.00 Mathematics, General	L.A. CITY	A.S.T Degree
Mathematics	1701.00 Mathematics, General	L.A. HARBOR	A.S.T Degree

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Mathematics	1701.00 Mathematics, General	L.A. HARBOR	A.S. Degree
Mathematics	1701.00 Mathematics, General	L.A. MISSION	A.A. Degree
Mathematics	1701.00 Mathematics, General	L.A. MISSION	A.S.T Degree
Mathematics	1701.00 Mathematics, General	L.A. PIERCE	A.S.T Degree
Mathematics	1701.00 Mathematics, General	L.A. PIERCE	A.A. Degree
Mathematics	1701.00 Mathematics, General	L.A. SOUTHWEST	A.S.T Degree
Mathematics	1701.00 Mathematics, General	L.A. SOUTHWEST	A.S. Degree
Mathematics	1701.00 Mathematics, General	L.A. SOUTHWEST	A.A. Degree
Mathematics	1701.00 Mathematics, General	L.A. TRADE-TECH	A.S.T Degree
Mathematics	1701.00 Mathematics, General	L.A. VALLEY	A.S.T Degree
Mathematics	1701.00 Mathematics, General	LONG BEACH CITY	A.S.T Degree
Mathematics	1701.00 Mathematics, General	LONG BEACH CITY	A.S. Degree
Mathematics	1701.00 Mathematics, General	MT. SAN ANTONIO	A.A. Degree
Mathematics	1701.00 Mathematics, General	MT. SAN ANTONIO	A.S.T Degree
Mathematics	1701.00 Mathematics, General	PASADENA CITY	A.S.T Degree
Mathematics	1701.00 Mathematics, General	RIO HONDO	A.S.T Degree
Mathematics	1701.00 Mathematics, General	RIO HONDO	A.S. Degree
Mathematics	1701.00 Mathematics, General	SANTA MONICA	A.S.T Degree
Mathematics	1701.00 Mathematics, General	WEST L.A.	A.A. Degree
Mathematics	1701.00 Mathematics, General	WEST L.A.	A.S.T Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	ANTELOPE VALLEY	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	L.A. PIERCE	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	L.A. PIERCE	A.A. Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	L.A. TRADE-TECH	A.S. Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	L.A. TRADE-TECH	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	MT. SAN ANTONIO	A.S. Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	MT. SAN ANTONIO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	PASADENA CITY	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	PASADENA CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	PASADENA CITY	A.S. Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	RIO HONDO	A.S. Degree
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	RIO HONDO	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Geographic Information Systems (GIS)	2206.10* Geographic Information Systems	SANTA MONICA	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units

Appendix A (continued)

SKILLS	PROGRAMS	SCHOOLS	CREDENTIAL
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	ANTELOPE VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	ANTELOPE VALLEY	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	CANYONS	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	CANYONS	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	CERRITOS	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	CERRITOS	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	EL CAMINO	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	EL CAMINO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	GLENDALE	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. TRADE-TECH	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. TRADE-TECH	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. TRADE-TECH	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. TRADE-TECH	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. VALLEY	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	L.A. VALLEY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	LONG BEACH CITY	Certificate of Achievement requiring 16 to less than 30 semester units or 24 to less than 45 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	LONG BEACH CITY	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	LONG BEACH CITY	Certificate of Achievement requiring 30 to less than 60 semester units or 45 to less than 90 quarter units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	LONG BEACH CITY	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	MT. SAN ANTONIO	Noncredit program
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	MT. SAN ANTONIO	A.S. Degree
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	MT. SAN ANTONIO	Certificate of Achievement: 18 or greater semester (or 27 or greater quarter) units
Process Technology and Improvement	0956.00* Manufacturing and Industrial Technology	WEST L.A.	Certificate of Achievement requiring 8 to less than 16 semester units or 12 to less than 24 quarter units

Appendix B: NOAA ENOW Industry Sector / NAICS Code Crosswalk

Ocean and Great Lakes Economy Sectors and Industries by NAICS Code

SECTOR	INDUSTRY	NAICS	NAICS INDUSTRY (2012 NAICS)
Living Resources	Fish Hatcheries and Aquaculture	112511	Finfish Farming and Harvesting
		112511	Shellfish Farming
		112519	Other Aquaculture
	Fishing	114111	Finfish Fishing
		114112	Shellfish fishing
		114119	Other Marine Fishing
	Seafood Processing	311710	Seafood Product Preparation and Packaging
	Seafood Markets	445220	Fish and Seafood Markets
		424460[1]	Fish and Seafood Merchant Wholesalers[2]
Marine Construction	Marine Related Construction	237990	Other Heavy and Civil Engineering Construction
Marine Transportation	Deep Sea Freight	483111	Deep Sea Freight Transportation
		483113	Coastal and Great Lakes Freight Transportation
	Marine Passenger Transportation	483112	Deep Sea Passenger Transportation
		483114	Coastal and Great Lakes Passenger Transportation
	Marine Transportation Services	488310	Port and Harbor Operations
		488320	Marine Cargo Handling
		488330	Navigational Services to Shipping
		488390	Other Support Activities for Water Transportation
	Search and Navigation Equipment	334511	Search, Detection, Navigation, Guidance, Aeronautical and Nautical System and Instrument Manufacturing
	Warehousing[3]	493110	General Warehousing and Storage
		493120	Refrigerated Warehousing and Storage
		493130	Farm Product Warehousing and Storage

1 The 4-digit NAICS codes are supplemented for counties where the 6-digit data are not available.
2 The Fish and Seafood Merchant Wholesalers (424460) industry category is only present for data years 2016 and beyond.
3 The 4-digit NAICS codes are supplemented for counties where the 6-digit data are not available.

Appendix B (Continued)

SECTOR	INDUSTRY	NAICS	NAICS INDUSTRY (2012 NAICS)
Offshore Mineral Resources	Limestone, Sand and Gravel	212321	Construction Sand and Gravel Mining
		212322	Industrial Sand Mining
	Oil and Gas Exploration and Production	211111	Crude Petroleum and Natural Gas Extraction
		211112	Natural Gas Liquid Extraction
		213111	Drilling Oil and Gas Wells
		213112	Support Activities for Oil and Gas Operations
		54360	Geophysical Exploration and Mapping Services
Ship and Boat Building	Boat Building and Repair	336612	Boat Building and Repair
	Ship Building and Repair	336611	Ship Building and Repair
Tourism and Recreation	Boat Dealers	441222	Boat Dealers
	Eating and Drinking Places	722511	Full Service Restaurants
		722513	Limited Service Eating Places
		722514	Cafeterias
		722515	Snack and Nonalcoholic Beverage Bars
	Hotels and Lodging	721110	Hotels (except Casino Hotels) and Motels
		721191	Bed and Breakfast Inns
	Marinas	713930	Marinas
	Recreational Vehicle Parks and Campsites	721211	RV Parks and Recreational Camps
	Scenic Water Tours	487210	Scenic and Sightseeing Transportation, Water
	Sporting Goods	339920	Sporting and Athletic Goods Manufacturing
	Amusement and Recreation Services	487990	Scenic and Sightseeing Transportation, Other
		611620	Sports and Recreation Goods Rental
		532292	Recreation Goods Rental
		713990	Amusement and Recreation Services Not Elsewhere Classified
	Zoos and Aquaria	712130	Zoo and Botanical Gardens
		712190	Nature Parks and Other Similar institutions

From NAICS Crosswalk Table, https://coast.noaa.gov/data/digitalcoast/pdf/enow-crosswalk-table.pdf

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California Community Colleges