The Conference Board of Canada

In partnership with Future Skills Centre

Blue Occupation Pathways

Career Transitions to the Sustainable Blue Economy

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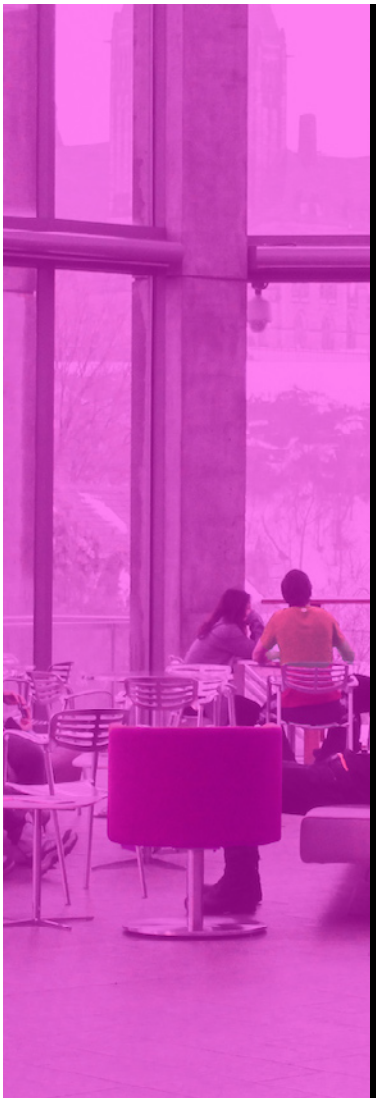

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Contents

Key Findings

- Rapidly growing occupations in the sustainable blue economy (SBE) are often specialized in science, technology, engineering, and math (STEM). Due to the nature of these occupations, most transitions from high-risk, low-mobility (HRLM) jobs to those in the SBE will likely require one to three years of training.
- Of 92 HRLM occupations, 79 have at least one transition available with six months of training. This will be sufficient for many workers; however, their options will be limited. Three years of training opens up the most opportunities for HRLM workers to enter rapid-growth SBE occupations. On average, nine transition pathways will be available to each worker.
- Based on employment projections in HRLM and SBE occupations over the next decade, HRLM workers in the Atlantic provinces have a surprisingly low transition potential. This is because there will be relatively more HRLM jobs compared with SBE jobs. In facilitating transitions from HRLM to SBE occupations, the Atlantic region should focus on upskilling HRLM occupations with the most desirable transition pathways to increase the likelihood of participation in the SBE.
- The cost of a career transition to the SBE varies widely across Canada. It is high in British Columbia due to the opportunity cost of training and is much lower in the Atlantic provinces of New Brunswick and Nova Scotia. The transition is especially less costly in Quebec because of the very low direct cost of training.
- There is a lack of training programs for the sustainable blue economy, especially short-term and lower-cost options. More equity, diversity, and inclusion (EDI); ocean technology; and ocean literacy training are needed to help fill some of the skills and labour gaps.

Introduction

The global ocean economy is expected to double in size to $3 trillion between 2016 and 2030. Given the increase in activity and Canada's enormous coastline, the sustainable blue economy (SBE) is an area of high economic potential for Canada.[1]

"The blue economy is a sustainable use of ocean resources for economic growth, improved livelihoods and jobs, and ocean ecosystem health. It encompasses renewable energy, fisheries, maritime transport, waste management, tourism, and climate change."

The World Bank

The government has signalled its commitment to developing the SBE through several programs:

- The Oceans Protection Plan is aimed at preserving and restoring marine ecosystems and building partnerships with Indigenous peoples and coastal communities.[2]
- The Ocean Supercluster is one of Canada's Global Innovation Clusters, which has injected the sector with billions in capital.[3]
- The Government of Canada announced an upcoming Blue Economy Strategy to further the economic development and conservation of Canada's oceans.[4]

Importantly, Canada will need a skilled workforce to grow its SBE. New graduates can alleviate some of this demand, as can highly skilled workers transitioning from industries outside of the SBE. However, companies will likely have to tap into other sources. For example, one strategy is to facilitate career pathways from high-risk, low-mobility (HRLM) jobs to rapid-growth opportunities in the SBE.

Workers in HRLM occupations are particularly prone to automation while facing limited opportunities for transitioning to more promising jobs in the absence of significant retraining (i.e., six months or more).[5]

1 Organisation for Economic Co-operation and Development, *The Ocean Economy in 2030*.
2 Government of Canada, "Oceans Protection Plan."
3 Government of Canada, "Canada's Ocean Supercluster."
4 Government of Canada, "Blue Economy Strategy."
5 See Gresch, *Responding to Automation* for the list of HRLM occupations.

Previously, we modelled potential transition pathways from HRLM occupations to rapid-growth occupations in the clean economy.[6] Policy-makers must understand which of these transitions are the most desirable. They must also realize which training is required so they can effectively and efficiently allocate resources to prepare Canada's economy for the future and achieve the greatest positive economic impact.

Objectives

This impact paper analyzes the occupational transitions from 92 HRLM occupations to 15 SBE rapid-growth occupations.[7] Understanding the occupational pathways for the transitions will advance the sector while providing a roadmap for career transitions that can mitigate worker displacement. We aim to inform policy-makers and human capital professionals on three crucial areas of occupational transitions:

1. The first area is to understand the training requirements for transitioning people from high-risk occupations into high-growth ones in the SBE. This includes the type of skills development and the length of time required to enable the transition.
2. The second is to provide a provincial and territorial breakdown of the high-growth SBE employment potential and its relationship to automation vulnerabilities.
3. The third is to model the cost of skills development by province and territory. Knowing the cost of these transitions can help provinces prioritize where resources should go to speed up and strengthen transitions from HRLM to rapid-growth SBE occupations. Modelling the cost can also help academic institutions and job training organizations determine the types of programs most needed.

The Sustainable Blue Economy

The SBE takes a holistic view of the ocean economy. The economic growth of the ocean economy and the subsectors that comprise it are important. But aiming for growth alone can be damaging. The SBE also incorporates environmental considerations (e.g., the effect of economic activity on biodiversity) and social considerations (e.g., how growth affects workers in coastal communities).

Our analysis of the SBE focuses on the following subsectors:

- fisheries and aquaculture
- marine transport, ports, and shipping
- ocean technologies
- offshore minerals and resources
- marine renewables
- marine and coastal tourism

Overall, we identified 71 occupations in the SBE. However, the focus of this analysis is on the 15 occupations that are:

- the most highly concentrated in these subsectors,
- rapidly growing,
- contributing to the social and environmental sustainability of the oceans and ocean communities. (See Table 1.)

6 Sonmez, Thomson, and Gresch, *Green Occupation Pathways*.

7 We define rapid-growth occupations as those we project to grow at a faster rate than the economy average.

These occupations are also vital to Canada's economic growth, especially along the coasts. (See Appendix B for more discussion on SBE occupations.)

Table 1
Fifteen SBE Occupations of Focus

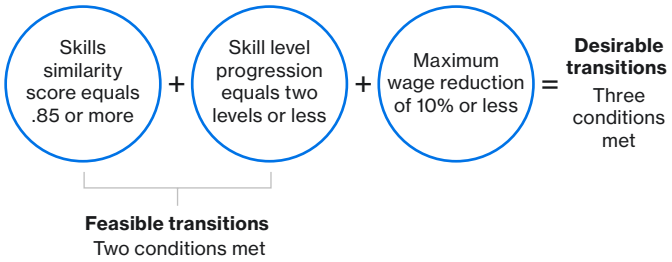
NOC	Occupation
0213	Computer and information systems managers
2131	Civil engineers
2132	Mechanical engineers
2133	Electrical and electronics engineers
2142	Metallurgical and materials engineers
2144	Geological engineers
2153	Urban and land use planners
2172	Database analysts and data administrators
2173	Software engineers and designers
2255	Technical occupations in geomatics and meteorology
5254	Program leaders and instructors in recreation, sport, and fitness
6531	Tour and travel guides
7451	Longshore workers
7532	Water transport deck and engine room crew
8222	Contractors and supervisors, oil and gas drilling and services

Source: The Conference Board of Canada.

Modelling Occupational Transitions

In modelling transitions from HRLM occupations to rapid-growth occupations, the feasibility and desirability of each transition need to be considered. Therefore, we examine three conditions for transitions: skills similarity, mobility between skill levels, and wage differences. (See Exhibit 1.)

Exhibit 1
Three Conditions That Define Feasible and Desirable Occupational Transitions



Source: The Conference Board of Canada.

Transitions Must First Be Feasible

For a transition from an HRLM to a high-growth SBE occupation to be feasible, the two occupations must have a high skills similarity score and a realistic progression to higher skill levels from training.

Skills are classified into two broad categories: cognitive skills and task-based skills. These categories distinguish between two necessary workplace skills: general human capital (i.e., cognitive skills) and specific human capital (i.e., task-based skills and knowledge areas). We estimate cognitive and task-based skill distances between a given pair of occupations using the cosine similarity score.[8]

Skill levels are determined by the amount of training, education, and experience required and the complexity of work involved compared with other occupations. Moving from a lower to a higher skill level category almost always requires on-the-job training or additional formal education. Therefore, any upward progression is proportional to the training effort. There is no progression for a minor training effort,[9] one level of progression for a moderate training effort, and two levels of progression for a major training effort. We exclude progression beyond two levels and transitions that involve excess skills.[10]

How Training Translates to Improved Skills

Identifying feasible occupational transitions is methodologically challenging as it requires determining the equivalence between years of training and skill gains. There is currently a lack of empirical data to show the skills improvement gained from a year of education or on-the-job training.

To address this shortfall, we take the identified desirable occupational transitions, examine the distribution of skills shortages among them, and reasonably assume that:[11]

- six months of training can close the 25th percentile of a worker's skill shortages;
- one year of training can close the 50th percentile of a worker's skill shortages;
- three years of training can close the 75th percentile of a worker's skill shortages.

They Must Also Be Desirable

For a transition to be desirable, skills similarity and skill level progression must be combined with a quality of life similar to that which a worker is accustomed. The Organisation for Economic Co-operation and Development estimates the average annual earnings loss of workers one year after displacement in five member countries as 10 per cent.[12] Our model, therefore, allows a maximum wage reduction of 10 per cent for a desirable transition as workers are unlikely to move to other occupations if transitions entail large wage drops.

More SBE Career Transitions Become Desirable With More Training

While there are 1,380 potential transitions between HRLM and high-growth SBE occupations, not all of these are feasible or desirable. (See Table 2.) The number of desirable transitions increases by 22 per cent from six months of training to one year of training.

8 Cosine similarity measures the angle between any two non-zero vectors. It is defined as the inner product space of the cosine of the angle between the two vectors. The values of cosine similarity range from 0 and 1. See Rao, Hindle, and Gabler, *Modelling Job Transitions in Canada* for a detailed explanation.

9 The minor training effort is necessary to transition to different occupations with the same skill level but is insufficient for upward mobility on the skill ladder.

10 We exclude transitions that involve excess skills (i.e., resulting from transitions from higher-skill to lower-skill jobs) because they are undesirable for workers and unproductive from a societal perspective.

11 See Bechichi and others, "Occupational Mobility, Skills and Training Needs" for the basis of these assumptions.

12 Organisation for Economic Co-operation and Development, *OECD Employment Outlook 2013*.

Table 2
Transition Pathways Increase Substantially With More Training
(number; percentage)

	All Transition Pathways	Feasible Transition Pathways		Desirable Transition Pathways		
Training scenario	All transition pathways	Number of transition pathways	Percentage of all transition pathways	Number of transition pathways	Percentage of feasible transition pathways	Percentage of all transition pathways
Minor training (i.e., six months)	1,380	308	22.3	**192**	62.3	**13.9**
Moderate training (i.e., one year)	1,380	687	49.8	**500**	72.8	**36.2**
Major training (i.e., three years)	1,380	687	49.8	**500**	72.8	**36.2**

Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

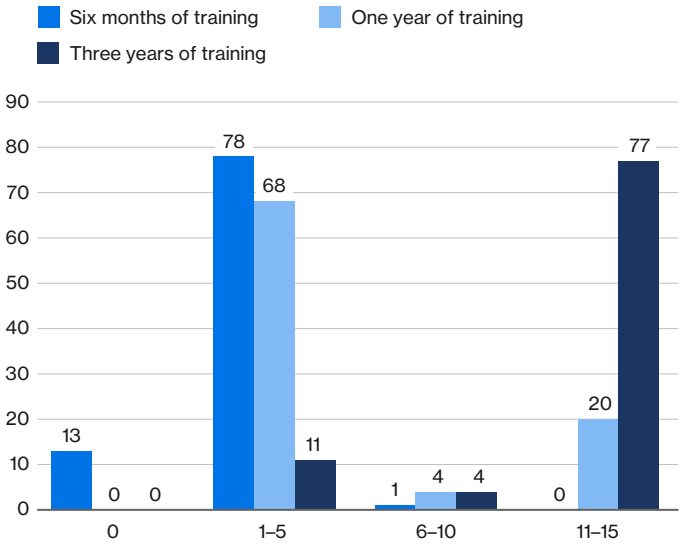
However, this still leaves a little more than a third of transitions desirable. The number of desirable transitions doubles to nearly 73 per cent after three years of training. This means that this training effort opens up the most opportunities for HRLM workers to enter rapid-growth SBE occupations.

Moving from one year to three years of training does not enable all transitions because the skills are either too dissimilar or the difference between skill levels is unrealistically large (i.e., greater than two). Many rapid-growth SBE occupations are dominated by science, technology, engineering, and mathematics (STEM), with highly specialized skills across all the SBE sub-sectors, which may explain why it is difficult to fully close this gap.

Moreover, the drop in transitions from adding our feasibility requirement demonstrates that many rapid-growth occupations in the SBE would pay too little for HRLM workers.

While six months of training enables a few desirable transition pathways for most HRLM workers, one year of training enables transitions for every HRLM occupation. (See Chart 1.) However, three years of training opens a significant number of transitions for most HRLM workers. This provides the most choice to workers looking to enter the SBE.

Chart 1
One Year of Training Enables High-Growth SBE Transitions for All HRLM Occupations
(vertical axis = number of HRLM occupations; horizontal axis = number of desirable transitions)



Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Except for one outlier, the minor training scenario provides a maximum of five desirable transition pathways for HRLM occupations. There are no desirable transitions for 13 HRLM occupations with six months of training. Due to this shortfall, the minor training scenario is unlikely to provide a valuable return for HRLM job training programs in the SBE. Still, the moderate and major training scenarios provide at least one desirable pathway for all HRLM workers. (See Appendix C for examples of distinct occupation pathways between HRLM and SBE jobs, as well as a detailed distribution of all available transition pathways.)

The Potential for High-Growth Transitions in the SBE Is Lower Than Expected in Atlantic Canada

When looking at employment projections to 2030, the potential for HRLM-to-SBE transitions varies significantly across Canada. (See Table 3.) The Transition Potential Ratio can be understood as the number of SBE jobs available for every HRLM job.

Alberta, British Columbia, and Ontario are the provinces with the highest transition potential, and the West Coast has a stronger transition potential than the Atlantic region.

While not on the coasts, Alberta and Ontario have good employment growth prospects for working in the ocean technology subsector – especially in computer and software engineering – as well as scientific research and development. With the increased shift to remote and virtual work, fewer of these positions will need to be located along the coasts.

There is a negative correlation between automation vulnerability and transition potential. (See Chart 2.) Provinces and territories with lower Automation Vulnerability Index scores generally have higher SBE/HRLM ratios, demonstrating their resiliency and high transition potential.[13] Prince Edward Island and New Brunswick have both high automation vulnerability and a low ability to transition workers in occupations at high risk of automation into fast-growing ones in the SBE.

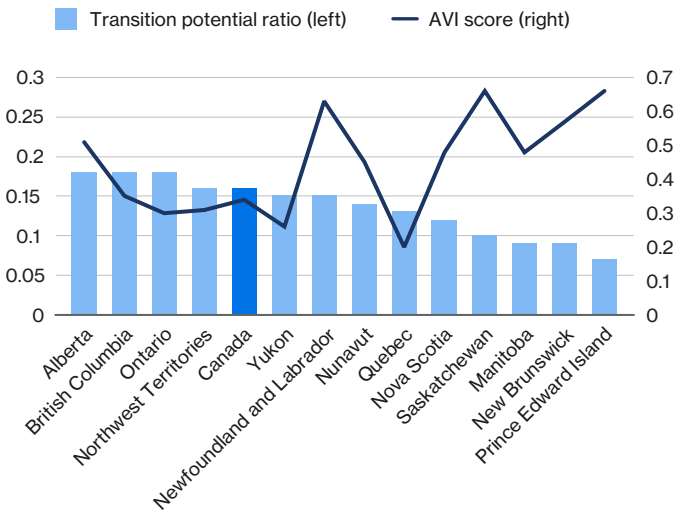
Table 3
The Potential for HRLM to SBE Transitions Varies Across Provinces and Territories
(number; percentage)

	HRLM Employment, 2030		SBE Employment, 2030		Transition Potential Ratio
Province/Territory	**Number**	**Percentage Share**	**Number**	**Percentage Share**	
Alberta	481,988	18.1	88,487	3.3	0.18
British Columbia	508,985	18.5	91,023	3.3	0.18
Ontario	1,555,511	18.8	273,806	3.3	0.18
Northwest Territories	3,019	13.5	491	2.2	0.16
Canada	**3,928,900**	**18.8**	**620,926**	**3.0**	**0.16**
Yukon	3,827	14.6	581	2.2	0.15
Newfoundland and Labrador	40,145	19.5	5,925	2.9	0.15
Nunavut	2,321	14.9	329	2.1	0.14
Quebec	876,988	19.1	115,777	2.5	0.13
Nova Scotia	96,653	20.4	11,138	2.3	0.12
Saskatchewan	125,206	19.8	12,791	2.0	0.1
Manitoba	142,599	19.6	12,824	1.8	0.09
New Brunswick	71,965	20.6	6,341	1.8	0.09
Prince Edward Island	19,693	23.2	1,414	1.8	0.07

Sources: The Conference Board of Canada; O*NET; Vicinity Jobs; Statistics Canada.

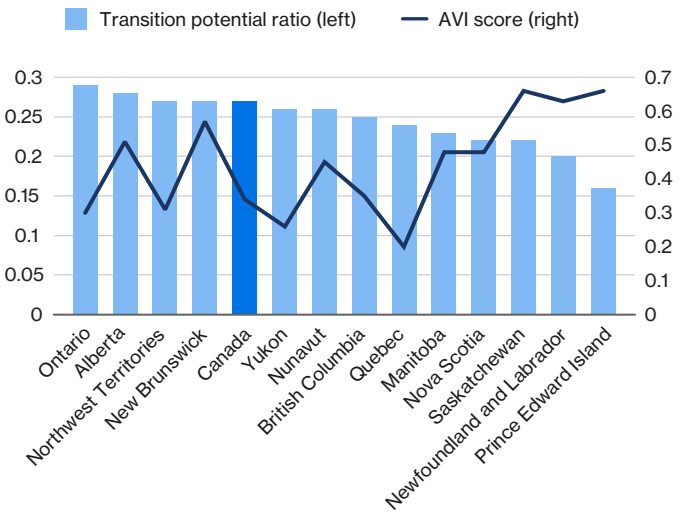
13 See Sonmez, *Preparing Canada's Economies for Automation* for more information on the Automation Vulnerability Index.

Chart 2
British Columbia and Ontario Have Low Automation Vulnerability and High Transition Potential for HRLM Workers
(transition potential ratio; AVI score)



Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Chart 3
Ontario and Alberta Have the Highest Transition Potential in the Rapid-Growth, Clean-Economy
(transition potential ratio; AVI score)



Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Employers in the Atlantic provinces may need to pursue employees located in other provinces for rapid-growth positions. Similarly, Atlantic provinces looking to strengthen and fill employment in the SBE should focus on the HRLM occupations with the most potential to transition in the shortest interval.

There Are Differing Opportunities in the SBE Relative to the Clean Economy

While there is no official definition of what constitutes the clean economy, previous research defined clean economy roles as those in clean energy production, energy efficiency, and environmental management. We identified 16 rapid-growth occupations within the clean economy that HRLM workers can transition toward.[14] The clean economy and the blue economy are not mutually exclusive, and they often intersect. Our analysis, however, did not discover any overlap between the top rapid-growth occupations in these two sectors.

The clean economy is overall much larger than the sustainable blue economy and there are several differences by province (See Chart 3.)

The Atlantic province with the highest SBE transition potential is Newfoundland and Labrador, which has a much higher transition potential in the SBE than in the clean economy. Therefore, their efforts may be better spent focusing on strengthening the SBE in the province. Alternatively, New Brunswick has a higher transition potential in the clean economy and may be better suited to devote more resources to training for those occupations than in the SBE.

Many rapid-growth careers in the clean economy and the SBE also have high demand outside of these sectors. Therefore, there will be strong competition for the same talent between provinces and territories and across industries. Organizations in the SBE will need to examine how to best position themselves to attract these in-demand workers.

14 See Sonmez, Thomson, and Gresch, *Green Occupation Pathways* for a list of these occupations.

The Cost to Transition Also Varies by Region

It is crucial for the federal, provincial, and territorial governments to inform their SBE strategies and programs about the costs of training. (See Table 4.)

Although the major training scenario has the most potential career paths between HRLM and rapid-growth SBE occupations, it is also the most expensive option. This is especially true in Alberta where there are high indirect costs because of the relatively high wages for HRLM positions in the province. (See Appendix C for a breakdown of direct and indirect costs.)

Major training (i.e., three years) opens up most pathways. But, given the difference in costs, it may be more cost-effective for provinces to focus on the potential transitions that come alongside moderate training for HRLM individuals. In the Atlantic provinces, the indirect costs of training are relatively low, but the direct costs are high. Therefore, it would be advisable for these provinces to find ways of lowering direct training costs to make it easier for workers to transition into occupations with more future potential.

Table 4
The Cost of Transitioning Varies Greatly by Training Effort and Province
(C$)

Province/Territory	Minor Training (i.e., six months)	Moderate Training (i.e., one year)	Major Training (i.e., three years)	Average
Alberta	35,767	72,816	208,425	105,669
Saskatchewan	32,765	66,813	190,707	96,762
Nunavut	37,020	69,930	182,822	96,591
Prince Edward Island	31,891	63,852	185,378	93,707
Northwest Territories	33,075	64,288	182,727	93,363
British Columbia	29,254	59,714	172,683	87,217
Newfoundland and Labrador	29,454	61,275	169,658	86,796
Manitoba	28,886	58,704	168,808	85,466
New Brunswick	28,535	57,942	167,099	84,525
Canada	**28,156**	**57,404**	**164,972**	**83,511**
Yukon	28,867	56,977	163,448	83,098
Ontario	28,132	57,232	163,557	82,974
Nova Scotia	27,320	55,764	161,198	81,427
Quebec	23,769	48,275	139,228	70,424

Note: Costs do not increase proportionally between training scenarios because each comprises different pathways (i.e., transition pairs), and each pathway is associated with a different cost.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs; Statistics Canada.

Understanding Specific Transition Gaps

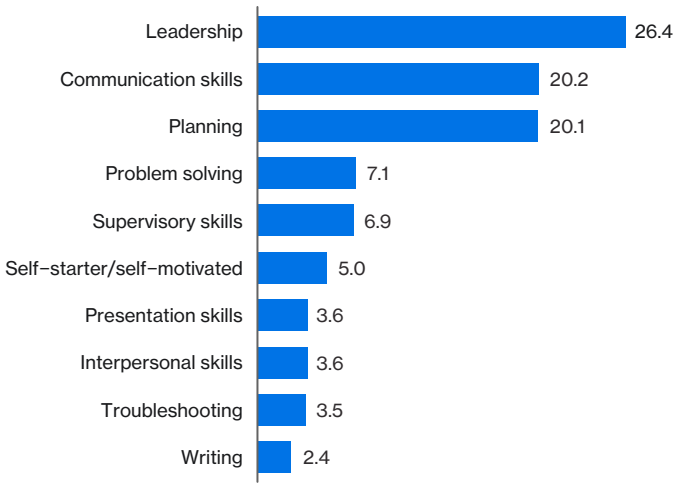
Identifying desirable occupation pathways and the associated training effort to realize these transitions is only one component of the equation. Workers and training providers must also know the specific knowledge, abilities, and skills upgrades needed to make those paths viable.[15] Using the same occupational survey data from O*NET and job postings data from Vicinity Jobs, we examine detailed gaps between rapid-growth occupations in the SBE and HRLM jobs.

Some Skills Gaps Are More Important Than Others

In aggregate, the top knowledge areas in need of upgrading are mostly associated with STEM fields. In terms of abilities, SBE occupations require workers to have more original ideas and robust mathematical and deductive reasoning skills than workers in HRLM jobs. In terms of specific work activities, employment in the SBE requires strong creative thinking, data analysis, knowledge development, and provision of consultation and advice.

Among general skills, leadership is the most important skill that HRLM workers transitioning into the SBE must acquire, reflecting the importance of leading by example and inspiring co-workers with creative thinking. (See Chart 4.) Communication is also an important skill to obtain as the SBE workers are expected to convey insights from complex analytical research.

Chart 4
To Transition to SBE Occupations, the Top Skills Are Leadership, Communication, and Planning
(percentage difference; top 10 skill differences)



Note: Differences in general skills correspond to the percentage difference of job postings between origin and destination occupations containing a given skill. For example, 26.4 per cent more job postings contained leadership for SBE occupations than for HRLM occupations.
Sources: The Conference Board of Canada; Vicinity Jobs.

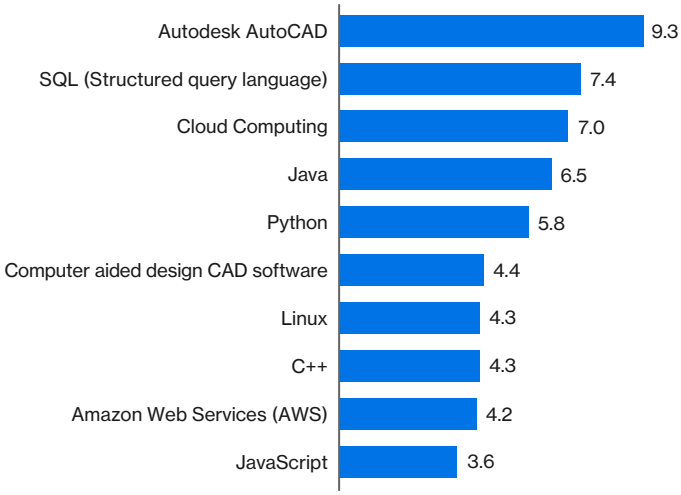
In terms of specialized skills, project management is the most important to acquire, reflecting the importance of assembling and leading a team to success. (See Chart 5.) Given the fast-evolving nature of quantitative tasks, software development and training are also important skills for SBE occupations.

15 Oschinski and Nguyen, *Finding the Right Job*.

Chart 5
Project Management Is the Most Needed Specialized Skill
(percentage difference; top 10 skill differences)

Note: Differences in specialized skills correspond to the percentage difference of job postings between origin and destination occupations containing a given skill. For example, 9.9 per cent more job postings contained agile software development for SBE occupations than for HRLM occupations.
Sources: The Conference Board of Canada; Vicinity Jobs.

Chart 6
Workers Transitioning to the SBE Need to Know Different Types of Software, Depending on the Job
(percentage difference; top 10 skill differences)



Note: Differences in technology skills correspond to the percentage difference of job postings between origin and destination occupations containing a given skill. For example, 4.3 per cent more job postings contained C++ for SBE occupations than for HRLM occupations.
Sources: The Conference Board of Canada; Vicinity Jobs.

Technology skills and tools are the most specific among the three types of skills we focus on. (See Chart 6.) Some technology skills have transferability but, ultimately, workers need to know different types of software depending on the job to which they want to transition.

Targeted Training Will Be Necessary

Having determined the most needed skills, abilities, and knowledge areas, we now examine the extent to which existing training programs target the SBE. The resulting gap between what workers need to acquire and what training programs offer will help inform existing and future education and training curriculums.

The High Degree of STEM Skills Needed in the SBE Lends Itself to Formal Undergraduate and Graduate Education

Due to the importance of STEM skills in the SBE, there are many ways to enter the sector through undergraduate training, whether in biology, engineering, or data analysis and statistics. There are also several SBE specialized programs offered for graduate-level training at schools such as the Marine Institute at Memorial University and Dalhousie University.

However, there are limited options available to those wishing to enter the SBE with fewer years of formal education and lower costs. Diploma programs exist, but many require prerequisites or high levels of previous experience. Marine transportation, for example, is a subsector with high levels of regulation and certification. Those wishing to enter this sector will need to obtain their certifications at Transport Canada-approved marine college programs.

For workers that already have a relevant degree or diploma and need more specialized training to enter into an SBE subsector or upgrade their potential within an SBE subsector, there are a few programs to facilitate this type of training. The Nova Scotia Community College (NSCC) offers advanced diplomas in Marine Engineering Management Technology and Marine Navigation Management Technology, as well as an Electro-Technical Officer program. Moreover, there are graduate diploma and certificate programs such as the NSCC Ocean Technology program and the Vancouver Island University Diploma in Fisheries and Aquaculture Technology.

Programs That Require a Smaller Training Effort Are Lacking, Especially for In-Demand STEM Skills

Certificate programs could be more accessible for HRLM workers since they are often offered without previous training requirements and of shorter duration than degree or diploma programs. Examples include the North Island College's Adventure Guiding Certificate program, which provides training for marine and coastal tourism activities and the New Brunswick Community College Aquaculture Operations program.

However, there is a lack of low-cost and short-term programming for the in-demand technical and STEM skills required in the SBE. With the success of boot camp-style training programs in the technology sector overall, the SBE could benefit from a similar style ocean technology program. This would allow HRLM workers to quickly gain quantitative and technical skills to enter the SBE in high-demand and quickly growing areas.

More Training Programs for Underrepresented and Equity-Seeking Groups to Enter the SBE Are Also Needed

There does not appear to be a large contingent of training programs geared toward bringing underrepresented groups into the SBE. Some notable examples that exist for Indigenous peoples are the Aboriginal Community Career Employment Services Society (ACCESS), Bridge Watch and Tourism training programs in British Columbia, as well as the Nunavut Fisheries and Marine Training Consortium.

The Atlantic Immigration Program could be used by SBE organizations in Atlantic Canada, but there are no SBE-specific bridging programs to help newcomers and internationally trained professionals enter the sector. There is also a lack of programming geared toward gender equity in the SBE, despite its reputation as a historically male-dominated area of the economy. The organization, Ocean Allies, is looking to remedy the lack of equity, diversity, and inclusion (EDI) programming in the blue economy, but more is needed to support equity-seeking groups.

To improve the skills shortages and increase diversity in the SBE, there needs to be an awareness of the ocean opportunities that exist for all workers in Canada. Without this awareness, training program slots may go unfulfilled. Therefore, ocean literacy should play a greater role in K–12 education and be a part of SBE training programs. Ocean literacy is a necessary project for governments, SBE companies, and academic institutes to ensure that there are sufficient labour and skill levels required for in-demand SBE roles.

Overall, better targeting of training and upskilling efforts has the potential to increase participation in training programs and completion rates. This will ultimately help Canadians with vulnerable jobs make the best career and training choices. Understanding which skills and abilities are most needed and where to acquire them will allow workers to quickly identify and take advantage of emerging opportunities. This will improve their resilience in a labour market that is constantly evolving in the face of technological changes.

Conclusion

Strengthening the SBE can lead to stronger coastal communities, healthier oceans, and a more diverse workforce. There are many potential transitions from vulnerable occupations to rapidly growing ones in the SBE. We aim to support these transitions and provide policy-makers and human capital program managers with the necessary information to begin planning transitions and training for these workers.

This strategy alleviates two risks to the Canadian economy. First, it increases the likelihood that workers vulnerable to automation can access new labour market opportunities. Second, it strengthens the sectors that regional economies need to grow. It does this while also focusing on environmental health and sustainability.

The opportunity to transition is different across the country and organizations in the SBE will have to compete for the same talent pool as many other sectors, including the digital and clean economies. In some provinces, such as New Brunswick, it may be more advantageous to focus on the clean economy because there is a greater potential for those types of transitions. For others, such as Newfoundland and Labrador, transitioning HRLM workers to the SBE may be the preferable approach.

Similarly, there are different cost considerations when transitioning from vulnerable occupations to rapid-growth ones in the SBE. Quebec has an advantage because of the low cost of training. Whereas, in Atlantic Canada, employers and governments alike may need to consider the relatively high cost of getting workers to transition into the SBE. In other words, they may need to be creative in attracting workers to the SBE.

Lastly, there are significant skills gaps for HRLM workers to overcome to enter into SBE occupations. While some specialized programs do exist, there is a need for more training programs in the SBE geared toward quantitative and technical skills. The SBE would also benefit from increased training for equity-seeking groups and a higher degree of ocean literacy, so more workers know the opportunities available to them.

Appendix A

Methodology

This project employs the methodology first used in *Green Occupation Pathways*.[1] We applied this methodology to examine the feasibility of transitioning workers from occupations susceptible to automation to rapidly growing jobs in the blue economy. We define this shift as a transition from high-risk, low-mobility (HRLM) occupations to rapid-growth, sustainable blue economy (SBE) occupations.
In particular, we seek to identify:

- the extent of skills gaps and task and knowledge area differences between HRLM and rapid-growth SBE occupations in Canada;
- the time and monetary costs of skills development and training for a transition between any given HRLM occupation and rapid-growth SBE occupations;
- regional variation, if any, in these transitions;
- specific skill, ability, and knowledge area gaps, and existing programs that can address them.

Skills Similarity

We estimate cognitive and task-based skill distances between a given pair of occupations using the cosine similarity score. Cosine similarity measures the angle between any two non-zero vectors. It is defined as the inner product space of the cosine of the angle between the two vectors. The values of cosine similarity range from 0 and 1.[2]

The transition similarity scores are based on two different skills data sources: O*NET and Vicinity Jobs. (See Table 1.) We weighted each source to reflect the richness of the data. We gave more weight to O*NET (0.6) than Vicinity Jobs (0.4) because O*NET provides more varied information about the transition process (i.e., knowledge, skills, abilities; work activities; and education, training, and experience). Vicinity Jobs provides information about two broad categories (i.e., skills, and education and experience).

Table 1
Data Inputs Are Used in the Calculation of the Similarity Score

Source	Input	Dimensions	Definition
O*NET	Knowledge	33	Organized sets of principles and facts applying in general domains.
	Skills	35	Developed capacities that facilitate learning or the more rapid acquisition of knowledge.
	Abilities	52	Enduring attributes of the individual that influence performance
	Work activities	41	General types of job behaviours occurring on multiple jobs.
	Education, training, and experience	41	The frequency of categories for education, training, and experience of each occupation.
Vicinity Jobs	General/soft skills	52	General/soft skills that apply to most occupations.
	Specialized skills	147	Specialized skills apply to specific jobs.
	Equipment, tools, and technology	4,099	Equipment, tools, and technological skills entail knowledge of information and communication technologies and heavy machinery.
	Experience	2	The experience requirements for the stated occupation.
	Education	7	The education requirements for the stated occupation.

Sources: O*NET; Vicinity Jobs.

1 Sonmez, Thomson, and Gresch, *Green Occupation Pathways*.
2 See Rao, Hindle, and Gabler, *Modelling Job Transitions in Canada* for a detailed explanation.

Skill Level Categories

We assign 4-digit NOC occupations to skill levels identified by Economic and Social Development Canada. (See Table 2.)

Table 2
Economic and Social Development Canada
Skill Level Categories

Level	Description
0	Management jobs.
A	Professional jobs that usually require a degree from a university.
B	Technical jobs and skilled trades that usually require a college diploma or training as an apprentice.
C	Intermediate jobs that usually require high school and/or job-specific training
D	Labour jobs that usually give on-the-job training.

Source: Economic and Social Development Canada.

Skills Gains

The values in Table 3 correspond to the bottom, median, and top quartiles of the distribution of skills shortages among occupational transitions that do not involve skills excesses. A score of 1 refers to a perfect similarity between origin and destination occupations in our model (i.e., 100 per cent similarity). For example, 0.25 is the combination of cognitive and task-based skills gained from six months of training. In other words, after six months of training, the overall skill set of an employee becomes 25 percentage points more similar to the overall skillsets associated with the occupation to which they want to transition. The same logic applies to the longer training scenarios in our transition model.

Table 3
Skills Gains Increase With More Training

Level	**Minor Training** (i.e., six months)	**Moderate Training** (i.e., one year)	**Major Training** (i.e., three years)
Quartile	25th	50th	75th
Average skill similarity	**0.25**	**0.29**	**0.34**

Sources: The Conference Board of Canada; Organisation for Economic Co-operation and Development.

Appendix B

Sustainable Blue Economy Occupations

To determine the 15 rapid-growth SBE occupations, we began by identifying the relevant industries in the blue economy. We then categorized the relevant 4-digit National Occupation Classifications (NOC) concentrated within each subsector. From there we determined which NOCs were forecast to grow rapidly at the national and subnational level (i.e., faster than the economy average).

To determine the most relevant high-growth occupations, we scored these NOCs by concentration within the SBE using a concentration quotient (CQ) and share of SBE employment. The CQ measures the relative importance of any given occupation to each SBE sector compared with the overall economy. The CQ formula is:

$$CQ = \frac{\text{Occupation's share of sectoral employment}}{\text{Occupation's share of national employment}}$$

Values greater than 1 indicate that a given occupation is more important to the SBE than the overall economy. Values less than 1 indicate that a given occupation is less important to the SBE than the overall economy. Values equal to 1 indicate that a given occupation is equally important to the SBE and the overall economy.

The average of these two scores provided us with 15 rapidly growing SBE occupations that provide a high potential for occupational transitions (See Table 1.)

One shortcoming of 4-digit NOC analysis is that most of the occupations at this level are not solely in the ocean sectors and may not fully reflect the diversity of roles within the oceans. Thus, our scoring by concentration and employment in the SBE. Still, these 15 occupations exist beyond the confines of the ocean economy, and this should be kept in mind for this analysis.

Table 1
Rapid Growth SBE Occupations Are Found Across the Ocean Economy

NOC	Original Description	Concentration Quotient (CQ)	Share of SBE Emp	CQ Standardized	Share Standardized	Average of CQ and Share of Occupational Employment
7451	Longshore workers	15.3	99.4	1.00	1.00	1.00
2144	Geological engineers	11.7	75.6	0.76	0.76	0.76
7532	Water transport deck and engine room crew	10.8	70.0	0.70	0.70	0.70
6531	Tour and travel guides	9.4	60.7	0.61	0.61	0.61
2173	Software engineers and designers	8.0	51.8	0.52	0.52	0.52
2131	Civil engineers	7.9	51.0	0.51	0.51	0.51
2133	Electrical and electronics engineers	7.9	51.0	0.51	0.51	0.51
5254	Program leaders and instructors in recreation, sport and fitness	6.6	42.5	0.43	0.43	0.43
2132	Mechanical engineers	6.2	40.5	0.41	0.41	0.41
2142	Metallurgical and materials engineers	5.5	35.9	0.36	0.36	0.36
213	Computer and information systems managers	5.4	35.0	0.35	0.35	0.35
8222	Contractors and supervisors, oil and gas drilling and services	4.9	31.8	0.32	0.32	0.32
2255	Technical occupations in geomatics and meteorology	4.5	29.0	0.29	0.29	0.29
2172	Database analysts and data administrators	3.7	24.1	0.24	0.24	0.24
2153	Urban and land use planners	3.1	20.2	0.20	0.20	0.20

Sources: The Conference Board of Canada; Statistics Canada; O*NET.

Appendix C

Detailed Results

Table 1

Top 10 HRLM Occupations That Can Transition to "Technical Occupations in Geomatics and Meteorology"

1	Medical laboratory technologists
2	Forestry technologists and technicians
3	Financial auditors and accountants
4	Inspectors and testers, mineral and metal processing
5	Court reporters, medical transcriptionists, and related occupations
6	Administrative assistants
7	General office support workers
8	Other medical technologists and technicians (except dental health)
9	Machine operators and inspectors, electrical apparatus manufacturing
10	Collectors

Note: Occupations are in descending order in terms of the ease of transition based on skills similarity.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Table 2

Top 10 HRLM Occupations That Can Transition to "Mining, Geological, and Petroleum Engineers"

1	Financial auditors and accountants
2	Medical laboratory technologists
3	Forestry technologists and technicians
4	Contractors and supervisors, machining, metal forming, shaping, and erecting trades and related occupations
5	Administrative assistants
6	Other medical technologists and technicians (except dental health)
7	Collectors
8	Inspectors and testers, mineral and metal processing
9	General office support workers
10	Other customer and information services representatives

Note: Occupations are in descending order in terms of the ease of transition based on skills similarity.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Table 3

Top 10 HRLM Occupations That Can Transition to "Computer and Information Systems Managers"

1	Financial auditors and accountants
2	Medical laboratory technologists
3	Contractors and supervisors, machining, metal forming, shaping and erecting trades and related occupations
4	Forestry technologists and technicians
5	Administrative assistants
6	Other medical technologists and technicians (except dental health)
7	Contractors and supervisors, heavy equipment operator crews
8	Court reporters, medical transcriptionists, and related occupations
9	Power engineers and power systems operators
10	Cooks

Note: Occupations are in descending order in terms of the ease of transition based on skills similarity.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Table 4

Detailed Distribution of the Number of Occupations by the Number of Desirable Transitions

Minor Training (i.e., six months)		**Moderate Training** (i.e., one year)		**Major Training** (i.e., three years)	
HRLM occupations	Desirable transitions	HRLM occupations	Desirable transitions	HRLM occupations	Desirable transitions
13	0	2	1	2	3
6	1	10	2	9	4
51	2	6	3	2	6
10	3	50	4	1	8
11	4	2	6	1	10
1	10	1	7	6	11
		1	10	58	12
		9	11	11	13
		11	12	2	14
Average	**3**	**Average**	**6**	**Average**	**9**

Sources: The Conference Board of Canada; O*NET; Vicinity Jobs.

Table 5

The Average Direct (i.e., Training) Cost of Transitions Varies by Training Scenario and Jurisdiction
(C$)

Province/Territory	Minor Training	Moderate Training	Major Training	Average
Prince Edward Island	13,685	27,344	82,070	41,033
Alberta	12,089	24,188	72,481	36,253
New Brunswick	11,387	22,785	68,250	34,141
Saskatchewan	11,226	22,459	67,255	33,647
Manitoba	10,107	20,220	60,587	30,305
Nova Scotia	9,629	19,264	57,734	28,876
Northwest Territories	9,163	18,309	55,201	27,558
British Columbia	8,871	17,747	53,187	26,601
Newfoundland and Labrador	8,870	17,749	53,156	26,592
Nunavut	8,721	17,442	52,326	26,163
Ontario	8,706	17,417	52,197	26,107
Canada	**8,618**	**17,241**	**51,671**	**25,843**
Yukon	7,633	15,214	45,770	22,872
Quebec	6,145	12,294	36,845	18,428

Note: Costs do not increase proportionally between training scenarios because each comprises different pathways (i.e. transition pairs), and each pathway is associated with different costs.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs; Statistics Canada.

Table 6

The Average Indirect (i.e., Training) Cost of Transitions Varies by Training Scenario and Jurisdiction
(C$)

Province/Territory	Minor Training	Moderate Training	Major Training	Average
Nunavut	28,299	52,488	130,496	70,428
Alberta	23,677	48,627	135,944	69,416
Northwest Territories	23,912	45,979	127,526	65,806
Saskatchewan	21,539	44,355	123,452	63,115
British Columbia	20,384	41,968	119,496	60,616
Yukon	21,234	41,763	117,678	60,225
Newfoundland and Labrador	20,584	43,525	116,502	60,204
Canada	**19,538**	**40,163**	**113,302**	**57,667**
Ontario	19,426	39,815	111,360	56,867
Manitoba	18,778	38,484	108,221	55,161
Prince Edward Island	18,206	36,509	103,308	52,674
Nova Scotia	17,691	36,500	103,464	52,551
Quebec	17,624	35,980	102,383	51,996
New Brunswick	17,148	35,157	98,849	50,384

Note: Costs do not increase proportionally between training scenarios because each comprises different pathways (i.e. transition pairs), and each pathway is associated with different costs.
Sources: The Conference Board of Canada; O*NET; Vicinity Jobs; Statistics Canada.

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